Ministry for the
Environment
Manatū Mō Te Taiao

ENVIRONMENT NEW ZEALAND 2007

Environment New Zealand 2007 project team

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Message from the Minister

The Government welcomes the publication of the second national state of the environment report. *Environment New Zealand 2007* provides a wealth of information about our environment and how it is changing over time. It also sets a compass against which we can chart New Zealand's journey towards greater sustainability.

Putting sustainability at the heart of our thinking and decision-making is important to this Government: the environment underpins the very foundations of New Zealand's national identity and quality of life. As the world moves to take greater action on environmental issues and a growing number of consumers demand environmentally-friendly products, we face both challenges and opportunities. With our enviable natural environment, efficient primary production, strong track record in renewable energy, and innovative business sector, New Zealand is well placed to respond.

Global climate change is probably the most significant environmental issue of the 21st century. Around the world, governments, businesses, households, and individuals are striving to reduce their greenhouse emissions. New Zealanders, too, must play their part. Using our energy and natural resources efficiently, adopting more sustainable transport and primary production, reducing waste, and encouraging afforestation are all important steps in responding to climate change and moving towards greater sustainability.

Climate change is not the only challenge we face. This report also highlights the decline in water quality New Zealand faces as a consequence of the increasing intensity of agricultural production. As we take action on this and other environmental concerns, regular environmental reporting will be important in tracking progress. Better understanding the impacts of our activities on the environment and targeting measures to reduce them will be an important part of reinforcing the 'clean and green' reputation we enjoy.

Environment New Zealand 2007 provides a timely platform for discussion about our environment and the pressures we are placing on it. I welcome the Ministry for the Environment's leadership in engaging with New Zealanders about how we can all play a part in making New Zealand a truly sustainable nation. I look forward to seeing progress towards this goal reflected in future state of the environment reports.

Hon Trevor Mallard
Minister for the Environment

Preface

The environment is central to New Zealand and the Kiwi way of life. Our iconic landscapes have shaped our identity as a nation, and the resources from the land, freshwater, and sea underpin our valuable primary industries. The varied urban and rural landscapes in which we live, work, and spend leisure time form an integral part of our social, cultural, and economic well-being.

Environment New Zealand 2007 is New Zealand's second state of the environment report. It is published at a time when there is heightened attention around the world on protecting the environment for our children and our children's children. The risks from a changing climate, the desire to use valuable natural resources more efficiently, and the need to protect our health have all created a global momentum for environmental action.

This report builds on *The State of New Zealand's Environment 1997*. It is not, however, a simple update of that report. A decade on, much has changed.

Environment New Zealand 2007:

- reflects improvements in environmental monitoring and reporting by central and local government
- sets a benchmark against which environmental outcomes can be monitored over time
- represents another step in the commitment by central government to regular reporting on the state of New Zealand's environment
- highlights changes to environmental policy and resource management and new environmental standards and regulations.

Since 1997, New Zealand has made significant progress in ensuring sound environmental information is available to support environmental decision-making. *Environment New Zealand 2007* advances this work by using environmental indicators and a range of mapping tools to present an overview of key aspects of New Zealand's environment. This report also summarises for decision-makers the most urgent pressures on, and challenges for, our environment.

I am very pleased to bring you *Environment New Zealand 2007*. I have confidence that, in creating a national picture of New Zealand's environmental well-being, this report will help shape the course of environmental management in New Zealand into the future.

Hugh Logan
Secretary for the Environment

Acknowledgements

Environment New Zealand 2007 represents the collective effort of many organisations. They have provided data, peer review comments, and made suggestions on the presentation of information. Without their support the completion of this report would not have been possible. We would like to thank the following organisations for their invaluable contribution:

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The report's strengths owe much to the above contributors and reviewers. However, the Ministry for the Environment bears full responsibility for the final text.

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About this report

Purpose of this report

Environment New Zealand 2007 uses a set of environmental indicators to report on key aspects of the New Zealand environment and to track how these aspects have changed over time.

This report will:

- provide useable and constructive information to foster informed decision-making on matters that affect the environment and encourage appropriate management approaches
- increase New Zealanders' understanding about the state of, and pressures on, our environment
- highlight the aspects of the environment that have come under particular pressure and those that require priority attention
- motivate all New Zealanders to take action to protect and conserve the environment.

Environment New Zealand 2007 is intended to be informative and thought-provoking for both those New Zealanders responsible for environmental decision-making and general readers alike. While much of the content is technical in nature, the report aims to present information at a level that is relevant to all readers.

The report will play an important role in establishing regular and ongoing national-level reporting on the state of New Zealand's environment. In part, its value is in setting a benchmark against which environmental outcomes can be monitored over time.

Differences between the 2007 and 1997 reports

Environment New Zealand 2007 is New Zealand's second national state of the environment report. The 2007 report differs in several fundamental ways from the first report, *The State of New Zealand's Environment 1997*.

The 1997 report drew largely on qualitative information to present a comprehensive, narrative picture of the state of New Zealand's environment. It gathered together detailed information on the historical and contemporary pressures and influences on the New Zealand environment, and analysed this in-depth. Because the majority of the analysis in the 1997 report remains valid today, the 2007 report does not repeat it.

Since 1997, there have been significant advances in environmental monitoring, data collection, and data reporting at the national level. These advances allow *Environment New Zealand 2007* to provide a more quantitative picture of key aspects of New Zealand's environment than was possible in the 1997 report. To do so, the 2007 report introduces a core set of national-level environmental indicators and reports against them. Unlike the 1997 report, the 2007 report makes use of ecological classification systems to extrapolate and interpret this quantitative information across New Zealand (see chapter 1, 'Environmental reporting'). In doing so, the 2007 report follows international best practice for state of the environment reporting at the national level.

Data used in this report

Environment New Zealand 2007 uses data collected by central and local government agencies, non-government organisations, and Crown Research Institutes at different time intervals. Consequently, much of the data does not neatly span the decade between 1997 and 2007. For each chapter, we have used the best data available to determine trends over time. This report is based on information and data available before the end of July 2007.

Some chapters in the 2007 report use data derived from national environmental monitoring networks. Readers should bear in mind that national-level monitoring in New Zealand is mostly carried out in locations known, or expected, to have poor environmental quality. This can mean that 'healthy' areas of the environment are not well represented in the data collected. For example, water quality in New Zealand's national parks network is not regularly monitored and reported on because water quality in national parks is known from occasional monitoring to be generally very good. Where such data anomalies occur, these are noted in the relevant chapters.

Structure of this report

Environment New Zealand 2007 is divided into three sections.

Section one: Setting the context

Section one describes the environmental indicators and classification tools used in this report and provides an overview of New Zealand's environment, population, and demography.

Section two: Pressures on the environment

Section two examines selected pressures on New Zealand's environment, including household consumption, transport, energy, and waste.

Section three: State of the environment

Section three reports on the quality of New Zealand's air, atmosphere, land, freshwater, oceans, and biodiversity.

Structure of chapters

The chapters in sections two and three are structured under six standard headings:

- At a glance
- Introduction
- National environmental indicator(s)
- Current pressures and trends or Current state and trends
- Changes since the 1997 report
- References.

Text boxes

The 2007 report uses 'text boxes' like this one to provide additional information to interested readers. Most text boxes are categorised as shown below.

- Text boxes entitled 'Government action on …' and 'Local action on …' outline how central government, local government, iwi, and community groups take action to protect the environment.
- 'More about …' text boxes provide more detailed information on technical matters discussed in the body of the chapter.

SETTING THE CONTEXT

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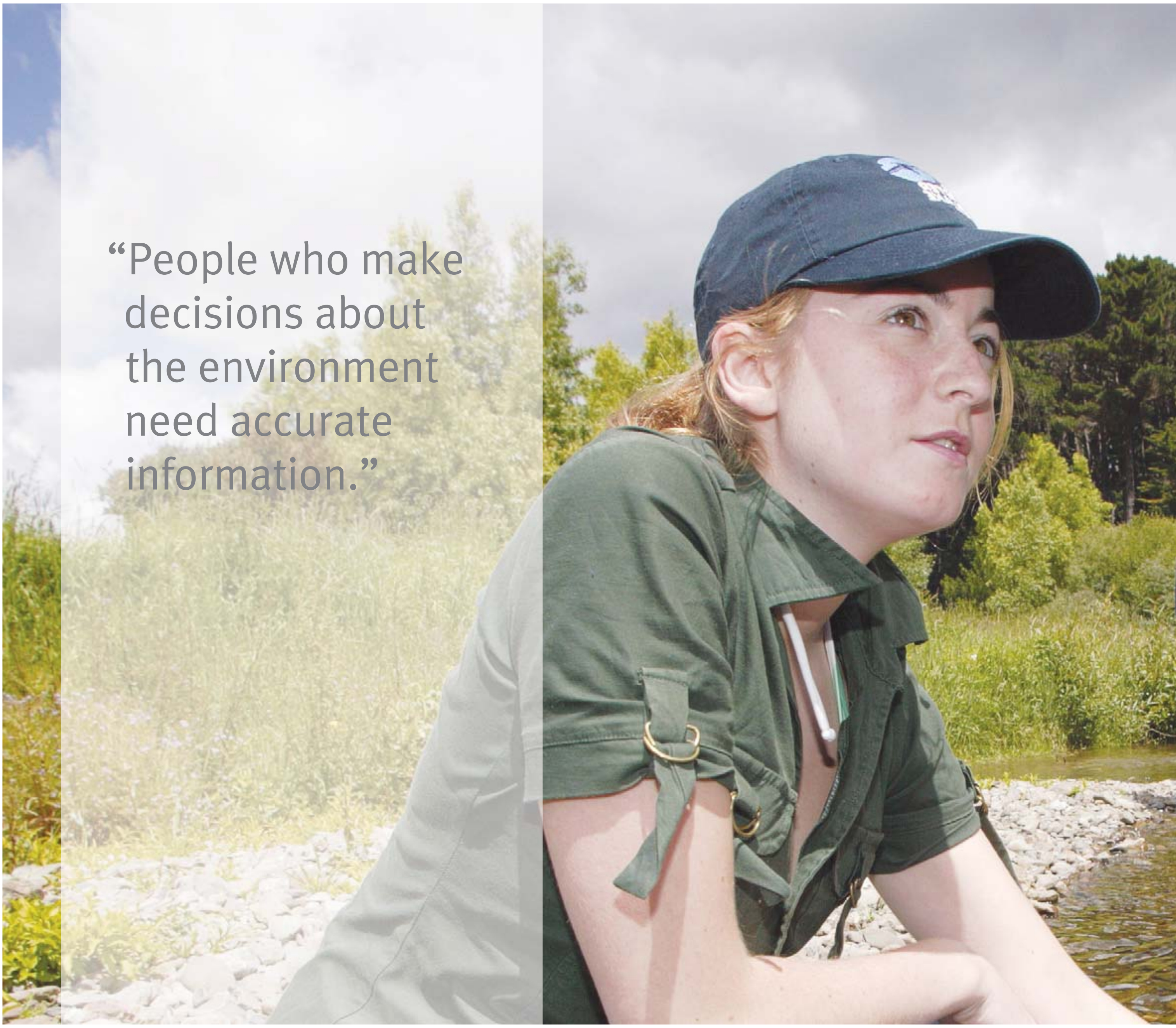

“People who make
decisions about
the environment
need accurate
information.”

1

ENVIRONMENTAL REPORTING

Contents

At a glance

Purpose of environmental reporting

People who make decisions about the environment need accurate and reliable environmental information. State of the environment reporting can provide this. It also helps us to know whether policy initiatives or environmental management approaches are effective over time.

Environmental indicators

We cannot continuously measure every aspect of our environment, so environmental reporting relies on using a range of 'indicators' to assess the overall state of the environment in a practical, cost-effective, and meaningful way.

In the same way that gross domestic product is an indicator of economic activity, each environmental indicator allows us to measure and report on a specific aspect of the state of our environment.

Ecological classification systems

Ecological classification systems can be used alongside environmental indicators to group and extrapolate data across geographical areas that are environmentally similar. Data from a limited number of monitored sites can then be used to build a national picture of the state of the environment.

Creating a national picture

This report uses a set of core national environmental indicators and ecological classification systems to present a national picture of key aspects of the New Zealand environment.

This national picture will highlight for decision-makers and environmental managers the aspects of our environment that have come under particular pressure and require priority attention.

Purpose of environmental reporting

People who make decisions about the environment need accurate and reliable environmental information. With this information, they can make informed decisions about natural resource management and set environmental policy. Environmental reporting also helps us know whether policy initiatives or environmental management approaches are effective over time.

We cannot continuously measure every aspect of the environment. In the same way that gross domestic product is used as an indicator of economic activity, an environmental indicator provides information on a specific aspect of our environment.

Environmental reporting relies on using a range of indicators to measure and report on the overall health of our environment in a cost-effective, practical, and meaningful way.

State of the environment reporting is widely used as an environmental management tool (Department of the Environment and Heritage, 2006). It uses environmental indicators to draw together scientific knowledge, information, and data to track:

- environmental trends
- activities that have an impact on the environment
- the effectiveness of environmental policies and management actions.

Environmental reporting at national, regional, and local levels

In New Zealand, environmental reporting happens at the national level (for example, in reports such as this one) and at regional and local levels.

Many different organisations and groups are involved in developing environmental indicators, collecting data against the indicators, and reporting on what the data shows.

This section gives details of some of the environmental reporting that occurs in New Zealand, and who is involved.

National reporting

The 1997 report, *The State of New Zealand's Environment 1997*, concluded:

> New Zealand's environmental information needs considerable upgrading if the state of the nation's environment is to be accurately described and trends detected.

(Ministry for the Environment, 1997, chapter 10.)

In response, the Ministry for the Environment developed a national environmental reporting programme to report regularly on New Zealand's key environmental issues.

As a result, a number of reports on the New Zealand environment have been produced over the last decade. These have primarily focused on particular pressures on the environment (for example, waste flows or greenhouse gas emissions) or specific aspects of the environment (for example, water quality or air quality), for which data is available across the whole country.

To give greater momentum to environmental reporting, the Ministry for the Environment defined a new set of core national environmental indicators in 2007. These indicators underpin the Ministry's new national environmental reporting programme, and will be used to support regular and ongoing national-level reporting on the state of key aspects of New Zealand's environment.

Many of the selected indicators link directly to aspects of the environment that are measured by other agencies in New Zealand (for example, local government).

This report introduces the set of national environmental indicators and uses them to present a national picture of the New Zealand environment.

Regional monitoring

Local government undertakes a wide range of environmental monitoring at the regional level to meet its obligations relating to the environment. Under section 35(2)(a) of the Resource Management Act 1991, local authorities must monitor '[t]he state of the whole or any part of the environment of its region or district to the extent that is appropriate to enable the local authority to effectively carry out its functions under this Act'.

Local government uses environmental monitoring to improve its understanding of the state of the environment for which it is responsible, and to make informed and appropriate management decisions about it. Monitoring also allows local government to determine whether management approaches have been effective, and whether new approaches to emerging environmental issues are needed.

The scope of environmental monitoring differs around the country. For example, Auckland Regional Council has an extensive marine sediment monitoring programme. This reflects the pressures on the Auckland marine environment from stormwater run-off, coastal construction and excavation activity, and intensive urban development.

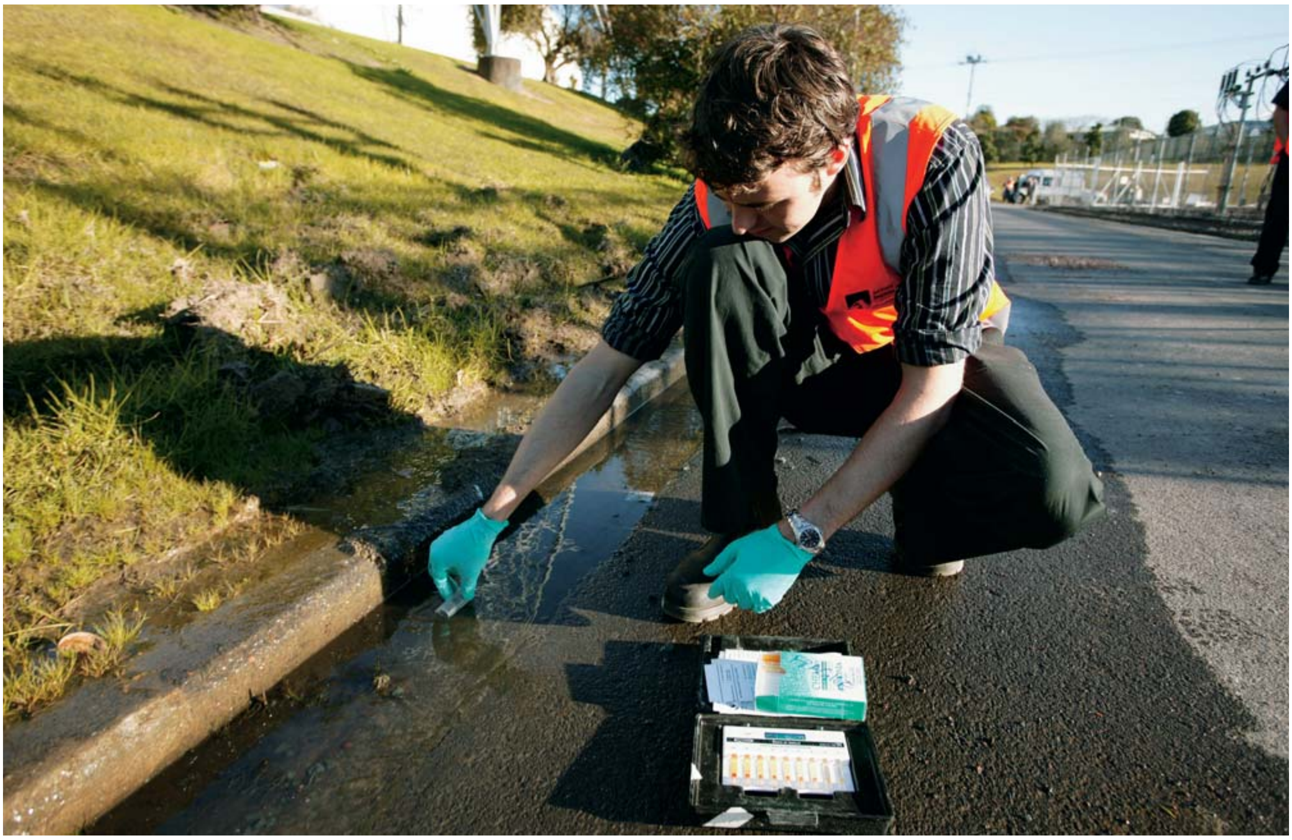
Different types of monitoring may be needed in regions facing other pressures. Councils in rural areas that are intensively farmed would be expected to focus their monitoring efforts on freshwater quality and quantity, the health of aquatic ecosystems, soil quality and erosion, and sustainable land management.

Regional reporting

Regional-level state of the environment reporting is not a legislative requirement. Councils must simply compile and make available to the public a review of the results of their monitoring at least every five years. The review is then used to assess the effectiveness of the policies, rules, or other methods in the council's policy statement or plan.

Most councils in New Zealand use their monitoring results to produce comprehensive state of the environment reports for their district or region every few years. Increasingly, these have become more targeted reports that use selected indicators to monitor specific aspects of the environment (for example, biodiversity or the coastal environment).

ROADSIDE MONITORING BY AUCKLAND REGIONAL COUNCIL.



Source: Ministry for the Environment.

Some councils (such as Environment Southland) produce summary 'report cards' that give a snapshot of the state of the environment in their region over the last monitoring period. These easy-to-read summaries provide a succinct picture of the quality of a particular dimension of the environment (for example, local air quality).

Local monitoring and reporting

Right across New Zealand, iwi, hapū, and community groups are involved in projects to monitor, protect, and enhance the health of their local environment. Local monitoring and reporting play an important role in environmental management: careful tracking of local environments can identify emerging pressures and ensure measures are put in place to manage them at an early stage.

Monitoring and reporting by local groups may be specific to a project with which they are involved, or may feed into more formal reporting networks. For example, community-based river care and restoration groups may gather information on the state of specific parts of the local environment, which in turn contributes to formal state of the environment reporting by councils.

One example of local monitoring is community-group participation in annual monitoring of shellfish at several locations in the Hauraki Gulf. With support from territorial authorities, Auckland Regional Council and the Department of Conservation, schools and community groups collect information on shellfish type, size, and distribution. The results are reported to both the community and the Ministry of Fisheries, and are used to inform the Hauraki Gulf State of the Environment Report.

A further example is research into tuna (eel) stocks in the Ngāti Raukawa area, which extends from Bulls to Ōtaki. Monitoring was conducted by Te Wānanga-o-Raukawa and involved a number of hapū. The project aimed to develop a tuna management plan by recording oral narratives about historic tuna levels and collecting present-day data about tuna in the area.

Takiwā – a culturally-based environmental monitoring system

Takiwā is a culturally-based environmental monitoring and reporting tool that incorporates both traditional and science-based knowledge and methods. Te Rūnanga o Ngāi Tahu worked with Papatipu Rūnanga, regional councils, and a number of Crown Research Institutes to develop Takiwā, with funding from the Ministry for the Environment.

The monitoring tool uses a specially designed database and a series of associated monitoring forms. Together, these allow for data from selected sites to be gathered, stored, analysed, and reported on in terms of the values Māori associate with the environment – in particular, the concept of mahinga kai, or customary food and resource gathering.

Currently, the system has a particular focus on freshwater monitoring, drawing on the Cultural Health Index (see box 'More about iwi monitoring of freshwater: Cultural Health Index' in chapter 10, 'Freshwater'). Plans are under way to develop and include specific cultural assessment tools for coastal, estuarine, and lake sites.

To date, Takiwā has been used to assess more than 100 sites within 11 catchments in Canterbury, Ōtago, and Southland, including sites of traditional importance and those within coastal, headwater, plains, and urban areas. Results from this monitoring will be used to develop a report on the quality of waterways in the South Island.

Takiwā monitoring has also been used to complement regional council monitoring of waterways, as well as to monitor the conditions of resource consents affecting sites of cultural significance, such as Te Waihora/ Lake Ellesmere.

This monitoring aims to identify the current health of catchments both as a baseline for future monitoring and restoration work, and to report the extent of change within these areas. It does so by allocating a 'score' to each site, based on factors such as pressures on the site, its suitability for harvesting mahinga kai, ease of access to the site, its degree of modification, and whether valued and pest species are present. Other natural resources, such as particular types of stone (for example, pounamu/ greenstone or hāngi stones), are also identified.

Where appropriate, Takiwā site assessments are complemented by the Cultural Health Index and other assessment methods.

Because Takiwā monitoring focuses on whether the environment is healthy enough to allow food and resources to be gathered, it plays an important role in building a more complete picture of overall environmental health. This is because conventional monitoring may focus only on either ecological or recreational requirements. For example, an assessment of the quality of water for swimming does not identify whether it is safe to gather mahinga kai or drink the water. Moreover, the presence at a site of a particular species, such as tuna (eels), does not mean the species is abundant or healthy enough to harvest.

Through its ongoing use and development of Takiwā, Te Rūnanga o Ngāi Tahu hopes culturally-based indicators will become a regular part of future environmental monitoring and reporting.

National environmental indicators

Many countries have defined their own environmental indicators, as have international bodies such as the Organisation for Economic Co-operation and Development (OECD) and the European Environment Agency (EEA).

As noted earlier, environmental indicators are used to provide an estimate of the overall state of the environment by:

- reporting on specific aspects of the environment
- tracking trends in these aspects over time.

As an example, air quality in managed airsheds is one of the core national environmental indicators used to report on the state of New Zealand's environment (see the section 'Core national environmental indicators' on the following page).

The air quality in managed airsheds is assessed by measuring and reporting on several aspects of air quality. These aspects are known as 'variables'. The variables used to assess air quality in managed airsheds are the maximum concentrations and annual averages of PM_{10} particulate matter, carbon monoxide, nitrogen dioxide, sulphur dioxide, and ground-level ozone.

The value of an indicator lies in its ability to show whether measured aspects of the environment are improving or getting worse over time. Indicators can be used to trigger appropriate and timely action to address environmental problems.

GREATER WELLINGTON REGIONAL COUNCIL AIR QUALITY MONITORING STATION.

Source: Ministry for the Environment.

Core national environmental indicators

Table 1.1 lists the set of core national environmental indicators used in this report.

The indicators have been chosen to provide the key information needed for national environmental policy-making and natural resource management in New Zealand. They were also selected for their ability to provide the best representation of the information that is currently available on high-priority issues for the environment. They form a representative sample of indicators, which can be added to over time as more national-level data becomes available.

The indicators were distilled from a wider set of 160 indicators, which were developed by the Ministry for the Environment and used in its earlier Environmental Performance Indicators Programme (Ministry for the Environment, 2006).

As Table 1.1 shows, many agencies collect and share the environmental data used to report against the core national environmental indicators. These agencies include central and local government agencies, non-government organisations, and Crown Research Institutes.

+ TABLE 1.1
NATIONAL ENVIRONMENTAL INDICATORS USED IN THIS REPORT

NATIONAL ENVIRONMENTAL INDICATOR	REPORTING PARTNER	RELEVANT CHAPTER OF THIS REPORT
Household consumption	StatsNZ	Household consumption
Vehicle kilometres travelled (VKT) by road	MoT	Transport
Energy supply and consumption	MED	Energy
Solid waste disposed of to landfill	Regional councils, territorial authorities	Waste
Air quality in managed airsheds	Regional councils	Air
Emissions and removals of greenhouse gases	MED, MoT	Atmosphere
Stratospheric ozone levels	NIWA	Atmosphere
Land cover	DOC, MAF, regional councils	Land
Land use	DOC, MAF, regional councils	Land
Soil health	Regional councils, MAF, CRIs	Land
Soil intactness of erosion-prone hill country	Regional councils, MAF, CRIs	Land
Water quality in rivers, lakes, and groundwater aquifers	Regional councils, NIWA	Freshwater
Freshwater demand	Regional councils	Freshwater
Fish stocks under the quota management system	MFish	Oceans
Seabed trawling in deep waters	MFish	Oceans
Water quality at coastal swimming spots	Regional councils, territorial authorities	Oceans
Marine areas with legal protection	DOC, MFish	Oceans
Land area with native vegetation, including area under legal protection	DOC, QEII, regional councils, territorial authorities	Biodiversity
Distribution of selected native plants and animals	DOC, OSNZ	Biodiversity

Note:
CRIs = Crown Research Institutes; DOC = Department of Conservation; MAF = Ministry of Agriculture and Forestry; MED = Ministry of Economic Development; MFish = Ministry of Fisheries; MoT = Ministry of Transport; NIWA = National Institute of Water and Atmospheric Research; OSNZ = Ornithological Society of New Zealand; QEII = Queen Elizabeth the Second National Trust; StatsNZ = Statistics New Zealand.

Source: Ministry for the Environment.

The DPSIR model

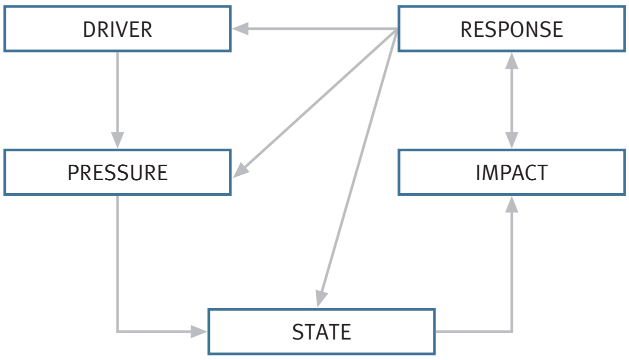
To help decision-makers use the information from the core environmental indicators in a meaningful way, indicators are often developed within a particular framework or model. The model is used to highlight what type of information the indicator is trying to show and how this information can best be used.

The Ministry for the Environment has developed the framework for the core set of national environmental indicators from two well-tested analytical models:

- the Driving force–Pressure–State–Impact–Response (DPSIR) model, which was developed from the OECD's Pressure–State–Response model
- the typology of indicators developed by the European Environment Agency (European Environment Agency, 1999; 2003; 2005).

The DPSIR model (see Figure 1.1) shows how human activity (also known as a driver or driving force) exerts pressure on the environment and, as a result, changes the state of the environment. The state of the environment can have impacts on people's health, ecosystems, and natural resources. These impacts can result in responses in the form of management approaches, policies, or actions that alter the driving forces, pressures, and, ultimately, the state of the environment. Changes in impacts over time can result in people modifying their response to those impacts (European Environment Agency, 2003).

+ FIGURE 1.1:
DPSIR MODEL



Source: Adapted from Smeets and Weterings, 1999.

An environmental indicator developed under the DPSIR model can be categorised as a 'driving force', 'pressure', 'state', 'impact', or 'response' indicator, according to the type of information it provides. For example, the indicator for the emissions and removals of greenhouse gases is a pressure indicator, because increasing greenhouse gas emissions put pressure on the atmosphere and change the climate. The indicator for national water quality tracks the quality or condition of waterways, so it is a state indicator.

Table 1.2 explains DPSIR indicators in more detail.

+ TABLE 1.2:
DESCRIPTION OF DPSIR INDICATORS

INDICATOR TYPE	DESCRIPTION OF INDICATOR TYPE
Driving force (driver)	Describes social, demographic, and economic developments. Primary driving forces are population growth and changes in people's needs and activities. These change lifestyles and overall levels of production and consumption, which in turn exert pressures on the environment.
Pressure	Tracks people's use of natural resources and land, and production of waste and emissions (for example, greenhouse gases and particulates into the air). These pressures can change environmental conditions.
State	Describes the quantity and quality of the environment and natural resources (for example, water quality, air quality, or land cover).
Impact	Describes the effects that environmental changes have on environmental or human health (for example, the level of human illness related to exposure to air pollution).
Response	Describes responses by government, organisations, or the community to prevent, compensate, ameliorate, or adapt to changes in the environment (for example, the introduction of regulations such as national environmental standards and legislative initiatives to protect native vegetation and biodiversity).

Source: Adapted from European Environment Agency, 2003.

Collectively, indicators developed under the DPSIR model demonstrate how people's activities and environmental effects are interconnected, and the effectiveness of policy and management responses to environmental problems.

DPSIR indicators aim to address four fundamental questions:

- What is happening to the environment?
- Why are changes happening to the environment?
- Are these changes to the environment significant?
- What is society's response to these changes to the environment?

Typology of indicators

Indicators can also be classified by type using the European Environment Agency's typology (European Environment Agency, 2003). This typology distinguishes four types of indicator, each of which addresses a different question and provides different information.

Descriptive indicators: What is happening in the environment and to people?

Descriptive indicators describe key environmental issues and their impact on people, and show changes over time.

Performance indicators: Is a policy or management approach making a difference?

Performance indicators compare actual conditions against a set of reference conditions (for example, progress towards targets, goals, or environmental objectives).

Efficiency indicators: Are we improving?

Efficiency indicators relate environmental pressures to people's activities, and to the efficiency of products and processes. Activities are measured in terms of the resources they use and the emissions and waste they generate.

Total welfare indicators: Are we better off?

Total welfare indicators are one measure of social, economic, and environmental well-being. In this way, they are indicators of sustainability.

Core indicators by DPSIR model and EEA type

The DPSIR model and EEA typology can be used to describe the core national environmental indicators in more detail (see Table 1.3).

Categorising the core indicators in this way makes explicit their value and limitations for decision-making. Policy-makers and natural resource managers can make best use of information that illustrates the most relevant aspects of complex environmental issues.

+ TABLE 1.3:
CLASSIFICATION OF NATIONAL ENVIRONMENTAL INDICATORS BY DPSIR MODEL AND EEA TYPE

NATIONAL ENVIRONMENTAL INDICATOR	POSITION IN DPSIR MODEL	EEA TYPE
Household consumption	Driving force	Descriptive
Vehicle kilometres travelled (VKT) by road	Driving force	Descriptive
Energy supply and consumption	Driving force	Descriptive Efficiency, when compared with gross domestic product or in a ratio such as total consumer energy / total primary energy supply
Solid waste disposed of to landfill	Pressure	Descriptive Efficiency, when compared with total waste generation Performance, when compared with New Zealand Waste Strategy targets
Air quality in managed airsheds	State	Performance
Emissions and removals of greenhouse gases	Pressure	Performance
Stratospheric ozone levels	State	Descriptive
Land cover	State	Descriptive
Land use	Pressure	Descriptive
Soil health	State	Efficiency
Soil intactness of erosion-prone hill country	State	Efficiency
Water quality in rivers, lakes, and groundwater aquifers	State	Descriptive Performance, when compared with national guideline or Australian and New Zealand Environment Conservation Council trigger values
Freshwater demand	Pressure	Efficiency
Fish stocks under the quota management system	Driving force, pressure, and response	Efficiency Performance
Seabed trawling in deep waters	Driving force and pressure	Descriptive
Water quality at coastal swimming spots	State	Performance
Marine areas with legal protection	Response	Descriptive Performance
Land area with native vegetation, including area under legal protection	State and response	Descriptive Performance, when compared with the New Zealand Biodiversity Strategy goals
Distribution of selected native plants and animals	State	Descriptive

Source: Ministry for the Environment.

Ecological classifications

New Zealand's geography is highly variable, and its environment can change greatly over relatively short distances. However, geographically remote areas can have similar environmental characteristics (that is, similar climate conditions, landforms, and soils) that support particular ecosystems (habitats and species). These areas are said to be ecologically similar.

As an example, swampy areas on poorly drained recent soils in river valleys occur in many places between Gisborne and mid-Canterbury, although these places are geographically separate. Another example is the similarity of kiwi habitats found in some parts of the North Island, South Island, and Stewart Island, even though these habitats are not geographically connected.

Once we have identified and mapped areas that have a similar ecological character, we can compare environmental data from these areas. This helps build a greater understanding of the state of New Zealand's environment (Snelder et al, 2000), and helps decision-makers make appropriate environmental management decisions.

Environmental data from one area can also be used to extrapolate what might be happening in an area with similar ecological character, for which environmental data is not available. In this way, data from a limited number of monitored sites can be used to build a national picture of the state of the environment.

To identify, map, and extrapolate data in the ways described above, we use ecological classification systems. These systems compile information to identify and then map similar environments, biological regions, or land covers.

The five ecological classifications used in New Zealand for national state of the environment reporting are:

- Land Cover Database series 1 and 2
- River Environment Classification
- Coastal and Marine Habitat and Ecosystem Classification System, comprising:
  - Coastal Biogeographic Regions Classification
  - Marine Environment Classification (which is not used in this report, but will be used for ongoing national environmental reporting)
- Demersal Fish Community Classification
- Land Environments of New Zealand.

A brief explanation of each classification follows. Technical information about the classifications can be found in Environment New Zealand 2007 – A Technical Guide to New Zealand's Environmental Indicators (Ministry for the Environment, forthcoming).

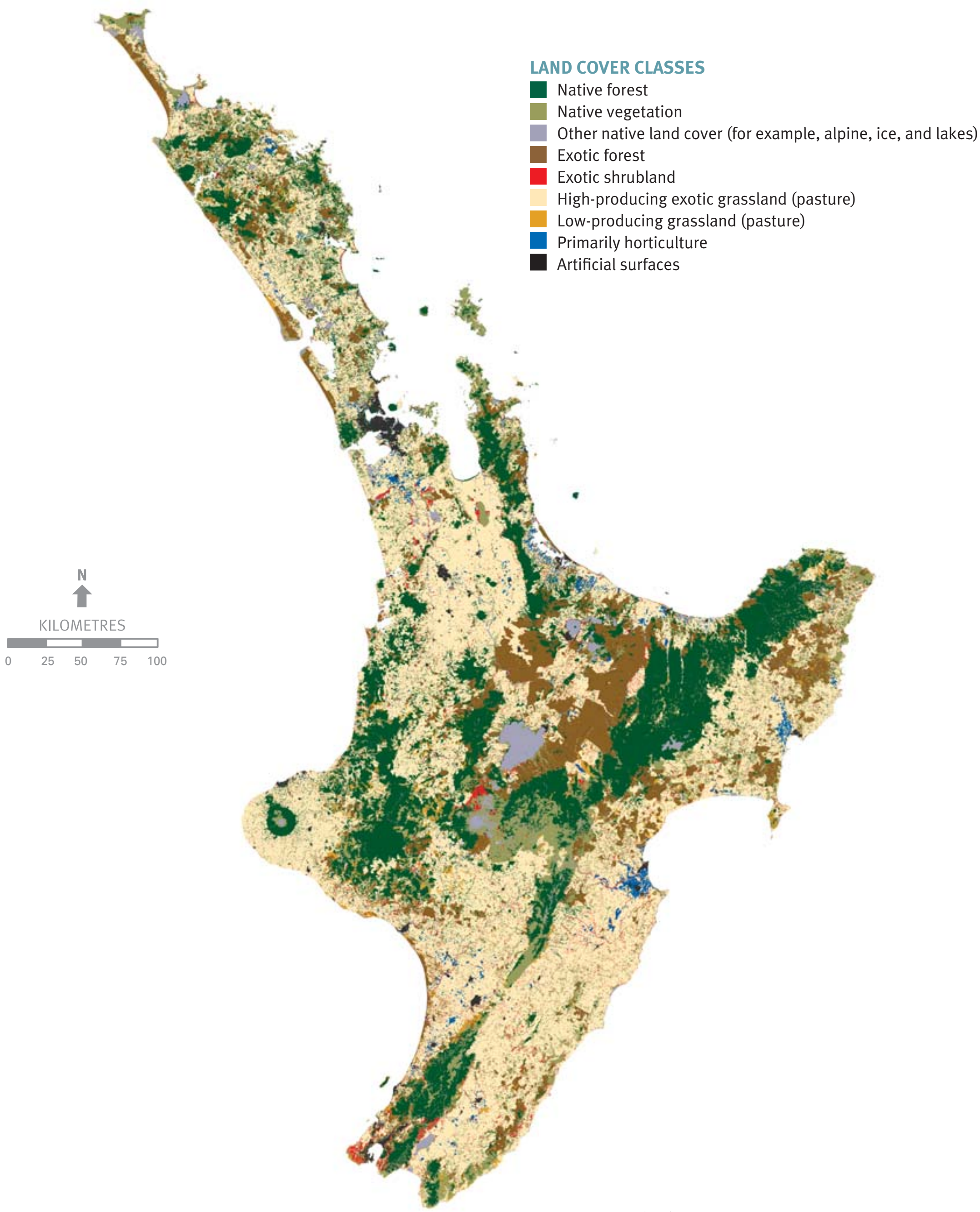
Land Cover Database

The Land Cover Database series 1 and 2 is a geographically spatial (satellite) map of New Zealand's land cover. Land cover describes the types of features present on the surface of the earth (for example, pastures, lakes, forests, or concrete).

Both database series are made up of 43 classes of land cover. This report uses these classes to monitor and report on the national environmental indicators for land cover, land use, soil intactness on erosion-prone hill country, and areas of land under legal protection.

The Land Cover Database series 2 is shown in Figures 1.2 and 1.3, with its 43 classes grouped into nine major land cover classes.

+ FIGURE 1.2:
LAND COVER DATABASE SERIES 2, NORTH ISLAND, 2002

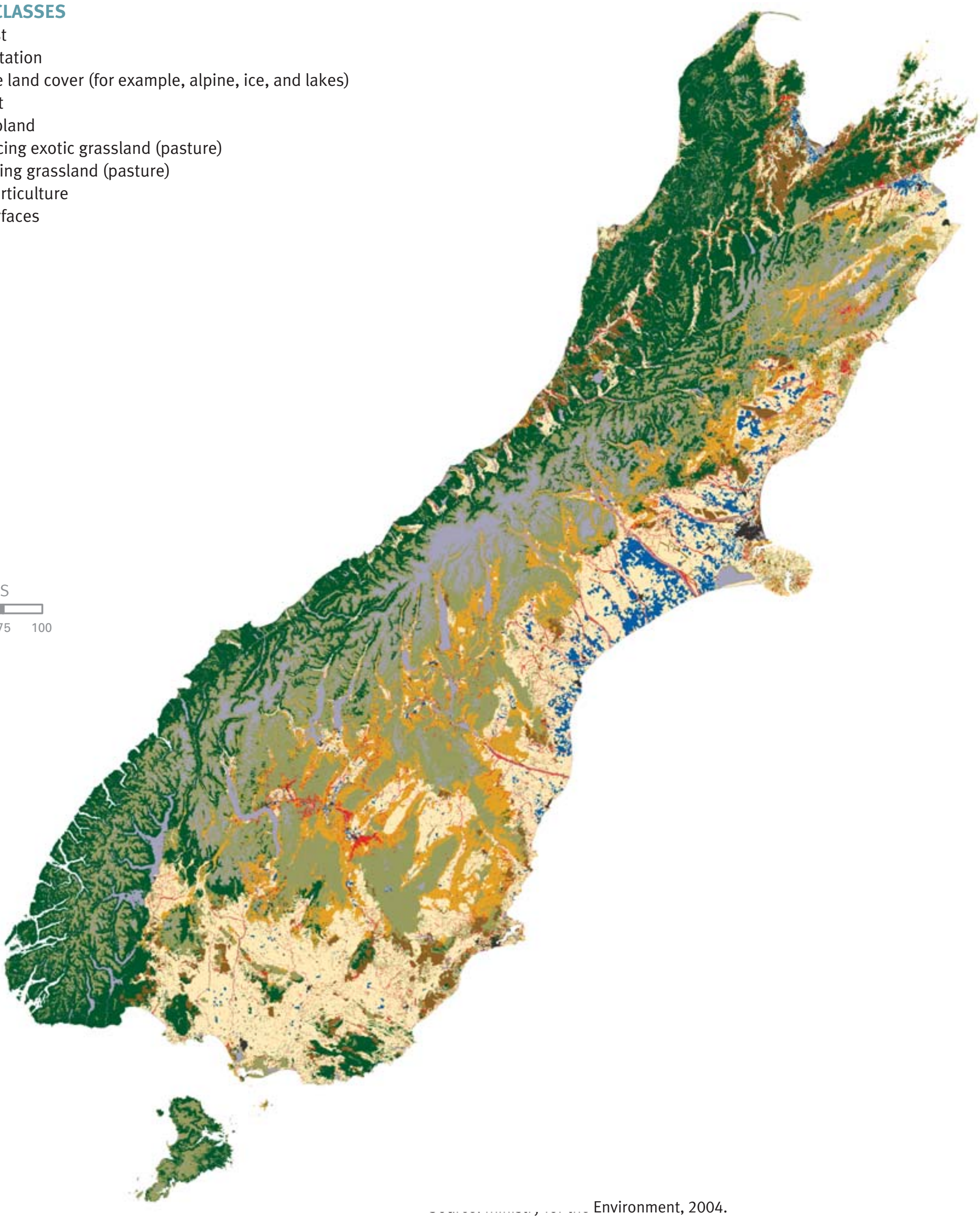


Source: Ministry for the Environment, 2004.

+ FIGURE 1.3:
LAND COVER DATABASE SERIES 2, SOUTH ISLAND, 2002

LAND COVER CLASSES
- Native forest
- Native vegetation
- Other native land cover (for example, alpine, ice, and lakes)
- Exotic forest
- Exotic shrubland
- High-producing exotic grassland (pasture)
- Low-producing grassland (pasture)
- Primarily horticulture
- Artificial surfaces

N
KILOMETRES
0 25 50 75 100



Source: Ministry for the Environment, 2004.

River Environment Classification

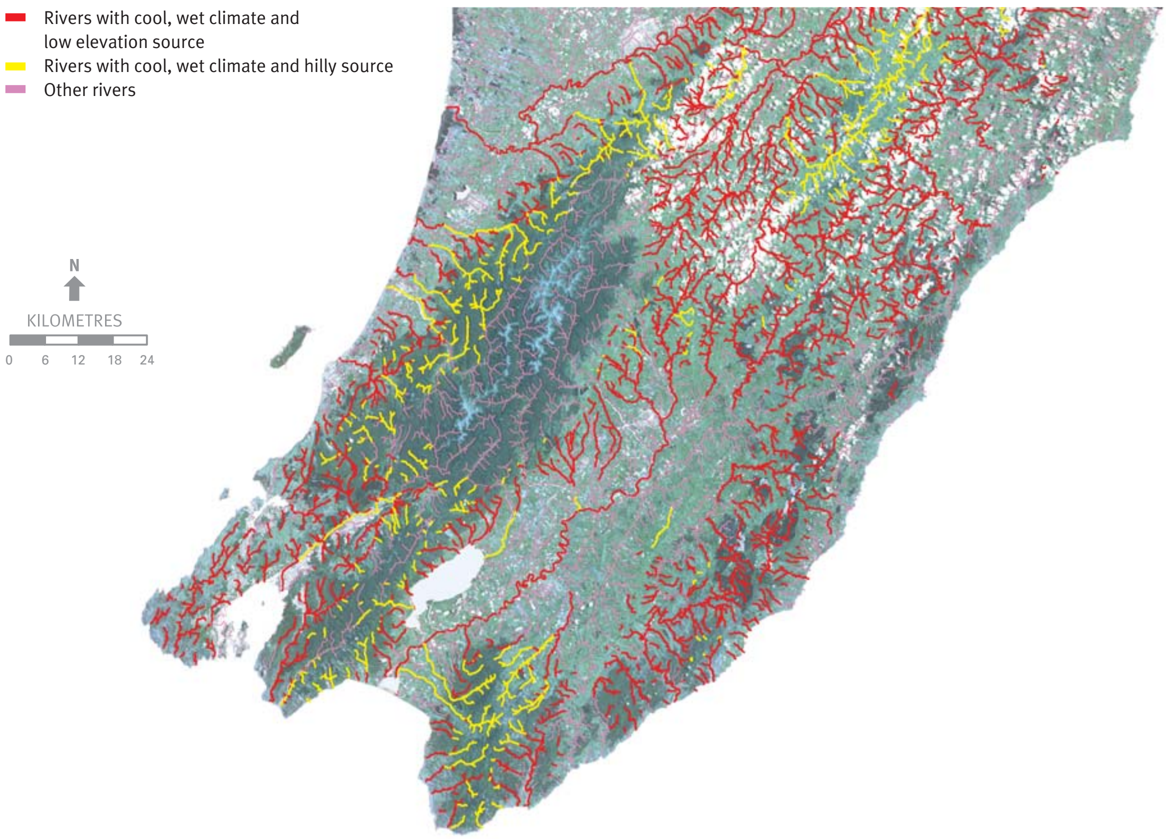
The River Environment Classification maps rivers that have a similar character across New Zealand's landscape. Individual river sections are mapped according to physical factors such as climate, topography, and geology, and land cover conditions. Sections of river that have similar ecological characteristics can then be grouped together, no matter where they are (Snelder et al, 2004).

Figure 1.4 shows an image of the lower North Island. The coloured ribbons show the river network in these areas. The River Environment Classification identifies rivers according to their climate and source of flow. For example, the red rivers have a cool, wet climate and low elevation source, while the yellow rivers have a cool, wet climate and hilly source. 'Other rivers' includes several categories of climate and source of flow that have been combined for the purposes of this figure.

Different types of river respond differently to the pressures placed on them; the River Environment Classification can be used to highlight the most appropriate management tools and approaches to reduce these pressures for each river type. Information from the classification is used to develop policy, assess the environment, and report on the quality of river water.

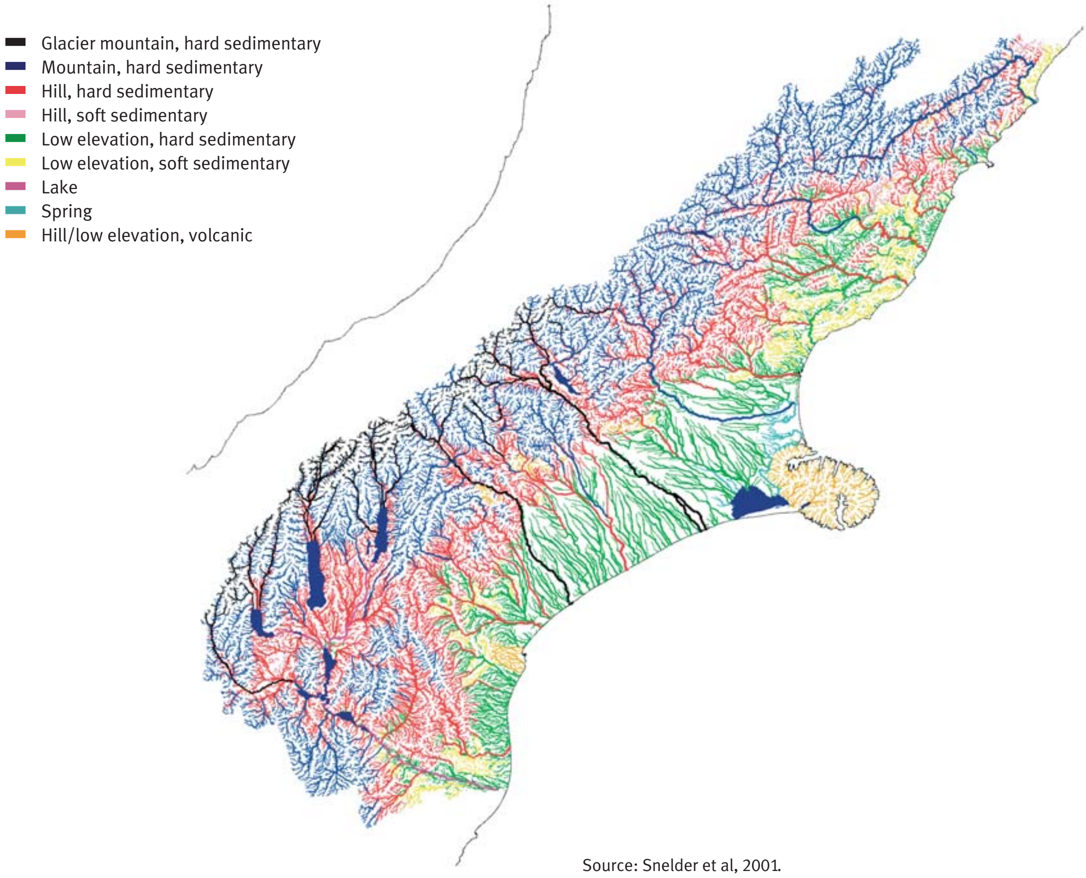
Figure 1.5 shows the River Environment Classification for the river network in the Canterbury region. The rivers are divided into nine groups, according to the type of landscape they spring from (for example, a glacial mountain) and their underlying geology (for example, soft sedimentary rock). The key shows a colour code for each different river type.

+ FIGURE 1.4:
IMAGE OF LOWER NORTH ISLAND WITH RIVERS AND STREAMS OVERLAID USING THE RIVER ENVIRONMENT CLASSIFICATION



Source: Ministry for the Environment.

+ FIGURE 1.5:
RIVER ENVIRONMENT CLASSIFICATION OF RIVERS AND STREAMS IN THE CANTERBURY REGION



Source: Snelder et al, 2001.

Coastal and Marine Habitat and Ecosystem Classification System

New Zealand's marine environment is characterised by sandy and rocky beaches, exposed cliffs, bays, and estuaries of varying sizes; and a variety of coastal and deep-sea habitats and ecosystems. Beneath the surface are diverse seascapes and plant and animal life.

Two ecological classifications for New Zealand's marine environment have been developed and are used together for state of the environment reporting. The Coastal Biogeographic Regions Classification is used as a framework to provide information on the coastal marine environment (that is, waters less than 200 metres deep), and the Marine Environment Classification is used as a framework for deep-water environments (waters 200 metres or more deep) (Department of Conservation and Ministry of Fisheries, 2007; also see Figures 1.6 and 1.7).

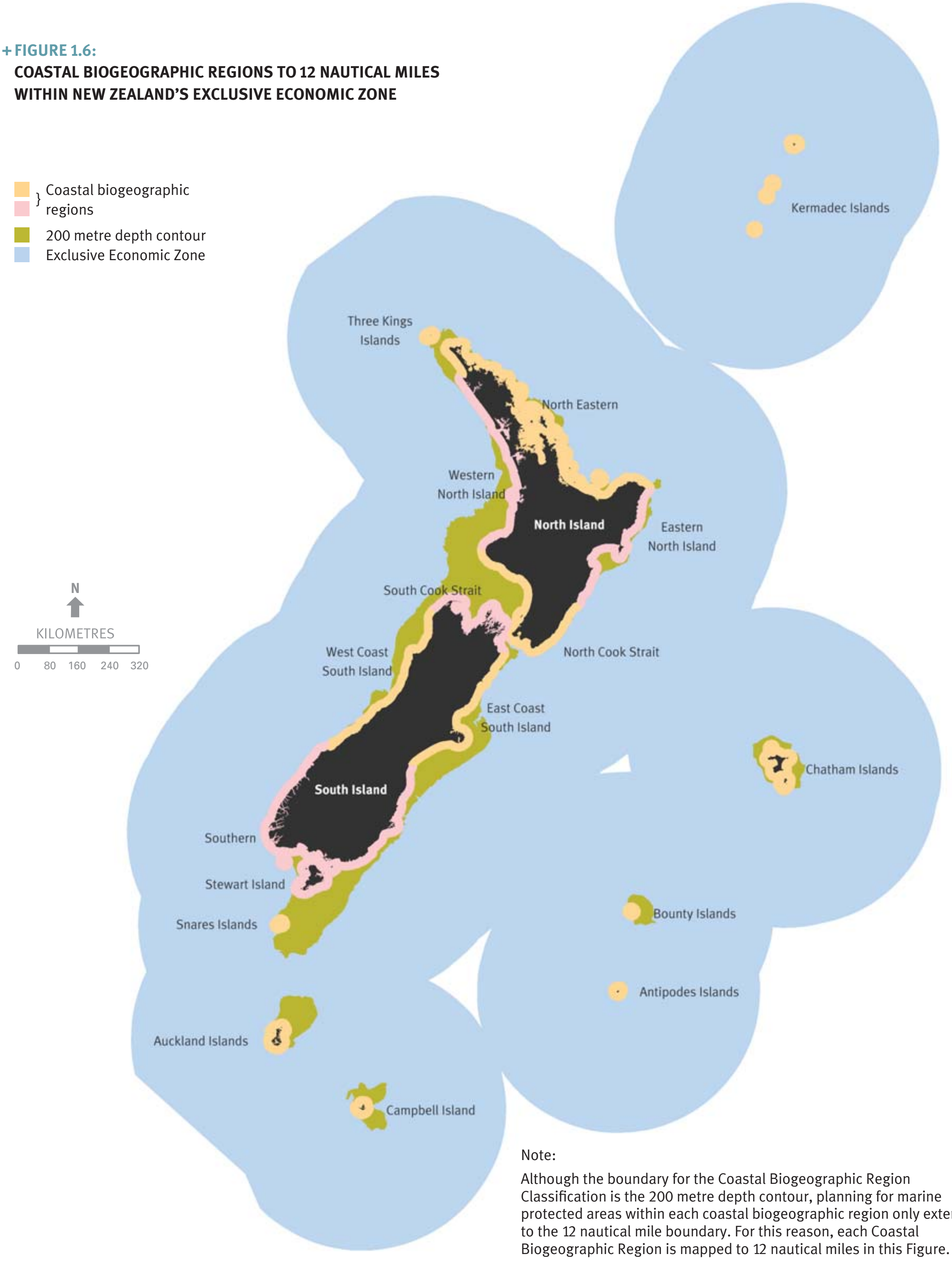
Coastal Biogeographic Regions Classification

A biogeographic region is an area defined and classified according to visible ecological patterns and the physical characteristics of a geographic or hydrographic area. New Zealand is divided into 13 coastal biogeographic regions.

The Coastal Biogeographic Regions Classification (see Figure 1.6) can be used for assessing the health of the coastal marine environment, planning associated with marine protected areas, and reporting on the extent of marine reserves by ecosystem type within the territorial sea.

+ FIGURE 1.6:

COASTAL BIOGEOGRAPHIC REGIONS TO 12 NAUTICAL MILES WITHIN NEW ZEALAND'S EXCLUSIVE ECONOMIC ZONE



Note:

Although the boundary for the Coastal Biogeographic Region Classification is the 200 metre depth contour, planning for marine protected areas within each coastal biogeographic region only extends to the 12 nautical mile boundary. For this reason, each Coastal Biogeographic Region is mapped to 12 nautical miles in this Figure.

Data source: Department of Conservation and Ministry of Fisheries.

Marine Environment Classification

The 2005 Marine Environment Classification uses eight physical factors (for example, depth, sea-surface temperature, seabed slope, tidal current, and annual solar radiation) to classify and map marine areas that have a similar environmental character. The marine environments can be mapped to different levels of detail, ranging from two to more than 70 marine environment groups (Ministry for the Environment, 2005).

The Marine Environment Classification can be used at different levels for state of the environment reporting on deep-water environments to 200 nautical miles offshore (that is, the full extent of New Zealand's Exclusive Economic Zone). Figure 1.7 shows the Marine Environment Classification at the 20-group level.

Demersal Fish Community Classification

The Demersal Fish Community Classification uses an extensive set of research data about trawling to model the distribution of 122 demersal fish species (species that live near the sea floor). This includes blue cod, hake, hoki, John dory, orange roughy, snapper, and tarakihi (Leathwick et al, 2006).

This research data was used to estimate the abundance of fish in each species across New Zealand's entire Exclusive Economic Zone, including at sites for which trawl data was not available. These estimations enabled areas with a similar composition of species to be classified together.

The Demersal Fish Community Classification shows the geographic distribution of particular demersal fish communities, and describes their composition (the types of fish that live in the area) and the environmental conditions in which the fish occur. See chapter 11, 'Oceans' for an example of how the classification has been used.

Land Environments of New Zealand

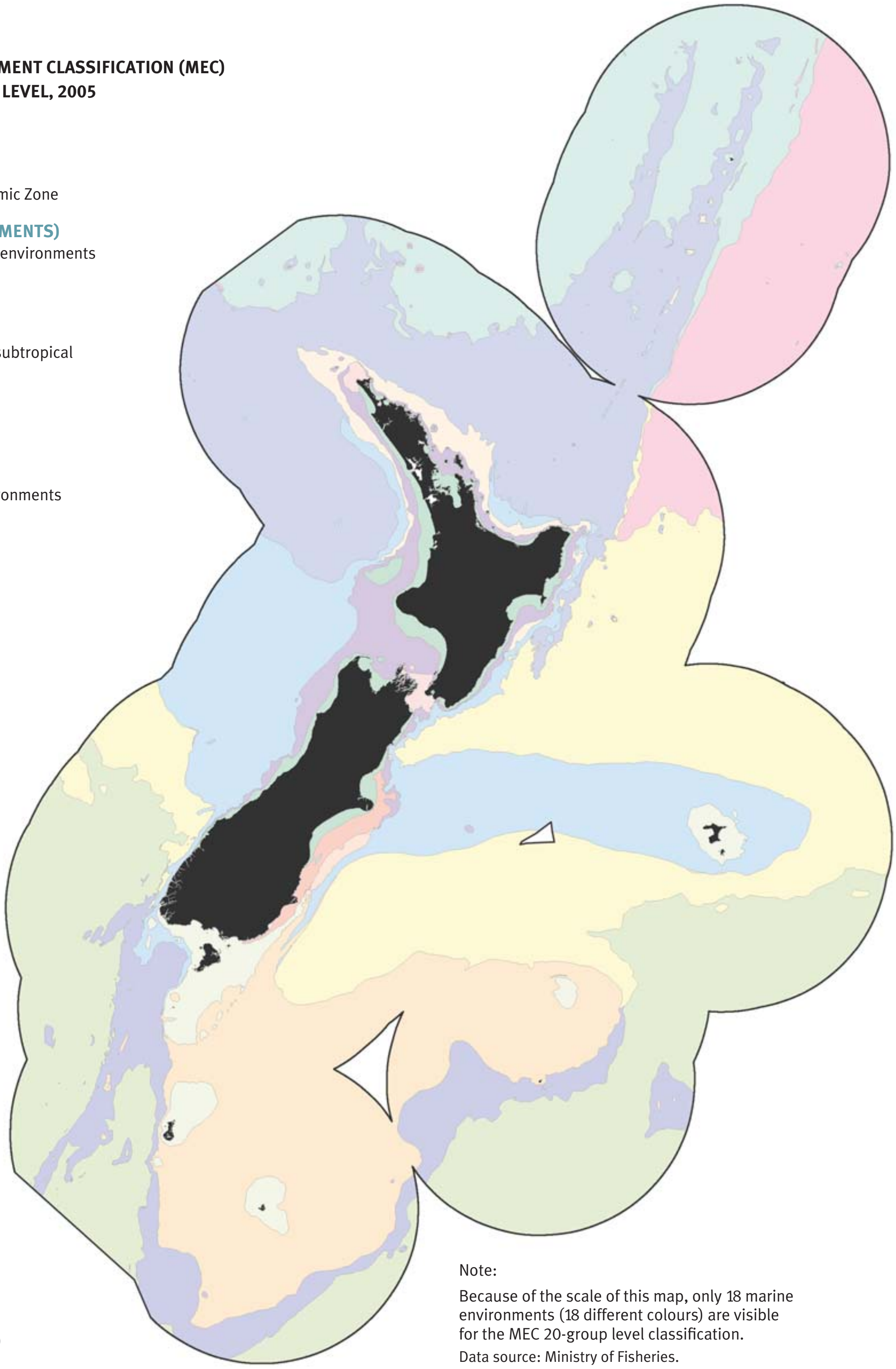
The Land Environments of New Zealand classification maps areas of the New Zealand landscape that have a similar environmental character. It is used to identify areas that are similar, regardless of where they occur (that is, which areas are not necessarily the same in all respects, but are likely to contain similar species, and have similar biological interactions and processes) (Ministry for the Environment and Landcare Research, 2002).

This classification differs from the Land Cover Database series 1 and 2 discussed earlier in this chapter. These simply identify land cover (what is growing on the ground or what feature covers the ground), whereas Land Environments of New Zealand uses 15 climate, landform, and soil factors that are considered likely to influence the distribution of animal or plant species. Based on these factors, land environments can be used as a surrogate for ecosystems.

Land Environments of New Zealand can be used at four levels of detail to map 20, 100, 200, or 500 land environments (see Figure 1.8). The higher levels provide greater detail by showing more land environments.

This classification is used to report on native biodiversity indicators. (See also Figure 12.2 in chapter 12, 'Biodiversity', which illustrates the mapping of 20 environments.)

+ FIGURE 1.7:
MARINE ENVIRONMENT CLASSIFICATION (MEC) AT THE 20-GROUP LEVEL, 2005



— Exclusive Economic Zone

MEC (20 ENVIRONMENTS)

Oceanic subtropical environments
1
2
3

Oceanic, shelf, and subtropical front environments
4
5
6
7

Central coastal environments
8
9
10
11
12
13
14
15

Oceanic subantarctic environments
16
17
18

N

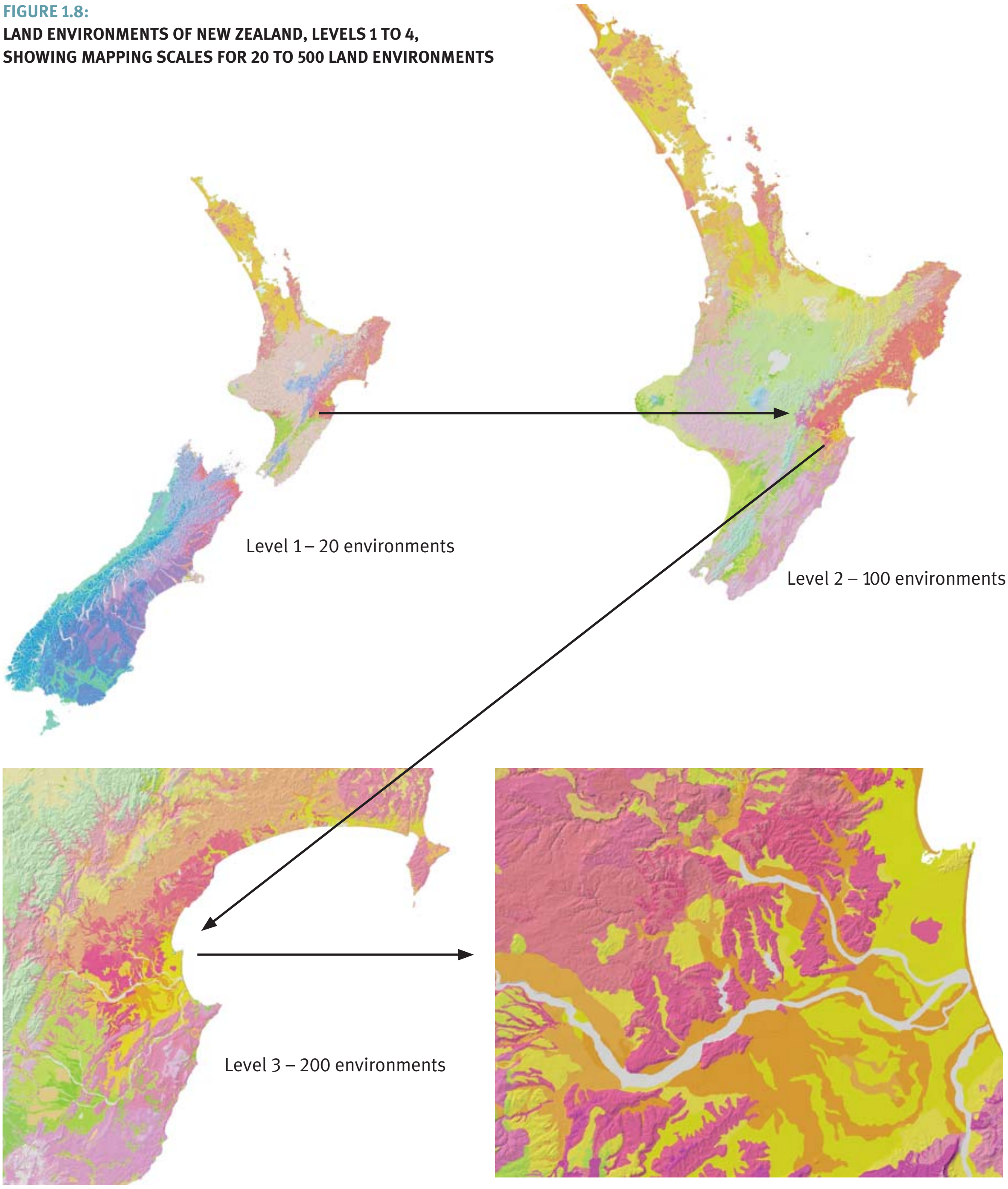
KILOMETRES

0 80 160 240 320

Note:
Because of the scale of this map, only 18 marine environments (18 different colours) are visible for the MEC 20-group level classification.

Data source: Ministry of Fisheries.

+ FIGURE 1.8:
LAND ENVIRONMENTS OF NEW ZEALAND, LEVELS 1 TO 4, SHOWING MAPPING SCALES FOR 20 TO 500 LAND ENVIRONMENTS



Source: Ministry for the Environment and Landcare Research, 2003.

Creating a national picture of the environment

For practical and cost reasons, we cannot measure all aspects of the environment. However, an indicator set needs to be more than a loose assortment of unconnected indicators if it is to provide an informative national picture of the state of the environment.

In selecting the core national environmental indicators and how they would be monitored, the Ministry for the Environment considered:

- standard international criteria for indicator selection – for example, whether the indicator was:
  - relevant to policy
  - measurable at a reasonable cost
  - analytically valid and scientifically defensible
  - environmentally informative
  - cost-effective
  - easily understood
- what data and information are available for national-level reporting in New Zealand
- the information needs of New Zealand environmental managers and policy-makers.

As noted earlier, the primary objective of this report is to use the set of core national environmental indicators to present a national picture of environmental conditions in New Zealand. This national picture will highlight for decision-makers and environmental managers the aspects of our environment that have come under particular pressure and require priority attention.

Many of the findings in this report will not surprise decision-makers. Anecdotally, we already know many of the pressures on the New Zealand environment and the particular aspects of the environment that are most at risk.

However, by reporting against the indicators, we have been able to present quantitative data at the national level, in some cases for the first time, to support this anecdotal knowledge.

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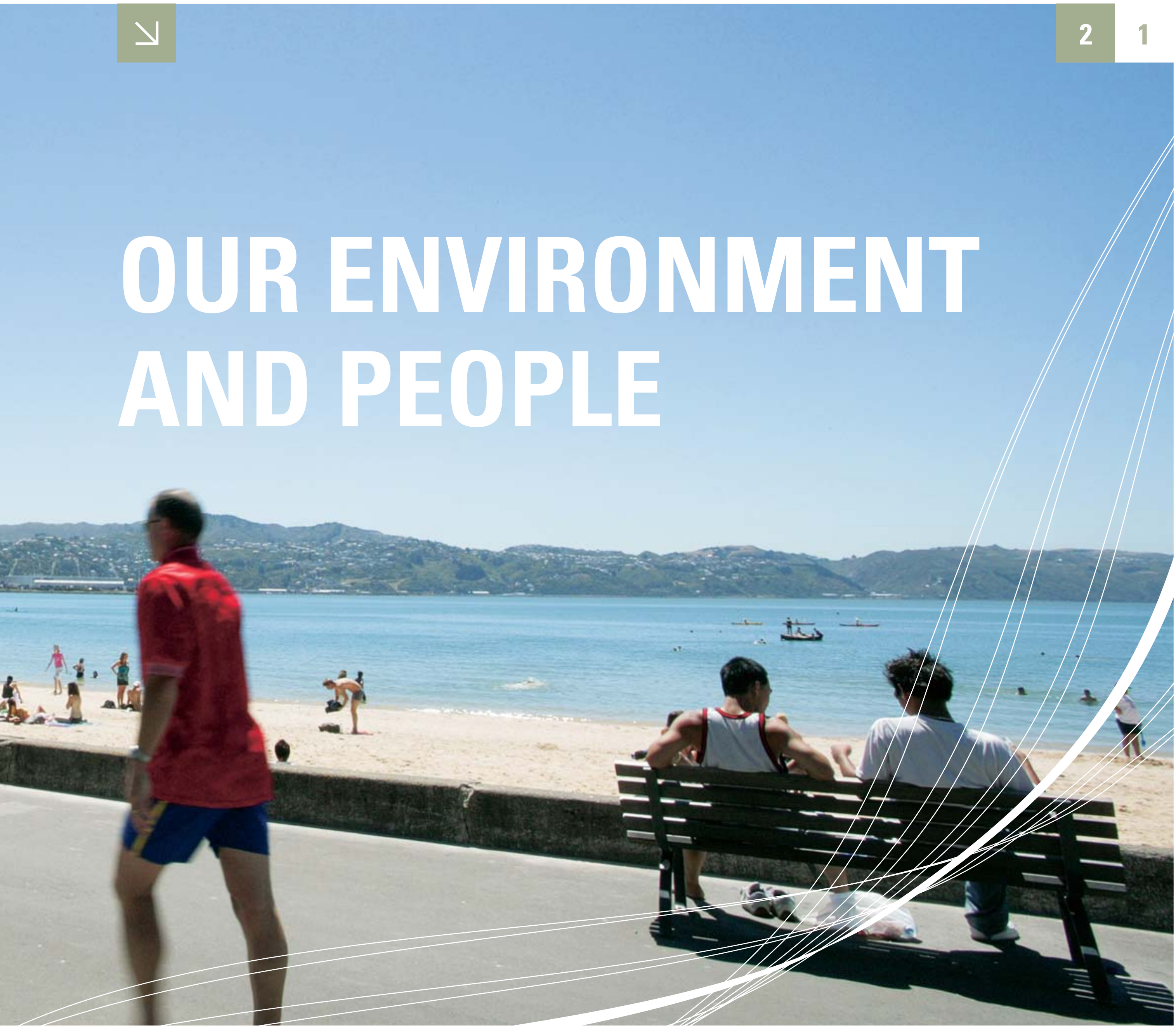
“The environment influences nearly every aspect of New Zealand life.”

2 1

OUR ENVIRONMENT AND PEOPLE



Contents

At a glance

Geography, flora, and fauna

New Zealand's geographic isolation and the long period without human habitation allowed a unique natural environment to flourish.

Our environment is known for the richness of its biodiversity, with more than 80,000 species of native animals, plants, and fungi. Much of our flora and fauna are not found anywhere else on earth.

Demography

New Zealand is home to just over four million people. Our population increased by almost 11 per cent over the last decade. On the whole, the New Zealand population is ageing, with our average age now 36 years.

Most New Zealanders live in urban areas within 50 kilometres of the coast. Three out of four of us live in the North Island. While our overall population density is low, it is high in major urban areas.

Environmental values

The environment dominates or influences nearly every aspect of New Zealand life. There is a growing understanding that our environment is not only our iconic wilderness and rural areas, but also the urban areas where most of us live and work.

Increasingly, New Zealanders are taking action to conserve the environment for future generations in ways that protect our economic well-being, social systems, and cultural wealth.

The economic value of the environment

We frequently use images of our natural scenery and rural heritage to present New Zealand to the rest of the world. Our country is recognised internationally for its stunning landscapes, forests, and valuable agricultural and horticultural land.

The environment is vital to our economic well-being. Our land- and sea-based primary production and tourism sectors both rely on New Zealand's 'clean and green' reputation, generating about 17 per cent of New Zealand's gross domestic product.

Environmental legislation and governance

Management of natural resources in New Zealand is governed by several statutes, particularly the Resource Management Act 1991, Local Government Act 2002, and Hazardous Substances and New Organisms Act 1996.

Environmental governance in New Zealand is shared between central government and local government. Iwi authorities, industry groups, community interest groups, and non-government organisations also play a role in managing the environment.

Introduction

New Zealand is a small island nation in the southwest Pacific Ocean. Its geographic isolation, maritime location, relatively recent geological formation, and continuing tectonic activity have created diverse and unique ecosystems.

This chapter sets the environmental context for *Environment New Zealand 2007*. It presents a high-level overview of:

- the key biophysical factors that interact to shape New Zealand's environment
- the New Zealand people, including where we choose to live and how we interact with the environment
- environmental values and how these have changed over time
- the economic value of New Zealand's environment
- New Zealand's environmental legislation and governance.

NEW ZEALAND IS A SMALL ISLAND NATION IN THE SOUTHWEST PACIFIC OCEAN.

Source: Nature's Pic Images.

Physical geography

Geography

New Zealand – also called Aotearoa New Zealand – consists of two large islands (the North and South Islands) and several smaller islands (such as Stewart Island and the Chatham Islands). It is situated in the southwest Pacific Ocean between 34 degrees and 47 degrees of latitude south (see Figure 2.1).

New Zealand's land area of about 270,000 km^2 (approximately 26,822,000 hectares) is about the same as that of Japan or the United Kingdom. The country's land mass extends more than 1,600 kilometres (1,000 miles) along its main north-northeast axis.

Our location on the boundary of the Pacific and Indo-Australian tectonic plates has shaped our landforms. The resulting earth movements have produced hilly and mountainous terrain over two-thirds of the land, with frequent earthquakes in most parts of the country and a zone of volcanic and geothermal activity in the central North Island (Ministry for the Environment, 1997).

The terrain, climate, rock type, and vegetation have interacted to produce more than a hundred different soil types. These can be grouped into three main categories: pumice soils (in the central North Island volcanic area); ash soils (common in Taranaki, the Waikato, parts of Northland, and western Southland); and sedimentary soils (on plains, hill country, and coastal areas throughout both main islands). Despite this diversity, New Zealand's soils are generally low in nutrients because the rocks they come from are geologically young (Ministry for the Environment, 1997).

+ FIGURE 2.1:
NEW ZEALAND'S GEOGRAPHY, 2007

Data source: Land Information New Zealand.

Flora and fauna

New Zealand is known for the wealth of its biodiversity, with more than 80,000 species of native animals, plants, and fungi. It is especially rich in bird, insect, and marine life. Although as much as 80 per cent of the country's biodiversity lives in the marine environment, little is known about many of our marine species.

New Zealand's early separation from its geographic neighbours, Australia and Antarctica, played a large role in shaping its flora and fauna. Because our native plants and animals developed in isolation for 60 million to 80 million years, many of them are unique.

Among our most notable species are the:

- kiwi, which lays one of the largest eggs in the world compared with its body size
- kākāpō, the world's heaviest and only flightless parrot (Powlesland et al, 2006)
- kea, one of the world's only mountain parrots
- giant wētā, the heaviest insect (Williams, 2001)
- tuatara, a reptile of prehistoric origins
- giant kauri tree, which is among the largest in the world and holds the record for the greatest timber volume of any tree.

TUATARA, NEW ZEALAND'S REPTILE OF PREHISTORIC ORIGINS.

Source: iStockphoto.

While most of the world's ferns grow in tropical climates, New Zealand hosts an unusually large number of ferns for a temperate country. Primeval trees, mosses, and lichens continue to flourish here, and flightless, ground-dwelling birds have evolved to fill niches that elsewhere in the world would have been taken by mammals. Indeed, New Zealand's only endemic land-based mammal is the bat, of which we have several species. By comparison with other countries, we have comparatively few native flowering plants and land-based vertebrate animals.

New Zealand's isolation also means that a high proportion of our species are not found anywhere else on earth. All of our frogs and reptiles, more than 90 per cent of our insects, about 80 per cent of our plants (other than mosses, liverworts, and hornworts), and a quarter of all of our bird species are found only in New Zealand. Forty-four per cent of our known marine species live only in New Zealand waters.

Climate

New Zealand's climate is influenced strongly by geographic factors. These include:

- its location in a latitude zone with prevailing westerly winds
- the large area of surrounding ocean
- mountain chains that modify weather systems as they move eastward, so that climatic contrasts are much sharper from west to east than they are from north to south
- tropical weather patterns (that is, storms that start out as tropical cyclones elsewhere can redevelop in the region, bringing warm moisture-laden tropical air that interacts with colder polar air).

As a result of these factors, New Zealand's weather is more variable than that of larger, continental countries.

The average rainfall experienced in most urban areas is between 600 millimetres and 1.5 metres a year. However, in the mountain ranges, annual rainfall often exceeds 5 metres, and in the Southern Alps, annual rainfall can be more than 10 metres a year.

Regions exposed to weather from the west and southwest experience showery weather, and rain falls in these areas on about half of the days of the year.

The rest of the country experiences much lower rainfall, particularly in eastern areas. Areas in the South Island to the east of the main ranges – Central and North Ōtago and South Canterbury – are the only areas of the country with average rainfalls of less than 600 millimetres, and generally have only about 80 rain days a year. In the North Island, the driest areas are central and southern Hawke's Bay, the Wairarapa, and Manawatū, where the average rainfall is between 700 millimetres and 1,000 millimetres a year.

Average temperatures at sea level decrease steadily from the north to the south, from about 15°C in the far north of the North Island to about 10°C in the far south of the South Island (MetService, 2007).

Rivers and lakes

Dynamic tectonic movement means New Zealand's landscape is dominated by mountains: more than three-quarters of our land area is higher than 200 metres above sea level. As a result, steep and fast-flowing stony streams and rivers dissect the landscape. Because New Zealand is relatively narrow (450 kilometres at its widest point), these mountain-fed rivers quickly reach the sea after flowing through narrow and then winding river beds.

Rivers also feed numerous lakes, of which 3,820 are more than 1 hectare in area. Most lakes were formed through volcanic or glacial activity, or after the formation of land barriers (Ministry for the Environment, 2006). Lake Taupō in the North Island is New Zealand's largest lake, with an area of about 62,000 hectares and a maximum depth of 163 metres.

As well as having numerous mountains, lakes, rivers, and geothermal areas, New Zealand has 360 glaciers in the South Island, which carry away snow and ice from the many peaks of the Southern Alps.

Coasts and oceans

Compared with its land area, New Zealand has one of the longest coastlines of any country in the world, at more than 18,000 kilometres (Department of Conservation, 2007).

New Zealand's Exclusive Economic Zone extends from 12 nautical miles off the coast to 200 nautical miles offshore, an area of 4.4 million km^2. This is the sixth largest Exclusive Economic Zone in the world, and forms a marine area that is 14 times bigger than New Zealand's land area.

New Zealand's vast marine area contains a diverse range of marine ecosystems, which provide habitats for many species. Scientists have identified almost 16,000 marine species in New Zealand waters, although it is estimated that tens of thousands of species may still be undiscovered (Gordon, 2007).

Demography

New Zealand's changing demography has implications both for the way we live our lives, and for the impact our lifestyles have on the environment.

Human settlement

Humans are very recent additions to the New Zealand environment from an ecological perspective. All New Zealanders are migrants to these islands. The Polynesian ancestors of Māori, the indigenous people of New Zealand, arrived here about 30 generations ago, some time between 1000 AD and 1350 AD.

The first European explorer to see New Zealand was the Dutch explorer Abel Tasman in 1642 AD (365 years ago). The next European contact came nearly 130 years later, when the British explorer James Cook reached New Zealand. By contrast, Asia, Australia, and Melanesia were colonised at least 50,000–60,000 years ago (about 2,400 generations), Europe 35,000–40,000 years ago, and the Americas at least 15,000 years ago (Ministry for the Environment, 1997).

Size and age of our population

The March 2006 Census of Population and Dwellings established that New Zealand's islands were home to 4,027,947 people (Statistics New Zealand, 2007a). The population has increased by around 11 per cent since the 1996 census.

The median age in 2006 was 35.9 years (that is, half the population was younger than this age and half older), compared with 33.0 years in 1996 (Statistics New Zealand, 1996; 2007a). This shows that New Zealand's total population is ageing, despite having an increasing proportion of young Māori and Pacific New Zealanders.

Distribution of population in rural and urban areas

Most New Zealanders live in urban areas. While many New Zealanders identify with our rural landscape or wilderness areas, 86 per cent of the population lives in urban areas. This makes New Zealand one of the most urbanised nations in the world. About 90 per cent of New Zealanders' time is spent in the built environment (Keall and Baker, 2006).

New Zealand has 138 towns and cities, many of them located close to the coast. Across the country, 90 per cent of the population lives within 50 kilometres of the coastline (Dahm et al, 2005).

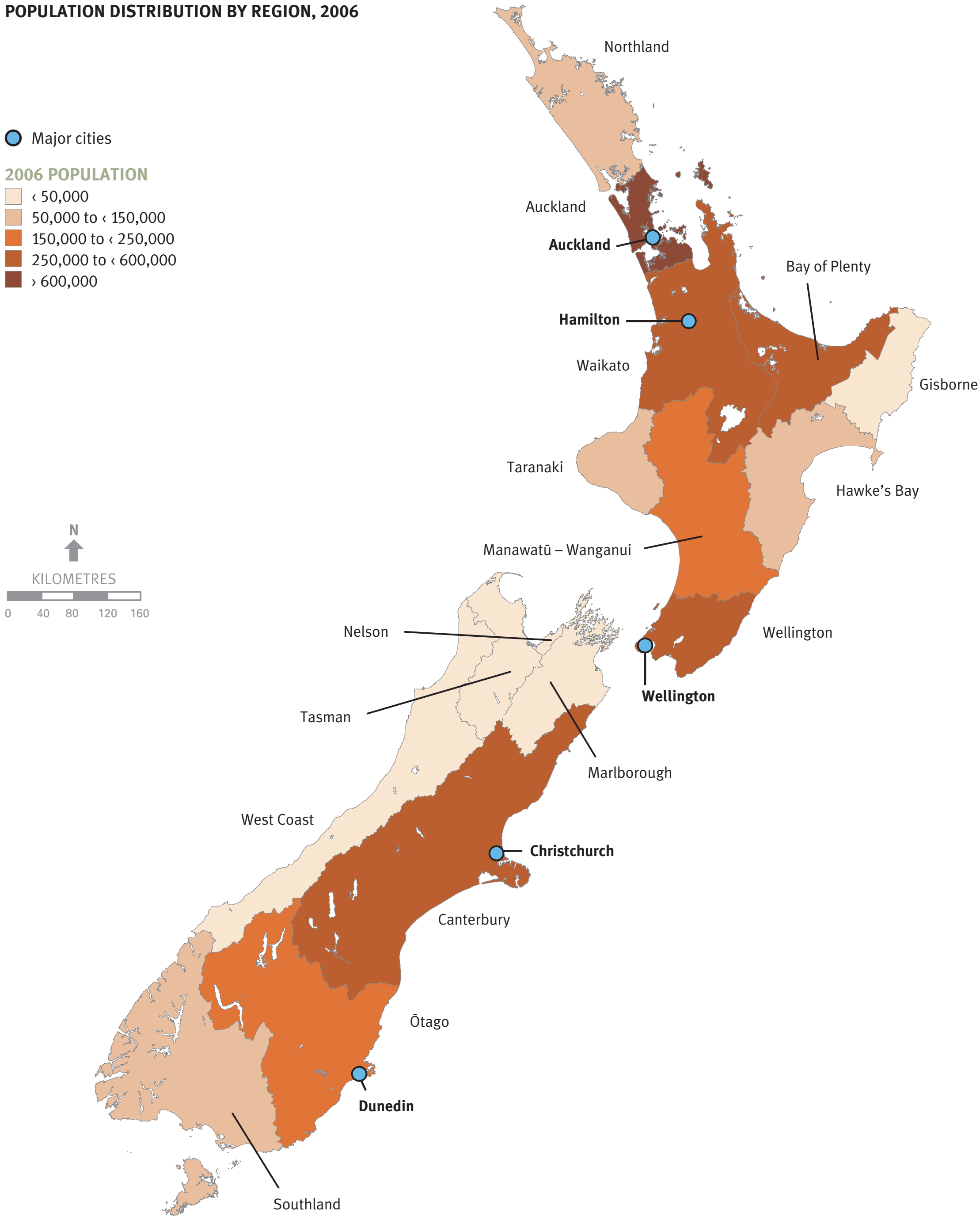
Three out of four New Zealanders live in the North Island. The increase in population from 1996 to 2006 was greater in North Island towns and cities than in the South Island (12.6 per cent, compared with 7.6 per cent).

The three regions with the fastest growing populations from 1996 to 2006 were Auckland (with a 21.9 per cent increase), Tasman (17.5 per cent), and the Bay of Plenty (14.7 per cent) (Statistics New Zealand, 2007a).

In 2006, the most highly populated regions were Auckland (1,303,068), Canterbury (521,832), Wellington (448,959), and the Waikato (382,716). The Bay of Plenty, Manawatū–Wanganui, Ōtago, Northland, Hawke's Bay, and Taranaki all have populations of between 100,000 and 300,000. Population distribution by region is shown in Figure 2.2.

The pattern of a low overall population density with high densities in the major urban areas has implications for New Zealand's ecological footprint (see chapter 3, 'Household consumption') and for environmental policy and resource management.

+ FIGURE 2.2:
POPULATION DISTRIBUTION BY REGION, 2006



Data source: Statistics New Zealand, 2007a.

Distribution of population by ethnicity

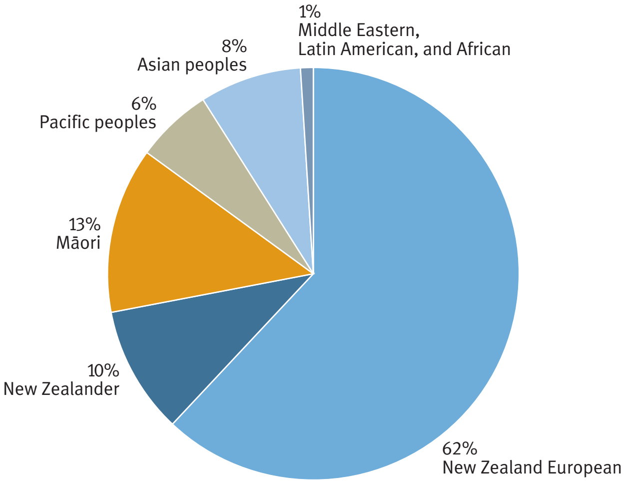
New Zealand's population is made up of an increasingly diverse range of ethnic groups. The 2006 census identified 232 different ethnic groups, with 22.9 per cent of New Zealanders born overseas. Not only is the country's ethnic make-up changing, but 10.4 per cent of people identified with more than one ethnic group in 2006.

In New Zealand, one in seven people identifies as Māori (see Figure 2.3). The total number of Māori increased by 39,048 (7.4 per cent) between the 1996 and 2006 censuses, to a total of 565,329. Māori in the 2006 census were affiliated to 136 iwi.

The number of people identifying with one of the many Asian ethnic groups more than doubled in New Zealand between 1996 and 2006, increasing from 173,505 in 1996, to 354,552 in 2006. The Pacific ethnic groups had the second largest increase over the same period, increasing 31.5 per cent, from 202,236 to 265,974 people.

New Zealand Europeans remain the largest ethnic group in New Zealand, totalling 2,609,592 people (67.6 per cent of the population) in 2006. The 2006 census reported a new ethnic category of 'New Zealander' for the first time and 429,429 people identified this way. (In previous years, 'New Zealander' responses were included in the category New Zealand Europeans.) The category 'Middle Eastern, Latin American, and African' was also reported for the first time in the 2006 census and represented 34,743 respondents.

+ FIGURE 2.3:
ETHNIC DISTRIBUTION IN NEW ZEALAND, 2006



Notes:

(1) This graph shows the number of people identifying with each ethnic group as a proportion of total responses to the ethnicity question in the 2006 census. Respondents may identify with more than one ethnicity, so the total number of responses (4,261,107) exceeds the total population (4,027,947).

(2) The Middle Eastern, Latin American and African category represents 0.035 per cent of total respondents.

Data Source: Statistics New Zealand, 2007a.

Distribution of population by gender

The 2006 census showed there are 96,705 more females (2,062,326) than males (1,965,621) in the population.

Average household size

In 2006, the average size of a New Zealand household was 2.7 people. However, a large number of New Zealanders live alone: in 2006, 328,299 people lived in one-person households (23 per cent of all households). This was an increase of 28 per cent from 1996, when 256,569 people lived in one-person households (21 per cent of all households).

Couple-only and one-person households are the fastest growing household types in New Zealand and are projected to increase the most over the next 15 years (Ministry of Social Development, 2006).

Environmental values

The environment dominates or influences nearly every aspect of New Zealand's national life. New Zealanders are an outdoor-loving people, with a way of life that is shaped around action and interaction with the environment. Many New Zealanders regularly walk in parks, visit the coast, swim or fish in rivers or lakes, and play outdoor sports (Phillips, 2007).

Many New Zealanders also relate to the rural environment, with its outdoor lifestyle and focus on agricultural and horticultural production. Our farming heritage is an important element of our national identity (Jacomb, 2002).

As a nation, we frequently use images of the natural environment to present New Zealand to the rest of the world. Our natural scenery attracts tourists and underpins our 'clean and green' image internationally.

A recent survey found that 87 per cent of New Zealanders consider the environment is important or very important to them (Growth and Innovation Advisory Board, 2004). In the same survey, New Zealanders rate the quality of the natural environment as being the third most important aspect of New Zealand, behind quality of life and the quality of education.

New Zealanders are also increasingly considering environmental values when they travel. According to a survey conducted by Lonely Planet, 61 per cent of New Zealand travellers said they had purposefully travelled in a low-impact way in the past (for example, catching a bus rather than flying) and 90 per cent of New Zealanders said they would or might do so in the future (Lonely Planet, 2007).

Māori environmental values

The Polynesian ancestors of the Māori people came to New Zealand by canoe between 1000 AD and 1350 AD. After Polynesian settlement, fire had a more widespread and frequent impact on the environment. By about 1600 AD, about a third of the original forest cover had been cleared and replaced by tussock, bracken, and light scrub. With the change in landscape, a quarter of New Zealand's endemic land-based birds, including eight species of moa, and a fifth of endemic seabirds became extinct (Ministry for the Environment, 1997).

Over subsequent generations, Māori acquired in-depth knowledge of the New Zealand environment and developed effective conservation practices. These practices became customs that iwi and hapū used to manage access to and limit the depletion of the environment. These customs continue to shape Māori approaches to environmental management today.

Traditionally, Māori relate to New Zealand, as tangata whenua (people of the land). The land, rivers, and mountains of each person's tribal area are the first things many Māori mention when they introduce themselves formally.

In Māori terms, all living things, including natural and physical resources, possess a mauri (life principle or life force). The mana (authority or prestige) of the tangata whenua is closely related to how well they manage their taonga (highly valued resources or objects), and how successfully they preserve mauri. Therefore, each iwi has responsibilities and obligations for environmental management in its own rohe (area).

For Māori, the concept of kaitiakitanga is of primary importance. Kaitiakitanga is a fundamental concept of the guardianship of a resource for future generations. It is practised as part of tikanga Māori (customary values and practices).

Māori conservation tools

To manage people's impact on the environment and on mauri, Māori developed the practice of rāhui. Rāhui are periods when no one may take any resources or particular resources (such as shellfish) from an area. These bans may also limit the size of the species people may take, or the amount of their total catch (Hutching and Walrond, 2007). Today, rāhui are often imposed to conserve a resource or to allow a species to regenerate.

In addition to rāhui, Māori traditionally limited harvests of certain species by season and by restricting access to areas such as fishing grounds. Māori also applied other forms of tapu (restriction) to prevent mauri being degraded (for example, through the pollution of fishing areas by human waste, or fishing grounds being damaged by nets and lines).

Changing environmental values

Pākehā or European relationships with New Zealand's environment have also changed over time. Whalers and sealers arrived in New Zealand in the 1790s, followed a decade or so later by missionaries and traders. Along with large quantities of seal oil and fur, and whale oil (which markedly reduced seal and sea lion populations and took the southern right whale to near extinction), early traders exported harakeke (flax) and native timber to European markets.

Rapid European settlement from 1840 led to the large-scale clearance of land for farming, the establishment of pasture, the reshaping of river systems for gold mining, timber felling, the draining of wetlands, and the introduction of a large number of exotic plants and animals. According to Molloy, 1998:

> … in the half century from 1860–1910, New Zealand underwent possibly the most rapid landscape transformation of any nation; over 6.5 million hectares of lowland forest (nearly 25 percent of the total land area) were cleared – as much as was destroyed by fires during 1000 years of Polynesian settlement.

New species and pests

Thousands of new species have been introduced to New Zealand, many of which have proved beneficial. In fact, nearly all of the country's economically important species have been introduced; it would be hard to imagine the current landscape without sheep, cattle, deer, grain crops, apples, grapes, kiwifruit, and pasture grasses.

Until human settlement, native species had no need to defend themselves against hunting, habitat destruction, and the more than 25,000 introduced species. In the thousand or so years since human settlement, many animals (including three species of frog, a bat, the huia, and almost 50 other bird species) have become extinct, and the survival of others is threatened (Ministry for the Environment, 1997; Museum of New Zealand Te Papa Tongarewa, 2006).

Early conservation efforts

As early as the late 19th century, New Zealanders were voicing concerns about the sweeping changes taking place in our environment. In particular, public discussion grew about the effects of land clearance, which had become more obvious with regular floods and soil erosion in settled areas.

Notions of conserving and protecting areas became more prominent from the start of the 20th century. Tongariro National Park was established as the country's first national park in 1887 when Te Heuheu Tūkino IV, the leader of Ngāti Tūwharetoa, gifted it to the nation. As more national parks were established, New Zealanders, as well as international tourists, visited them for sightseeing and mountaineering.

Soil conservation, land-use planning practices, and flood management were also initiated at this time. For example, the River Boards Act 1884 established a national network to manage rivers. This was followed by the Soil Conservation and Rivers Control Act 1941, which established local catchment boards to coordinate soil and water conservation across whole catchments. This approach of managing land and water in an integrated way, and using natural catchment boundaries as a management unit, represented a world first in environmental management.

More recently, major works such as the Manapōuri and Clyde Dams in the 1970s raised concerns about the impact of infrastructure development on the environment. New Zealanders' environmental awareness has also been influenced by the growth of new global values which popularised conservation of the environment. Today, the New Zealand public, led by community interest groups and non-government organisations, expect to participate in decision-making that affects the environment to a much greater extent than in the past.

Changing attitudes to the environment

A regular survey that examines New Zealanders' perceptions of the environment identified that the major environmental concerns have shifted over the past few years from air quality, waste disposal, industrial pollution, and introduced pests, weeds, and diseases to water pollution, other pollution, and climate change (Hughey, 2002; 2006).

Attitudes towards the environment have also changed as New Zealanders have come to understand that the environment constitutes not only our rural and wilderness areas, but also the urban areas where most of us live and work.

Another change over the last decade has been the growing focus on sustainable development. Sustainability involves making choices that conserve the environment for future generations, while still maintaining our economic well-being, social systems, and cultural wealth. The current focus on sustainability highlights how actions that benefit the environment can also have social, cultural, and economic benefits, and other implications, and vice versa.

Sustainability is now a mainstream concept among businesses, with 90 per cent of surveyed businesses agreeing that sustainable practices are required across the whole economy (Jayne, 2007). Seventy-eight per cent of surveyed businesses also believed New Zealand would benefit internationally if it became more sustainable.

When surveyed, 77 per cent of New Zealand companies had an environmental policy in place (Massey University, 2005). Environmental reporting, also known as triple bottom line or sustainability reporting, is becoming a more common business practice.

Value of the environment to the economy

New Zealand's economic wealth and well-being are heavily dependent on our natural environment.

Renewable energy sources – the water that flows in rivers, steam that comes out of the ground, and wind that spins turbines – provide about 66 per cent of New Zealand's electricity (see chapter 5, 'Energy').

Cattle and deer, which are sources of high-value dairy and meat products, graze in outdoor pastures year-round without having to be housed in barns. Our industrial, agriculture, and horticultural sectors also benefit from irrigation taken from our waterways.

Export goods such as wool, food crops, wood, wine, and natural cosmetic products are other examples of high-value goods that New Zealand is able to produce because of its natural environment.

Value of primary production

Our primary production sectors rely heavily on the environment. New Zealand's temperate climate provides beneficial growing conditions and ensures good pasture and crop growth, and we have plenty of rainfall in most parts of the country. While it is difficult to put a dollar value on these and other benefits that the environment provides to our primary production sectors, awareness is growing in New Zealand of the significant value of our environment to our economy.

Forestry products exported from New Zealand also contribute significantly to our economy: exported forestry products were valued at $3.6 billion for the year ending 31 March 2007 (Ministry of Agriculture and Forestry, 2007). In 2006, forestry and wood processing employed 20,909 people (Ministry of Agriculture and Forestry, 2006).

OUR PRIMARY PRODUCTION SECTORS RELY ON THE ENVIRONMENT.

Source: Ministry for the Environment.

The export of agricultural products makes a significant contribution to our economy. In the year ended 31 March 2007, this amounted to $16.1 billion (Ministry of Agriculture and Forestry, 2007). In 1996, agricultural exports contributed $5.3 billion, or 5.5 per cent of gross domestic product. Two agricultural exports, dairy products and meat, were the top two export earners for New Zealand in 2006, making up 18.1 per cent and 13.5 per cent of New Zealand's total exports respectively (Statistics New Zealand, 2007d).

Between 1996 and 2006, the value of New Zealand's commercial fishing industry increased 40 per cent, from $2.7 billion to $3.8 billion (Statistics New Zealand, 2007b).

One example of the increasing economic value of New Zealand's primary products is the merino wool industry. New Zealand businesses have developed a range of offshore markets for super-fine merino fashion and outdoor clothing, positioning their products at the high-value end of the international fashion industry. New fibre blends have also been commercialised, including possum fur and cashmere.

The sale of many of our export products depends on the value that consumers place on New Zealand's environment being 'clean and green'.

Value of tourism

New Zealand's tourism industry relies on the country having a positive environmental image to attract international tourists. In the year ended 31 December 2006, more than 1 million people visited New Zealand for the main purpose of holidaying. This was a 57 per cent increase from the year ended 31 December 1999 (Ministry of Tourism, 2007).

International tourism has become one of the country's largest foreign exchange earners and a driver of many regional economies (Department of Conservation, 2006). International tourism contributed $8.3 billion, or 19.2 per cent, of New Zealand's total export earnings in 2006 (Statistics New Zealand, 2007e). Eighteen per cent of the tourism industry is directly involved in ecotourism or adventure tourism (Tourism Strategy Group, 2001).

In addition, the tourism sector accounted for the direct employment of 108,600 employees and the indirect employment of a further 74,500 full-time employees in 2005 (Statistics New Zealand, 2007e). This is equivalent to tourism supporting around one in every 10 jobs in New Zealand.

The majority of tourists visiting New Zealand (91 per cent) indicate that a key reason they come here is for our landscape, with over half of the international tourists visiting national parks and reserves during their stay (Ministry of Tourism, 2005).

Combined, the export earnings of New Zealand's top two earners, tourism and land- and sea-based primary production in 2006, were about $22 billion. This equates to around 17 per cent of New Zealand's gross domestic product.

It is clear that the New Zealand environment contributes significantly to our economy, and to our standard of living and way of life.

Environmental legislation and governance

Environmental legislation

Management of natural resources in New Zealand is governed by a number of statutes. These include:

- Resource Management Act 1991
- Local Government Act 2002
- Hazardous Substances and New Organisms Act 1996
- Conservation Act 1987 (and its accompanying protected areas legislation)
- Fisheries Act 1996.

Environmental management is also integrated in other statutes. These include:

- Aquaculture Reform (Repeals and Transitional Provisions) Act 2004
- Biosecurity Act 1993
- Climate Change Response Act 2002
- Energy Efficiency and Conservation Act 2000
- Environment Act 1986
- Fiordland (Te Moana o Atawhenua) Marine Management Act 2005
- Foreshore and Seabed Act 2004
- Land Transport Management Act 2003
- Ozone Layer Protection Act 1996
- Queen Elizabeth the Second National Trust Act 1977.

Resource Management Act 1991

The Resource Management Act 1991, which has been significantly amended twice in the past 10 years (2003 and 2005), has a single, overarching purpose: to promote the sustainable management of natural and physical resources.

The Act defines sustainable management as:

> '*managing the use, development, and protection of natural and physical resources in a way, or at a rate, which enables people and communities to provide for their social, economic, and cultural well-being and for their health and safety while sustaining the potential of natural and physical resources (excluding minerals) to meet the reasonably foreseeable needs of future generations*'.

The Act also provides for the:

> '*safeguarding of the life-supporting capacity of air, water, soil, and ecosystems*', and '*avoiding, remedying, or mitigating the adverse effects of activities on the environment*'.

The Act's three central functions are to:

- manage the environmental effects of activities on air, water, and land
- manage the use of publicly owned or managed natural resources (water, geothermal resources, the surface of lakes and rivers, river beds, and the foreshore and seabed)
- control the discharge of contaminants to land, air, and water.

Responsibility for decision-making and managing these functions is generally devolved to the community most closely affected by the use of the specific resource. This makes local government a critical part of environmental management in New Zealand, much more so than in other Organisation for Economic Co-operation and Development countries with different regulatory regimes.

Central government has powers under the Resource Management Act to develop national policy statements on matters of national significance, national environmental standards, and water conservation orders. These statements, standards, and orders are binding on local authorities. For example, councils must give effect to national policy statements in their policy statements and district or regional plans, and national environmental standards must be followed.

The 1994 New Zealand Coastal Policy Statement is the only national policy statement in place under the Resource Management Act (Minister of Conservation, 1994). The statement sets out policies for managing the natural and physical resources in New Zealand's coastal environment.

In 2004, the Government introduced 14 national environmental standards for air quality. Of these standards, seven are to prevent toxic emissions; five are to protect ambient (outdoor) air quality; one is a design standard for new wood burners to be installed in urban areas; and one requires landfills with more than 1 million tonnes of refuse to collect or destroy their greenhouse gas emissions or reuse them for energy generation. (See chapter 7, 'Air' for more information on these standards.)

Standards or national policy statements on water, flood management, electricity transmission, and telecommunications infrastructure are also being developed.

The Resource Management Act also gives the Minister for the Environment the power to establish heritage protection authorities and requiring authorities.

Local Government Act 2002

As well as having day-to-day responsibility for environmental management under the Resource Management Act, local government is also responsible for community well-being, including environmental well-being, under the Local Government Act 2002.

The Local Government Act is intended, among other things, to encourage communities to address all four aspects of sustainability: social, economic, environmental, and cultural well-being, in the present and for the future. Communities identify the outcomes they desire in each area, and these form the content of a long-term council community plan. These plans integrate the vision and goals for councils and their communities to work towards.

A long-term council community plan does not override plans created under the Resource Management Act or other statutory documents. However, it is expected that all council activities, including those required under other Acts, will contribute to achieving community outcomes.

Hazardous Substances and New Organisms Act 1996

The Hazardous Substances and New Organisms Act 1996 regulates the importation and manufacture of hazardous substances such as explosives and flammable, corrosive, toxic, and eco-toxic substances. The Act also regulates the introduction of new organisms into New Zealand, including genetically modified plants, animals, and other living things.

The passing of the Hazardous Substances and New Organisms Act in June 1996 represented one of the most significant reforms to environmental legislation since the Resource Management Act.

The Act's implementation has been staged. Provisions relating to new organisms took effect in July 1998, followed by provisions for hazardous substances, which came into force in July 2001. A five-year transitional period for hazardous substances ended in July 2006.

The Hazardous Substances and New Organisms Act established the Environmental Risk Management Authority to make decisions about hazardous substances and new organisms. The Minister for the Environment appoints the Authority's eight members.

The Authority considers applications to import, develop, or field-test new organisms, including genetically modified organisms. It also decides about the importation or manufacture of hazardous substances.

The Authority is supported and advised by:

- Ngā Kaihautū Tikanga Taiao, a statutory committee that provides advice and assistance on policies, processes, and applications that have significant implications or interest for Māori
- an Ethics Advisory Panel, which the Authority established to help it consider ethical and spiritual matters.

Conservation Act 1987

The Conservation Act 1987 was developed to promote the conservation of New Zealand's natural and historic resources. It also established the Department of Conservation (DOC).

Some key functions of DOC under the Conservation Act are to:

- manage land, and natural and physical resources, held under the Conservation Act
- advocate the conservation of natural and physical resources
- promote the benefits of conservation of natural and physical resources
- preserve (as far as practicable) all indigenous freshwater fisheries, and protect recreational fisheries and freshwater habitats
- foster recreation and allow tourism on conservation land, to the extent that use is not inconsistent with the conservation of any natural or historic resource.

Fisheries Act 1996

The Fisheries Act 1996 implements a system for ensuring sustainability of New Zealand's fishing resources. The Act aims to provide for the use, conservation, enhancement, and development of fisheries resources so people can provide for their social, economic, and cultural well-being while:

- ensuring the potential of those resources to meet the foreseeable needs of future generations is maintained
- avoiding, remedying, or mitigating any adverse effects of fishing on the aquatic environment.

The Act therefore incorporates sustainability as its underlying principle. This means the long-term viability of stocks for each species, the biological diversity of the aquatic environment, and human interests in using fishing resources are all considerations under the management system. A Quota Management System provides for the sustainability of fisheries resources. Under this system, the Minister of Fisheries can put in place fishing quotas for specific stock.

Environmental governance

In New Zealand, environmental governance is shared between central and local government. It is also shaped by the participation of iwi authorities, industry groups, community interest groups, and non-government organisations.

Ministry for the Environment

The Ministry for the Environment provides advice, information, and leadership on New Zealand's environment. It was established under the Environment Act 1986.

The Ministry oversees the administration of the Resource Management Act 1991, and has specific functions under this Act, as well as the Hazardous Substances and New Organisms Act 1996, Ozone Layer Protection Act 1996, and Climate Change Response Act 2002.

Department of Conservation

The Department of Conservation preserves and protects the natural and historic resources of national parks, reserves, and other protected areas in terrestrial, freshwater, and marine environments. The Department also manages protected native wildlife and non-commercial freshwater fisheries. It was established under the Conservation Act 1987.

Other government agencies and Crown entities

Other government agencies and Crown entities with responsibility for the environment include:

- Ministry of Agriculture and Forestry
- Biosecurity New Zealand
- Ministry of Fisheries
- Environmental Risk Management Authority
- Energy Efficiency and Conservation Authority
- Ministry of Transport
- Ministry of Health
- Ministry of Foreign Affairs and Trade
- Ministry of Economic Development
- Ministry of Research, Science and Technology.

Parliamentary Commissioner for the Environment

The Parliamentary Commissioner for the Environment is an independent officer who reports directly to Parliament.

The Commissioner's functions under the Environment Act 1986 include:

- reviewing the effectiveness of environmental management by central and local government
- investigating and advising on any matter that may adversely affect the environment, as requested by Parliament or the public
- disseminating information
- encouraging actions to protect the environment.

Local government, regional councils, and territorial authorities

Local government oversees environmental management at a local level.

Regional councils as well as unitary authorities (councils that combine the functions of a territorial authority and a regional council) are responsible for developing regional plans and policy statements under the Resource Management Act. Their powers cover:

- managing freshwater, groundwater, and coastal water
- conserving the soil
- allocating and managing geothermal energy
- controlling the discharge of contaminants to air, land, and water
- managing the foreshore, water column, and seabed, including implementing controls on aquaculture in coastal waters.

Under other legislation, regional councils are also responsible for:

- regional land transport planning
- regional parks
- the biosecurity control of plant and animal pests
- river management, flood control, and mitigation of erosion
- environmental education
- harbour navigation and safety, marine pollution, and oil spills
- regional civil defence preparedness and response.

Territorial authorities and unitary authorities are responsible under the Resource Management Act for controlling the effects of land use, noise, and subdivision. They manage these functions through district plans.

Under the Local Government Act 2002, Land Transport Management Act 2003, Reserves Act 1977, Health Act 1956, and other related legislation, territorial authorities are also responsible for:

- infrastructure (that is, roading and transport, sewerage, and water, including stormwater)
- management of reserves
- environmental education
- community development
- environmental health and safety.

Local authorities must recognise and provide for the relationship of Māori with the environment under the Resource Management Act. This includes having particular regard to kaitiakitanga and taking into account the principles of the Treaty of Waitangi.

Local authorities must monitor the efficiency and effectiveness of their policies and plans in meeting these many functions, and report on this at least every five years.

ANYONE CAN MAKE A SUBMISSION ON A DISTRICT OR REGIONAL PLAN, A REGIONAL POLICY STATEMENT, OR A LONG-TERM COUNCIL COMMUNITY PLAN.

Source: Ministry for the Environment.

Kaitiaki groups

Kaitiaki groups have an important role in environmental management. Kaitiaki are closely involved in monitoring their local environments, which may include streams, lakes, estuaries, coastal areas, and wāhi tapu (sacred sites).

Over the last decade, tangata whenua and local and central government have built closer working relationships on matters of environmental governance. Iwi management plans, which incorporate iwi environmental goals, are one of the ways iwi become involved.

Sixty-one per cent of local authorities have formal and/or informal memoranda of understanding, protocols, joint management agreements, or service level agreements with local iwi (Ministry for the Environment, 2007).

The Treaty of Waitangi settlement process has also led to management partnerships being established that support the kaitiakitanga of iwi.

Community groups

Many New Zealand community groups work at the local level to clean up streams, revegetate riparian areas and coastal dunes, and promote practical community actions in areas such as waste minimisation, recycling, and energy efficiency. Many regions operate environment centres, which provide educational resources and meeting places for environmental community groups.

Local government processes also support the participation of local communities in environmental decision-making. Any member of the public can make a submission on a district or regional plan, a regional policy statement, or a long-term council community plan.

The participatory nature of the Resource Management Act and Local Government Act gives all New Zealanders an opportunity to help shape local policies for managing environmental impacts.

Business and industry groups

New Zealand businesses are increasingly taking the environment into account in their day-to-day activities. Business and industry groups also actively work with central and local government to improve the way they manage their activities to minimise their impacts on the environment. Examples of such partnerships between business and government include the Dairying and Clean Streams Accord and the New Zealand Packaging Accord.

In New Zealand, there are now a number of business groups and associations that have sustainability as their primary focus (for example, the New Zealand Business Council for Sustainable Development and the Sustainable Business Network).

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PRESSURES ON THE ENVIRONMENT

02

"Our lifestyles – including the goods and services we use – can affect the environment."

HOUSEHOLD CONSUMPTION

Contents

At a glance

Household consumption

Consumption by households affects the environment. Our lifestyle choices, the goods and services we consume, and how these are produced and disposed of all affect the extent and manner of our impact on the environment.

Household purchasing of goods and services is an approximate measure of the pressure households place on the environment through consumption. Therefore, it can be a useful indicator of the impact our lifestyles have on the environment.

Purchasing patterns can change over time. They are influenced by a range of factors such as population size, income, the availability and affordability of goods and services, economic trends, and consumer preferences.

Trends in household consumption expenditure

New Zealand households spent more in 2006 than they spent in 1997. Between 1997 and 2006, real total household consumption expenditure (that is, expenditure adjusted for inflation) increased by $21,532 million (39 per cent). Over the same period, real per capita household consumption expenditure increased by nearly $4,000 (26 per cent), and real per household consumption expenditure by just over $8,700 (20 per cent).

The 39 per cent increase in real total household consumption expenditure compares to an increase in New Zealand's population of around 11 per cent and in real gross domestic product of just over 30 per cent for the same period.

Trends in household expenditure across consumption categories

Real household consumption expenditure (expressed in 1995/1996 prices) across each of the seven consumption categories measured increased between 1997 and 2006, in total, and on a per capita and per household basis.

Since 1997, housing (which excludes mortgage repayments and house purchases), transport, and food and beverages have consistently appeared as the top three consumption categories, in terms of both real and nominal (unadjusted for inflation) total expenditure, expenditure per capita, and per household.

Between 1997 and 2006, most of New Zealanders' spending each year was on housing. In nominal terms, housing was the category on which most money was spent in 2006 (about 18 per cent of total household consumption expenditure, which is a decrease from about 21 per cent in 1997). However, in real terms, in 2006 New Zealanders spent more on food and beverages than on any of the other goods and services categories ($3,262 per person per year in real terms).

Between 1997 and 2006, expenditure on food and beverages and on household goods and services (for example, electricity, major appliances, and furniture) showed the greatest monetary increases (in real terms): $3,908 million ($727 per person) and $3,768 million ($768 per person), respectively. Expenditure on household goods and services, clothing and footwear, and food and beverages showed the greatest percentage increases (in real terms) in the same period (about 60 per cent, 59 per cent, and 41 per cent respectively).

Factors affecting household consumption

Rising consumption in New Zealand is likely to be related partly to population growth and to the growing number of households. However, increased household consumption expenditure can also be attributed to increasing consumption over time; that is, more people buying more things, not just more people buying the same things. Increased consumption can mean greater use of natural resources and generation of waste, both of which have implications for the environment.

Our changing ecological footprint

An 'ecological footprint' is one of several tools used to illustrate the pressure placed on the environment by our production and consumption of natural resources.

Between 1998 and 2004, New Zealand's ecological footprint increased from 19.9 million global hectares to 22.9 million global hectares, including imports but excluding exports.

In 2003, New Zealand had a per capita ecological footprint of 5.9 global hectares. This was higher than the Organisation for Economic Co-operation and Development (OECD) average of 5.1 global hectares, and the sixth highest in the OECD.

In addition, as New Zealand has a significant role in exporting goods and services to overseas markets, we export an ecological footprint equating to 15.5 million global hectares. This means that we contribute to the ecological footprint of other countries.

Present and future management

Today, New Zealanders are increasingly aware of the need to reduce the impacts of consumption on the environment, while at the same time improving our standard of living. In the future, this issue is likely to remain a focus in view of the national and global interest in sustainability.

According to the OECD, 'de-coupling environmental pressures from economic growth, while satisfying human needs, is a key challenge for OECD countries over the next few decades' (Organisation for Economic Co-operation and Development, 2002b, p 3).

Introduction

Human pressure on the environment is influenced to a large degree by our lifestyles, including the goods and services we purchase and consume.

An increasing population, economic changes, and changes in people's needs and activities are driving forces that cause changes in production and consumption, and therefore exert pressure on the environment.

In this chapter we look at consumption. At a basic level, consumption can be thought of as buying and/or using things. In a broader sense, consumption can encompass the range of processes, goods, and services that contribute to a final product or service, and even the waste that is generated when the product is used. When we purchase and use a product, it is just one point in its life cycle.

Implications of consumption

New Zealanders' patterns of purchasing and consumption have several implications for the environment. Our purchasing choices directly and indirectly involve the consumption of natural resources and the generation of waste as goods and services are produced and delivered. Our purchasing of goods and services can also be indirectly linked to harmful environmental effects (for example, air pollution caused by manufacturing processes). Therefore, household[1] purchases of goods and services (referred to as 'household consumption expenditure') can be used as an indirect measure of households' consumption of natural resources and the impact of our lifestyles on the environment.

The way we consume goods and services today may affect the future availability of some natural and physical resources, depending on how they are managed. Therefore, patterns of household consumption also have implications for sustainable development (Statistics New Zealand, 2002).

Both the volume and the kinds of things we purchase can influence the effect our consumption has on the environment. For example, people may reduce their home energy use by purchasing more energy-efficient appliances, but this may be offset by an increase in the total number of appliances purchased and used in the home.

NEARLY 300 TONNES OF OLD COMPUTER EQUIPMENT AND MOBILE PHONES WERE COLLECTED FREE-OF-CHARGE DURING NEW ZEALAND'S FIRST NATIONAL 'E-DAY' IN SEPTEMBER 2007.

Source: Ministry for the Environment.

Household consumption

Household consumption includes the goods and services we buy and use on a daily basis in our homes, from appliances to the food and beverages we consume, and the transport we use to make our daily trips to and from home.

Households comprise just one sector of the economy and, arguably, consumption by individual households contributes minimally to environmental degradation. The pressure on the environment caused by a single household may be small compared with the environmental impacts from the industrial, agricultural, or public sectors, but the combined impact of many households is an important contributor to several environmental problems, including water and air pollution, waste generation, and climate change (Organisation for Economic Co-operation and Development, 2002b) (see Table 3.1). As an example, householders are the largest energy user 'sector' in New Zealand when transport fuels are included (see chapter 4, 'Energy').

1 A 'household' consists of any number of people usually living together in a private dwelling. Households whose members are all temporarily away elsewhere in New Zealand and/or temporarily overseas are included in the definition, but visitors are excluded (Statistics New Zealand, 2007a). The national accounts data used in this chapter for household consumption expenditure, and the number of households in New Zealand, also includes non-private dwellings (for example, hospitals and boarding houses). See also note (3) to Table 3.3.

Household consumption and the environment

Household consumption is a driving force behind the production of goods and services and waste generation, and the resulting effects on the environment. For example, laying down a concrete slab in a backyard may have minimal environmental impact in the local environment, but the production of cement requires energy and releases carbon dioxide.

An assessment of OECD member countries published in 2002 found that impacts on the environment resulting from household activities had grown over the previous three decades, and were expected to intensify over the next two decades, particularly for energy, transport, and waste (Organisation for Economic Co-operation and Development, 2002a).

For New Zealand, ‘the two main direct impacts of New Zealand’s household consumption on the environment are as a result of energy use (including transport) and waste production’ (Statistics New Zealand, 2002, p 73).

+ TABLE 3.1:
SUMMARY OF TRENDS IN AND ENVIRONMENTAL IMPACTS OF HOUSEHOLD WASTE GENERATION AND CONSUMPTION OF ENERGY AND WATER

TRENDS AT HOUSEHOLD LEVEL	DETERMINANTS OF ENVIRONMENTAL IMPACT	ENVIRONMENTAL IMPACT
Growing demand for energy and water services tied to larger homes, and more energy and water appliances Growing waste generation and recycling Diversification of waste stream	Scale of energy and water use Energy and water efficiency rates Fuel source for heating and electricity generation Availability and quality of water resources Volume and composition of waste and method of waste disposal Recycling rates and waste prevention	Greenhouse gas emissions and air and water pollution linked to the generation and use of energy Water resource depletion and pollution Greenhouse gas emissions and air, water, and soil pollution from inappropriate waste management

Source: Adapted from Organisation for Economic Co-operation and Development, 2002b.

National environmental indicator

See chapter 1 'Environmental reporting' for more information on the core national environmental indicators and how they are used.

Household consumption expenditure

Household consumption expenditure is a proxy measure of the pressure that households place on the environment through their consumption. It reports how much money households spend on a variety of goods and services. These goods and services can be grouped into categories as shown in Table 3.2.

+ TABLE 3.2:
DESCRIPTION OF CONSUMPTION CATEGORIES

CATEGORY	DESCRIPTION OF WHAT CATEGORY INCLUDES
Food and beverages	Retail food and alcoholic and non-alcoholic drinks
Clothing and footwear	Clothing, footwear, and footwear repairs
Housing[1]	Rental payments (including rent, rental expenses, wages in kind, maintenance materials, and maintenance services), and imputed rent (where a cash value is ascribed to the services gained from housing, such as shelter, that are not usually exchanged for money)
Household goods and services	Fuel and energy for the home (for example, electricity), furniture, and major appliances (for example, purchases and repairs), textiles (for example, curtains), and tableware (for example, crockery)
Transport	Vehicle operation (for example, petrol, vehicle parts, and repairs), purchased transport (for example, taxi, bus, rail, and aeroplane fares), and vehicles purchased
Recreation and education[2]	A complete data set for this category is not available
Hotels and restaurants	Takeaways and food and beverages purchased in restaurants, and accommodation
Other goods and services	Personal goods and services, post and telephone, and services not classified elsewhere
Health and medical goods and services[2]	A complete data set for this category is not available

Notes:
(1) Housing excludes mortgage payments and house purchases. Mortgage payments are not included in any of these categories.
(2) Complete data sets for the categories recreation and education, and health and medical goods and services are not available, so these categories have only a basic analysis in this chapter: nominal data has been used to determine the combined total of these two categories in current price terms, and these figures are included in Table 3.3.
Data source: Adapted from Statistics New Zealand, pers comm.

There is one national environmental indicator for reporting on household consumption. It provides information on household consumption expenditure.

To report on the indicator, data on expenditure is presented against the following seven consumption categories from Table 3.2:

- food and beverages
- clothing and footwear
- housing
- household goods and services
- transport
- hotels and restaurants
- other goods and services.

Real and nominal data

Both real and nominal data have been used in this chapter.

Real data has been adjusted to remove the impact of price change (that is, inflation). A time series expressed in real terms relates to the underlying volumes of goods and services being bought and sold over time. The real household consumption expenditure figures in this chapter are based on a constant price (expressed in 1995/1996 prices), chain-linked series.

Nominal data is based on current prices and not adjusted for inflation.

Limitations of the indicator

The amount of money spent on the purchase of household goods and services is not necessarily a direct measure of the environmental impacts of these goods and services. This is because the links between consumption, economic growth, and environmental impact are not straightforward (see, for example, Haas et al, 2005; Organisation for Economic Co-operation and Development, 1999; and Yandle et al, 2004). For example, although economic activity influences our use of natural resources, economic growth can also provide the means to address environmental concerns (Statistics New Zealand, 2002). Another example is where producers and consumers can reduce the environmental impact of household consumption by making or purchasing more resource-efficient products.

Current pressures and trends

In terms of the effects of household consumption on the environment, two important aspects of household consumption expenditure are:

- the volume of household consumption expenditure – that is, how much money is spent (as an indication of the volume of consumption)
- household consumption expenditure across consumption categories – that is, spending patterns (the kinds of products and services that are consumed).

Household consumption expenditure, 2006

Between 1 April 2005 and 31 March 2006, New Zealand households spent about $91 billion (in nominal prices) on goods and services (see Table 3.3). Each New Zealander spent about $22,000, and each household spent about $61,700.

The top three consumption categories (excluding the combined recreation and education, and health and medical goods and services category) were food and beverages, housing, and transport.

+TABLE 3.3:
HOUSEHOLD CONSUMPTION EXPENDITURE IN NOMINAL FIGURES, YEAR ENDED 31 MARCH 2006

CATEGORY	HOUSEHOLD CONSUMPTION EXPENDITURE ($ MILLIONS)	PROXY PER CAPITA EXPENDITURE ($)	PROXY PER HOUSEHOLD EXPENDITURE ($)
Food and beverages	16,159	3,931	10,929
Clothing and footwear	4,424	1,076	2,992
Housing	17,198	4,184	11,632
Household goods and services	10,248	2,493	6,931
Transport	13,618	3,313	9,210
Hotels and restaurants	7,204	1,753	4,872
Other goods and services	10,018	2,437	6,775
Recreation and education, and health and medical goods and services	15,481	3,766	10,470
Total	91,235	22,197	61,705

Notes:
(1) Numbers are rounded to the nearest dollar.
(2) The categories recreation and education, and health and medical goods and services were calculated as a combined group, because complete data sets for the individual categories were unavailable (see note 2 to Table 3.2).
(3) Household consumption expenditure in each category includes purchasing by New Zealanders and people visiting New Zealand, but excludes New Zealand resident household expenditure while overseas. Figures for total household consumption expenditure do not include expenditure by people visiting New Zealand, but do include New Zealand resident household expenditure while overseas.

Data sources: Adapted from Statistics New Zealand, 2007b; 2007d; Statistics New Zealand, pers comm.

Trends in household consumption expenditure

Total household consumption expenditure has been increasing since 1993, although the rate of change has varied from year to year (see Figure 3.1). Total real household consumption expenditure increased about 65 per cent from 1993 to 2006. However, this increase is smaller on a per capita basis (about 42 per cent), because it takes increases in population into account.

Between 2004 and 2006, the percentage change in per capita household consumption expenditure exceeded the percentage change in per capita gross domestic product (see Figure 3.1).

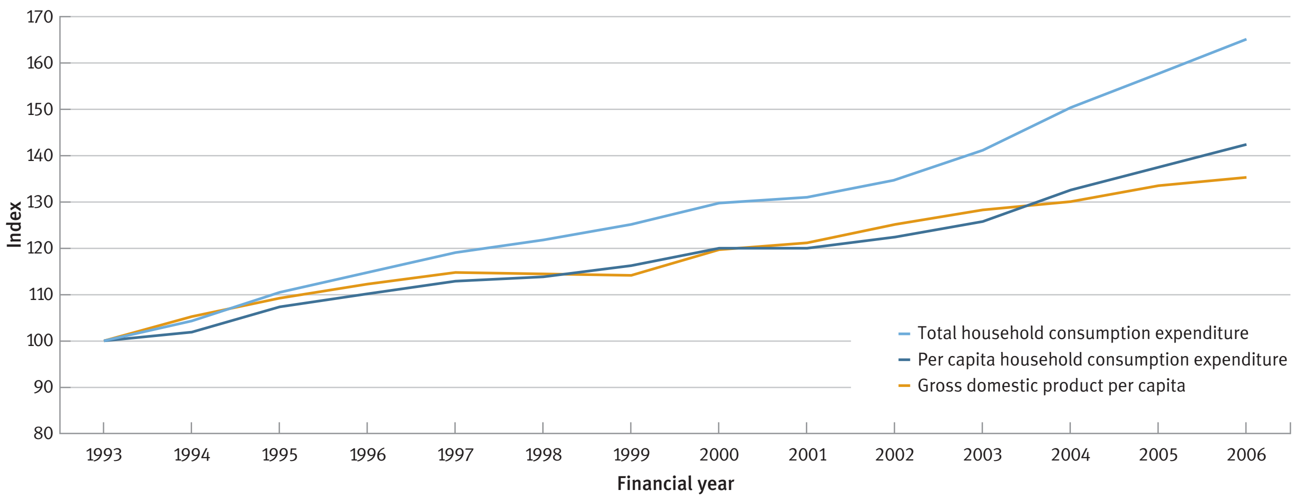
On average, every New Zealander spent more on household expenditure in 2006 than they did in 1993. This is consistent with what has happened in other Organisation for Economic Co-operation and Development (OECD) countries – according to the OECD, 'per capita private consumption has increased steadily in OECD countries over the last two decades, and is expected to continue to follow GDP growth in the period to 2020' (Organisation for Economic Co-operation and Development, 2002b, p 3).

Between 1997 and 2006, real total household consumption expenditure increased by $21,532 million (39 per cent). Over the same period, real per capita household consumption expenditure increased by nearly $4,000 (26 per cent), and real per household consumption expenditure by just over $8,700 (20 per cent) (see Table 3.4).

Trends in household expenditure by consumption category

Real household consumption expenditure (expressed in 1995/1996 prices) across all categories increased between 1997 and 2006 (see Table 3.4 and Figure 3.2).

+ FIGURE 3.1:
CHANGE IN TOTAL HOUSEHOLD CONSUMPTION EXPENDITURE, PROXY HOUSEHOLD CONSUMPTION EXPENDITURE PER CAPITA, AND GROSS DOMESTIC PRODUCT PER CAPITA, 1993–2006 (MARCH FINANCIAL YEARS, REAL DATA)



Note:
The graph is indexed to 1993.
Data sources: Adapted from Statistics New Zealand, 2007b; 2007c; 2007e.

+ TABLE 3.4:
REAL HOUSEHOLD CONSUMPTION EXPENDITURE (EXPRESSED IN 1995/1996 PRICES), IN 1997 AND 2006 (MARCH FINANCIAL YEARS)

CATEGORIES	1997	2006	PERCENTAGE CHANGE BETWEEN 1997 AND 2006 (%)
FOOD AND BEVERAGES			
Real household consumption expenditure ($ millions)	9,501	13,409	41.1
Proxy per capita real household consumption expenditure ($)	*2,535*	*3,262*	*28.7*
Proxy per household real consumption expenditure ($)	*7,414*	*9,069*	*22.3*
CLOTHING AND FOOTWEAR			
Expenditure ($ millions)	2,674	4,249	58.9
Per capita ($)	*714*	*1,034*	*44.9*
Per household ($)	*2,087*	*2,874*	*37.7*
HOUSING			
Expenditure ($ millions)	11,404	13,188	15.6
Per capita ($)	*3,043*	*3,209*	*5.4*
Per household ($)	*8,899*	*8,919*	*0.2*
HOUSEHOLD GOODS AND SERVICES			
Expenditure ($ millions)	6,307	10,075	59.7
Per capita ($)	*1,683*	*2,451*	*45.6*
Per household ($)	*4,921*	*6,814*	*38.5*
TRANSPORT			
Expenditure ($ millions)	9,361	12,480	33.3
Per capita ($)	*2,498*	*3,036*	*21.5*
Per household ($)	*7,305*	*8,441*	*15.6*
HOTELS AND RESTAURANTS			
Expenditure ($ millions)	4,206	5,481	30.3
Per capita ($)	*1,122*	*1,333*	*18.8*
Per household ($)	*3,282*	*3,707*	*12.9*
OTHER GOODS AND SERVICES			
Expenditure ($ millions)	6,158	8,482	37.7
Per capita ($)	*1,643*	*2,064*	*25.6*
Per household ($)	*4,805*	*5,737*	*19.4*
TOTAL			
Expenditure ($ millions)	55,835	77,367	38.6
Per capita ($)	*14,900*	*18,823*	*26.3*
Per household ($)	*43,569*	*52,326*	*20.1*

Notes:

(1) Dollar figures have been rounded to the nearest dollar.

(2) Percentages have been rounded to one decimal place.

(3) Household consumption expenditure in each category includes purchasing by New Zealanders and people visiting New Zealand, but excludes New Zealand resident household expenditure while overseas. Figures for total household consumption expenditure do not include expenditure by people visiting New Zealand, but do include New Zealand resident household expenditure while overseas.

(4) Expenditure on fuel for transportation (for example, petrol for cars) is included in the transport category (see Table 3.2).

(5) Expenditure on fuel and energy for the home (for example, electricity) is included in the household goods and services category (see Table 3.2).

(6) Rent, but not mortgage payments, is included in the housing category (see Table 3.2).

Data sources: Adapted from Statistics New Zealand, 2007b; 2007c; Statistics New Zealand, pers comm.

In 1997, in real terms, New Zealanders spent most on housing (excluding mortgage repayments or the purchase of houses – see Table 3.2), and the second highest amount on food and beverages. In 2006, that had reversed (see Figure 3.2). The relative ranking of the other categories remained the same.

When the data is not adjusted for inflation, housing remains the category on which most was spent in 2006 (see Table 3.3).

Since 1997, housing (which excludes mortgage repayments and house purchases), transport, and food and beverages have consistently appeared as the top three consumption categories, in terms of both real and nominal total expenditure, expenditure per capita, and per household expenditure.

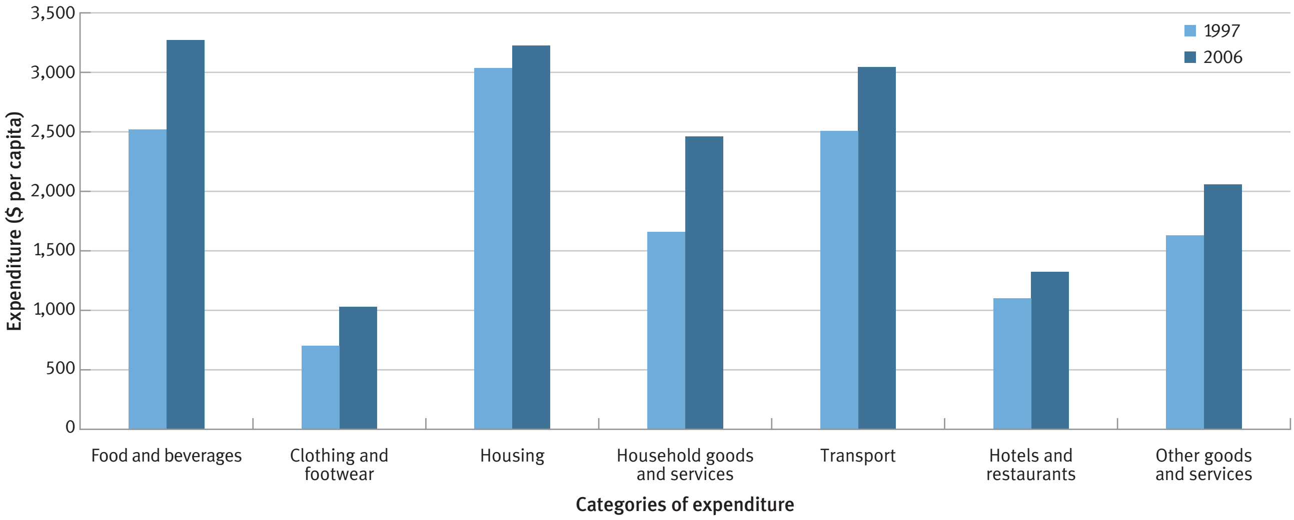
Between 1997 and 2006, expenditure on food and beverages and on household goods and services showed the greatest monetary increases (in real terms): increases of $3,908 million ($727 per person) and $3,768 million ($768 per person), respectively.

In percentage terms, between 1997 and 2006, New Zealanders' real total spending increased the most on household goods and services (about 60 per cent), clothing and footwear (nearly 59 per cent), and food and beverages (about 41 per cent) (see Figure 3.3). Housing (which excludes mortgage repayments and house purchases), showed the least percentage increase, with comparatively low increases of 15.6 per cent overall, 5.4 per cent per capita, and 0.2 per cent per household.

Between 1997 and 2006, total real expenditure in each of the categories except housing increased by a greater percentage than did gross domestic product (see Figure 3.3) (although hotels and restaurants was only marginally higher).

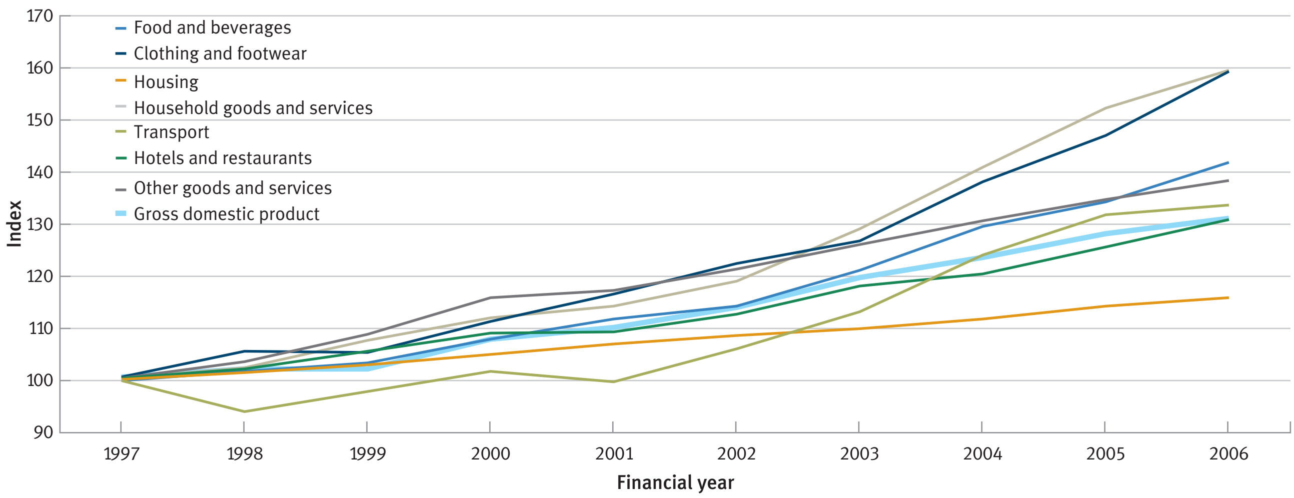
In nominal terms the greatest percentage increases in total spending on each category were for hotels and restaurants (about 68 per cent), food and beverages (about 67 per cent), and clothing and footwear (about 66 per cent). Household goods and services, and other goods and services also showed increases of more than 50 per cent.

+ FIGURE 3.2:
PROXY REAL HOUSEHOLD CONSUMPTION EXPENDITURE PER CAPITA, IN 1997 AND 2006 (MARCH FINANCIAL YEARS)



Note:
Data is expressed in 1995/1996 prices.
Data sources: Adapted from Statistics New Zealand, 2007b; 2007c.

+ FIGURE 3.3:
CHANGE IN REAL HOUSEHOLD CONSUMPTION EXPENDITURE BY CATEGORY, AND REAL GROSS DOMESTIC PRODUCT, 1997–2006 (MARCH FINANCIAL YEARS)



Note:
The graph is indexed to 1997.
Data sources: Adapted from Statistics New Zealand, 2007c; 2007e.

Changes in the proportion of spending in each category over time can indicate how New Zealanders' spending preferences are changing. Nominal data was used to calculate these percentages, so the changes reflect nominal rather than real figures (Statistics New Zealand, 2007d). Overall, the proportion of spending on each category did not change greatly between 1997 and 2006. Generally, between 1997 and 2006, New Zealanders spent the greatest proportions of overall expenditure on housing, food and beverages, and transport.

In 2006, housing comprised 18 per cent of total household consumption expenditure, which is a decrease from nearly 21 per cent in 1997. Housing, transport, and other goods and services are the only categories to have decreased as a percentage of total spending since 1997.

Factors that affect household consumption

A variety of factors can influence household expenditure patterns at individual and national levels, and, consequently, the degree to which our consumption affects the environment. Our purchasing patterns change as our lifestyles change, as the size of our families and homes change, and as our population and economy grows.

Factors that can influence household consumption expenditure patterns include lifestyle changes, emerging technologies, marketing campaigns, and changes in styles and tastes. Other factors, discussed in more detail in this chapter, are:

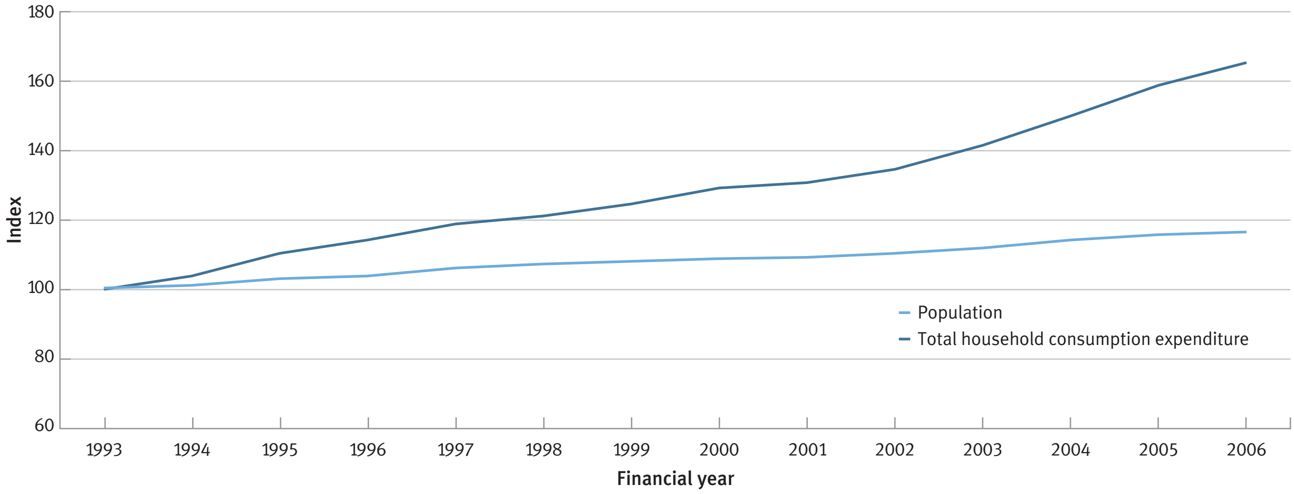
- population
- the number of households and household size
- the availability and affordability of goods and services
- economic growth and income levels
- individual choices.

Population

Between 1993 and 2006, New Zealand's population increased about 16 per cent and the estimated number of households increased about 22 per cent. While these increases could be expected to cause household consumption expenditure to rise, total expenditure has been increasing at a comparatively greater rate than the population has been increasing.

Total household consumption expenditure increased about 65 per cent between 1993 and 2006 (see Figure 3.4), suggesting that rising household consumption expenditure is not solely the result of having a larger population or more households. In other words, New Zealanders are spending relatively more now than they were spending 10 years ago.

+ FIGURE 3.4:
CHANGE IN POPULATION AND REAL TOTAL HOUSEHOLD CONSUMPTION EXPENDITURE, 1993–2006 (MARCH FINANCIAL YEARS)



Note:
The graph is indexed to 1993.
Data sources: Adapted from Statistics New Zealand, 2007b, 2007c.

Households and household size

Between 1997 and 2006, the number of households in New Zealand increased, while the average number of people living in each household decreased slightly. Overall, the trend has been towards larger dwellings with fewer occupants (Statistics New Zealand, 2003).

Data from the 2006 census shows that the average number of people per household marginally declined from 1996 to 2006, from 2.8 people per household to 2.7 people per household (Statistics New Zealand, 2007f).

Over the same period, the proportion of one-person households in New Zealand increased from nearly 21 per cent (256,569) to 23 per cent (328,299) of households (Statistics New Zealand, 2007f).

Without any resource-efficiency measures, such as energy-efficient fit-outs and appliances, larger houses can be expected to consume more resources. At the same time, smaller households (fewer people occupying a housing unit) 'generally use more space, energy, and water, and generate more waste per person' than do larger households (European Environment Agency, 2005).

Availability and affordability of goods and services

Consumers base their purchasing decisions on a wide range of factors, but the products and services that are available determine what consumers can buy. Over recent years, the variety of goods available for households to purchase has increased, and many goods have also become more affordable. As in other countries, New Zealanders have access to 'a steadily expanding range of low-priced, mass-produced goods and access to a progressively more global marketplace' (Organisation for Economic Co-operation and Development, 2002b, p 6).

Such trends can change not only the volume of household consumption, but also the kinds of goods households purchase. For example, in some cases it may become more affordable to buy something new rather than to repair it. As another example, the choices households make regarding transport can be affected by factors such as the price of petrol, or the availability of various transport options. The greater variety of products for consumers to buy is also reflected in an increase in the availability and variety of 'eco-friendly' products and services.

Eco-labelling schemes

Labelling schemes that identify products that meet certain 'eco-friendly' criteria can inform consumers' purchasing choices.

Environmental Choice New Zealand

Environmental Choice New Zealand is a voluntary eco-labelling programme owned by the Government and run independently by the New Zealand Ecolabelling Trust. Products must meet publicly available criteria, based on life-cycle principles, that have been developed to international standards and are designed to indicate 'environmental preferability'. Products that achieve the appropriate standards are entitled to use the Environmental Choice label (Environmental Choice New Zealand, no date).

Source: Courtesy of the Energy Efficiency and Conservation Authority.

Energy

ENERGY STAR is an independent, international label that indicates which products are the most energy efficient in a product category. Products displaying the blue ENERGY STAR mark have to meet stringent energy efficiency standards. At present, the ENERGY STAR mark can be found on the most energy efficient heat pumps, washing machines, dishwashers, computers, imaging equipment, and home electronics. More products will be added over the coming years (Energy Efficiency and Conservation Authority, no date).

Energy rating label. Consumers can compare the energy consumption of different appliances by the number of stars on the energy rating label (the more stars, the better the efficiency of the model). In New Zealand, it is mandatory to display this label on whiteware (refrigerators and freezers, washing machines, dishwashers, and dryers), and heat pumps (Energy Efficiency and Conservation Authority, pers comm).

Source: Courtesy of the Energy Efficiency and Conservation Authority.

Economic growth and income levels

Economic growth and household consumption growth are closely linked, and have followed similar trends. Higher levels of income mean greater discretionary spending (that is, money available to spend on consumables beyond the basic necessities) and a greater ability to purchase more and/or higher-priced goods. Between 1997 and 2006, New Zealand's economy grew by just over 30 per cent in real terms (Statistics New Zealand, 2007e) and real household consumption expenditure increased 38.6 per cent (see Table 3.4).

Between 1997 and 2006, total real expenditure in each of the categories, except housing, increased by a greater percentage than gross domestic product (see Figure 3.3) (although hotels and restaurants was only marginally higher).

Individual choices

By making environmentally conscious decisions, such as choosing appliances or vehicles that are more energy efficient, people can reduce the effects of their consumption on the environment. The opposite is true when household activities increase energy consumption or generate more waste that needs disposal.

Even when improvements are made in energy efficiency, reductions in environmental impacts may be offset by the overall increases in the volume of goods and services consumed (Organisation for Economic Co-operation and Development, 2002b).

While using energy-efficient appliances may not necessarily result in reduced energy consumption, it may have benefits such as people's health improving as a result of living in warmer homes.

LOCAL ACTION to reduce household consumption

Hamilton Energy Blitz

Over the month of May 2007, Hamilton Environment Centre, supported by Hamilton City Council and Environment Waikato, ran what was called an 'energy blitz' in Hamilton City – a month of events focusing on encouraging energy efficiency and reducing energy use in the home (Environment Waikato, no date).

Promoting energy efficiency in the home is one way of helping to reduce household energy consumption. (For a discussion of the environmental implications of energy consumption, see chapter 5, 'Energy'.)

Sustainable Living Programme

The Sustainable Living Programme was developed by eight local and regional councils, led by Marlborough District Council, with involvement from community groups and high schools. The programme now runs evening classes in 20 regions and cities, and has a website with information about practical steps that can be taken to improve sustainability at the household level. The programme is intended to encourage consumers to make informed choices about how their activities and purchases impact on the environment (Sustainable Living Programme, no date).

Green business

Many businesses, such as those in the tourism sector, are starting to take action to become more environmentally sustainable, including by reducing their carbon footprint. They may market these actions as a point of difference from their competitors, or join a recognised eco-labelling scheme (see box, 'Eco-labelling schemes' on the previous page). Such actions by businesses allow consumers to make a more informed choice about what they buy, based on the environmental pressures or impacts of those products and services. Indirectly, the 'green business' movement can reduce the environmental impacts of household consumption.

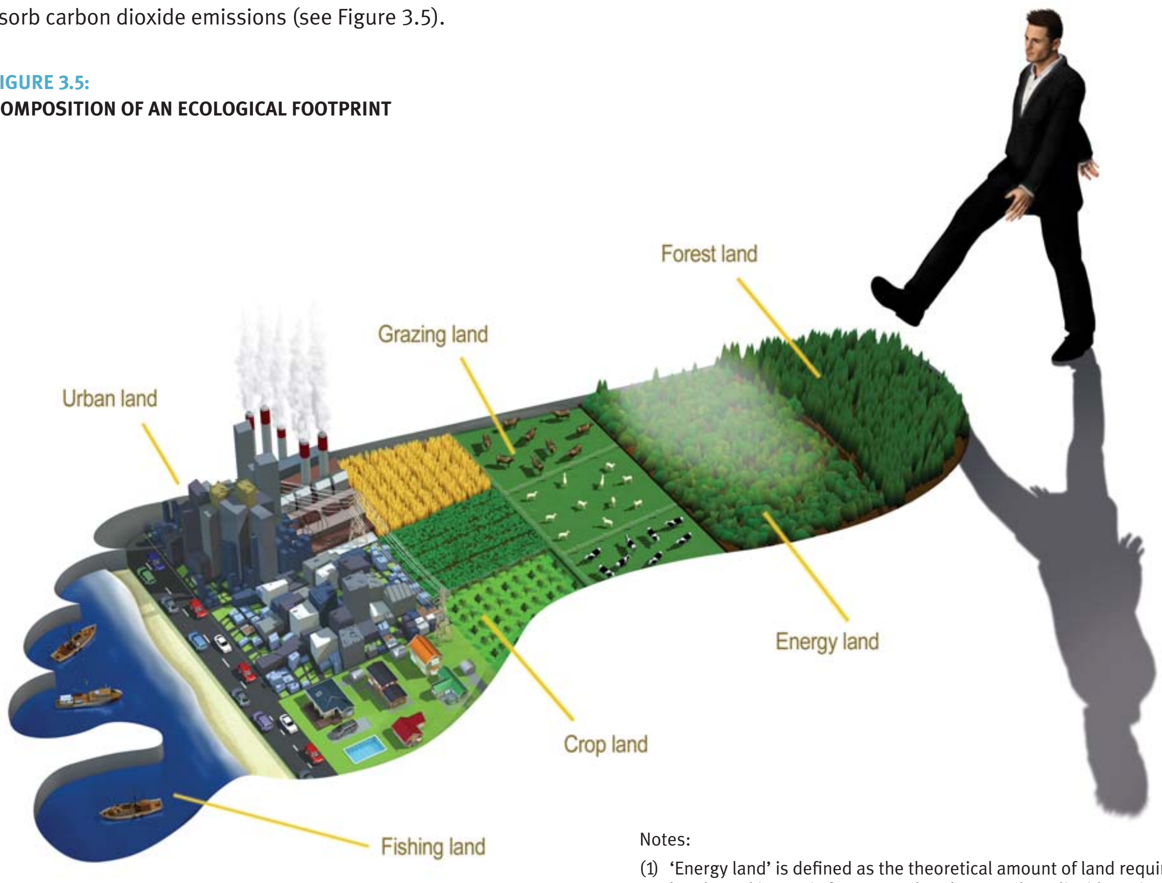
Ecological footprint

An ‘ecological footprint’ is one of several tools that may be used to illustrate the pressure placed on the environment by our production and consumption of natural resources (see box ‘More about sustainability indices’). The larger a population’s ecological footprint, the more natural resources that are needed to sustain that population’s lifestyle.

An ecological footprint estimates the amount of productive land and sea area[2] that is required to support the lifestyle of a particular population (for example, a country, region, or household). This includes the land needed to produce food and fibre and other goods and services, and to support infrastructure and housing. It also includes the area of land that is needed to absorb carbon dioxide emissions (see Figure 3.5).

The ecological footprint can be used to show whether a population’s demand for natural resources exceeds the supply of those resources – that is, whether a population is living within its land’s ecological carrying capacity. In this way, an ecological footprint can be used as a proxy measure of the environmental sustainability of a population’s lifestyle.

+ FIGURE 3.5:
COMPOSITION OF AN ECOLOGICAL FOOTPRINT



Notes:

(1) ‘Energy land’ is defined as the theoretical amount of land required to be planted in exotic forests to absorb our carbon dioxide emissions.

(2) ‘Fishing land’ is the area required to support the fishing industry and the production of seafood.

Source: Ministry for the Environment.

2 For the purposes of this section, the area of productive land and sea are referred to collectively as ‘land’.

More about sustainability indices

The ecological footprint is just one measure of environmental sustainability. Other tools that may be used to measure and aggregate environmental performance indicators include the Environmental Sustainability Index (ESI) and Environmental Performance Index (EPI).

The ESI reports against five indicators: environmental systems, environmental stresses, human vulnerability to environmental risk, social and institutional capacity to respond to issues, and global stewardship.

The EPI records performance against targets in areas such as environmental health, air quality, water resources, biodiversity and habitat, sustainable energy, and productive natural resources, and is narrower in focus than the ESI (Department of Environment and Conservation, 2006).

+ TABLE 3.5:
PERFORMANCE OF SELECTED COUNTRIES AGAINST SELECTED SUSTAINABILITY INDICES

COUNTRY	ECOLOGICAL FOOTPRINT (2003)		ENVIRONMENTAL SUSTAINABILITY INDEX (2005)		ENVIRONMENTAL PERFORMANCE INDEX (2005)	
	Size (hectares per capita)	Rank (1=worst)[a]	Score (1–100)	Rank (1=best)[b]	Score (1–100)	Rank (1=best)[c]
United States	9.6	2	52.9	45	78.5	28
Canada	7.6	4	64.4	6	84.0	8
Australia	6.6	6	61.0	13	80.1	20
Finland	7.6	3	75.1	1	87.0	3
New Zealand	5.9	9	60.9	14	88.0	1
United Kingdom	5.6	14	50.2	65	85.6	5
Sweden	6.1	8	71.7	4	87.8	2
Spain	5.4	15	48.8	76	79.2	23
Russia	4.4	25	56.9	31	79.4	22
Germany	4.5	23	53.7	40	78.7	27
Netherlands	4.4	26	56.1	33	77.5	32
Japan	4.4	27	57.3	30	81.9	14
South Africa	2.3	53	46.2	93	62.0	76
Argentina	2.3	55	62.7	9	77.7	30
Brazil	2.1	58	62.2	11	77.0	34
China	1.6	69	38.6	133	56.2	94
Total number of countries measured		149		146		133

Note:
(a) 10 largest ecological footprints: United Arab Emirates, United States, Finland, Canada, Kuwait, Australia, Estonia, Sweden, New Zealand, and Norway.
(b) 10 best performing ESI countries: Finland, Norway, Uruguay, Sweden, Iceland, Canada, Switzerland, Guyana, Argentina, and Austria.
(c) 10 best performing EPI countries: New Zealand, Sweden, Finland, Czech Republic, United Kingdom, Austria, Denmark, Canada, Malaysia, and Ireland.
Some of these countries are not listed in Table 3.5.
Data sources: Adapted from Global Footprint Network, 2006; Esty et al, 2005; Esty et al, 2006.

New Zealand's changing footprint

Population growth is a key influence on the size of an ecological footprint. In addition, as an economy grows, so too does its ecological footprint. The wealthier a country or region is, the higher levels of material affluence and consumption of goods and services it has (Ministry for the Environment, no date).

Between the 1998 and 2004 March financial years, New Zealand's ecological footprint is estimated to have increased 15.4 per cent, from 19.9 million global hectares to 22.9 million global hectares (Ministry for the Environment, no date). This was accompanied by an increase in the ecological footprint of each of New Zealand's 16 regions (as defined by regional authority area).

On a per capita basis, New Zealand's ecological footprint increased from 5.24 global hectares in 1998 to 5.65 global hectares per person in 2004, which is an increase of 7.8 per cent (Ministry for the Environment, no date).

Trade and New Zealand's ecological footprint

In 2007, the Ministry for the Environment estimated New Zealand's 2004 biocapacity to be 58.2 million global hectares. With an ecological footprint of 22.9 million global hectares, the New Zealand population uses 39.4 per cent of its available biocapacity. This indicates that New Zealand is living within its ecological carrying capacity, as measured by the ecological footprint tool.

However, New Zealand's ecological footprint does not include the amount of land used to produce goods and services for export. These goods and services are included in the importing country's ecological footprint.

New Zealand's 'ecological balance of trade' highlights that we are a significant exporter of goods and services to the rest of the world. At 15.5 million global hectares, the area of land used for the production of our exports is just over twice that used for our imports (Ministry for the Environment, no date).

International ecological footprints

The ecological footprint provides a useful tool to compare relative environmental pressures across countries. Figure 3.6 shows that in 2003 New Zealand had the sixth largest per capita ecological footprint within the Organisation for Economic Co-operation and Development (OECD) at 5.9 global hectares. The OECD average at that time was 5.1 global hectares per person.

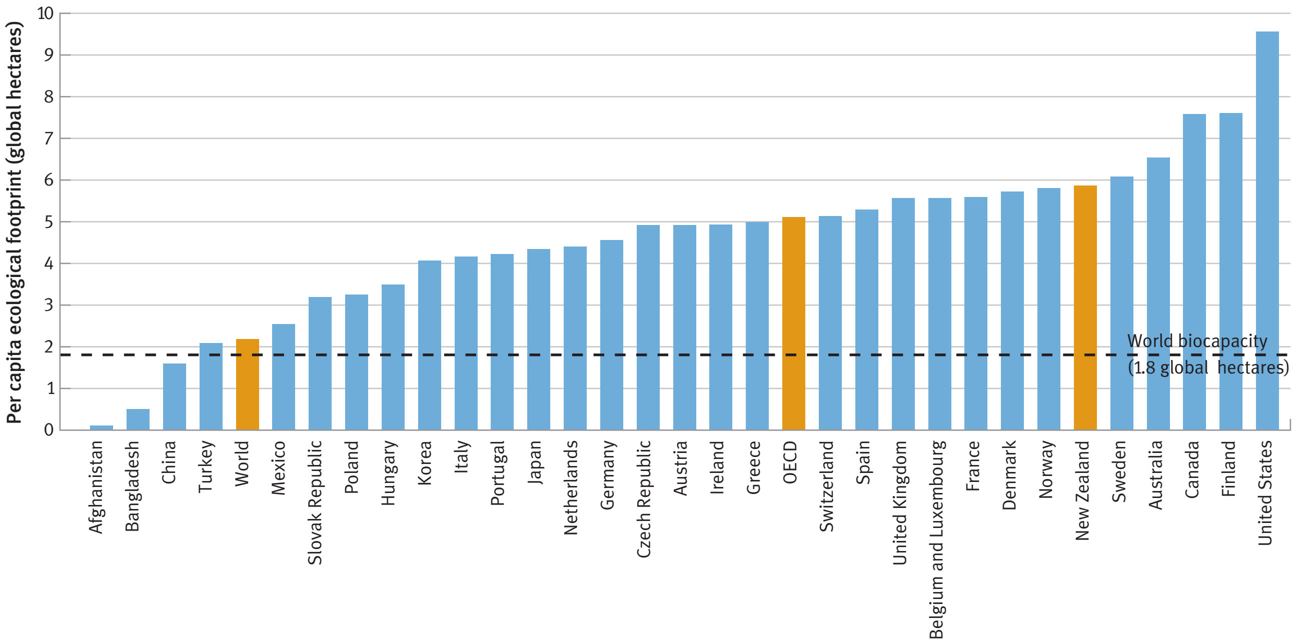
In 2003, New Zealand's ecological footprint was larger than the global average per capita footprint of 2.2 global hectares per person[3]; which is also higher than the earth's estimated biocapacity of 1.8 global hectares per person (Global Footprint Network, 2006).

Note that the ecological footprint for New Zealand calculated by the OECD differs from that estimated in New Zealand due to different calculation methodologies.

3 This includes the per capita ecological footprints of all countries with populations of 1 million or more for which data is available, including the significantly smaller footprints of developing countries such as Afghanistan (0.1 hectare) and Bangladesh (0.5 hectare) (Global Footprint Network, 2006).

+ FIGURE 3.6:

COMPARISON OF PER CAPITA ECOLOGICAL FOOTPRINTS OF OECD COUNTRIES IN 2003, INCLUDING OECD AND WORLD AVERAGES



Notes:

(1) No data is available for Iceland.

(2) Belgium and Luxembourg have been grouped together for the purposes of this figure.

(3) Afghanistan, Bangladesh, and China are not members of the OECD, but have been included to provide a global scale.

Data source: Adapted from Global Footprint Network, 2006.

Changes since the 1997 report

The 1997 report, *The State of New Zealand's Environment 1997* (Ministry for the Environment, 1997), reported on production and consumption patterns, but not on household consumption. As an indicator of the state of and trends in one of the pressures on our environment, household consumption is a relevant addition to the present report.

Influences on household consumption expenditure

New Zealand's real household consumption expenditure increased between 1997 and 2006 overall, on a per capita basis, and on a per household basis. This continues a longer trend of increasing consumption. Expenditure (in dollar terms) in total, per capita, and per household, increased in all seven categories measured.

Since 1997, there have been a number of changes to the influences on the way New Zealand households spend money. For example, population growth and an increase in the number of households have contributed to increases in the nominal volume of household consumption expenditure. Trends towards smaller households and larger houses may have contributed to increases in household consumption expenditure per household and per person. The increasing availability and affordability of goods and services has implications for both the volume and the kinds of goods purchased, as do economic, cultural, and social changes.

Impact of household consumption on the environment

The impacts on the environment of New Zealand households' consumption cannot currently be accurately quantified, either overall or within the various consumption categories. However, consumption is one of the driving forces behind the pressures people place on the environment. Therefore, it can be used as an indicator of the effect we have on the environment.

As noted above, New Zealand's household consumption expenditure per person has increased since 1997. It can be inferred that this increasing consumption is driving an increase in environmental pressures.

Household consumption choices

The pressures that consumption can bring to bear on the environment can be influenced by the volume of goods and services we consume and the kinds of things we consume. For example, if we purchase goods and services that are more environmentally friendly, we can reduce the impact of our consumption on the environment.

Environmental awareness has created demand for particular kinds of products, such as reusable shopping bags, and energy-efficient cars and appliances. New technologies introduced in recent years also affect the types of products available for us to purchase (for example, hybrid cars), and the way we make those purchases (for example, internet purchasing).

It is important to note, however, that the gains made by making the consumption process more sustainable or less detrimental to the environment (for example, by households using energy-efficient appliances) can be offset if the overall level of consumption increases.

GOVERNMENT ACTION on sustainability

sustainability.govt.nz

Six flagship sustainability initiatives were introduced in February 2007 to help move New Zealand towards greater environmental sustainability, including at the household level.

Household Sustainability Programme

The Household Sustainability Programme focuses on helping New Zealanders take practical action in and around the home, particularly in the areas of energy, water, waste, building and renovating, and transport.

Business Partnerships for Sustainability

The Business Partnerships for Sustainability initiative aims to promote and develop the adoption of sustainable business practices in New Zealand. In doing so, the initiative will help position New Zealand as a world-leader in smart, innovative, and business-savvy responses to environmental issues.

Towards a Carbon Neutral Public Service

Six central government departments have committed to the goal of being carbon neutral by 2012, and it will be mandatory for the remaining 28 agencies to be working towards carbon neutrality by this time. Carbon neutrality involves:

- measuring all greenhouse gas emissions associated with energy, transport, and waste to landfill
- developing plans to reduce emissions
- offsetting unavoidable emissions through New Zealand-based projects.

Sustainable Government Procurement

A new sustainable government procurement policy was launched in August 2007 to bring sustainability to the core of government procurement policy and practice. Government departments must now consider the environmental credentials of goods and services they buy against mandated standards, guidelines, and targets.

Through this initiative, the Government will use its purchasing power to drive the market for environmentally-friendly goods and services. The new policy will ensure government departments purchase goods and services that are water and energy efficient, emit low levels of greenhouse gases, produce less waste, and are environmentally certified, wherever possible.

Enhanced Eco-Verification

The Enhanced Eco-Verification programme will support sustainable procurement by enabling firms to measure and reduce their environmental and carbon footprints through verified programmes, including certified eco-labelling programmes. (For more information on eco-labelling, see box 'Eco-labelling schemes'.)

Towards Zero Waste

The Towards Zero Waste initiative seeks to establish a network of recycling facilities in public areas, particularly in larger cities and high-profile tourist destinations, and at large events. It complements a broad range of waste minimisation and management initiatives underway at the national and local level.

The future

In the future, as consumer preferences evolve and awareness grows, there is likely to be a continued focus on considering the environmental effects of goods and services at the time of purchase and how to reduce these effects through purchasing more sustainably.

In view of the growing national and international interest in sustainability, there is also likely to be a greater focus on decoupling environmental pressures from economic growth through smarter consumption and greater resource efficiency in the production of the goods and services bought.

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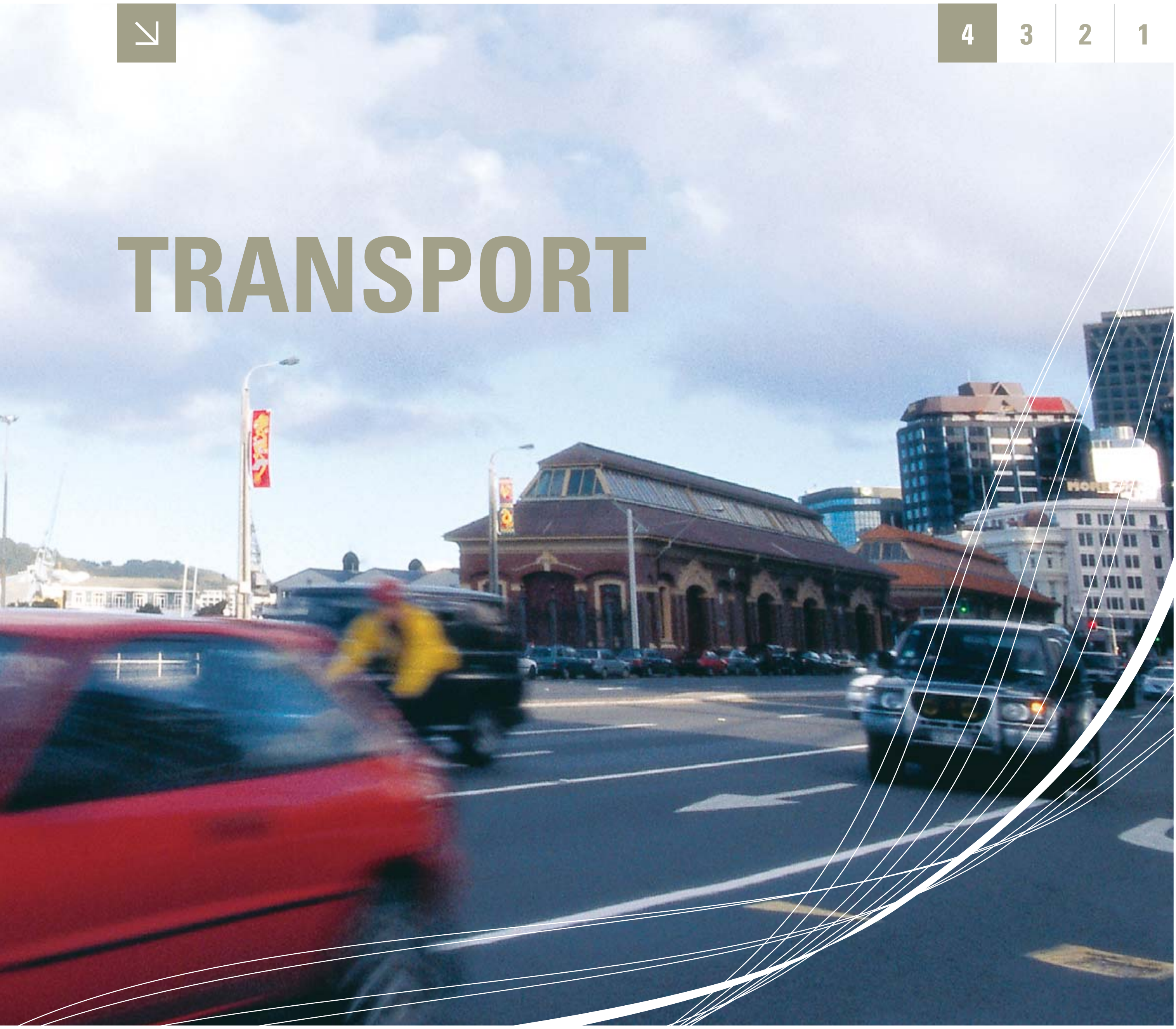
“Sustainable transport networks connect people and places.”

TRANSPORT



Contents

At a glance

Transport in New Zealand

New Zealanders value their mobility. We rely on transport to access work, educational, social, and recreational activities. Transport also underpins New Zealand's economic prosperity by enabling the movement of people and goods, and connecting New Zealand to international markets.

Road transport is the central element of New Zealand's transport system, reflecting our small pockets of population and comparatively large land area. In recent years, New Zealanders have become increasingly reliant on road transport, and the number of vehicles per person is growing; we tend to buy larger vehicles and use them more.

Impacts of transport

Our extensive use of cars and trucks is putting pressure on the environment and human health.

- The consumption of fossil fuels creates exhaust emissions that negatively affect our air quality.
- Run-off from roads negatively affects our waterways.
- Greenhouse gas emissions from our transport fuels contribute to climate change.
- End-of-life oil, tyres, and vehicles require careful disposal.

Vehicle kilometres travelled

The number of vehicle kilometres travelled on New Zealand roads has more than doubled since 1980, indicating that New Zealanders have become increasingly mobile. The car is the largest contributor to total vehicle kilometres travelled.

In 2006, New Zealanders travelled over 39.2 billion vehicle kilometres. Between 2001 and 2005, the vehicle kilometres travelled on New Zealand roads increased for all vehicle types. In 2006, however, the vehicle kilometres travelled for all vehicle types decreased slightly from the previous year.

New Zealand's vehicle fleet

In 2006, 61 per cent of New Zealand's vehicle fleet was more than 10 years old. This represents a 4 percentage point increase in age from 2001.

New Zealand's vehicle fleet is dominated by ageing, petrol-fuelled vehicles, although the share of diesel vehicles on the road has increased 3 per cent between 2001 and 2006. The number of diesel vehicles in the fleet increased by 39 per cent over the same period.

Vehicle ownership in New Zealand has more than tripled since the 1950s. In 2005, the number of vehicles per person was 0.7, the fifth highest rate of vehicle ownership among member countries of the Organisation for Economic Co-operation and Development.

Other modes

Shipping is an essential component of New Zealand's transport system. In 2006, 99.5 per cent of New Zealand's total export cargo (by weight) left from seaports. Transportation by ship can have a lower 'carbon footprint' than comparable air and road transport.

Air transport is another key component of New Zealand's transport system. In 2005, more than 8.61 million passengers travelled to and from New Zealand by plane.

Present and future management

Increasingly, transport planners are recognising the impacts of transport on the environment. They are putting more effort into increasing the use of public transport, encouraging people to walk or cycle, designing our urban spaces to minimise the need for motorised forms of transport, and encouraging people to buy and use more fuel-efficient vehicles.

These issues will continue to remain a focus for transport planning. The need to reduce greenhouse gas emissions from transport – a major contributor to emissions – is likely to drive greater effort to improve fuel efficiency and increase the use of biofuels and alternative means of powering vehicles, such as electricity.

Introduction

New Zealanders value their mobility. We rely on transport to access a range of work, educational, social, and recreational activities. Transport also underpins New Zealand's economic prosperity by enabling the movement of people and goods, and by connecting New Zealand to international markets.

New Zealand has a well-developed transport system. It comprises nearly 91,000 kilometres of roads and highways, 4,000 kilometres of railway tracks, 13 major commercial seaports, 7 international airports, and several smaller provincial airports.

Road transport – the central element of our transport system

New Zealand roads carry over 39 billion vehicle kilometres of traffic every year. Road transport is the central element of New Zealand's transport system, reflecting our small pockets of population, comparatively large land area, and high rates of vehicle ownership. This chapter therefore focuses primarily on road transport.

New Zealand has no vehicle manufacturing industry, so all our vehicles are imported, which makes us a 'technology taker' with respect to our vehicle fleet. Being a 'technology taker' means our vehicle fleet is greatly influenced by technological developments and standards in other countries. In 2005, 230,000 cars were imported, of which 152,000 (66 per cent) were used cars previously registered overseas and 78,000 (34 per cent) were new cars (Land Transport New Zealand, 2007).

Rail, sea, and air transport

Although New Zealanders rely mainly on motor vehicles to move from place to place, rail is used for freight and some passenger transport between towns and cities and within larger cities. New Zealand has a national rail network of about 4,000 kilometres, with comparatively well-developed urban networks in Wellington and Auckland.

Shipping is essential for transporting New Zealand's export goods to overseas markets. In the year ended 30 June 2006, 21.7 million tonnes of export cargo, valued at $27,814 million, left from New Zealand's seaports. The amount of cargo transported by sea equates to 99.5 per cent of total export cargo by weight and 84.3 per cent of total export cargo by value (Statistics New Zealand, 2006c).

Maritime transport is also responsible for a small number of passenger arrivals and departures. However, most passengers travel to and from New Zealand by air, with more than 8.61 million passengers travelling to and from New Zealand by plane in 2005.

Impacts of transport on the environment and human health

Road, rail, shipping, and air transport all have an impact on the environment, including noise, wastes such as end-of-life vehicles and used oil and tyres (see chapter 6, 'Waste'), and contaminated run-off from roads to freshwater and marine ecosystems (see chapter 10, 'Freshwater' and chapter 11, 'Oceans').

Transport accounts for 86 per cent of New Zealand's total oil consumption, with road transport making up 89 per cent of that amount. As a result, 18 per cent of New Zealand's total greenhouse gas emissions come from transport, mostly from road transport (see chapter 8, 'Atmosphere').

Motorised transport can also affect human health. The combustion of fossil fuels produces fine airborne emissions (called particulates), which can damage people's health if they penetrate the lungs. The ill-health effects of transport pollution include irritated eyes, throat, and lungs. For people with respiratory conditions, such as asthma or bronchitis, breathing in particulates can make the conditions worse. (See chapter 7, 'Air' for further information on the impacts on health of vehicle emissions.)

Particulates from transport are primarily produced by diesel vehicles, especially older diesel vehicles that have not been well maintained.

Walking and cycling are among the most sustainable forms of transport. They also have benefits for our health and fitness, allowing us to build exercise into our daily routine.

CYCLING IS A SUSTAINABLE MODE OF TRANSPORT WITH BENEFITS FOR HEALTH AND FITNESS.

Source: Ministry for the Environment.

GOVERNMENT ACTION on transport

New Zealand Transport Strategy

The New Zealand Transport Strategy is the Government's strategic framework for achieving the vision that 'by 2010 New Zealand will have an affordable, integrated, safe, responsive, and sustainable transport system' (Minister of Transport, 2002).

National Walking and Cycling Strategy

In February 2005, the Government launched a national strategy to encourage walking and cycling, Getting There – On Foot, By Cycle (Minister of Transport, 2005). Funding for walking and cycling initiatives was also boosted at this time by $1.15 million.

Mandatory Vehicle Fuel Economy Labelling

In 2007, a Mandatory Vehicle Fuel Economy Labelling Scheme was approved for both new and used vehicles. The labelling scheme will apply at the point of sale for later model vehicles for which fuel economy information is available.

The label will have a comparative 'star-rating' similar to the energy efficiency label seen on whiteware appliances, allowing buyers to compare fuel economy ratings across vehicles. The label will also show the annual fuel cost for a typical driver. The labelling scheme will help increase the level of information to consumers regarding fuel economy and encourage the purchase of more fuel efficient vehicles. (Energy Efficiency and Conservation Authority, 2007).

Biofuels Sales Obligation

The Government has announced a Biofuels Sales Obligation, which requires companies that sell petrol or diesel in New Zealand to also sell biofuels. The amount of biofuels they will have to sell will be a percentage of their total combined petrol and diesel sales each year, measured in petajoules and based on the volumetric energy content of each fuel. The amount has been set at a minimum of 0.53 per cent for year 1 (2008) and will increase each subsequent year. By 2012, at least 3.4 per cent of all fuel that oil companies sell in New Zealand will have to be biofuels.

Fuel $aver website

The Fuel $aver website (www.fuelsaver.govt.nz) was launched in 2006. The website provides up-to-date information about the fuel efficiency of vehicles sold in New Zealand. This information lets consumers assess different vehicles on the basis of fuel consumption.

National environmental indicator

See chapter 1, 'Environmental reporting' for more information on the core national environmental indicators and how they are used.

Vehicle kilometres travelled

The national environmental indicator for transport provides information on vehicle kilometres travelled (VKT) by road.

The report on the indicator derives its data from measurements of the following:

- vehicle kilometres travelled by vehicle type (cars, light commercial vehicles, heavy commercial vehicles, and motorbikes)
- vehicle kilometres travelled by vehicle age
- vehicle kilometres travelled by fuel type (petrol or diesel).

The characteristics of our vehicles, such as age and type, and the distance we drive them determine the pressures on the environment. We use the 'vehicle kilometres travelled' indicator to identify changes in the composition and use of New Zealand's vehicle fleet and to determine how these changes may be affecting the environment. Improving the vehicle fleet's environmental performance is one way to reduce the pressures transport places on our environment.

Limitations of the indicator

The 'vehicle kilometres travelled' indicator only accounts for kilometres travelled by road vehicles. It excludes rail, sea, or air transport modes, which also have impacts on the environment.

The indicator does not take traffic congestion into account. Therefore, it is not possible to assess the proportion of vehicle kilometres travelled during peak traffic, when congestion leads to greater fuel consumption and exhaust emissions per kilometre travelled than during off-peak traffic.

The indicator does not take into account improvements over time in fuel quality or emissions reduction technology when it compares vehicle kilometres travelled year on year.

Other information

As the 'vehicle kilometres travelled' indicator accounts only for road transport, this chapter presents a wider picture of transport in New Zealand by using:

- vehicle ownership rates to show the average number of vehicles owned per person in New Zealand
- the 2006 Census of Population and Dwellings to show our use of motorised vehicles for travel to work, and the extent to which we use other modes of transport (for example, public transport, walking, and cycling)
- information on the average engine size of vehicles used on New Zealand roads
- records of international passenger arrivals and departures for all modes of transport
- information about public transport.

Current pressures and trends

This section discusses the national environmental indicator for transport, vehicle kilometres travelled. The section also includes information about vehicle ownership, average engine size, how we travel to work, and international passenger arrivals to and departures from New Zealand.

Vehicle kilometres travelled by vehicle type

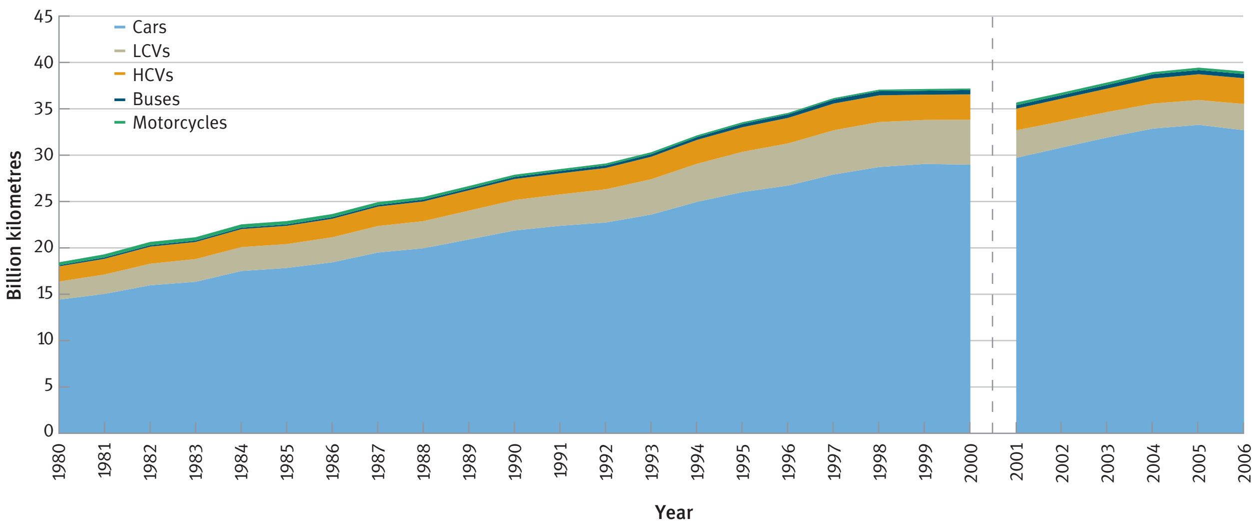
On average, New Zealanders drive much further today than in the past. Between 1980 and 2000, total annual vehicle kilometres travelled in New Zealand more than doubled, from 18.52 billion kilometres to 37.33 billion kilometres (see Figure 4.1). In part, this increase reflects the growth in the total number of vehicles on our roads. Kilometres travelled by cars, light commercial vehicles, heavy commercial vehicles, and buses all increased over this period, but kilometres travelled by motorbikes decreased.

As a result of changes in data collection methods in 2001, it is not possible to compare trends in total vehicle kilometres travelled before 2001 with those travelled after 2001. (Figure 4.1 represents this with a broken line.)

Data from 2006 shows that we travelled over 39.2 billion vehicle kilometres in that year. Between 2001 and 2006, the proportional ranking of each vehicle class has remained largely unchanged, with the car still being the largest contributor to kilometres travelled.

Between 2001 and 2005, total vehicle kilometres travelled increased for all vehicle types. In 2006, total vehicle kilometres travelled for all vehicle types decreased slightly from the previous year.

+ FIGURE 4.1:
TRENDS IN VEHICLE KILOMETRES TRAVELLED (VKT) BY VEHICLE TYPE, 1980–2006



Notes:

(1) LCVs = light commercial vehicles; HCVs = heavy commercial vehicles.

(2) The broken line is used because data was collected differently after 2001, so total vehicle kilometres travelled before 2001 are not directly comparable with those travelled after 2001.

Data source: Ministry of Economic Development, 2006a; Ministry of Transport.

Vehicle kilometres travelled by vehicle age

On average, the vehicles on our roads are getting older. The age of vehicles has an effect on their fuel efficiency, and on how polluting they are.

In particular, the age of a vehicle indicates its overall efficiency and whether it is likely to have technology to control its exhaust emissions. Older vehicles are more likely to use fuel inefficiently (which increases greenhouse gas emissions), and to emit PM_{10} particulates and harmful gases that contribute to poor air quality. (See chapter 7, 'Air' for further information on the impact of vehicle emissions on air quality.)

The majority of vehicles on New Zealand roads are over 10 years old. This is partly because of the high number of used imports and our ageing fleet. In 2006, more than 61 per cent of New Zealand's vehicle fleet was over 10 years old. This figure represents a 4 percentage point increase from 2001 when 57 per cent of New Zealand's vehicle fleet was over 10 years old.

In 2006, the average age of New Zealand's light vehicles (all private and commercial vehicles under 3.5 tonnes, excluding motorbikes) was 12.4 years. This is an increase from 2000 when the average age was 11.9 years (Ministry of Transport, 2007).

Figure 4.2 provides a snapshot of average vehicle kilometres travelled per vehicle in each age class in 2006, excluding vehicles that do not have to be licensed. The average vehicle kilometres travelled per vehicle decreased as the age of the vehicle increased; that is, we drive our newer vehicles further than we drive our older ones.

Vehicles in the age class 0–4 years, which make up 17 per cent of the fleet (just over 530,000 vehicles), contributed the highest average vehicle kilometres travelled (17,271 kilometres) per vehicle. This is partly because of the rapid turnover of vehicles in business and rental fleets. Vehicles in the age class 20 or more years contributed the lowest average kilometres (6,515 kilometres) of all vehicle classes.

+ FIGURE 4.2:
AVERAGE VEHICLE KILOMETRES TRAVELLED (VKT) PER VEHICLE AND TOTAL NUMBER OF VEHICLES IN EACH AGE CLASS, 2006

Note:

Vehicles that do not have to be licensed are excluded (for example, vehicles used off-road (such as tractors, agricultural machinery, and quad bikes) and vehicles with restoration licences (held when a vehicle is under repair or being restored)).

Data source: Ministry of Transport.

Vehicle kilometres travelled by fuel type

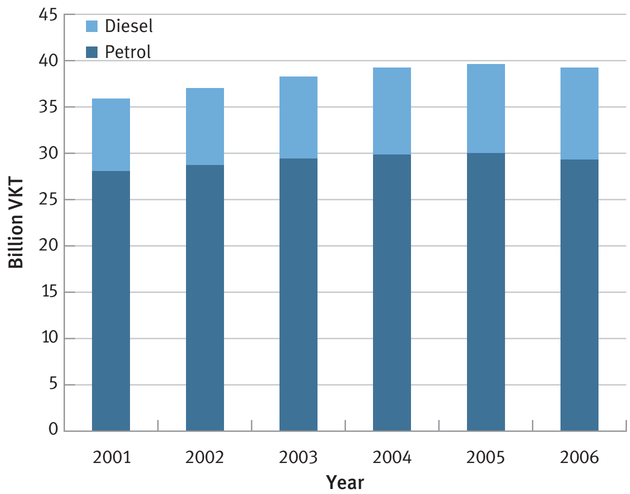
The vast majority (81 per cent) of vehicles on New Zealand roads are fuelled by petrol; the remaining 19 per cent are fuelled by diesel. As a result, petrol vehicles in New Zealand travel further in terms of total distance than diesel vehicles. In this discussion we exclude the small number of vehicles powered by alternatives such as biofuels and electricity.

In 2006, petrol vehicles in New Zealand travelled just over 29.34 billion kilometres, while diesel vehicles travelled about 9.86 million kilometres (see Figure 4.3). However, on average, each diesel vehicle travels further in a year than each petrol vehicle (15,300 kilometres per vehicle compared with 10,500 kilometres per vehicle).

Petrol vehicles contributed the majority of the kilometres travelled in New Zealand between 2001 and 2006. The share of kilometres travelled by diesel vehicles increased slightly from 22 per cent to 25 per cent of total vehicle kilometres travelled during the same period (probably because the number of diesel vehicles in the fleet increased 39 per cent over that period). The percentage share of diesel vehicles in the fleet, relative to petrol vehicles, also increased from 15 per cent to 18 per cent between 2001 and 2006.

The increase in diesel vehicle kilometres travelled has negative implications for our health. Diesel vehicles have a greater impact on air quality than petrol vehicles, because they produce about 73 per cent of all particulate emissions from transport (Auckland Regional Council, 2006). In addition, they produce more sulphur dioxide emissions than petrol vehicles (see chapter 7, 'Air').

+ FIGURE 4.3:
VEHICLE KILOMETRES TRAVELLED (VKT) BY FUEL TYPE, 2001–2006



Note:
The data excludes the small number of vehicle kilometres travelled by vehicles powered by alternative fuels such as biofuels and electricity.
Data source: Ministry of Transport.

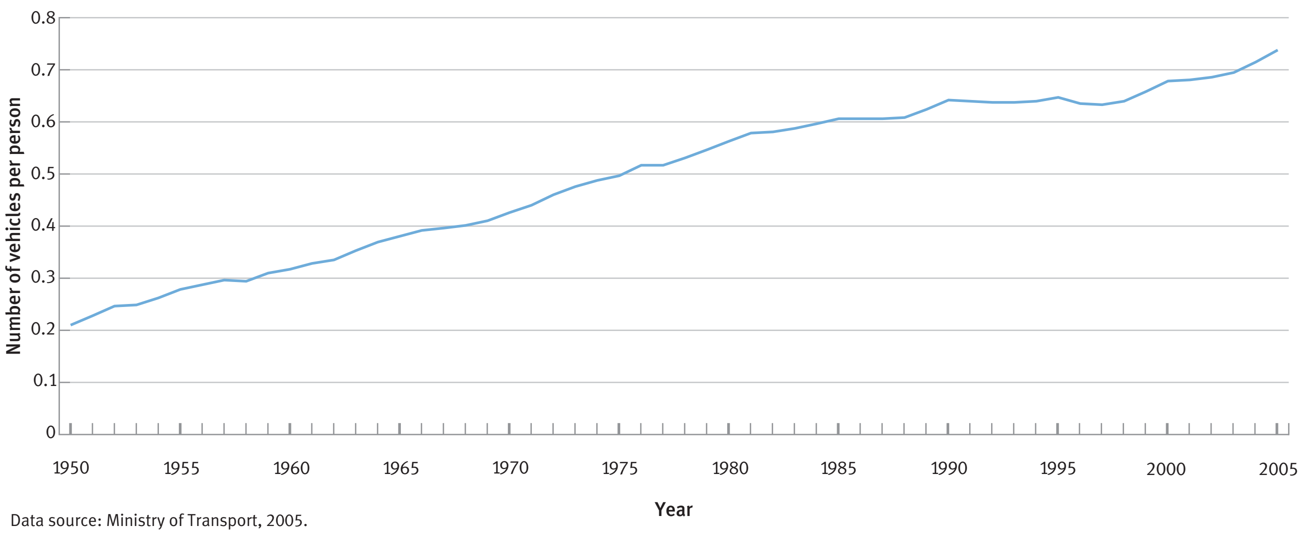
Vehicle ownership in New Zealand

Since the 1950s, New Zealanders have become increasingly reliant on road transport. Vehicle ownership records in New Zealand show that the number of vehicles per person more than tripled from the 1950s to 2005 (the most recent year for which we have data).

In 2005, New Zealanders owned an average of 0.7 vehicles each, or 70 vehicles per 100 people. As a result, we have the fifth highest rate of vehicle ownership of member countries of the Organisation for Economic Co-operation and Development (Organisation for Economic Co-Operation and Development, 2007).

The number of vehicles per person in New Zealand has increased steadily over time since the 1950s, although growth has remained relatively static for brief periods (for example, during the 1990s). (See Figure 4.4.)

+ FIGURE 4.4:
VEHICLE OWNERSHIP PER PERSON IN NEW ZEALAND, 1950–2005



Data source: Ministry of Transport, 2005.

In 1996, the Census of Populations and Dwellings found that 45 per cent of New Zealand households had access to two or more vehicles (Statistics New Zealand, 1996). A decade on, the proportion of New Zealand households with access to two or more vehicles had risen to 54 per cent (Statistics New Zealand, 2006b).

Vehicle and engine size

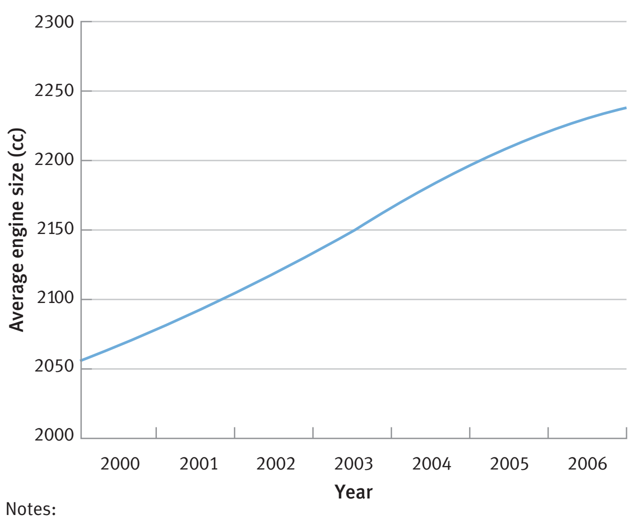
The number of vehicles in New Zealand is increasing and, at the same time, engine sizes are increasing. In 2006, the average engine size of a vehicle in New Zealand was more than 2.2 litres. This has increased from just over 2 litres in 2000. (See Figure 4.5.)

The size of the engines in the vehicles we drive determines the amount of fuel the vehicles consume – smaller engines generally consume less fuel. Increased overall fuel consumption has an impact on exhaust emissions – an increase in fuel consumption usually results in an increase in greenhouse gas and particulate emissions.

The size of the vehicles we drive usually also determines engine size – the larger the vehicle, the heavier it is, and the larger the engine required to power it. Recent years have seen a trend in consumers buying larger and heavier vehicles. The popularity of sport utility vehicles (SUVs) is one example of this trend. Registrations of SUVs increased from 26 per cent of the relevant vehicle class in January 2003 to 81 per cent in June 2006 (Land Transport New Zealand, no date).

+ FIGURE 4.5:

AVERAGE ENGINE SIZE OF THE LIGHT VEHICLE FLEET, 2000–2006



Notes:

(1) The light vehicle fleet includes all light private and commercial vehicles under 3.5 tonnes (excluding motorcycles) and accounts for 93 per cent of all licensed vehicles on New Zealand roads.

(2) cc = cubic centimetre.

Data source: Ministry of Transport, 2007.

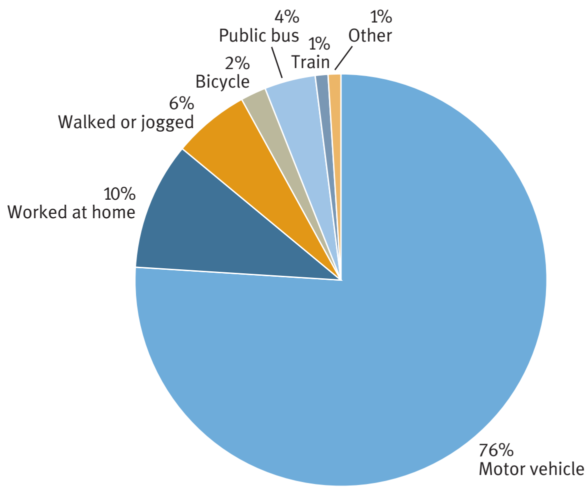
Travelling to work

The way New Zealanders travel to work illustrates our dependence on motorised vehicles and the extent to which we use other means of transport.

Figure 4.6 presents data on how New Zealanders aged 15 years and over engaged in full-time employment travelled to work on census day (7 March) in 2006. On this day, 76 per cent of people travelled to work, as a driver or passenger, by motor vehicle (car, truck, van, motorcycle, or power cycle); 5 per cent travelled by public transport (bus or train); and 9 per cent walked, jogged, or cycled. Of those surveyed, 10 per cent worked from home and did not travel to work.

+ FIGURE 4.6:

MEANS OF TRAVEL TO WORK ON CENSUS DAY, 7 MARCH 2006



Notes:

(1) The data excludes people who did not work on census day or did not respond to the survey.

(2) Data discrepancies between the text and the figure are due to rounding.

Data source: Statistics New Zealand, 2006a.

More about public transport in New Zealand

Public transport generally provides a lower-cost and more environmentally friendly transport choice than using a private car. It also provides mobility for those who cannot or do not want to drive a car.

Public transport offers benefits to the environment in the form of less air pollution, lower fuel consumption, and less traffic congestion compared with private transport.

Public transport systems in New Zealand tend to be better developed in the main centres (Auckland, Wellington, Christchurch, and Dunedin) than in smaller centres. Public transport systems rely on being well used to remain a cost-effective alternative to private vehicles, so they need a large population base. Reliability, convenience, safety, cost, and frequency of public transport services determine how likely people are to use the services.

Public transport use is generally low in New Zealand compared with other modes of transport, but the number of people using public transport is growing. Between 1999 and 2006, the number of people who boarded bus, rail, and ferry services increased 68 per cent in Christchurch, 43 per cent in Auckland, and 23 per cent in Wellington. The number of people who used bus, rail, and ferry services increased across the country by 45 per cent. This increase in public transport replaced an estimated 49 million car trips (Ministry of Economic Development, 2006b).

Investment in public transport has also increased. In the 2006/2007 financial year, the Government committed $301 million to fund public transport and buy back the nation's rail tracks. The 2006/2007 financial year National Land Transport Programme allocated $136 million to passenger transport community services and almost $160 million to passenger transport infrastructure.

Government funding for passenger transport services increased 16 per cent between the 2005/2006 financial year and the 2006/2007 financial year. In addition, the Government committed $600 million over four years to upgrade the Auckland rail network.

PUBLIC TRANSPORT OFFERS BENEFITS TO THE ENVIRONMENT IN THE FORM OF LESS AIR POLLUTION, LOWER FUEL CONSUMPTION, AND LESS TRAFFIC CONGESTION COMPARED WITH PRIVATE TRANSPORT.

Source: Ministry for the Environment.

International arrivals and departures

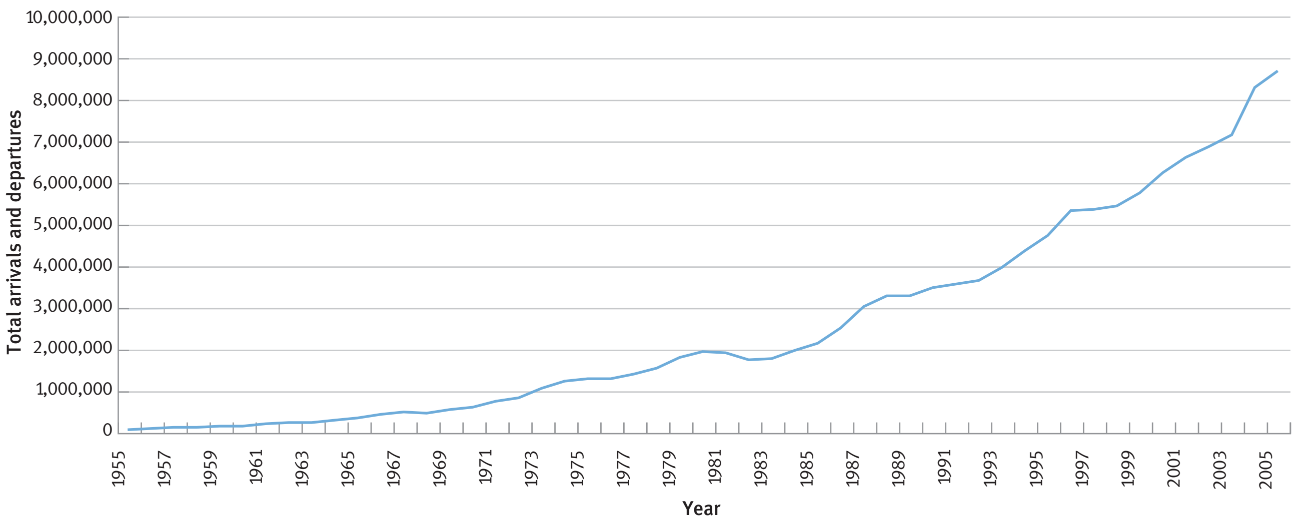
New Zealand's location in the Pacific Ocean means we rely on air and sea transport for imports and exports. Tourism, which contributes to our foreign exchange earnings, also relies heavily on air transport, with a small proportion of tourists arriving by sea.

However, until international jet services were introduced in the 1960s, most people travelled by sea, with two-thirds of all passengers travelling to or from New Zealand by sea in 1950 (Statistics New Zealand, 2006d).

Since the 1960s, the number of international passenger arrivals to and departures from New Zealand by all modes of transport has continued to increase. In 2005, 8.69 million passengers travelled to or departed from New Zealand by sea or air, with the vast majority (8.61 million or 99 per cent) travelling by air. This is an 83 per cent increase from 1995. (See Figure 4.7.)

The rise in international arrivals and departures can be attributed to international travel becoming more affordable and more accessible. In 2005, more than 60,000 flights arrived at and departed from New Zealand's seven international airports.

+ FIGURE 4.7:
TOTAL INTERNATIONAL PASSENGER ARRIVALS TO AND DEPARTURES FROM NEW ZEALAND, 1955–2005



Note:
Data includes arrivals and departures by sea and air by overseas visitors and New Zealand residents.
Data source: Statistics New Zealand, 2006d.

LOCAL ACTION on sustainable transport

Walking school buses

Walking school buses have been established in communities throughout New Zealand to give children a safe and sustainable way to travel to school and back. Groups of families form a roster to take turns walking the families' children to school. A walking school bus usually comprises several families, with one parent 'driving' up to eight children, either from the 'driver's' house or by 'picking up' children on the way to school (Land Transport New Zealand, 2006).

Cycle Safe Christchurch

Cycle Safe Christchurch is a cycle safety education programme targeting year 6 pupils in Christchurch primary schools.

Land Transport New Zealand and the Christchurch City Council fund the programme.

The programme aims to enable children to cycle more safely to and from school by increasing their competency and confidence levels, and to encourage parents to let their children cycle (Christchurch City Council, no date).

'Park and ride' bus stations

Poor accessibility to public transport can inhibit people's use of public transport. To help overcome this, two 'park and ride' bus stations have been created in Auckland. People who commute by bus from North Shore City to Auckland City can drive to the 'park and ride' bus stations at Constellation and Albany, park their cars, and board an express bus to Auckland City. Parking is free, so people have an incentive to leave their car at the bus stop and take the bus, instead of driving across the Auckland Harbour Bridge and adding to traffic congestion (North Shore City Council, no date).

WALKING SCHOOL BUSES ARE A SAFE AND SUSTAINABLE WAY TO TRAVEL TO AND FROM SCHOOL.

Source: Courtesy of Land Transport New Zealand.

Changes since the 1997 report

The 1997 report, *The State of New Zealand's Environment 1997*, concluded that:

> Limited air and stormwater studies show that at times, carbon monoxide levels in some urban traffic corridors exceed the New Zealand Ambient Air Guidelines, and transport is also responsible for some of the extensive heavy metal contamination of some harbours and estuarine areas. Transport also contributes 40 percent of New Zealand's CO_2 emissions. …
>
> Apart from banning lead in petrol, systematic measures do not currently exist to deal with the environmental impacts of transport services. The Vehicle Fleet Emissions Control Strategy is investigating appropriate measures to control transport noise and emissions to air and water.

(Ministry for the Environment, 1997, chapter 10.)

Since the 1997 report, transportation in New Zealand has remained heavily weighted towards road transport, although other modes of transport (rail, sea, and air) also move people and goods.

Rate of car ownership

The average New Zealander owns 0.7 vehicles, the fifth highest rate of vehicle ownership among OECD countries. This increase reflects the increasing affordability of vehicles since 1997. The removal of import tariffs in 1998 made it cheaper to import cars, and led to a boom in the sale of imported used vehicles in New Zealand, along with a corresponding decline in the sale of new vehicles (Statistics New Zealand, 1998).

The increasing affordability of vehicles has meant half of all New Zealand households now own more than one vehicle. The 2003–2004 *Household Travel Survey* found that the average number of vehicles per household had increased by nearly 13 per cent (from 1.6 to 1.8 vehicles per household) since the 1997–1998 survey (Ministry of Transport, 2004).

Average age of used imported vehicles

In 2006, the average age of a used imported vehicle entering New Zealand was 8.2 years (Ministry of Transport, 2007).

The high number of used vehicles entering the country has contributed to the increasing age of New Zealand's vehicle fleet: in 2006, the average age of light vehicles in the New Zealand fleet was 12.4 years, up from 11.9 years in 2000.

Vehicle engine size

Reflecting global trends, the size of our vehicles has increased since 1997, with the average engine size of vehicles in the light fleet now more than 2.2 litres, having increased from just over 2.0 litres in 2000. This change partly reflects the fact that New Zealand is a 'technology taker', which means we have to import our vehicles. It also reflects lower vehicle prices. As the average price of vehicles has fallen, we have been able to afford to buy larger vehicles.

Vehicle kilometres travelled

Also reflecting global trends, on average, we are driving our vehicles much further today than we did in the past. Between 1980 and 2000, total annual vehicle kilometres travelled in New Zealand more than doubled. In part, this increase reflects the growing number of vehicles on our roads. It also reflects our increasing mobility as our lifestyles change.

Technological changes

The trends discussed above often have a negative effect on the environment and human health. Since 1997, we have learnt much more about these effects and the extent of air pollution in New Zealand caused by vehicle emissions.

In the past 10 years there have been some improvements. New vehicles are less polluting of the air than they were 10 years ago, because engine technologies have improved in response to more stringent health and environmental standards. New engine technologies have also improved vehicle fuel economy over the past 10 years. However, some of these gains have been offset by consumers choosing larger and more powerful vehicles.

Technology to control exhaust emissions has developed significantly in recent years. New Zealand introduced vehicle exhaust emissions regulations in 2003 (requiring all vehicles to be built to recognised emissions standards) and 2006 (requiring a visible exhaust smoke test at the warrant of fitness or certificate of fitness check).

The quality of the fuels we use in New Zealand, and the impact these have on air pollution, has also improved since 1997. The sulphur content of diesel fuel has been significantly reduced. Since 2001, the sulphur content of diesel fuel has been reduced 60-fold, with further reductions expected by 2009. Reducing the sulphur content of diesel ensures the fuel is suitable for use in the newer, low-emission diesel vehicles New Zealand is importing.

We are continuing to experience changes in the fuels we use in our vehicles, with the uptake of biofuels (renewable transport fuels) and an increasing number of hybrid vehicles on our roads.

Encouraging the use of biofuels is expected to bring several benefits for our environment and health. Biofuels have already shown their potential to reduce greenhouse gas and particulate emissions and to reduce New Zealand's dependence on imported transport fuels.

International pressures to reduce greenhouse gas emissions from transport are likely to encourage efforts in New Zealand and other countries to improve fuel efficiency and increase the use of biofuels. As an importer of vehicles and transport fuels, New Zealand will reap health and environmental benefits from improved fuel efficiency and greater use of biofuels.

Transport planning

Since 1997, transport planning has increasingly recognised the impact of transport on the environment. Greater effort has been put into encouraging the use of public transport, walking, and cycling; designing urban spaces to minimise the need for motorised forms of transport; and encouraging the use of more fuel-efficient vehicles.

Reducing New Zealand's greenhouse gas emissions from the transport sector will continue to be a challenge. In part, the challenge arises from the scale of the issue; transport is one of our major contributors to emissions. Given the average, and increasing, age of the vehicles we import, it may be some time before we see the results of global action to reduce emissions in our vehicle fleet.

These issues will continue to remain a focus for transport planners into the future. In addition, New Zealand is likely to be able to capitalise on international and onshore opportunities for developing and using biofuels and other alternative transport fuels, for example, using electricity to power cars.

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“A secure and sustainable energy supply is vital for New Zealand’s future.”

ENERGY

Contents

At a glance

Energy in New Zealand

Energy is an essential part of everyday life. Fuels and electricity power our transport systems, heat our buildings, and produce the goods and services that underpin New Zealand's economic and social well-being.

Using energy supplies efficiently saves money and helps New Zealand companies produce their goods and services more competitively.

New Zealand has access to a wide range of energy sources, both renewable (hydro, geothermal, wood, wind, biogas, and solar) and non-renewable (oil, gas, and coal). We have some of the most efficient forms of renewable energy in the world, such as wind and hydro.

While our energy needs are increasing, they are not increasing as fast as our economy is growing. Since 1990, New Zealand's economic growth has exceeded energy demand, indicating that New Zealand's economy has reduced, to some degree, its reliance on energy.

Impacts of energy

All forms of energy generation and use have an impact on the environment. For example, our growing consumption of non-renewable energy contributes to increased greenhouse gas and particulate emissions, which have negative impacts on the environment and human health.

Energy supply and consumption

New Zealand's total primary energy supply is growing to meet increased consumer demand. Between 1995 and 2005, New Zealand's total primary energy supply increased by 10 per cent, from 675 petajoules to 740 petajoules. In 2005, 72 per cent of this supply comes from fossil-fuel-based oil and natural gas. The remaining 28 per cent is from renewable sources.

As our population grows and our lifestyles change, so do our energy needs. Between 1995 and 2005, total consumer energy demand increased by 21 per cent from 407 petajoules to 494 petajoules. Much of this growth in demand is from transport, which accounted for 43 per cent of New Zealand's total energy consumption in 2005. To meet this demand, New Zealand has become more reliant on imported oil and oil products.

New Zealand's use of renewable sources for electricity generation is high by international standards. In 2005, renewable sources accounted for about 66 per cent of New Zealand's electricity generation, with hydro-electricity providing 56 per cent of New Zealand's total electricity generation.

Present and future management

In 2007, New Zealand is increasing its focus on renewable energy, energy efficiency and conservation, and security of supply to meet our increasing energy demands.

This focus on efficiency, conservation, and renewable energy will continue as New Zealand responds to national and international demands for action on climate change.

Domestically, the increasing demand for energy is likely to require the development of new infrastructure for electricity generation (such as power stations and wind turbines) and transmission (transmission lines).

We are also likely to experience changes in the future to the fuels we use in our vehicles, with the uptake of biofuels and an increasing number of hybrid vehicles on our roads.

Introduction

Energy is an essential part of almost all our industrial, commercial, transport, and household activities. A secure and sustainable energy supply is therefore vital to ensuring New Zealand's continued economic and social well-being.

Renewable energy sources

New Zealand has access to a diverse range of renewable energy sources (see Figure 5.1). The water in our rivers is harnessed to provide hydro-electric generation, with well-developed systems in the Waikato River catchment in the North Island and the Waitaki River and Clutha River catchments in the South Island.

Since the 1900s, geothermal energy has been used to generate electricity in New Zealand, with high-temperature geothermal reservoirs concentrated in the Taupō Volcanic Zone. New Zealand's first geothermal power station was commissioned at Wairākei in 1958.

Further contributions to New Zealand's renewable energy supply come from wood, biogas, the sun, and wind. The marine environment has the potential to contribute to New Zealand's energy needs in the future – wave and tidal energy can be harnessed to generate renewable electricity. Some industrial processes burn waste materials, such as used oil and wood waste, to create energy (see box 'Local action: waste-to-energy later in this chapter for more information).

There are potential limitations with some renewable energy sources, such as hydro and wind. While New Zealand has a lot of potential capacity, public opinion is divided on further growth in the number of hydro-electric power stations on rivers and the number of large wind farms.

Non-renewable energy sources

Reserves of natural gas and limited quantities of oil are extracted from gas and oil fields in the Taranaki region. The balance of New Zealand's oil supply is imported. Coal deposits exist throughout New Zealand, although most production is from mines on the South Island's West Coast and from the Waikato region.

Environmental and human health impacts

The production and use of renewable and non-renewable energy impacts on the environment as listed in the examples below.

- The extraction and processing of fossil fuels affects adjacent air, land, and sea.
- The burning of fossil fuels contributes to:
  - climate change through a build-up of greenhouse gases, primarily carbon dioxide
  - localised air pollution due to particulate emissions.
- Construction of storage lakes and dams for hydro-electric generation alters the surrounding land, ecosystems, and settlements.
- Wind farms have a visual impact on the landscape and selecting suitable sites for wind power developments can be difficult because such sites are often exposed locations on prominent ridgelines. The potential noise impact of wind farms is also a consideration in the assessment of environmental impacts.

The by-products of fossil fuel energy use include harmful particulate emissions, which can impact on human health causing irritation of the eyes, throat, and lungs. For people with existing respiratory conditions, such as asthma or bronchitis, inhaling particulates can exacerbate the condition (see chapter 7, 'Air' for more information about particulates).

Energy consumption

As our population grows and our lifestyles change, so do our energy needs. Over the past 10 years our consumption of goods and services has increased (see chapter 3, 'Household consumption'), and so has our consumption of energy.

+ FIGURE 5.1:
LOCATION OF NEW ZEALAND'S MAJOR ENERGY SOURCES

Source: Ministry for the Environment.

National environmental indicators

See chapter 1, 'Environmental reporting' for more information on the core national environmental indicators and how they are used.

There are four national environmental indicators for energy. They are:

- total consumer energy demand
- total primary energy supply
- consumer energy demand compared to gross domestic product
- electricity generation.

Total consumer energy demand

This indicator measures the total amount of energy consumed in New Zealand, by fuel type and by sector.

Total primary energy supply

This indicator measures the total amount of energy available for use in New Zealand. It includes energy as it is first obtained from natural sources. This means that coal is accounted for as it is mined, domestic oil and natural gas as they are extracted from wells, imported oil and oil products as they are imported, and hydro as it is used for electricity generation.

The indicator accounts for imports and exports, and allows for changes in energy stocks between months, quarters, or years. By convention, fuels used for international transport are excluded from total primary energy supply.

Consumer energy demand compared to gross domestic product

This indicator measures the progress New Zealand is making towards separating ('decoupling') energy demand from economic growth. It compares economic growth as measured by gross domestic product (GDP) with consumer energy demand and aims to indicate the economy's reliance on energy resources (that is, the extent to which GDP and energy demand are decoupled).

Decoupling can be either 'relative' or 'absolute'. Absolute decoupling is said to occur when energy demand is stable or decreasing while GDP is growing. Decoupling is said to be relative when energy demand is increasing, but at a lesser rate than GDP (Organisation for Economic Co-operation and Development, 2002).

The ideal trend is for the economy to grow while demand for energy decreases (absolute decoupling) or at least grows at a slower rate or remains constant (relative decoupling), indicating economic prosperity at a reduced cost to the environment.

Electricity generation

This indicator measures electricity generation by fuel type and the relative efficiency of each fuel type. Relative efficiency is determined by comparing the total amount of each fuel type available for electricity generation with the net amount of electricity it generates.

GOVERNMENT ACTION on energy

New Zealand Energy Strategy to 2050

The New Zealand Energy Strategy to 2050, *Powering our Future: Towards a sustainable low emissions energy system,* was released in October 2007. The strategy provides long-term direction for energy policy and promotes the development of an energy system that supports economic growth in an environmentally responsible way (Ministry of Economic Development, 2007).

New Zealand Energy Efficiency and Conservation Strategy

The Energy Efficiency and Conservation Authority was established as a Crown entity in 2000 and, with the Ministry for the Environment, developed the National Energy Efficiency and Conservation Strategy (NEECS). The strategy set out the Government's policies on energy efficiency, energy conservation, and the use of renewable energy. It also set national targets relating to both energy efficiency and the level of energy supply for renewable energy sources.

In October 2007, the New Zealand Energy Efficiency and Conservation Strategy, *Making it Happen: Action plan to maximise energy efficiency and renewable energy* was released to replace the NEECS. It will help achieve the objectives of the New Zealand Energy Strategy to 2050. It includes measures 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 (Energy Efficiency and Conservation Authority, 2007).

Energy Efficiency and Conservation Act 2000

The Energy Efficiency and Conservation Act 2000 is the legislative basis in New Zealand for promoting energy efficiency, energy conservation, and renewable energy. The Act established the Energy Efficiency and Conservation Authority as a stand-alone Crown entity with a role to promote energy efficiency, energy conservation, and renewable energy across all sectors of the economy.

The Act provides for the preparation of regulations for product energy efficiency standards and labelling, as well as disclosing information to compile statistics on energy efficiency, energy conservation, and renewable energy.

Current pressures and trends

Total consumer energy demand

Energy consumption cannot simply be thought of in terms of the amount of energy used to fuel our cars and to heat and light our homes. Before reaching us, many forms of energy are converted from their initial state (primary energy) into a more convenient, useable state (consumer energy). This process is called energy transformation.

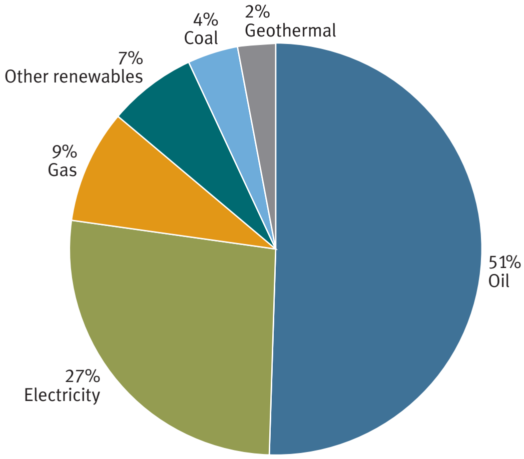
Approximately one-third of New Zealand's primary energy is 'lost' during the transformation process. Where conversion involves heat (for example, converting geothermal steam into electricity), large amounts of energy are lost as waste heat.

Further primary energy is diverted into non-energy products (for example, the production of urea fertiliser and methanol from natural gas). As a result, our total primary energy consumption is far greater than the amount consumed by end users suggests.

Figure 5.2 shows consumer energy demand by fuel type for 2005. Just over half of New Zealand's consumer energy demand was met by oil (51 per cent) and nearly a third (27 per cent) by electricity. The remaining demand was met by gas (9 per cent), other renewables (biogas, wind, wood, and solar) (7 per cent), coal (4 per cent), and geothermal (2 per cent).

See 'Electricity generation' later in this chapter for more information about fuel consumption for generating electricity.

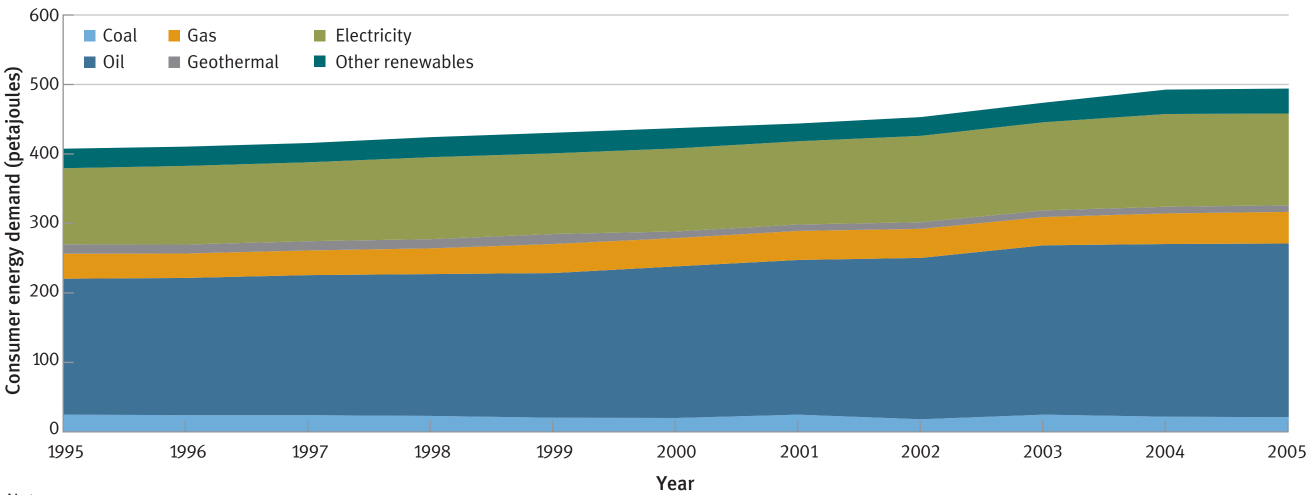
+ FIGURE 5.2:
CONSUMER ENERGY DEMAND BY FUEL TYPE, 2005



Note:
'Other renewables' includes solar water heating and electricity generation from wind, biogas, and wood.
Source: Ministry of Economic Development, 2006.

Figure 5.3 shows that between 1995 and 2005, consumer energy demand increased 21 per cent, from 407 petajoules to 494 petajoules. Consumption of coal and geothermal energy decreased by 15 per cent and 29 per cent respectively, while consumption of oil increased by 28 per cent, gas 26 per cent, electricity 20 per cent, and other renewables by 28 per cent.

+ FIGURE 5.3:
CONSUMER ENERGY DEMAND BY FUEL TYPE, 1995–2005

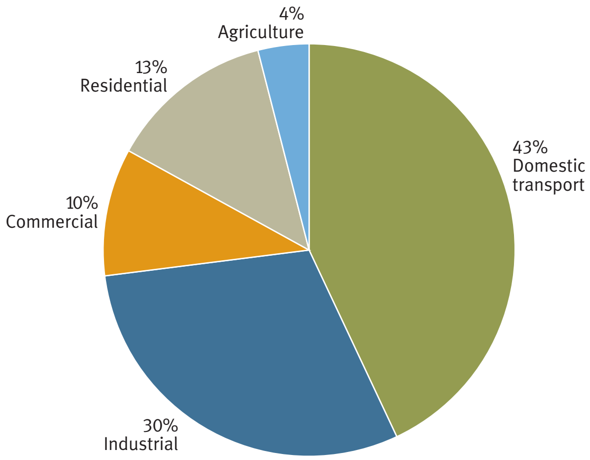


Note:
'Other renewables' includes solar water heating and electricity generation from wind, biogas, and wood.
Data source: Adapted from Ministry of Economic Development, 2006.

Figure 5.4 shows consumer energy demand by sector for 2005. Domestic transport accounted for the largest share (43 per cent) of New Zealand's total energy consumption, while industry had the second largest share, at 30 per cent. The balance was made up by the residential (13 per cent), commercial (10 per cent), and agricultural sectors (4 per cent).

Figure 5.5 shows that between 1995 and 2005, consumer energy demand increased 21 per cent. The greatest growth was seen in the commercial sector, which increased 32 per cent. This was closely followed by the domestic transport sector, whose share increased by 30 per cent. The domestic transport sector also accounted for the largest share of energy consumed during this period.

+ FIGURE 5.4:
CONSUMER ENERGY DEMAND BY SECTOR, 2005



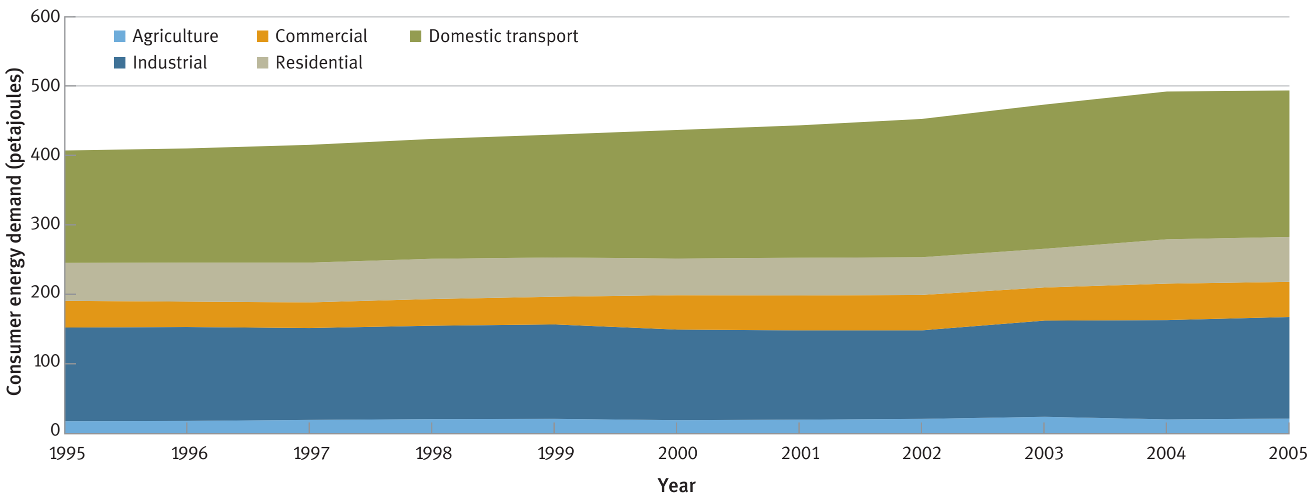
Notes:

(1) The industrial sector includes primary industry not accounted for in the other sectors; food processing; textiles; wood, pulp, paper, and printing; chemicals; non-metallic minerals; basic metals; mechanical/electrical equipment; and building and construction.

(2) Domestic transport includes land transport (road, off-road, and rail), coastal shipping, and national air transport. It also includes transport fuel that could not be accurately allocated to the agricultural, industrial, commercial, or residential sectors.

Source: Ministry of Economic Development, 2006.

+ FIGURE 5.5:
CONSUMER ENERGY DEMAND BY SECTOR, 1995–2005



Notes:

(1) The industrial sector includes primary industry not accounted for in the other sectors; food processing; textiles; wood, pulp, paper, and printing; chemicals; non-metallic minerals; basic metals; mechanical/electrical equipment; and building and construction.

(2) Domestic transport includes land transport (road, off-road, and rail), coastal shipping, and national air transport. It also includes transport fuel that could not be accurately allocated to the agricultural, industrial, commercial, or residential sectors.

Data source: Adapted from Ministry of Economic Development, 2006.

Total primary energy supply

In 2005, New Zealand's total primary energy supply was about 740 petajoules. About two-thirds of this (494 petajoules) was used as consumer energy. The remaining third was used or lost during energy transformation and distribution of the energy to consumers.

New Zealand's primary energy supply has been and still is, dominated by fossil fuels – oil, natural gas, and coal. In 2005, 72 per cent of New Zealand's energy supply came from these sources. Of the total primary energy supply, oil accounted for 39 per cent, gas for 20 per cent, and coal 13 per cent (see Figure 5.6).

Renewable energy sources accounted for the remaining 28 per cent of New Zealand's primary energy supply in 2005, comprising a mix of hydro (11 per cent), geothermal (11 per cent), and other renewable sources, including solar, wind, biogas, and wood (6 per cent).

A small amount of energy is generated in New Zealand from waste products such as used oil and methane gas. Refer to box 'Local action: waste-to-energy' for an example of a successful project.

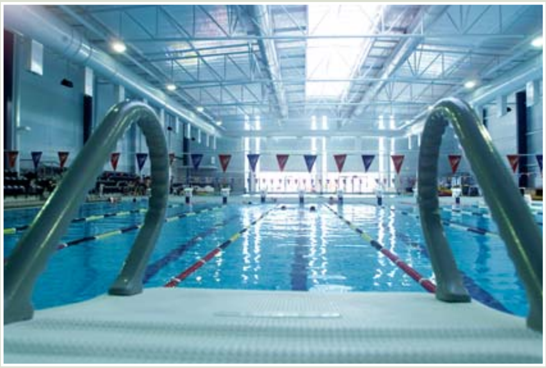
LOCAL ACTION: waste-to-energy

There is a growing awareness in New Zealand of opportunities to produce energy from waste. Waste-to-energy projects have benefits for the environment, including reduced greenhouse gas emissions and reduced reliance on fossil fuels.

Christchurch City Council has turned waste into a resource by capturing gas from the closed Burwood landfill to heat and power the QEII Park swimming pool complex. Using landfill gas at QEII Park will replace 1.5 million litres of liquid petroleum gas each year, helping to reduce the Council's reliance on fossil fuels. The project also has benefits for reducing greenhouse gas emissions, because methane gas is captured instead of being released into the environment.

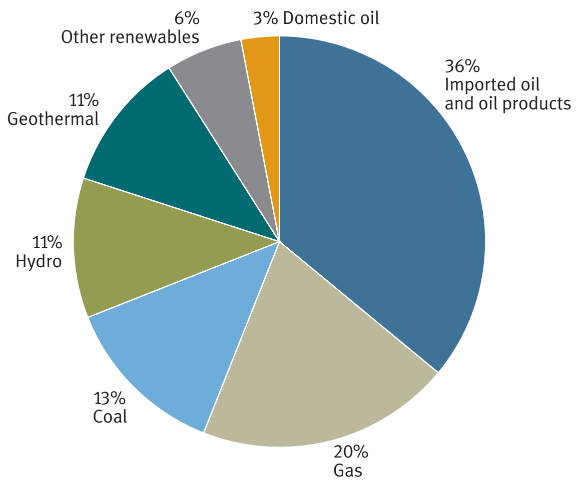
Through the Projects to Reduce Emissions programme, Christchurch City Council was allocated 200,000 carbon credits by the Government for the project. The carbon credits will be transferred to Christchurch City Council in return for emission reductions from 2008 to 2012.

METHANE GAS FROM THE FORMER BURWOOD LANDFILL HEATS THE QUEEN ELIZABETH II SWIMMING POOL COMPLEX IN CHRISTCHURCH.



Source: Courtesy of Christchurch City Council.

+FIGURE 5.6:
PRIMARY ENERGY SUPPLY, 2005



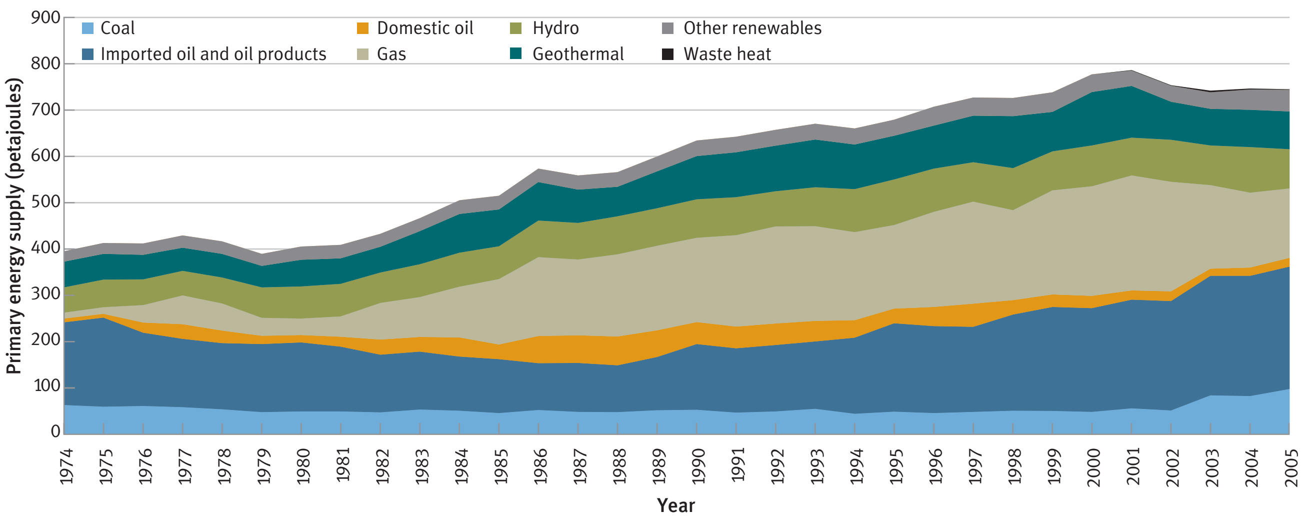
Note:
'Other renewables' includes solar water heating and electricity generation from wind, biogas, and wood.
Source: Ministry of Economic Development, 2006.

Since 1974, New Zealand's primary energy supply has increased by 89 per cent, from 392 petajoules to 740 petajoules. Changes in the mix of fuels that contribute to our energy supply have also occurred over that time (see Figure 5.7). For example, the development of the Maui gas field off the coast of Taranaki in the 1970s resulted in an increase in the amount of gas available for use from the early 1980s on. As New Zealand's gas and oil reserves declined over the 10 years between 1995 and 2005, there was a 40 per cent decrease in the primary energy supply of domestic oil. To maintain security of supply, New Zealand increased its imports of oil and oil products by 38 per cent during the same period.

From 1995 to 2005, New Zealand's primary energy supply increased by about 10 per cent, from 675 petajoules to 740 petajoules. The sources of energy supply varied during this time, with the most notable trend being a 100 per cent increase in the amount of energy supplied by coal.

The split between renewable and non-renewable energy sources has remained relatively constant during the period 1995 to 2005, with fossil fuels contributing about 70 per cent and renewable sources about 30 per cent of the primary energy supply. The share of renewable energy varies from year to year, depending on water inflows to hydro-electricity lakes and consumer demand for energy.

+FIGURE 5.7:
PRIMARY ENERGY SUPPLY, 1974–2005



Note:
'Other renewables' includes solar water heating and electricity generation from wind, biogas, and wood.
Source: Ministry of Economic Development, 2006.

Consumer energy demand compared to gross domestic product

From 1990 to 2005, New Zealand's total consumer energy demand increased by 37 per cent. Over the same period, the size of the New Zealand economy, as measured by gross domestic product (GDP), increased by 56 per cent. This increase suggests the economy is reducing its reliance on energy, at least to some degree. As shown in Figure 5.8, the relationship between energy demand and economic growth has varied during the period.

Electricity generation

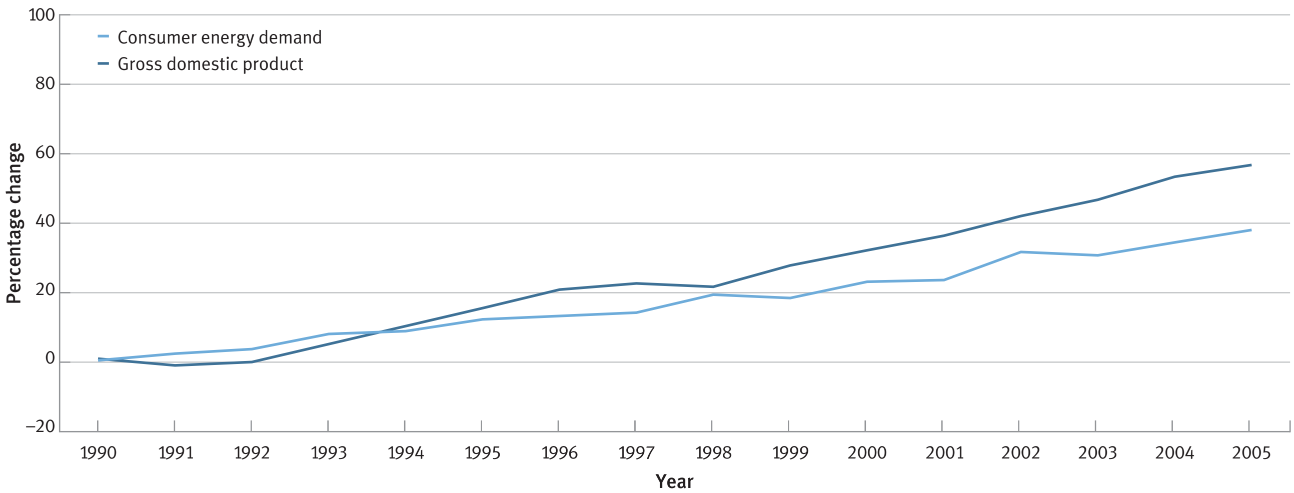
Over the last decade, New Zealand's electricity industry has gone through a process of reform to establish a competitive market.

New Zealand's electricity is produced at generation stations connected at high voltage to the national transmission network, known as the national grid. Transpower New Zealand Limited owns and operates the national grid, which connects most of the major power stations around the country to local distribution lines.

Electricity in New Zealand often has to travel a considerable distance from where it is generated to the end user. This results in comparatively high transmission losses, by international standards.

The Electricity Commission was established in 2003 to regulate the industry. It regulates the operation of the electricity industry and markets to ensure electricity is generated and delivered to consumers in an efficient, fair, reliable, and environmentally sustainable manner (Electricity Commission, 2005).

+ FIGURE 5.8:
CONSUMER ENERGY DEMAND COMPARED TO GROSS DOMESTIC PRODUCT (PERCENTAGE CHANGE, 1990–2005)



Data source: Adapted from Ministry of Economic Development, 2006; Statistics New Zealand, 2006.

New Zealand's fuels for electricity generation

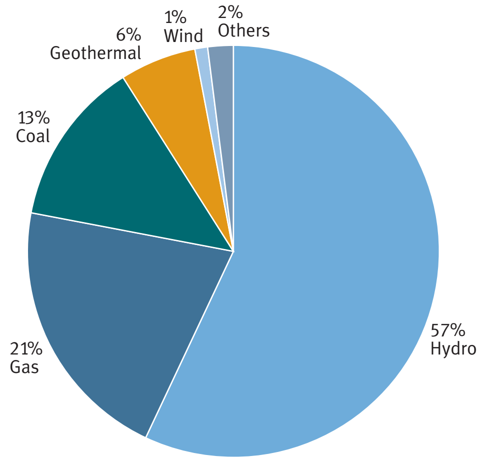
In comparison to many countries, New Zealand generates a high proportion of electricity from renewable sources. In 2005, renewable sources accounted for 66 per cent of New Zealand's electricity generation, with hydro-electricity providing 56 per cent of that amount. Geothermal (6 per cent), wind (1 per cent), and others (biogas, waste heat, and wood) (2 per cent) are the other renewable sources contributing to New Zealand's annual electricity generation (these figures add up to 65 per cent due to rounding). (See Figure 5.9).

Most of New Zealand's renewable electricity is generated by hydro-electric power stations in the South Island. The amount varies from year to year, depending on water inflows to storage lakes from rainfall and snowmelt. In dry years, such as 2005 when storage lake levels were low due to lack of rainfall, fossil fuels (coal and gas) are relied on to make up the shortfall in generation. (See Figure 5.10).

Figure 5.9 shows that in 2005, fossil fuels (coal and gas) provided 34 per cent of New Zealand's total electricity generation. This is an increase from the previous year, when coal and gas made up 27 per cent of the total.

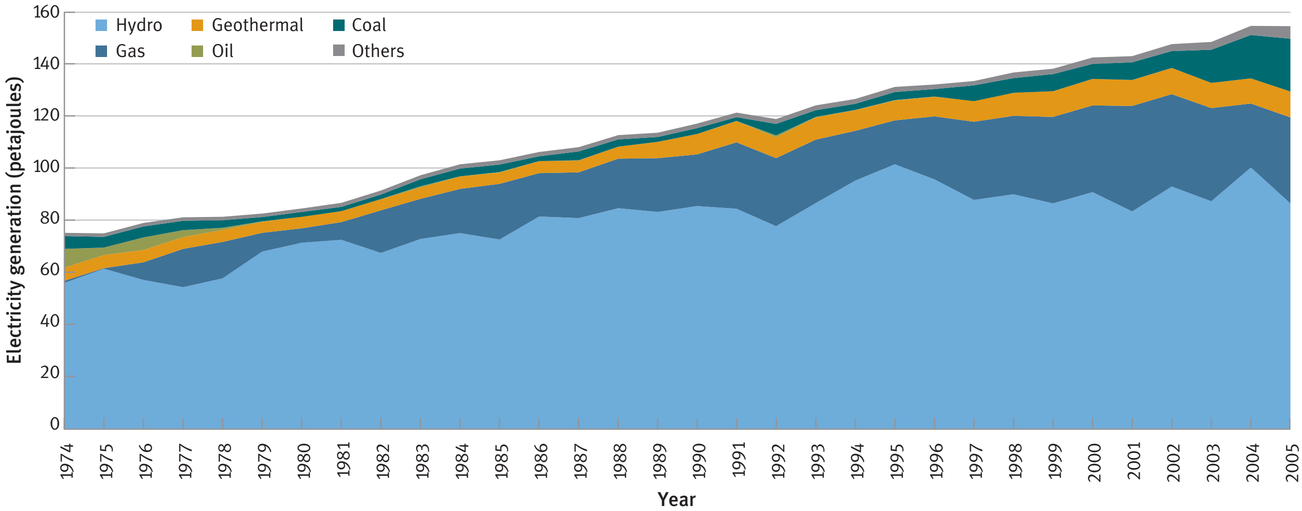
Wind has played an increasingly important role in electricity generation, contributing 1.5 per cent of total generation in 2005, compared with 0.9 per cent the previous year (discrepancies between text and figure are due to rounding). New Zealand currently has eight wind farms in operation, capable of generating more than 228 megawatts in total. This is enough energy to power about 100,000 households (assuming the wind farms are operating 40 per cent of the time).

+ FIGURE 5.9:
ELECTRICITY GENERATION BY FUEL TYPE, 2005



Note:
'Others' includes electricity generation from biogas, waste heat, and wood.
Data source: Adapted from Ministry of Economic Development, 2006.

+ FIGURE 5.10:
ELECTRICITY GENERATION BY FUEL TYPE, 1974–2005



Note:
'Others' includes electricity generation from wind, biogas, waste heat, and wood.
Source: Ministry of Economic Development, 2006.

Efficiency of fuel types for electricity generation

Energy efficiency means doing more with the same amount of energy, or doing the same thing using less energy. By using more efficient fuels to generate electricity, New Zealand can minimise the amount of energy we need to produce and use. The efficiency of each fuel type for generating electricity is calculated as the difference between the primary energy use and the net amount of electricity generated by each fuel type.

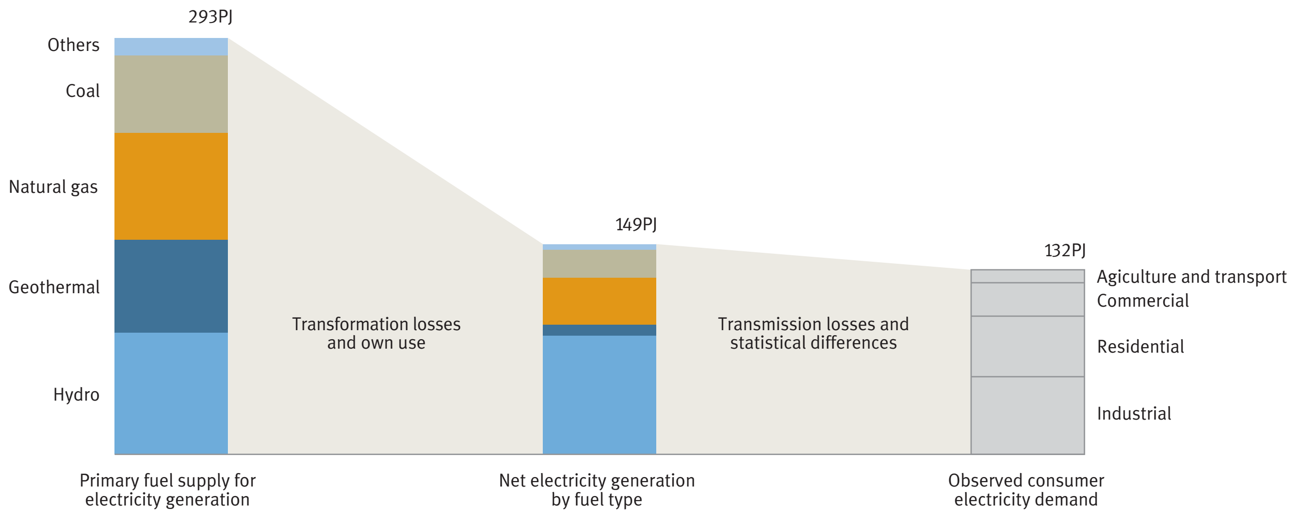
Figure 5.11 presents a 'snapshot' of energy flows within New Zealand's electricity system (based on 2005 data). It shows the fuel types used to generate electricity, how much electricity they generate, and where it is used.

The process of generating electricity from primary energy (for example, burning coal to drive turbines) generates a lot of heat that cannot easily be harnessed to generate electricity and is therefore lost. This lost energy is an example of the 'transformation losses' that occur during the process of converting primary energy, such as coal, into a more useful form of energy, such as electricity.

A small proportion of the generated electricity is used within power stations for lighting and heating (a quantity referred to as 'own use'). Some of the electricity is also lost from power lines in the form of heat and faults while being transmitted to consumers (referred to as 'transmission losses'). Completing the balance are 'statistical differences', which are small reporting errors that may occur in processing this information.

Figure 5.11 shows that in 2005, the total primary energy supply for electricity generation was 293 petajoules, while the net amount of electricity generated was 149 petajoules, which represents an average efficiency of just over 50 per cent. The remaining 144 petajoules were lost as heat when transforming the primary energy sources into electricity, and also used as electricity within power stations ('own use'). In 2005, 132 petajoules of the electricity generated were used by the consumer once further losses in transmitting and distributing the electricity and statistical differences were taken into account.

+ FIGURE 5.11:
RELATIVE EFFICIENCY OF FUEL TYPES FOR ELECTRICITY GENERATION, 2005



Note:
(1) 'Others' includes wind, biogas, waste heat, wood, and cogeneration.
(2) PJ = petajoules.
Data source: Adapted from Ministry of Economic Development, 2006.

On average, hydro and wind are the most efficient forms of energy for generating electricity in New Zealand, at almost 100 per cent efficient. By convention, geothermal generation is around 15 per cent efficient. In general, the efficiency of thermal fuels (coal and natural gas) ranges from 30 to 50 per cent. While thermal fuel may seem relatively inefficient compared with hydro and wind, thermal fuels are important, at least at present, for meeting our energy needs at times of peak demand, or in dry years.

It is important to note that these efficiencies reflect national averages and some generation plants may be more efficient than others. In addition, while the use of geothermal energy for electricity is relatively inefficient, the direct use of geothermal energy (for example, for heating water) is much more efficient than converting that energy to electricity.

GOVERNMENT ACTION on energy efficiency and conservation

Several government programmes have been developed in recent years to raise community awareness about energy efficiency and provide businesses and households with the tools to improve their energy choices. Energy efficiency initiatives include the following programmes:

Solar Water Heating programme

The Solar Water Heating programme promotes the uptake of solar water heating in homes, which in turn reduces the demand for electricity and gas. In 2006, the Government announced an investment of $15.5 million over the first three-and-a-half years of a five-year programme to increase the use of solar water heating. The New Zealand Energy Efficiency and Conservation Strategy has set a target of 15,000–20,000 solar water heating units to be installed by 2010 (Energy Efficiency and Conservation Authority, 2006).

AS OF JUNE 2006, ABOUT 35,000 SOLAR WATER HEATING SYSTEMS WERE INSTALLED IN NEW ZEALAND HOMES AND COMMERCIAL BUILDINGS.

Source: Courtesy of the Energy Efficiency and Conservation Authority.

The Minimum Energy Performance Standards programme

This programme reduces energy consumption by ensuring products such as fridges/freezers, hot-water cylinders and air conditioners comply with specific minimum standards for energy efficiency.

Emprove

Emprove is a suite of management tools to help businesses cut energy costs by adopting an energy management plan to control the amount of energy used. The Energy Efficiency and Conservation Authority encourages businesses to regard energy as a variable cost, rather than a fixed overhead, assisting them with energy audit grants and advice to identify opportunities to reduce their energy use.

Energy Intensive Businesses programme

This programme offers cash grants to help businesses adopt energy saving technologies, which may not be widely adopted in their sector. It is aimed at companies in nine energy intensive sectors which spend more than 5 per cent of their business costs on energy.

EnergyWise Home Grants scheme

This scheme retrofits the homes of low-income households with better insulation, leading to health and energy-saving benefits. As of March 2007, more than 30,000 homes have been retrofitted in this way.

Source: The Energy Efficiency and Conservation Authority.

Changes since the 1997 report

The 1997 report, *The State of New Zealand's Environment 1997*, concluded that:

> Most of our electricity is of hydro origin (with impacts on river flows and lake levels) but around two-thirds of our total primary energy supply is from fossil fuels (with pollutant impacts on atmosphere, water and soil). …
>
> Responses to the environmental impacts of energy services include the requirement to obtain consents under the Resource Management Act, moves toward greater use of renewable energy forms (including the development of wind power) and the encouragement of energy efficiency.

(Ministry for the Environment, 1997, chapter 10.)

In 2007, most of New Zealand's electricity is still generated from its hydro resources and more than two-thirds of its total primary energy supply comes from fossil fuels.

Consumer demand for energy

Since 1997, total consumer demand for energy has grown. During this time, consumption of oil, gas, electricity, and renewable fuels (biogas, wind, wood, and solar) has increased, while consumption of geothermal energy and coal has decreased (excluding the geothermal energy and coal used to generate electricity). Since 1997, the transport sector has consumed the largest share of energy; however, the commercial sector has shown the greatest growth in consumption.

Similarly, Statistics New Zealand's 2007 report, *Energy and the Economy: 1997–2005*, found that use of transport fuels by households accounts for a considerable proportion of New Zealand's energy consumption. In 2005, households used 83 per cent of New Zealand's consumer petrol. When electricity use by households is combined with their transport fuel use, households are the largest user of energy in New Zealand.

Total primary energy supply

To meet growing consumer demand, New Zealand's total primary energy supply has increased since 1997 and is still dominated by fossil fuels.

New Zealand's domestic gas and oil reserves have declined over the past 10 years, and as a result the amount of primary energy supplied by New Zealand oil has decreased. However, the contribution of New Zealand oil sources to its total primary energy supply has always been relatively small, and we rely on imported oil to ensure security of supply.

Use of renewable energy

Since 1997, New Zealand has been moving towards greater use of renewable energy forms such as wind power, solar power, and biofuels.

In 1997, New Zealand had one wind farm, Hau Nui in the Wairarapa region, and one turbine at Brooklyn in Wellington. There are now eight wind farms operating throughout the country, with several more projects at various stages of planning.

Demand for solar energy is small but is increasing, particularly for water heating. Industry sales of solar water heating systems indicate that, as of June 2006, about 35,000 solar water heating systems were installed in New Zealand homes and commercial buildings. Ten per cent (3,500) of these were installed in the year leading up to June 2006 (Energy Efficiency Conservation Authority, 2006b).

International energy policies have led to the development of a global market for renewable transport fuels and technologies. This has prompted the introduction of biofuels for commercial use in New Zealand.

Energy efficiency and conservation

Since the introduction of the Energy Efficiency and Conservation Act in 2000, there has been an increased focus on energy efficiency and conservation in New Zealand. Energy efficiency and conservation measures focus on demand management – that is, influencing the quantity and pattern of energy used by the consumer. Examples include:

- programmes to improve insulation in older homes and to encourage the uptake of efficient home heating and lighting options
- the Energy Star rating programme, which enables consumers to compare the energy efficiency of household appliances
- the introduction of energy efficiency requirements in the Building Code
- schemes to help businesses, households, and organisations save energy.

By improving how we use energy, New Zealand can reduce the need for new energy supplies, improve security of supply, reduce greenhouse gas emissions, and increase productivity. This will free up valuable capital for more productive enterprises.

Since 1997, consumer energy demand has increased at a lesser rate than the growth of the economy (as measured by gross domestic product). This trend indicates weak relative decoupling of energy demand from economic growth. In the future, there will be a greater focus on decoupling energy demand and economic growth.

Present and future management

New Zealand continues to move towards greater use of renewable energy and an increased focus on energy efficiency.

The recent changes in international energy supply and higher energy costs, coupled with concerns about climate change, have resulted in a global drive towards even greater energy efficiency and greater use of renewable fuels. These concerns are likely to continue into the future. The challenge for New Zealand is to maintain economic and social well-being, while reducing the environmental costs of energy use.

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"Waste can represent an inefficient use of our valuable resources."

WASTE

Contents

At a glance

Overview of waste in New Zealand

Waste represents an inefficient use of our resources. Improperly disposed of, waste can also pose a risk to human health and the environment.

The amount of waste generated in New Zealand has increased over time as our population and levels of production and consumption have grown. However, in recent decades, the amount of waste recovered from the waste stream to be reused, recycled, or reprocessed has increased.

Recycling and landfills

The amount of solid waste disposed of to New Zealand landfills has reduced slightly from an estimated 3.180 million tonnes in 1995 to 3.156 million tonnes in 2006. Converted to tonnes of waste disposed of to landfill per thousand dollars of gross domestic product (GDP), the estimated waste disposed of in 2006 was 29 per cent lower than in 1995. The shift to increased recycling and reprocessing, and the introduction of user-charges to dispose of waste, has helped reduce the amount of waste disposed of to landfills.

In 1995, 327 landfills were in use in New Zealand. Many of these had poor environmental controls. Today, there are about 60 landfills in use. Of these, 54 per cent use engineered liners (these help minimise leachate entering and contaminating surface and groundwater systems), 77 per cent collect leachate (liquid produced in landfills through the decomposition of waste), and 23 per cent recover landfill gas. New Zealand also has about 300 cleanfills across the country; these sites accept material that is not harmful to the environment when buried.

Recycling rates are increasing. In 2006, 73 per cent of New Zealanders had access to kerbside recycling, up from 20 per cent in 1996, and 97 per cent had access to either kerbside recycling or drop-off centres.

In 2005, 329,283 tonnes of paper, plastic, card, glass, steel, and aluminium collected through municipal recycling were diverted from being sent to landfills. When commercial waste is included, the total amount of material diverted from landfills is estimated to be about 2.4 million tonnes a year.

However, despite these advances, many potentially useful materials continue to be disposed of to New Zealand landfills and cleanfills. Organic (mostly garden and food) waste, timber, and construction and demolition waste make up nearly 50 per cent of waste disposed of to landfills.

Hazardous waste flows and treatment of wastewater

Quantities of hazardous waste are not yet well understood in New Zealand because of a lack of available data. A significant portion of hazardous waste is liquid and disposed of to the sewerage system, where it is treated at one of the country's 320 wastewater treatment plants.

Wastewater treatment plants discharge approximately 1.5 billion litres of domestic wastewater daily into the sea and other waterways, and onto land. Sewage sludge (biosolids) is removed from the wastewater during treatment and has, traditionally, been disposed of in landfills. Each year, wastewater treatment plants, serving almost 30 per cent of the country's population divert about 155,000 tonnes of sewage sludge to beneficial uses such as land reclamation, application to forested land as fertiliser, and blending with green waste to produce compost.

Present and future management

Since 1997, waste management in New Zealand has focused on managing the human health and environmental effects of waste, primarily by putting in place standards for waste disposal.

Today, many businesses, householders, and communities are paying greater attention to minimising the amount of waste they generate and dispose of. This reflects an international shift towards using valuable natural resources more efficiently, and reducing the costs associated with production and disposal of waste. Producers are also taking greater responsibility for reducing the environmental effects of their products, from manufacture to disposal. Consumer purchasing choices will increasingly drive the 'green design' of products, including products which produce less waste throughout their life cycle.

In the future, the minimisation of waste generation and disposal is likely to remain a focus for New Zealand. In particular, attention is likely to focus on reducing the levels of potentially valuable wastes such as organic waste, construction and demolition waste, and some hazardous wastes. A further challenge is to improve the monitoring of waste flows.

Introduction

This chapter provides an overview of the state of, and trends in, waste management in New Zealand since 1997. The chapter focuses on the disposal of solid waste to landfills, although information on other aspects of waste is also presented, including cleanfill disposal, waste recovery, and recycling. The chapter includes brief assessments of liquid waste including wastewater, sewage sludge, and hazardous waste.

What is waste?

The New Zealand Waste Strategy 2002 (see box 'More about the New Zealand Waste Strategy 2002') defines waste as any material – solid, liquid, or gas – that is unwanted and/or unvalued, and has been discarded or discharged by its owner (Ministry for the Environment, 2002).

Waste is generated in a variety of forms, and can also change its form over time.

Solid waste includes common household waste (including kitchen and garden waste), commercial and industrial waste, sewage sludge, construction and demolition waste, waste from agriculture and food processing, and mine and quarry tailings.

Liquid waste includes domestic wastewater (liquid kitchen, laundry, and bathroom waste), stormwater, used oil, and waste from industrial processes.

Gaseous waste comprises gases and small particles emitted from open fires, incinerators, and vehicles, or produced by agricultural and industrial processes. Once released, the effects of these gases and particles are hard to control. Gaseous wastes and their impact on air quality and the atmosphere are discussed further in chapter 7, 'Air' and chapter 8, 'Atmosphere'.

Hazardous waste is solid, liquid, or gaseous waste that poses a risk to human health and the environment. It includes paint, medical waste, used oil, solvents, electronic waste, and toxic gases.

Waste in New Zealand

Solid waste

The character of New Zealand's economic activity has important implications for our waste. The large proportion of our land that is dedicated to agricultural, horticultural, forestry, and other primary production, and our comparatively limited manufacturing and heavy industry, have a significant impact on the types of waste we both generate and dispose of in New Zealand.

Much of the solid waste generated in New Zealand is disposed of to landfills and cleanfills, although industrial waste such as that produced by agricultural, forestry, quarrying, and mining activities is generally disposed of on site.

Cleanfill sites accept material that, when buried, will have no harmful effects on people or the environment. This includes natural materials such as clay, soil and rock, as well as other inert materials such as concrete or brick.

Many of our landfills and cleanfills are owned and operated by councils, although managed on a commercial basis.

Large volumes of waste are also disposed of at privately owned and operated construction and demolition waste landfills. These landfills have local authority consents that allow them to accept cleanfill materials, as well as limited amounts of construction timber, green waste, plastics, and steel, depending on the consent conditions for the site.

Gaseous waste

Gaseous waste is primarily controlled by the resource consent process or national environmental standards under the Resource Management Act 1991 (see box 'More about national environmental standards'). These national environmental standards include regulations that ban waste incineration at schools and hospitals, unless resource consent is granted to allow the discharge of the substance to the air. The regulations also prohibit the high-temperature incineration of hazardous waste, with the exception of some medical waste. Unlike many Organisation for Economic Co-operation and Development (OECD) countries, only a fraction of the waste produced in New Zealand is disposed of by incineration.

More about national environmental standards

Fourteen national environmental standards were introduced in 2004 under the Resource Management Act 1991 to control the release of gaseous wastes into the air. The standards include:

- seven activity standards that ban various activities that discharge unacceptable quantities of dioxins and other toxins into the air (such as lighting fires and burning waste at landfills, the burning of bitumen, tyres, coated wire, and oil)
- prohibitions on the use of school and healthcare incinerators without resource consent and new high temperature hazardous wastes incinerators
- a design standard for the collection and destruction of landfill gas at large landfills.

Hazardous waste

A significant portion of the hazardous waste produced in New Zealand is discharged in dilute form to municipal wastewater treatment systems. Other types of hazardous waste have to be exported for disposal because they cannot be safely treated and disposed of in New Zealand.

Liquid waste

Every day, 1.5 billion litres of domestic wastewater is discharged in New Zealand. By volume, liquid waste is our largest waste stream. Liquid waste is generally managed and disposed of in wastewater treatment plants. However, some liquid waste from diffuse sources – such as effluent that has leached from agricultural land – is not currently managed or controlled. Waste management legislation (see box ‘Waste legislation’) empowers councils to play a key role in waste management through their administering of the resource consent process.

Waste legislation

Local Government Act 1974

Part 31 of the Local Government Act 1974 assigns responsibilities for waste management to territorial authorities. In particular, they are required to:

- promote effective and efficient waste management within their districts
- establish plans for managing waste through the waste hierarchy (from reduction and reuse through to disposal).

The range of powers that territorial authorities have in relation to waste management includes making bylaws to prohibit the dumping of waste, regulating waste collection and transport, and setting charges for public use of landfills and other waste management facilities. Territorial authorities are required to recover the costs of implementing their waste management plans.

Resource Management Act 1991

The purpose of the Resource Management Act 1991 (RMA) is to promote the sustainable management of natural and physical resources by regulating discharges into the environment. Councils therefore play a key role in waste management by administering the resource consent process. The RMA also provides opportunities for the creation of tools, such as national policy statements and national environmental standards, which could affect waste management. However, the RMA plays a minimal role in promoting waste minimisation.

The Hazardous Substances and New Organisms (Approvals and Enforcement) Amendment Act 2005

The Hazardous Substances and New Organisms (Approvals and Enforcement) Amendment Act 2005 established standards, known as ‘group standards’, for groups of materials with similar hazards. These standards were introduced to ensure the safe disposal of hazardous waste, and to provide data on hazardous waste generation and disposal.

Environmental and health effects of waste

Waste is not only unsightly, it can also pollute our water, air, and land unless it is adequately managed. Waste of all types can affect human health and the environment. The effects can be direct, such as high levels of air pollution that causes respiratory problems, (see chapter 7, 'Air') or indirect, such as contaminants in soils that reduce the productivity of land or affect the quality of food (see chapter 9, 'Land').

Inert wastes, such as those produced by earthworks, building, and demolition activities, do not usually affect the environment significantly.

Some waste can produce hazardous substances that cause asthma and other respiratory diseases, bacterial illnesses, birth defects, and cancer. Some hazardous waste, such as persistent organic pollutants (POPs), can be especially toxic. Persistent organic pollutants remain in the environment for long periods, are widely dispersed – usually by water or wind – and accumulate in the fatty tissue of people and animals.

Waste is of concern to many New Zealanders for many different reasons. For example, Māori have a particular concern about the way in which waste disposal degrades the mauri, or life force, of the environment. They consider the disposal of waste at wāhi tapu (sacred sites) to be particularly inappropriate.

ILLEGALLY DUMPED WASTE AND ITS IMPACT ON THE ENVIRONMENT.

Source: Ministry for the Environment.

Waste and the economy

Waste is the by-product of economic activity. Waste can be generated at different times during the material life cycle: when raw natural resources are extracted or harvested; when goods are manufactured or services produced; and when goods are packaged, transported, and consumed.

Waste generation can indicate the inefficient use of resources. Some business commentators consider waste to be a design flaw (*Economist: Science Technology Quarterly*, 2007). Studies have shown that up to 93 per cent of raw materials are discarded during processing and do not end up in saleable products, and that 80 per cent of saleable products are discarded after a single use (Von Weizsacker et al, 1997, in Ministry for the Environment, 2002).

Historically, the relationship between the amount of waste generated and economic growth has meant that the greater the wealth, the greater the consumption of goods and services (and the resources used to produce these), and the more waste produced. A 40 per cent increase in Organisation for Economic Co-operation and Development (OECD) gross domestic product since 1980 has been accompanied by a 40 per cent increase in municipal waste over the same period (Organisation of Economic Co-operation and Development, in Ministry for the Environment, 2002).

Internationally, a key goal is to 'decouple' waste generation from economic growth. Waste generation can be decoupled by:

- increasing the resource efficiency of goods and services by using fewer resources in production
- decreasing the resource intensity in the production of goods and services through improved processes, designs, and materials.

The efficient use of our valuable natural resources saves us money, reduces our impact on the environment, and ensures that our goods and services are competitive. Some international businesses, such as Wal-Mart in America, recognise the benefits of resource efficiency and have adopted zero-waste targets (*Economist: Science Technology Quarterly*, 2007).

The New Zealand Waste Strategy recognises the benefits that can be achieved by using our natural resources more efficiently. In particular, the strategy supports the 'waste hierarchy' – the '5Rs' of reduction, reuse, recycling, recovery, and management of residual waste. Under this hierarchy, the reduction in the amount of waste generated is put ahead of all other forms of waste management (see box 'More about the New Zealand Waste Strategy 2002'). The avoidance of waste generation is more economical than paying for waste to be reused, recycled, or treated and managed to final disposal.

More about the New Zealand Waste Strategy 2002

The New Zealand Waste Strategy, published in 2002, was developed in partnership with local government. Its vision is for 'zero waste and a sustainable New Zealand'. The strategy has three core goals:

- to lower the costs and risks of waste to society
- to reduce environmental damage from the generation and disposal of waste
- to increase economic benefit by using material resources efficiently.

The strategy recognises that waste management and minimisation in New Zealand are everyone's responsibility, including central and local government, the private sector, the waste sector (including commercial waste operators and non-government organisations), and households.

The strategy identified nine priority waste areas and 30 targets. Progress against these targets has been reviewed regularly (Ministry for the Environment, 2004; 2007c). The most recent review showed that, while much of the groundwork had been laid for achieving the strategy's wider goals and objectives, progress against the strategy targets has been variable.

Good progress has been made in providing community recycling facilities and 'green waste' schemes. Central government has made progress in engaging with businesses and in developing guidelines to improve the management of landfills and hazardous wastes. However, less progress has been made in reducing commercial organic, and construction and demolition wastes; improving the management of cleanfills; and identifying and managing contaminated sites. Progress against other targets was either unable to be achieved or unable to be measured.

Reuse, recycling, and recovery

The reuse, recycling, and recovery of much waste is often technologically feasible, but may be hampered by economic factors. These include:

- the relatively low cost of raw materials, which makes it difficult or impossible for reprocessed waste materials to compete in the market
- New Zealand's small and dispersed population, which adds to the cost of collecting and transporting materials for recycling, reuse, and recovery
- the traditionally low cost of waste disposal
- the lack of a regulatory framework or strong market signals for more efficient resource use.

Despite the difficulties listed above, the recovery and reuse of waste that has some economic value is increasing in New Zealand. For example, a small but growing proportion of waste is being used to generate energy or heat, instead of being disposed of to landfills. The Used Oil Recovery Programme recovers half to two-thirds of all used oil in New Zealand. The oil is collected from oil producers, major industrial oil consumers, garages and workshops, then transported to Westport to fire kilns at the Holcim cement plant.

Public expenditure on waste management

In 2003, public expenditure on waste management in New Zealand amounted to $218 million, or about 0.16 per cent of gross domestic product (GDP). The management of wastewater cost an additional $603 million, or 0.45 per cent of GDP. Since 2001, the operation and maintenance of facilities for managing waste and wastewater have accounted for about 58 per cent of the total expenditure on waste and wastewater, with local authorities accounting for 99 per cent of that figure (Organisation for Economic Co-operation and Development, 2007).

National environmental indicator

See chapter 1, 'Environmental reporting', for more information on the core national environmental indicators and how they are used.

There is one national environmental indicator for reporting on waste in New Zealand: solid waste disposed of to municipal landfills.

This indicator tracks changes over time in the quantity and composition of the solid waste disposed of to landfills. It provides valuable information on waste flows, including the quantities and types of materials that can be recycled or recovered to avoid their disposal.

Limitations of the indicator

The indicator includes only solid waste disposed of to municipal landfills. It does not include disposal to cleanfills or other disposal sites, such as construction and demolition waste landfills. Liquid, gaseous, and hazardous wastes are not specifically measured by the indicator (although hazardous waste is included in estimates of solid waste disposed of to landfills).

The indicator does not measure any activities aimed at minimising waste and increasing resource efficiency, such as improvements to production methods. Nor does it measure the decoupling of waste generation from influencing factors, such as population and economic growth.

To present a wider picture of waste disposal in New Zealand, this chapter also draws on information about landfills, cleanfills, waste recovery and recycling, liquid waste including wastewater, sewage sludge (biosolids), and hazardous waste.

Current state and trends

It is estimated that around 8.7 million tonnes of solid waste (from domestic, commercial, industrial, and institutional waste sources) was generated in New Zealand in 2006, of which 2.4 million tonnes was subsequently diverted from disposal to landfills (Waste Not Consulting, 2006). This means that approximately 6.3 million tonnes of waste are sent to landfill and cleanfill sites each year. When averaged across the total population, that represents 1,572 kilograms of solid waste per person per year.

Waste to landfill

Waste volumes

Estimates of the total quantities of solid waste disposed of to landfill in New Zealand since 1990 are shown in Figure 6.1. Estimates have varied significantly since 1990, partly as a result of the changing quality of available waste data.

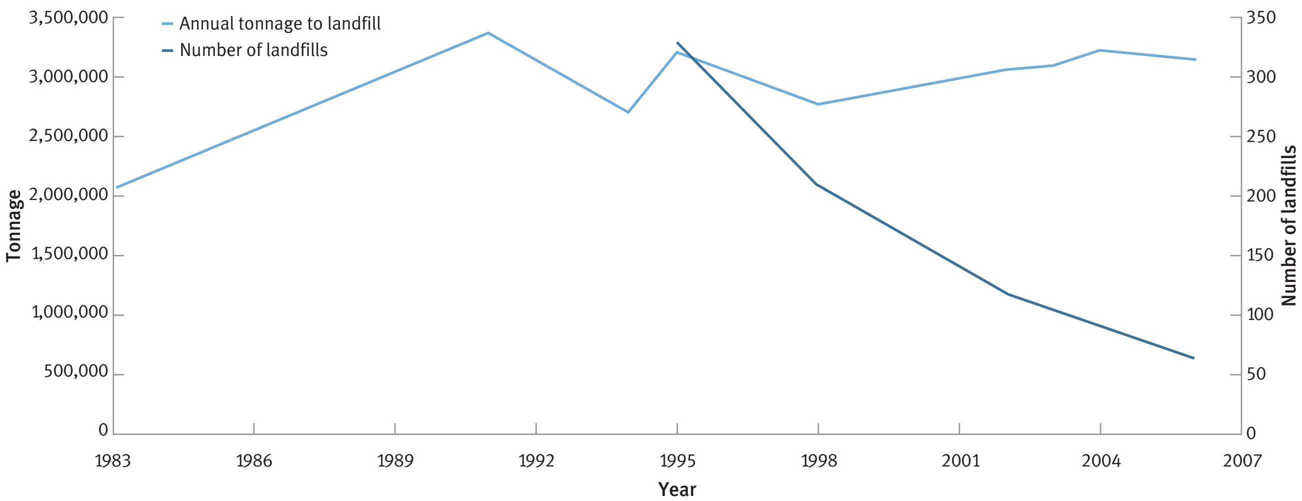
Figure 6.1 shows that the estimated amount of solid waste disposed of to landfill in New Zealand decreased slightly from 1995 to 2006, from 3.180 million tonnes or 898 kilograms per person per year in 1995, to 3.156 million tonnes or 784 kilograms per person per year in 2006. During this period, New Zealand's wealth, expressed as real gross domestic product (GDP) (adjusted for inflation), increased by 40 per cent, largely as a result of expansion in the economic sectors that are major sources of waste (for example, agriculture, manufacturing, transport, tourism, energy, and construction).

Converted to tonnes of waste disposed of to landfills per thousand dollars of GDP, the estimated waste disposed of in 2006 was 29 per cent lower than in 1995 (New Zealand Institute of Economic Research, pers comm). This decrease indicates a decoupling from economic growth of waste disposal to landfills. However, it is not known whether this decrease was accompanied by an increase in the waste disposed of to cleanfills or other disposal sites, such as construction and demolition waste landfills.

Although construction and demolition waste landfills are not consented to accept domestic, liquid, or hazardous waste, these landfills are thought to accept large quantities of the total waste disposed of in some areas of New Zealand.

Figure 6.1 shows that the amount of waste disposed of to landfills annually since 1998 has stabilised. This trend coincides with an increase in the availability of waste recovery initiatives and recycling services throughout New Zealand. At the same time, the proportion of local authorities applying user charges for landfills has now reached 93 per cent. User charges act as an incentive to reduce waste disposal to landfills.

+ FIGURE 6.1:
ESTIMATES OF WASTE DISPOSED OF TO LANDFILL, 1983–2006, AND NUMBER OF LANDFILLS OPERATING, 1995–2006



Source: Ministry for the Environment, 2007c

Landfill management

Figure 6.1 shows that the number of landfills operating in New Zealand decreased from 327 in 1995 to 60 in 2006. This decrease is partly the result of a drive to improve the performance and management of landfills through the stronger environmental controls provided by the Resource Management Act 1991, national environmental standards, and best practice guidelines for landfill management. The decrease is also likely to reflect the introduction of user charges to landfills and the consolidation of some waste management operations.

Landfill management practices have greatly improved in the last decade. The proportion of landfills with an engineered liner (liners help to minimise leachate entering and contaminating surface and groundwater systems) rose from 4 per cent in 1998 to 54 per cent in 2006, while those that collect potentially hazardous landfill leachate rose from 13 per cent in 1995 to 77 per cent in 2006.

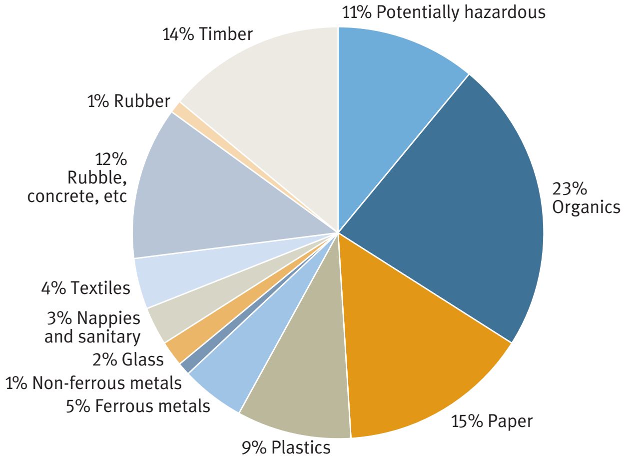
The proportion of landfills that collect methane gas and use it to generate energy has increased from 5 per cent in 1998 to 23 per cent in 2007. At larger landfills, this shift reflects new landfill gas management requirements under the national environmental standards. It also reflects a growing recognition of the benefits of reusing this potentially valuable waste gas.

Waste composition

No comprehensive data is available on the composition of solid waste disposed of to landfills in New Zealand. However, data from 16 waste facilities (representing more than 50 per cent of the waste disposed of to landfills in New Zealand) can be used to provide a 'snapshot' (see Figure 6.2) of waste composition (Waste Not Consulting, 2006). The percentages shown are indicative only, because the margin of error associated with analysing the composition of waste disposed of to landfills is typically 20 per cent.

Figure 6.2 indicates that nearly a quarter of the waste received at municipal landfills consists of organic material (23 per cent). Paper comprises 15 per cent, timber 14 per cent, and rubble and concrete 12 per cent. Potentially, these waste types can be diverted from landfills for reuse or reprocessing.

+ FIGURE 6.2:
ESTIMATES OF THE COMPOSITION OF WASTE DISPOSED OF TO LANDFILLS, 2004



Source: Waste Not Consulting, 2006.

Waste to cleanfill sites

Cleanfill sites accept materials that, when buried, will have no harmful effect on people or the environment. These materials include natural materials that are free of combustible, biodegradable, or leachable components; hazardous substances; or liquid waste. The materials are also free of substances that may present a risk to human or animal health, such as medical and veterinary waste, asbestos, or radioactive substances.

Cleanfills are a permitted activity in many regional and district plans, provided they meet specified criteria. Because cleanfills are a permitted activity, only limited monitoring of them takes place. In addition, many cleanfills are commercially operated, and information about them is therefore considered to be commercially sensitive. Regional councils and territorial authorities estimate that there may be more than 300 cleanfills in New Zealand, although the actual number is not known.

From available information, it is estimated that between 0.65 to 0.91 tonnes of waste are disposed of to cleanfills in New Zealand for each person every year (Waste Not Consulting, 2006). From this estimate, the total amount of waste disposed of to cleanfills in New Zealand each year can be estimated at between 2.7 to 3.7 million tonnes per year. This amount is about the same as that of solid waste disposed of to landfills.

Recovered materials

The uptake in recycling in New Zealand has increased significantly over the last decade, as a result of major recovery and recycling initiatives that have been introduced to divert materials from going to landfills and cleanfills. These initiatives range from the recycling and composting services offered by local authorities and community-based groups, to industry-led recovery and recycling, and product stewardship schemes (see box 'More about product stewardship').

In 2005, municipal recycling diverted 329,283 tonnes of paper, plastic, glass, steel, and aluminium from landfills. When commercial waste is included, the total amount of material diverted from landfills each year in New Zealand is estimated to be about 2.4 million tonnes a year.

SEVENTY-THREE PER CENT OF NEW ZEALANDERS HAD ACCESS TO KERBSIDE RECYCLING IN 2006.

Source: Ministry for the Environment.

More about product stewardship

Industry sectors in New Zealand lead several business sustainability and waste minimisation programmes. In 2007, at least 10 sectors were involved in product stewardship schemes, which enabled manufacturers, brand owners, importers, and retailers to reduce the environmental effects of their products, throughout the production process, from manufacture to disposal.

The 2004 New Zealand Packaging Accord sets several waste minimisation targets for participating sectors, and monitors progress against these targets. The accord brings together recycling operators and representatives from the paper, plastic, glass, steel, and aluminium materials sectors, in partnership with local and central government. Each sector has a sector-specific action plan to reduce packaging and to increase the rates of recycling.

Agrecovery is a programme to recover empty plastic agrichemical containers from the agricultural and forestry sectors. Used containers are recovered at 52 local authority transfer stations around the country. Reuse of the containers includes shredding and reprocessing the plastic to make casings for underground electrical cable.

Schemes to reuse, recycle, or recover waste from electrical goods have also been introduced in New Zealand, including by Hewlett Packard, IBM, Dell, Fisher & Paykel, Vodafone, and Telecom.

Industrial recovery and recycling

Estimates of the amounts of some industrial waste diverted from landfills and cleanfills are shown in Table 6.1. However, the figures do not include:

- materials diverted from one business to another
- materials recovered and reused during commercial operations, such as the on-site recovery and reuse of building materials.

Community recycling

As noted earlier, territorial authorities diverted an estimated 329,283 tonnes of glass packaging, scrap metal, plastics, and paper from landfills in 2005–2006, through kerbside recycling and drop-off centres.

Overall, 73 per cent of New Zealanders had access to kerbside recycling in 2006, up from 20 per cent in 1996, while 97 per cent of New Zealanders had access to either kerbside or drop-off recycling services. For New Zealanders with access to recycling services, 83 kilograms of waste per person was diverted to recycling each year.

Table 6.2 shows the availability of recycling services provided by territorial authorities in metropolitan, urban, and rural areas.

+TABLE 6.1:
ESTIMATES OF INDUSTRY WASTE DIVERTED FROM LANDFILLS AND CLEANFILLS ANNUALLY

WASTE STREAM	AMOUNT DIVERTED (TONNES)	DATA SOURCE
Glass packaging	92,826	Packaging Accord Data for 2005
Paper	454,212	New Zealand Paperboard Packaging Association estimate for 2005
Plastics	39,100	Plastics New Zealand estimate for 2005
Scrap metal	495,000–550,000	Scrap Metal Recycling Association annual estimates for 2006
Construction and demolition	1 million	Estimates from direct contact with the construction and demolition industry

Source: Ministry for the Environment, 2007c.

+TABLE 6.2:
RECYCLING IN METROPOLITAN, URBAN, AND RURAL AREAS, 2006

	NEW ZEALAND POPULATION IN AREA (%)	POPULATION WITH ACCESS TO KERBSIDE RECYCLING (%)	POPULATION WITH ACCESS TO RECYCLING FACILITIES (%)	TERRITORIAL AUTHORITIES PROVIDING GREEN WASTE FACILITIES (%)
Metropolitan	52	97	99.7	70
Urban	24	53	97	84
Rural	24	45	92	64

Note:
Metropolitan areas include Auckland, Hamilton, Wellington, Christchurch, and Dunedin.
Source: Ministry for the Environment, 2007c.

LOCAL ACTION to reduce waste

Christchurch cleanfill bylaw

Christchurch City Council introduced its Cleanfill Licensing Bylaw in 2003 to regulate the types of material that can be disposed of to local cleanfills. The bylaw encouraged the recovery, reuse, and recycling of materials by imposing a levy on 'non-natural' materials.

In the first year following the introduction of the bylaw, the total annual volume of material disposed of to cleanfills dropped from 370,000 to 300,000 cubic metres, a reduction of about 20 per cent. Around 15 per cent of this reduction was estimated to be directly attributable to the levy.

In 2005–2006, the total volume of materials disposed of to cleanfills increased by 12 per cent, reflecting the continuing high levels of construction activity in Christchurch. However, materials on which the levy was charged increased less (8 per cent) than other materials that did not attract the levy (15 per cent). The proportion of materials on which the levy is charged has decreased from 38 per cent to 36 per cent of the total materials disposed of to cleanfills in the city.

In March 2006, the High Court of New Zealand ruled that the section of the bylaw containing the levy on 'non-natural' materials was *ultra vires* (beyond the legal powers of the Council), and the bylaw was thus overturned. Since then, disposal prices have remained at the level that included the levy, even though the levy is no longer being collected. Waste minimisation levels have also remained similar to those when the levy was in place.

Second Hand Sundays

Gisborne District Council has made progress over the past few years in reducing the level of community waste being disposed of to landfills and in increasing the rates of recycling. Refuse collection volumes are down 59 per cent since 1999. Recycling tonnages are up 52 per cent since 2000.

A number of innovative Council programmes have contributed to this success. One such initiative is Second Hand Sundays, well-publicised days on which people may put used goods out on the kerbside for others in the community to take away for reuse. Each time this initiative is run, about 50 tonnes of waste is diverted from landfills.

Kai to Compost

Kai to Compost is a food waste collection scheme for restaurants and businesses in Wellington city. The scheme collects food waste from restaurants and takes it to the Living Earth plant at the Southern Landfill, where the material is mixed with green waste and used to produce compost.

A trial scheme was funded by the Ministry for the Environment's Sustainable Management Fund, Wellington City Council, and Living Earth and involved 50 local businesses. The scheme is now run on a user-pays basis. Up until the end of 2006, the Council had collected 456 tonnes of food waste as part of the programme (177 tonnes in 2005–2006 and 278 tonnes in 2006–2007), which has reduced carbon dioxide emissions by an estimated 411 tonnes.

KAI TO COMPOST FOOD WASTE COLLECTION SCHEME.

Source: Courtesy of Mark Coote.

Business and community initiatives

Throughout New Zealand, a large number of non-government organisations have set up programmes to work with the community to reduce waste and promote recycling and resource efficiency. These organisations include professional and industry associations, and not-for-profit organisations such as the Waste Management Institute of New Zealand, New Zealand Business Council for Sustainable Development, Sustainable Business Network, Packaging Council of New Zealand, and Zero Waste New Zealand Trust. The programmes also include a significant number of community-based recovery and recycling centres, which make an important contribution to the quantities of waste that are reused, recycled, and recovered in New Zealand.

Organic waste

Organic waste includes food (kitchen) waste, animal and human sewage waste, and garden waste. The agricultural and food and beverage sectors generate a large proportion of New Zealand's organic waste. It also originates from wastewater treatment plants in the form of sewage sludge. Organic waste in landfills decomposes in the absence of oxygen, generating methane (a greenhouse gas), which contributes to climate change. Organic waste in landfills also creates leachate, which has the potential to contaminate surface and groundwater systems.

Only a small proportion of the organic waste produced in New Zealand is handled by territorial authorities. However, councils diverted an estimated 312,085 tonnes of organic waste from landfills in 2005–2006. Kitchen and garden waste made up 92 per cent of the total amount diverted (Ministry for the Environment, 2007c).

A 2004 survey estimated that organic waste represented 23 per cent, or 743,324 tonnes, of all waste disposed of to landfills (Waste Not Consulting, 2006) (see Figure 6.2). Notably, this percentage has reduced from 47 per cent according to a survey in 1995 (Ministry for the Environment, 1997). Even so, the 2004 result illustrates that potentially recoverable organic material continues to be disposed of to New Zealand landfills.

In 2005–2006, it was estimated that 153,885 tonnes of garden waste was diverted from landfills by territorial authorities. Garden waste is most commonly composted or mulched at transfer stations and some landfills. More than 70 per cent of local authorities provide this service.

New Zealanders compost an unknown quantity of food and garden waste at home.

GOVERNMENT ACTION to minimise waste

govt³: towards sustainable practice
ENVIRONMENTAL. SOCIAL. ECONOMIC

The Govt³ programme was established by the Ministry for the Environment in 2003 to encourage government departments to show leadership in waste minimisation as well as sustainability in buildings, transport, and the purchase of office consumables and equipment.

In the waste area, the Govt³ programme helps agencies reduce the waste they send to landfills by recycling and composting it instead.

By July 2007, 48 agencies had joined the Govt³ programme.

Wastewater disposal

Wastewater, which is made up of sewage, some stormwater and liquid trade waste, is usually very dilute. Domestic wastewater is discharged into the environment at a rate of approximately 1.5 billion litres a day (Ministry for the Environment, 2007d). Wastewater has the potential to physically alter and contaminate the environment into which it is discharged (that is, the sea or other waterways; see chapter 10, 'Freshwater' and chapter 11, 'Oceans' for further details).

Most domestic and commercial wastewater in New Zealand is treated at one of 320 public wastewater treatment plants before being discharged into the environment. Domestic wastewater is managed by septic tanks for 15–20 per cent of the population (Ministry for the Environment, 2005). Many industrial plants have their own wastewater treatment or pre-treatment facilities.

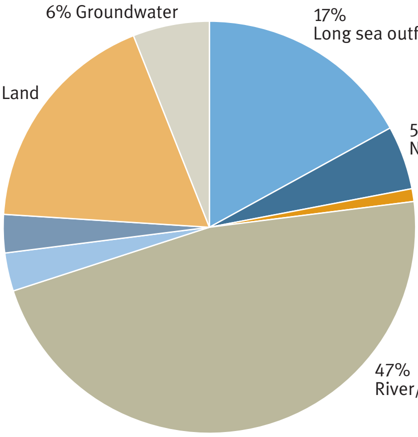
TAURANGA WASTEWATER TREATMENT PLANT: ACTIVATED SLUDGE TREATMENT (AEROBIC, RIGHT AND ANAEROBIC, LEFT).

Source: Ministry for the Environment.

The degree of treatment, and the resulting quality of the treated wastewater, varies widely from plant to plant. Most wastewater treatment plants use primary treatment, which is the physical removal of both organic and inorganic solids. Of the 269 plants for which information is available, 56 per cent employ secondary treatment to remove solids and associated contaminants (Ministry for the Environment, 2005). Another 36 per cent have tertiary treatment (the final stage in treating wastewater), which typically involves the removal of substances such as nitrates and sometimes includes disinfection of the water.

About half of the 125 public wastewater treatment plants for which information is available discharge treated sewage into rivers and streams. About a quarter of them discharge into the sea (either long sea outfall or near shore outfall). The remainder discharge onto land or wetlands, estuaries, or into groundwater see Figure 6.3).

+ FIGURE 6.3:
RECEIVING ENVIRONMENTS FOR WASTEWATER DISCHARGED FROM 125 TREATMENT PLANTS, 2007



Data source: Waste Information, 2007.

The Resource Management Act 1991 requires all wastewater treatment facilities to have consent to operate, and to meet relevant discharge standards for the receiving environment. As consents are renewed, the performance of each plant is reassessed. This process has significantly improved the standard of wastewater discharges around New Zealand, and is supported by best practice guidance for wastewater treatment.

More about trade waste bylaws

More than 89 per cent of local authorities have a trade waste bylaw. This enables them to set limits on discharges by industries and businesses to municipal wastewater. This helps protect reticulation and treatment systems, and the health and safety of workers, and ensures resource consent conditions are met. Many authorities use the Model Trade Waste Bylaw (NZS9201:23) as an example to develop their bylaws. Bylaws may also be used to regulate the pre-treatment of wastes at source, and to minimise the organic, nutrient, and contaminant levels in wastewater.

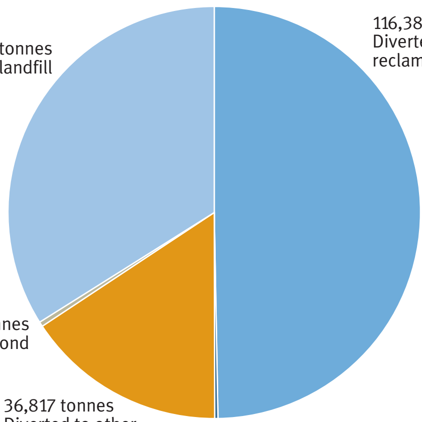
Sewage sludge

Each year in New Zealand, wastewater treatment plants generate 234,112 tonnes of sewage sludge. About 66 per cent of this is diverted from landfills to be reused in some way (Ministry for the Environment, 1997).

Detailed information on the generation of sewage sludge is available for 26 municipal treatment plants, which serve nearly 30 per cent of the population. These monitored plants divert an estimated 155,000 tonnes of wet and dry sewage sludge from landfills each year, which is reused in some way, as shown in Figure 6.4.

Most of the sewage sludge that the monitored plants divert is used to reclaim land (116,380 tonnes). Other uses include applying sludge to forested land as a fertiliser (600 tonnes), making compost (included in the 36,817 tonnes figure for 'other beneficial reuse'), and pond storage (875 tonnes).

+ FIGURE 6.4:
SEWAGE SLUDGE FROM MONITORED TREATMENT PLANTS, 2006



Data source: Waste Information, 2007.

The diversion of sewage sludge from landfills is important because it reduces pressure on space in the landfills and extends their lifespan. A further advantage of this diversion is that less methane is generated. In some communities, sewage sludge can account for between 5 and 10 per cent of all waste sent to landfills.

Upgrades to wastewater treatment plants around New Zealand will result in greater quantities of sewage sludge being produced. For example, after a recent upgrade to the Mangere wastewater treatment plant in Auckland, the volume of solids removed from wastewater increased from 40,000 tonnes in the mid-1990s to 116,000 tonnes a year in 2005–2006 (Ministry for the Environment, 2007c). While a significant portion of these solids will be able to be reused, an increasing quantity will not, because it will have unacceptable contamination levels. This highlights the importance of reducing and pre-treating liquid waste (especially hazardous industrial waste) at source before it is disposed of through the wastewater system.

Hazardous substances

Hazardous substances are those that can cause damage to human health or the environment. They may be explosive, flammable, toxic, or corrosive, or accelerate the combustion of other materials. They may also be eco-toxic (toxic to the environment). Most hazardous substances have more than one hazardous property. For example, petrol is flammable, toxic, and eco-toxic.

Many of the chemicals we use in our daily lives are hazardous substances. These include common household chemicals (for example, bleaches), solvents, paints, adhesives, swimming pool chemicals, and petroleum products.

Hazardous substances can enter the environment in a variety of ways, for example, as a result of emissions from burning fossil fuels; as industrial and municipal wastewater discharges; as stormwater run-off; or as by-products of activities such as agriculture, mining, manufacturing, chemical transport, or landfills.

Whatever the source and route into the environment, there is a risk that hazardous substances may be absorbed by humans and other living things. The most common ways that humans are exposed to hazardous substances are through inhalation, absorption through the skin, or ingestion.

Use of hazardous substances in industry

In the past, hazardous substances were commonly used in New Zealand's agricultural, horticultural, mining, and forestry sectors. As an example, pesticides and other agrichemicals were widely used to increase the economic returns from farmed or cropped land. They were often used with little or no equipment to protect human health.

The use of agrichemicals continues today, but protective practices have improved, and the toxicity levels of many agrichemical products have been reduced. As a result, the levels of agrichemical residues in our food have dropped. A 2003–2004 survey of 100 New Zealand foods found that agrichemical residues were detectable in 50 per cent of the sampled foods, down from 59 per cent in a 1997–1998 survey. In both surveys, the levels of chemical residues detected were well within acceptable limits (New Zealand Food Safety Authority, 2006).

Hazardous substances are used extensively in a number of other sectors. Small and medium enterprises are estimated to make up more than 96 per cent of all businesses in New Zealand. Many of these businesses use, transport, store, or sell hazardous substances (for example, solvents, acids, and heavy metals).

Health effects of hazardous substances

The use of hazardous substances can affect our health. Approximately nine deaths and 773 hospitalisations occur each year as a result of short-term exposure to hazardous substances (Ministry for the Environment, 2007b), mostly as the result of accidents. It is estimated that long-term exposure to hazardous substances causes at least 400 premature deaths and a further 300 cancers each year in New Zealand (Driscoll et al, 2004).

In addition, more than 40 per cent of incidents involving hazardous substances result in some kind of environmental pollution (Environmental Risk Management Authority, 2006).

Regulatory controls

Given the need to protect both human health and the environment, New Zealand closely controls hazardous substances. The Hazardous Substances and New Organisms Act 1996 and associated regulations set rules for managing the risks linked with the manufacturing, use, storage, transportation, and disposal of hazardous substances, including those used in the agricultural sector. These controls are in line with international commitments that New Zealand has made to manage hazardous substances (for example, the Stockholm Convention on Persistent Organic Pollutants).

Hazardous Substances and New Organisms Act 1996

Under this Act, the Environmental Risk Management Authority can impose controls on certain hazardous wastes to avoid risks to people and the environment. A key limitation is that wastes must also be hazardous substances under the Act (that is, they must meet the 'minimum degrees of hazard' as established in the Act).

The Hazardous Substances and New Organisms (Approvals and Enforcement) Amendment Act 2005 established a 'group standards' mechanism to allow the Environmental Risk Management Authority to place controls on hazardous wastes (including manufactured articles and waste products). The controls can address the disposal, transport, tracking, and reporting of these wastes.

For more information on the Hazardous Substances and New Organisms Act 1996 see chapter 2, 'Our environment and people'.

The Resource Management Act 1991 regulates the environmental effects of discharges, including waste disposal and the discharge of hazardous substances. These effects can be managed through resource consent conditions, rules in council plans, and national environmental standards. In this way, territorial authorities and regional councils can prevent or mitigate any adverse effects arising from the disposal of hazardous substances.

Hazardous waste

When hazardous substances reach the end of their useful life, they can become hazardous waste that requires careful handling and disposal. Hazardous waste can take a variety of forms – liquid, sludge, solid, and gas, and can be managed in a variety of ways, for example, at wastewater treatment plants or through the used oil recovery programme. Private sector waste operators play a key role in the treatment and disposal of hazardous waste.

A key issue in New Zealand is that most hazardous waste is mixed either at source or during its transport, treatment, or disposal. As a result, treatment and disposal is made more difficult and opportunities for hazardous waste to be recovered and recycled are reduced.

Information on hazardous waste is limited in New Zealand, because of a lack of formal record keeping and reporting on waste flows in the past. As well as this, a significant proportion of hazardous waste is handled by private waste operators, whose data is considered commercially sensitive.

The information available about hazardous waste primarily relates to specific waste streams, such as those for electronic equipment, agrichemicals, end-of-life vehicles (vehicles that have come to the end of their useful life), and waste oil.

Disposal of hazardous waste

By volume, most hazardous waste is discharged to the sewerage system, to be treated and disposed of in municipal wastewater treatment plants. A recent hazardous waste survey estimated that 72 per cent of the hazardous waste in the Bay of Plenty region, and 85 per cent in the Waikato region, was disposed of to sewers (Environment Bay of Plenty, 2004).

In 2004, solid hazardous waste was estimated to account for 11 per cent of the waste disposed of to landfills (Waste Not Consulting, 2006). About a quarter of this waste is rendered inert (stabilised) before disposal at waste treatment facilities.

Several major industries – for example, the mining industry – treat and dispose of hazardous waste independently.

Used oil is generated at a rate of 33 to 40 million litres in New Zealand each year (Slaughter et al, 2007). In 1997, 77 per cent of used oil was dumped to landfills, burned, poured onto roads to control dust, used to lubricate chainsaws and stain fences, or lost or discarded in various unknown ways (Ministry for the Environment, 1997). Today, the Used Oil Recovery Programme collects and reuses 21 million litres of used oil a year.

Waste electrical and electronic equipment (including products such as batteries, computers, cell phones, and televisions), and lighting appliances (such as fluorescent tubes), are disposed of to landfills in New Zealand every year at a rate of up to 80,000 tonnes (Ministry for the Environment, 2007c). Several schemes to reuse, recycle, or recover waste electrical and electronic goods have been introduced in New Zealand.

End-of-life vehicles can cause a waste problem even if they are sent to the scrap yard. Various hazardous substances, such as used oil, refrigerants, batteries, and circuit boards, must be removed from end-of-life vehicles for appropriate treatment or disposal. Approximately 25,000 cars are dumped illegally in New Zealand each year, at a cost to authorities of $6 million (Ministry for the Environment, 2007a).

LOCAL ACTION on hazardous waste

HazMobile

HazMobile is a mobile hazardous waste collection service run in the Auckland, Bay of Plenty, Hawke's Bay, Hutt Valley, Waimakariri, and Tasman regions. It is a free service provided by councils so householders can safely dispose of their hazardous wastes.

HazMobile visits public areas on scheduled dates to collect household and garden chemicals, waste oil, poisons, batteries and paints, and other products that could potentially harm people and the environment, or contaminate land.

In the Bay of Plenty in 2007, the HazMobile collected more than 1,110 loads of hazardous waste. This included about 600 loads in Tauranga, close to 300 in Te Puke, 200 in Whakatāne, and almost 60 in Ōpōtiki. The volumes collected in 2007 were lower than in 2006. A large haul of 2,4,5-T was the highlight of the HazMobile's Bay of Plenty visit in 2007.

Agrichemical wastes

Agrichemicals are chemicals commonly used to destroy insects, fungi, bacteria, pests, and weeds, and to regulate plant growth. They are toxic to both human health and the environment, and may remain in the environment for very long periods once they are released.

For more than a decade, local authorities have played a key role in collecting and safely disposing of banned and unwanted agrichemicals that have accumulated on farms and rural properties. From 2003, this collection has been enabled by the Agrichemicals Collection Programme, which is jointly funded by central and local government.

By June 2006, approximately 260 tonnes of agrichemicals had been collected through the programme. Of these, 228 tonnes were agrichemicals that cannot be safely treated or disposed of in New Zealand, and they have been exported for safe disposal.

Nine of New Zealand's 16 regions are now considered to be free of agrichemical stockpiles (that is, there are estimated to be fewer than 5 tonnes of stockpiles remaining in each of those regions). The Agrichemicals Collection Programme has committed to removing a further 175 tonnes of unwanted agrichemicals from rural properties by June 2009.

260 TONNES OF AGRICHEMICALS HAD BEEN COLLECTED BY JUNE 2006 THROUGH THE AGRICHEMICAL COLLECTION PROGRAMME.

Source: Ministry for the Environment.

Changes since the 1997 report

The 1997 report, *The State of New Zealand's Environment 1997*, concluded that:

> In many cities the amount of recycling has increased, in some places landfill fees have been raised, and cleaner production is being attempted by some organisations. ...
>
> While waste management responses increasingly include recycling, cleaner production systems and higher landfill fees, total waste has increased, our landfill management practices are generally poor, as are our practices and attitudes towards managing hazardous waste.

(Ministry for the Environment, 1997, chapter 10.)

Waste disposal and management

Since the 1997 report, significant gains have been made in New Zealand in managing the effects of waste on human health and the environment. These have been driven primarily by stronger controls on waste disposal and management under the Resource Management Act 1991, the Hazardous Substances and New Organisms Act 1996, and the Local Government Acts (1974 and 2002).

In response to these controls, the management and environmental performance of both landfills and wastewater treatment plants in New Zealand has significantly improved over the last decade. The number of landfills in New Zealand has decreased, from 327 in 1995 to about 60 in 2007, with substandard landfills having closed.

As at 2007, 56 per cent of the 269 wastewater treatment plants for which information is available operate secondary treatment for wastewater, and 36 per cent treat their wastewater to the highest level (tertiary treatment). As a result, the quality of wastewater discharged to the environment has improved significantly since 1997.

In addition, most local authorities now have in place trade waste bylaws to manage the effects of industrial waste on the quality of wastewater.

While hazardous waste flows are still not well understood because of the lack of available data, hazardous substances and their wastes are now better controlled through the Hazardous Substances and New Organisms Act, trade waste bylaws, and national environmental standards.

The New Zealand Waste Strategy

In 2002, the New Zealand Waste Strategy came into effect, providing the strategic direction for waste management and minimisation in New Zealand. It set several targets to improve the management and minimisation of wastes, including those considered to be priority wastes, such as hazardous waste.

However, progress against the 30 waste strategy targets has been variable. Good progress has been made in community recycling and 'green waste' schemes, through central government's engagement with businesses, and guidelines to improve the management of landfills and hazardous waste. Less progress has been made in diverting commercial organic, and construction and demolition waste from landfills; improving the management of cleanfills; and identifying and managing contaminated sites. Progress against several targets was unable to be measured.

Local government responsibilities

Both the Local Government Act 2002 and the New Zealand Waste Strategy have clarified and formalised the role of local government in managing and minimising waste. Each territorial authority is required to prepare a waste management plan to address the reduction, reuse, recycling, recovery, and treatment and disposal of waste in the district.

Territorial authorities continue to have responsibility for collecting municipal waste, and for operating kerbside recycling and drop-off centres, transfer stations, and sanitary municipal landfills. Councils also play an important part in raising awareness of the benefits of minimising waste and recycling.

Commercial involvement

A commercial waste industry has developed since 1997, which has allowed market forces to operate for waste disposal and recovery.

As a result of the commercialisation of the waste sector, important progress has been made towards charging full costs for waste disposal and management since 1997. This has boosted efforts by industry to use resources more efficiently to reduce the generation and subsequent disposal of waste.

Waste minimisation and resource efficiency

The development of the New Zealand Waste Strategy and its targets illustrates a shifting focus away from controlling the effects of waste disposal towards:

- minimising the amount of waste requiring disposal
- increasing how efficiently valuable resources are used.

A significant number of government, private industry, and community-based initiatives are now working towards wider waste minimisation and resource efficiency goals. In particular, producers are taking greater responsibility for reducing their waste.

Several sectors are now involved in industry-led product stewardship schemes that enable manufacturers, brand owners, importers, and retailers to reduce the environmental effects of products, from the manufacture of products through to their disposal. One example is the 2004 New Zealand Packaging Accord, which sets several waste minimisation targets for participating sectors, and monitors progress against them.

Government agencies have also taken on greater responsibility for their waste. The introduction of the Govt³ programme in 2003 has enabled 48 government departments and other agencies to show leadership in waste minimisation.

Trends in solid waste

Partly in response to initiatives such as those described above, the total amount of waste disposed of to landfills in New Zealand has stabilised between 1995 and 2006 and, in fact, has decreased by 29 per cent when measured against the economic growth New Zealand has experienced (that is, in terms of real gross domestic product).

However, it is not known whether this stabilisation was accompanied by an increase in waste disposed of to cleanfills or other disposal sites. The stabilisation has coincided with the establishment of municipal and industry-led recycling and recovery programmes in many parts of the country. Seventy-three per cent of New Zealanders now have access to kerbside recycling, and 97 percent have access to either kerbside or drop-off recycling services.

Since 1997, there have been significant increases in the amounts of material recovered from the waste stream, and recycled, or reprocessed. The total amount of material diverted from landfills and cleanfills is estimated to be about 2.4 million tonnes a year.

As in 1997, many potentially useful materials continue to be disposed of to New Zealand landfills and cleanfills. Organic waste, timber, and construction and demolition waste make up nearly 50 per cent of the waste disposed of to landfills. Much of this waste could be recycled, reused, or reprocessed in some way. However, the evaluation of waste flows in New Zealand is still hampered by a continuing lack of standardised reporting and monitoring systems, and a resulting lack of reliable waste data.

Present and future management

With environmental sustainability now a global focus, increased attention is being given to minimising the amount of waste generated and disposed of by businesses, households, and communities. This trend reflects an international drive to use valuable natural resources more efficiently, and to reduce costs. It also coincides with global pressures to respond to climate change by reducing the greenhouse gas emissions from waste (see chapter 8, ‘Atmosphere’).

In the future, waste policy in New Zealand is likely to continue to focus on minimising the generation and disposal of waste. A further challenge will be to monitor waste flows better, and to reduce waste throughout the life of products, through their ‘greener’ design. Consumer purchasing choices and an increased availability of ‘lower waste’ goods will largely influence the extent to which this minimisation and reduction of waste will occur.

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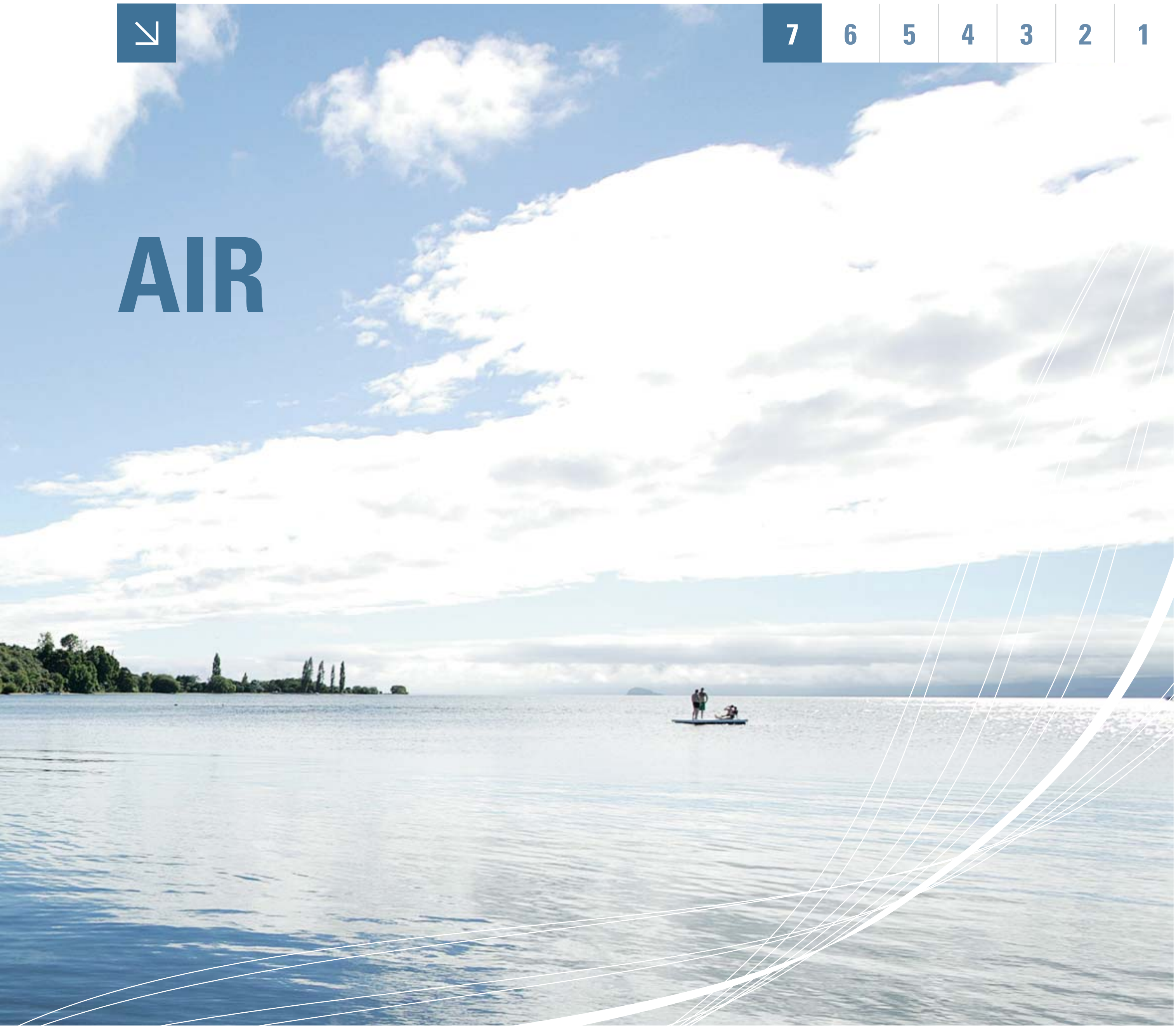
STATE OF THE ENVIRONMENT

03


“Good air quality
is fundamental
to our health.”

AIR



Contents

At a glance

Air quality in New Zealand

Good air quality is fundamental to our well-being. Every day each New Zealander inhales about 14,000 litres of air, the equivalent of about 150 full bath tubs.

New Zealand has good air quality in most locations for most of the time. However, coal and wood used for home heating and exhaust emissions from transport can affect air quality in about 30 locations, particularly during winter. About 53 per cent of New Zealanders live in these affected locations.

Pollutants in the air can affect our health, because we inhale them into our lungs. Vulnerable groups such as the very young, the very old, and people with underlying respiratory or cardiac disease are particularly at risk. About 1,100 New Zealanders die prematurely each year from exposure to air pollution. The number of New Zealanders who die prematurely from traffic-related air pollution is similar to the number killed in road accidents each year.

Levels of air pollution in New Zealand

PM_{10} particulates

In most of the areas in New Zealand where air quality can be poor, the cause is high winter levels of PM_{10} particulates from coal and wood used for home heating. Auckland, where about a third of New Zealand's population lives, also experiences high levels of PM_{10} particulates from road transport. Levels of PM_{10} particulates appear to be falling in some of the main centres of population, although the influence of weather on air pollution makes it difficult to assess trends. Levels of PM_{10} particulates at roadside locations in Auckland appear to have fallen over the past 10 years.

Nitrogen dioxide

Levels of nitrogen dioxide are at an acceptable level around New Zealand, with the exception of some locations in Auckland affected by traffic emissions. Emissions of nitrogen dioxide in Auckland appear to be increasing.

Carbon monoxide

Levels of carbon monoxide, mostly from traffic emissions, were of concern 10 years ago. Since then, levels appear to have fallen at locations that have historically experienced high concentrations. The improvement is most likely due to improved vehicle technology.

Sulphur dioxide

Sulphur dioxide levels declined in the 1980s and are considered to be low in most parts of the country. However, the areas around the Marsden Point Oil Refinery and other individual locations have higher levels than the rest of the country.

Ozone

Based on traffic emissions data, areas around Auckland, Hamilton, and Christchurch were identified in the mid-1990s as having the greatest potential for elevated levels of ground-level ozone. However, the results from monitoring indicate that ozone levels are satisfactory in these locations.

$PM_{2.5}$ particulates, benzene, and airborne lead

Monitoring for $PM_{2.5}$ particulates is not widespread in New Zealand. However, where $PM_{2.5}$ particulates are monitored, a strong relationship exists between high levels of PM_{10} particulates and high levels of $PM_{2.5}$ particulates.

Benzene levels at monitored locations are at an acceptable level. Levels are higher near busy roads than in residential areas, but appear to be improving. This improvement is probably due to changes in vehicle fuel composition.

Lead was eliminated from New Zealand petrol in 1996, so airborne lead levels are now very low.

Present and future management

Today, the main focus for improving air quality in New Zealand is to reduce PM_{10} particulate emissions from home heating and traffic. Having put in place regular monitoring of air quality in managed airsheds, future effort will continue to focus on tracking PM_{10} particulate levels against the 2013 target set under the national environmental standards for air quality.

Future work on improving air quality may also focus on developing a better understanding of $PM_{2.5}$ levels around New Zealand.

Introduction

Clean air contributes to New Zealand's quality of life, not only in terms of people's health, but also in terms of the beauty of the natural and physical environment.

New Zealand is located in a windy and geographically isolated part of the world. This location means air pollution is often blown away and readily dispersed. New Zealand is not significantly polluted by neighbouring countries and has a low population density and limited amount of heavy industry. The combination of these factors results in good air quality in most locations for most of the time.

As in many developed countries, however, the intensity of human activities in centres of population has an impact on ambient (outdoor) air quality from time to time. An ageing vehicle fleet and the use of coal and wood for home heating can have a detrimental effect on air quality in some areas. In addition, busy, congested roads in some built-up urban areas can adversely affect local air quality.

Natural factors that affect air quality

Two key natural factors that affect air quality are the weather and New Zealand's geography.

Weather

Pollution levels depend not just on the amount of pollution generated (that is, 'emissions'), but also on how quickly pollution can be dispersed. In this respect, the weather has a strong influence on pollution levels. For example, 'temperature inversions', which trap pollution near ground level, can have an adverse effect on air quality (see box 'What is a temperature inversion?' and Figure 7.1). Conversely, particularly windy and unsettled weather can have a beneficial effect on air quality.

Geography

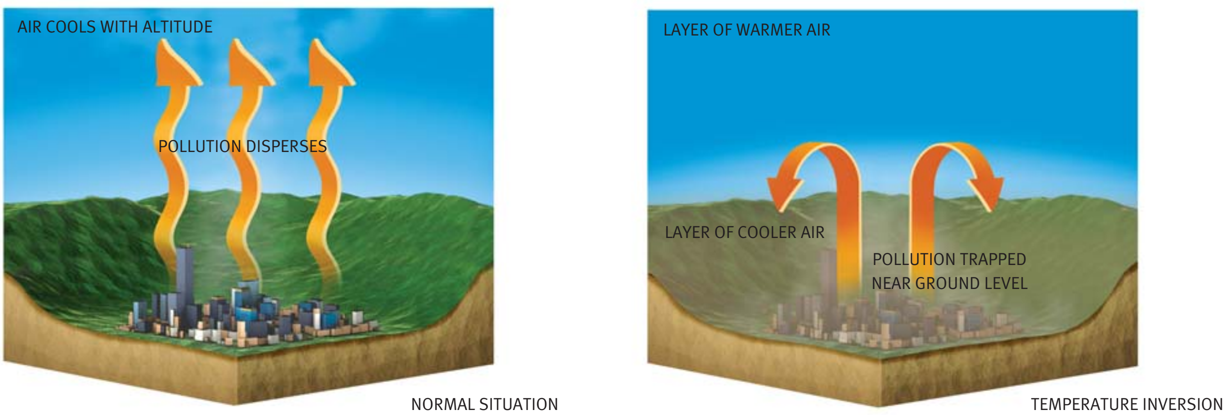
Geographical features also affect the dispersion of air pollution. Settlements in locations with geographical features such as valleys or low-lying land surrounded by hills are often more susceptible to a build-up of pollution.

What is a temperature inversion?

A temperature inversion is a layer of warm air that sits over a layer of cooler air near the ground. Temperature inversion layers typically form just after sundown on still winter nights as the air temperature at ground level rapidly decreases. Because cool air is heavier than warm air, the cool air often remains trapped close to the ground.

Inversion layers occur between 10 and several hundred metres above the ground depending on the weather conditions. Air pollution that gets trapped under the inversion layer can build up, causing air pollution levels to rise (see Figure 7.1).

+ FIGURE 7.1:
HOW TEMPERATURE INVERSIONS TRAP POLLUTION



Source: Ministry for the Environment.

Human factors that affect air quality

Home heating and transport are the greatest human influences on ambient air quality in New Zealand.

Our air quality is constantly changing. Pollution levels fluctuate as the amount of pollution emitted varies over time. Morning and evening traffic rush hours cause variations over the day. The use of coal and wood for home heating can make air quality in winter very different from that in summer. Even air quality experienced from one year to the next can vary considerably.

Home heating – the main cause of air pollution

Home heating is the main cause of air pollution in populated areas in the winter. On average, 45 per cent of households in New Zealand burn solid fuels (coal and wood) for home heating. At a regional level, this figure varies considerably across the country, ranging from 32 per cent in Auckland to over 75 per cent on the West Coast of the South Island (Ministry for the Environment, 2005).

Pollution from road transport

Pollution from vehicles can be significant in urban areas, particularly on heavily used roads. New Zealand has one of the highest rates of private vehicle ownership in the world: transportation accounts for the largest share of our energy consumption, and is the second fastest-growing sector in terms of energy demand.

Large centres of population, such as Auckland, are more likely to experience air pollution from vehicles than smaller locations (see photo below).

Older and high-mileage petrol vehicles are more likely to be high emitters of pollution than are newer vehicles (Covec, 2005). The average age of New Zealand motor vehicles is 12.4 years. Nearly two-thirds of the newly registered vehicles in New Zealand are used imports rather than new vehicles (see chapter 4, ‘Transport’).

Until 1996, New Zealand’s petrol contained lead additives, which prevented the use of equipment to control exhaust emissions from petrol vehicles. As a result, many vehicles on New Zealand roads are not built to any emission standards.

BUSY AUCKLAND MOTORWAY.

Source: Courtesy of Gavin Fisher.

GOVERNMENT ACTION on air quality

Central government undertakes a range of regulatory and non-regulatory initiatives to improve New Zealand's air quality. Below are examples of government initiatives that have been undertaken in recent years.

Warm Homes initiatives

Through the Warm Homes project, central government is working with local government to help New Zealanders reduce the pollution effects of home heating while staying warm. The project aims to ensure all New Zealanders heat their homes cleanly, efficiently, and sufficiently. Pilot programmes were run in Tokoroa, Timaru, and Taumarunui to retrofit homes with insulation and new heating sources, and evaluate the impacts of this on air quality and health. In 2006, the Warm Homes project also ran seven community workshops in six regions across New Zealand.

In addition, the Government has committed $72 million over four years to help New Zealand families live in warm, dry, healthy, and energy efficient homes. This includes $23 million for an interest-free loans scheme to help householders pay for energy efficiency and cleaner heating options. While the main focus is on energy efficiency, $5.4 million will be targeted at the installation of clean forms of heating for low-income households in areas of poor air quality.

Transport initiatives

Petroleum Products Specifications Regulations 2003

These Regulations specify the technical requirements for petrol and diesel supplied for retail sale (excluding aviation, jet boat, and motor racing). Progressive improvements in fuel specifications have reduced the amount of pollutants such as PM_{10} and benzene that are emitted from vehicle exhausts. Reduction of aromatics and the lowering of vapour pressure also limit the amount of petrol that evaporates into the air during refuelling and from hot vehicle engines.

The Vehicle Exhaust Emissions Rule

This Land Transport Rule, introduced in 2003, requires all motor vehicles entering the New Zealand fleet for the first time to have been manufactured to the applicable emissions standards specified in the rule. Since 2006, the rule has required all vehicles to undergo a visible smoke test check at every compliance test (that is, border entry, warrant of fitness, and certificate of fitness inspections). This complements the Land Transport (Road User) Rule 2004 which requires that vehicles do not emit visible smoke for more than 10 seconds.

At the time of writing, government is consulting on proposed tighter emissions standards for new vehicles and used vehicles entering New Zealand.

Reducing the sulphur content of diesel in New Zealand

In 2002, the Government introduced regulations that reduced the sulphur content of diesel. By September 2002, the sulphur content of diesel available in Auckland and Northland had reduced from 3,000 parts per million to 1,000 parts per million.

In August 2004, levels were further reduced throughout New Zealand to 500 parts per million. This was followed by another decrease to 50 parts per million in January 2006, representing a 60-fold reduction in sulphur content since 2002. The sulphur content in diesel will be further reduced to 10 parts per million in January 2009.

Other programmes and initiatives

Other programmes and initiatives undertaken by central government include educational or public awareness campaigns, or programmes which support initiatives led by local government. Examples include the following initiatives:

- The Sustainable Management Fund (SMF) was established in 1994 to help communities, iwi, local government, and industry with projects that have a long-term environmental benefit. In 2005, $800,000 of SMF funding was made available to local government to help them implement new air quality monitoring requirements under the national environmental standards for air quality.
- Recent government research relating to air quality includes work on the health and air quality impacts of home heating, and a performance review of the wood burner design standard.
- A number of recent transport initiatives contribute to improved air quality in New Zealand. These include the New Zealand Transport Strategy, *Towards a sustainable transport system by 2010*, the Biofuels Sales Obligation 2006, a draft New Zealand Rail Strategy, and the 'Choke the Smoke' public awareness campaign on vehicle emissions.

National environmental indicator

See chapter 1, 'Environmental reporting', for more information on the core national environmental indicators and how they are used.

The national environmental indicator for air provides information on air quality in managed airsheds (also known as gazetted airsheds – see box 'Gazetted airsheds'). To report on the indicator, regional councils and unitary authorities measure levels of PM_{10} particulates, nitrogen dioxide, carbon monoxide, sulphur dioxide, and ground-level ozone. The indicator compares air quality with New Zealand's national environmental standards (NESs) for ambient air quality. In this chapter, we refer to the NESs for ambient air quality as 'ambient standards'.

Gazetted airsheds

Regional councils and unitary authorities have identified and made public (through the New Zealand Gazette) populated areas that are known, or have the potential, to have levels of pollutants higher than permitted by the ambient standards. These areas are referred to as gazetted airsheds.

At the time of publication, 69 airsheds had been gazetted. Of these, 68 were gazetted because of their potential to breach the ambient standard for PM_{10} particulates. The other airshed is at Marsden Point, Northland. It has the potential to breach the ambient standard for sulphur dioxide.

During the winter of 2006, air quality failed to meet the ambient standard for PM_{10} particulates at 28 airsheds. Most of these events occurred during winter temperature inversions.

National environmental standards for ambient air quality

In September 2005, five ambient standards for air quality came into effect. These are part of 14 national environmental standards introduced through the Resource Management (National Environmental Standards Relating to Certain Air Pollutants, Dioxins, and Other Toxics) Regulations 2004 (made under the Resource Management Act 1991).

The ambient standards set maximum thresholds for five commonly recognised, or key, air pollutants. These are PM_{10} particulates, nitrogen dioxide, carbon monoxide, sulphur dioxide, and ground-level ozone. Although the effects of air pollution on the natural environment are recognised, New Zealand's ambient standards are measured primarily against human health thresholds.

Reporting on air quality

The Regulations require regional councils and unitary authorities to measure and publicly report on air quality whenever pollution in a gazetted airshed exceeds limits set by the ambient standards. Regional councils and unitary authorities have identified airsheds where PM_{10} particulates are known or suspected to be of concern. PM_{10} particulate levels in these airsheds are required to comply with the ambient standard for that pollutant by 2013.

In addition to ambient standards, the Regulations introduced other measures to improve air quality, including prohibition and design standards as discussed below.

Prohibition standards

Certain activities such as burning tyres, bitumen, coated wire, and oil in the open air have been prohibited. The standards also prohibited the use of incinerators at schools and health-care institutions unless authorised by resource consent, and prohibited the use of new high-temperature hazardous waste incinerators.

Design standard for wood burners

A design standard for new wood burners installed after September 2005 has been introduced to ensure the reduction of particulate emissions and provide better heat efficiency than that achieved by older wood burners. Although the wood burner standard limits emissions of particulates, it has the additional benefit of controlling emissions of other harmful pollutants such as carbon monoxide, volatile organic compounds (VOCs), hydrocarbons, and dioxins (see box 'What are dioxins?').

What are dioxins?

Dioxins are highly toxic compounds (known as persistent organochlorines) that build up in the fatty tissue of animals and humans. They are known to affect the immune, nervous, and reproductive systems, and have been linked to cancer. The World Health Organization has determined that no safe levels exist for exposure to dioxins.

Dioxins are formed as the result of chemical processes. Discharges of dioxins to the air mainly come from burning waste, fuel combustion, and industrial activities such as metal smelting.

Dioxins released into the air move with air currents but eventually settle on the land or water. Dioxins can enter the food chain when grazing animals or fish ingest them, and they are stored in their fatty tissue. Over 90 per cent of people's exposure to dioxins in New Zealand is thought to come from their eating meat, fish, and dairy products.

Background levels of dioxins in New Zealand are generally low compared with levels in many northern hemisphere countries (Ministry for the Environment, 2001). Historically, activities such as the manufacture of 2,4,5-T (for example, in New Plymouth) and some timber-tanalising processes were significant sources of dioxin. However, dioxin levels have fallen over past decades as New Zealand has moved away from activities that generate dioxins (Ministry for the Environment, 2006b).

A study undertaken to determine the concentration of persistent organochlorine compounds (including dioxins) in the breast milk of New Zealand women showed that levels of these pollutants decreased by about 70 per cent between 1988 and 1998 (Bates et al, 2001).

In line with our international commitments under the 2001 Stockholm Convention, a series of measures have been taken to reduce the release of dioxins through the New Zealand Dioxin Action Plan agreed in 2002 (Ministry for the Environment, 2006b).

In addition, seven national environmental standards were introduced from 2004 to ban certain dioxin-producing activities, such as burning waste in school and hospital incinerators, burning tyres or coated wire in the open, and operating new high-temperature hazardous waste incinerators.

Limits set by the five ambient standards

The limits set by the ambient standards are summarised in Table 7.1.

+TABLE 7.1:
NEW ZEALAND'S NATIONAL ENVIRONMENTAL STANDARDS FOR AMBIENT AIR QUALITY

POLLUTANT	CONCENTRATION LIMIT	NUMBER OF OCCASIONS CONCENTRATION LIMIT MAY BE EXCEEDED
PM_{10} particulates	50 µg/m^3 (measured as a 24-hour average)	One 24-hour period in a 12-month period
Nitrogen dioxide	200 µg/m^3 (measured as a 1-hour average)	Nine hours in a 12-month period
Carbon monoxide	10 mg/m^3 (measured as a running 8-hour average)	One 8-hour period in a 12-month period
Sulphur dioxide	350 µg/m^3 (measured as a 1-hour average)	Nine hours in a 12-month period
	570 µg/m^3 (measured as a 1-hour average)	Not to be exceeded at any time
Ozone	150 µg/m^3 (measured as a 1-hour average)	Not to be exceeded at any time

Note:
µg/m^3 = micrograms per cubic metre.
Source: Resource Management (National Environmental Standards Relating to Certain Air Pollutants, Dioxins, and Other Toxics) Regulations 2004.

The indicator discussed in this chapter measures air quality in terms of the number of exceedences, peak levels, and annual averages for each pollutant.

Exceedences are the number of times a pollutant fails to meet an ambient standard. Each ambient standard provides a permissible number of occasions in which the standard may be exceeded in any 12-month period. When more exceedences occur than are permitted by the Regulations, the air quality is described as breaching the standard. For example, the Te Kūiti airshed exceeded the ambient standard for PM_{10} particulates twice during 2005, constituting one breach of the ambient standard.

Peak levels indicate the *severity* of pollution events (that is, the maximum level) over a 12-month period, while exceedences indicate the *frequency* of pollution events over a reporting period. For example, the highest 24-hour concentration for PM_{10} particulates in the Te Kūiti airshed during 2005 was 54 micrograms per cubic metre.

Annual averages are the average concentration of the pollutant over a year. Annual averages are useful for trend analysis, because data is averaged over a year, so is less affected by unusual, or atypical, values. Annual averages can also indicate the long-term exposure of New Zealanders to pollutants. The ambient guidelines recommend an annual average concentration limit of 20 micrograms per cubic metre for PM_{10} particulates.

Pollutants measured by the national environmental indicator for air

PM_{10} particulates

PM_{10} particulates are airborne particles that are smaller than 10 microns in diameter (about a fifth of the thickness of a human hair). These particles are described as 'thoracic' because they are small enough to penetrate deeply into the human lung. They have a broad range of negative health effects on people's respiratory and cardiovascular systems.

Particulates are produced by the combustion of wood (see Figure 7.2a) and fossil fuels (mostly by home heating and road traffic), as well as various industrial processes.

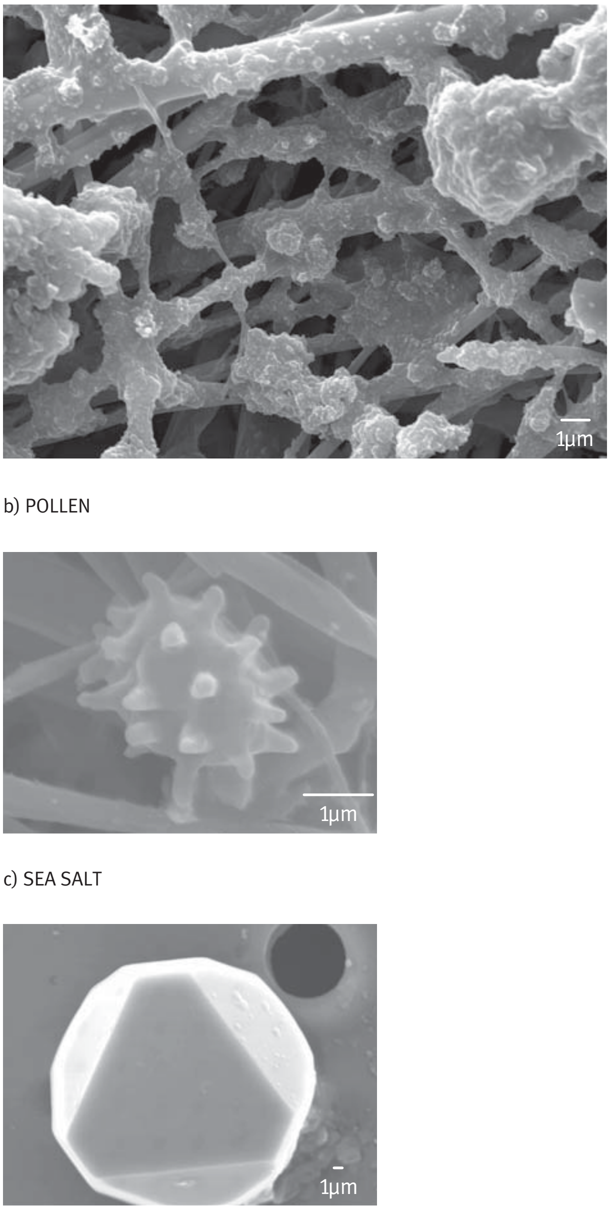
Secondary particulates also form through atmospheric reactions of sulphur dioxide, oxides of nitrogen, and certain organic compounds. Particulates do not come just from human sources. Natural sources such as dust, pollen (see Figure 7.2b), sea salt (see Figure 7.2c), and soil particles also contribute to PM_{10} particulate levels in the environment. Though the ambient standards set acceptable levels of PM_{10} particulates, there are no safe levels (that is, any level of PM_{10} particulates has some adverse effect on health).

+ FIGURE 7.2:
ELECTRON MICROSCOPE IMAGES OF PARTICULATES

a) WOOD BURNER PARTICULATES

b) POLLEN

c) SEA SALT



Source: Courtesy of Perry Davy.

Nitrogen dioxide

Nitrogen dioxide results from the combustion of fossil fuels (coal, gas, and oil) and some industrial processes.

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

Traffic tends to be the main source of nitrogen dioxide emissions in the urban environment, although industry is the main source of nitrogen dioxide emissions in several locations.

Carbon monoxide

Carbon monoxide is a product of the incomplete combustion of carbon-containing fuels such as wood, coal, petrol, and diesel.

Carbon monoxide is readily absorbed by the lungs and interferes with the blood's ability to carry oxygen. The effects of carbon monoxide exposure increase in severity as exposure increases. Foetuses and people with heart disease are the most vulnerable to elevated carbon monoxide levels.

The main sources of carbon monoxide in most urban areas are traffic and home heating.

Sulphur dioxide

Sulphur dioxide is produced during the combustion of fuels containing sulphur, such as coal and diesel.

Sulphur dioxide is a respiratory system irritant and can restrict the airways of people suffering from asthma or chronic lung disease. The effects of sulphur dioxide are worse when a person is exercising, because they draw this highly reactive pollutant more deeply into the lungs. Sulphur dioxide has also been linked to cardiovascular disease.

In most parts of New Zealand the main source of sulphur dioxide is industry. Motor vehicles are the main contributor in areas with little industry. Diesel vehicles produce higher emissions than do petrol vehicles. In Wellington, the main source of sulphur dioxide is shipping.

Ozone

Ozone occurs naturally in the upper atmosphere, or stratosphere (see chapter 8, 'Atmosphere'), where it screens out harmful ultraviolet radiation. However, at ground level, ozone affects the respiratory and cardiovascular system and can cause tissue damage to the lungs. Acute effects occur if a person is exercising in high levels of ozone.

Ground-level ozone is a secondary pollutant. It is not emitted directly but forms when volatile organic compounds (VOCs) react with oxides of nitrogen in the presence of sunlight.

Transport is a significant contributor of oxides of nitrogen and VOCs. Other sources of VOCs include home heating and some industrial processes.

Other pollutants not measured by the national environmental indicator for air

Air quality in New Zealand can be affected by pollutants that are not included as part of the national environmental indicator for air. In addition to the ambient standards, New Zealand has ambient air quality guidelines (ambient guidelines) that recommend health-based concentration limits for 15 pollutants. Table 7.2 summarises the limits set by the ambient guidelines for three pollutants that have reached elevated levels across New Zealand in the past.

+ TABLE 7.2:
AMBIENT GUIDELINES FOR OTHER POLLUTANTS

POLLUTANT	RECOMMENDED CONCENTRATION LIMIT
$PM_{2.5}$	25 µg/m^3 (measured as a 24-hour average)
Benzene	10 µg/m^3 (measured as an annual average reducing to 3.6 µg/m^3 measured as an annual average from 2010)
Lead	0.2 µg/m^3 (measured as a three-month moving average)

Notes:
(1) µg/m^3 = micrograms per cubic metre.
(2) The $PM_{2.5}$ concentration limit is not strictly a health-based guideline. It is recommended that levels above this limit are further investigated.
Source: Ministry for the Environment, 2002.

$PM_{2.5}$ particulates

Particulate matter is composed of particles of varying sizes, but is often described as 'coarse' or 'fine'.[4] PM_{10} particulates include particulates smaller than 10 microns in diameter, and encompass both coarse and fine components. $PM_{2.5}$ particulates represent the fine component alone, being solely composed of particles smaller than 2.5 microns in diameter.

Several studies indicate that $PM_{2.5}$ particulates are more directly linked to negative health effects than are PM_{10} particulates. $PM_{2.5}$ particulates can penetrate further into the lungs than can PM_{10} particulates, and can reach the alveoli or gas-exchange region of the lungs.

Most $PM_{2.5}$ particulates come from combustion sources. Most particulate matter from natural sources (such as sea salt and soil particles) is larger than 2.5 microns in diameter.

Benzene

The main sources of benzene in urban areas are transport and home heating. Benzene is emitted from the exhaust pipes of vehicles and through the evaporation of petrol. Other sources of benzene include oil refineries and petrochemical production.

Benzene is a known carcinogen that can negatively affect bone marrow, leading to anaemia and other complications.

Lead

Lead is a heavy metal that can be absorbed into the body through the lungs, stomach, and intestines. The absorption of lead can affect the development of foetuses and impair brain development in young children.

Exhaust-pipe emissions from petrol vehicles used to be a significant source of airborne lead when petrol contained lead additives to boost the octane rating. However, reductions of the lead levels in petrol in New Zealand began in 1986, culminating in the complete removal of lead additives in 1996.

Airborne lead emissions can also come from industrial activities such as metal smelting.

Limitations of the indicator

The four key limitations are listed below.

Number and type of pollutants covered

The indicator covers only the five key ambient air pollutants of national significance. In addition, it does not include indoor air pollution.

Health impacts of air quality

The indicator is set up to track air quality against limits for protecting people's health. However, it is not able to show the health effects of air quality on people.

Furthermore, the indicator does not show synergistic effects from exposure to two or more pollutants in the environment. This is relevant because combustion processes give rise to several pollutants simultaneously.

Variations in weather and climate

The indicator reports on the state of air quality over time, but does not allow for the influence of variations in weather and climate from year to year. This makes it difficult to assess whether changes in air quality are caused by changing environmental pressures (reduction in the emission of pollutants) or meteorological variations.

Main centres of population

Before the introduction of the ambient standards in 2005, many locations had little or no nationally comparable monitoring that provided data for long-term trends of air quality. As a result, and given that the air indicator is concerned with human exposure to pollution, this chapter focuses on the following five major centres of population for which longer data sets are available: Auckland, Hamilton, Wellington, Christchurch, and Dunedin.

4 Some publications describe PM_{10} particulates as 'fine' particulates. While PM_{10} particulates do have a fine particulate component, they also contain a coarse component. For this reason, PM_{10} particulates are not called 'fine' particulates in this report.

Current state and trends

This section covers the state and trends of the following five key air pollutants:

- PM_{10} particulates
- nitrogen dioxide
- carbon monoxide
- sulphur dioxide
- ozone.

In addition to these five key air pollutants, this section also looks at $PM_{2.5}$ particulates, benzene, and lead.

PM_{10} particulates

State of PM_{10} particulates in gazetted airsheds during 2005

This section provides an overview of the state of PM_{10} particulates across New Zealand.

As most of New Zealand is expected to have good air quality, only 1.5 per cent of New Zealand's total land area has been gazetted as airsheds to date. However, about 65 per cent of New Zealanders live in a gazetted airshed as a result of New Zealand having a highly urbanised population (see chapter 2, 'Our environment and people'). Furthermore, about 53 per cent of New Zealanders live in a gazetted airshed that has breached the PM_{10} particulate ambient standard.

Elevated PM_{10} particulate levels

About 30 locations in New Zealand experience periods of poor air quality[5] each year resulting from elevated levels of PM_{10} particulates. Elevated PM_{10} particulate levels are not restricted to large centres of population (see photo below). Even very small communities can experience poor air quality during winter, where domestic coal or wood burning is prevalent and conditions prevent adequate dispersion of pollutants. Auckland is particularly affected by emissions from road traffic as well as by emissions from home heating in the winter.

AIR POLLUTION IN A RURAL COMMUNITY DURING A WINTER TEMPERATURE INVERSION.

Source: Courtesy of Greater Wellington Regional Council.

5 For the purposes of this report, where air quality breaches ambient standards, or exceeds ambient guidelines, air quality is described as 'poor'.

Poor air quality in winter

Air pollution episodes during winter in Christchurch are generally well known. However, smaller settlements around the country such as Alexandra, Tīmaru, Nelson, and Richmond also experience poor winter air quality from elevated PM_{10} particulate levels. Reefton, with a population of about 990, is New Zealand's smallest gazetted airshed that experiences high winter PM_{10} particulate levels.

Exceedences in monitored airsheds during 2005

Figure 7.3 shows the frequency and extent of exceedences of PM_{10} particulates in monitored airsheds during 2005 (that is, the number of times levels of PM_{10} particulates were higher than the level allowed by the ambient standard and the highest 24-hour concentration experienced).

During 2005, several airsheds, including Nelson, Tīmaru, Alexandra, and Christchurch, experienced a large number of exceedences of the ambient standard for PM_{10} particulates.

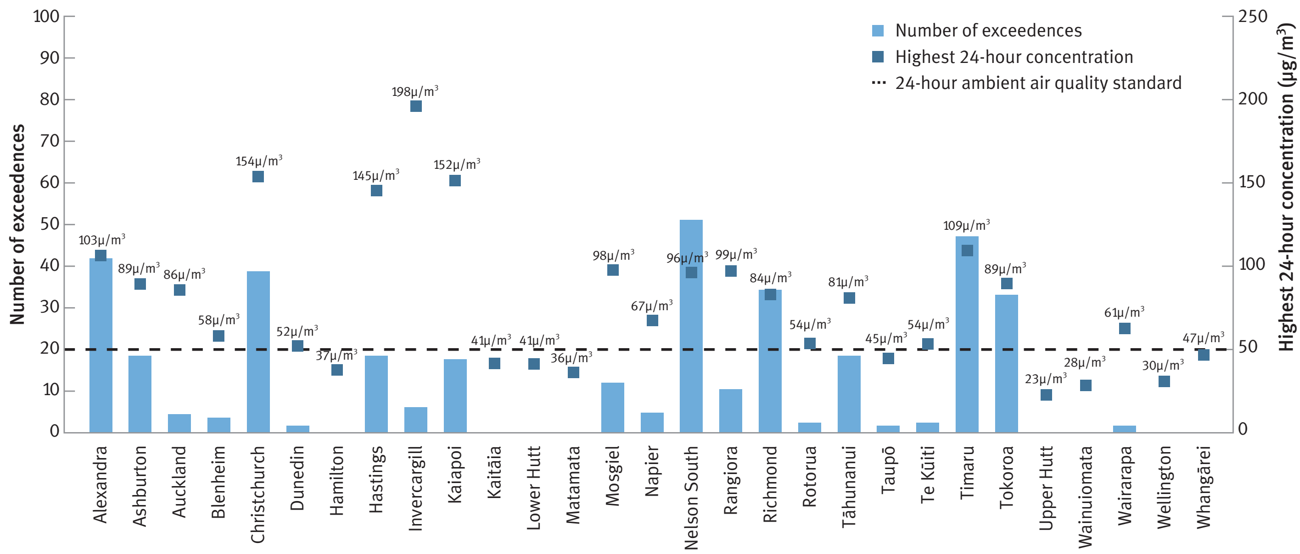
The greatest number of exceedences (51) was experienced in the Nelson South airshed. Although Nelson South exceeded the ambient standard most frequently, monitoring in other airsheds recorded higher 24-hour concentrations. The highest 24-hour concentration in the Nelson South airshed for 2005 was 96 micrograms per cubic metre, compared with 198 micrograms per cubic metre and 154 micrograms per cubic metre in the Invercargill and Christchurch airsheds respectively.

The ambient standard for PM_{10} permits one annual PM_{10} particulate exceedence in 12 months. Therefore, the ambient standard was not breached in Dunedin, Taupō, and the Wairarapa for 2005 (each of which had one exceedence in 2005). The ambient standard was also not breached in the locations in Figure 7.3 for which no exceedences are shown.

The majority of the exceedences shown in Figure 7.3 are limited to the winter months, with PM_{10} particulate levels usually meeting the ambient standard for the rest of the year. This pattern is demonstrated for Christchurch in Figure 7.4.

+ FIGURE 7.3:

HIGHEST 24-HOUR CONCENTRATIONS AND EXTENT OF EXCEEDENCES OF PM_{10} PARTICULATES IN MONITORED AIRSHEDS, 2005



Notes:

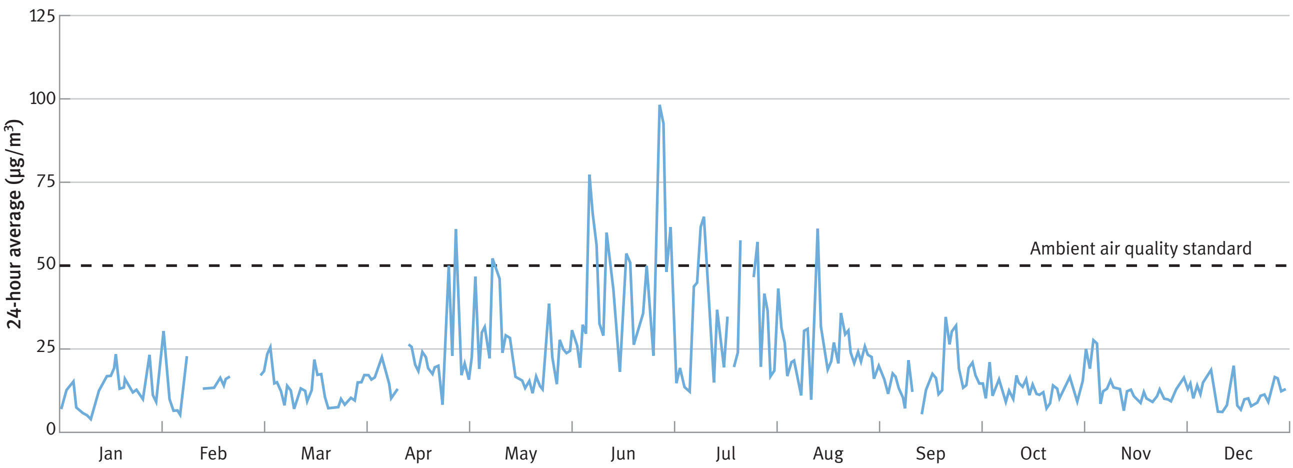
(1) μg/m^3 = micrograms per cubic metre.

(2) No data was available for Reefton for 2005.

(3) The data for Richmond was extrapolated to account for one-day-in-three monitoring.

Source: Ministry for the Environment.

+ FIGURE 7.4:
PM_{10} PARTICULATE LEVELS IN BURNSIDE, CHRISTCHURCH, 2005



Note:
µg/m³ = micrograms per cubic metre.
Data source: Ministry for the Environment, 2006a.

State of PM_{10} particulates outside gazetted airsheds

Areas outside gazetted airsheds are sparsely populated, and, as a result, little PM_{10} particulate monitoring occurs in the rural environment and areas free from emissions caused by human activity. However, data collected outside of the airsheds does confirm that New Zealand is expected to have good air quality in most locations.

The National Institute of Water and Atmospheric Research (NIWA) measures aerosol optical depth (AOD) in Lauder, Central Ōtago. AOD is a measure of the clarity, or visibility, of the air, and is affected by the amount of particles and light-absorbing gases in the air. Measurements of AOD at Lauder are among the lowest observed in the world (up to 10 times lower than at sites in the northern hemisphere that are considered clean), and are often similar to measurements in Antarctica and Hawaii, indicating that New Zealand has comparatively excellent air quality by world standards.

More about health effects of pollution – the Health and Air Pollution in New Zealand study

The 2007 Health and Air Pollution in New Zealand study identifies and quantifies the human health risks of exposure to air pollution, based on results from 67 urban areas. The study confirms the findings of a study in 2002 that estimated the number of New Zealanders dying prematurely because of traffic-related air pollution was similar to the number of people dying from road traffic accidents (Fisher et al, 2007).

The 2007 study also found the following:

- Each year, about 1,100 people die prematurely from exposure to urban air pollution.
- The total economic cost of air pollution in New Zealand is estimated to be $1.14 billion each year. This figure equates to $421 for each person.
- People whose health is most affected by air pollution are:
  - older people, particularly those over 65 years
  - infants, particularly those under 1 year
  - people with asthma and other respiratory problems
  - people with other chronic diseases, such as heart disease.

Other less obvious effects from air pollution include restricted activity days (for example, days off work from illness) that occur during periods of poor air quality.

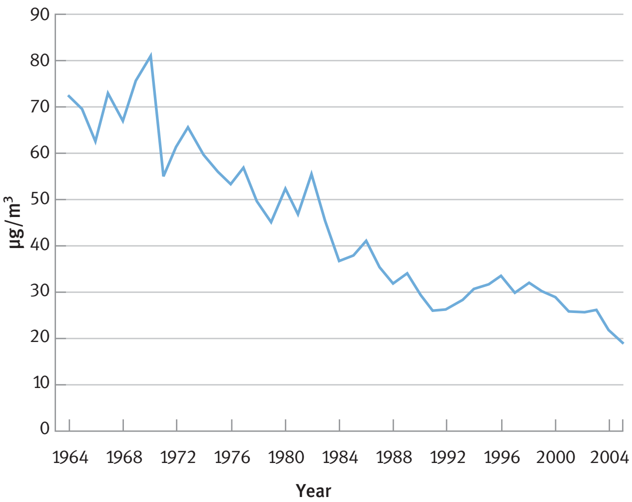
Recent trends in PM_{10} particulate levels in the main centres

Total suspended particulate levels

The earliest data for particulate matter dates back to monitoring established in Auckland in 1964 to measure total suspended particulate (TSP) levels. TSP encompasses a wide range of particle sizes, and includes any particles with a diameter up to 50 microns. This measurement has been superseded by PM_{10} particulate monitoring, which focuses on the more specific size range of particles associated with negative health effects.

Figure 7.5 shows a significant decrease in TSP levels over the past 40 years. Though the amount of particulates released into the air has fallen over this period, it is not known what proportion of the TSP was made up of PM_{10} particulates. This factor makes it difficult to quantify the extent to which PM_{10} particulate levels have fallen over the 40-year period, although some correlation would be expected.

+ FIGURE 7.5:
ANNUAL TOTAL SUSPENDED PARTICULATE LEVELS IN AUCKLAND, 1964–2005



Note:
µg/m³ = micrograms per cubic metre.
Data source: Auckland Regional Council, 2006a.

Poor air quality in the Auckland airshed

Monitoring of PM_{10} particulates at 12 sites in the Auckland airshed indicates that the region experiences incidences of poor air quality, including at the residential site, Takapuna (see Figure 7.6). Levels at other residential sites in Auckland show similar or slightly lower levels of PM_{10} particulates.

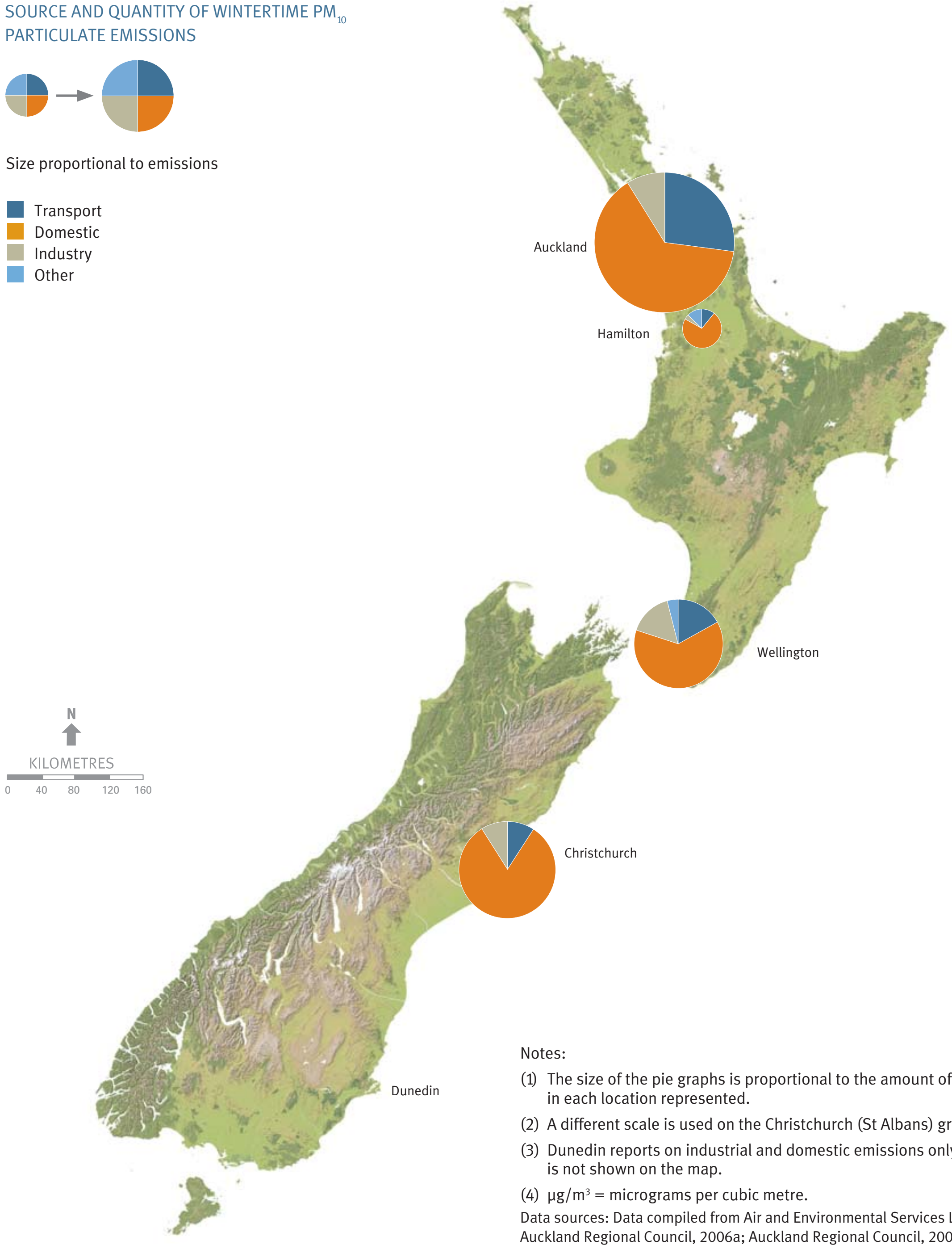
Monitoring of PM_{10} particulates at busy transport corridors in Auckland shows higher levels than in residential areas, though annual average levels at two roadside sites appear to be improving. However, this trend may have been influenced by reduced traffic flows resulting from nearby road improvements, rather than representing an overall improvement in the region.

High peak levels of PM_{10} particulates in Christchurch

Of the five main centres of population, Christchurch experiences some of the highest peak levels of PM_{10} particulates, mostly during winter temperature inversions. Monitoring at the residential site, St Albans, shows incidences of poor air quality each year, with more than 50 exceedences recorded in 1999 and 2001 (see Figure 7.6). The topography of the Canterbury Plains is particularly vulnerable to temperature inversions, so several other airsheds in the region have similar incidences of poor air quality during the winter.

+ FIGURE 7.6:
PM_{10} PARTICULATE LEVELS AND EMISSIONS IN MAIN CENTRES OF POPULATION

SOURCE AND QUANTITY OF WINTERTIME PM_{10} PARTICULATE EMISSIONS



Notes:

(1) The size of the pie graphs is proportional to the amount of emissions in each location represented.

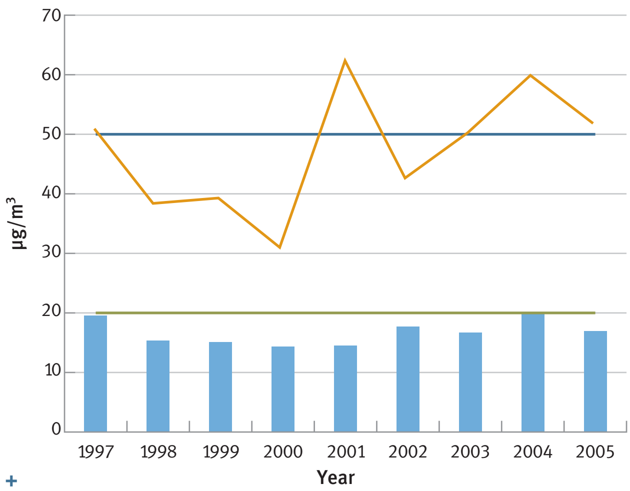
(2) A different scale is used on the Christchurch (St Albans) graph.

(3) Dunedin reports on industrial and domestic emissions only and therefore is not shown on the map.

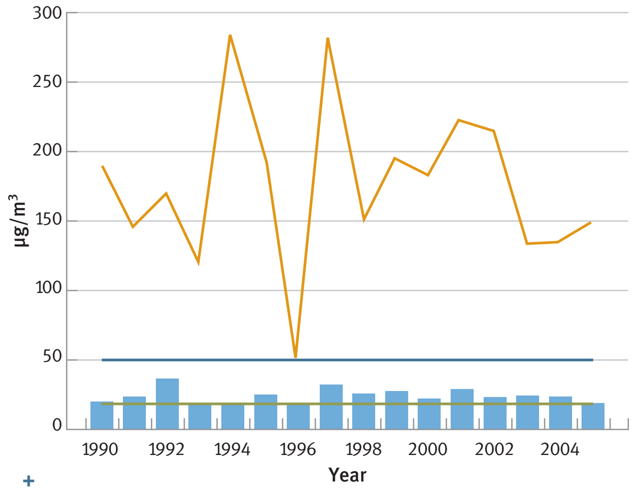
(4) μg/m³ = micrograms per cubic metre.

Data sources: Data compiled from Air and Environmental Services Ltd, 2001; Auckland Regional Council, 2006a; Auckland Regional Council, 2006b; Environment Canterbury, 2004; Environment Canterbury, 2006; Environment Waikato, 2006a; Environment Waikato, 2006b; Greater Wellington Regional Council, 2005; Otago Regional Council, 2005a; Otago Regional Council, 2005b.

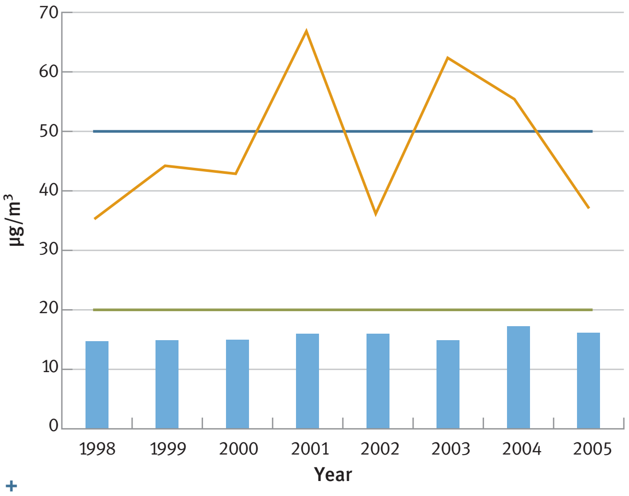
+
AUCKLAND (TAKAPUNA) PM_{10}



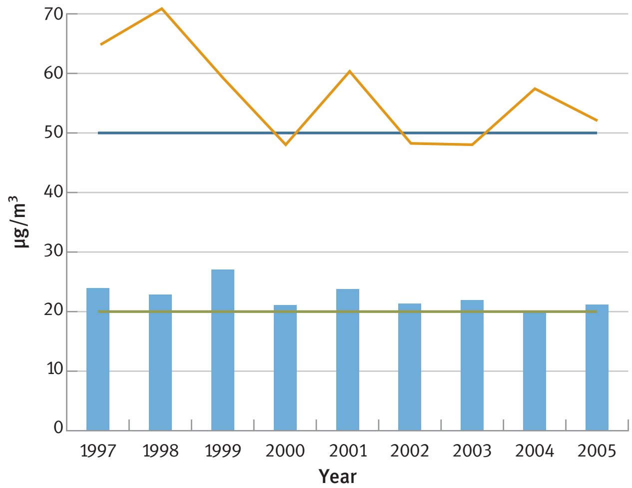
+
CHRISTCHURCH (ST ALBANS) PM_{10}



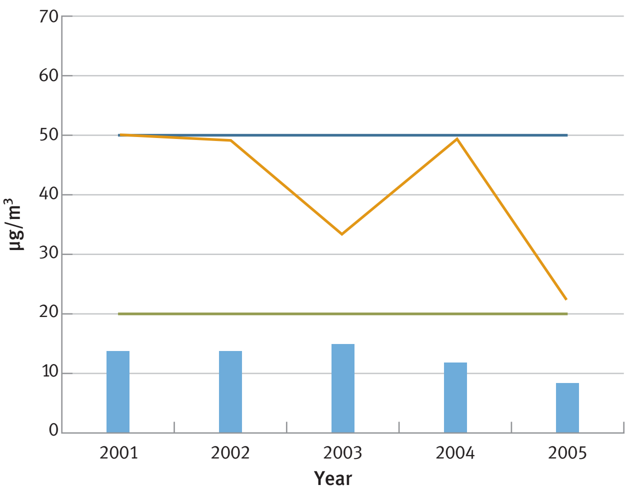
+
HAMILTON PM_{10}



+
DUNEDIN PM_{10}



+
WELLINGTON (UPPER HUTT) PM_{10}



Annual averages
24-hour NES standard
24-hour maximum
Annual guideline

Winter exceedences of PM_{10} particulates in Hamilton and Dunedin

Hamilton and Dunedin experience exceedences of the ambient standard for PM_{10} particulates during the winter. Residential monitoring sites in Hamilton and Dunedin have experienced poor air quality in recent years (see Figure 7.6). Note that the Dunedin data is based on monitoring equipment that is unable to monitor on a daily basis. Continuous monitoring equipment has recently been installed that will provide a better picture of annual PM_{10} particulate levels over the year than was previously possible.

No exceedences recorded in Wellington

No long-term data on air quality in residential areas is available for central Wellington. However, monitoring at busy roadside locations around Wellington indicates no exceedences of the ambient standard to date.

Monitoring of PM_{10} particulates in residential areas is carried out in other parts of the Wellington region, such as Upper Hutt (see Figure 7.6). Though potentially susceptible to wintertime pollution episodes, this site has had no exceedences of the ambient air quality standard recorded.

Sources of PM_{10} particulates

Emissions vary depending on the time of year

The quantity and main sources of PM_{10} particulate emissions caused by human activity change seasonally, depending on the type of activities at different times of the year. Winter emissions have the greatest effect on air quality because this time of year tends to be when emissions are highest. For example, Auckland produces an estimated 29 tonnes of PM_{10} particulates each day during the winter, with 64 per cent of emissions coming from home heating sources. In the summer, this level falls to an estimated 10 tonnes each day, with most emissions coming from the transport sector.

Home heating is a main source of PM_{10} particulates in winter

Home heating is the biggest source of PM_{10} particulates during winter in all five main centres of population. In metropolitan Christchurch and Dunedin a particularly high proportion of winter PM_{10} particulates come from home heating.

LOCAL ACTION on home heating

Regional councils and territorial authorities undertake a wide range of programmes in their communities to reduce the effects of air pollution caused by home heating emissions. Below are examples of local initiatives that contribute to national improvements in air quality.

Environment Canterbury Clean Heat project

Environment Canterbury's Clean Heat project offers householders a free energy audit of their homes. The project also provides assistance to low-income homeowners to replace open fires and burners with cleaner heating options and to upgrade housing insulation.

Nelson City Council Clean Heat Warm Homes programme

The Nelson City Council Clean Heat Warm Homes programme is modelled on Environment Canterbury's Clean Heat project and has operated since 2003.

Nelson City Council and Tasman District Council Good Wood scheme

Firewood retailers are encouraged to become 'Good Wood' suppliers who agree to supply dry wood (or wood that will be dry for the following winter). Suppliers must have moisture meters to confirm the moisture content of the wood supplied. Retailers who agree to the code can use the Good Wood logo. Regular marketing and promotion of Good Wood suppliers is carried out by the Nelson City Council and Tasman District Council.

Nelson City Council Smoke Patrol

Nelson City Council has a dedicated smoke patrol officer. The officer's role is to identify excessively smoky domestic fires and offer the householder advice on ways to reduce smoke, information about Good Wood, and financial assistance to upgrade old burners and improve insulation.

Method of home heating affects PM_{10} particulates

Although home heating is the main source of winter PM_{10} particulates in Hamilton, emissions are lower than for many other urban areas in the region. A large proportion of Hamilton households (64 per cent) use gas to heat their main living areas, and only 1 per cent of households burn coal (Environment Waikato, 2006b). (Particulate emissions from gas appliances are negligible.)

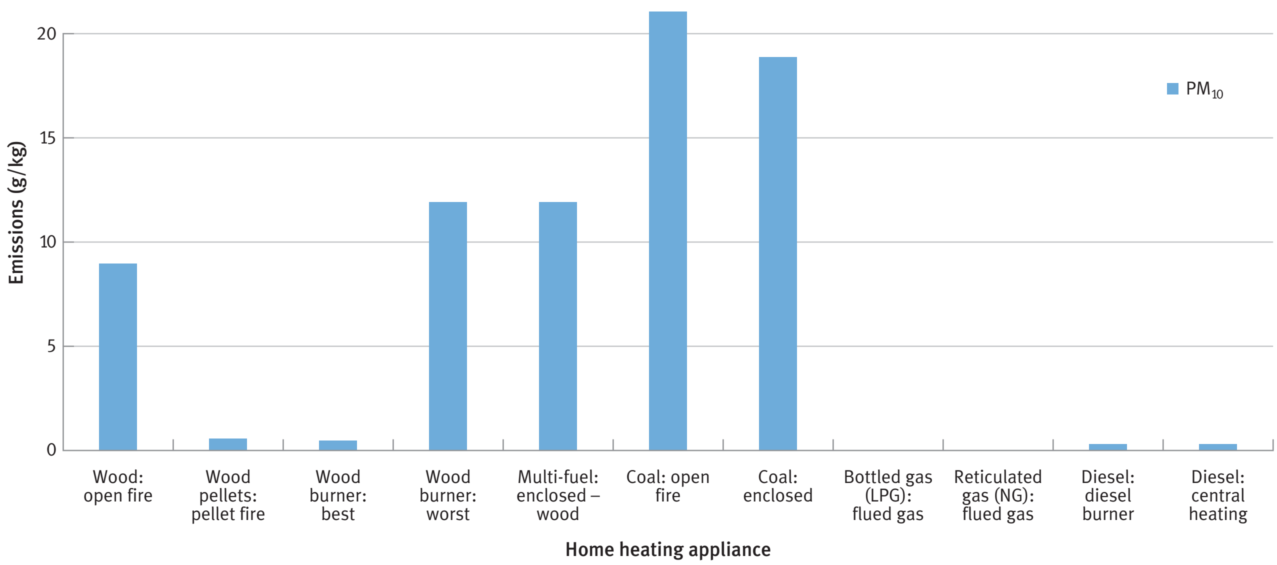
Figure 7.7 shows typical PM_{10} particulate emissions from different types of home heating appliances. Both Auckland and Christchurch have reported lower PM_{10} particulate emissions in recent years. Over the same period, homeowners have changed to methods of home heating that produce less pollution.

Total home heating emissions in metropolitan Christchurch decreased by 15 per cent between 1999 and 2002 (despite an increase in the number of households). This decrease in emissions coincided with a regional decrease in the use of open fires, coal, and wood and an increase in the use of electricity, oil, and gas (Environment Canterbury, 2004).

More about emissions from home heating appliances

Figure 7.7 shows the emissions of PM_{10} particulates from different types of heating appliance. Open coal fires have the highest emissions and are the least thermally efficient. Emissions from wood burners vary because older appliances were designed to less stringent standards than the current national environmental standard wood burner design standard (1.5 grams of PM_{10} particulates per kilogram of wood burnt). Real-life emissions (as distinct from the laboratory tests on which the design standard is based) from solid fuel burners vary considerably, depending on the quality of fuel used and how the appliance is operated and maintained.

+FIGURE 7.7:
PM_{10} PARTICULATE EMISSIONS FROM DIFFERENT TYPES OF HOME HEATING APPLIANCES



Note:
This figure does not include emissions from heating appliances that have no flue or chimney to carry combustion products outside. The Ministry of Health advises caution in the use of unflued gas heaters indoors because of the potentially harmful build-up of nitrogen dioxide, carbon monoxide, and excessive water vapour indoors.

Source: Ministry for the Environment, 2005.

Road traffic emissions as a source of PM_{10} particulates

Road traffic is another significant source of PM_{10} particulates, and is the main source of PM_{10} particulate emissions in Auckland over an entire year. About 73 per cent of PM_{10} particulate emissions from motor vehicles come from diesel exhaust alone (Auckland Regional Council, 2006b). The use of diesel fuel is expected to increase, particularly in commercial vehicles (Ministry of Economic Development, 2006).

Contribution to emissions from diesel vehicles

Badly tuned vehicles contribute a significant amount of air pollution. It is estimated that 10 per cent of all vehicles produce about 40 per cent of total vehicle emissions (Ministry of Transport, 2007). Emissions are made worse when an engine is poorly tuned. A diesel engine can continue running in a more neglected state than can a petrol engine.

Both diesel and petrol contain small amounts of sulphur that is not removed during the refining process. Sulphur in diesel leads to the formation of sulphate particulates. Reducing the sulphur content of diesel reduces emissions of PM_{10} particulates and ensures fuel is suitable for the introduction of newer-technology vehicles that produce lower emissions.

LOCAL ACTION on traffic pollution

The following initiatives are examples of actions regional councils and territorial authorities can take to reduce air pollution caused by traffic emissions.

Auckland Regional Council 0800 Smokey campaign

In August 2000, Auckland Regional Council began a public education campaign designed to raise awareness of Auckland's air pollution problems from motor vehicles, and to get Aucklanders to take action. The aims of the 0800 Smokey campaign were to:

- raise awareness that motor vehicle emissions cause more than 80 per cent of the air pollution in Auckland and that owners should tune their vehicles to reduce the impact of motor vehicle emissions
- promote the 0800 SMOKEY hotline and website through which people could report smoky vehicles
- raise the profile of air quality in the region to influence national policies on fuel quality and vehicle importation.

Free exhaust emission checks were offered to vehicle owners.

Over a 15-week period, 20,000 people reported 23,000 different vehicles. One vehicle was reported 67 times.

Auckland Regional Council Bus Emissions Reduction project

In July 2003, Auckland Regional Council funded the collaborative Bus Emissions Reduction project to identify and trial initiatives for reducing emissions from buses and heavy vehicles. Key outcomes include:

- developing a *bus emissions prediction model* to evaluate the environmental performance of different fleet options
- undertaking *emissions testing* to identify buses for targeted maintenance
- trialling *retrofitting of diesel oxidation catalysts* as a cost-effective means of reducing emissions from older buses
- participating in a joint *biodiesel trial* with other stakeholders to identify potential air quality benefits.

Nitrogen dioxide

Recent trends in nitrogen dioxide levels in the main centres

Sites close to major roads or industrial sources are the most likely locations to be affected by elevated levels of nitrogen dioxide. The roadside Khyber Pass Road site in Auckland (see Figure 7.8) is located alongside a heavily congested road, carrying more than 27,000 vehicles each day. This site experiences periods of poor air quality each year. In 2001, the site experienced an unusually high number of exceedences (53 exceedences over 23 days), illustrating the effect that atmospheric conditions can have on pollution levels in different years.

Monitoring at two recently commissioned roadside sites in Wellington reports higher levels of nitrogen dioxide than in residential areas, but nevertheless indicates good air quality.

Levels of nitrogen dioxide in residential areas of Christchurch and Wellington also indicate good air quality (see Figure 7.8). Though the Christchurch site has experienced poor air quality in the past, nitrogen dioxide levels have been good over the past 10 years.

Figure 7.8 also shows nitrogen dioxide levels at the industrial Penrose site in Auckland. This site is fringed with residential properties that are likely to experience higher levels of nitrogen dioxide than are other Auckland residential monitoring sites. The industrial Penrose site has not exceeded the ambient standard more than the nine times permitted by the standard. However, this site has experienced exceedences of the ambient standard for nitrogen dioxide during some years.

No long-term, continuous nitrogen dioxide monitoring occurs in Hamilton or Dunedin. Monitoring surveys conducted in Hamilton during 1998 and 1999 indicate that nitrogen dioxide levels were low. Monitoring methods used in Dunedin differ from methods used at sites in Figure 7.8, so results from Dunedin cannot be assessed in the same way as the results of other main centres.

Sources of oxides of nitrogen

Most emissions are not emitted as nitrogen dioxide but mainly in the form of nitric oxide. Once released to the atmosphere, nitric oxide can be further oxidised to form harmful nitrogen dioxide. Estimates of emissions are for this reason always expressed as oxides of nitrogen.

Transport is the main source of oxides of nitrogen in all main centres of population, accounting for about 80–90 per cent of emissions. It is interesting to note that a significant proportion of oxides of nitrogen emissions in Wellington come from shipping.

In Auckland, estimates of oxides of nitrogen emissions have increased slightly since 1998. This is attributed to an increase in the number of diesel vehicles in the region (Auckland Regional Council, 2006b). Diesel vehicles produce higher oxides of nitrogen emissions than an equivalent petrol engine. At a national level, the number of diesel vehicles on the roads has increased by 39 per cent between 2001 and 2006 (see chapter 4, 'Transport').

In contrast, estimates of oxides of nitrogen emissions from motor vehicles in Christchurch have decreased by 5 per cent, despite a 12 per cent increase in the number of vehicle kilometres travelled. This is thought to be the result of an increase in the number of vehicles with emission control equipment in the region (Environment Canterbury, 2004).

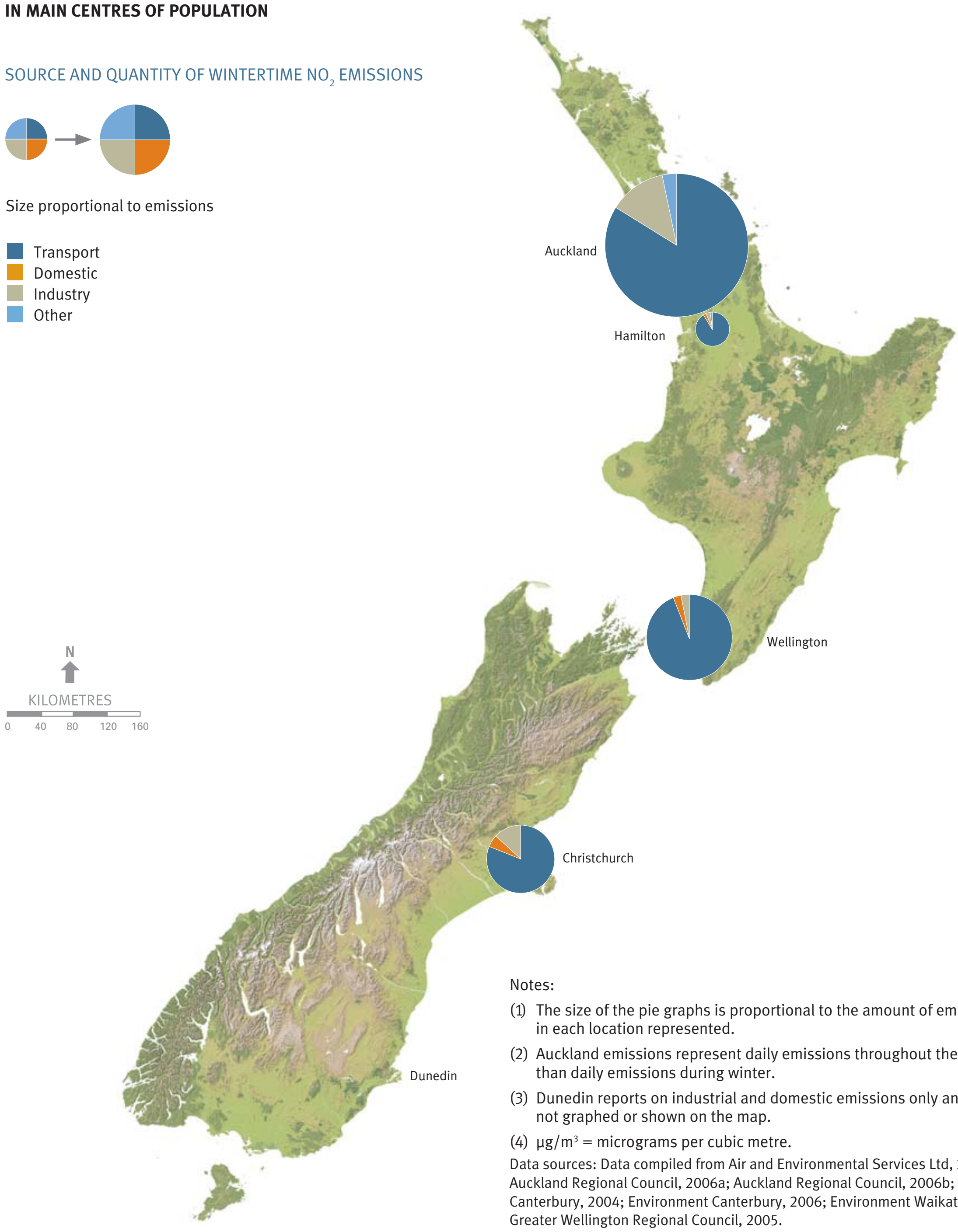
Recent emission estimates for Dunedin do not include motor vehicle emissions.

+FIGURE 7.8:
NITROGEN DIOXIDE (NO_2) LEVELS AND EMISSIONS IN MAIN CENTRES OF POPULATION

SOURCE AND QUANTITY OF WINTERTIME NO_2 EMISSIONS

Size proportional to emissions

- Transport
- Domestic
- Industry
- Other



Notes:

(1) The size of the pie graphs is proportional to the amount of emissions in each location represented.

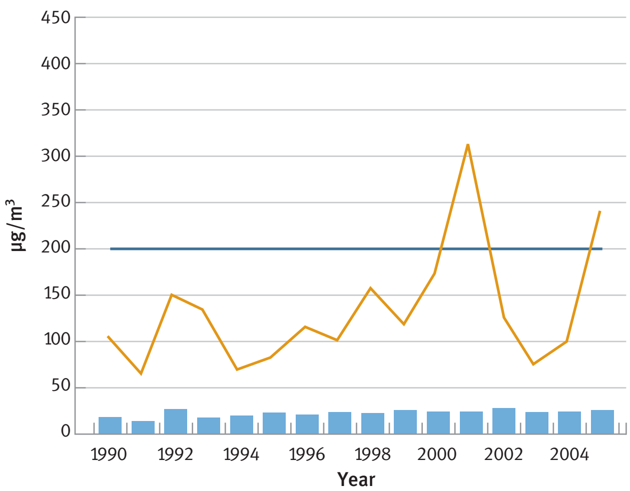
(2) Auckland emissions represent daily emissions throughout the year rather than daily emissions during winter.

(3) Dunedin reports on industrial and domestic emissions only and therefore is not graphed or shown on the map.

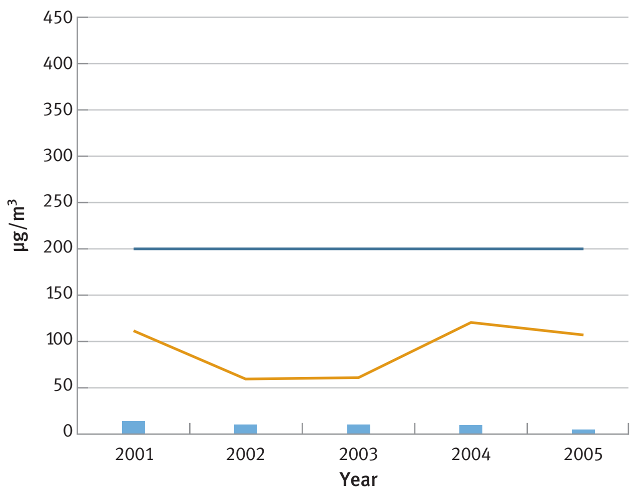
(4) µg/m³ = micrograms per cubic metre.

Data sources: Data compiled from Air and Environmental Services Ltd, 2001; Auckland Regional Council, 2006a; Auckland Regional Council, 2006b; Environment Canterbury, 2004; Environment Canterbury, 2006; Environment Waikato, 2006b; Greater Wellington Regional Council, 2005.

+
AUCKLAND (PENROSE) NO_2



+
WELLINGTON (UPPER HUTT) NO_2



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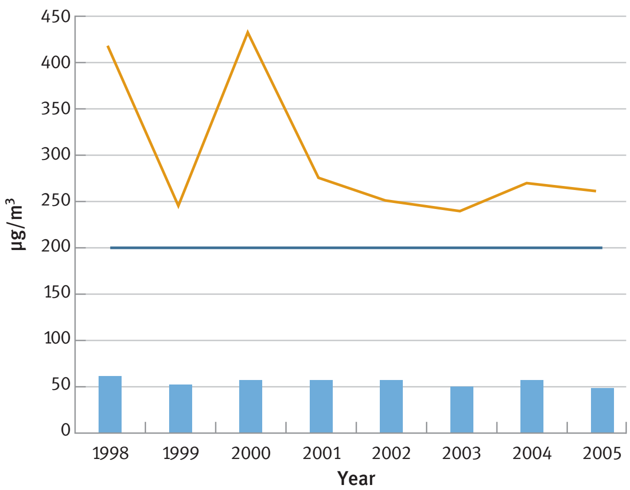
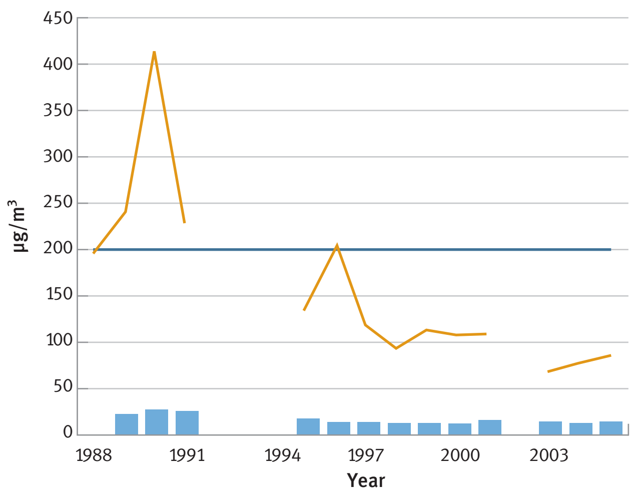
AUCKLAND (KHYBER PASS ROAD) NO_2



+
CHRISTCHURCH (ST ALBANS) NO_2



Annual averages
1-hour NES standard
1-hour maximum

Carbon monoxide

Recent trends in carbon monoxide levels in the main centres

Results of monitoring at Auckland and Christchurch sites

Levels of carbon monoxide at the Auckland and Christchurch monitoring sites appear to have fallen over the past 10 years (see Figure 7.10). This trend has been particularly noticeable at Auckland's roadside Khyber Pass Road site, which is strongly affected by traffic emissions. The site experienced a large number of exceedences of the ambient standard for carbon monoxide in the second half of the 1990s (including 190 exceedences over 47 days in 1997), but has experienced no exceedences since 1999.

Carbon monoxide levels measured in a residential area of Christchurch have also noticeably reduced. No data is available for roadside sites in Christchurch.

Results of monitoring at Hamilton and Wellington sites

Carbon monoxide levels in Hamilton and Wellington remain below the ambient standard. Monitoring was established in central Wellington in 2004 to assess the influence of transport emissions in a heavily trafficked area. Although levels are higher than those of the Lower Hutt site, levels of carbon monoxide at the central Wellington site remain well below the limit set by the ambient standard.

Dunedin screening surveys

No permanent monitoring has been established in Dunedin, but screening surveys suggest that carbon monoxide levels in Dunedin meet the ambient standard.

Sources of carbon monoxide emissions

Transport as a source of carbon monoxide emissions

Transport is the main source of carbon monoxide in New Zealand. Emissions estimates indicate that transport contributes 85 per cent of annual carbon monoxide emissions in Auckland and 51 per cent of winter emissions in metropolitan Christchurch.

Carbon monoxide emissions in both Auckland and Christchurch have fallen in recent years despite increasing numbers of vehicles and vehicle kilometres travelled. Although private vehicles and congestion increased in metropolitan Christchurch between 1999 and 2001, emissions estimates indicate that carbon monoxide from motor vehicles fell by 15 per cent (Environment Canterbury, 2004). The fall in carbon monoxide emissions is thought to result from the increasing numbers of vehicles with emission control equipment.

Home heating as a source of carbon monoxide emissions

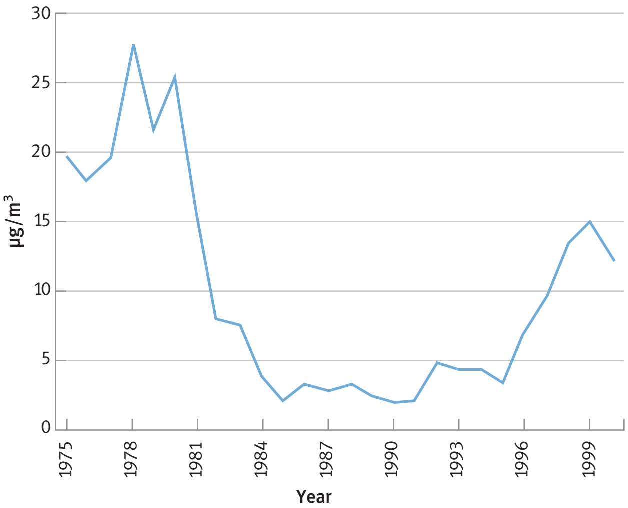
Changes in home heating also influence emissions of carbon monoxide. In Christchurch, 48 per cent of carbon monoxide emissions are estimated to come from home heating. Between 1999 and 2002 domestic emissions of carbon monoxide decreased by 13 per cent. This decrease was due to increased use of gas and electricity and a decrease in coal and wood burning, although wood remains a popular fuel choice in Christchurch (Environment Canterbury, 2004).

Sulphur dioxide

Recent trends in sulphur dioxide levels in the main centres

Figure 7.9 shows a steady fall in sulphur dioxide levels during the 1970s and 1980s as a result of the declining use of coal and heavy fuel oils in Auckland. Monitoring at other locations around New Zealand indicated a similar improvement in levels and was gradually discontinued. In the mid-1990s, sulphur dioxide levels in Auckland increased again, coinciding with an increase in the registration of new and imported diesel vehicles (particularly heavy goods vehicles).

+ FIGURE 7.9:
ANNUAL SULPHUR DIOXIDE (SO_2) LEVELS AT PENROSE, AUCKLAND, 1975–2000



Note:
µg/m³ = micrograms per cubic metre.
Data source: Auckland Regional Council, 2006a.

In recent years, improved monitoring methods have shown that the Penrose site in Auckland has had good air quality with respect to the ambient standard for sulphur dioxide (see Figure 7.11). The fall in sulphur dioxide levels at this site between 2001 and 2002 coincides with a significant reduction in the sulphur content of diesel fuel in the Auckland region. However, since 2002 the annual average has increased each year.

Levels at the residential Christchurch site (see Figure 7.11) have fallen since the early 1990s, and indicate that levels of sulphur dioxide are not of concern. However, other monitoring sites in the Canterbury region near industrial sources (such as Woolston and Hornby) have occasionally recorded high levels of sulphur dioxide.

Levels of sulphur dioxide in Hamilton, Wellington, and Dunedin are generally considered to be low and are not monitored.

Sources of sulphur dioxide

The main sources of sulphur dioxide vary across the country. In Auckland, the main source is transport emissions. In Christchurch, 80 per cent of daily wintertime emissions of oxides of sulphur come from industrial sources such as coal-fired boilers, and, to a lesser degree, diesel boilers. Vehicle emissions of sulphur dioxide in Christchurch are increasing and have been attributed to an increased number of diesel vehicles on the road (Environment Canterbury, 2004).

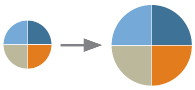
Figure 7.11 shows that 92 per cent of winter sulphur dioxide emissions in the Wellington region are from transport. Emissions inventories estimate that 93 per cent of these emissions come from commercial shipping (Air and Environmental Services Ltd, 2001). Motor vehicles are the largest source of winter sulphur dioxide in Hamilton (49 per cent), closely followed by industry (44 per cent) (Environment Waikato, 2006b). In contrast, the main source in Dunedin is industry (85 per cent), followed by home heating (15 per cent). (Otago Regional Council, 2005a). No data is available for transport in Dunedin.

Global air quality guidelines for sulphur dioxide

New Zealand's ambient standards and guidelines have been consistent with World Health Organization (WHO) recommendations. In the light of recent health research, WHO published its first global air quality guidelines in October 2006, recommending concentration limits for key pollutants. WHO's new guidelines reduce the 24-hour average sulphur dioxide guideline from 120 micrograms per cubic metre to 20 micrograms per cubic metre. New Zealand's ambient guideline is set at 120 micrograms per cubic metre. Most of New Zealand is likely to meet the new WHO guideline. However, some areas, particularly those downwind of refineries and coal-burning industrial plants, may exceed the guideline over a 24-hour period.

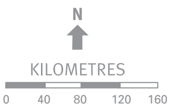
+ FIGURE 7.10:
CARBON MONOXIDE (CO) LEVELS AND EMISSIONS IN MAIN CENTRES OF POPULATION

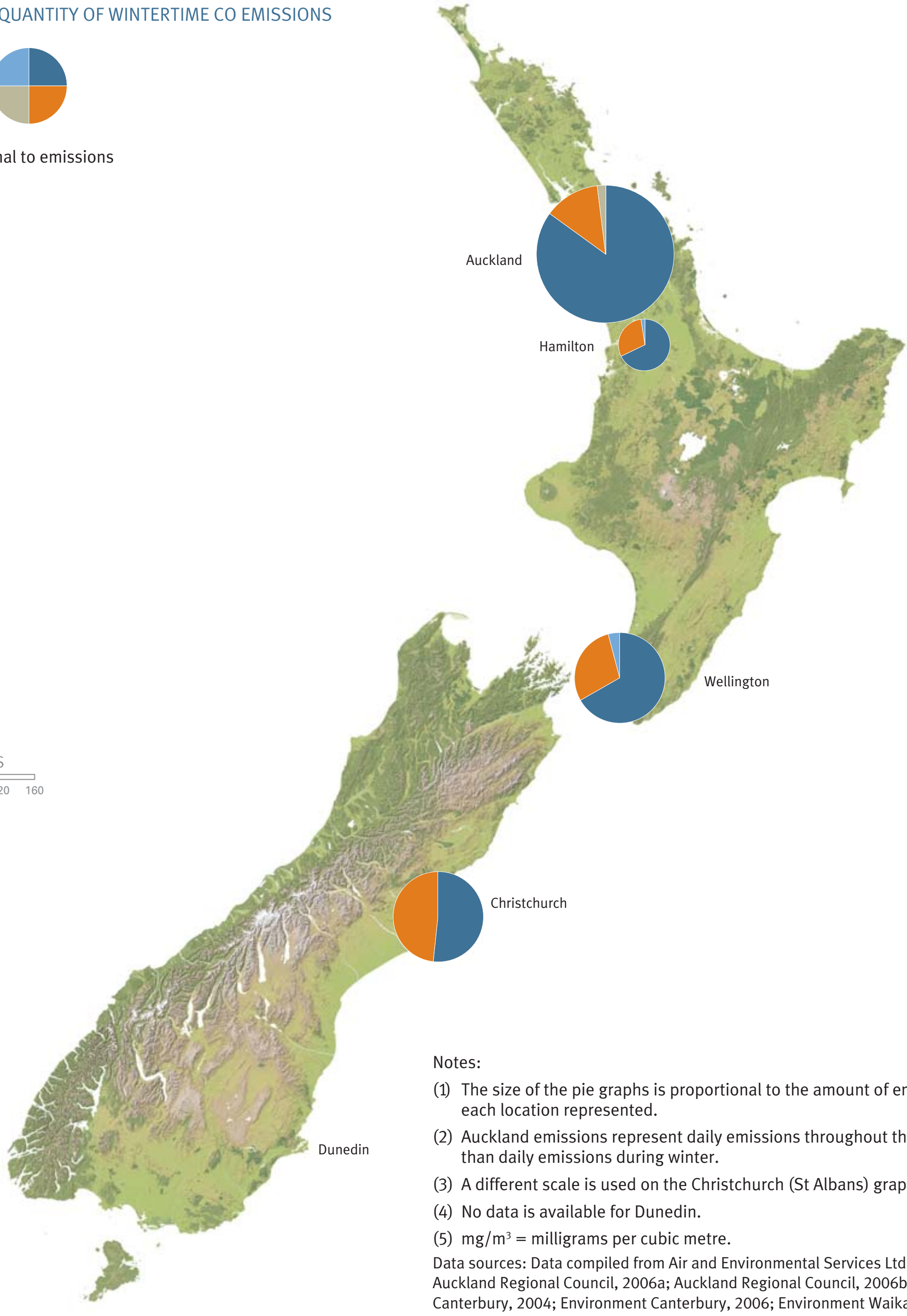
SOURCE AND QUANTITY OF WINTERTIME CO EMISSIONS



Size proportional to emissions

- Transport
- Domestic
- Industry
- Other





Notes:

(1) The size of the pie graphs is proportional to the amount of emissions in each location represented.

(2) Auckland emissions represent daily emissions throughout the year rather than daily emissions during winter.

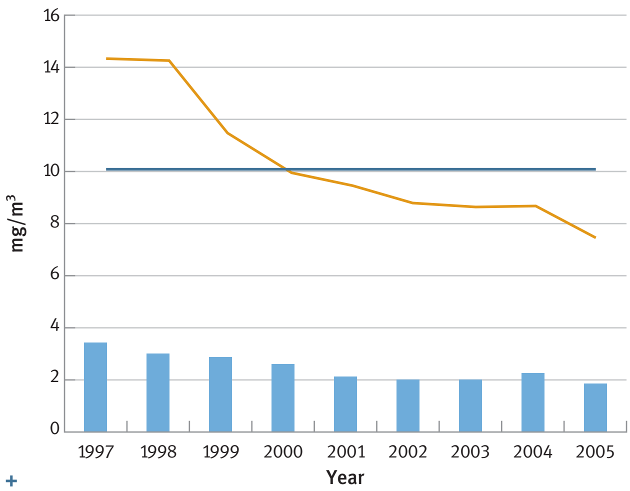
(3) A different scale is used on the Christchurch (St Albans) graph.

(4) No data is available for Dunedin.

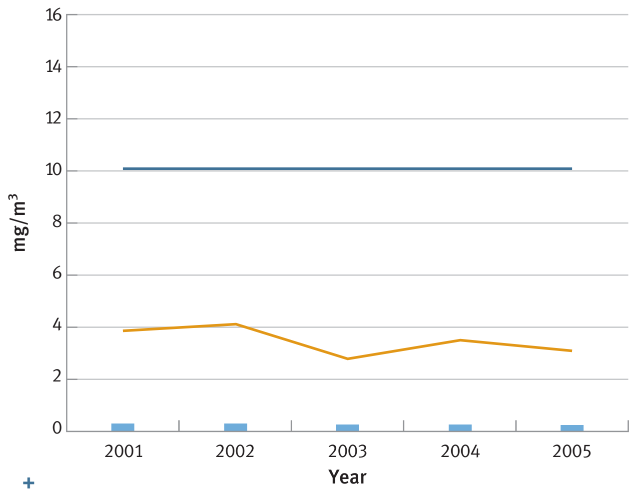
(5) mg/m^3 = milligrams per cubic metre.

Data sources: Data compiled from Air and Environmental Services Ltd, 2001; Auckland Regional Council, 2006a; Auckland Regional Council, 2006b; Environment Canterbury, 2004; Environment Canterbury, 2006; Environment Waikato, 2006a; Environment Waikato, 2006b; Greater Wellington Regional Council, 2005.

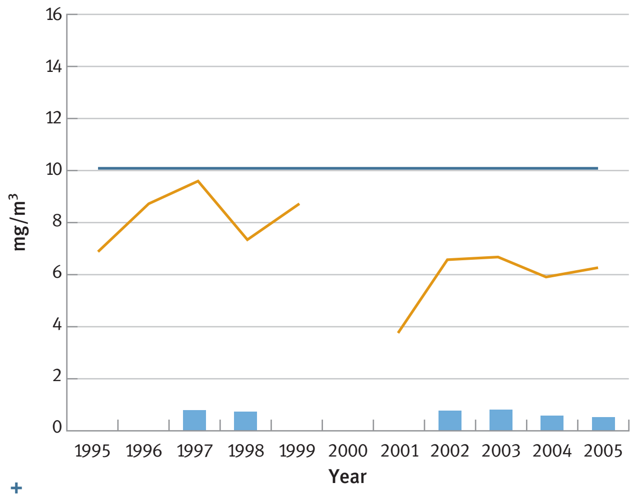
AUCKLAND (KHYBER PASS ROAD) CO



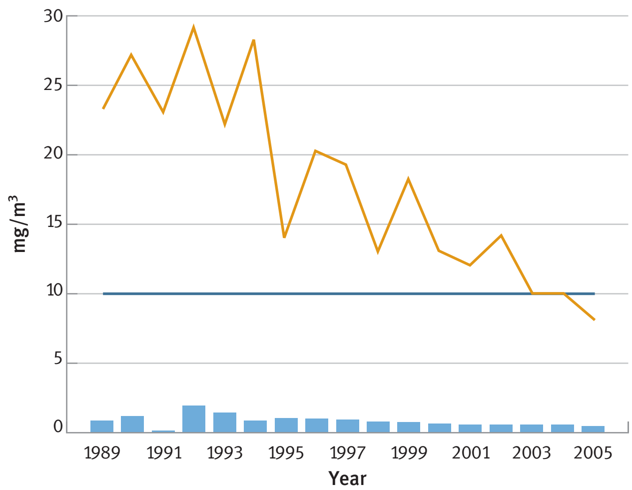
WELLINGTON (UPPER HUTT) CO



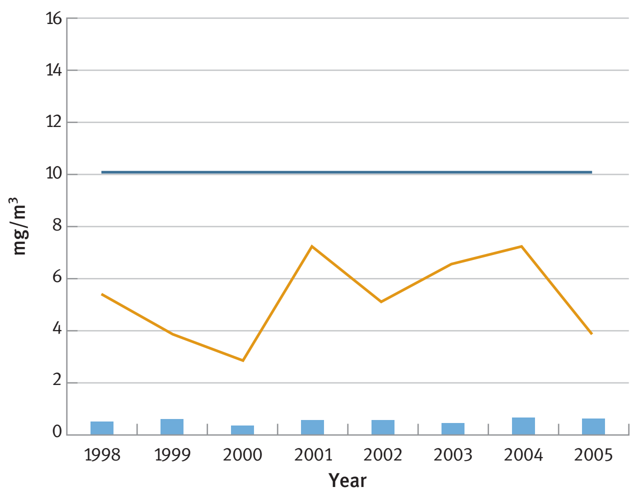
AUCKLAND (TAKAPUNA) CO



CHRISTCHURCH (ST ALBANS) CO

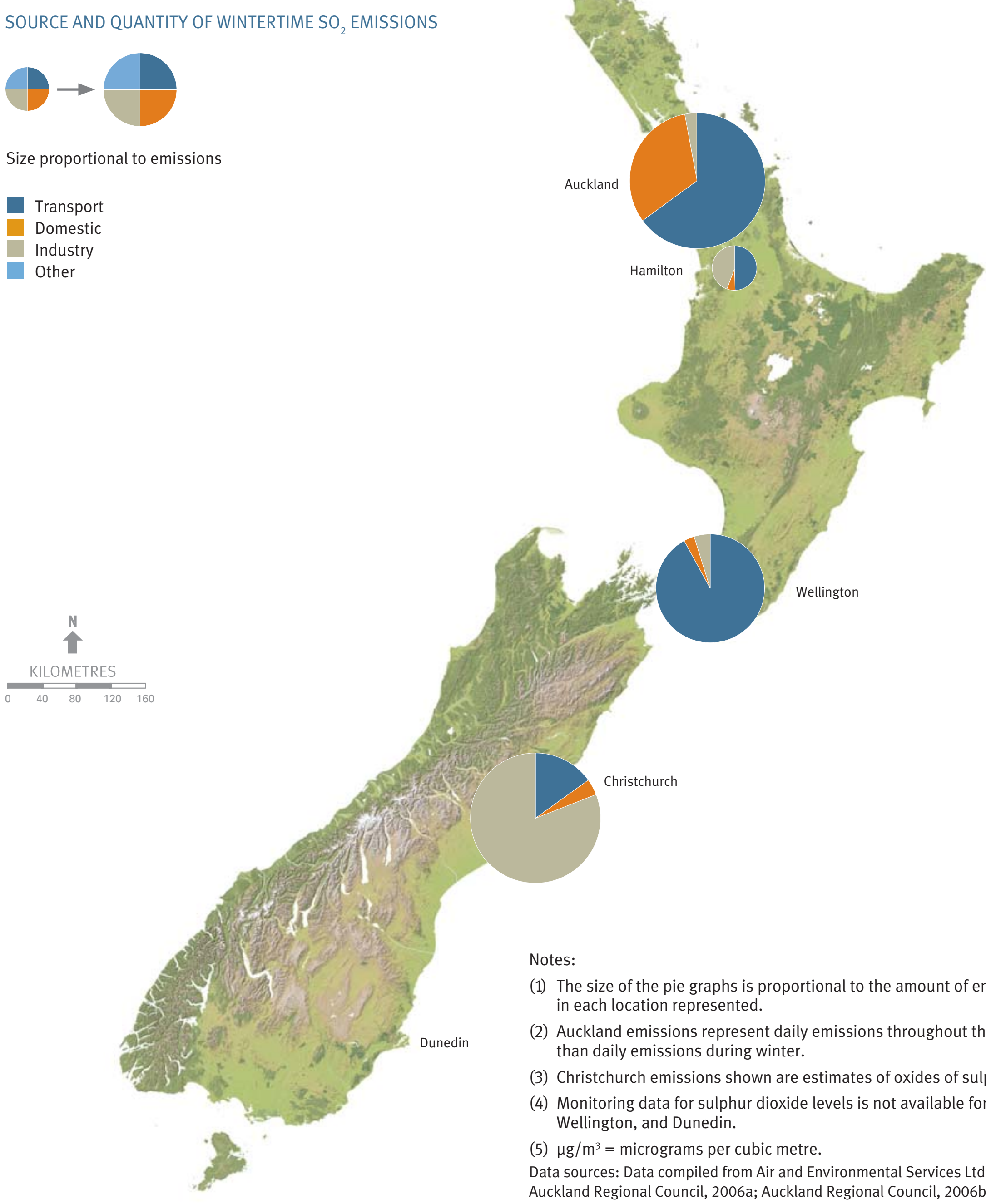


HAMILTON CO



Annual averages
8-hour NES standard
8-hour maximum

+ FIGURE 7.11:
SULPHUR DIOXIDE (SO_2) LEVELS AND EMISSIONS IN MAIN CENTRES OF POPULATION



Notes:

(1) The size of the pie graphs is proportional to the amount of emissions in each location represented.

(2) Auckland emissions represent daily emissions throughout the year rather than daily emissions during winter.

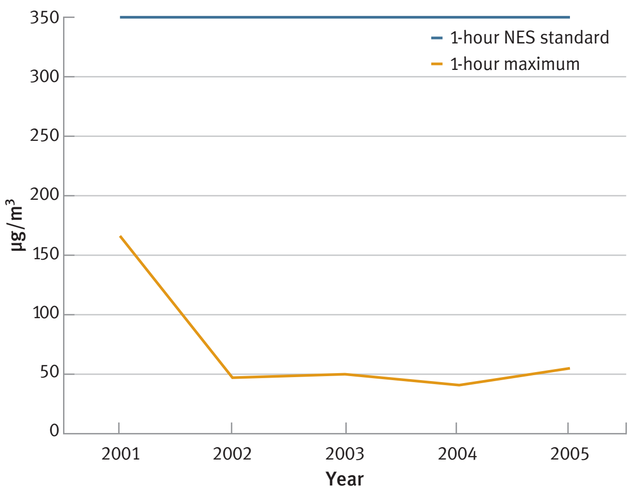
(3) Christchurch emissions shown are estimates of oxides of sulphur (SO_x).

(4) Monitoring data for sulphur dioxide levels is not available for Hamilton, Wellington, and Dunedin.

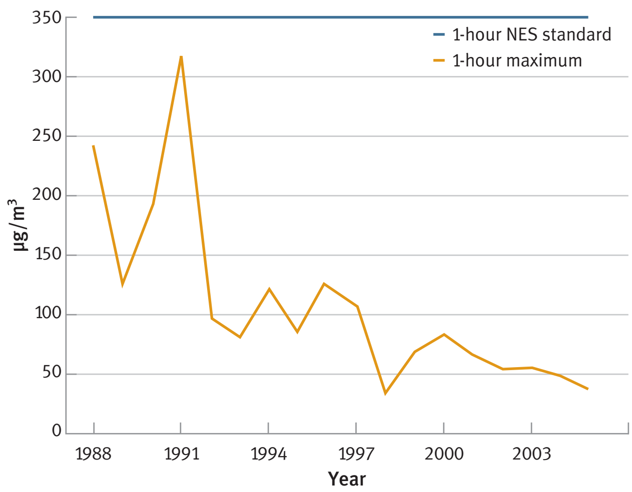
(5) µg/m³ = micrograms per cubic metre.

Data sources: Data compiled from Air and Environmental Services Ltd, 2001; Auckland Regional Council, 2006a; Auckland Regional Council, 2006b; Environment Canterbury, 2004; Environment Canterbury, 2006; Environment Waikato, 2006b.

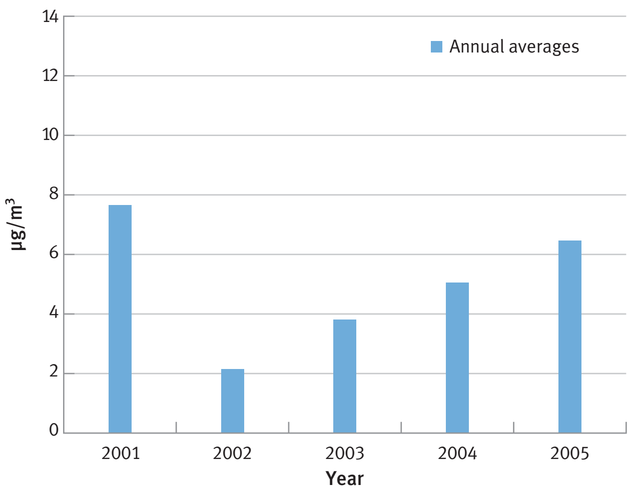
AUCKLAND (PENROSE) SO_2



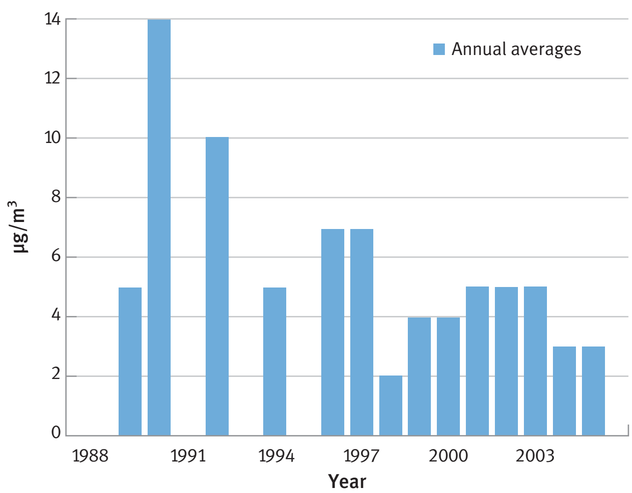
CHRISTCHURCH (ST ALBANS) SO_2



AUCKLAND (PENROSE) SO_2



CHRISTCHURCH (ST ALBANS) SO_2



Ozone

Recent trends in ozone levels in the main centres

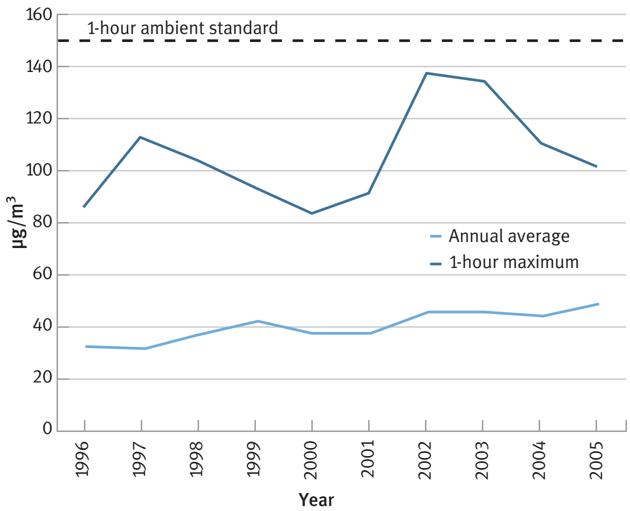
Auckland, Christchurch, and Hamilton have been identified as having the highest potential for ozone pollution (photochemical smog) during the summer (National Institute of Water and Atmospheric Research, 1996). Ozone is a secondary pollutant that requires precursor pollutants and its formation is a slow and complex process. Consequently, the highest levels tend to be found some tens of kilometres downwind of the sources of precursor pollutants.

Auckland has four ozone monitoring sites including Musick Point (see Figure 7.12). No exceedences of the ambient standard for ozone have occurred during the course of the monitoring. The Musick Point monitoring site did, however, exceed the ambient guideline twice in 2002.

Ozone is not monitored in metropolitan Christchurch. Instead, it is measured in Lincoln, 20 kilometres south west of Christchurch, where levels are expected to be highest. Monitoring for ozone during the summers of 1998 and 2003 indicated no exceedences of the ambient standard.

A short screening survey carried out in Hamilton during the 2003 summer indicated that ozone levels were considerably below the ambient standard.

+ FIGURE 7.12:
OZONE LEVELS AT MUSICK POINT, AUCKLAND, 1996–2005



Note:
µg/m³ = micrograms per cubic metre.
Data source: Auckland Regional Council, 2006a.

Sources of ozone precursors

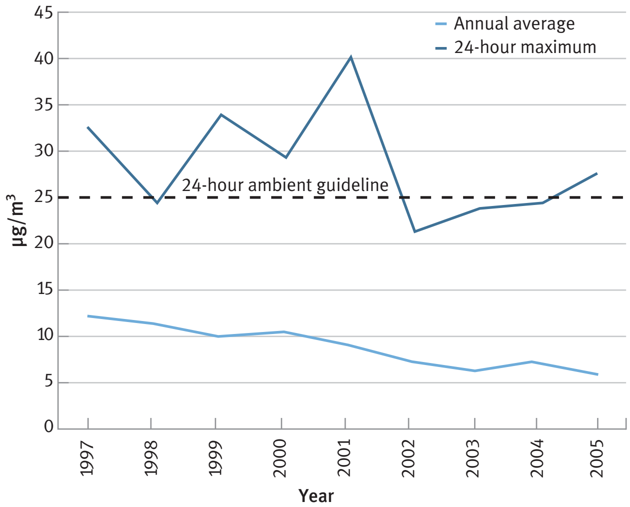
In Auckland and Hamilton, the main source of ozone precursors (oxides of nitrogen and volatile organic compounds) is traffic. In Christchurch, the main source of ozone precursors is traffic, but 60 per cent of the volatile organic compounds come from home heating (Ministry for the Environment, 2003).

$PM_{2.5}$ particulates

Monitoring indicates that the relationship between $PM_{2.5}$ and PM_{10} particulate levels can vary during the year. For example, monitoring in Christchurch indicates that the levels of PM_{10} and $PM_{2.5}$ particulates are similar in winter, but less so in summer. During summer, a larger proportion of the PM_{10} particulates come from natural sources such as sea salt and soil particles, which are largely absent in $PM_{2.5}$ particulates. During winter, both PM_{10} and $PM_{2.5}$ particulates in Christchurch come mainly from combustion sources such as home heating, so levels are more similar.

Most particulate monitoring in New Zealand is for PM_{10} particulates rather than $PM_{2.5}$ particulates.

+ FIGURE 7.13:
LEVELS OF $PM_{2.5}$ PARTICULATES IN MOUNT EDEN, AUCKLAND, 1997–2005



Note:
µg/m³ = micrograms per cubic metre.
Data source: Auckland Regional Council, 2006a.

Monitoring for $PM_{2.5}$ particulates has been carried out at several sites around Auckland. Long-term monitoring from Auckland's residential Mount Eden monitoring site indicates an overall decrease in the annual average (see Figure 7.13). Generally, Auckland experiences a few exceedences of the reporting guideline each year. The highest number of exceedences occurred at the Penrose industrial site. Exceedences of the reporting guideline are summarised in Table 7.3.

+ TABLE 7.3:
EXCEEDENCES OF THE REPORTING GUIDELINE FOR $PM_{2.5}$ PARTICULATES AROUND AUCKLAND, 1997–2005

YEAR	EXCEEDENCES OF THE $PM_{2.5}$ GUIDELINE (25 μg/m³)			
	MOUNT EDEN	PENROSE	KHYBER PASS ROAD	QUEEN STREET
1997	2	6		
1998	0	6		
1999	1	3		
2000	1	3		
2001	2	3		
2002	0	1	0	1
2003	0	5	1	1
2004	0		0	2
2005	1		1	1

Note:
μg/m³ = micrograms per cubic metre.
Data source: Auckland Regional Council, 2006a.

Some $PM_{2.5}$ particulate monitoring has been carried out in Christchurch. Environment Canterbury estimates that during nights of high PM_{10} particulate levels, 90 per cent of the particles are likely to be $PM_{2.5}$ particulates (Foster, 1998).

Winter $PM_{2.5}$ particulate levels are summarised in Table 7.4. In places where the source of PM_{10} particulates is predominantly from home heating, $PM_{2.5}$ particulate levels are likely to exceed the reporting guideline (25 micrograms per cubic metre) more frequently than the PM_{10} particulate levels exceed the ambient air quality standard (50 micrograms per cubic metre). For example, in 2001 there were 49 exceedences of the $PM_{2.5}$ particulate reporting guideline compared with 37 exceedences of the PM_{10} particulate ambient standard.

+ TABLE 7.4:
WINTER $PM_{2.5}$ PARTICULATE LEVELS AT ST ALBANS, CHRISTCHURCH, 2001 AND 2005

YEAR	MAXIMUM 24-HOUR AVERAGE	EXCEEDENCES OF THE 25 μg/m³ GUIDELINE
2001	123	49
2005	134	45

Note:
μg/m³ = micrograms per cubic metre.
Data source: Environment Canterbury, 2006.

Benzene

Annual benzene levels measured at an industrial Auckland site and residential Christchurch site (see Figure 7.14) are below both the current ambient guideline (10 micrograms per cubic metre) and the guideline limit of 3.6 micrograms per cubic metre that will take effect in 2010. Levels at roadside sites in Christchurch were higher than those in residential areas. While the Christchurch roadside levels of benzene met the current ambient guideline, annual average concentrations for 2004–2005 were greater than 3.6 micrograms per cubic metre.

Benzene levels at all Christchurch sites are decreasing (Environment Canterbury, 2005). Environment Canterbury attributes the decrease in benzene levels to improvements in vehicle emissions technology, changes in fuel specifications, and possibly, changes in the number of domestic wood burners in favour of electricity or gas. Benzene levels in petrol were reduced from 4 parts per million to 1 part per million in January 2006, which should help to further improve air quality.

Monitoring of benzene in Hamilton indicates improving air quality, with all monitored sites meeting the 2010 ambient guideline between September 2005 and September 2006 (Environment Waikato, 2006a).

+ FIGURE 7.14:
BENZENE LEVELS IN AUCKLAND AND CHRISTCHURCH, 2001–2005

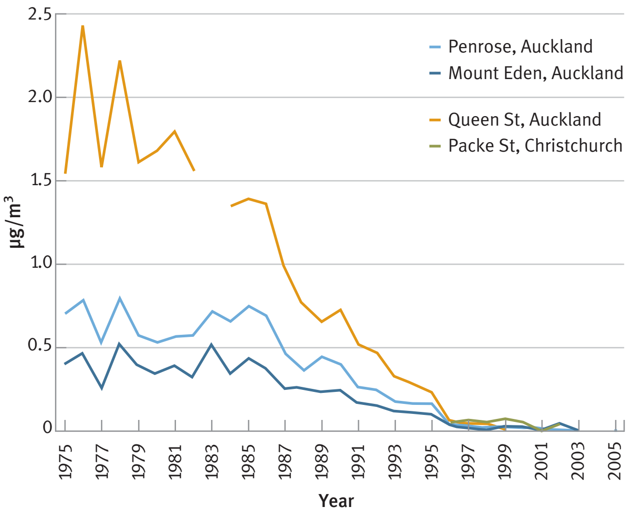
Note:
μg/m³ = micrograms per cubic metre.
Data source: Ministry for the Environment, 2006b.

Emissions data for benzene has not been widely compiled in New Zealand, and emissions factors for different sources are not well established. However, data indicates the main source of benzene emissions in Auckland is from motor vehicles. In Christchurch, home heating is the main source (51 per cent) followed by road transport (42 per cent) (Ministry for the Environment, 2003).

Lead

Figure 7.15 shows a downward trend in airborne lead levels measured at three Auckland sites as a result of the reduction of lead levels in petrol, culminating in lead-free petrol in 1996. Monitoring in Christchurch indicates that levels are also well below the ambient guideline for lead.

+ FIGURE 7.15:
ANNUAL LEAD LEVELS IN AUCKLAND AND CHRISTCHURCH, 1975–2005



Note:
μg/m³ = micrograms per cubic metre.
Data source: Auckland Regional Council, 2006a; Ministry for the Environment, 2006c.

Changes since the 1997 report

The 1997 report, *The State of New Zealand's Environment 1997*, concluded that:

> New Zealand is thought to have good air quality by international standards but this judgement is based on little, but increasing, monitoring. In some locations in our larger urban centres, however, there is evidence of ambient air quality at times exceeding New Zealand guideline limits for protecting human health. …
>
> Instances of significant air pollution are caused by the combined effect of discharges from industry, small businesses and homes and the growing use of our vehicle fleet. …
>
> Regional councils have mechanisms available under the Resource Management Act to deal satisfactorily with the point source discharges, both large and small, but these mechanisms are unlikely to be as effective on vehicle emissions.

(Ministry for the Environment, 1997, chapter 10.)

Improvements in air quality monitoring

Since 1997, the number of air quality monitoring sites in New Zealand has increased. Monitoring has shown that, across New Zealand, high levels of PM_{10} particulates caused by road traffic and winter home heating can affect both large urban areas and small settlements. These areas are now much better defined than in 1997, with the requirement to formally identify areas as gazetted airsheds. Regional PM_{10} particulate monitoring networks have been expanded and upgraded to ensure continuous monitoring where levels are of concern. Legislation has also been introduced to address air quality issues in specific locations.

Levels of carbon monoxide

The 1997 report identified concerns that elevated levels of roadside carbon monoxide were likely to increase as vehicle numbers increased. However, while the national vehicle fleet has continued to grow since the mid-1990s, carbon monoxide levels at many monitoring sites appear to have improved. This improvement is most likely a result of improved vehicle technology.

Ozone levels in Auckland, Hamilton, and Christchurch

In 1997 little ozone monitoring took place. This meant the extent of ozone pollution was not well understood. Since this time, monitoring in Auckland, Hamilton, and Christchurch (the areas of potential concern identified in the 1980s) indicates that ozone levels are not as high as those experienced in parts of Europe, and are unlikely to be a significant health problem.

New air quality regulations

Since the 1997 report, 14 national environmental standards have come into effect to improve air quality in New Zealand. They do so by setting maximum thresholds for five common ambient air pollutants, and introducing prohibition and design standards. This is a significant step forward in improving New Zealand's air quality.

Present and future management

Today, the main focus for improving New Zealand's air quality is on addressing PM_{10} particulate pollution from home heating and traffic in affected areas around New Zealand. A number of initiatives (such as the Warm Homes initiative) are under way to address emissions from home heating and ensure better health.

As the Resource Management Act 1991 is unlikely to be effective in controlling air pollution from traffic, other work is under way to minimise the impact of air pollution from road transport. This work includes the introduction of a visible smoke test for warrants of fitness or certificates of fitness, and the requirement for imported vehicles to meet certain emissions standards. Further reductions in air pollution from road transport are likely to result through improved emissions control equipment on imported vehicles.

Having put in place regular monitoring of air quality in managed airsheds, work will continue to track the effectiveness of the national environmental standards for air quality to ensure levels of PM_{10} particulates meet the target set for 2013.

Future work on improving air quality is likely to focus on developing a better understanding of $PM_{2.5}$ levels around New Zealand.

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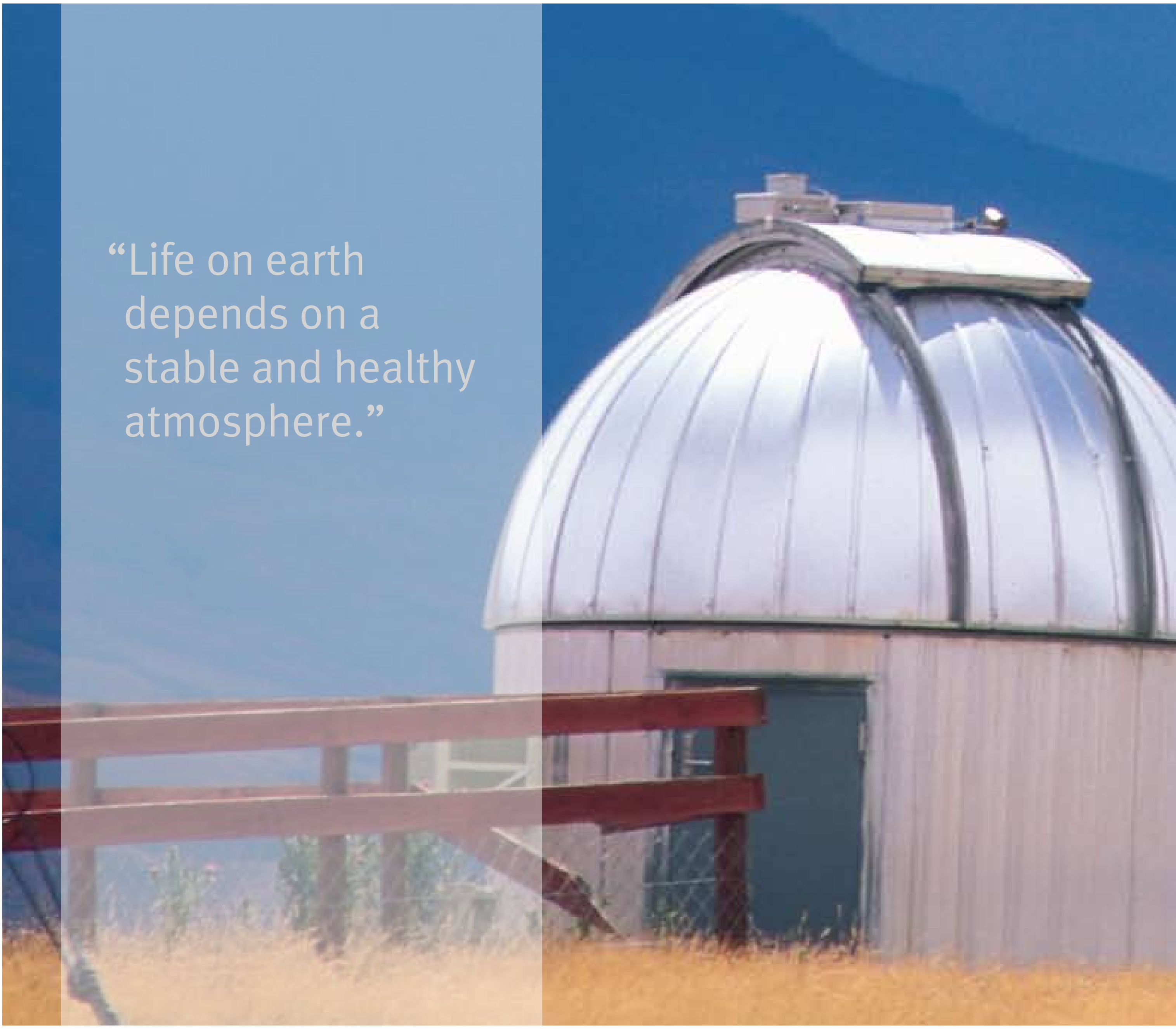


“Life on earth depends on a stable and healthy atmosphere.”

ATMOSPHERE

Contents

At a glance

In recent decades, global attention has focused on two environmental issues in relation to the atmosphere: climate change and depletion of atmospheric ozone. In response, the international community has acted to quantify and reduce emissions of greenhouse gases and ozone-depleting substances.

Climate change

Greenhouse gas concentrations over New Zealand

Atmospheric concentrations of carbon dioxide over New Zealand increased from 324 parts per million (ppm) in 1970 to 379 ppm in 2006. Atmospheric nitrous oxide concentrations showed an average increase of 0.9 parts per billion (ppb) each year over the last decade. Methane concentrations have shown a small reduction in recent years. These trends are in line with international trends.

National greenhouse gas emissions

In 2005, total emissions of greenhouse gases in New Zealand were 77.2 million tonnes of carbon dioxide equivalents. Between 1990 and 2005, total greenhouse gas emissions increased by 25 per cent, reflecting our growing population and economy. While New Zealand's greenhouse gas emissions represent much less than 1 per cent of global emissions, we rank 12th per head of population.

Sectoral emissions of greenhouse gases

New Zealand has an unusual profile of greenhouse gas emissions for a developed nation. Methane and nitrous oxide from the agricultural sector contribute nearly 50 per cent of our total emissions. Carbon dioxide emissions, largely from energy generation and transport, contribute most of the other 50 per cent. Many other developed nations have comparatively lower agricultural emissions, and higher emissions from energy generation.

Carbon removals by forest sinks

Between 1990 and 2005, carbon dioxide removed from the atmosphere by forest growth (termed forest sinks) increased by 29 per cent, largely because of increases in plantation forestry in the mid-1990s.

Climate change impacts on temperatures

In line with international trends, average New Zealand temperatures rose by 0.9°C between 1920 and 2006. This change means we can no longer take historical climate patterns as an accurate guide to the climate we will experience in the future.

Future impacts of climate change

As an island country reliant on primary production and tourism for its economic wealth, New Zealand will be particularly affected by climate change. Climate change is likely to bring about rising sea levels, an increase in floods and droughts, change wind and rainfall patterns, increase temperatures, reduce frosts, put pressure on our ecosystems, and increase the threat of pest species becoming established here.

Present and future management

Like many other developed countries, New Zealand is prioritising the development of a range of policies and initiatives to respond to climate change. In the future, the challenge will continue to be to reduce emissions from energy, transport, and the agricultural sector, and to increase afforestation. The need to adapt to both the positive and negative aspects of a changing climate is a challenge for all sectors.

Ozone

Changes in atmospheric ozone concentrations

In the 1980s, identification of the ozone hole over Antarctica led to international agreements to control the use of ozone-depleting substances. As a result, atmospheric ozone levels over Antarctica are now reducing more slowly than they were during the 1980s and 1990s, and ozone measured over Central Ōtago has stabilised since the late 1990s. The monitored summertime levels of ultraviolet radiation in New Zealand have tracked changes in ozone in recent years.

Future impacts of ozone management

Ozone levels are expected to continue to improve as refrigerants and other chemicals that deplete the ozone layer are phased out in line with international protocols.

Introduction

The atmosphere enveloping the earth is a vital part of the world we live in. It contains the oxygen we need to breathe, protects us from ultraviolet radiation and the extreme cold of space, and plays an essential role in recycling energy, water, and other essentials for life. Weather is a direct product of atmospheric processes, and influences our pattern of living.

As a result of industrial and other activities, human society is now emitting gases into the atmosphere in such quantities that the composition and dynamics of the atmosphere are changing. The changes occurring in the atmosphere as a result of human activity can have significant environmental, health, and economic effects.

In recent decades, global attention has focused on two environmental issues in relation to the atmosphere: climate change (often referred to as 'global warming') and depletion of atmospheric ozone. This chapter discusses the New Zealand aspects of these two environmental issues.

Climate change

Greenhouse gases in the earth's atmosphere trap warmth from the sun and make life possible. Without them, temperatures at the surface of the earth would be about 30°C colder. The major greenhouse gases include:

- water vapour
- carbon dioxide (CO_2)
- methane (CH_4)
- nitrous oxide (N_2O).

Other greenhouse gases at lower concentrations include:

- sulphur hexafluoride (SF_6)
- perfluorocarbons (PFCs)
- hydrofluorocarbons (HFCs).

The 'enhanced' greenhouse effect

The Intergovernmental Panel on Climate Change (see box 'International initiatives on climate change') recently brought together the most up-to-date knowledge on climate change in its Fourth Assessment Report (Intergovernmental Panel on Climate Change, 2007a; 2007b). Since the industrial revolution of the early 19th century, the concentration of greenhouse gases such as carbon dioxide, methane, and nitrous oxide has increased in the atmosphere. They now far exceed pre-industrial levels as determined from ice cores that span thousands of years.

Global increases in atmospheric carbon dioxide concentration are caused primarily by fossil fuel use and land-use change, while increases in methane and nitrous oxide are primarily due to agriculture (Intergovernmental Panel on Climate Change, 2007a). This increased concentration of gases traps more of the sun's warmth than normal, leading to a gradual warming of the atmosphere (the 'enhanced' greenhouse effect).

Fluctuations in the 'natural' atmospheric system bring about changes in climate (climate variability). However, changes in the climate as a result of increased concentrations of greenhouse gases in the atmosphere are expected to be much greater, and to happen more quickly, than any natural changes in the past 10,000 years.

Most of the increase in global temperatures since the mid-20th century is attributed to increased greenhouse gas concentrations caused by human activity. Human influence is also discernible on other aspects of the climate, such as ocean warming, temperature extremes, and wind patterns (Intergovernmental Panel on Climate Change, 2007a).

Impacts on New Zealand's climate

Temperature

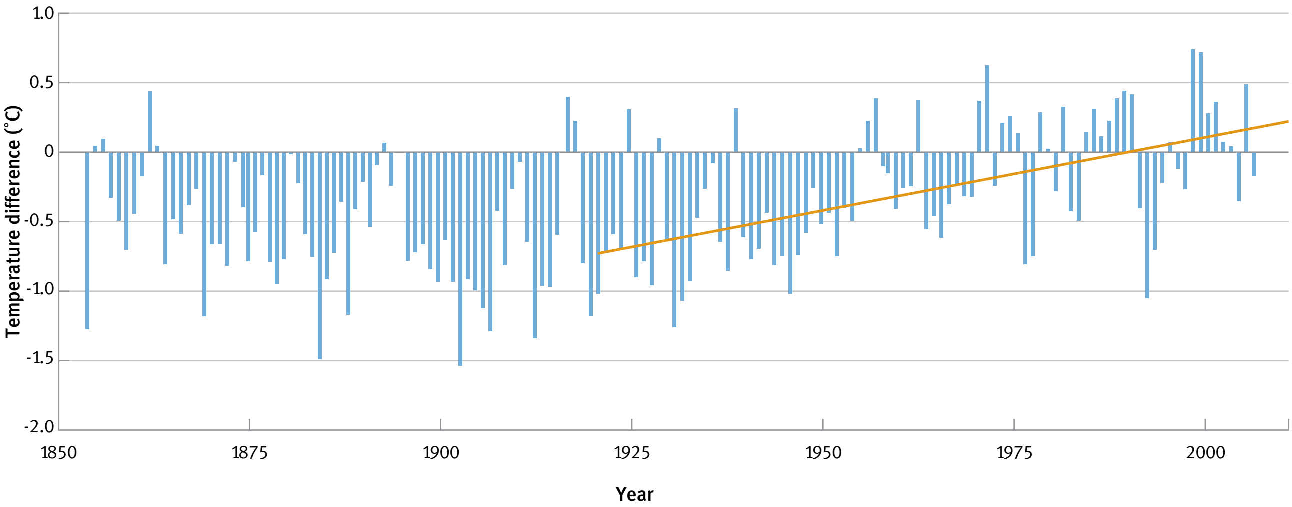
New Zealand's average surface temperature increased by 0.9°C between 1920 and 2006. This increase is consistent with increases in global temperature. The average global temperature has warmed by 0.76°C in the past century (Intergovernmental Panel on Climate Change, 2007a). The average minimum temperature has increased by 1.2°C and the maximum has increased by 0.7°C over the same period for New Zealand. Frost frequency has decreased since the 1950s (National Institute of Water and Atmospheric Research, pers comm).

For the next two decades (to 2030), global increases in temperature of about 0.2°C each decade are projected for a range of expected levels of greenhouse gas emissions (Intergovernmental Panel on Climate Change, 2007a). Best projections of global temperature increases by 2100 are between 1.8 and 4.0°C.

These changes suggest that we can no longer rely on using historical climate data to predict our future climate patterns. Figure 8.1 illustrates how current climate variables such as temperature differ from the historical pattern.

+ FIGURE 8.1:

NEW ZEALAND AVERAGE SURFACE TEMPERATURE, 1853–2006



Note:

The bars represent annual anomalies, that is, the difference in temperature in an individual year compared with the average for the 1971–2000 period. The straight line represents the linear trend in temperature anomaly between 1920 and 2006.

Source: Ministry for the Environment, 2004; National Institute of Water and Atmospheric Research.

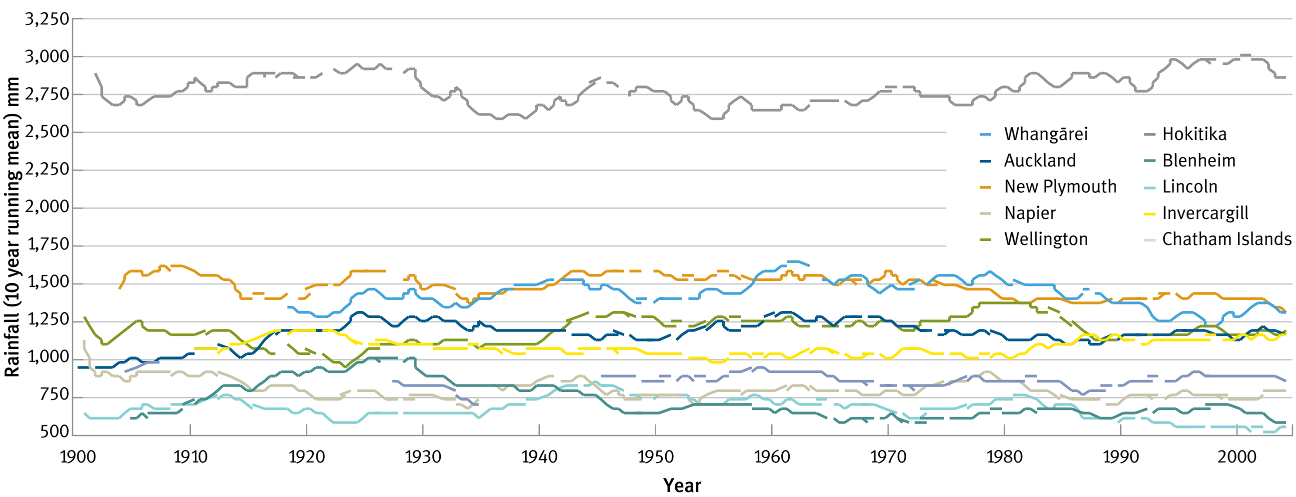
Rainfall

Changes in annual rainfall in New Zealand are expected as a consequence of climate change. A warmer atmosphere will hold more moisture, and so increased rainfall amount and intensity are likely (Intergovernmental Panel on Climate Change, 2007b).

However, Figure 8.2 shows that these expected changes in annual rainfall are not yet evident for several locations in New Zealand. No consistent, country-wide trend has so far been discernible in the rainfall record.

+ FIGURE 8.2:

ANNUAL RAINFALL SINCE 1900 FOR A RANGE OF LOCATIONS IN NEW ZEALAND



Source: National Institute of Water and Atmospheric Research.

Other climate impacts

Rising global temperatures are expected to lead to other changes in climate patterns that could impact significantly on the global environment, economy, and human society. As an example, the average global sea-level rise is expected to be between 0.19 metres and 0.58 metres by 2100 (Intergovernmental Panel on Climate Change, 2007b). This rise in sea level has the potential to affect coastal erosion and cause saltwater intrusion into aquifers.

Climate models also predict that New Zealand will experience an increased intensity and frequency of extreme weather events, including more droughts in already drought-prone areas, and larger and more frequent floods in regions already vulnerable to flooding. An increase in westerly winds is likely to result in more rainfall and flooding in the west, and less rainfall and more droughts in the east of the country (Ministry for the Environment 2004).

SEA LEVEL RISE HAS THE POTENTIAL TO IMPACT ON COASTAL EROSION.

Source: Courtesy of Peter Arnold, National Institute of Water and Atmospheric Research.

More about climate change impacts in New Zealand

As an island country reliant on primary production and tourism for its economic well-being, New Zealand stands to be significantly affected by climate change.

Rising temperatures are likely to lead to greater risks to our agricultural, horticultural, and forestry sectors, as extreme weather events become more frequent and tropical-pest plants and insects become established here. The type of, and suitable location for, key crops may also change. Higher temperatures could cause problems for crop production. For example, crops such as kiwifruit require cold winters for fruit development.

Climate change is also likely to accentuate existing pressures on New Zealand's native species (see chapter 12, 'Biodiversity') and natural ecosystems. Subtropical diseases may become a problem for human health if carrier insects, such as mosquitoes carrying the Ross River virus, become established here.

Predicted extreme weather events have significant costs associated with them, particularly when infrastructure and economic productivity are damaged. As an example, the drought in 1997–1998 is estimated to have cost the New Zealand economy a billion dollars, and the floods of February 2004 are estimated to have cost about $400 million. An increase in forest and grass wildfires in drier eastern areas of the country is likely to have a significant economic effect.

Coastal erosion and sea level rise can pose a particular problem for Māori, whose spiritual sites (urupā and wāhi tapu) are often located close to sea level.

However, a changing climate may also provide opportunities, such as new crops, and faster crop growth rates, made possible by elevated levels of carbon dioxide in the atmosphere. Warmer winters are expected to relieve the pressure on electricity and heating supplies, as well as to provide health benefits (and a reduction in heating costs). Increasing rainfall in the Southern Alps could boost electricity supply by raising water levels in our major hydro storage lakes.

Ozone

Ozone is a gas present in trace quantities in the atmosphere. It is a form of oxygen with three oxygen molecules instead of the normal two. More than 90 per cent of ozone is found in the stratosphere, 20–25 kilometres above the earth, in what is known as the ozone layer.

Ozone plays an important role in protecting the earth from the sun's harmful effects. Ozone is produced when ultraviolet (UV) radiation from the sun meets oxygen molecules. Once formed, ozone molecules absorb UV radiation before it reaches the surface of the earth. Without this process, life as we know it could not exist (National Institute of Water and Atmospheric Research, pers comm).

Although ozone is constantly created and destroyed in the stratosphere through natural processes, some chemicals increase the amount of ozone destroyed. This is particularly true of chlorofluorocarbons – chemicals that were used widely in the past as refrigerants and in some industrial processes.

When gases containing chlorine and bromine reach the stratosphere, they break down to release reactive molecules of chlorine or bromine, which alter the natural balance of ozone creation and destruction. As the concentrations of chlorine and bromine in the stratosphere rise, there is a consequential increase in the depletion of the ozone layer, and in the amount of UV radiation reaching the ground.

Atmospheric ozone and ground-level ozone

While ozone depletion in the upper atmosphere can cause harm to both the environment and human health, an increasing quantity of ozone at ground level can be a concern for air quality. Chapter 7, 'Air', describes the effect of increasing ground-level ozone.

What is the 'ozone hole'?

Over the past 30 years, ozone levels over Antarctica have dropped by almost 60 per cent during the spring of each year, and a 'hole' in the ozone layer is clearly visible in satellite observations. This hole does not extend over New Zealand. In fact, New Zealand experiences its highest ozone levels in October, at the same time as the ozone hole occurs over Antarctica.

Nonetheless, summertime ozone levels over New Zealand continue to be strongly influenced by Antarctic ozone depletion. When the ozone hole over Antarctica breaks up in November or December, ozone-depleted air moves into surrounding areas in the southern hemisphere, including New Zealand. The later the ozone hole breaks up, the higher the sun is in the sky over New Zealand and so the larger the effect on UV levels. If New Zealand experiences a combination of lower ozone with high sun and few clouds, then skin-damaging UV levels can be extreme (National Institute of Water and Atmospheric Research, pers comm).

Increased UV levels

New Zealand's location in the remote southern Pacific and Southern oceans and its low population density mean it has an exceptionally 'clean' atmosphere over most of the country. For example, New Zealand has little of the particulates and shorter-lived industrial gases that impact on heavily industrialised countries in the northern hemisphere (see chapter 7, 'Air', for further detail on air quality).

Our latitude and clarity of atmosphere mean that high levels of radiation from the sun reach the ground relatively unhindered. This results in higher levels of UV radiation at ground level in New Zealand than in other developed countries (National Institute of Water and Atmospheric Research, pers comm). Ozone depletion further exacerbates this effect, resulting in increased intensity of the UV radiation that causes sunburn.

The environmental and health impacts of raised levels of UV can be severe, particularly for New Zealand where high levels of UV are already experienced. The impacts include increases in the rates of skin cancers and eye cataracts. Raised levels of UV also suppress human and animal immune systems. Plants can also be affected. For example, high UV levels reduce the growth of plankton, a critical building block of the marine food chain. Increased exposure to UV damages some man-made materials such as paints, plastics, and construction materials.

Seasonal variability in UV levels

In New Zealand there is high seasonal variability in UV levels, especially in the south of the country, where:

- winter levels of sunburn-causing UV are less than 10 per cent of those in summer
- winter intensities of UV that produce vitamin D are probably less than 5 per cent of their summertime peaks.

This variability means that there are two concerns relating to UV in New Zealand. In the summer months, high UV intensities increase our risk of skin damage compared with corresponding northern hemisphere countries. But during the winter months, there may not actually be enough UV radiation to produce sufficient vitamin D in our bodies (McKenzie et al, 2006).

Links between climate change and ozone depletion

Climate change and ozone depletion are accelerated by human activity. Many ozone-depleting gases are also greenhouse gases. By reducing the use of ozone depleting gases, we can both protect the ozone layer and reduce climate change.

At the same time, climate change is likely to accelerate the recovery of the ozone layer, at least outside polar regions. While the earth's surface is expected to warm in response to increases in greenhouse gases, the stratosphere is expected to cool. Outside polar regions, this combination results in a decrease of the rate of ozone depletion. However, in polar regions, the lower stratospheric temperatures and stronger polar winds could extend the period over which stratospheric clouds are present, which in turn promotes chlorine-caused ozone destruction.

National environmental indicators

See chapter 1, 'Environmental reporting', for more information on the core national environmental indicators and how they are used.

There are two national environmental indicators for atmosphere.

The first is a climate change-related indicator that provides information on emissions and removals of greenhouse gases. The second is an ozone-related indicator that provides information on concentrations of stratospheric ozone.

Further detail follows on the two national environmental indicators for atmosphere.

Greenhouse gas emissions and removals

This indicator is used to measure New Zealand's contribution to global climate change.

The quantity of greenhouse gases emitted in to the atmosphere as a result of human activity in New Zealand is estimated as part of a national inventory. Gases included in this inventory are: carbon dioxide, methane, nitrous oxide, sulphur hexafluoride, hydrofluorocarbons, and perfluorocarbons. The amount of greenhouse gases removed from the atmosphere as a result of absorption by forestry is also estimated. (Greenhouse gases are removed from the atmosphere by forests, because the trees absorb carbon dioxide as they grow – these are termed 'forest sinks' or 'carbon sinks'.)

Methodologies and reporting formats for use in compiling national inventories have been agreed by the parties to the United Nations Framework Convention on Climate Change (UNFCCC). These methodologies have been used in reporting the New Zealand greenhouse gas inventory.

Additional information on the atmospheric concentrations of greenhouse gases in New Zealand is also reported.

Ozone

This indicator measures concentrations of stratospheric ozone over New Zealand. It is used to provide information on the condition of the ozone layer over mid-latitudes in the southern hemisphere.

To report on this indicator, the National Institute of Water and Atmospheric Research measures stratospheric ozone levels over Lauder in Central Ōtago. At this site, ozone is measured as 'total column ozone': the total amount of ozone in a column of air from the earth's surface to the top of the atmosphere. Data is used to illustrate the degree of ozone depletion, or how fast the ozone layer may be recovering at mid-latitudes in the southern hemisphere.

The following additional information is also discussed:

- levels of ozone-depleting substances in the atmosphere
- levels of UV radiation.

Limitations of the indicators

The indicators for atmosphere measure only stratospheric ozone and the greenhouse gases covered by the UNFCCC and Kyoto Protocol (see box 'International initiatives on climate change'). Several other gases can cause concern about the atmosphere, but these are not discussed in this report.

International initiatives on climate change

United Nations Framework Convention on Climate Change

The United Nations Framework Convention on Climate Change (UNFCCC) took effect in 1994. Its main objective is to stabilise greenhouse gas concentrations to prevent dangerous human-caused interference with the climate system. Developed countries that have ratified the UNFCCC have a commitment to limit greenhouse gas emissions and to protect and enhance greenhouse gas sinks. The UNFCCC requires parties to submit a national greenhouse gas inventory of emissions by source and removals by sinks for an annual technical review process. (In New Zealand, forests are the primary carbon sink.)

Kyoto Protocol

The Kyoto Protocol under the UNFCCC was agreed in 1997 and came into force in 2005. The protocol sets targets for the greenhouse gas emissions of developed countries for the period 2008 to 2012 (the first commitment period). For that period it aims to reduce the total greenhouse gas emissions of developed countries to 5 per cent below the level they were in 1990.

Different countries have different targets to achieve. New Zealand's target is to reduce its greenhouse gas emissions to the level they were in 1990, or take responsibility for excess emissions. Negotiations are now under way on further commitments for developed countries under the Kyoto Protocol.

Intergovernmental Panel on Climate Change

The Intergovernmental Panel on Climate Change (IPCC) was established by governments in 1988 to improve understanding of and response to climate change. The role of the IPCC is to assess scientific, technical, and socio-economic information relevant to:

- the risk of human-induced climate change
- global vulnerability to climate change
- negative and positive consequences of climate change
- options for adapting to climate change.

The IPCC also assesses options for how to limit greenhouse gas emissions and how to otherwise mitigate climate change. The IPCC assesses and develops methods and practices for the development of national greenhouse gas inventories and disseminates information about inventory methods and practices. These methodologies have been agreed by the UNFCCC for use in compiling national inventories.

Current state and trends

Concentrations of atmospheric greenhouse gases

Concentrations of three greenhouse gases (carbon dioxide, methane, and nitrous oxide) in the atmosphere over New Zealand are measured at Baring Head, to the southeast of Wellington. The measurements at Baring Head are representative of atmospheric gases over a wide region of the ocean to the south of New Zealand.

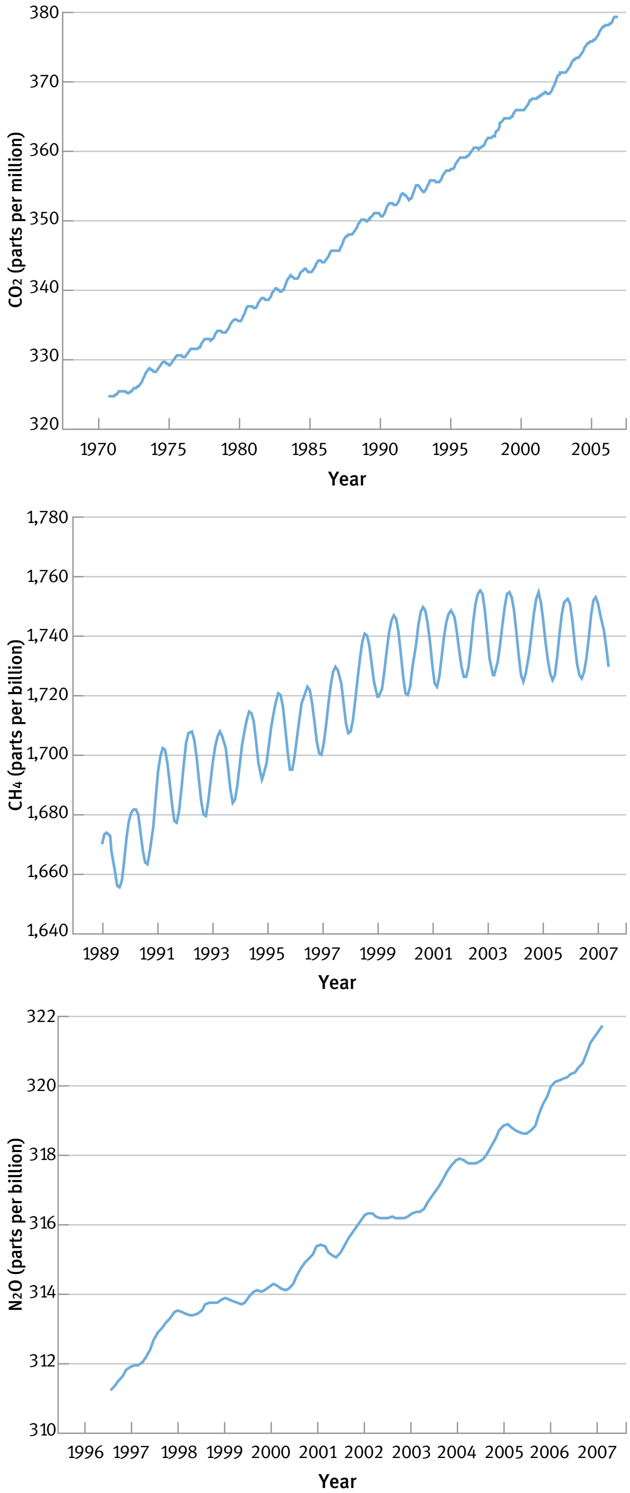
The concentration of all three gases has increased in the past 35 years (see Figure 8.3). The trends in greenhouse gas concentrations observed at Baring Head are consistent with global trends in atmospheric greenhouse gas concentrations (Intergovernmental Panel on Climate Change, 2007a). It is the *global* atmospheric concentration of greenhouse gases that determines the risk of climate change.

Carbon dioxide concentrations measured at Baring Head have risen from 324 parts per million (ppm) in 1970, to 379 ppm in 2006. The 35-year record measured at Baring Head has an average growth rate of 1.5 ppm each year. The average growth rate of carbon dioxide concentration in the past 10 years of 1.9 ppm is greater than at any other time over the instrumental record starting in 1960. This trend is supported by global observations.

Methane concentrations at Baring Head show an annual growth rate from 1989 to 1997 of 6.5 parts per billion (ppb) each year (see Figure 8.3). Since 1998, there has been a small decrease in methane concentrations in recent years. This pattern is reflected in measurements taken at Arrival Heights, Antarctica, and other global sites. We do not fully understand what drives these changes in methane concentrations.

The observations for **nitrous oxide** at Baring Head indicate a steady growth trend (see Figure 8.3). Seasonal variation is very small compared with the annual growth rate, because of the long atmospheric lifetime of nitrous oxide. The average annual growth rate is 0.9 ppb each year.

+ FIGURE 8.3:
ATMOSPHERIC CONCENTRATIONS OF CARBON DIOXIDE (CO_2), METHANE (CH_4), AND NITROUS OXIDE (N_2O) AT BARING HEAD



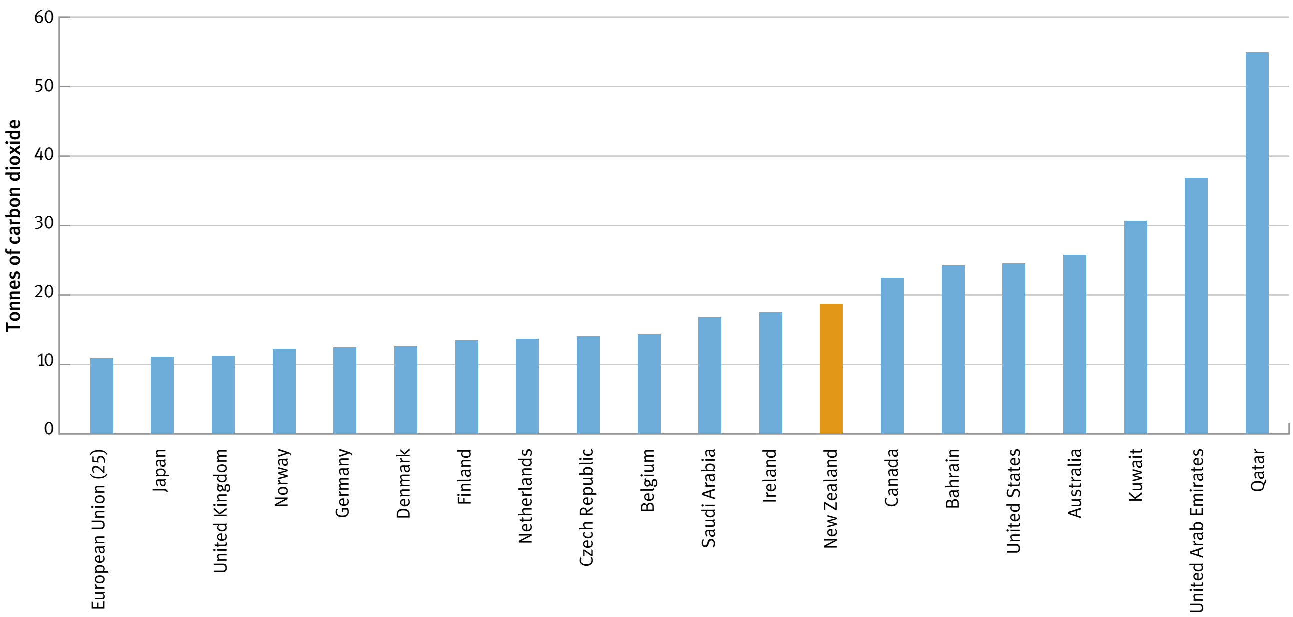
Source: National Institute of Water and Atmospheric Research.

Greenhouse gas emissions and removals

New Zealand's greenhouse gas emissions represent much less than 1 per cent of total global emissions (Organisation for Economic Co-operation and Development, 2007). While our total emissions are small in the global context, New Zealand ranks 12th in the world for emissions per head of population. For comparison purposes, Figure 8.4 shows carbon dioxide emissions on a population basis for key countries.

+ FIGURE 8.4:

TONNES OF CARBON DIOXIDE EMITTED ON A PER CAPITA BASIS BASED ON ALL GREENHOUSE GAS EMISSIONS IN 2000 FOR SELECTED COUNTRIES

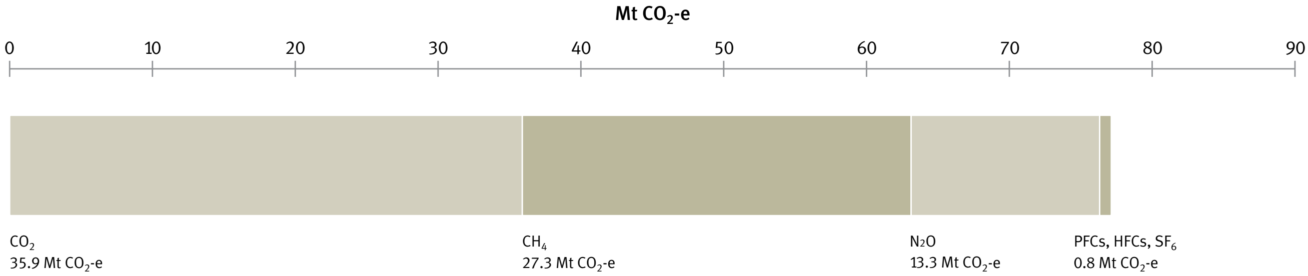


Note:
The European Union represents 25 countries, and is an average.
Source: Baumert et al, 2005.

National information on greenhouse gas emissions is compiled annually. The data is reported two years in arrears according to international obligations, allowing time for collection, analysis, and reporting. This means that the most recent compiled data for New Zealand is for 2005.

As Figure 8.5 shows, New Zealand has an unusual greenhouse gas emission profile for a developed nation: methane and nitrous oxide from our agricultural sector account for close to 50 per cent of our total emissions. Most of the remainder (43 per cent) is carbon dioxide from energy generation and transport. Many other developed nations have comparatively lower agricultural emissions, and higher emissions from energy generation.

+ FIGURE 8.5:
NEW ZEALAND'S GROSS GREENHOUSE GAS EMISSIONS BY GAS, 2005



Note:
Mt CO_2-e = megatonnes of carbon dioxide equivalents.
Source: Ministry for the Environment, 2007.

Global warming potentials and CO_2 equivalents

Each greenhouse gas has a different warming potential (the relative warming effect of the gas when compared with carbon dioxide). For example, methane has 21 times the global warming potential of carbon dioxide. For ease of comparison, volumes of greenhouse gas emissions and removals are reported in terms of carbon dioxide equivalents (CO_2-e) based on 100-year global warming potentials.

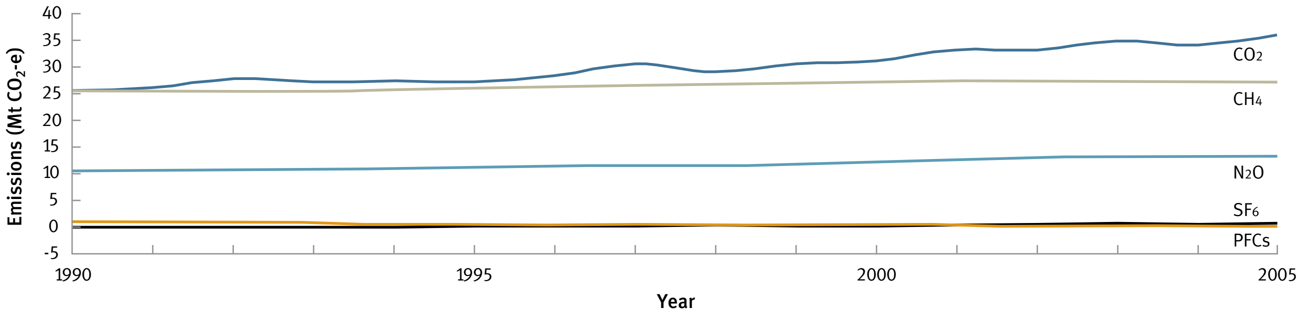
Figure 8.6 tracks emissions of carbon dioxide, methane, nitrous oxide, sulphur hexafluoride (SF_6), and perfluorocarbons (PFCs) in New Zealand between 1990 and 2005. It shows that emissions of carbon dioxide, methane, and nitrous oxide increased between 1990 and 2005. The increase between 1990 and 2005 for carbon dioxide emissions is 41 per cent.

Total emissions of greenhouse gases in New Zealand for 2005 were 77.2 million tonnes of carbon dioxide equivalents (Mt CO_2-e). Figure 8.7 shows that the total emissions in 2005 were 25 per cent higher (15.3 Mt CO_2-e) than they were in 1990 (61.9 Mt CO_2-e).

Greenhouse gases are removed from the atmosphere by forests, because the trees absorb carbon dioxide as they grow – these are termed 'forest sinks' or 'carbon sinks'.

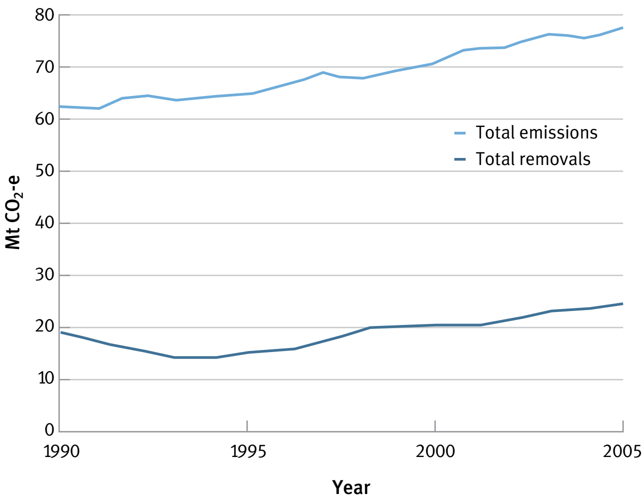
Planted forests removed a total of 24.5 Mt CO_2-e from the atmosphere in 2005, equivalent to 32 per cent of New Zealand's total greenhouse emissions in that year. This represents an increase in 'removals' of 29 per cent since 1990.

+ FIGURE 8.6:
NEW ZEALAND'S GREENHOUSE GAS EMISSIONS BY GAS TYPE, 1990–2005



Note:
Mt CO_2-e = megatonnes of carbon dioxide equivalents.
Source: Ministry for the Environment, 2007.

+ FIGURE 8.7:
NEW ZEALAND'S TOTAL GREENHOUSE GAS EMISSIONS AND REMOVALS, 1990–2005



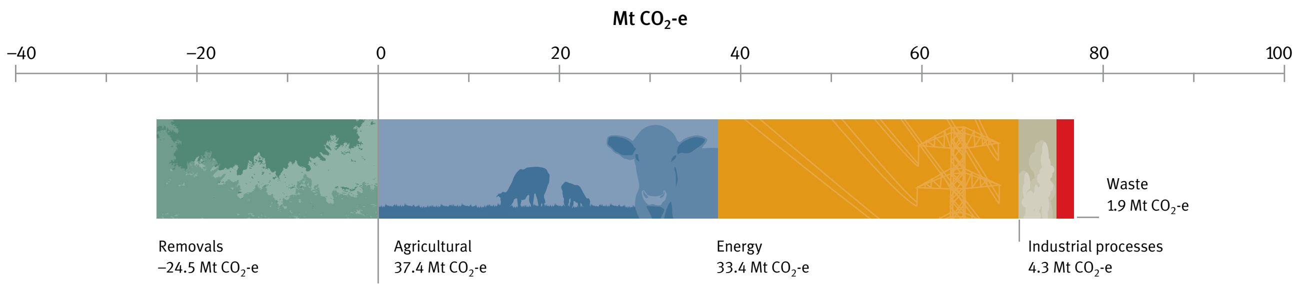
Note:
Mt CO_2-e = megatonnes of carbon dioxide equivalents.
Source: Ministry for the Environment, 2007.

Summary of greenhouse gases by sector

Figure 8.8 shows a summary of New Zealand's greenhouse gas emissions by sector.

In 2005, agriculture made up 49 per cent of our total emissions, energy 43 per cent, industrial processes 6 per cent, and waste 2 per cent.

+ FIGURE 8.8:
NEW ZEALAND'S GREENHOUSE GAS EMISSIONS BY SECTOR, 2005



Notes:
(1) Removals indicate the uptake of carbon dioxide by forest sinks.
(2) Mt CO_2-e = megatonnes of carbon dioxide equivalents.
Source: Ministry for the Environment, 2007.

Emissions from the energy sector

The energy sector covers emissions from fuel combustion (including combustion that produces heat in industrial processes), as well as fugitive emissions (emissions that escape from activities relating to fossil fuels). This category includes emissions from the transport sector.

The energy sector produced 33.4 Mt CO_2-e, or 43 per cent of total New Zealand emissions in 2005 (see Figure 8.9). Its rate of emissions growth was the highest of any sector in New Zealand between 1990 and 2005. Emissions increased by 9.9 Mt CO_2-e, or 42 per cent over the period.

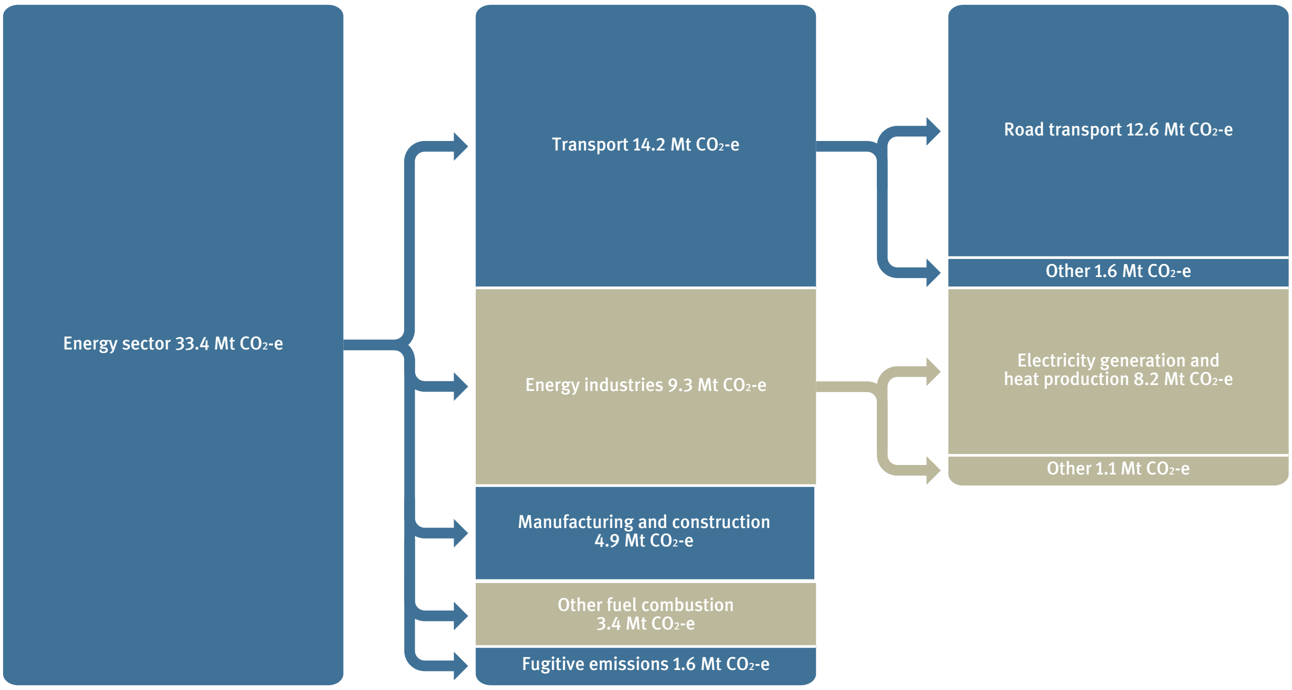
Transport

Transport emissions include those from domestic road, rail, air, and sea transport. In line with international reporting guidelines, international air transport and shipping are not included in these emissions totals.

In 2005, transport contributed 14.2 Mt CO_2-e or 18 per cent of New Zealand's total emissions. Emissions were 62 per cent higher in 2005 than in 1990 (8.8 Mt CO_2-e).

Road transport represented 89 per cent (12.6 Mt CO_2-e) of domestic transport emissions in 2005. Domestic aviation contributed a further 7 per cent (1.0 Mt CO_2-e), shipping 3 per cent (0.4 Mt CO_2-e), and rail 1 per cent (0.2 Mt CO_2-e). The largest growth in transport emissions is associated with road transport. Emissions from road transport increased by 65 per cent (5.0 MtCO_2-e) between 1990 and 2005.

+ FIGURE 8.9:
ENERGY SECTOR GREENHOUSE GAS EMISSIONS, 2005



Note:
Mt CO_2-e = megatonnes of carbon dioxide equivalents.
Source: Ministry for the Environment, 2007.

Energy industries

The energy industries category comprises stationary energy supplies. These include electricity generation, petroleum refining, gas processing, and solid fuel manufacturing. Emissions from energy industries were 9.3 Mt CO_2-e in 2005 or 12 per cent of national emissions. Energy industries emissions increased by 54 per cent between 1990 and 2005. This increase is primarily due to growth in electricity demand in New Zealand. Growing demand has required more burning of gas, coal, and oil to produce energy. (See chapter 5, 'Energy'.)

Electricity generation and heat production comprised 88 per cent (8.2 Mt CO_2-e) of the energy industries subcategory in 2005.

Manufacturing industries and construction

This category includes emissions from the manufacture of steel, non-ferrous metals, and pulp and paper, and emissions from food processing. Emissions from manufacturing industries and construction contributed 6 per cent (4.9 Mt CO_2-e) to New Zealand's total greenhouse gas emissions in 2005. This represents a 6 per cent increase from 1990 levels.

Other fuel combustion

This category includes emissions from commercial, public, and residential sectors. It covers fuel used by agricultural, fishery, and forestry equipment, and all other fuel combustion emissions. Emissions were 3.4 Mt CO_2-e, or 4 per cent of national greenhouse gas emissions in 2005. This was a 17 per cent increase on emissions reported in 1990.

Emissions from the industrial processes and solvents sectors

The industrial processes and solvents sectors produce only a small proportion of New Zealand's total greenhouse gas emissions.

Industrial processes sector

Emissions from industrial processes include the chemical transformation of one product to another, for example, the reduction of ironsand in steel production. (Emissions from energy used to produce heat in the process are reported within the energy sector.)

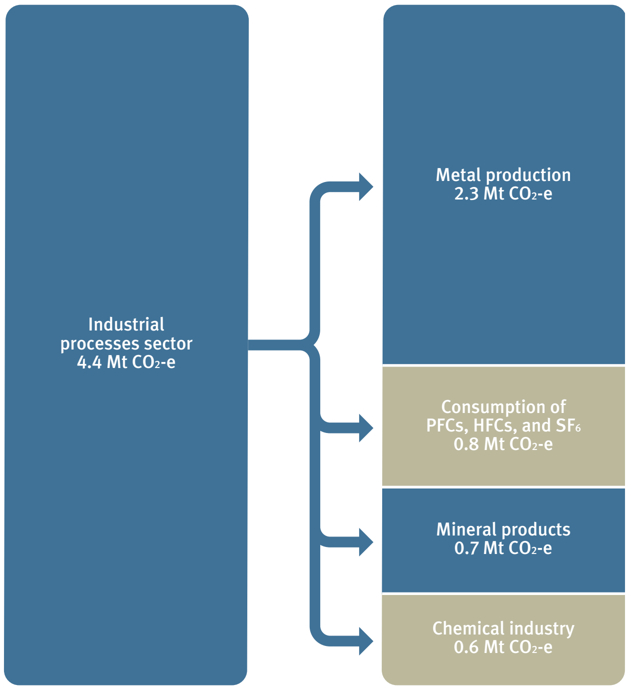
The main industrial processes producing greenhouse gases in New Zealand are:

- reduction of ironsand in steel production
- oxidisation of anodes in aluminium production
- production of hydrogen
- calcination of limestone for use in cement production
- calcination of limestone for lime
- production of ammonia and urea.

Most greenhouse gas emissions in this sector are in the form of carbon dioxide. Small contributions come from perfluorocarbons and sulphur hexafluoride.

Emissions from industrial processes were 4.4 Mt CO_2-e in 2005 (see Figure 8.10) and represent 6 per cent of total national emissions. This emission category has grown by 32 per cent since 1990, mainly due to an increase in emissions from metal production and consumption of perfluorocarbons.

+ FIGURE 8.10:
INDUSTRIAL PROCESSES SECTOR GREENHOUSE GAS EMISSIONS, 2005



Note:
Mt CO_2-e = megatonnes of carbon dioxide equivalents.
Source: Ministry for the Environment, 2007.

Solvents sector

Most emissions in the solvents sector are indirect emissions, which are reported but do not get counted with New Zealand's total emissions. Indirect emissions are from evaporation of volatile chemicals when solvent-based products are exposed to air. This occurs during processes such as chemical cleaning, dry cleaning, printing, metal degreasing, and from a variety of industrial and household chemical uses. Emissions from paints, lacquers, thinners, and related materials are also included.

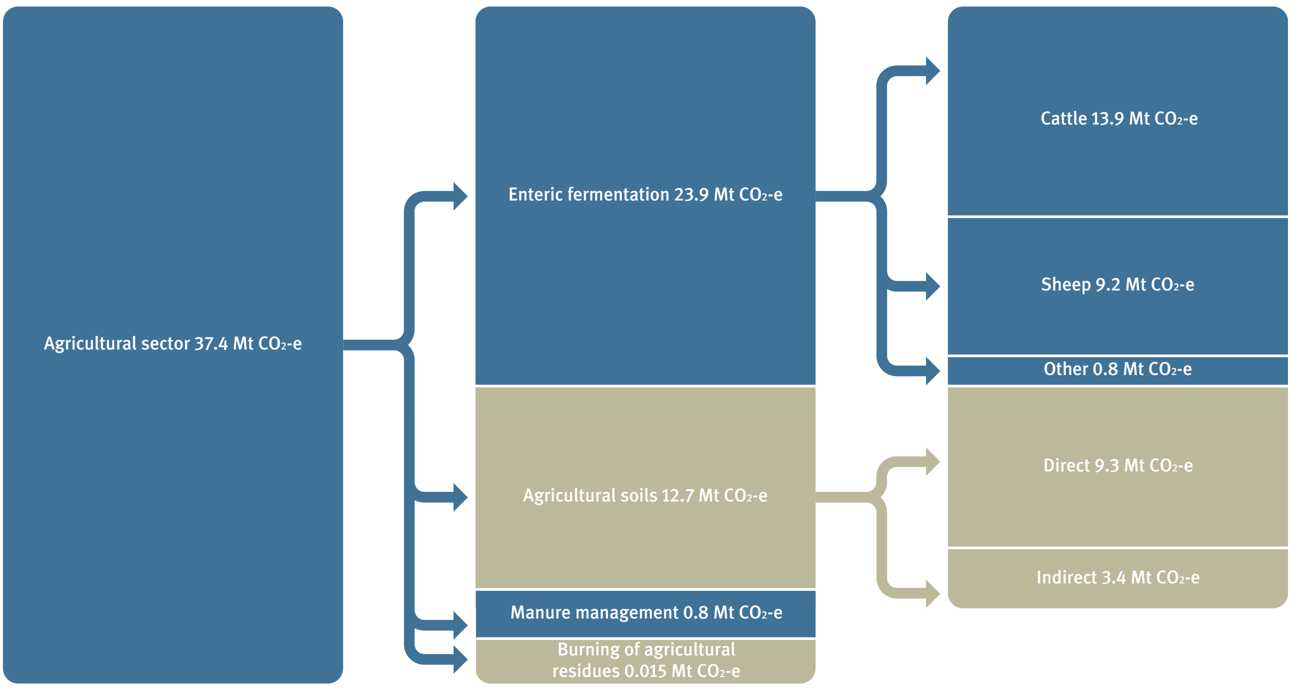
The category, which includes solvents and other product use, is a minor contributor to New Zealand's total greenhouse gas emissions, being responsible for just 0.05 Mt CO_2-e. Emissions have increased by 16 per cent since 1990.

Emissions from the agricultural sector

New Zealand has a unique emissions profile with 49 per cent (37.4 Mt CO_2-e) of emissions in 2005 produced by the agricultural sector (see Figure 8.11). Typically, emissions from agriculture for other developed countries make up around 12 per cent of total emissions. Agriculture contributes 96 per cent of New Zealand's total nitrous oxide emissions and 91 per cent of total methane emissions. Emissions have increased by 15 per cent from 1990 levels (32.5 Mt CO_2-e).

Emissions of methane and nitrous oxide are produced when biomass (organic matter) is consumed or decays. Naturally occurring emissions are modified by human activities such as cultivation, addition of nitrogenous fertilisers, farming of livestock, and deliberate burning.

+ FIGURE 8.11:
AGRICULTURAL SECTOR GREENHOUSE GAS EMISSIONS, 2005



Note:
Mt CO_2-e = megatonnes of carbon dioxide equivalents.
Source: Ministry for the Environment, 2007.

Enteric fermentation

Enteric fermentation is a digestion process in ruminant livestock. The process produces methane. This is New Zealand's highest single emissions category, contributing 23.9 Mt CO_2-e, or 31 per cent to total national emissions in 2005. Enteric fermentation represents 64 per cent of all emissions from agriculture. Emissions have increased by 10 per cent since 1990.

Agricultural soils

Nitrous oxide emissions in this category are associated with the application of nitrogenous fertilisers, animal effluent deposited on agricultural soils, and the use of nitrogen-fixing crops. Emissions can be direct from the soil, and indirect through atmospheric deposition, leaching, and run-off. Agricultural soils contributed 34 per cent of all agricultural emissions primarily as nitrous oxide (12.7 Mt CO_2-e) in 2005. Emissions were 27 per cent higher than in 1990.

Manure management

This category produces nitrous oxide and methane emissions from the decomposition of animal waste held in manure management systems (for example, stored in ponds). Emissions were 0.8 Mt CO_2-e in 2005.

Grassland burning and burning of agricultural residues

This category includes emissions from the controlled burning of tussock grasslands. The amount of tussock burned has been steadily decreasing since 1959. Emissions from this category comprised 0.001 Mt CO_2-e in 2005.

Emissions are also produced from field burning of crop residues (from barley, wheat, and oats). Emissions were 0.014 Mt CO_2-e in 2005.

Emissions from the waste sector

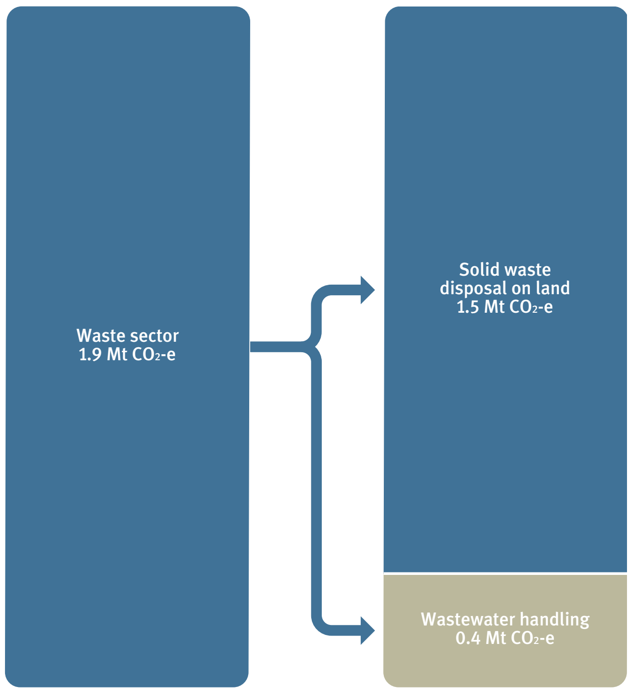
Greenhouse gas emissions from waste are predominantly methane, formed from organic wastes (such as food) as they break down over time. Small amounts of nitrous oxide are also generated from the incineration of solvents and decomposition of human waste.

Carbon dioxide emissions from the breakdown of organic material derived from plant materials are not reported because the carbon dioxide emitted is assumed to be reabsorbed in crops in the following year.

Waste emissions were 1.9 Mt CO_2-e in 2005, a decrease of 26 per cent since 1990 (see Figure 8.12). This decrease is because of improved capturing of landfill gas from solid waste disposal. The waste sector contributed 2 per cent to New Zealand's total greenhouse gas emissions in 2005.

Solid waste disposal on land represented 79 per cent (1.5 Mt CO_2-e) of waste sector greenhouse gas emissions in 2005. The remainder (21 per cent) is associated with wastewater handling. Wastewater emissions are largely associated with sewage from New Zealand's human population.

+ FIGURE 8.12:
WASTE SECTOR GREENHOUSE GAS EMISSIONS, 2005



Note:
Mt CO_2-e = megatonnes of carbon dioxide equivalents.
Source: Ministry for the Environment, 2007.

Climate change legislation

Climate Change Response Act 2002

The Climate Change Response Act 2002 put in place a legal framework to allow New Zealand to ratify the Kyoto Protocol and to meet its obligations under the United Nations Framework Convention on Climate Change and Kyoto Protocol. The Act will enable New Zealand to trade emissions units (carbon credits) on the international market, and establishes a registry to record holdings and transfers of units. The Act also establishes a national inventory agency to record and report information relating to greenhouse gas emissions in accordance with international requirements.

Resource Management Act 1991 and climate change

Under the Resource Management (Energy and Climate Change) Amendment Act 2004 the Resource Management Act 1991 was amended to:

(a) make explicit provision for all persons exercising functions and powers under the principal Act to have particular regard to—

- *(i) the efficiency of the end use of energy; and*
- *(ii) the effects of climate change; and*
- *(iii) the benefits to be derived from the use and development of renewable energy; and*

(b) to require local authorities—

- *(i) to plan for the effects of climate change; but*
- *(ii) not to consider the effects on climate change of discharges into air of greenhouse gases.*

The Resource Management (Energy and Climate Change) Amendment Act 2004 confirmed the Government's policy that emissions of greenhouse gases be controlled at a national level. The Act removed the power of local government to consider the effect of greenhouse gas emissions on climate change when making rules in regional plans, or when determining air discharge consents, except where necessary to implement a national environmental standard.

One national environmental standard for air quality relates to greenhouse gas emissions. It requires that all operating landfills with a capacity of over 1 million tonnes of refuse collect and either destroy or utilise greenhouse gas emissions (methane).

Under the Resource Management Act 1991, there remains some power for regional councils to control emissions, but not for climate change purposes.

Emissions and removals from the land use, land-use change, and forestry sector

Changes in the amount of carbon in vegetation and soil as a result of human activity are reported in the land use, land-use change, and forestry (LULUCF) sector. This includes removals of greenhouse gases from the atmosphere by forest sinks, as well as emissions from changes in land use.

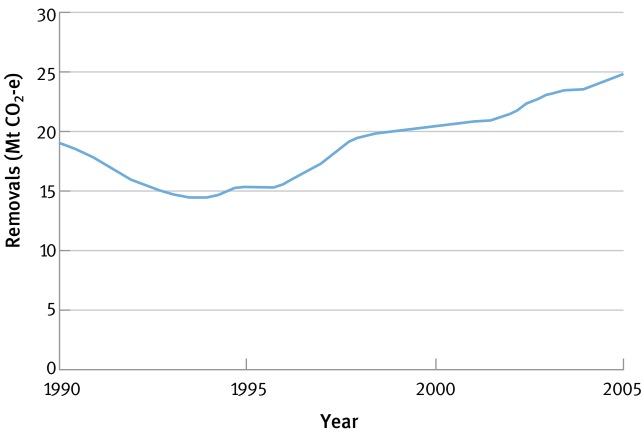
FORESTS REMOVE CARBON DIOXIDE FROM THE ATMOSPHERE AND STORE IT AS CARBON.

Source: Courtesy of Peter Wiles, Ngahere Muri Forestry Limited.

The category includes changes in six land-use types: forest land, cropland, grassland, wetlands, settlements, and other land. Transfers of land use from one type to another can result in either carbon dioxide emissions or removals. In addition, even where land use stays the same, changes in carbon emissions or removals can occur. An example is where planted forest growth removes carbon dioxide from the atmosphere and stores it as carbon. Emissions can also arise from burning of forest slash (branches and other woody debris from forest harvesting that are not removed from the site), decay of biomass, and changes in soil carbon.

In New Zealand, on balance, this sector represents a carbon sink; that is, there are more removals in this sector than emissions. As noted earlier, removals of greenhouse gas emissions in 2005 equated to 24.5 Mt CO_2-e (see Figure 8.13). This removal is equivalent to 32 per cent of our total greenhouse gas emissions. Overall, total LULUCF removals have increased in New Zealand by 29 per cent between 1990 and 2005.

+ FIGURE 8.13:
LAND USE, LAND-USE CHANGE, AND FORESTRY GREENHOUSE GAS REMOVALS, 1990–2005



Note:
Mt CO_2-e = megatonnes of carbon dioxide equivalents.
Source: Ministry for the Environment.

The trends observed in this sector primarily reflect New Zealand's changing land-use and forestry activities, particularly during the 1990s with the high forestry planting rates (see chapter 9, 'Land', for details on forestry planting and deforestation). In 2005, removals of greenhouse gases from forestry represented the majority of removals in the sector. Removals of greenhouse gases from other changes in land use were not significant.

LOCAL ACTION on climate change

Communities for Climate Protection – New Zealand

Communities for Climate Protection – New Zealand (CCP–NZ) is a voluntary programme that helps local government reduce greenhouse gas emissions from council operations and their wider communities. CCP–NZ provides a framework for taking action to reduce greenhouse gas emissions through energy conservation, renewable energy, sustainable transport, waste reduction, improved building and urban design, and emission-reduction technologies.

Bay of Plenty adaption to climate change

In May 2005, the Western Bay of Plenty was hit by an intense storm that caused flooding throughout the region. A state of emergency was declared, because stormwater infrastructure, roading, and private properties were substantially damaged by the flooding.

While average annual rainfall in the Bay of Plenty is expected to decrease with climate change, extreme rainfall events and flooding such as that which occurred in May 2005 are projected to increase. This has significant implications for new subdivisions and development in the area.

In response, the Tauranga City Council now considers climate change impacts when designing all new or upgraded stormwater infrastructure. The Council has also incorporated the factor of increased high-intensity rainfall into its planning for growth and development in the region over the next 50 years.

Impacts of sea level rise on the Avon River, Christchurch

In 2003, Christchurch City Council examined the potential effects of climate change on the Avon catchment and associated coastal areas, and how these risks could be managed.

The study focused primarily on an economic analysis of likely damages, and the response options available to local government to mitigate these. Possible responses the study discussed included minimum floor levels for buildings, subdivision restrictions, stopbank improvements, and tidal barrages.

Since this study was undertaken, changes have been made to the city plan and aspects of the study's findings have been incorporated into the Urban Development Strategy that seeks to reduce the risks to the community from climate change. Options such as set-backs from waterways and raised floor levels of buildings in flood-prone areas have been incorporated.

TAURANGA CITY COUNCIL HAS UPGRADED THE CITY'S STORMWATER INFRASTRUCTURE.

Source: Courtesy of Tauranga City Council.

LOCAL ACTION on climate change

Wellington City Council and CLINZI

Wellington City Council has undertaken a CLINZI (Climate's Long-term Impact on New Zealand's Infrastructure) study that asked, 'What is the impact of climate change on infrastructure systems and services in Wellington City?'

CLINZI is an integrated assessment process for assessing the long-term impact of climate on infrastructure investments. It has been developed by the New Zealand Centre for Ecological Economics in conjunction with the National Institute of Water and Atmospheric Research and the International Global Change Institute, and involves the generation of local climate scenarios, regression modelling, and qualitative analysis, all within a risk-management framework.

The risk analysis work identified several areas requiring further attention by Wellington City Council, including:

- change in water demand
- possible reduction in water quality
- effect of sea-level rise on stormwater discharge rates to the sea
- changes in electricity demand
- impacts on transmission assets
- impacts of erosion and extreme rainfall events on maintenance of roads
- changes in traffic demand.

The analysis of policies and strategies concluded that, while Wellington acknowledged potential climate-change risk in a range of official documents such as the Regional Policy Statement, further work is needed on incorporating climate change impacts in other policies and plans.

Incorporating climate change adaptation into the state highway network

As the Crown Entity responsible for state highways, Transit New Zealand is required to assess and manage risks to New Zealand's transport network, and ensure its sustainability.

Transit New Zealand recognises that it is prudent to consider climate change in the design and planning of all major long-life infrastructures such as bridges, culverts, and causeways that could be affected by climate change impacts within the working life of the structure.

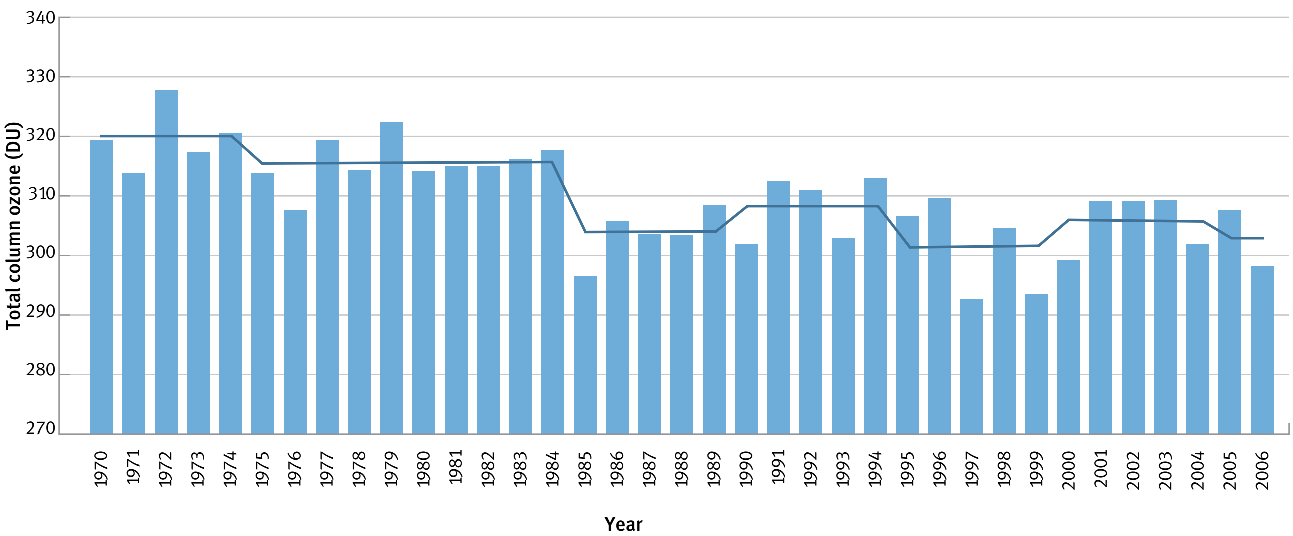
Future-proofing at the design stage makes later retrofits both feasible and cost-effective. Some new state highway projects are already considering the impacts of climate change during design and construction. For example, the new section of causeway for Auckland's Upper Harbour Corridor (State Highway 18) was built 0.3 metres higher than the existing causeway, which was then raised to match it. This was in direct response to predicted sea-level rise.

Stratospheric ozone levels

Stratospheric ozone levels in New Zealand have changed considerably over time, as shown in Figure 8.14. Levels have stabilised in the last decade, reversing decreases in the 1980s and 1990s. A turning point in ozone concentrations may have been reached in 1997. Much of the stabilisation over the last decade can be attributed to reduced ozone depletion over Antarctica as a result of higher springtime polar temperatures and slightly reduced levels of chlorine and bromine in the stratosphere.

The average ozone concentration in 2006 was 298 DU (Dobson units), one of the five lowest levels on record (National Institute of Water and Atmospheric Research, pers comm). The 2006 level can be explained by unusual stratospheric weather in that year (Bodeker et al, 2007).

+ FIGURE 8.14:
AVERAGE YEARLY OZONE LEVELS OVER NEW ZEALAND, 1970–2006



Notes:
(1) Five-year averages have been plotted to give an indication of trend in ozone concentration.
(2) DU = Dobson units.
Source: National Institute of Water and Atmospheric Research.

Levels of ozone-depleting substances in the atmosphere

As discussed earlier, atmospheric concentrations of chlorine and bromine drive ozone depletion. Figure 8.15 shows the changing concentration of atmospheric chlorine and bromine expressed as 'chlorine equivalents'. Levels of these gases are expressed in units of equivalent effective chlorine, in much the same way as greenhouse gases are expressed in carbon dioxide equivalents.

Comparison of Figures 8.14 and 8.15 shows that ozone levels track closely to average annual levels of chlorine equivalents, although there is a time lag. Concentrations of atmospheric chlorine and bromine have decreased over New Zealand since 1996 and over Antarctica since 2001 (National Institute of Water and Atmospheric Research, pers comm). This decrease is primarily because of the global adherence by parties to the Montreal Protocol (see box 'Montreal Protocol'), which established targets for the reduction in the use of ozone-depleting substances.

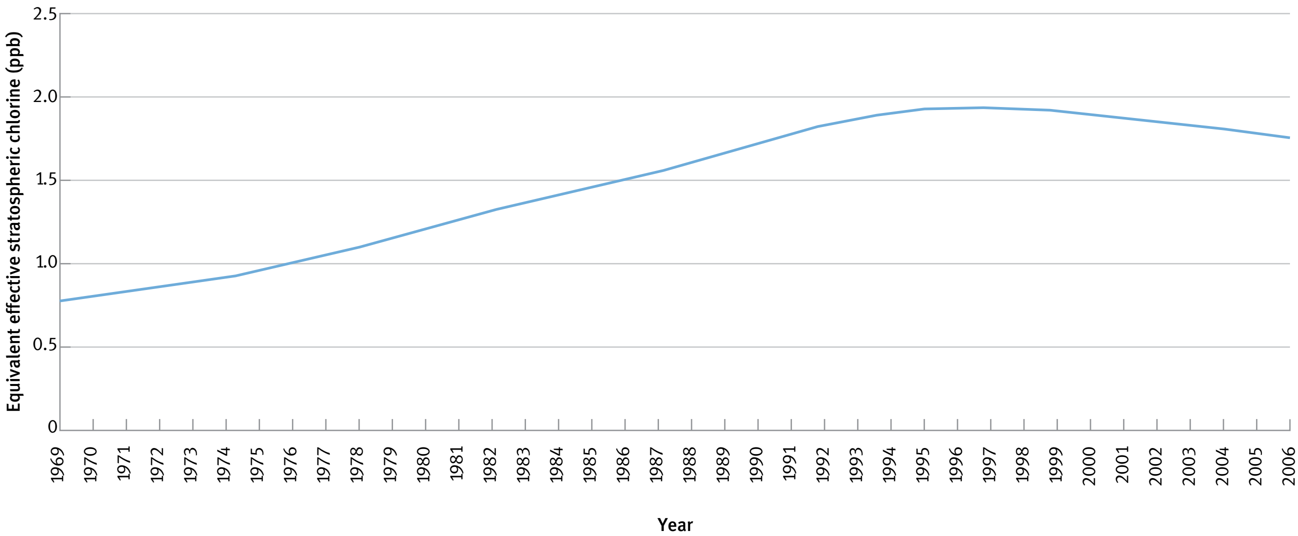
Montreal Protocol

The Montreal Protocol on Substances that Deplete the Ozone Layer 1987 sets targets for reducing the production and consumption of ozone-depleting substances. The protocol originally required parties to reduce chlorofluorocarbon (CFC) use to 50 per cent below 1986 levels by 1998, and to freeze halon consumption at 1986 levels from 1992.

The provisions of the protocol have since been tightened through a series of amendments. Halons and CFCs were phased out completely by the early to mid-1990s. Phase-out schedules were agreed for other substances as the impact of those substances on ozone layer depletion became better understood.

New Zealand's obligations under the Montreal Protocol are implemented through the Ozone Layer Protection Act 1996 and the Ozone Layer Protection Regulations 1996.

+ FIGURE 8.15:
CONCENTRATION OF EQUIVALENT EFFECTIVE STRATOSPHERIC CHLORINE, 1969–2006



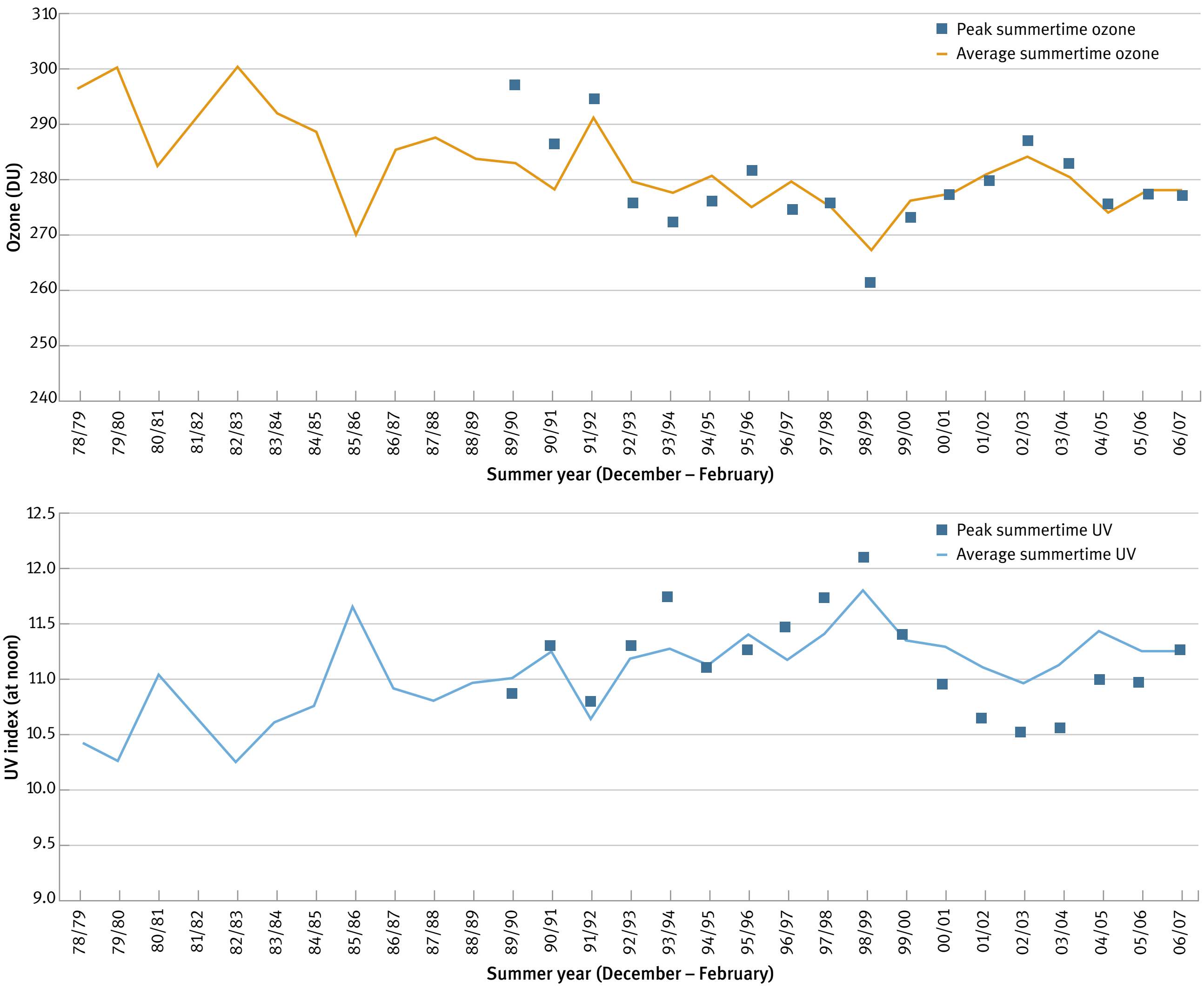
Note:
ppb = parts per billion.

Source: National Institute of Water and Atmospheric Research.

Ultraviolet radiation

Ozone depletion reduces the protective properties of the atmosphere and allows higher levels of UV radiation to reach the earth's surface. Figure 8.16 tracks summertime UV index levels over New Zealand against ozone concentrations. This comparison shows the impact of ozone levels on UV: when ozone levels are low, we experience a high UV index.

+ FIGURE 8.16:
CHANGES IN SUMMERTIME OZONE AND PEAK ULTRAVIOLET INDEX AT LAUDER, CENTRAL ŌTAGO



Notes:

(1) The upper panel represents changes in summertime ozone and the lower panel peak summertime UV index. The symbols show the average ozone and corresponding noontime measurement of the mean noon UV index for summer's five highest UV index days in each month (15 days in total). The lines represent average summertime ozone calculated from satellite data, and a corresponding value for UV index calculated from these ozone values.

(2) DU = Dobson units.

Source: National Institute of Water and Atmospheric Research.

Changes since the 1997 report

The 1997 report, *The State of New Zealand's Environment 1997,* concluded that:

> New Zealand contributes an above-average share to the world total of human induced carbon dioxide gas emissions but less than the average for developed countries. …
>
> Although existing measures have achieved some reduction below a 'business as usual' projection, New Zealand is not on track to achieve its current commitment under the Framework Convention on Climate Change of stabilising CO_2 at 1990 levels by the year 2000. …
>
> Depletion of the ozone layer will continue for many decades and requires international action. New Zealand has been, and remains, an active participant in the responses to ozone loss including the signing of the Montreal Protocol and the banning of CFC imports in their raw form. We have moved to phase out the use of ozone-depleting substances faster than internationally required but do not yet have a phase-out schedule for methyl bromide.

(Ministry for the Environment, 1997, chapter 10.)

The report also raised some issues about the availability of data.

Greenhouse gases and potential climate change:

> National data on weather patterns, temperature, rainfall etc. are generally of high quality and go back many decades. Data on greenhouse gas concentrations in the atmosphere are also of high quality and go back two decades. Data on some greenhouse gas emissions are still limited and uncertain, but estimates of carbon dioxide emissions from energy and industrial processes can be accurately calculated from economic data. Good data on carbon storage in pine plantations are available, but are lacking for indigenous forests and soils.

(Ministry for the Environment, 1997, chapter 10.)

Ozone depletion:

> Data on ozone concentrations are of high quality and go back about a decade. National data on imports of some ozone-depleting substances exist, but no data exist on the use of and emission of ozone depleting substances.

(Ministry for the Environment, 1997, chapter 10.)

Climate change

In 1997, much of the global debate on climate change was still focused on the growing body of scientific evidence and interpreting what this meant. Today, there is global consensus on the urgent need for response to climate change, both in terms of reducing greenhouse gas emissions, and in preparing for its impacts. This global consensus was set in motion, in part, through the Kyoto Protocol, which set binding reduction targets for developed countries for the period 2008–2012.

New Zealand's greenhouse gas emissions

New Zealand's greenhouse gas emissions represent much less than 1 per cent of total global emissions (Organisation for Economic Co-operation and Development, 2007). However, relative to its population size, New Zealand continues to have high emissions, and is ranked 12th in the world per head of population. New Zealand has a lower level of per capita emissions than other Organisation for Economic Co-operation and Development countries, such as Australia and Canada, but higher levels than the United Kingdom and Germany.

Our annual emissions have grown by 25 per cent since 1990 as the population and economy have grown. This growth continues to present a challenge in light of our Kyoto Protocol commitments to reduce emissions to 1990 levels, on average, over the period 2008–2012.

The largest growth in emissions since 1990 has been in the energy sector (an increase of 9.9 Mt CO_2-e) and the agricultural sector (almost 5 Mt CO_2-e). However, growth in our emissions has been tempered by an increase in removals of greenhouse gases by carbon sinks since 1990 (–5 Mt CO_2-e).

New Zealand faces particular difficulty in reducing greenhouse gas emissions because of our unique emissions profile – half of our emissions come from the agricultural sector. Since 1997, the management of greenhouse gas emissions in New Zealand has largely focused on investing in research to reduce our significant agricultural emissions and developing programmes to reduce energy and transport emissions, deforestation, and encourage new forest sinks.

Present and future management

Climate change is a long-term issue that presents both risks and opportunities for New Zealanders. We start from a relatively favoured situation with high levels of renewable electricity generation, and low population density. Forest cover is extensive, we enjoy a temperate climate, and awareness of environmental issues is well-established. But we also face challenges. Much of our economy is based on biological industries which will be affected by a changing climate. We are also distant from markets and customers, including our tourism markets, so there is a perception that the carbon footprint of our exported goods and services is high.

Present policy development is focusing on policies that reflect our own particular national circumstances, as well as those that seek global solutions.

In addition to sector-specific policies, an emissions trading scheme is under development to reduce greenhouse gas emissions nationally (see box 'Government action on climate change').

Under such a scheme, prices are established for units to emit greenhouse gases. Those prices then influence decisions throughout the economy by producers, consumers, and investors, driving the reduction of emissions and the expansion of more environmentally friendly alternatives.

For New Zealand, both now and in the future, taking effective domestic action will mean both shouldering responsibility for managing the reduction of our national emissions, and creating the platform upon which we can contribute internationally to achieving a broad and effective global response to climate change.

GOVERNMENT ACTION on climate change

Sector-specific policies

A number of initiatives and policies are underway to reduce New Zealand's greenhouse gas emissions. These include:

- sustainable transport programmes
- energy conservation and efficiency initiatives
- minimum energy-performance regulations
- funding for healthy housing
- air quality regulations
- sustainable land-use policies
- vehicle fuel efficiency labelling schemes
- new building standards.

Emissions Trading Scheme

In addition to sector-specific policies, the Government announced in September 2007 that it would introduce an economy-wide Emissions Trading Scheme to reduce New Zealand's greenhouse gas emissions. The scheme is to be phased in from 2008, beginning with the forestry sector, and including all sectors (transport, energy, industry, and agriculture) and greenhouse gases over time.

The Emissions Trading Scheme will set up a market that puts a value on greenhouse gas emissions. It will encourage companies that cut their emissions and make it more expensive for companies who do not.

Commitments and targets

At the same time, the Government has announced several specific targets relating to energy and climate change:

- a goal to increase renewable electricity generation to 90 per cent of New Zealand's total electricity generation by 2025
- a goal to reduce per capita emissions from the transport sector by half by 2040
- a goal to increase forest area by 250,000 hectares by 2020
- for New Zealand to be one of the first countries to widely deploy electric vehicles
- six lead public sector agencies to be carbon neutral by 2012, and the remaining 28 core public sector agencies to be on the path to carbon neutrality by 2012. (See box 'Government action on sustainability' in chapter 3, 'Household consumption'.)

continued over

GOVERNMENT ACTION on climate change

Pastoral Greenhouse Gas Research Consortium

The Government and the agricultural sector signed a memorandum of understanding in 2003 to jointly initiate the Pastoral Greenhouse Gas Research Consortium. The signatories cooperate on research to develop practical and cost-effective farm practices and technologies to reduce agricultural emissions.

The research aims to:

- develop on-farm technologies to improve production efficiency for ruminants
- develop on-farm technologies that lower methane emissions from New Zealand ruminants and nitrous oxide from grazing-animal systems
- exploit commercial opportunities arising in a global market.

Projects to Reduce Emissions programme

The Projects to Reduce Emissions programme introduced its first tender round in 2003 to support new initiatives – mainly in the energy sector – that reduce greenhouse gas emissions by awarding emissions units, or 'carbon credits'. As these emission units are internationally tradable, the programme was designed to 'lift over the line' projects that were not commercially viable.

Permanent Forest Sink Initiative

The Permanent Forest Sink Initiative was introduced in 2006 to promote the establishment of new, permanent forests on previously unforested land. The initiative gives landowners the opportunity to generate income through 'carbon farming' – creating new carbon sinks. Participants are able to claim credits under the Kyoto Protocol that can then be on-sold.

Plan of Action for Sustainable Land Management and Climate Change

In 2006, a discussion document, *Sustainable Land Management and Climate Change: Options for a Plan of Action*, was released for public consultation. $170 million has been committed between 2007–2012 to develop and deliver the plan of action, which centres around five key pillars of work (adaptation to climate change; reducing greenhouse gas emissions alongside the Emissions Trading Scheme; business opportunities arising from climate change; research and technology transfer; and communications).

Stratospheric ozone

The 1997 report identified that the ozone layer was depleting and would continue to do so for several decades. The report also observed that UV radiation appeared to be increasing in response to ozone depletion.

Internationally, as a result of actions under the Montreal Protocol, there has been rapid progress in reducing the use of ozone-depleting chemicals. This has led to more stable levels of ozone over New Zealand and Antarctica. As a consequence, UV radiation is no longer increasing, and in recent years has decreased.

However, stratospheric chlorine and bromine levels are falling only slowly, so full recovery of the ozone layer is some way off.

Ozone-depleting chemicals

Although New Zealand is not a producer of ozone-depleting chemicals, the Government has regulated imports of them. Domestic controls (through the Ozone Layer Protection Act 1996 and Ozone Layer Protection Regulations 1996) reduce New Zealand's reliance on ozone-depleting substances by progressively restricting the volumes imported. Efforts have also focused on reducing the quantity of ozone-depleting substances in use.

With the introduction of the Halon Management Strategy in 2000, over 30,000 tonnes of halons have been collected for safe destruction. This quantity of halons had the potential to destroy over 1.6 billion tonnes of atmospheric ozone.

A recent Organisation for Economic Co-operation and Development report (Organisation for Economic Co-operation and Development, 2007) states that New Zealand is the world's 11th largest user of ozone-depleting methyl bromide. The use of methyl bromide for quarantine and pre-shipment processes can be attributed to increased biosecurity requirements for imports and exports (The Minister of Commerce and the Minister for the Environment, 2006).

Importing methyl bromide for uses other than quarantine and pre-shipment treatments is now prohibited, unless allowed by an exemption for 'critical use'. The parties to the Montreal Protocol approved an exemption for the New Zealand strawberry industry for soil fumigation for the year ending 31 December 2007. The Government has decided that no further nominations for critical use of methyl bromide in the strawberry industry will be supported.

Improvements in data

The 1997 report identified some shortcomings in atmospheric data. In particular, the report found that New Zealand did not hold data on the use and emission of ozone-depleting substances. Progress has been made since that time, with more comprehensive data collected annually since legislation came into force.

There have also been improvements in estimations and calculations of our greenhouse gas inventory data. Emphasis has been placed on development of a Land-Use and Carbon Analysis System, a database to store and analyse land use and carbon stock changes over time. This database will assist with the development and reporting of climate change policy to meet New Zealand's obligations under the Kyoto Protocol. Mandatory reporting of greenhouse emissions under the United Nations Framework Convention on Climate Change and Kyoto Protocol will ensure data in New Zealand continues to improve over time.

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LAND

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At a glance

New Zealand is recognised internationally for its stunning landscapes and productive agricultural and horticultural land. Since human settlement, the way we have used our land has fundamentally shaped our nation.

Land use and our economy

Land underpins a significant part of our economy. Seventeen per cent of New Zealand's gross domestic product depends on the top 15 centimetres of our soil.

Land plays an integral part in supporting New Zealand's top two export earners: tourism and primary production. In 2007, agriculture, forestry, horticulture, and viticulture generated $16.1 billion, $3.6 billion, $2.5 billion, and $662 million respectively in export earnings. In 2006, tourism generated $8.3 billion in export earnings.

Land cover

Reflecting changes in land use, land cover in New Zealand continues to change as our population grows, land prices change, and international commodity prices fluctuate.

In 2002, natural land cover (native forest, native vegetation, and other native land cover, for example, rivers, lakes, snow, ice, and scrub) was New Zealand's largest land cover at 50 per cent of New Zealand's total land area. Pasture was our second largest land cover at just over 39 per cent. Exotic forest covered 7.31 per cent of New Zealand's land area.

Between 1997 and 2002, satellite measurements showed that:

- pastoral land cover decreased by 125,200 hectares (or just over 1 per cent)
- human settlements increased by just over 5,300 hectares (or 3 per cent)
- native vegetation and native forest decreased by 17,200 hectares (or 0.15 per cent)
- exotic forest cover increased by 139,500 hectares (or about 8 per cent)
- horticultural land area increased by 4,500 hectares, with the total area of horticultural land remaining at just under 1.6 per cent of New Zealand's total land area.

In 2006, the total land area of planted forestry was estimated to be 1.8 million hectares. From 1990 until 2003, a trend of increasing land area in exotic forestry was observed.

Land use

In 2004, pastoral land use (for example, sheep, beef, and dairy farming) was New Zealand's largest human land use at just over 37 per cent of New Zealand's total land area.

Although the total area of New Zealand land in pasture has been decreasing since 1972, the area of land in *dairy* pasture has increased. Between 1996 and 2006, the national dairy herd has grown by 24 per cent. This intensification of agricultural land use has occurred as farmers have responded to economic signals by converting suitable dry-stock pasture, exotic forestry, and existing dairy farms into more intensive dairy farms.

A change to more intensive farming in some regions has resulted in:

- further reduction of freshwater quality in lowland rivers and waterways
- changes in soil health
- increases in some greenhouse gases, for example, methane.

Over the past 10 years, greater diversification of land use has been evident, especially for horticultural land including vineyards, orchards, and perennial crops. As an example, the area of land in vineyards increased by 28 per cent between 1997 and 2002.

From the mid-1990s, there has been a significant reduction in the amount of new exotic forestry plantings. In 2005, the rate of new exotic forest plantings declined to its lowest level since 1959. In 2004, a new trend of not replanting exotic forestry after harvesting became apparent. In addition, some planted exotic forest planting has been converted to pastoral land use before maturity.

Hill-country erosion

Hill-country erosion is estimated to cost New Zealand between $100 million and $150 million each year through the loss of soil and nutrients; loss of production; damage to houses, fences, roads, phone and power lines; and damage to waterways and aquatic habitats. About 10 per cent of New Zealand is classed as severely erodible.

During the 1990s, hill-country erosion eased in some regions. Satellite measurements between 1997 and 2002 showed that 36,400 hectares of land on erosion-prone hill country was converted from pasture to other land covers during this period. The large majority of this (36,300 hectares) was converted to exotic forestry or retired and left to revert to scrub.

Land use affects the environment

Land use puts many different pressures on our environment.

- Urban and rural run-off pollute our waterways and coasts.
- Urban expansion can lead to the loss of land for food and fibre production or the loss of plant and animal habitats.
- Intensive farming (with high animal stocking rates and increased use of fertilisers) can have detrimental effects on groundwater and surface water quality.
- Intensification of agricultural activity can also increase greenhouse gas emissions from animals.

Land use and soil health

Intensively cropped soils (such as market gardens) have lower organic content and poorer soil structure compared with pasture soils, and very high nutrient levels. High levels of available phosphate were also observed under some croplands, reflecting application of fertilisers.

Soils under exotic pasture generally have higher nutrient levels and are less acidic than forestry soils, reflecting the use of lime and phosphate fertilisers to develop agricultural land. Under some dairy farming soils, phosphate levels are high and some forms of nitrogen may be reaching saturation point. When nitrogen levels reach saturation point, excess nitrogen can be leached from soils, affecting water quality. Nitrogen and potentially mineralisable nitrogen were highest under pastoral land use than any other land use.

Monitoring found moderate soil compaction on a large proportion of monitored pastures and some cropping land uses. Soil compaction is caused by farm animals treading on pastures, and vehicle traffic and cultivation on croplands. Compaction can reduce pasture growth and increase rates of nutrient run-off to waterways.

Soil pH (acidity or alkalinity) under exotic forests was found to be similar to that under native forests. Other agricultural land uses exhibit higher pH values (are more alkaline).

Past uses have contaminated some land

New Zealand soils generally contain low levels of contaminants, but past industrial, domestic, or agricultural activities have contaminated some sites. Local government is working to identify these sites and ensure they are appropriately managed.

Our understanding of the extent of land contamination in New Zealand has improved, but a substantial amount of work is still required:

- to assess sites identified as potentially contaminated
- to record information about contaminated sites in a consistent format.

Legislation such as the Hazardous Substances and New Organisms Act 1996 has been enacted to prevent the present-day contamination of land.

Past, present, and future management

Historically, environmental management of land in New Zealand has focused on:

- managing hill-country erosion
- minimising flood risk
- improving the health of pasture soils.

More recently, greater focus has been placed on:

- protecting riparian stream margins
- excluding stock from waterways
- minimising nutrient enrichment of our waterways, including through nutrient budgeting and use of nitrification inhibitors
- protecting our land-based primary production sector from pests and diseases from overseas.

Looking ahead, focus is likely to sharpen on how best to:

- manage the impacts of intensified land use on our soils and waterways
- identify and manage land contaminated by historical agricultural and industrial activities
- continue to manage hill-country erosion
- continue to manage biosecurity risks to New Zealand's primary production sector and native species
- meet growing consumer demand for sustainably produced agricultural, horticultural, and forestry products.

Introduction

The way we have used our land has fundamentally shaped our nation. From earliest times, settlers in New Zealand have worked the land to produce food and fibre (for example, wool and flax), to raise animals, and to build dwellings. Today, New Zealanders value land for its scenic, recreational, historical, and cultural significance.

Māori relate to land as the tangata whenua (people of the land). This term expresses an understanding that land and people are inseparable through whakapapa (kinship) (Durie, 1998). Iwi (tribes) relate to specific places within New Zealand over which they have mana whenua (customary authority).

While many people equate New Zealand's landscape with its natural areas, most of our landscapes have been modified by human use. Many of our urban and pastoral landscapes have changed significantly from the landscapes that existed in the first 100 years of European settlement.

A definition of land

Land is considered to include:

- the aesthetic components of landform and landscape including the vegetation cover
- the physical components of soil and parent material (the soils and underlying rock types that give rise to soil)
- the plant and animal communities in the soil, such as insects, mites, springtails, nematodes, worms, fungi, bacteria, and algae
- the exotic and native ecosystems resident on the land, such as exotic forestry, urban settlements, native forests, and tussock grasslands.

(Williams and Mulcock, 1996.)

Landform and landscape

Landforms are the result of geological processes and chemical and physical weathering. Landforms interact constantly with living and non-living features such as plants and waterways to make up a landscape.

New Zealand's geological history has resulted in significant variations in landscape from dry plains, to steep hill country, snow-capped mountains, and coastal dunes. Even within a few kilometres, neighbouring landscapes can differ greatly. Except for the occasional large earthquake, volcanic eruption, forest fire, or extreme storm event, the natural factors that created and continue to change New Zealand's landforms tend to operate slowly over hundreds, thousands, or millions of years.

Today, New Zealand's landscapes include both cultural landscapes (those modified by people) and natural landscapes. While both landscapes are subject to constant change, the speed of this change depends on whether the change is due to natural or human influence.

Land use defines New Zealand's identity

Reliance on land resources is a defining feature of New Zealand's national identity. The expertise we have developed in using our land resources has put New Zealand on the international stage. Land underpins New Zealand's top two export earners: tourism and primary production.

Our high-value agricultural, horticultural, wine, and forestry products are exported around the world. And, in recent years, New Zealand has marketed itself internationally as a premier destination for scenic and adventure tourism.

Export earnings

In the year ended 31 March 2007, primary production generated export earnings that equated to:

- agriculture – $16.1 billion
- forestry – $3.6 billion
- horticulture – $2.5 billion
- viticulture – $662 million.

(Ministry of Agriculture and Forestry, 2007b; New Zealand Wine, 2007).

In the year ended 31 March 2006, tourism generated export earnings of $8.3 billion (Statistics New Zealand, 2007b).

Primary production

Dairy products were New Zealand's single largest export earner in the year to December 2006, making up 18.1 per cent of total exports. Meat and timber were our next largest export products, accounting for 13.5 and 6.2 per cent of total exports respectively (Statistics New Zealand, 2007a).

Primary production also provides direct and indirect employment for a significant proportion of the New Zealand workforce, particularly in rural areas.

Tourism

In terms of both export earnings and onshore economic value, international tourism contributed $12.3 billion to New Zealand's economy in the year ending 31 March 2005 (Ministry of Tourism, 2007).

New Zealand's changing land cover and land use

'Land cover' describes the types of features present on the surface of the earth (Lillesand and Kiefer, 1994). Pastures, snow and ice, forests, human settlements, and lakes are all examples of land cover types.

The term 'land use' relates to the human activity or economic function associated with a piece of land, such as built-up areas, commercially planted forestry, and different types of farming or horticulture (for example, dairy, sheep and beef, grapes, berryfruit) (Lillesand and Kiefer, 1994).

Human activity modifies many aspects of the environment, particularly land cover and land use. Before human settlement, forests were New Zealand's predominant land cover (see chapter 12, 'Biodiversity'). Since then, New Zealand's land cover has undergone significant human-influenced change.

New forms of cultural landscapes (those modified by people) were created from natural landscapes. Settlements grew around the river mouths that provided harbours as settlers made use of New Zealand's most suitable land for economic, social, and cultural development. About 24 per cent of New Zealand's original native-forest land cover remains today; however, nearly all lowland areas have been cleared of forest for human uses, including agriculture, horticulture, and urban development.

Topography and geology influenced the choice of land use. Thirty per cent of our country is hilly with a slope of more than 25 degrees (Sparling, 2007). Our preference for animal production over crop production reflects the lack of flat land available for cultivation in many areas (Ministry for the Environment, 1997). Climatic variations and soil types also affect land productivity, and have resulted in different patterns of primary production and land use around the country.

New Zealand's soils

New Zealand has a diverse range of soils and parent materials. This range has been further increased by human activity to enhance soil fertility.

New Zealand soils are naturally acidic with low levels of nitrogen, phosphorus, and sulphur. Consequently, soils used to grow crops and pasture derived from European agriculture need to be developed and maintained with nitrogen-fixing plants (such as clover), fertilisers and, often, lime to sustain high-yield plant growth. As a result, farmed soils today are not the same as the soils farmed by early settlers (they have different biological, chemical, and physical properties than earlier soils) (During, 1984).

In general, North Island soils are strongly influenced by volcanic ash, with many areas naturally low in minerals such as magnesium, copper, iron, cobalt, and boron. In the South Island, most arable soils come from parent material carried down from mountains and foothills by rivers and wind, aided by glacial action. Mineral deficiencies in South Island soils follow rainfall patterns – the wetter the area, the greater the potential for minerals to be leached out (Hewitt, pers comm).

Figures 9.1 and 9.2 show the location of New Zealand's 15 soil orders – the highest and most generalised level of soil groups in a soil classification (see box 'More about soil classification in New Zealand').

Nitrification inhibitors: tackling nitrous oxide emissions from soils

The agricultural sector produces close to 50 per cent of New Zealand's greenhouse gas emissions (see chapter 8, 'Atmosphere').

Around one third of New Zealand's agricultural emissions are in the form of nitrous oxide. Nitrous oxide is emitted from soil processes. Increased emissions can result from the addition of nitrogen to soils (for example, urine and dung from grazing sheep and cattle, the application of nitrogen fertilisers, and from the absorption (fixation) by clover of nitrogen from the atmosphere).

What are nitrification inhibitors?

Nitrification inhibitors are chemical compounds which stop the conversion of nitrogen into nitrous oxide in soils. These inhibitors can be applied to soil to reduce emissions of nitrous oxide to the atmosphere.

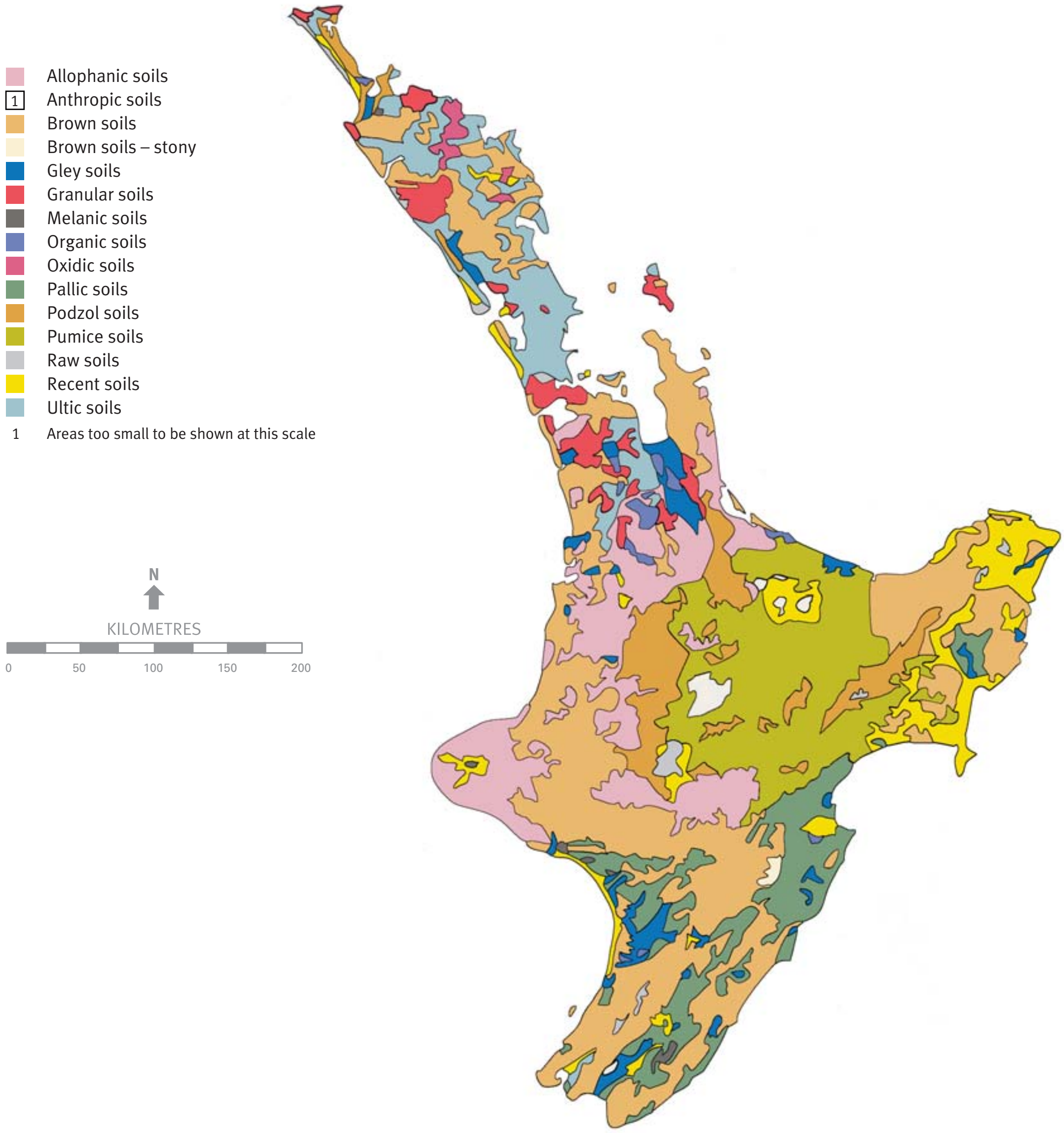
What is the impact of nitrification inhibitors?

Research conducted at a number of sites in New Zealand indicates that the application of nitrification inhibitors to soil results in an average 70 per cent reduction in nitrous oxide emissions when urine is applied to pasture (Di et al, 2007). Similar, although more variable, reductions in nitrate leaching have been recorded. Actual reductions in both nitrate leaching and nitrous oxide emissions may be lower in an on-farm environment.

An added benefit is the potential for increased pasture production associated with the reduction in loss of nitrogen. In addition, reductions in nitrogen losses from soils help keep our waterways clean: leaching of nitrates from agricultural soils affects water quality in many areas (see chapter 8, 'Atmosphere and chapter 10, 'Freshwater').

Research is continuing to evaluate this innovative technology in New Zealand.

+ FIGURE 9.1:
NEW ZEALAND'S SOIL ORDERS (NORTH ISLAND)



Notes:

(1) Only 14 of New Zealand's 15 soil orders occur in the North Island.

(2) The brown soil order is divided into two sub-orders (brown soils and brown soils – stony) for the purposes of this Figure.

Source: Adapted from Molloy, 1998.

+ FIGURE 9.2:
NEW ZEALAND'S SOIL ORDERS (SOUTH ISLAND)

Notes:

(1) Only 12 of New Zealand's 15 soil orders occur in the South Island.

(2) The brown soil order is divided into two sub-orders (brown soils and brown soils – stony) for the purposes of this Figure.

Source: Adapted from Molloy, 1998.

Table 9.1 notes the predominant land uses and locations for the 15 soil orders shown in Figures 9.1 and 9.2.

+TABLE 9.1:
NEW ZEALAND'S 15 SOIL ORDERS AND THEIR PREDOMINANT LAND USES

SOIL ORDER	REGION OF NEW ZEALAND	PERCENTAGE COVER IN NEW ZEALAND (%)	PREDOMINANT LAND USE
Allophanic	Central North Island	5	Pastoral farming, cropping, and horticulture
Anthropic	Central Ōtago, Westland	<1	Modified soils – extensive in urban areas and areas that have been mined
Brown	East Taranaki, Wanganui–Rangitīkei, east coast of North Island, Wellington, Marlborough, Nelson–Buller, Southland, and South Island high country	43	Intensive pastoral farming and forestry
Gley	Wetlands – low parts of the landscape prone to water logging	3	High-producing dairy farms (with drainage systems)
Granular	Northland, South Auckland, Waikato, and some areas in Wanganui	1	Pastoral farming, cropping, and forestry; horticulture in some areas
Melanic	Lowland plains on east coast of South Island (some in Northland)	1	Pastoral farming, mixed cropping, and market gardening
Organic	Lowlands of Waikato and Bay of Plenty wetlands	1	Vegetable growing and horticulture
Oxidic	Northland, Banks Peninsula, and Ōtago Peninsula	<1	Pastoral farming, forestry, and native bush
Pallic	East coast of North Island and Manawatū	12	Pastoral farming and mixed cropping
Podzols	Northland and Westland	13	Agriculture and forestry
Pumice	Central North Island, Hawke's Bay, and Bay of Plenty	7	Pastoral farming, forestry, and native bush
Raw	Central North Island, Hawke's Bay, and Bay of Plenty	3	Pastoral farming, forestry, and native bush
Recent (alluvial and coastal)	All districts (floodplains, lower terraces of rivers, and coastal areas)	6	Alluvial: dairy farming, arable crops, market gardening, horticulture, and sports fields Coastal: pastoral and exotic forestry
Semi-arid	Central Ōtago	1	Pastoral farming, pipfruit, tussock land, and mountains
Ultic	Northland/Auckland	3	Urban, pastoral farming, and native vegetation

Source: Adapted from Molloy, 1998.

Soil classification and its use in New Zealand are explained in the box 'More about soil classification in New Zealand'.

More about soil classification in New Zealand

What is a soil classification used for?

A soil classification can be used to trace the formation, or evolution, of soils through time. The need for soil classification has been part of human activity in New Zealand. Soil classification has been used in New Zealand since the arrival of the first Polynesian canoe. Māori horticulturalists recognised and named soil classes that were relevant to the establishment and management of their gardens, in particular, kūmara gardens. They recognised classes such as oneharuru (a light but good sandy loam) and onetea (white soil from sandy volcanic material).

Who developed New Zealand's classification?

The New Zealand soil scientist, Norman Taylor, developed the New Zealand Genetic Classification in 1948, which recognised 'soil groups' and related them to the environmental factors that most influenced their character. Knowledge of these relationships helped the prediction of soil classes from observations of geology, landscape, climate, and vegetation. Such predictions enabled rapid progress in the broad-scale mapping of New Zealand soils.

By the late 1970s, Taylor's classification was becoming outdated. With new information, the New Zealand Soil Classification was developed (see Figures 9.1 and 9.2). Under this classification there are 73 major soil groups that can be aggregated into 15 different soil orders. Soil orders are the highest and most generalised level of the classification. The soil groups can be divided into 272 subgroups with a further subdivision into soilforms. The top three levels of the classification (orders, groups, and subgroups) were described by Hewitt (1993) and the fourth level (soilforms) by Clayden and Webb (1994).

Source: Molloy, 1998.

Factors that affect land

New Zealand's land is constantly changing. The speed of this change depends on natural or human influences. Land use, a change due to human activity, directly influences land cover. Urban land uses generally go hand-in-hand with artificial land cover such as roadways, pavements, and buildings. Rural land uses generally go hand-in-hand with land cover such as pastures, forests, vineyards, croplands, and orchards. Changing land use and land cover can create pressures on the environment, which in turn affect land-based ecosystems, soils, plants and animals, waterways, and our atmosphere (see chapter 8, 'Atmosphere'; chapter 10, 'Freshwater'; chapter 11, 'Oceans'; and chapter 12, 'Biodiversity').

Some environmental pressures on land include:

- changes in land cover that affect land-based ecosystems and native or exotic (introduced) biodiversity
- changes in land use that affect soil health (that is, soil quality) or soil intactness (that is, the ability of soils to stay in place), and have flow-on effects for water quality in rivers, lakes, estuaries, and the coastal marine environment, and increase the risk of erosion and flooding
- pesticide, herbicide, and other chemical contamination of soils that result in contaminated land
- introduced animal pests, diseases, and weeds that affect land-based ecosystems and threaten biosecurity, animal health, productivity, or human health.

Historic land use

Nearly all New Zealand's cultural landscapes have been modified by agriculture, horticulture or forestry at some time in the past. As in other countries, historic land-use practices have had serious impacts on New Zealand's environment, including soil erosion (which causes siltation of streams, rivers, and estuaries) and increased flooding risk (see box 'More about flooding in New Zealand').

In many areas, the effect of historic land use is only now being felt – it often takes decades for nutrients from farm run-off to reach our lakes and groundwaters, where they cause algal blooms and dense growth of aquatic weeds (Ministry for the Environment, 1996).

More about flooding in New Zealand

About 100 of our towns and cities are located on floodplains. As a result, flooding remains the most common cause of civil defence emergencies in New Zealand.

Although flooding occurred in New Zealand before human settlement, the nature of flooding was changed significantly by the European settlers' intensive land clearing. The capacity of the land to retain rainfall was reduced by converting forests to pasture. This change caused greater flood peaks, more intensive erosion, and changes in river systems, leading to more frequent and severe flooding.

Early flood protection measures

The importance of protecting our valuable topsoils was recognised in New Zealand in the mid-1900s. The Soil Conservation and Rivers Control Act 1941 was introduced to limit soil erosion and the effects of flooding. Most of New Zealand's large-scale river-control schemes were built under this regime. About 3,000 kilometres of stopbanks were constructed in the 1950s and 1960s alone.

Stopbanks protected communities from regular flooding, but they also allowed more intensive development on floodplains. In some cases, stopbanks actually increased the consequences of flooding, because more people and assets were affected when large floods breached stopbanks. Over time, the traditional approach of building structures to protect people and property from flooding shifted to focusing on planning measures to control development in flood zones.

Integrated catchment management schemes

Integrated catchment management schemes were introduced in the 1970s and 1980s. These schemes put in place soil conservation measures in upper catchments, and river control and erosion protection in the lower reaches of rivers and floodplains. An integrated approach is particularly relevant to dealing with flood risk.

The '4Rs' approach (risk, readiness, response, recovery)

Since 2002, New Zealand has followed a risk management approach to natural hazards, including floods. This approach relies on reducing risk, being ready (risk-preparedness), response, and recovery.

Severe consequences

Widespread flooding in the lower North Island in February 2004 reminded New Zealanders how disastrous floods can be. Heavy rainfall (up to 300 millimetres in 2 days) saw rivers and streams flood in Hutt Valley, Kapiti Coast, Wairarapa, South Taranaki, Wanganui, and Manawatū. Manawatū was worst affected, with 1,800 people evacuated from their homes and farms, and economic losses estimated at $400 million (McSaveney, no date).

Lesser floods can also have significant consequences. In July 2004, flooding in the Eastern Bay of Plenty led to the evacuation of 3,200 people. About 450 farms were affected, and 200 houses were left uninhabitable. Mangawhero River flooding in July 2006 caused a bridge to collapse, isolated the settlement of Mangawai and caused damage estimated at $10 million. (National Institute of Water and Atmospheric Research, and Institute of Geological and Nuclear Sciences, 2006).

Future management of flooding

Climate change is expected to increase the frequency and severity of flood events in some areas of New Zealand, particularly those already prone to flooding. Integrated catchment management and the 4Rs approach to hazard management are particularly relevant to managing future flood risk. Central and local government are working together to meet this challenge.

Changing and intensifying land use

Today, although many land management practices have improved, there remain some significant pressures on the environment from changing and/or intensifying land use.

Over the past 10 years, a change to more intensive farming in some regions has resulted in:

- further reduction of freshwater quality in lowland rivers and waterways (see chapter 10, 'Freshwater')
- changes in soil health (see 'Current state and trends')
- increases in some greenhouse gases, such as methane (see chapter 8, 'Atmosphere').

Effects of commodity prices

Changes in land use in our primary production sectors are driven by export prices (Ministry for the Environment, 1997). High market prices for particular commodities (such as milk and dairy products, timber and forestry products, and more recently grapes and wine products) can cause farmers to convert from one land use to another.

Versatile soils

In recent years, the spread of urban and rural lifestyle subdivision in some regions has put pressure on soils known as 'versatile soils' (Molloy, 1998). Versatile soils cover about 10 per cent of New Zealand's total land area. These soils are fertile, generally well-drained, and found on slopes of less than 12 degrees (Molloy, 1998).

Because versatile soils are of high value for food production, they are traditionally used for horticulture or arable cropping. While changing the use of these soils from large scale food production to human settlement may result in a loss of fertile productive land, it also changes the pressures on the immediate land environment.

HORTICULTURE IS ESTIMATED TO COVER 1.6 PER CENT OF NEW ZEALAND'S TOTAL LAND AREA COMPARED TO 24 PER CENT IN EUROPE.

Source: Ministry for the Environment.

Tourism infrastructure needs

Scenic and adventure tourism, a growth industry in New Zealand, relies on natural and pastoral landscapes and native biodiversity.

Land use for tourism purposes has different impacts on the environment than other land uses. Revenue from tourism can help protect valuable native land cover and biodiversity. The infrastructure needs associated with tourism (such as roads, accommodation, and waste management) place different pressures on our land than other land uses (for example, primary production). However, tourism can have a wider positive environmental impact when the tourism demand is for a 'clean and green' environment.

Vulnerability to introduced pests

As an island nation, New Zealand has unique biological characteristics that have developed in isolation over millions of years. This isolated development has meant New Zealand's primary production has benefited from a high health status; that is, being relatively free from pests and diseases compared with other countries.

Over the past few decades, increased trade and travel and changing climatic conditions have increased New Zealand's vulnerability to introduced pests that can affect our land-based economy. An example is the varroa mite, which affects bees and, therefore, pollination activity.

An increasing number of vessels, cargo shipments, and people are arriving from other regions which have organisms with the potential to become high-risk pests for New Zealand's primary production sectors.

Land management legislation

Resource Management Act 1991

The Resource Management Act 1991 is the primary piece of legislation that governs the use, development, and protection of land in New Zealand. The Resource Management Act promotes the sustainable management of natural and physical resources, including land.

District council functions under the Resource Management Act include the integrated management and control of the effects of the use, development, or protection of land.

Territorial authority functions include controlling the effects of land use relating to natural hazards, hazardous substances, and biodiversity.

Regional council functions include the control of the use of land for purposes of soil conservation, natural hazards, water quality, and hazardous substances.

Both territorial and regional councils have functions relating to identifying, monitoring, and managing the effects of contaminated land.

A number of other Acts impact on land management. These include:

- Biosecurity Act 1993
- Building Act 2004
- Crown Minerals Act 1991
- Hazardous Substances and New Organisms Act 1996
- Historic Places Act 1993
- Local Government Act 1974
- Local Government Act 2002
- Soil Conservation and Rivers Control Act 1941.

Legislation relating to land tenure includes:

- Land Act 1948
- Land Transfer Act 1952
- Property Law Act 1952
- Te Ture Whenua Māori Act 1993.

National environmental indicators

See chapter 1, 'Environmental reporting', for more information on the core set of national environmental indicators and how they are used.

There are four national indicators for land. These indicators provide information on:

- land cover
- land use
- soil health
- soil intactness of erosion-prone hill country.

Reporting on changes in the land indicators, combined with other more detailed information about land use (such as trends in agricultural production and exotic forestry), will help identify some of the greatest pressures on New Zealand's land.

Land cover

Land cover is an indicator of the state of our land.

Since 1997, land cover in New Zealand has been mapped periodically from satellite imagery to create the national Land Cover Databases (LCDB) 1 and 2 (see the 'Ecological classifications' section in chapter 1, 'Environmental reporting'). The LCDB maps 43 different land-cover classes.

This chapter reports on the current state of and changes in land cover using LCDB land-cover classes in nine major groupings, as well as other agricultural production data.

Land use

Change in land use is an indicator of pressure on the land, but is not the same as change in land cover. For example, one land cover (for example, pasture) could be used for a number of land uses (for example, sheep, beef, dairy, or deer farming).

Land-use information can also provide information about land-use intensity, such as stocking rates and productivity.

Land-use maps, and estimates from the Agricultural Production Survey and the National Exotic Forest Description, are used in this chapter to report on national changes in land use and land-use intensity.

Soil health

Soil health (or soil quality) is the biological, chemical, and physical condition of different soil types under specific land uses.

The biological health of soil is determined by measuring the level of potentially mineralisable nitrogen in the soil.

The chemical health of soil is determined by measuring the levels of the following chemical compounds or properties of the soil:

- carbon
- nitrogen
- pH
- Olsen phosphate.

The physical health of the soil is determined by measuring macroporosity.

This chapter reports on the health of soils under New Zealand's major primary production land uses (cropping, pastoral farming, and forestry).

To do so, this chapter draws on the results of a soil health monitoring project (the 500 Soils Project). The 500 Soils Project monitored six key measures of soil quality (see Table 9.2) across New Zealand's 15 main soil orders (see Figures 9.1 and 9.2 and Table 9.1).

As part of the 500 Soils Project, the six key measures of soil health were monitored across seven major land-use categories (Sparling and Schipper, 2004; Sparling, 2007):

- arable cropping (for example, grains and fodder crops)
- mixed cropping (for example, vegetables)
- drystock pasture
- dairy pasture
- tussock grasslands
- plantation (exotic) forestry
- native forests.

+ TABLE 9.2:
MEASURES OF SOIL HEALTH AND INFORMATION THESE PROVIDE

MEASURES	SOIL HEALTH INFORMATION
BIOLOGICAL PROPERTIES	
Potentially mineralisable nitrogen	Readily mineralised nitrogen reserves
CHEMICAL PROPERTIES	
Total carbon content	Organic matter status
Total nitrogen content	Organic nitrogen reserves
pH	Acidity or alkalinity
Olsen phosphate	Plant-available phosphate
PHYSICAL PROPERTIES	
Macroporosity	Soil compaction, root environment, aeration

Data source: Adapted from Sparling and Schipper, 2004; Sparling, 2007.

Soil intactness of erosion-prone hill country

Erosion-prone land is mainly hill country with a slope of more than 21 degrees. The most erosion-prone hill-country lands are in pastoral land cover and have soils that are known as 'yellow-brown earths' situated on weakly consolidated mudstones and sandstones.

Land cover can be used to assess the soil intactness of erosion-prone hill country (that is, the ability of soils to stay in place on erosion-prone hill country).

This chapter reports on changes in pasture on erosion-prone hill country around New Zealand. To do so, hill-country pasture is identified from the LCDB, and its erosion potential graded as 'severe', 'very severe', or 'extreme' depending on its slope, the underlying soils, and any limits to land-use capability (land-use capability describes the capacity of land to sustain permanent primary production).

Other forms of soil erosion, such as wind erosion, are not discussed in this chapter.

Current state and trends

Land cover

New Zealand's varying land-cover patterns are the result of human and natural pressures, such as land-use changes and geological and ecosystem processes.

Table 9.3 shows the area of the nine major land-cover classes from the LCDB, including the percentage contribution each class makes to New Zealand's total land area. The table also illustrates the change within each class for the five-year period between 1997 and 2002.

North and South Island maps showing these same nine land-cover classes for 2002 are presented in chapter 1, 'Environmental reporting'. Changes in native vegetation since human settlement, between 1997 and 2002, are reported in chapter 12, 'Biodiversity'.

+TABLE 9.3:
CHANGES IN LAND COVER BETWEEN 1997 (LCDB 1) AND 2002 (LCDB 2)

LAND-COVER CLASS		1997 AREA (HECTARES)	PERCENTAGE OF TOTAL LAND AREA (%)	2002 AREA (HECTARES)	PERCENTAGE OF TOTAL LAND AREA (%)	CHANGE IN AREA (HECTARES)
Exotic forest		1,822,300	6.79	1,961,800	7.31	139,500
Exotic shrubland		370,900	1.38	363,300	1.35	–7,600
Native forest (including mangroves)		6,485,400	24.18	6,483,100	24.17	–2,300
Native vegetation		5,263,400	19.62	5,248,500	19.57	–14,900
Other native land cover		1,588,400	5.92	1,589,100	5.92	700
Primarily horticulture		413,000	1.54	417,400	1.56	4,500
Primarily pasture	High-producing exotic grassland	8,985,200	33.50	8,885,800	33.13	–99,400
	Low-producing grassland	1,678,100	6.26	1,652,300	6.16	–25,800
Artificial surfaces		215,000	0.80	220,500	0.82	5,500
Total		26,821,600	100	26,821,600	100	

Note:
Figures rounded to the nearest 100 hectares.
Data source: Ministry for the Environment.

Vegetation cover

As shown in Table 9.3, exotic forest covered 7.31 per cent of New Zealand's total land area in 2002. Between 1997 and 2002, exotic forest increased in area by 139,500 hectares. During this time, native forest (including mangroves), native vegetation, and primarily pasture land-cover classes reduced in area by 142,400 hectares. Over the same period, exotic forests were primarily planted onto pasture with some exotic forest replacing exotic shrubland and, in some cases, native vegetation (mānuka and kānuka).

Table 9.3 also shows that land area in exotic shrubland reduced by 7,600 hectares between 1997 and 2002. Much of this was gorse and broom which may have been converted to forestry land, left to revert to native scrub, or converted into vineyards. (See discussion under 'Primarily horticulture' and 'Primarily pasture' below.)

Between 1997 and 2002, native forest decreased by 2,300 hectares. In 2002, native forest, native vegetation, and other native land cover made up around 50 per cent of New Zealand's total land area – just over 13 million hectares. (See chapter 12, 'Biodiversity' for more information about changes in native forest, native vegetation, and other native land cover.)

Native vegetation (excluding native forest and other native land cover) reduced in area by 14,900 hectares between 1997 and 2002. This reduction was predominantly due to changes in land area covered by:

- broadleaved native hardwoods (a reduction of 6,600 hectares)
- mānuka and kānuka (a reduction of 5,400 hectares)
- tall tussock grassland (a reduction of 2,500 hectares).

LCDB analysis shows that 83 per cent of the land area in broadleaved native hardwoods was converted into exotic forest land cover and 12.5 per cent was converted into pasture and grassland. Of the mānuka and kānuka, 52.5 per cent was converted into exotic forest land cover, 36 per cent into low-producing grassland, and 10 per cent into high-producing exotic grassland. All tall tussock grassland that experienced land-use change was converted into exotic forest land cover.

Overall, about 65 per cent of the 14,900 hectare reduction in native vegetation was converted into exotic forest land cover, with 7 per cent into high-producing exotic pasture and 17 per cent into low-producing grassland.

Primarily horticulture

Horticultural, viticultural, and cropping land-cover classes made up just under 1.6 per cent (or 417,400 hectares) of New Zealand's total land area in 2002. This included:

- 58,300 hectares in orchard and other perennial cropland (for example, nuts, berryfruit)
- 25,400 hectares in vineyard
- 333,700 hectares in short rotation cropland (for example, arable cropping such as grains and fodder crops for livestock feed, or market gardens for vegetables).

There was little change between 1997 and 2002 in the land area in orchard and perennial cropland (an increase of 0.39 per cent or 200 hectares) and short rotation cropland (a reduction of 0.37 per cent or 1,200 hectares). However, LCDB analysis shows the land area in vineyards increased by 28 per cent (or 5,500 hectares). Part of this increase was due to conversion of short rotation (arable) cropland.

Primarily pasture

'Primarily pasture' classes (high-producing exotic grassland and low-producing grassland) covered just over 39 per cent of New Zealand's total land area in 2002. There was a reduction in high-producing exotic pasture of 99,400 hectares (or 1.1 per cent) between 1997 and 2002. LCDB analysis shows that some of this land area was converted into urban areas (see 'Artificial surfaces' on the following page). Over the same period, the land area in low-producing grassland reduced by 25,800 hectares (or 1.54 per cent), and was mainly converted to exotic forestry.

As a comparison, New Zealand's Agricultural Production Statistics surveys between 1972 and 1996 show that the land area in grassland including lucerne (that is, pastoral land cover) was about 8.0 million hectares in 1972 and just over 9.1 million hectares in 1996 – an increase of 1,153,992 hectares or about 15 per cent over 24 years. The total land area in pasture increased to just over 9.5 million hectares by 1992, but dropped to 9.4 million hectares by 1994. Over the same 24-year survey period, pasture for dairy farming increased from about 1.4 million hectares to just over 1.9 million hectares or 39 per cent (Ministry of Agriculture and Forestry, pers comm; Statistics New Zealand, 1972–1996).

Artificial surfaces

Artificial surfaces include urban and built-up areas (towns and cities), landfills and surface mines, transport infrastructure, and urban parkland and open space. Artificial surfaces covered 220,500 hectares (just under 1 per cent) of New Zealand's total land area in 2002.

Table 9.3 above shows a 2.5 per cent increase, or 5,500 hectares, for artificial surfaces between 1997 and 2002. The land areas in surface mines and landfills, however, reduced over this same period. Built-up areas (human settlements) made up 5,300 hectares or 96 per cent of the 5,500 hectare total, and increased by 3 per cent over the same period.

The increase in built-up areas is mainly occurring on the fringes of cities and towns through rural subdivision. For example, 88 per cent of the 5,300 hectare increase was urban and built-up areas that came from pastoral land, with a further 6 per cent from exotic forest land not replanted. Growing rural towns, such as those in the Waimakariri District in the South Island, illustrate this trend in rural subdivision.

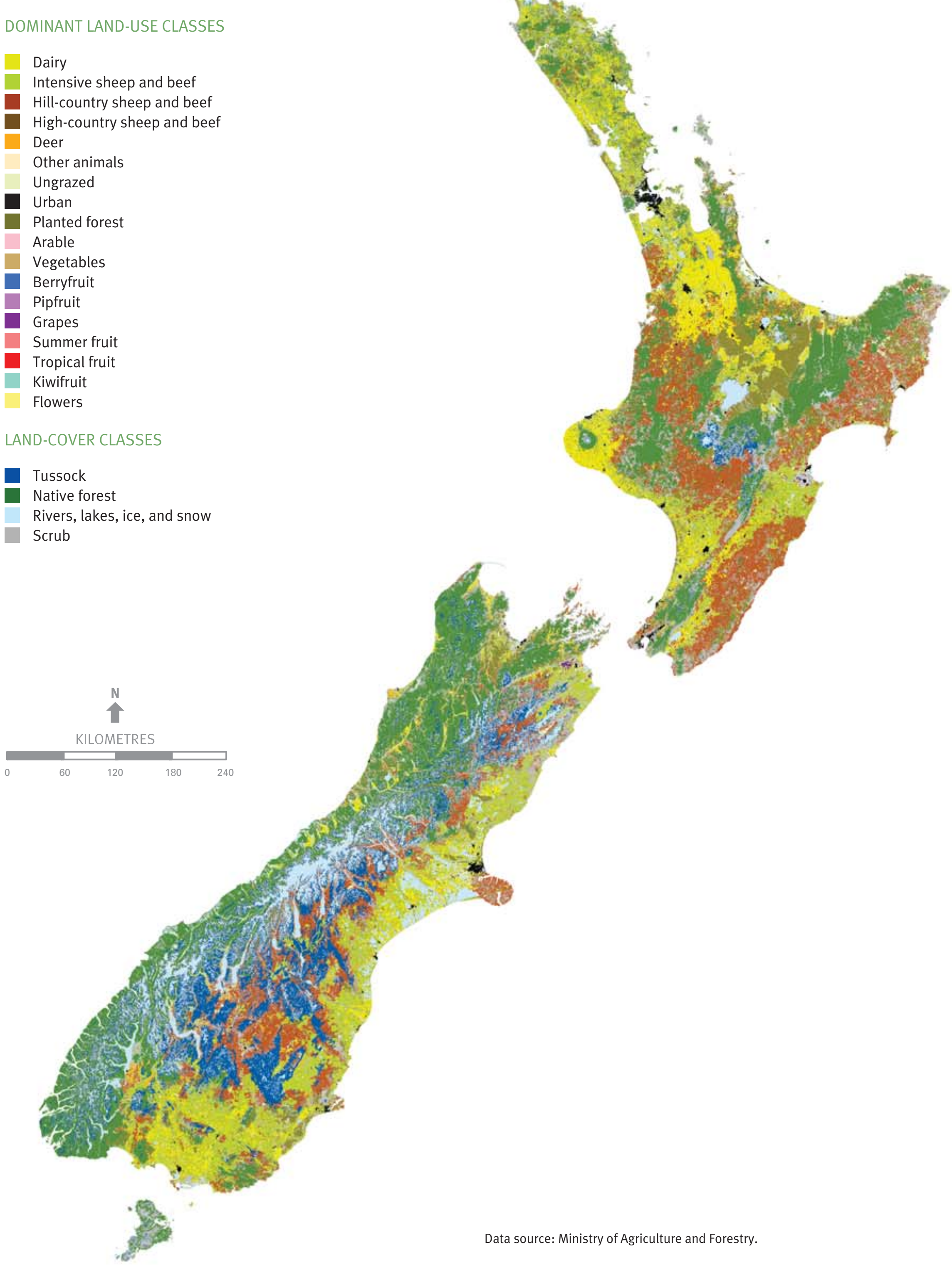
Land use

The map in Figure 9.3 provides a snapshot of land use for 2004. It also provides a baseline (that is, a reference point) for ongoing reporting on the state of the environment. This map shows the location and extent of 18 predominant land-use classes and four land-cover classes in New Zealand. Table 9.4 shows the total area and percentage of land use of these mapped classes.

HUMAN SETTLEMENT IN NEW ZEALAND INCREASED BY JUST OVER 3 PER CENT BETWEEN 1997 AND 2002.

Source: Ministry for the Environment.

+ FIGURE 9.3:
LAND USE IN NEW ZEALAND, 2004



Data source: Ministry of Agriculture and Forestry.

+TABLE 9.4:
DOMINANT LAND USE AND SELECTED LAND COVER IN NEW ZEALAND, 2004

LAND-USE CLASSES	HECTARES	PERCENTAGE OF TOTAL LAND AREA (%)
Dairy	1,879,600	7.00
Intensive sheep and beef	3,841,100	14.32
Hill-country sheep and beef	4,023,200	15.00
High-country sheep and beef	48,900	0.18
Deer	249,700	0.93
Other animals	64,900	0.24
Ungrazed	659,800	2.46
Urban	203,600	0.76
Planted forest	1,957,000	7.30
Arable crops	1,200	0.0044
Vegetables	2,200	0.0083
Berryfruit	1,200	0.0045
Pipfruit	10,200	0.038
Grapes	18,800	0.070
Summer fruit	1,800	0.0069
Tropical fruit	1,600	0.006
Kiwifruit	6,400	0.024
Flowers	57	0.0002
LAND-COVER CLASSES		
Tussock	2,645,200	9.86
Native forest	6,567,200	24.48
Rivers, lakes, snow, and ice	2,094,200	7.81
Scrub	2,543,600	9.48
Total	26,821,500	100

Data source: Ministry of Agriculture and Forestry.

Figure 9.3 and Table 9.4 show that in 2004, pastoral land use (for example, sheep, beef, and dairy farming) was New Zealand's largest human land use at just over 37 per cent of New Zealand's total land area. In the same year, natural land cover – such as tussock, native forest, rivers, lakes, snow, ice, and scrub – covered just over 52 per cent of New Zealand's total land area. Natural land cover is expected to be primarily used for recreation and conservation purposes.

These figures support land cover measurements taken by LCDB satellite in 2002, which recorded that natural land cover was 50 per cent of New Zealand's total land area that year, with land cover in pasture at 39 per cent.

More about intensive land use

Recent trends in land use in New Zealand include an increase in intensive pastoral land use with higher stocking rates and stocking densities.

According to the United Nations Food and Agriculture Organisation's *Agricultural Production Index 2006* (cited in Organisation for Economic Co-operation and Development, 2007), production rates from pastoral farming increased in New Zealand by 38 per cent between 1990 and 2003. The increase in production is mainly attributable to:

- more intensive farming (that is, an increase in stocking rates or more livestock numbers per hectare)
- more productivity per animal (for example, increased milk production per cow, or higher lambing percentages and carcass weights) (Organisation for Economic Co-operation and Development, 2007).

Figure 9.4 shows trends in livestock numbers in New Zealand over the past three decades. Sheep and beef cattle numbers have fallen since the early 1980s, while dairy cow and deer numbers have increased.

While the total area of New Zealand land in pasture has been decreasing since 1972, the area of land in *dairy* pasture has increased (Ministry of Agriculture and Forestry, pers comm).

Figure 9.4 shows that dairy cow numbers have almost doubled (from 2.92 million in 1981 to 5.22 million by 2006) even though the number of dairy farms has decreased, as shown in Table 9.5. More recent figures indicate that the national dairy herd has grown by 24 per cent between 1996 and 2006.

This intensification of agricultural land use has occurred as farmers have responded to economic signals by converting suitable dry-stock pasture, exotic forestry, and existing dairy farms into more intensive dairy farms.

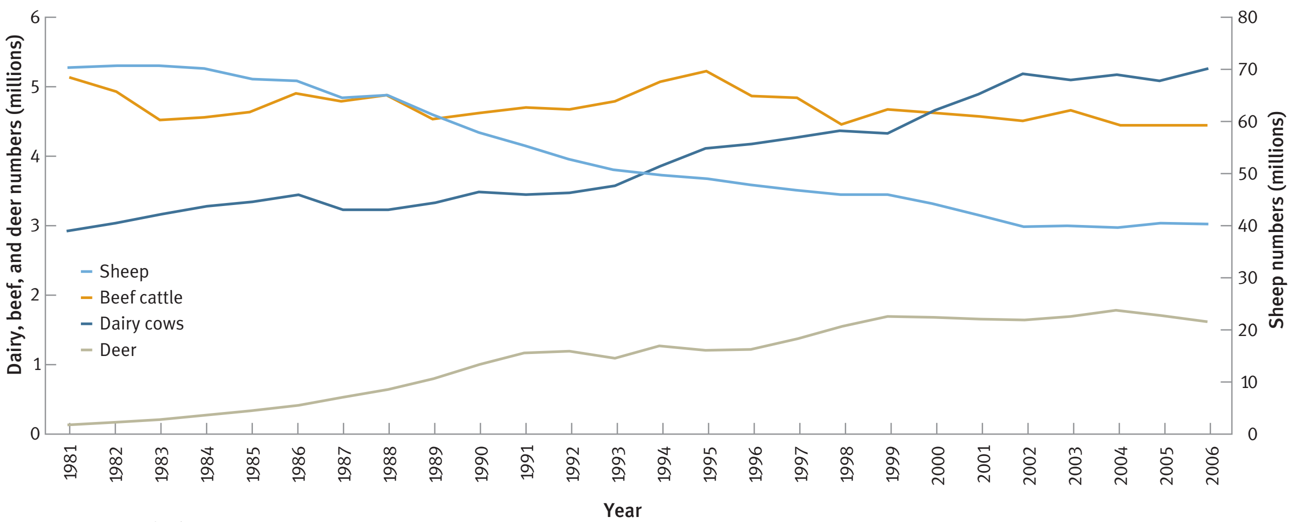
A change to more intensive farming in some regions has resulted in:

- further reduction of freshwater quality in lowland rivers and waterways
- changes in soil health
- increases in some greenhouse gas emissions (for example, methane).

The intensification of dairy and deer farming has been particularly notable in the South Island. Intensive agriculture is most common in the lowland areas of Northland, Waikato, Taranaki, Manawatū, Canterbury, and Southland.

Table 9.5 shows that dairy farms decreased in number from 16,843 in 1994 to 12,810 in 2005. As the area farmed fell, agricultural productivity increased (Organisation for Economic Co-operation and Development, 2007).

+ FIGURE 9.4:
LIVESTOCK NUMBERS IN NEW ZEALAND, 1981–2006



Data source: Ministry for the Environment, 2007a.

+ TABLE 9.5:
NUMBER OF DAIRY FARMS IN NEW ZEALAND, 1994–2005

YEAR	1994	1995	1996	1999	2002	2003	2004	2005
North Island	14,808	14,387	14,170	13,515	11,928	10,791	10,707	10,362
South Island	2,035	2,134	2,296	2,436	2,424	2,160	2,280	2,448
Total New Zealand	16,843	16,521	16,466	15,951	14,352	12,951	12,987	12,810

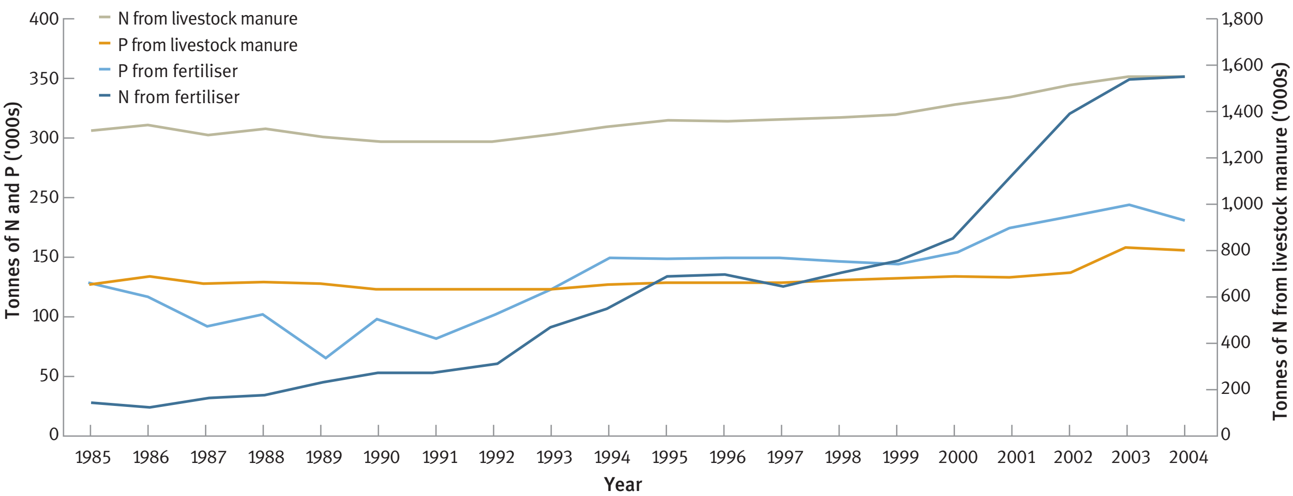
Note:
No Agricultural Production Survey was conducted for 1997, 1998, or 2001. In 2000, the survey related only to horticulture. Farm counts have been based on New Zealand Standard Industrial Classifications.
Data source: Statistics New Zealand.

The intensification of pastoral land use has led to a noticeable increase in the use of fertilisers and irrigation in high-producing exotic pastures, both of which have increased the environmental pressures on our waterways and groundwater (see chapter 10, 'Freshwater').

Figure 9.5 shows the change in nitrogen and phosphorus inputs to agricultural catchments since the mid-1980s. The amount of nitrogen fertiliser used in New Zealand has increased by about 10 times since 1985 and doubled since the mid-1990s. This is in line with the findings of a 2004 report on agriculture in New Zealand. The report found that the use of synthetic fertilisers based on fossil fuels on dairy farms had increased in recent decades. This doubled energy inputs into the average New Zealand dairy farm over the past 20 years, mostly due to the increase in nitrogen fertiliser usage (Parliamentary Commissioner for the Environment, 2004).

Nitrogen from livestock manure, which contributes around five times the amount of nitrogen to the land as nitrogenous fertilisers, has also steadily increased. This increase is consistent with the recent trend towards more intensive forms of farming in New Zealand; particularly dairy farming. The high density of grazing stock on dairy farms delivers more nutrients[6] to the land than other forms of farming.

+ FIGURE 9.5:
SOURCES OF NITROGEN AND PHOSPHORUS IN AGRICULTURAL CATCHMENTS, 1985–2004



Notes:
(1) N = nitrogen.
(2) P = phosphorus.
Data source: Ministry of Agriculture and Forestry.

6 Dairy cows excrete almost seven times the amount of nitrogen and phosphorus in their faeces and urine as do breeding ewes, and around three-and-a-half times that of breeding hinds (Environment Southland, 2000).

LOCAL ACTION for sustainable land management

Increasingly, farmers are taking collective action to achieve sustainable land use. Over 250 land-care or community-based groups have formed throughout the country to address local land-management issues. Projects these groups are working on include:

- land and water monitoring
- pest and weed control
- revegetation and research into alternative land management techniques.

Many projects are worked on in partnership with local authorities and research agencies. Federated Farmers, farm discussion groups, and producer boards are also working on a variety of issues related to sustainable land care.

While some of these issues are significant to New Zealand as a whole, the decision rests with individual farmers as to how they respond to the challenge of changing to more sustainable land-use practices.

The nature and scale of land management issues vary from farm to farm. Some can be dealt with by an individual farmer using existing information. Other issues, for example, poor water quality, will require a partnership of some kind, such as neighbours working together, or a group of farmers working with a researcher and a local authority.

New Zealand Landcare Trust

The New Zealand Landcare Trust was established in 1996. Currently more than 250 landcare groups operate around New Zealand with the vision of promoting sustainable land management. Each group's level of activity depends on the community in which they are based and the specific issues they are trying to address. Landcare groups are particularly active where regional councils have programmes for biodiversity protection and offer incentives or assistance to landholders.

New Zealand Farm Forestry Association

The New Zealand Farm Forestry Association (NZFFA) was formed in 1957. Membership is spread over 29 branches throughout New Zealand. NZFFA estimates their members own or manage up to 100,000 hectares of forest, and influence the management of a similar area. These forests consist of radiata pine, cypresses, eucalypts, douglas fir, blackwoods, poplars, and other hardwoods, as well as native species. Around 800 members will each harvest, on average, 12.7 hectares of plantation forest over the next five years. NZFFA provides a forum for members to share advice with one another on farm forestry.

Diversification of land use

The last decade has seen the diversification of many land-use activities in New Zealand. This diversification is particularly evident in the horticultural industry – changing land use to viticulture is just one example. In both 1997 and 2002, horticulture, including vineyards, orchards, and perennial crops, covered just under 1.6 per cent of our land. However, the area of vineyards grew by 28 per cent over the same period, illustrating the changing face of horticultural land. Horticultural land use has also diversified in other ways. Over the past 20 years, in response to niche market demand, certification schemes have enabled the development of organic land use, such as dairy, vegetable, and meat products.

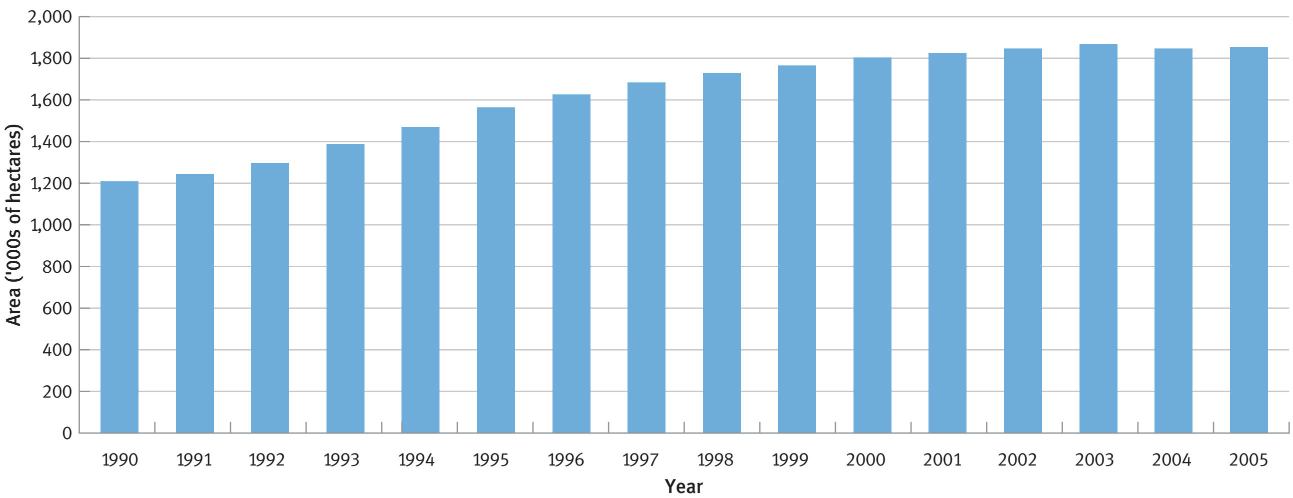
Exotic forestry land use

The last decade has also seen a decrease in activity in the forestry sector resulting in reductions in new exotic forest plantings and replantings following harvesting. In April 2006, planted forests were estimated to cover 1.8 million hectares of New Zealand's total land area (Ministry of Agriculture and Forestry, 2007a). Figure 9.6 shows the estimated total area of exotic forest land cover from 1990 to 2005. It illustrates that while the total land area in exotic forestry in New Zealand between 1991 and 2005 remained higher than that in 1990, the trend of increasing land area in exotic forestry peaked in 2003, and the total land area in exotic forestry has begun to decline since that time.

OVER THE PAST 10 YEARS, GREATER DIVERSIFICATION OF LAND USE HAS BEEN EVIDENT IN NEW ZEALAND.

Source: Courtesy of Devcich Design.

+ FIGURE 9.6:
TOTAL EXOTIC FOREST LAND IN NEW ZEALAND, 1990–2005

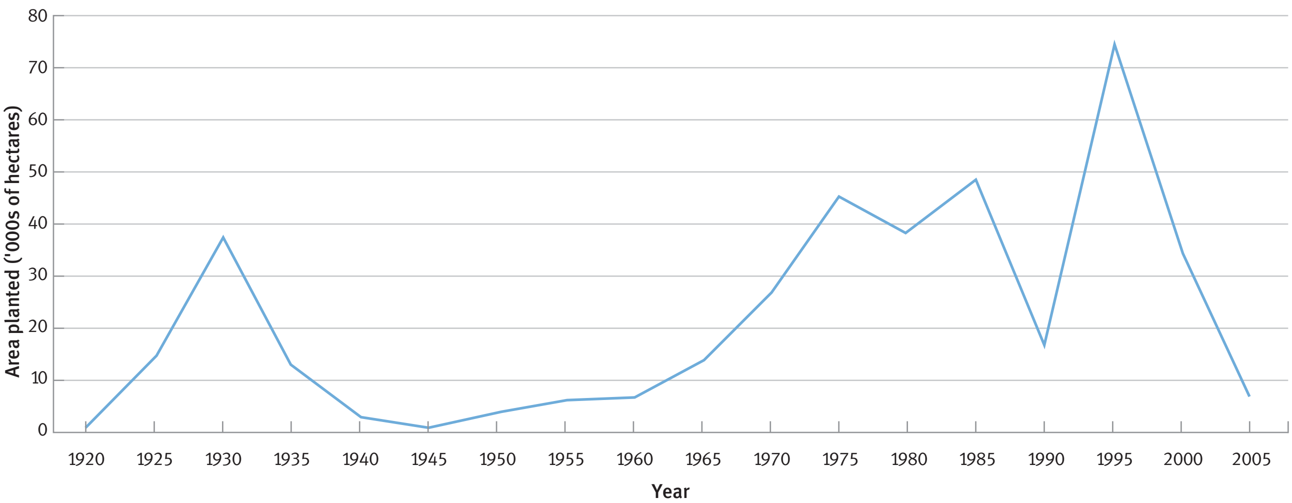


Data source: Ministry of Agriculture and Forestry.

Exotic forestry land use is monitored for new plantings and for replantings of harvested plantations.

In the period 1992 to 1998, new area planting rates were high – averaging 69,000 hectares per year (Ministry of Agriculture and Forestry, 2007a). Since 1998, the rate of new forest plantings has declined. In 2005, only 5,000 hectares were planted – the lowest level since 1959 (Ministry of Agriculture and Forestry, 2007a). Figure 9.7 shows the change in the total area of new forest plantings from 1920 to 2005.

+ FIGURE 9.7:
AREA OF NEW EXOTIC FORESTRY PLANTINGS, 1920–2005, AT FIVE-YEARLY INTERVALS

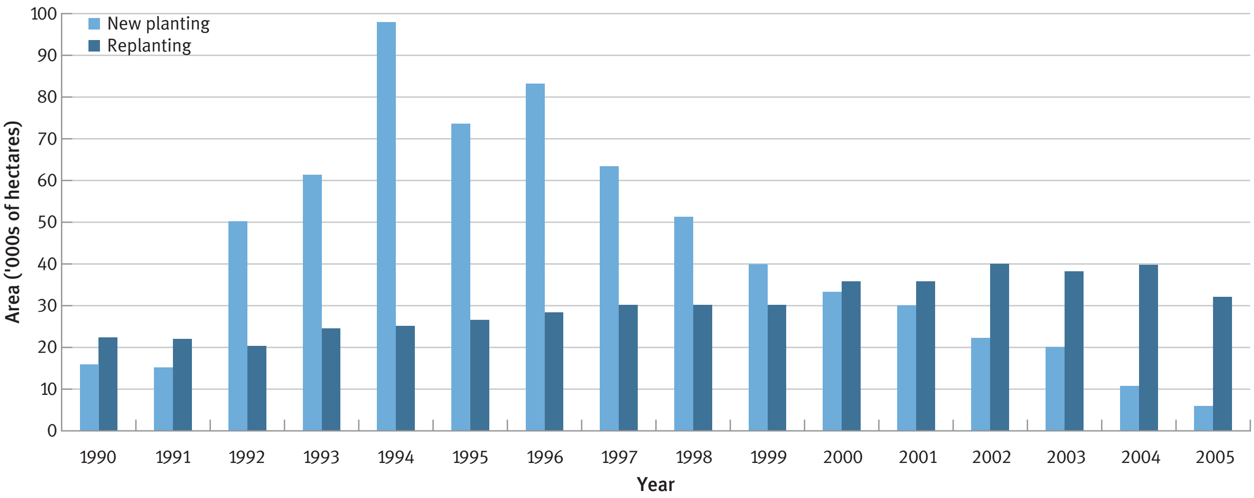


Data source: Ministry of Agriculture and Forestry.

Figure 9.8 shows the trends in new plantings and replantings of exotic forestry between 1990 and 2005. The reduction in new plantings since the mid-1990s means that New Zealand's land area in exotic (commercially planted) forest is no longer increasing (as shown in Figure 9.6). The maintenance of the current area of exotic forestry land will depend on replanting trends, that is, whether forestry land use is maintained after harvest.

Historically, most commercially planted forest was replanted after harvest. However, in 2004, a new trend of not replanting forest after harvesting started to become apparent. In a few cases immature forest has been converted to pasture. The 2006 National Exotic Forest Description survey indicates that approximately 12,900 hectares of forest (33 per cent of the total area harvested) will not be replanted after clear-felling (Ministry of Agriculture and Forestry, 2007a). This compares with a historical average of 2 to 5 per cent of exotic forests not being replanted after harvesting (Ministry of Agriculture and Forestry, 2007a).

+ FIGURE 9.8:
NEW PLANTINGS AND REPLANTING OF EXOTIC FORESTRY, 1990–2005



Data source: Ministry of Agriculture and Forestry.

If low replanting rates continue, New Zealand's total exotic (production) forest land area will continue to decline. A reduction in total exotic forest land area will have implications for the sequestration of carbon dioxide, a greenhouse gas (see chapter 8, 'Atmosphere'). It may also affect flood management, nutrients and soil health, soil erosion, and ecosystem processes related to the displacement of species living in exotic forest habitats. The impacts of deforestation on the environment will largely depend on the land use that is replacing forestry, how that land use is managed, and the management of the surrounding catchment.

Soil health

Seventeen per cent of New Zealand's gross domestic product depends on the top 15 centimetres of our soil (Sustainable Land Use Research Inititative, no date). Soils underpin food and fibre production in New Zealand and protect our environment by:

- acting as buffers and filters to reduce nutrient loss
- limiting the need for irrigation
- breaking down pollutants
- regulating greenhouse gas emissions
- acting as a fundamental part of the water cycle.

Monitoring under the 500 Soils Project (and subsequent regional council programmes) shows there have been changes over time to the health of New Zealand soils. Results of monitoring show:

- widespread moderate compaction under pastures and some cropping land uses
- a loss of organic matter and soil structural stability under cropping
- nitrogen build-up under some dairy pastures, coupled with high levels of available phosphate (Sparling, 2007).

Table 9.6 shows the soil health variables used to assess the biological, chemical, and physical state of New Zealand's soils nationally for seven major land-use types (arable cropping, mixed cropping, drystock pasture, dairy pasture, tussock grasslands, exotic forestry, and native forests) monitored across New Zealand's 15 soil orders. Monitoring New Zealand's soils by major land-use types and soil orders helps us to better understand how different soils respond to land-use pressures.

+ TABLE 9.6:
SOIL PROPERTIES UNDER THE 500 SOILS PROJECT, ARRANGED BY LAND-USE CATEGORIES

SOIL PROPERTY	ARABLE CROPPING (N=44)	MIXED CROPPING (N=17)	DRYSTOCK PASTURE (N=142)	DAIRY PASTURE (N=127)	TUSSOCK GRASSLANDS (N=20)	EXOTIC FORESTRY (N=67)	NATIVE FORESTS (N=58)
Mineralisable nitrogen (µg/cm³)	56	70	128	160	88	63	100
Total carbon (mg/cm³)	40.7	37.6	50.8	66.9	38.3	46.4	56.5
Total nitrogen (mg/cm³)	2.32	3.13	4.29	5.92	2.62	2.99	3.48
pH in water	6.17	6.17	5.75	5.74	5.61	5.36	5.36
Olsen phosphate (µg/cm³)	49	44	19	44	16	10	11
Macroporosity (%v/v)	14.7	9.3	13.3	10.1	15.6	25.6	9.3

Notes:
(1) The number of soil sites is indicated by 'N'.
(2) µg/cm³ = micrograms per cubic centimetre.
(3) mg/cm³ = milligrams per cubic centimetre.
Source: Sparling and Schipper, 2004.

Because pasture lands are so widespread in New Zealand, the condition of pasture soils has a major bearing on soil health nationally. Most declines in soil health are potentially reversible, but the shift towards more intensive farming practices in many regions around New Zealand may make a reversal difficult to achieve for some soils.

Chemical and biological soil health

Organic matter

As Table 9.6 shows, total organic carbon (a measure of soil organic matter) was lowest on cropping land and on tussock grasslands. Arable and mixed cropland soils often have lower organic matter than soils under pasture because the cropland soil is regularly cultivated.

On a national scale, horticulture in New Zealand, including vineyards, orchards, and perennial crops, covers 1.6 per cent of the total land area, compared with 24 per cent in Europe, making environmental effects from cropping in New Zealand comparatively localised.

Because tussock grassland grows on drier soils, they are naturally low in organic carbon. Drier soils build up organic matter very slowly because the growing conditions result in lower productivity.

Monitored pasture topsoils all had high levels of organic matter in the top 10 centimetres of the soil (total carbon, total nitrogen, and mineralisable nitrogen). This result was found to be similar or greater than organic matter levels under long-standing native vegetation. However, evidence in the soil profile down to 0.5 metres shows that over the past 25 years organic matter losses have occurred on intensively farmed pastures (Sparling, 2007).

Nitrogen and phosphorus

As Table 9.6 shows, both total nitrogen and mineralisable nitrogen were greater under pastures than under other land uses. While a supply of mineralised nitrogen is essential for pasture productivity, there is a risk that when supply exceeds demand (when saturation is reached) any excess soluble nitrogen can be leached from the soil and adversely affect water quality (see chapter 10, 'Freshwater'). Excess soluble nitrogen is of particular concern given the high proportion of New Zealand land area in pasture.

The monitored dairy pastures and cropland soils exhibited high Olsen phosphate results (plant-available phosphate). This result reflects the regular application of superphosphate to New Zealand soils to stimulate the growth of introduced grasses, clovers, and arable crops.

Monitoring suggests continued soil compaction in pastures (macroporosity of less than 10 per cent) along with increased (possibly excess) levels of phosphate and nitrogen are likely to continue. Overall, results from soil health monitoring may indicate that storage of nitrogen in organic forms, particularly in dairy pasture topsoils, is nearing saturation point.

Acidity

Soil pH (acidity or alkalinity) under exotic forests was found to be similar to that under native forests. Other agricultural land uses exhibit higher pH values (that is, they are more alkaline). Higher pH values under agricultural land reflect the widespread topdressing of lime following the clearance of forest land cover and the change in land use to more intensive pastoral farming.

Physical soil health

Macroporosity

Moderate soil compaction (low macroporosity) was found on a large proportion of monitored pasture soils. Soil compaction is caused by farm animals treading on pastures, and vehicle traffic and cultivation on croplands.

Macroporosity below a 10 per cent threshold has been shown to adversely affect pasture production. About half the monitored sites under dairy land use were below this desirable threshold. Mixed cropping soils also had low macroporosity.

Maintaining healthy soils

Maintaining healthy soils is fundamental to sustainable land use. See box 'More about maintaining healthy soils', which outlines:

- why healthy soils are important
- what happens when soil health is compromised.

More about maintaining healthy soils

Soil forms a thin skin of mineral and organic matter on the earth's surface and maintains the ecosystems on which we depend. The soil resource is non-renewable in a human lifespan (Doran et al, 1996). Monitoring soil health identifies whether soils are degraded and the factors that contribute to degraded soils. The results of this monitoring provide the opportunity to evaluate and redesign land management systems for sustainability.

Degraded soil can result from:

- soil compaction
- reduced organic matter
- an imbalance in soil nutrient status
- a mismatch between soil pH in relation to land use
- changes to the biological, chemical, and physical characteristics of a particular soil order.

Soil compaction

Soil compaction reduces pasture growth and, when coupled with high-surface soil fertility (that is, high availability of soil nutrients), increases the risk of phosphates and nitrogen reaching streams and lakes through greater surface run-off.

Organic matter

The terms 'soil organic matter' and 'soil organic carbon' are used interchangeably. Total (organic) carbon is a measure of soil organic matter. When measured over time, the rate of soil organic matter turnover (total carbon content) provides information about soil health, for example:

- the loss of soil biological activity (animal and plant communities in the soil such as worms and fungi)
- soil nutrient depletion
- changes in water infiltration and storage potential.

Soil nutrients

Soil nutrients are essential for plant growth and for maintaining soil health. Levels of nutrients may be affected by the excessive build-up of soil nutrients (from high stocking rates, imported feed high in nitrogen, or use of nitrogen fertiliser) or their removal. When excess nutrients are flushed through the soil by water flow, they can cause imbalances in the soil system or surrounding environment. For example, the excessive use of nitrogenous fertilisers may result in a build-up of nitrates in groundwater and rivers.

In the reverse situation, the mining of soil nutrients can also create a problem. Removing vegetation or animal products from the land can result in loss of soil nutrients. Cultivation and vegetation burn-off can also reduce soil fertility. Soil nutrients can be replaced by returning organic matter to the soil, using fertiliser, and using nitrogen-fixing pasture plants (such as clovers).

Soil acidity

Soil acidity is relevant to the nutrient management and biological function of soils. Soil acidification affects plant productivity. Acidification occurs naturally in soils but it can be accelerated by different land uses. For example, the application of fertilisers that contain ammonium or elemental sulphur can lead to acidification, as can the removal of soil nutrients (through cropping and nitrate leaching). Acidity can be manipulated with the addition of lime. In general, as soils become more acidic, their ability to support most kinds of vegetation is reduced.

Soil intactness of erosion-prone hill country

Soil intactness (the ability of soils to stay in place) on erosion-prone hill country is important for three main reasons.

- Soil loss (through actions of water or wind erosion) accelerates sedimentation and nutrient run-off, and degrades water quality in adjacent or downstream water bodies.
- Downstream erosion debris causes rivers to become filled in with silts and gravels, increasing the risk of flooding in heavy rainfall.
- The gradual loss of topsoil affects the general health of the soil and reduces the fertility and productive capacity of the soil resource – the restoration of which may take hundreds of years (under natural conditions a centimetre of topsoil takes 100 to 400 years to build) (Doran, 1996).

Resource and policy managers are primarily concerned with soil erosion caused by human activity (induced erosion), rather than natural erosion processes. Soil erosion caused by human activity has been accelerated in many hill-country areas of New Zealand because of a mismatch between land cover and land use. Where pasture covers soft erodible soils, there is no appropriate vegetation to hold the soils in place.

SOIL SLIP EROSION ON HILL-COUNTRY PASTURE.

Source: Ministry for the Environment.

Figures 9.9 and 9.10 show hill-country areas in pasture that are at risk of soil erosion. The measure of risk is based on information from the Land Cover Database and the Land-Use Capability survey classes from the New Zealand Land Resource Inventory (NZLRI). The NZLRI is a national database and inventory of land-use capability classes according to five major physical factors that control productive land uses: geology, soils, relief (slope), erosion potential, and vegetation cover.

Tussock grasslands (high-country sheep and beef areas) are not included in this analysis.

Erosion risk is classified by degree: severe, very severe, or extreme. This classification is based on:

- soils and underlying geology – areas with yellow-brown earths situated on weakly consolidated mudstones and sandstones pose greater erosion risk
- slope or altitude – areas with more than 21 degrees or that are 1,000 metres above sea level pose greater erosion risk
- land cover – whether erosion-prone areas are in pasture or other more appropriate vegetation to hold the soils in place.

Figures 9.9 and 9.10 can be compared with Figures 9.1 and 9.2 (soil order maps), Table 9.1 (soil orders and land uses), and Figure 9.3 (land-use map identifying hill-country sheep and beef areas for 2004).

New Zealand's geological and land-use histories have worsened hill-country erosion. See box 'More about hill-country erosion and our geological history'.

More about hill-country erosion and our geological history

New Zealand's land management problems are compounded by its unique geological history. Much of our land is mountainous and still undergoing uplift. Many land slopes are close to the maximum for pastoral farming. Thirty per cent of our land is hilly with a slope of more than 25 degrees (Sparling, 2007). Many areas are underlaid by soft, erodible materials. About 10 per cent of New Zealand is classed as severely erodible. The removal of native forest between the 1880s and 1920s for pastoral land use increased erosion rates.

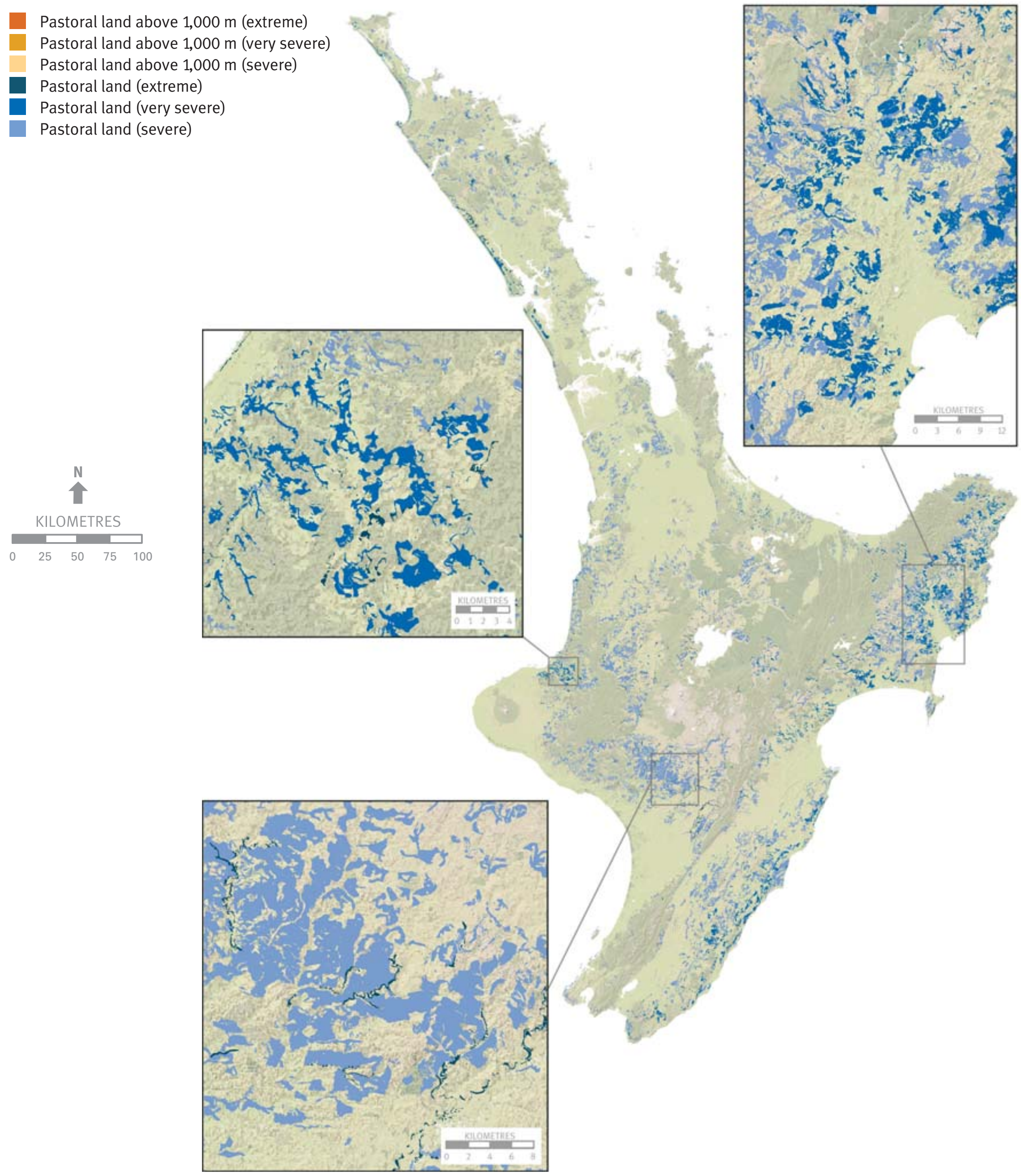
All these factors mean that many parts of the country are prone to mass movement soil erosion (that is, extreme landslip, tunnel gully, gully, and earth-flow forms of soil erosion). The loss of soil through erosion, and transport by rivers to the sea, was estimated in 1996 to be 400 million tonnes a year (Ministry for the Environment, 1996).

Earth flows, soil slips, and gully formations seriously impair the viability and productivity of farms in erosion-prone areas. After hill-country slip erosion, for example, pasture production takes approximately 20 years to recover to within 70 to 80 per cent of its pre-erosion levels (Ministry for the Environment, 1996). Downstream, erosion debris causes rivers to become filled in with silts and gravels, with the consequential increased risk of flooding. Erosion can also contribute to water quality problems such as loss of aquatic habitat and increased sediment loads.

New Zealand's soil erosion problem on the East Coast of the North Island is unique in that the magnitude of the problem is far greater than elsewhere in New Zealand. The Gisborne region comprises 7.8 per cent of the North Island and 26 per cent of the country's severely erodible land. The impacts of erosion (flooding and sedimentation) in the Gisborne region are considered greater than in other areas of New Zealand, particularly for the southern part of the region, the Waipoa catchment.

Other regions that have erosion-prone hill country include Waikato, Bay of Plenty, Hawke's Bay, Taranaki, Manawatū–Wanganui, Wellington, Tasman, and Marlborough.

+ FIGURE 9.9:
HILL-COUNTRY PASTURE AREAS AT RISK OF EROSION – NORTH ISLAND (LCDB 2, 2002)

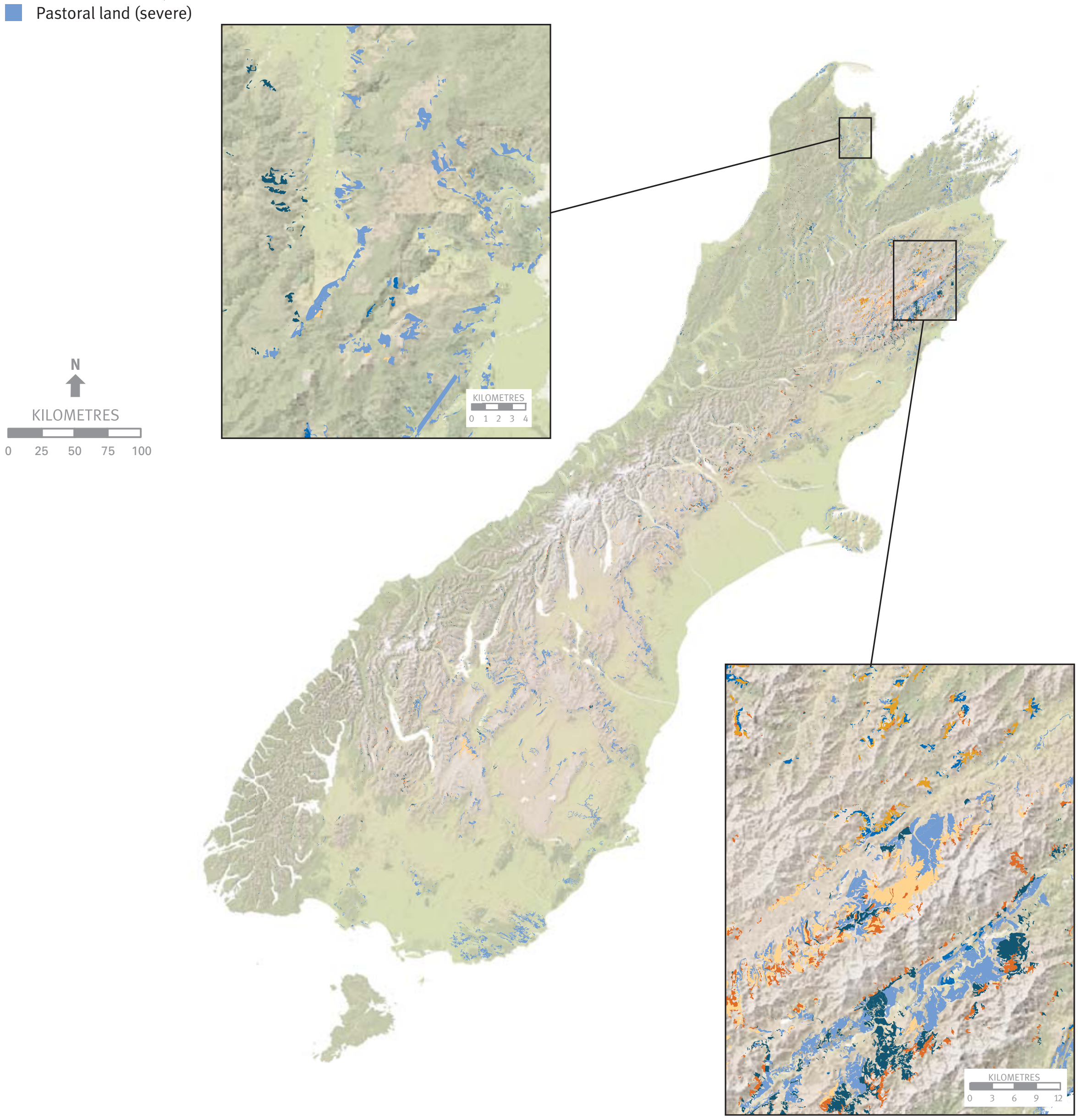


Note:
Mapping limited to developed pasture with no woody vegetation.
Data source: Landcare Research.

+ FIGURE 9.10:
HILL-COUNTRY PASTURE AREAS AT RISK OF EROSION – SOUTH ISLAND (LCDB 2, 2002)

EROSION RISK CLASSIFICATION

- Pastoral land above 1,000 m (extreme)
- Pastoral land above 1,000 m (very severe)
- Pastoral land above 1,000 m (severe)
- Pastoral land (extreme)
- Pastoral land (very severe)
- Pastoral land (severe)



Note:

Mapping limited to developed pasture with no woody vegetation.

Data source: Landcare Research.

Monitoring of erosion-prone hill country includes measuring changes in land cover from pastoral vegetation. Table 9.7 shows the satellite measurements of land-cover change for areas at risk of erosion in 1997 and how many hectares of pasture in these areas underwent a land-cover change by 2002.

While the percentage change from pasture is small, the results do show a reduction of just over 36,000 hectares nationally between the two periods of land-cover monitoring. Just over half of this total was in the Gisborne, Hawke's Bay, and Manawatū–Wanganui regions (17,481 hectares in total). In the South Island, the Marlborough and Tasman regions experienced a combined pastoral land-cover change of 4,119 hectares.

LCDB analysis shows that of the 36,400-hectare reduction in pasture on erosion-prone hill country, 36,300 hectares were converted to exotic forestry or retired and left to revert to scrub.

The changes in the land area under pastoral land cover highlight efforts to replace pasture with more stabilising vegetation on erosion-prone hill country. For example, planting bare land in trees has a noticeable impact on erosion rates. In four to five years, the tree roots will have intertwined, the tree foliage will intercept the strike of heavy rainfall, and the soil will begin to be protected. This process is complete when the tree canopy closes.

A number of programmes and initiatives have been set up to help promote sustainable land management, including afforestation of hill-country pasture on erosion-prone land. See box 'Government action on sustainable land management'.

+TABLE 9.7:
AREA (IN HECTARES) OF PASTURE ON HILL-COUNTRY EROSION-PRONE LAND BY REGION BETWEEN 1997 (LCDB 1) AND 2002 (LCDB 2)

REGION	EROSION-PRONE AREA (HECTARES) IN PASTURE (LCDB 1)	EROSION-PRONE AREA (HECTARES) IN PASTURE (LCDB 2)	PERCENTAGE OF TOTAL NEW ZEALAND LAND AREA (LCDB 2) (%)	PERCENTAGE OF TOTAL REGIONAL LAND AREA (%)	AREA (HECTARES) CHANGE FROM PASTURE (LCDB 2)	PERCENTAGE CHANGE (%)
Northland	67,723	65,832	0.25	5.10	–1,691	–2.50
Auckland	13,101	12,988	0.05	2.49	–53	–0.40
Bay of Plenty	27,000	25,855	0.10	2.10	–1,104	–4.09
Waikato	116,049	112,315	0.42	4.58	–3,680	–3.17
Gisborne	167,141	158,382	0.59	19.01	–8,151	–4.88
Hawke's Bay	113,128	110,416	0.41	7.80	–2,537	–2.24
Manawatū	230,585	223,535	0.83	10.08	–6,793	–2.95
Taranaki	40,580	38,444	0.14	5.30	–2,136	–5.26
Wellington	54,281	51,387	0.19	6.33	–2,794	–5.15
Nelson	1,612	1,535	0.01	3.52	–76	–4.74
Tasman	24,249	22,697	0.09	2.39	–1,012	–4.17
Marlborough	75,042	71,946	0.27	6.84	–3,107	–4.14
Canterbury	113,995	113,770	0.42	2.52	–220	–0.19
West Coast	4,623	4,592	0.02	0.20	–16	–0.35
Ōtago	101,531	101,236	0.38	3.17	–294	–0.29
Southland	26,083	25,437	0.09	0.80	–646	–2.48
North Island	*829,587*	*799,154*	*2.98*	*na*	*–30,433*	*–3.67*
South Island	*347,134*	*341,213*	*1.27*	*na*	*–5,921*	*–1.71*
Total	1,176,721	1,140,367	4.25	na	–36,354	–3.09

Notes:

(1) Figures rounded to the nearest 100 hectares.

(2) Pasture classes from the erosion risk data used for this analysis limited to the LCDB Database 'Primarily Pastoral' classes for reporting.

Data source: Landcare Research.

GOVERNMENT ACTION on sustainable land management

Plan of Action for Sustainable Land Management and Climate Change

In 2006, a discussion document, *Sustainable Land Management and Climate Change: Options for a Plan of Action,* was released for public consultation. $170 million has been committed between 2007–2012 to develop and deliver the plan of action, which includes:

- A five-year adaptation programme that will help the land management sector build the capability to address the risks and opportunities from climate change. As part of this programme a $5.7 million community irrigation fund will be established to help rural communities adapt to increasing drought risk.
- A range of complementary measures to the Emissions Trading Scheme, including the establishment of farm-scale greenhouse gas monitoring and reporting, and a $50 million Afforestation Grant Scheme that allows landowners who elect not to enter the Emissions Trading Scheme to realise the climate change benefits of afforestation.
- A five-year work programme aimed at addressing barriers that hinder the private sector capitalising on climate change opportunities. This includes the development of a greenhouse gas footprint response for the primary sector and reviewing market opportunities such as the creation of markets for emission-reducing technologies.
- A strategic framework for research and technology to underpin the plan of action and coordinate the investment of $10 million per annum by 2010 in new research funding to better enable the agricultural and forestry sectors to reduce their emissions and adapt to climate change. This will build on the work of the Pastoral Greenhouse Gas Research Consortium discussed in Chapter 8, ‘Atmosphere’.
- A Technology Transfer work programme to enhance the ability of the sector to quickly roll out and adapt to new technology.

Sustainable Land Management Programme

The Ministry of Agriculture and Forestry leads government initiatives to achieve sustainable land management. The Ministry’s Sustainable Land Management Programme:

- makes sound science and good information available to support land-management decisions
- provides regulatory support through various local and national regulatory tools
- helps establish partnerships for long-term sustainable land-use solutions
- builds knowledge and capacity in both central and local government.

As part of this programme, the Ministry of Agriculture and Forestry has completed a Sustainable Land Management Framework. The framework guides:

- government funding for local sustainable land management
- assessment of the quality and effectiveness of initiatives under the Sustainable Land Management Fund.

Sustainable Land Management Fund

The Sustainable Land Management Fund supports local projects to achieve sustainable land management. A water and soil section of this fund is aimed specifically at reducing non-point-source water pollution (pollution that does not have a single source of origin) from land use. The funding includes working with hill-country farmers to manage erosion and encourage afforestation of erosion-prone land to reduce sediment flows and protect communities in lower catchment areas.

East Coast Forestry Project

The East Coast Forestry Project was established in 1992 to plant 200,000 hectares of commercial forest over 28 years on erosion-prone land on the East Coast of the North Island. In late 1999, the project changed its focus to target the worst 60,000 hectares of severely eroding land.

To date, approximately 32,000 hectares of erosion-prone land have been planted and a further 5,000 hectares have been approved for planting in the near future. The project offers grants to land owners towards the cost of establishing and managing planted forest areas on erosion-prone land. The project has an annual budget of $6.5 million (Ministry of Agriculture and Forestry, no date).

Contaminated land

Inappropriate storage and use of hazardous substances, and disposal of hazardous wastes, can contaminate the environment. Contamination is not always limited to a specific site (see chapter 6, 'Waste').

Hazardous substances may:

- seep through the soil into groundwater
- be carried to nearby land and waterways in rainwater or as small dust-like particles
- pollute our air.

Industrial, domestic, and rural activities have all contributed to contaminated land in New Zealand. However, as our economy relies on primary production to a larger degree than most of our OECD counterparts, many of our contaminated sites are due to historical agricultural, horticultural, and silvicultural practices. In particular, contaminated sites have often resulted from past:

- manufacture and use of pesticides and fertilisers
- production of coal and gas
- mining
- timber treatment
- sheep dipping.

Many of these activities were not known to be hazardous in the past. For example, using DDT in sheep dips and insecticides was a common activity from the 1940s to the 1960s, undertaken without protective clothing or other protective apparatus.

To date, most of the effort to identify, manage, and clean up contaminated sites has focused on urban and rural sites contaminated by activities and industries on the Hazardous Activities and Industries List (HAIL). The HAIL sets out activities and industries that are considered likely to cause contamination from hazardous substance use, storage, or disposal.

Local authorities use the HAIL to systematically identify **potentially** contaminated sites. Further investigation of an individual site is needed to determine whether the site is in fact contaminated land. To date, only a small proportion of HAIL sites have undergone sufficient investigation to determine whether or not they are contaminated.

Local authorities use a national risk screening system to set priorities for investigating potentially contaminated sites. Using readily available information, the risk screening system ranks potentially contaminated sites according to a standard set of criteria.

A total of 4,424 sites have now been screened across the country. Of the 559 high-risk sites that have been identified, 56 per cent have been cleaned up or have a programme in place to either clean up or manage the contamination (Ministry for the Environment, 2007b).

The Resource Management Act 1991 is the core piece of environmental legislation for controlling the effects of contaminated land on the environment and people. See the box 'Resource Management Act 1991 and contaminated land'.

Resource Management Act 1991 and contaminated land

In 2005, the Resource Management Act 1991 was updated to include a definition of contaminated land. This definition is wider in scope than that implicit under the Hazardous Activities and Industries List. Local authorities will be reviewing their processes to reflect this new definition.

The Resource Management Amendment Act 2005 also clarified the roles and responsibilities of:

- regional councils in investigating, identifying, and monitoring contamination
- territorial authorities in preventing or mitigating the effects of the development, subdivision, or use of contaminated land.

Managing the health and environmental effects of developing, subdividing, or using contaminated land is especially important. Our growing population and increasing urban development have accelerated changes in land use at the perimeters of built-up areas. This growth in residential areas has led to increased development and subdivision of former agricultural or industrial land, some of which may be contaminated.

The Building Act 2004 and the Local Government Official Information and Meetings Act 1987 also help the public access information about contaminated land. For example, under the Local Government Official Information and Meetings Act, territorial authorities must include information about the likely presence of hazardous contaminants on land information memoranda (LIM reports).

The identification of contaminated sites in New Zealand has proven to be a challenge even with tools such as the HAIL, the risk screening system, and the new definition and provisions under the Resource Management Act 1991.

Significant resources are needed to confirm the determination of contaminated sites from potentially contaminated sites. In the 1990s, the number of contaminated sites in New Zealand was estimated at between 7,000 and 8,000 (Worley Consultants Ltd, 1992). About 1,500 of these were deemed to be high risk to human health or the environment (Organisation for Economic Co-operation and Development, 2007). However, there are now thought to be over 50,000 contaminated sheep-dip sites alone (Ministry for the Environment, 2006).

There are presently no standards that set maximum levels for contaminants in soil to determine whether or not a site is contaminated. Local authorities may therefore interpret the definition of contaminated land differently and apply different maximum thresholds for levels of contamination.

Land owners and tenants are not presently required to report contaminated sites to local authorities. For example, former sheep-dip sites can be difficult to locate, and knowledge of these sites may be lost when original land owners sell their land or retire.

In the past, assessments of contaminated sites were not carried out to a consistent standard. Some sites may not have been correctly identified as being contaminated and the extent of contamination may be unknown.

Contaminated sites by region

Ten regions in New Zealand have self-reported on contaminated sites. Table 9.8 shows the total number of sites reported as contaminated, and the number of reported sites which have been confirmed as contaminated, cleaned up, or managed.

To date, 1,238 sites have been reported as contaminated. Most of these sites are likely to be industrial sites (that is, contaminated sites under the HAIL), rather than sites that come under the Resource Management Amendment Act 2005 definition of contaminated land. Of these sites, 545 have been cleaned up, and 301 are being managed to make sure they do not significantly affect the environment. The remaining 392 sites have not yet been dealt with.

The figures show that most **reported contaminated** sites are in more populated regions with high industrial and agricultural activity:

- Auckland (368)
- Waikato (258)
- Wellington (149)
- Canterbury (134).

The greatest numbers of **confirmed contaminated** sites yet to be dealt with are also in more populated regions:

- Waikato (118)
- Auckland (93)
- Wellington (77).

Some of the contaminated sites listed in Table 9.8 are likely to have been caused by leaking underground tanks used to store petroleum products. The petroleum industry has largely taken responsibility for cleaning up or managing these sites (Environment Canterbury, pers comm).

+TABLE 9.8:
SELF-REPORTED INFORMATION ON CONTAMINATED SITES IN 10 REGIONS, 2006–2007

REGION	TOTAL NUMBER OF CONTAMINATED SITES	NUMBER OF CONTAMINATED SITES NOT YET CLEANED UP OR ACTIVELY MANAGED[1]	NUMBER OF CLEANED-UP SITES	NUMBER OF ACTIVELY MANAGED SITES
Auckland	368	93	109	166
Waikato	258	118	140	See note 2
Wellington	149	77	46	26
Canterbury	134	10	124	See note 2
Ōtago	93	35	21	37
Bay of Plenty	85	42	4	39
Hawke’s Bay	65	8	57	See note 2
Taranaki	39	0	10	29
Marlborough	24	5	15	4
Tasman	23	4	19	See note 2
Total	1,238	392	545	301

Notes:

(1) This column includes only sites that have not yet been cleaned up or managed, except for the Auckland figure, which includes some sites that have resource consents (and are therefore managed).

(2) The number of managed sites in this region are included under the column for confirmed cleaned-up sites.

Data source: Listed regional councils.

Up until now, most cleaning up of contaminated sites has been done voluntarily by site owners. It is difficult to establish who is liable for clean-up costs because most land contamination occurred before the Resource Management Act 1991, and potentially liable companies may no longer exist (Organisation for Economic Co-operation and Development, 2007). It can also be difficult to establish liability for contamination from unregulated activities since 1991, such as illegal discharges of chemicals into waterways.

Some types of land contamination have been addressed through changes in policy or regulation. See box 'Removal of lead from petrol'.

Removal of lead from petrol

The past use of lead additives in petrol caused high concentrations of lead in urban air. Vehicle emissions during this time also caused widespread accumulation of lead in urban soils. Land closest to busy roads and intersections received the most lead. Most urban gardens in New Zealand show elevated levels of lead from vehicle emissions, although usually not enough to meet the Resource Management Act 1991 definition of contaminated land. For example, in the 1990s, the average lead concentration in a sample of 80 front-lawn soils in Hamilton was found to be about 75 milligrams per kilogram of lawn soil or five times the natural concentration (Environment Waikato, pers comm). This source of land contamination was eliminated in 1996 when leaded petrol was prohibited.

Several tools have been developed to help identify, manage, and clean up contaminated sites in New Zealand. These include guidelines, funds to assist local government, and tax deductions for business-related costs.

Central government guidelines have been established for identifying, assessing, and managing contaminated sites. These guidelines illustrate and promote best practice in:

- reporting
- risk screening
- classifying sites
- investigating sites
- analysing soils.

Industry-based guidelines have been developed for hazardous substances in soil, water, and air. These guidelines establish best practice, recommend safe levels, and protect health and the environment in:

- timber-treatment chemicals
- gasworks sites
- petroleum industry sites
- sheep-dip sites
- application of biosolids (sewage sludges or sewage sludges mixed with other materials) onto land.

The Contaminated Sites Remediation Fund (CSRF) was established in 2003 to help local government investigate and clean up contaminated sites. Over $10 million has been awarded to 33 projects since the fund was established. CSRF's funding has been increased to $3.7 million per year for 2006 to 2009.

The Income Tax Act 2004 provides for tax deductions for business expenditure related to cleaning up and managing contaminated land.

Local clean-ups

Local government, industry, and community groups are all involved in contaminated site investigations and clean-up work. Examples of local projects include:

- investigating agricultural land potentially contaminated by pesticide use (including sheep-dip sites)
- cleaning up old gasworks and landfill sites
- investigating and cleaning up timber treatment and wood-waste disposal sites
- cleaning up former petrol station sites.

Companies involved in oil and petroleum, timber treatment and processing, and property development are particularly active in managing contaminated sites.

The former Tui mine near Te Aroha in the Waikato is about to be cleaned up. Heavy metals seeping from the old mine shafts, tailings, and dumps have affected the water quality of two streams that flow into the Waihou River. The tailings dam is also at risk of collapse. Environment Waikato, Matamata–Piako District Council, and the Ministry for the Environment are working in partnership to clean up the site by 2010. This project was allocated $9.88 million in the 2007 Budget.

The abandoned Fruitgrowers Chemical Company site at Mapua, near Nelson, was heavily contaminated by a range of toxic pesticides such as DDT, aldrin, lindane, and dieldrin. Central government and the local council, working in partnership, provided $8 million to clean up the site.

By August 2007, all known contaminated soil had been treated on-site, and decommissioning of the plant had begun. The project is on target to be completed in late 2007, when the land will be handed back to its owners, Tasman District Council. About 40 per cent of the land is to be set aside as public space, and the rest is designated residential and commercial.

AERIAL VIEW OF THE ABANDONED FRUITGROWERS CHEMICAL COMPANY SITE AT MAPUA.

Source: Courtesy of John Roosen.

Changes since the 1997 report

The 1997 report, *The State of New Zealand's Environment 1997*, concluded that:

> The main pressures on soil are from past deforestation of erodible land, localised accumulations of harmful chemicals or waste products, and the impacts of over-cultivation or overstocking on erosion-prone and compaction-prone land. …
>
> Soil conservation is increasingly the land users' responsibility. Forest planting, regeneration of native vegetation on some erosion-prone land, and the formation of landcare groups are the main response trend.

(Ministry for the Environment, 1997, chapter 10.)

Current status

As in 1997, New Zealanders today continue to rely heavily on the land for their economic, social, and cultural well-being.

The main pressures on New Zealand's land today continue to be driven by the predominant land uses of agriculture, horticulture, and forestry.

Agriculture

Today, pastoral agriculture remains New Zealand's main land use.

While the total area of New Zealand land in pasture has been decreasing since 1972, the area of land in *dairy* pasture has increased (Ministry of Agriculture and Forestry, pers comm).

Between 1997 and 2002, satellite measurements of the area of pasture (high-producing exotic grassland and low-producing grassland) show that:

- in 1997, pasture covered almost 40 per cent of New Zealand's total land area
- in 2002, pasture covered just over 39 per cent – a decrease of 125,200 hectares (or almost 1 per cent).

As the extent of pastoral land shrank, its productivity grew. Economic drivers in our primary sector have seen a significant intensification of pastoral land use in New Zealand, particularly over the last decade. The average farm size has grown by 19 per cent since 1997, as has greater use of off-farm inputs, such as irrigation water and fertiliser (Organisation for Economic Co-operation and Development, 2007).

The shift to more intensive pastoral land use has placed greater pressures on the health of some soils, in turn affecting water quality. For example, dairy cows excrete almost seven times the amount of nitrogen and phosphorus in their faeces and urine as breeding ewes. Moderately compacted soils, nitrogen build-up, and high levels of available phosphate under some dairy pastures means the condition of pasture soils continues to have a major bearing on water quality nationally. In addition, with irrigation (primarily for agriculture) now using 80 per cent of all allocated water in New Zealand, intensification of land use has had a significant impact on water availability in some regions.

Changes in livestock numbers between 1996 and 2006 also reflect the recent trend towards intensification of land use.

- Sheep numbers decreased from 47 million to 40 million (from a peak of 70 million in 1983).
- Beef cattle numbers decreased from 4.8 million to just under 4.5 million.
- Dairy cow numbers increased from just over 4 million to just over 5.2 million.
- Deer numbers increased from 1.1 million to just over 1.5 million.

In 2006, numbers of livestock equated to 9.93 sheep, 2.39 cattle (1.29 dairy cattle and 1.09 beef cattle), and 0.39 deer for every person in New Zealand.

The increases in some herd sizes have also increased our total greenhouse gas emissions from agriculture. This is particularly so for larger-sized animals, which produce more greenhouse gases than smaller-sized animals.

The intensification of dairy and deer farming has been particularly notable in Canterbury and Southland.

Horticulture

Since 1997, while land in horticultural use is estimated to have remained relatively steady at just under 1.6 per cent of our total land area, horticultural land use in New Zealand has shown significant diversification. As an example, between 1997 and 2002, vineyards increased in area by 5,500 hectares (28 per cent). As the horticultural sector has diversified, export earnings have increased from $115 million in 1980 to $2.5 billion in 2006.

In addition, new emerging 'niche' crops are now being commercially grown. For example, olives, a number of new grape varieties, wasabi, hazelnuts, saffron, and truffles are all now commercially grown in New Zealand, despite little historical tradition of these crops. The area of land used for organic farming more than tripled over the same period (Organisation for Economic Co-operation and Development, 2007).

In part, diversification in the horticultural sector reflects changing land use in other sectors. For example, the arable cropping sector has increased its focus on producing maize silage for the dairy sector.

The expansion in recent years of urban growth and rural lifestyle subdivision is putting increasing pressure on soils of high value for mixed cropping and vegetable production ('versatile soils').

Forestry

In 2006, exotic forestry covered 1.8 million hectares of New Zealand land. However, since 2004, replanting rates have declined. New planting rates have dropped from 60,000 hectares in 1997 to 5,000 hectares in 2006 (the lowest since 1959). An increasing proportion of exotic forests are not being replanted after harvesting with some of that land now being converted into pasture. If this trend continues, New Zealand's total land area in commercially planted exotic forest will continue to decline from its post-1990 peak in 2003.

The reduction in exotic forest cover has implications for the sequestration of carbon dioxide (a greenhouse gas), and may affect hill-country erosion, and flood management. Agriculture on converted forestry land may also produce higher nutrient run-off and affect water quality.

However, farm forestry has remained popular over the last decade as farmers moved to further diversify their farms and benefit from other values that farm forestry provides. This includes planting for soil conservation on erosion-prone hill country.

Changing soil health

Today, as in 1997, our soils underpin food and fibre production in New Zealand. Seventeen per cent of New Zealand's gross domestic product now depends on the top 15 centimetres of our soil. This percentage is likely to increase as primary land use continues to diversify and intensify (for example, more new niche crops or more intensive farms).

Over the last decade, soil monitoring shows there have been changes to the health of soils under New Zealand's predominant land uses. Monitoring results show:

- widespread moderate compaction under pastures and some cropping land uses
- a loss of organic matter and soil structural stability under cropping
- nitrogen build-up under some dairy pastures, coupled with high levels of available phosphate (Sparling, 2007).

Most declines in soil health are potentially reversible, but the shift to more intensive farming practices in many regions may make a reversal difficult to achieve for some soils.

Sustainable land management

A notable change since 1997 is growing awareness, both domestically and internationally, of the environmental impacts of land use, including for food production.

In response, a wide range of groups have implemented initiatives for sustainable land management and primary production. A number of key sector groups have also adopted formal environmental management systems.

Soil conservation programmes

Since 1997, land owners and users have increasingly taken responsibility for soil conservation, including soil health, and soil erosion. Voluntary and government-subsidised soil conservation programmes, including the East Coast Forestry Project, have achieved localised reduction in soil erosion on hill-country farmlands over the past 10 or more years. Budget 2007 announced a commitment of $10 million for the next four years to continue this work and to manage hill-country erosion under the Sustainable Land Management Framework and Fund.

The Sustainable Management Fund (established in 1996) and Sustainable Farming Fund (established in 2002) continue to support land-care groups and farming-related projects. Over 45 projects have been funded since 1997 and just over $8.5 million has been made available specifically for sustainable land management projects to address:

- soil erosion
- flood prevention and management
- poor soil health.

New national-level monitoring information about freshwater quality has helped target soil conservation and sustainable land-management efforts in catchments where water quality has been degraded. This information has aided the development of integrated catchment management programmes. The need for better regional soil mapping information has also been highlighted as a critical information need for effective sustainable land management planning.

Regional council programmes

Regional councils around the country continue to work with land-care groups and farmers to encourage best environmental management practices on rural land in their regions. This work has included:

- programmes that promote revegetation of river and stream banks to enhance water quality, which also benefits soil conservation and biodiversity
- the National Land Monitoring Forum completing a soil quality monitoring protocol and beginning a soil erosion monitoring protocol
- involvement in the 2005–2006 Envirolink initiative, which supports regional council research into environmental management and sustainability, for example, to fill knowledge gaps about the soils in their regions and assist better decision-making about sustainable land use.

Environmental management systems and codes of practice

Since 1997, increasing numbers of farm, horticulture, and forest operators have adopted environmental management systems (EMS) and codes of practice, for example:

- Sustainable Winegrowing New Zealand (490 members in 2006)
- Forest Stewardship Council standards (covering 42 per cent of New Zealand's commercial plantation forests)
- Market Focused (a dairy farmers' EMS initiative in 2001)
- Official Organic Assurance (as of 2003, 800 farms were either certified organic or converting to organic status) (Organisation for Economic Co-operation and Development, 2007).

Dairying and Clean Streams Accord

In 2003, the Dairying and Clean Streams Accord was agreed between Fonterra Cooperative Group (which represents over 95 per cent of New Zealand's dairy farm milk producers), regional councils, and the Government.

The Accord includes five targets aimed to achieve clean healthy water in streams, rivers, lakes, groundwater, and wetlands in dairying areas. Progress against the Accord targets is measured by the results of an independently audited *On-farm Environmental and Animal Welfare Assessment*. Results for 2005/2006 show progress towards the Accord's five targets has been steady, although not all targets have been met.

New Zealand Forest Owners' Association code of practice

In August 2007, the New Zealand Forest Owners' Association released its new *Environmental Code of Practice for Plantation Forestry*.

This new code is a practical guide to forest operations throughout the life cycle of a forest crop. The code helps forest owners identify and manage the environmental values that plantation forestry provides:

- soil conservation
- stable water flows
- wildlife habitat
- carbon storage and oxygen exchange
- recreational areas for people to enjoy.

(New Zealand Forest Owners' Association, 2007).

Funding for agri-environmental research

Between 1997 and 2004, public science funding for agri-environmental research in the agricultural and forestry sectors grew from $136 million to $193 million (Organisation for Economic Co-operation and Development, 2007).

Contaminated sites

Contamination of localised sites around the country as a result of past horticultural, forestry, and agricultural practices has left New Zealand with a suite of 'legacy' land-use pressures on the environment.

Since 1997, local government has continued to work to identify contaminated sites and ensure contaminated land is appropriately managed. A total of 4,424 sites have now been screened across the country. To date, 559 high-risk sites have been identified. Of these, 56 per cent have already been cleaned up or have a clean-up or management programme in place.

Several tools have been developed in the last decade to accelerate and improve the identification, management, and remediation of contaminated sites in New Zealand. They include government and industry-based guidelines, funds to assist local government investigate and clean-up sites, and tax deductions for business related clean-up costs.

In 2005, the Resource Management Act 1991 was amended to include a definition of contaminated land.

Biosecurity

Pests and diseases brought into New Zealand have the potential to seriously damage natural resources and to threaten our land-based economy. Some successes have been achieved in eradicating unwanted pests, such as the white-spotted tussock moth. However, new invasive species such as the varroa bee mite, didymo, and the clover root weevil have become established since 1997 (Organisation for Economic Co-operation and Development, 2007; Ministry of Agriculture and Forestry, pers comm.).

With the flow of goods and people into New Zealand increasing every year, biosecurity is now as much about preventing unwanted pests and diseases from arriving in New Zealand as it is about controlling or eradicating them once they are here.

This widening focus for biosecurity led to the formation of Biosecurity New Zealand in 2004. Biosecurity New Zealand, a division of the Ministry of Agriculture and Forestry, has the lead role in:

- preventing unwanted pests and diseases from reaching New Zealand
- controlling, managing, or eradicating them should they arrive.

Future management

In the future, the focus on land management in New Zealand is likely to intensify on how to:

- continue to minimise the impacts of intensified land use on our soils and waterways
- identify and manage land contaminated by historical agricultural and industrial activities
- continue to manage hill-country erosion
- continue to manage biosecurity risks to New Zealand's primary production sector and native species
- meet growing consumer demand for sustainably produced agricultural, horticultural, and forestry products.

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"An abundance
of clean water
is essential to our
well-being."

FRESHWATER

Contents

At a glance

Freshwater in New Zealand

Water is essential to New Zealand's social, cultural, and economic well-being. It is also a focal point for recreational activities and our outdoor-focused way of life. New Zealand has 425,000 kilometres of rivers and streams, almost 4,000 lakes that are larger than 1 hectare, and about 200 aquifers.

By international standards, freshwater in New Zealand is both clean and plentiful in supply. However, demand for water is increasing. At the same time, some aspects of water quality are getting worse in areas that are dominated by intensive land use.

River and lake water quality

Land-use impacts on river water quality

Rivers in catchments that have little or no farming or urban development make up about half of the total length of New Zealand's rivers and have good water quality. Water quality is generally poorest in rivers and streams in urban and farmed catchments. This reflects the impact of non-point-sources of pollution in these catchments, that is, pollution that does not have a single identified point of origin, such as urban stormwater, animal effluent, or fertiliser run-off. The proportion of the total river length that is in farmed catchments is more than 40 times the proportion that is in urban catchments.

Nutrients in rivers

While the levels of nutrients (which, in excessive amounts, reduce water quality) in our most polluted rivers are only about half the average for all rivers reported by countries to the Organisation for Economic Co-operation and Development (OECD), nitrogen and phosphorus levels have increased over the past two decades. Nitrogen levels have increased most rapidly in rivers that are already nutrient-enriched.

Point-source pollution of rivers

Pollution from organic waste in rivers has reduced since the late 1980s. This indicates improved management of point-source discharges of organic waste, that is, pollution from a single facility at a known location, such as discharges from wastewater treatment plants, meatworks, and farm effluent ponds.

Nutrients in lakes

Two-thirds of New Zealand's lakes are in natural or partially developed catchments, such as native bush, and are likely to have good to excellent water quality. Small, shallow lakes surrounded by farmland have the poorest water quality of all our lakes.

Water quality at swimming spots

Over the 2006–2007 summer, 60 per cent of the swimming spots on rivers and lakes that were monitored had low levels of bacteria, indicating that these sites have good water quality and are suitable for swimming. Ten per cent of the monitored swimming spots frequently had levels of high bacteria, indicating that they are generally unsuitable for swimming. Bacteria levels appear to have improved in our recreational waters over the past few years.

Groundwater quality

Sixty-one per cent of the groundwaters in New Zealand that are monitored have normal nitrate levels; the remainder have nitrate levels that are higher than the natural background levels, and 5 per cent have nitrate levels that make the water unsafe for infants to drink. Twenty per cent of monitored groundwaters have bacteria levels that make the water unsafe to drink. High levels of nitrates and bacteria are particularly common in shallow, unconfined aquifers. These aquifers are the most vulnerable to pollution from land-use activities, such as farming and urban development.

Freshwater demand

Abundance of freshwater

Because New Zealand has a low population and high average rainfall, it has more total freshwater per person than more than 90 per cent of almost 200 other countries around the world. However, not all of this water is in the right place at the right time; some areas experience a surplus or shortage of water.

Demand and allocation

It is estimated that total water use in New Zealand currently equates to two to three times more water per person than in most other OECD countries. Demand for water is increasing, particularly in areas that are already short of water. Drier parts of the country have the highest demand. For example, Canterbury accounts for over half of all water allocated in New Zealand; that is, the amount of water that is permitted to be used. Several eastern regions, including Canterbury and Ōtago, have surface water catchments that are highly allocated, so come under pressure during drier times of the year.

The allocation of water in New Zealand increased by 50 per cent between 1999 and 2006. This is mainly a result of an increase in the area of irrigated land. Irrigation now uses almost 80 per cent of all water allocated.

Present and future management

Because pollution of freshwater from point-source discharges is now largely controlled under the Resource Management Act 1991, attention of resource managers has turned to reducing non-point-source pollution from intensive land use. As a result, there is greater emphasis than in the past on managing intensively used land through stream-bank (riparian) planting, nutrient management, and excluding stock from waterways using bridging and fencing.

Water allocation and pollution caused by intensive rural and urban land use will continue to be the focus of freshwater management in New Zealand. Balancing the competing needs of water users – recreational users, town water suppliers, hydro-electricity generators, tourist operators, and farmers – is likely to become increasingly important.

Introduction

New Zealand has 425,000 kilometres of rivers and streams, almost 4,000 lakes that are larger than 1 hectare (Ministry for the Environment, 2006c), and about 200 groundwater bodies (aquifers) (White, 2001).

Freshwater is among our most valuable natural assets. New Zealand's rivers, streams, and lakes are a focal point of our national identity and outdoor way of life. They are highly valued for recreational activities such as swimming, boating, and fishing, and are the centrepiece of some of the country's best-known tourist destinations.

Clean and plentiful water provides us with a safe drinking supply, and also sustains the natural ecosystems that are home to many of New Zealand's native species.

In addition, freshwater is a vital part of the New Zealand economy: it is used to irrigate crops and pastures, dispose of or dilute trade wastes and sewage, and produce hydro-electric energy (see chapter 5, 'Energy').

Water is also a fundamental taonga (treasure) for Māori. Waterways are considered the arteries of Papatūānuku (Mother Earth) (Ministry for the Environment, 2005b). Māori have cultural, historical, and spiritual links with many of the country's springs, wetlands, rivers, hot pools, and lakes. They also value having healthy water bodies for mahinga kai (customary food and resource gathering).

By international standards, freshwater in New Zealand is both abundant and clean. Rainfall, which is the source of replenishment for our streams, rivers, lakes, and groundwater, is generally plentiful. With a population of just over 4 million and limited heavy industry, New Zealand's human pressures on freshwater are relatively light compared with the pressures on such resources in many other developed countries.

However, protecting the country's freshwaters is a growing challenge. With land-use practices becoming more intensive, particularly in farming, there is greater demand for water now than ever before, and evidence is building that its quality is declining in many water bodies.

Freshwater environments of New Zealand

New Zealand is a narrow, mountainous country characterised by relatively small catchments and fast-flowing rivers and streams. Half of its 425,000 kilometres of rivers and streams are small headwater streams.

Of New Zealand's total length of rivers and streams, 51 per cent lies in catchments with predominantly natural land cover, such as native bush or alpine rock and tussock. The remaining 49 per cent of river length is in catchments that have been modified by agriculture (43 per cent), plantation forestry (5 per cent), or urban settlement (1 per cent).

New Zealand has 3,820 lakes that are larger than 1 hectare. Of these, 229 have an area greater than 50 hectares (Ministry for the Environment, 2006b). About 40 per cent of all lakes are in catchments in which the predominant land cover is pasture. Less than 2 per cent of lakes are in towns and cities (Ministry for the Environment, in press c).

The underground areas in which groundwater collects are known as aquifers. In New Zealand, the largest aquifers are porous gravels. Examples include the Heretaunga Plains in Hawke's Bay and the Wairarapa, Manawatū, Canterbury, and Southland Plains. Other forms of aquifer include the fractured basalts of the Auckland region and the Coromandel Peninsula's coastal sand aquifers.

Natural factors that affect freshwater

Three main natural factors influence the quantity and quality of freshwater in New Zealand: climate, topography, and geology.

Rainfall patterns vary across the country and between seasons. Generally, rainfall is much higher on the western side of both the North and South Islands, because the prevailing westerly winds pass over mountains that form the backbone of much of the country.

Rainfall is also higher in the winter than in the summer. This seasonal variation is more extreme on the east coast of both main islands, where summers are relatively dry, compared with on the west coast. Not only does rainfall control the amount of water that flows in rivers and aquifers, it can also affect water quality by carrying pollutants from the surface of the land to water bodies. The pattern of rainfall in New Zealand is expected to change in the future; the anticipated affects on freshwater quantity and quality are summarised in the box 'More about climate change and freshwater'.

More about climate change and freshwater

Current research suggests that New Zealand will experience changes in the frequency of droughts, rainfall patterns, and evaporation rates, which are likely to change water flows and worsen existing problems with water availability. Irrigation needs will increase in the east of both main islands, where pressure on available water resources is already significant. At the same time, water quality is likely to deteriorate in some areas because of lower flows in rivers and streams. Algal blooms may occur more frequently because of higher water temperatures.

The shape and geology of New Zealand's catchments also strongly influence water quality. Catchments that are steep-sided (such as those in mountainous regions) or made up of soft sediments are more prone to natural erosion. As a result, rivers draining from these catchments may carry high levels of sediment.

The type of rock and soil the water moves past and the time over which this interaction takes place also determine the characteristics of our freshwater. For example, groundwaters moving through volcanic rocks or geothermal areas are more likely to contain higher concentrations of minerals (such as sulphates and/or chloride) and metals (such as arsenic) than are fast-moving river waters.

Human factors that affect freshwater

The main pressures on freshwater quantity and quality are the growing demand for water to meet society's various needs and pollution resulting from human activities on land.

Water quantity

Demand for freshwater resources is increasing as New Zealand's population grows and more intensive forms of land use, particularly farming, become increasingly widespread. This is especially noticeable in drier regions, such as Canterbury, where relatively high volumes of water are needed to irrigate pasture.

Damming and diverting water to meet needs for power generation, irrigation storage, and human consumption can deplete flows in rivers and reduce groundwater levels. As well as having effects on water quality (described below), flow depletion can lead to insufficient water being available to meet the needs of downstream users.

Draining land to improve farming productivity or enable urban development also reduces the size of water bodies. The Waikato region's shallow peat lakes are examples of lakes that have shrunk in size and number as the surrounding farmland has been drained.

Water quality

Figure 10.1 summarises the main sources of pollution in rivers, lakes, and groundwater. These are identified as point-sources and non-point-sources. Point-sources refer to discharges of pollutants from a single facility at a known location (for example, a wastewater treatment plant). Non-point-source pollutants do not have a single point of origin (for example, they may include pollutants that have run off wide areas of disturbed or developed land after rainfall).

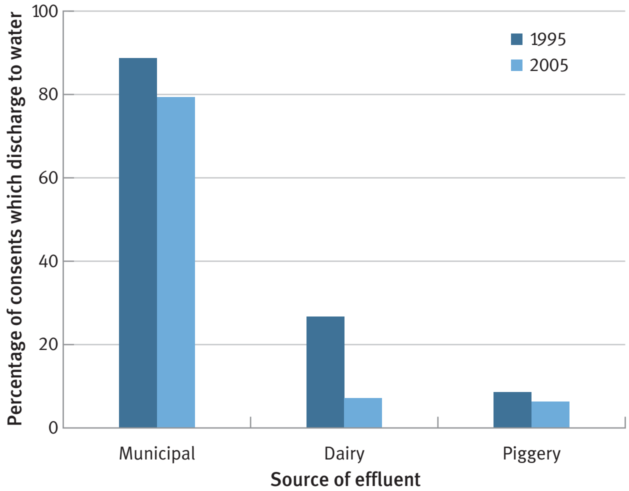
+ FIGURE 10.1:
COMMON SOURCES OF FRESHWATER POLLUTION

Source: Ministry for the Environment.

Point-source and non-point-source pollution

Until the 1970s, the major cause of deterioration in water quality in New Zealand was the discharge of poorly treated sewage, stock effluent, and other wastes from primary production and industry directly into water bodies. These discharges came from both urban and rural point-sources. However, stricter controls on discharge practices were introduced with the Water and Soil Conservation Act 1967 and the Resource Management Act 1991. Wastewater treatment systems have been upgraded and there has been a continuing trend towards applying effluent to land, rather than discharging it into waterways (see Figure 10.2). Pollution from point-sources has declined significantly as a result of these measures.

+ FIGURE 10.2:
CONSENTS FOR EFFLUENT DISCHARGES TO WATER, 1995 AND 2005, BY SOURCE



Note:

These percentages are averaged from resource consent data provided by regional councils and unitary authorities in Auckland, Hawke's Bay, Manawatū–Wanganui, Wellington, and Marlborough.

Data source: Ministry for the Environment.

While sewage and wastewater discharges from point-sources are still a significant influence on water quality in some areas, the effects of non-point-sources of pollution on streams, rivers, and lakes have been identified as the most serious freshwater management challenge in New Zealand today (Hill Young Cooper, 2006).

Urban land use

Urban land use affects the quality of our freshwater; 86 per cent of people live in towns and cities and produce large amounts of different types of pollution. The most significant source of bacteria and nutrients (nitrogen and phosphorus) in urban streams is human wastewater and sewage leaking from broken sewer pipes, or being discharged into stormwater systems through faulty connections. In addition, run-off to streams from paved surfaces, gardens, and disturbed land commonly has high levels of sediments (see the photo opposite) and can contain pollutants, including bacteria from animal faecal matter, herbicides, pesticides, detergents, and other household chemicals.

Run-off from busy roads carries pollutants such as metals (particularly zinc, copper, and lead), and hydrocarbons. (These pollutants come from the road itself, through asphalt wear, and from vehicles using the road, through exhaust emissions, brake linings, and tyre wear.)

Agricultural land use

As the dominant land use in New Zealand, agriculture has the most widespread impact on water quality. Agricultural pasture makes up almost 40 per cent of New Zealand's total land area and occupies about four times the area of planted forestry and all other modified types of land cover combined (that is, horticultural, viticultural, industrial, and other urban land uses). (See chapter 9, 'Land'.)

In recent years, the impact of agricultural land use on water quality has grown as a result of increased stocking rates and use of nitrogen fertilisers. Within the agricultural sector, there has also been a move away from low-intensity to high-intensity land use (for example, converting from sheep farming to dairy or deer farming). The net effect of most intensified land use is to increase the amount of nutrients, sediment, and animal effluent dispersed into water bodies (Davies-Colley et al, 2003).

POLLUTION OFFICER SAMPLING SEDIMENT RUN-OFF FROM A RESIDENTIAL SUBDIVISION AS IT ENTERS AN URBAN STREAM.

Source: Courtesy of Greater Wellington Regional Council.

Horticultural and arable land use

Horticultural and arable land use occupies a small proportion of New Zealand land (less than 2 per cent of total land area) compared with the land occupied by agricultural farming. Most of the land producing arable, vegetable, and fruit crops in New Zealand has flat to gently rolling terrain. As a result, the surface run-off is low. However, nutrients (from fertiliser application) and herbicides and pesticides leaching through soils may still pollute freshwater in some areas (particularly those where market gardening is common).

Plantation forestry and other forms of land use

The pressure on freshwaters from plantation forestry is comparatively low. Nutrient yields from plantation forestry are very similar to those from native forest (Davies-Colley et al, 2003). However, when forest is being harvested, the sediment dispersed to waterways, particularly from roadways and landings, can increase.

Other forms of land use can affect water quality. As noted earlier under 'Water quality', the damming of rivers can change a river's natural flow and cause increased sedimentation, higher water temperatures, and reduced oxygen concentrations. Algae and other nuisance plants may proliferate downstream from dams because the high flows that regularly flush the river system have been reduced.

National environmental indicators

See chapter 1, 'Environmental reporting', for more information on the core national environmental indicators and how they are used.

There are two national environmental indicators for freshwater.

The first provides information on water quality in rivers, lakes, and groundwater aquifers. This indicator is reported using the following measurements:

- concentrations of nutrients (nitrogen and phosphorus in rivers and lakes, and nitrate in groundwater)
- concentrations of the bacterium *Escherichia coli* (*E. coli*) in rivers and lakes, including freshwater swimming spots
- visual clarity in rivers and lakes
- water temperature in rivers
- dissolved oxygen in rivers
- richness of macroinvertebrate species (%EPT) in rivers.

The second freshwater indicator provides information on freshwater demand. This indicator is reported using the following measurement:

- volume of water allocated to human uses. This is also known as total (consumptive) water allocation.

Understanding how these indicators change over time will allow us to improve our response to existing and emerging pressures on New Zealand's water resources.

In addition to the measurements listed above, further measurements of freshwater quality in this chapter include:

- organic pollution of rivers (as shown by measurements of biochemical oxygen demand)
- salinity and concentrations of metals (iron, manganese, and arsenic) and chemicals (sodium, sulphate, and chloride) in groundwater.

Freshwater quality

Concentrations of nutrients

Aquatic plants need many types of nutrients for growth, including nitrogen and phosphorus. (This includes the dissolved forms of nitrogen (nitrate) and phosphorus (dissolved reactive phosphorus)). However, increased levels of these nutrients in water bodies cause plant growth rates to increase excessively, especially if water flows, sunlight, and temperature conditions are favourable to them. This can lead to algal blooms, as well as an over-abundance of aquatic weeds in river channels and on lake margins. Excessive algal or weed growth can reduce the recreational and aesthetic value of water bodies, and alter water quality (for example, by changing the acidity or oxygen levels).

Fertilisers and stock effluent are major sources of the nitrogen and phosphorus in water bodies in agricultural catchments. The erosion of soil also contributes significant amounts of soil-bound phosphorus to waterways.

Concentrations of bacteria

E. coli is a bacterium that indicates the presence of faecal material in freshwater. This, in turn, indicates the presence of disease-causing (pathogenic) micro-organisms caused by discharges of treated human sewage (from wastewater plants, septic tanks, or faulty sewerage systems) and dung from birds and animals.

A high concentration of *E. coli* indicates an increased risk of digestive and respiratory system diseases among people who come into contact with, or drink, the contaminated water. Very young children, the elderly, or people with impaired immune systems are particularly vulnerable to this risk. The health of livestock that drink contaminated water may also be affected.

Visual clarity

Visual clarity refers to how far you can see through the water in rivers and lakes. It provides an indication of the levels of suspended sediment: high clarity indicates low levels of suspended sediment.

Rivers and lakes with high clarity appear clean and are often highly valued for fishing and other recreation. A river or lake with low clarity will have murky water, which may indicate significant erosion in the catchment (producing suspended sediment) or abundant algal growth in the water. Murky water prevents sunlight penetrating, while sediment can smother aquatic habitats, which affects the feeding and spawning habits of fish and other animals, and the growth rates of plants.

Visual clarity is reported on its own as an indicator for rivers. However, it is combined with measurements of nutrients and algae (to form a Trophic Level Index) to indicate the water quality of lakes (see box 'What is the Trophic Level Index?' in the 'Current state and trends' section of this chapter).

Water temperature

If water temperatures increase beyond their usual ranges for too long, plants and animals in waterways can become stressed and die. (Low elevation streams and rivers in New Zealand typically have a water temperature that fluctuates within the range 10–20˚C across seasons. Alpine or spring-fed streams and rivers can be much colder, and the water temperature in un-shaded shallow streams may rise to nearly 30˚C in the peak of summer.) Temperature changes can be caused by changes in climate, or by human activities such as removing stream-bank vegetation, storing water in dams, or discharging heated or cooled water after it has been used in industrial processes (for example, in power generation). Taking too much water from a river or stream (referred to as 'over-abstraction') can also increase its temperature.

Dissolved oxygen

Dissolved oxygen is an indicator of the health of freshwater ecosystems. Fish and other aquatic life require dissolved oxygen to breathe. When dissolved oxygen levels are depleted, aquatic animals can become stressed and die. Oxygen depletion is commonly caused by organic pollutants breaking down in waterways, elevated water temperatures, or night-time respiration by dense algal blooms in nutrient-rich waters.

Macroinvertebrate richness (%EPT)

Freshwater macroinvertebrates are aquatic animals such as insects, worms, and snails. Sampling both the type of macroinvertebrate taxa (that is, groups of similar individuals) present in a waterway, and the population of each of these taxa provides an indication of overall river or stream health and water quality.

Some macroinvertebrates are particularly sensitive to pollution, so are good indicators of water quality degradation that has been caused by human activity. In particular, *Ephemeroptera, Plecoptera,* and *Trichoptera* taxa together form a measurement called '%EPT'. Low %EPT indicates a river or stream is under pollution stress.

Freshwater demand

Allocation of water to consumptive uses

Regional councils are responsible for granting resource consents in New Zealand. These consents are generally required before surface water or groundwater may be removed for irrigation, drinking water supply, industrial and manufacturing works, and other activities. Smaller volumes of water, such as for low-level home supply, can also be allocated through permitted activity rules under councils' regional plans.

The consent process, which is generally set up through regional plans, is also known as 'the allocation of freshwater'. It can determine both the maximum **volume** of water that may be taken, and the maximum **rate** at which water may be taken.

The allocation indicator in this report assesses consumptive water use only (that is, water that is taken from a river, lake, or aquifer, and not returned directly to that source). Allocation of water for hydro-electric power generation is not a consumptive use, although hydro-electric schemes can significantly alter the pattern of water flow in rivers and lakes.

Limitations of the indicators

While the indicators for freshwater provide an overview of the quality and level of allocation in New Zealand, they do not provide a complete picture of the health of the freshwater resource. The indicators do not include several other pollutants that can affect water quality, such as herbicide and pesticide residues, dissolved metals, pharmaceuticals, and hydrocarbons (although some information on metals and pesticides in groundwater is presented in the section 'Current state and trends' later in this chapter).

The indicators also do not cover many aspects of freshwater ecosystem health, such as the type and abundance of fish and aquatic plants. While many regional councils undertake such monitoring as part of their freshwater management programmes, data is not yet readily available for this to be reported at the national level. Some aspects of freshwater biodiversity, including the distribution of native and invasive (introduced) aquatic animals and plants, are discussed in chapter 12, 'Biodiversity'.

Similarly, while many councils and other agencies monitor changes in water quantity (river and groundwater flows) in New Zealand, this data is not yet readily available for national reporting. Therefore, the indicator for water quantity focuses on demand (allocation).

Current state and trends

This section describes the current state of freshwater quality and demand in New Zealand. Trends are also described, where possible, using data collected over the past 20 years.

Surface water quality

The section begins by assessing the water quality of surface waters (rivers, streams, and lakes) by considering their nutrient and bacteria levels, visual clarity, and their biochemical oxygen demand. The water quality of groundwater is then assessed, primarily by considering nitrate and bacteria levels, then water demand is assessed by considering levels of allocation.

WAIKATO RIVER DOWNSTREAM OF LAKE TAUPŌ – ONE OF THE RIVERS MONITORED AS PART OF THE NATIONAL MONITORING NETWORK.

Source: Ministry for the Environment.

Nutrients in rivers and streams

Monitoring river water quality

More than 800 sites on New Zealand rivers and streams are regularly monitored for water quality (Ministry for the Environment, 2006a), including the Waikato River, shown in the photo on the previous page. Of these sites, 77 are located on 35 rivers throughout New Zealand and collectively make up the National River Water Quality Monitoring Network operated by the National Institute of Water and Atmospheric Research (see Figure 10.3). The remaining sites, located on both rivers and smaller streams, are part of monitoring networks operated by regional councils.

All national monitoring networks consist of river and stream sites found towards the top of a catchment where water quality is typically relatively good (often termed 'reference sites') and sites found lower down in catchments, where the water quality is more likely to be affected by human activities (referred to as 'impacted sites').

In addition to monitoring the physical, chemical, and biological properties of rivers and streams, agencies have developed other, complementary, approaches to assessing stream health in recent times. One example is the Cultural Health Index for Streams and Waterways, described in more detail in the box 'More about iwi monitoring of freshwater: Cultural Health Index' in 'Changes since the 1997 report' section of this chapter.

Nutrient levels increasing (nitrogen and phosphorus)

Figure 10.3 shows changes over time in the concentration of major nutrients in rivers within the national monitoring network (see box 'Monitoring river water quality'). The dark blue line in each graph represents the rivers' median nutrient concentration. The orange and light blue lines show trends for the rivers that have the highest and lowest concentrations of nutrients, respectively; that is, the rivers with nutrient concentrations in the top and bottom 5 per cent of the range of monitored sites.

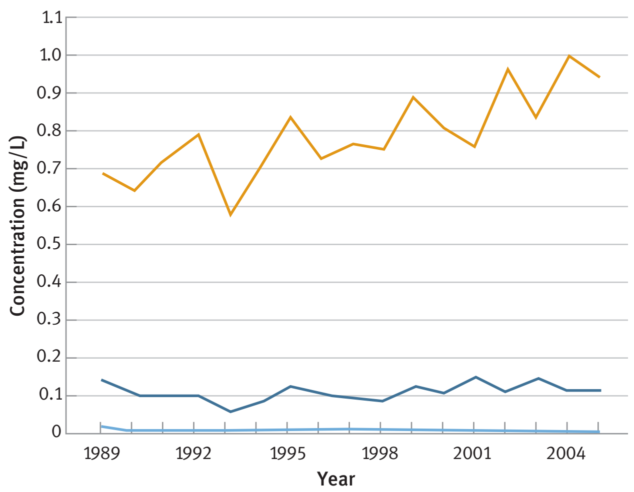
The median levels of nitrogen and phosphorus have increased in rivers within the national monitoring network over the past two decades. More specifically, over 1989–2003, there was an average annual increase in levels of total nitrogen and dissolved reactive phosphorus of 0.5 per cent to 1 per cent (Ministry for the Environment, 2006d). While this increase may seem small, and is difficult to detect from the slope of the median (dark blue) lines in Figure 10.3, it signals a long-term trend towards nutrient-enriched conditions that are likely to trigger undesirable changes to river ecosystems.

Furthermore, New Zealand rivers with relatively high levels of nitrogen are deteriorating – becoming more enriched – more rapidly than rivers with low levels of nitrogen. This is illustrated most clearly in Figure 10.3 by the strength of the trends for nitrate nitrogen and total nitrogen (that is, the relatively steep orange lines).

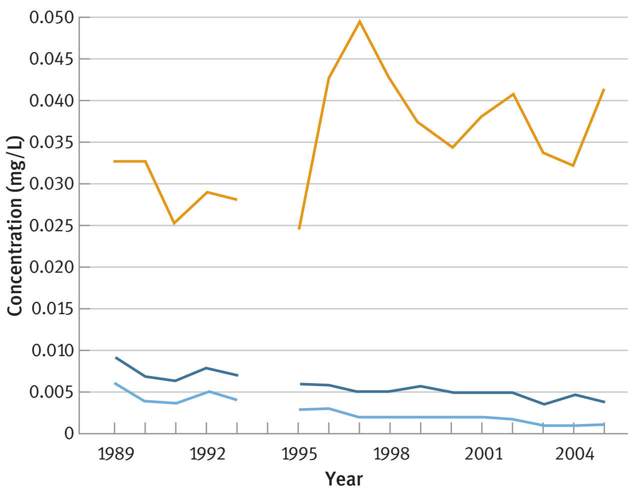
+ FIGURE 10.3:
NUTRIENT TRENDS IN RIVERS IN THE NATIONAL MONITORING NETWORK, 1989–2005

Monitoring sites in the national monitoring network

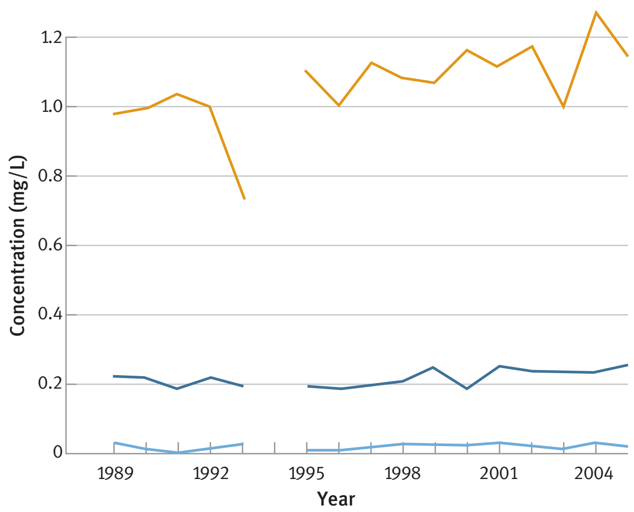
NITRATE NITROGEN



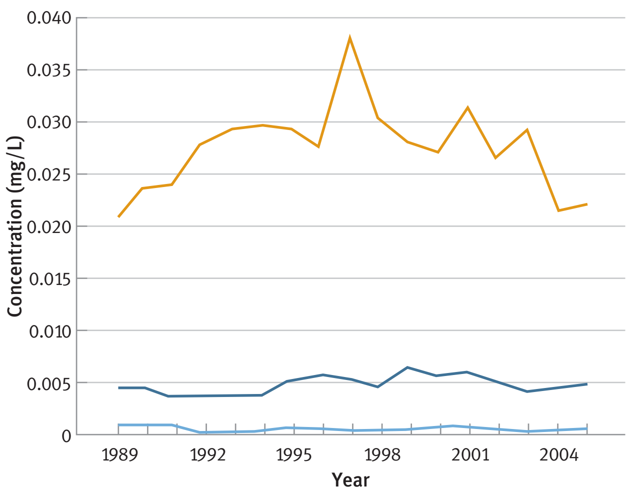
AMMONIACAL NITROGEN



TOTAL NITROGEN



DISSOLVED REACTIVE PHOSPHORUS



NUTRIENT CONCENTRATIONS

- Rivers with highest concentration (95th percentile)
- Rivers with median concentration (50th percentile)
- Rivers with lowest concentration (5th percentile)

Note:

mg/L = milligrams per litre.

Source: Adapted from Ministry for the Environment, 2006d.

Comparison with nutrient levels in other countries

The trend of increasing nitrogen in New Zealand rivers is consistent with patterns observed in other countries around the world. Globally, 30 per cent of 82 major river basins have higher nitrogen concentrations now than they had in the late 1970s (United Nations Educational, Scientific and Cultural Organization, 2006).

Nutrient levels in New Zealand rivers are still low by international standards. Our most nutrient-enriched rivers have about half the average nutrient levels of rivers in Europe, North America, and Asia that have been reported by the Organisation for Economic Co-operation and Development (Organisation for Economic Co-operation and Development, 2006).

Note that it is reasonable to compare only our most nutrient-enriched rivers with rivers reported by the Organisation for Economic Co-operation and Development (OECD). This is because, in general, OECD measurements are taken at the mouths of rivers flowing from large catchments. As a result, the OECD data represents relatively highly nutrient-enriched river systems that do not compare readily with New Zealand's less nutrient-enriched and, in many cases, smaller river systems.

Rivers with high levels of nutrients

The most nutrient-enriched rivers (represented by the orange lines in Figure 10.3) are located throughout the country and include the Mataura (Southland), Waingongoro (Taranaki), Waihou (Waikato), and the lower Manawatū. While these rivers are in lowland areas and are surrounded by predominantly pastoral farmland, factors unrelated to the predominant landscape may be contributing to their poor water quality. For example, in the past, a large point-source discharged effluent from a meatworks on the mid-reaches of the Waingongoro River (Taranaki Regional Council, 2006), although it now discharges to land during periods of low river flow.

Some improvement in nutrient levels

On average, levels of dissolved reactive phosphorus have increased in rivers of the national monitoring network (described earlier). However, there has been a steady decrease in phosphorus in rivers with high levels of this nutrient since a peak in the mid-1990s (indicated by the orange line in the graph for dissolved reactive phosphorus in Figure 10.3). This may signal improved pasture management in intensively farmed areas (for example, through reduced erosion and better fertiliser application practices), which may have led to reductions in the amount of phosphorus run-off to waterways.

Effluent, particularly from humans and farmed animals, such as sheep and cows, is the primary source of ammoniacal nitrogen. In contrast with other nutrients, levels of ammoniacal nitrogen have decreased in most of New Zealand's rivers over the past two decades. This improvement is consistent with reductions in point-source pollution, particularly the trend in recent decades towards applying ammonia-rich stock effluent to land, rather than discharging it into waterways (see Figure 10.2).

Land use and nutrient enrichment in rivers

The level of nutrients in our rivers is influenced by natural factors such as rainfall and river flow patterns. For example, rivers in areas with relatively low rainfall have higher median nutrient (and bacteria) levels than rivers in wetter areas (Ministry for the Environment, 2005a). This is because contaminants are able to accumulate in stagnant or slow-flowing waters rather than being flushed downstream. However, the largest impact on nutrient levels in our rivers comes from land use.

Figure 10.4 compares the median nutrient levels in rivers and streams in unmodified catchments with the levels in rivers and streams in pastoral and urban catchments.

ALGAL BLOOM IN A FRESHWATER LAKE.

Source: Nature's Pic Images.

Figure 10.4 shows urban streams are the most nutrient-enriched waterways in New Zealand, followed by rivers and streams in predominantly pastoral catchments. The median nutrient concentrations in both urban and pastoral waterways breach the Australia and New Zealand Environment Committee Council guidelines (see the notes to Figure 10.4) for ecosystem protection (Australia and New Zealand Environment Committee Council, 2000). Rivers and streams in unmodified catchments, such as those that are covered in native bush or alpine tussock, have the lowest levels of nutrients measured in New Zealand waterways.

Nutrients in urban waterways

The main source of nutrients in urban waterways is human wastewater (sewage). Wastewater may leak from broken sewer pipes or be discharged into stormwater systems through faulty pipe connections and sewer overflows. Some nutrients may also come from run-off from suburban lawns and gardens that have had fertilisers applied.

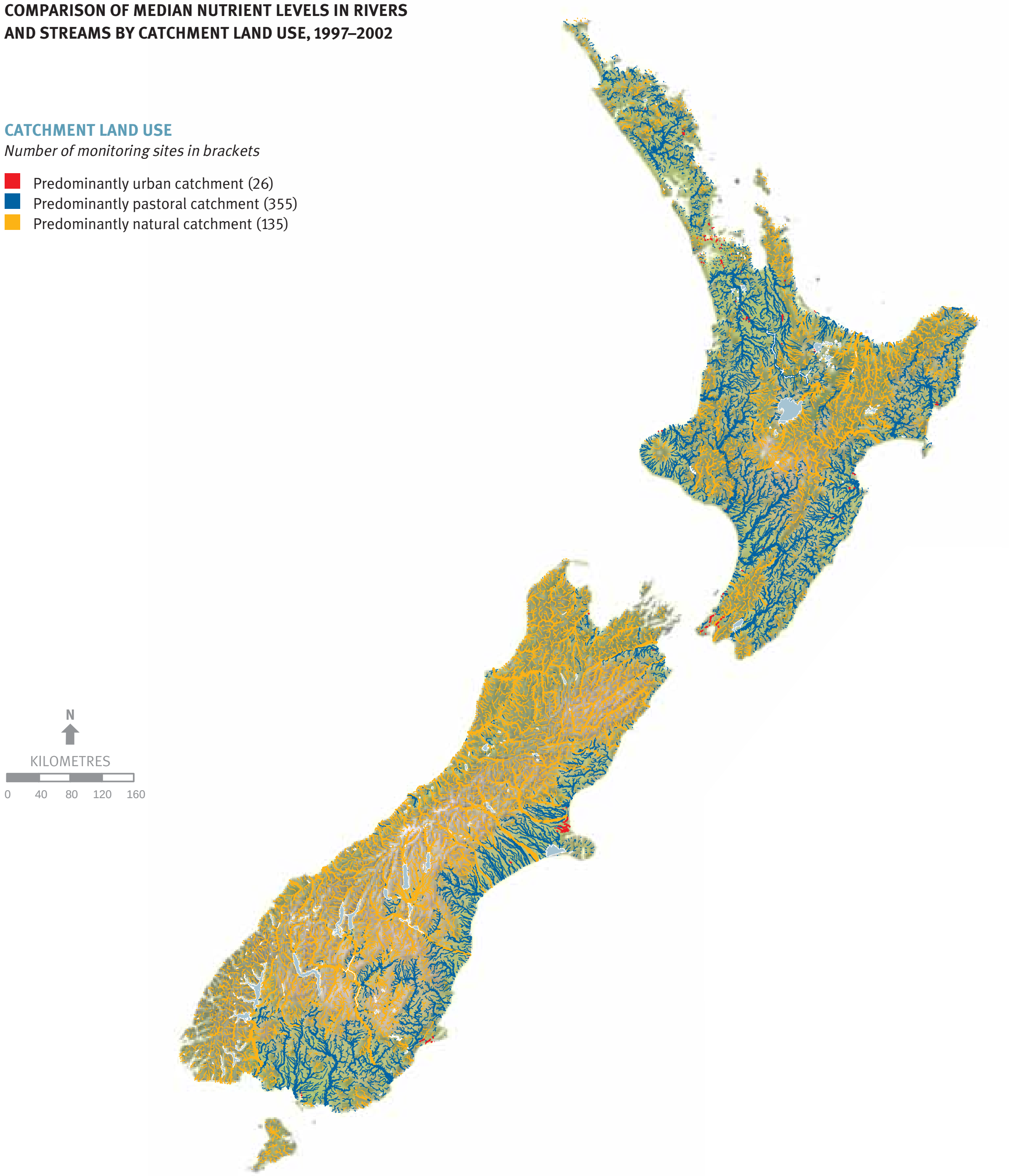
Urban streams with poor water quality can also have downstream impacts. Because most large towns and cities in New Zealand are situated on the coast, urban streams commonly discharge into harbours and estuaries (see chapter 11, 'Oceans').

Impact of agricultural activity

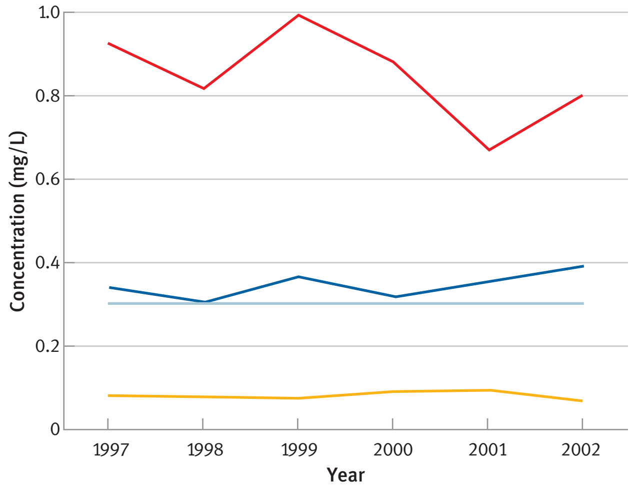
In rural environments, agricultural fertilisers and stock manure and urine are the major non-point-sources of nitrogen and phosphorus. These nutrients can enter water bodies relatively quickly if they are carried across the land surface by rainfall run-off, particularly if there are drains such as the mole and tile drains that are common on farmed pasture in Ōtago and Southland. (Mole and tile drains are subsurface channels constructed to drain surplus water.)

There is strong evidence at both the regional level (Environment Waikato, 2004; Hamill and McBride, 2003) and nationally that the levels of nutrients in rivers increase in proportion to the levels of agricultural activity in river catchments. The amount of nutrients going into the land from fertiliser application and livestock continues to increase in New Zealand as farming becomes more intensive (see box 'More about intensive farming and land use' in chapter 9, 'Land').

+ FIGURE 10.4:
COMPARISON OF MEDIAN NUTRIENT LEVELS IN RIVERS AND STREAMS BY CATCHMENT LAND USE, 1997–2002



+
NITRATE NITROGEN



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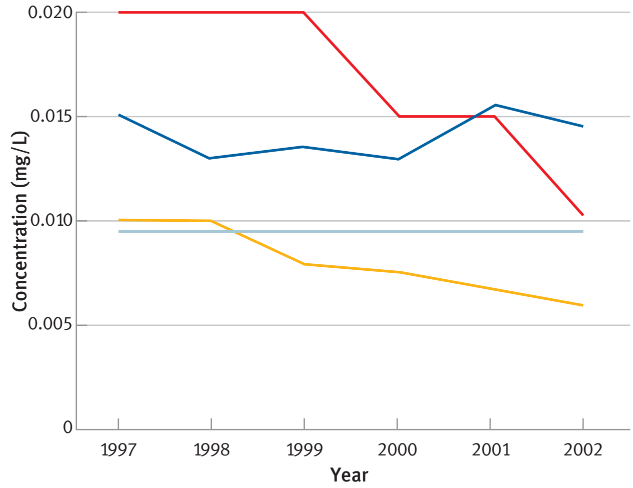
DISSOLVED REACTIVE PHOSPHORUS



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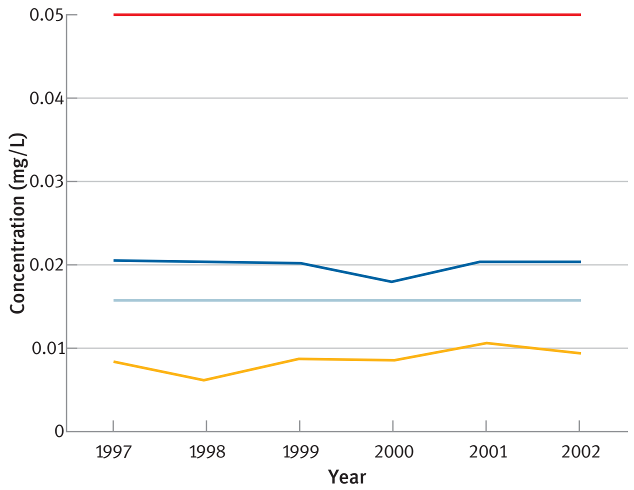
AMMONIACAL NITROGEN



CATCHMENT LAND USE
Number of monitoring sites in brackets

— Predominantly urban catchment (26)
— Predominantly pastoral catchment (355)
— Predominantly natural catchment (135)
— ANZECC guidelines (ecosystem protection)

Notes:

(1) River environments have been defined using the River Environment Classification (see chapter 1, 'Environmental reporting'). Catchments are defined as 'natural' unless pasture exceeds 25 per cent of the catchment area (in which case, it is classed as 'pastoral'), or unless urban land use exceeds 15 per cent of the catchment area (in which case, it is classed as 'urban').

(2) The Australia and New Zealand Environment Committee Council (ANZECC) guidelines provide 'trigger values' for the protection of ecosystems and the recreational and aesthetic values of waterways (Australia and New Zealand Environment Committee Council, 2000). If a trigger value is reached, it does not necessarily mean that ecosystem damage is occurring or that recreation is no longer possible, but it provides advance warning that a problem may be emerging.

(3) mg/L = milligrams per litre.

Data source: Adapted from Ministry for the Environment, in press a.

GOVERNMENT ACTION to manage freshwater quality

The Sustainable Water Programme of Action

In 2003, the Ministry for the Environment and the Ministry of Agriculture and Forestry jointly launched the Sustainable Water Programme of Action (SWPoA) to identify priorities for government action to improve freshwater management in New Zealand. The SWPoA has a particular focus on addressing the pressures on water bodies from land-use change and intensification. Extensive consultation in 2005 revealed broad support for the development of policy in a number of areas of freshwater demand and quality management.

By 2007, Cabinet had approved the development of a national policy statement on freshwater, as well as two national environmental standards, including one that will ensure methods used to allocate water are geared to safeguard aquatic ecosystems. Another focus of the SWPoA is to produce tools and best-practice guidance for regional councils on aspects of water quality and land-use management.

See also box ‘Government action to manage freshwater demand’.

National environmental standard for drinking water sources

In November 2006, the Government gave approval for a national environmental standard (NES) for sources of human drinking water. The purpose of this NES is to reduce the risk of contaminating sources of human drinking water (eg, rivers and groundwater). The NES will prevent resource consents from being granted, or permitted activity rules being included in regional plans, if they were to result in drinking water becoming unsafe to drink (after treatment by existing means).

Guidance and standards for freshwater management

Government has published various non-regulatory guidelines and standards since the late 1990s to help resource managers assess the quality of New Zealand’s freshwater. These include:

- *Australian and New Zealand Guidelines for Fresh and Marine Water Quality.* (Australia and New Zealand Environment Committee Council, 2000)
- *Microbiological Water Quality Guidelines for Marine and Freshwater Recreational Areas* (Ministry for the Environment and Ministry of Health, 2003)
- *Drinking-water Standards for New Zealand 2005* (Ministry of Health, 2005).

Nutrients in lakes

Monitoring lake water quality

The long-term monitoring of lakes in New Zealand is undertaken primarily by regional councils. Councils currently monitor the nutrient status of about 120 lakes around the country (although there are 134 lakes for which recent nutrient data are available). About half of all the lakes monitored are shallow (less than 10 metres deep) and about half are smaller than 50 hectares.

Of the 229 lakes in New Zealand that are larger than 50 hectares, about one-third are monitored. Many of the large unmonitored lakes are in national parks (such as Fiordland) or are reservoirs for hydro-electric power generation. Regular monitoring is not regarded as being necessary at these lakes because they generally do not experience the same land-use pressures as lakes in developed catchments, and changes to the quality of their water are expected to be much slower.

What is the Trophic Level Index?

In New Zealand, the Trophic Level Index is widely used to measure changes in the nutrient (trophic) status of lakes. This index considers phosphorus and nitrogen levels, as well as visual clarity and algal biomass. It takes account of both particulate and dissolved nitrogen (nitrate) and phosphorus in the water, which is important because water generally remains in lakes for long periods, so that even particulate nutrients can eventually be used to boost growth in aquatic plants.

Monitored lakes make up only a small proportion (4 per cent) of all lakes in New Zealand, and many of the lake monitoring programmes focus on lakes that have poor water quality or are at risk of water quality being impaired by land use in their catchment (see box ‘Monitoring lake water quality’). This means care should be taken when interpreting the results of the monitoring of water quality of New Zealand lakes.

A more balanced picture of lake water quality across the country can be obtained by classifying all unmonitored lakes according to the environmental factors that drive water quality (such as climate, lake depth, and the size and types of land cover in the lake catchment).

Key findings for both monitored and unmonitored lakes are presented in the following section.

Nutrient levels in monitored lakes

Seventy-five of the 134 lakes in New Zealand for which nutrient data are available have high to very high levels of nutrients (see Figure 10.5). Thirteen per cent of these lakes are known as ‘hypertrophic’, meaning they are ‘saturated’ with nutrients and their water quality is extremely degraded. In such lakes, algal blooms are common and the health of aquatic animals is often at risk. While some recreation may take place on the surface of these degraded lakes (such as sailing), activities such as swimming are restricted because of the lakes’ prolific weed growth and poor water clarity.

Deep lakes hold more water than shallow ones and have a greater capacity to absorb incoming nutrients before showing definite signs of deterioration in water quality. In addition, the nutrient status of lakes is strongly related to their depth and the type of land use and human activities in the catchment.

All of the monitored lakes that have high levels of nutrients are shallow. They include lakes surrounded by farmland in the Waikato (for example, Lake Hakanoa and Lake Mangakawhere), several of the dune lakes in Northland (Lakes Ōmāpere, Kapoai, Rotokawau, and Waiporohita), and two coastal lagoons in Canterbury (Lake Ellesmere/Te Waihora and Lake Forsyth/ Te Wairewa).

The monitored lakes with the lowest levels of nutrients are nearly all deep lakes in mountain country in the South Island (for example, Lakes Coleridge, Pūkaki, Wānaka, and Tekapō) and do not have particularly intensive farming or urban activity in their catchments.

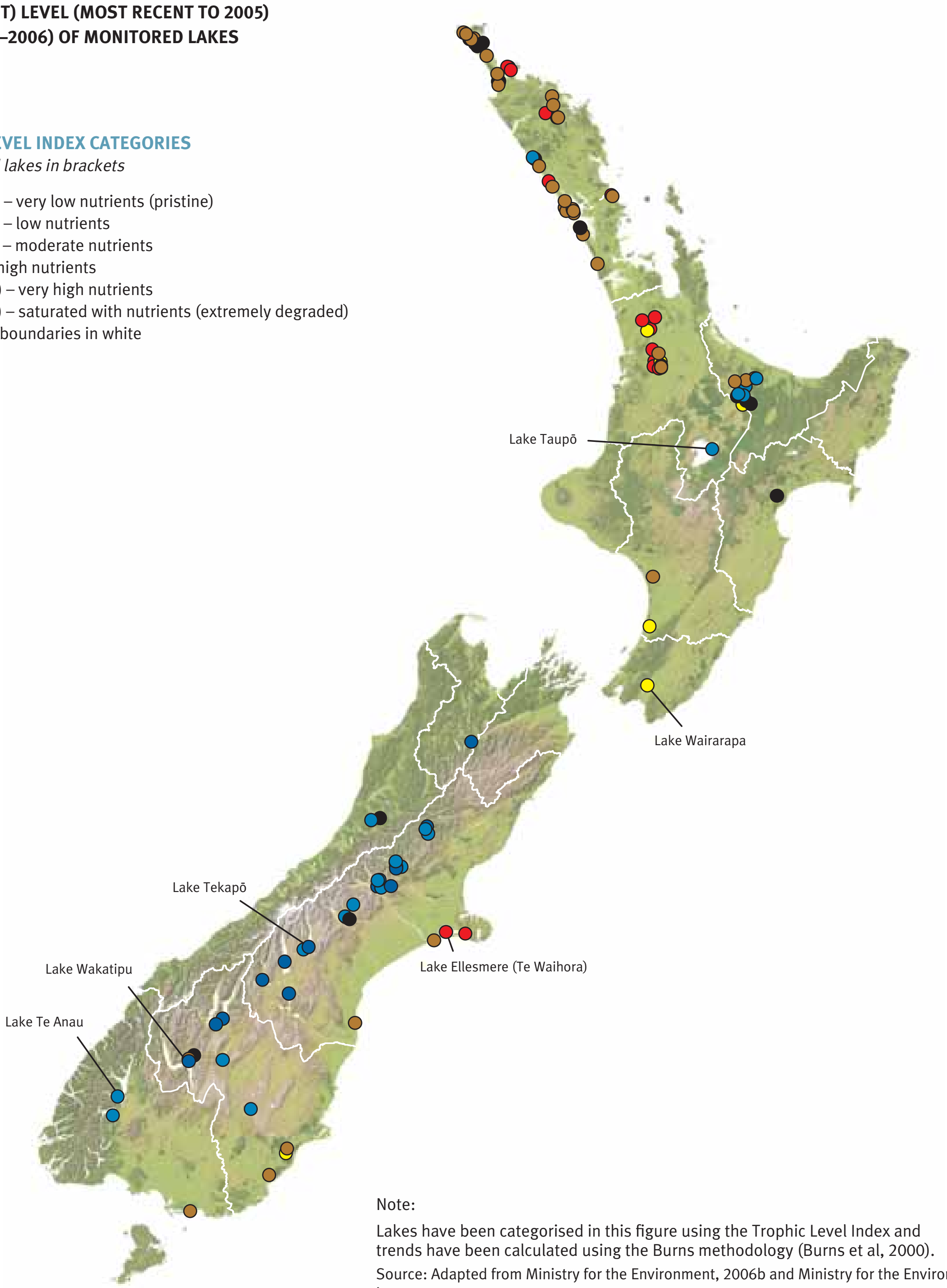
LAKE TEKAPŌ.

Source: iStockphoto.

+ FIGURE 10.5:
TROPHIC (NUTRIENT) LEVEL (MOST RECENT TO 2005) AND TRENDS (1990–2006) OF MONITORED LAKES

KEY TO TROPHIC LEVEL INDEX CATEGORIES
Number of monitored lakes in brackets

- Microtrophic (13) – very low nutrients (pristine)
- Oligotrophic (25) – low nutrients
- Mesotrophic (21) – moderate nutrients
- Eutrophic (44) – high nutrients
- Supertrophic (13) – very high nutrients
- Hypertrophic (18) – saturated with nutrients (extremely degraded)
- Regional council boundaries in white



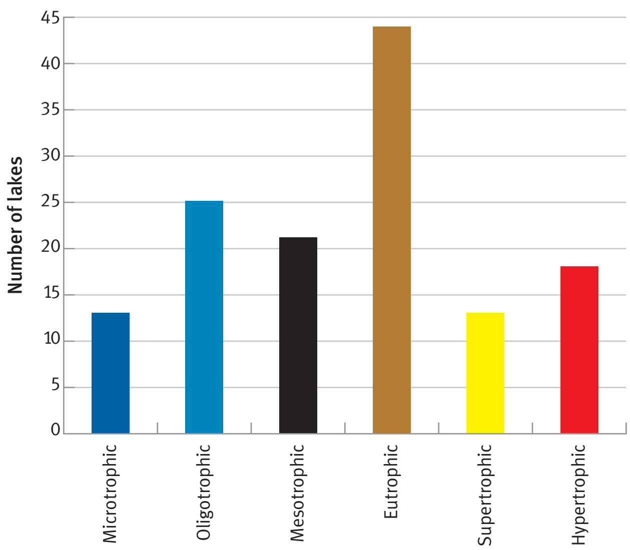
N
KILOMETRES
0 40 80 120 160

Note:

Lakes have been categorised in this figure using the Trophic Level Index and trends have been calculated using the Burns methodology (Burns et al, 2000).

Source: Adapted from Ministry for the Environment, 2006b and Ministry for the Environment, in press c.

+
TROPHIC LEVEL OF 134 MONITORED LAKES



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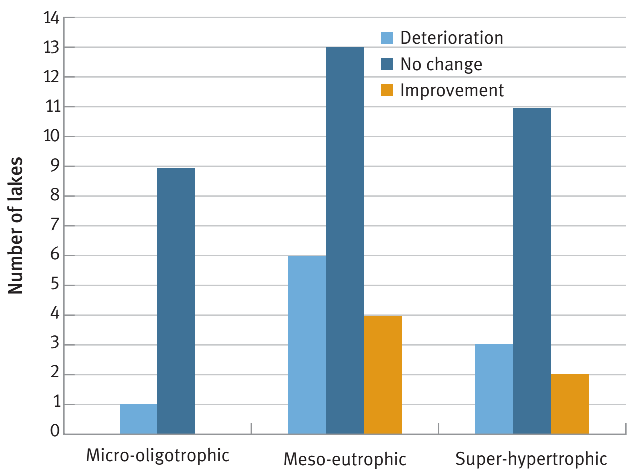
TROPHIC LEVEL TRENDS IN 49 LAKES



An estimate of water quality in unmonitored lakes

A large majority of the 3,820 lakes greater than 1 hectare in area in New Zealand are not monitored. By extrapolating the results for monitored lakes, it is estimated that the majority (about two-thirds) of all lakes are likely to have relatively low concentrations of nutrients and good to excellent water quality because they lie in natural, or only partially developed, catchments (Ministry for the Environment, in press c). The remaining third of lakes are likely to have high levels of nutrients and poor water quality.

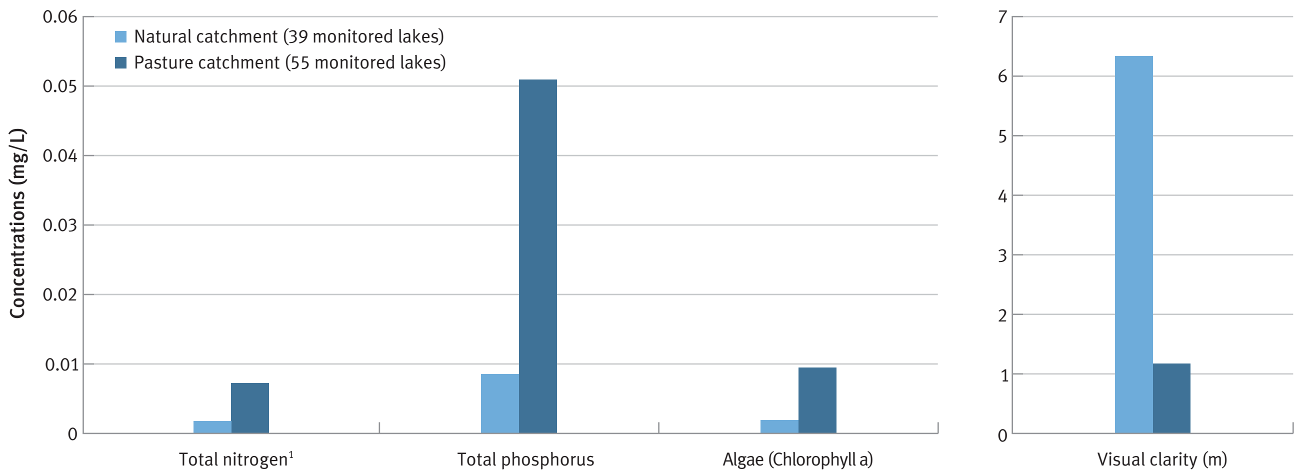
Measured trends in lake water quality

Trends in water quality have been assessed for 49 lakes. Figure 10.5 shows that the levels of nutrients in most of these lakes have shown no signs of change since 1990. Ten of the 49 lakes show possible or definite signs of deterioration (that is, an increase in nutrient or algae levels or a decrease in visual clarity), and six show signs of improvement. Many of the lakes showing signs of deterioration are already moderately nutrient-enriched (meso-eutrophic) and lie in largely developed catchments (for example, Waikere in Northland, and Waikare and Rotomanuka in the Waikato).

Land use and lake water quality

Figure 10.6 compares the water quality of monitored lakes in predominantly pastoral catchments with lakes in catchments with predominantly natural land cover. Levels of nutrients (nitrogen and phosphorus) and algae are between two and six times higher in lakes in pastoral catchments than in lakes that are in natural catchments.

+ FIGURE 10.6:
COMPARISON OF TROPHIC LEVEL INDEX WATER QUALITY VARIABLES BETWEEN LAKES IN PASTURE CATCHMENTS AND LAKES IN NATURAL CATCHMENTS, 2004–2006



Notes:

(1) Total nitrogen concentrations are much higher than total phosphorus concentrations, but nitrogen values have been scaled down by 100 in this graph for the purposes of presenting information on both nutrients together.

(2) mg/L = milligrams per litre.

Data source: Ministry for the Environment, in press c.

Because algal concentrations affect water clarity, the lakes in natural catchments have water that is, on average, five times clearer than water in lakes in pastoral catchments. For example, lakes in the mountainous terrain of the South Island commonly have underwater visibility for more than 10 metres (Ministry for the Environment, 2006b), although this is lowered naturally in some cases by tannins leaching from beech forests or by fine glacial sediment.

The photo opposite shows an example of a degraded lowland lake that is surrounded by farmland – Lake Spectacle in the Auckland region. Many lakes that lie in intensively used catchments are the subject of management programmes that aim to stem the inflow of pollutants from the surrounding land (see box 'Local action to protect water quality in Lake Taupō and the Rotorua Lakes').

LAKE SPECTACLE IN THE AUCKLAND REGION (WITH LAKE TOMORATA IN THE BACKGROUND).

Source: Courtesy of Auckland Regional Council.

LOCAL ACTION to protect water quality in Lake Taupō and the Rotorua Lakes

The Bay of Plenty and Waikato regional councils are working with district councils, Mäori trust boards, land owners, and the wider community to protect the water quality of Lake Taupö and the Rotorua Lakes.

In the Rotorua district, action plans are under development for each of 12 lakes to reduce their nutrient (nitrogen and phosphorus) levels. One example of action planned is the construction of a channel that will limit the input of nutrient-rich water to Lake Rotoiti.

Environment Bay of Plenty has produced Rule 11, a set of regional rules designed to limit the loss of nitrogen and phosphorus from land-use activities.

In the Waikato, a proposed variation to the regional plan sets a water quality objective for Lake Taupö and changes land-use controls on nutrients entering the lake from urban and rural sources.

In addition, higher than previous standards are proposed for domestic wastewater treatment and disposal near the lake, as well as limits on nitrogen leaching from all land in the catchment. For the first time, farmers in the Waikato region will be required to cap the amount of nitrogen that may leach from their farming activities.

The Government has committed $81.5 million to the long-term Lake Taupö protection programme and $4 million towards remedial work to improve water quality in Lake Rotoiti.

Other factors affecting lake water quality

Natural factors such as air temperature and wind are also important determinants of water quality in lakes. Algal blooms are more likely to occur in lakes in warmer climates (those at lower elevations and in the north) and in the summer. Wind can create waves and currents, particularly in shallow lakes, and lift sediments from the lake bed into the water. As well as reducing the clarity of a lake's water, this can cause the amount of nutrients that are available for algal growth to increase. Clarity and the appearance of lake water may be affected by soil type. For example, lakes surrounded by peaty soil, such as those commonly found in Westland and Waikato, have water that is naturally brown-stained or 'dirty' looking.

Bacterial (faecal) pollution in rivers and lakes

Monitoring swimming spots

Across the country, 230 sites on rivers and lakes are regularly monitored for recreational water quality. These are sites where water-based activities such as swimming, water-skiing, and diving are common. Water samples are typically taken once a week over the summer (November to March) and are tested for *E. coli*, the indicator of faecal pollutants in freshwater. (The 230 sites monitored include only those sites where at least 10 water quality samples are taken over the summer. Another 33 sites are monitored, but less frequently.)

When *E. coli* levels are higher than those recommended by the *Microbiological Water Quality Guidelines for Marine and Freshwater Recreational Areas* (Ministry for the Environment and Ministry of Health, 2003), councils liaise with health authorities to ensure the public is warned (by signs or other means) that there is an unacceptable health risk.

Water quality at freshwater swimming spots

Figure 10.7 shows that over the 2006–2007 summer, 60 per cent of the 230 monitored freshwater swimming spots had water quality that met New Zealand guidelines for water-based (contact) recreation almost all of the time (that is, at least 95 per cent of the samples taken at these sites had concentrations of *E. coli* that were within acceptable levels). Ten per cent of the sites breached the guidelines regularly (that is, more than 25 per cent of the samples taken from these sites were non-compliant), indicating that these sites often have poor water quality and are not suitable for swimming.

The number of freshwater sites meeting the New Zealand guidelines in 2006–2007 is higher than in previous years for which data has been reported (2003–2004 and 2005–2006). (See the graph in Figure 10.7.) While this increase is encouraging, the period of monitoring is not yet long enough to be able to determine whether there is a trend of improving recreational water quality over time.

Several natural and human factors may cause variations in water quality between seasons. For example, during a wet summer (with frequent rain), more faecal matter is carried from the land into rivers and lakes. Therefore, bacteria levels in the water during wet summers are often high compared with dry summers. Also, sediment mixing as a result of wind and wave action can elevate bacteria levels.

Freshwater swimming spots generally have higher background levels of bacteria and longer-lasting contamination events than coastal beaches. This is largely because faecal matter is more rapidly diluted and dispersed by currents and the large volumes of water at the coast. The difference between bacteria levels at freshwater and coastal swimming spots is illustrated by comparing monitoring results for the 2006–2007 summer; the water quality of 80 per cent of monitored coastal beaches met the guidelines for swimming almost all of the time (compared with 60 per cent of freshwater sites), while only 1 per cent of the coastal beaches breached the guidelines regularly (compared with 10 per cent of freshwater sites) (see chapter 11, 'Oceans').

WATER-SKIING ON LAKE TAUPŌ.

Source: Ministry for the Environment.

+ **FIGURE 10.7:**
BACTERIAL WATER QUALITY AT MONITORED FRESHWATER SWIMMING SPOTS, 2003–2007

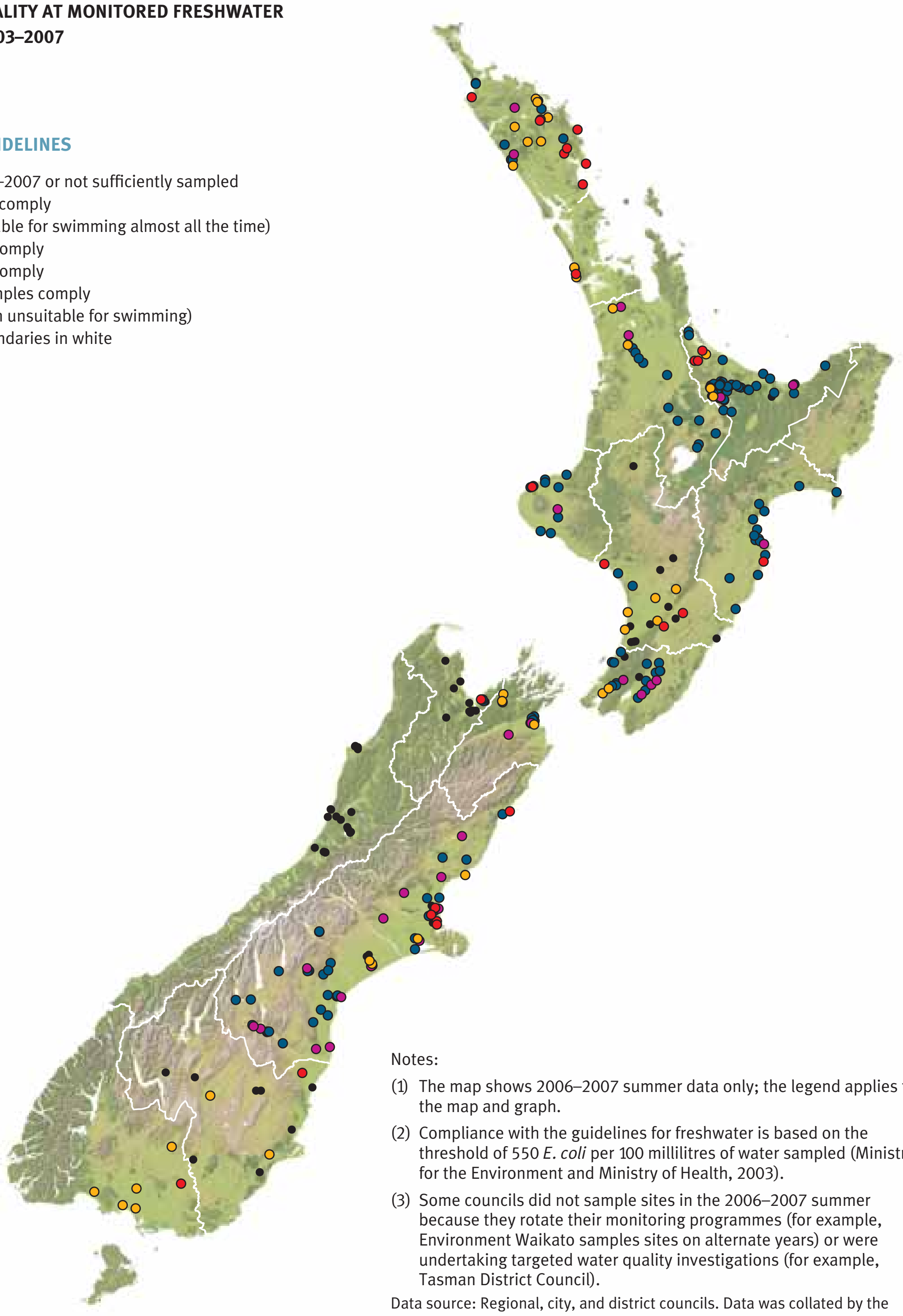
COMPLIANCE WITH GUIDELINES

- Not sampled in 2006–2007 or not sufficiently sampled
- 95–100% of samples comply (water quality is suitable for swimming almost all the time)
- 90–95% of samples comply
- 75–90% of samples comply
- Less than 75% of samples comply (water quality is often unsuitable for swimming)
- Regional council boundaries in white

N

KILOMETRES

0 40 80 120 160



Notes:

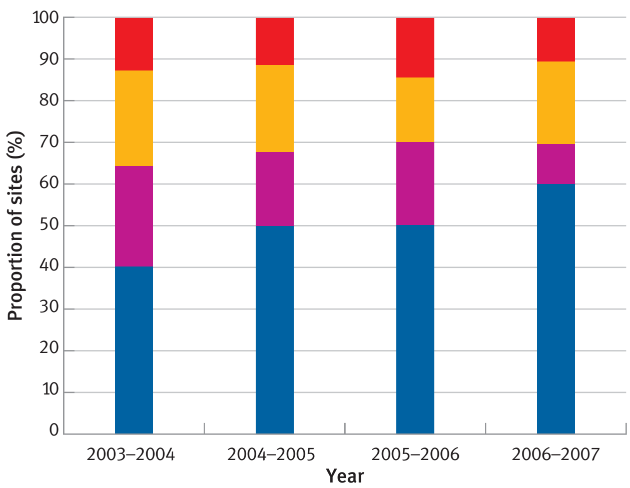
(1) The map shows 2006–2007 summer data only; the legend applies to the map and graph.

(2) Compliance with the guidelines for freshwater is based on the threshold of 550 *E. coli* per 100 millilitres of water sampled (Ministry for the Environment and Ministry of Health, 2003).

(3) Some councils did not sample sites in the 2006–2007 summer because they rotate their monitoring programmes (for example, Environment Waikato samples sites on alternate years) or were undertaking targeted water quality investigations (for example, Tasman District Council).

Data source: Regional, city, and district councils. Data was collated by the Ministry for the Environment in 2007.

+
PROPORTION OF SITES IN EACH COMPLIANCE CATEGORY 2003–2007



Land use and bacterial (faecal) pollution in rivers

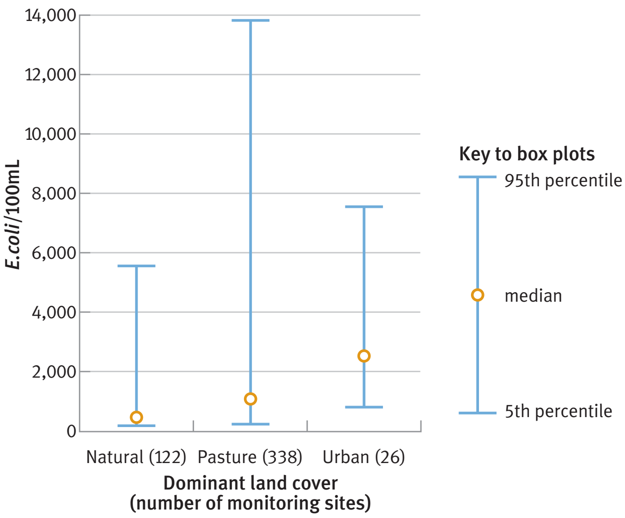
Rivers and streams with the highest average levels of faecal pollution are those in towns and cities (see the comparison of median levels in Figure 10.8). Faecal matter from birds, cats, and dogs may be carried by stormwater into urban waterways, although there is little evidence that this source on its own results in infectious levels of bacteria (Ministry for the Environment, 2002). A significant amount of faecal material comes from human waste leaking from sewerage systems.

Like those in urban areas, rivers and streams in pastoral areas also have high levels of bacteria (relative to waterways in natural catchments). While the levels of bacteria in pastoral waterways are lower than in urban sites, the worst pastoral sites that are monitored have significantly higher levels of bacteria than the worst urban sites that are monitored (as indicated by the relatively high 95th percentile for pastoral sites in Figure 10.8).

It is known that farm stock with access to river and stream beds can contribute high amounts of faecal matter directly to the water. One study has shown that if cows cross a stream on their way to and from milking, they are 50 times more likely to defecate in the water than on adjacent raceways (Davies-Colley et al, 2004).

Many sites in predominantly natural catchments, where land-use pressures are considered to be lowest, also have high levels of bacteria. These high levels could be caused by faecal matter from birds and other wild animals, such as possums, deer, and goats. Predominantly natural catchments may also have small pockets of urban or pastoral land use that deliver significant amounts of faecal material to the water.

+ FIGURE 10.8:
CONCENTRATIONS OF *ESCHERICHIA COLI* (*E. COLI*) BACTERIA IN RIVERS AND STREAMS IN CATCHMENTS WITH DIFFERENT LAND USES, 1997–2002



Notes:

(1) Statistics in the graph are derived from 95th percentile data.

(2) These results include winter sampling results, when faecal-bacteria loads are typically relatively high. This is because there is increased run-off from higher winter rainfall and bacteria tend to live longer in cooler temperatures. However, in general, recreational activities such as swimming do not take place in winter.

(3) mL = millilitres (of water).

Data source: Ministry for the Environment, in press a.

Visual clarity

Between 1989 and 2003, the median visual clarity improved in rivers within the national monitoring network. Almost half of the 77 monitored sites showed increases in visual clarity of more than 1 per cent per year over this time. Since 2000, the median visual clarity for monitored New Zealand rivers ranged between 1.0 and 1.9 metres (Ministry for the Environment, 2006d). This meets the requirements for ecosystem protection (Australia and New Zealand Environment Committee Council guidelines state that clarity of less than 0.7 metres, averaged for upland and lowland rivers, is unacceptable) but has, at times, been below the recommended minimum for human recreation (1.6 metres) (Australia and New Zealand Environment Committee Council, 2000).

Water clarity varies widely between rivers around the country. Visual clarity of only 10 to 40 centimetres is common in rivers with very high levels of sediment. These rivers include the lower Manawatū, the Waitara in Taranaki, and the Waipaoa in the Gisborne district.

Soil erosion is a common cause of low levels of clarity in New Zealand rivers and streams. This may be a consequence of poorly managed farmland (for example, the collapse of unprotected stream banks and sediment run-off from paddocks). Urban development and harvesting of plantation forestry can also produce high volumes of sediment run-off.

Natural factors can also determine clarity. For example, the low level of clarity in the Waipaoa River is caused by the geology of the catchment. Sandstones, mudstones, and gravels are easily eroded, which leads to high suspended-sediment loads (Gisborne District Council, no date). See also box 'More about hill-country erosion and our geological history' in chapter 9, 'Land'.

Visibility of more than 10 metres is common in the country's clearest rivers (the upper Motueka, Clutha, and Monowai in the South Island high country). The upper catchment of the Motueka River is almost entirely native bush or bare mountain rock and, as a result, the amount of sediment-laden run-off that enters the upper reaches of the river after rainfall is minimal. The photo on the opposite page shows an example of a river with high visual clarity – the Waiohine River in the Wairarapa.

WAIOHINE RIVER GORGE IN THE WAIRARAPA, A RIVER WITH VERY HIGH VISUAL CLARITY.

Source: Courtesy of Greater Wellington Regional Council.

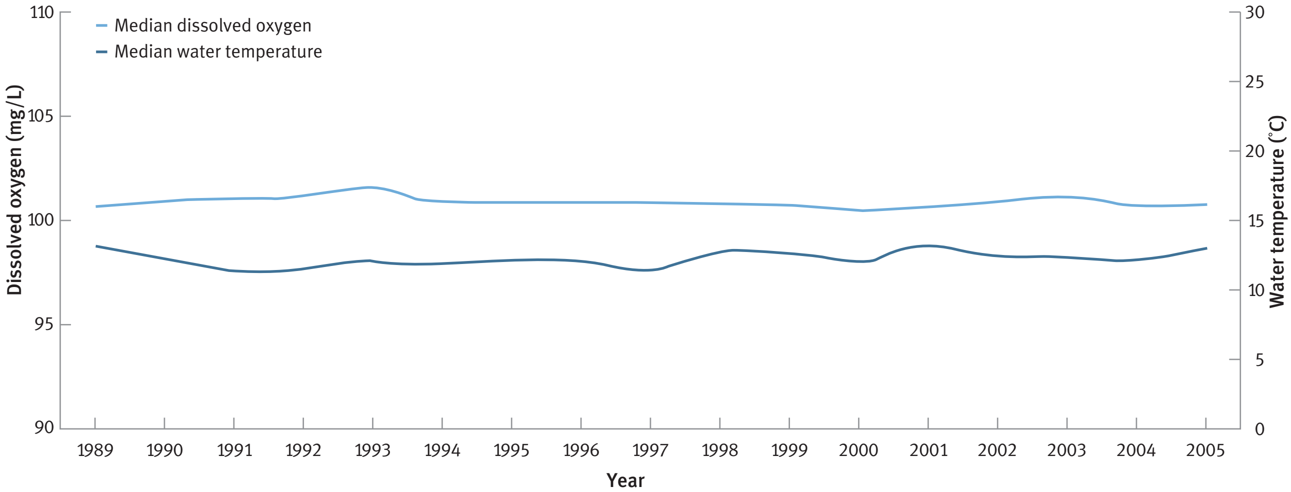
It is not yet possible to identify why the water clarity in rivers has improved. However, the improvement may be related to a reduction in sediment in the water as a result of better forestry and farm management (for example, fencing to prevent stock trampling river and stream banks).

Water temperature and dissolved oxygen

Water temperatures and levels of dissolved oxygen remained stable in rivers in the national monitoring network over 1989–2005 (see Figure 10.9). This is encouraging because trends towards higher temperatures and lower levels of dissolved oxygen would indicate water quality was declining.

Large rivers are less susceptible to significant temperature changes than streams. There is some evidence from regional council reporting (for example, Tasman District Council, 2005) that streams in developed catchments regularly experience water temperatures that are high enough to threaten their ecology. These streams are typically unshaded because the riparian vegetation has been cleared.

+ FIGURE 10.9:
TRENDS IN DISSOLVED OXYGEN AND WATER TEMPERATURE IN RIVERS IN THE NATIONAL MONITORING NETWORK, 1989–2005

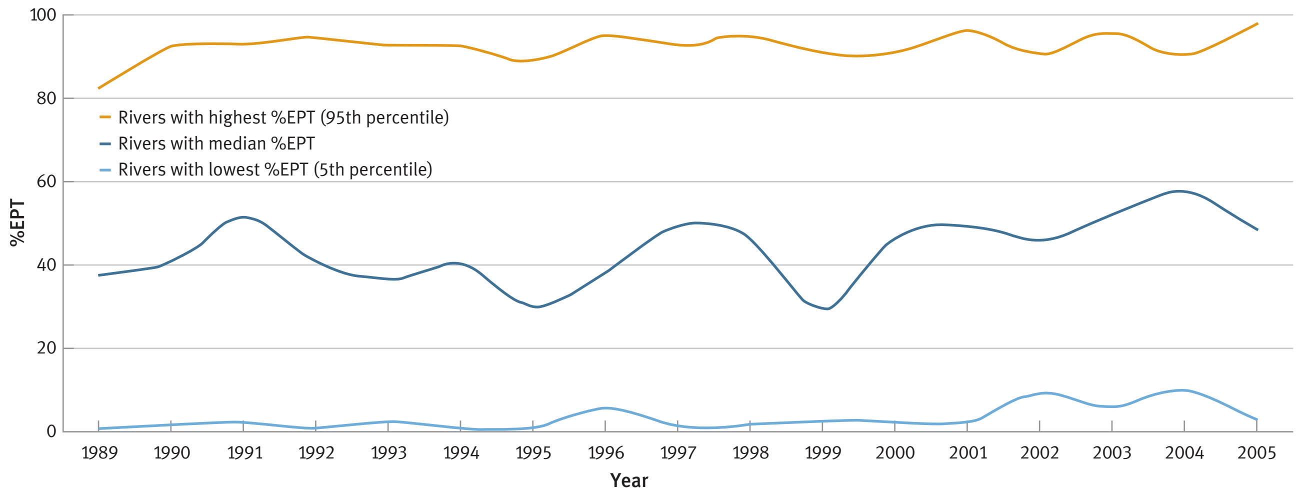


Notes:
(1) Different scales are used for dissolved oxygen and water temperature.
(2) mg/L = milligrams per litre.
Source: Adapted from Ministry for the Environment, 2006d.

Macroinvertebrate richness (%EPT)

High macroinvertebrate richness (%EPT) indicates good water quality. Monitoring of rivers in the national network over 1989–2005 showed that the relative abundance of macroinvertebrates sensitive to pollution (as measured by %EPT) increased in rivers that had low or median numbers of macroinvertebrates to start with (see Figure 10.10). These increases are consistent with decreases in ammoniacal nitrogen and biochemical oxygen demand (reported in earlier sections of this chapter), and further indicate that levels of organic pollution have decreased.

+ FIGURE 10.10:
TRENDS IN MACROINVERTEBRATES (%EPT) IN RIVERS IN THE NATIONAL MONITORING NETWORK, 1989–2005



Notes:
(1) Data is derived from 66 sites of the 77 that make up the national monitoring network.
(2) Higher %EPT indicates better water quality.
Data source: National Institute of Water and Atmospheric Research.

Biochemical oxygen demand

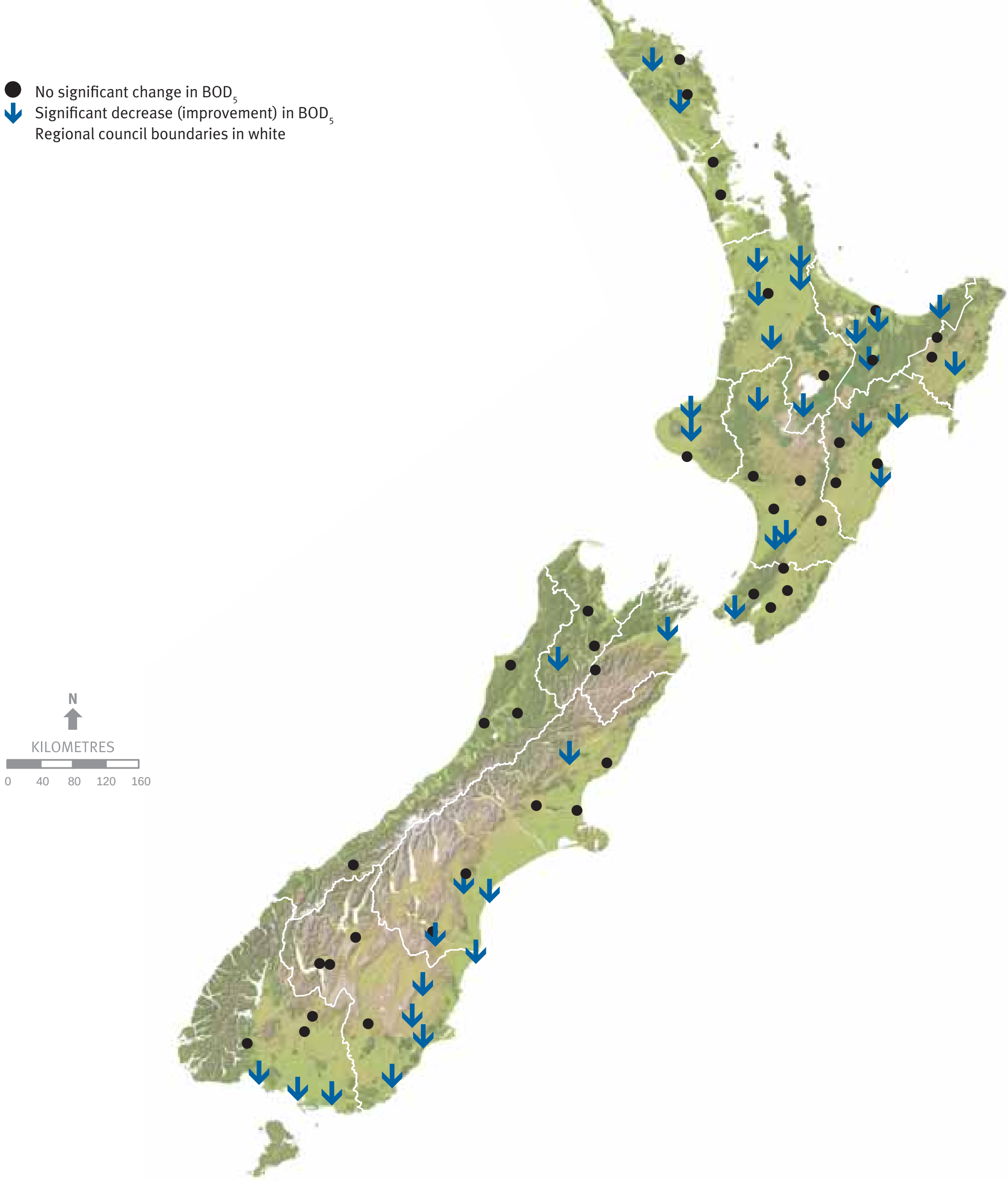
Biochemical oxygen demand (see box 'What is biochemical oxygen demand?') decreased steadily in rivers across the country in 1989–2002, indicating an improvement in water quality. This is illustrated in Figure 10.11, which shows that about half of the 77 sites monitored have had significant decreases in organic pollution and none of them has worsened over 1989–2002. This improved water quality is probably the result of better management of point-sources of pollution, such as dairyshed and factory wastewater discharges.

What is biochemical oxygen demand?

Biochemical oxygen demand (also known as 'BOD_5') indicates the amount of organic waste in the water. Common sources of organic waste are point-source discharges of sewage from wastewater treatment plants and discharges of carbohydrate and protein material from timber treatment plants, meatworks, and dairy factories.

Biochemical oxygen demand is not a national environmental indicator. However, it is reported in this chapter because biochemical oxygen demand levels have changed significantly over the past two decades, which illustrates the effects of freshwater management during and before that period.

+ FIGURE 10.11:
TRENDS IN BIOCHEMICAL OXYGEN DEMAND (BOD_5) FOR RIVERS IN THE NATIONAL MONITORING NETWORK, 1989–2002



Source: Adapted from Ministry for the Environment, 2006d.

The average levels of biochemical oxygen demand in New Zealand's most polluted rivers are three times lower than in large rivers in other OECD countries (Organisation for Economic Co-operation and Development, 2006).

The Mataura River in Southland is an example of a major New Zealand waterway in which water quality has improved since point-source discharges of organic waste were reduced and/or received improved treatment before discharge. In 1975, 15.5 tonnes of organic waste were discharged into the river each day. By 2000, because of improvements to effluent treatment at a large meatworks alongside the river, the organic waste discharged had decreased to just over 3 tonnes a day. Similar reductions in the amount of suspended-solid material were achieved over the same period.

While the Mataura River still has elevated nutrient and bacteria levels from non-point-sources, marked improvements in the appearance of the river (less surface scum and foam) have been attributed to the reduction in organic matter entering it (Environment Southland, 2000).

Groundwater quality

Monitoring groundwater

There are almost 1,100 sites (that is, wells or bores) for monitoring groundwater quality in New Zealand. The average well is about 20 metres deep, with a quarter of all monitoring wells less than 9 metres deep, and another quarter deeper than 45 metres.

In New Zealand, monitoring tends to focus on aquifers that are considered by water managers to be either an important source of supply, or particularly vulnerable to pollution. Therefore, the results of monitoring surveys presented in this section should be considered to represent areas where contamination is likely, rather than representing the overall groundwater resource in New Zealand.

The most extensive aquifers in New Zealand are shallow, unconfined sand and gravel sediments. These aquifers contain relatively young, well-oxygenated, and fast-flowing groundwater. While the mineral content of this groundwater is typically low, it is vulnerable to pollution from human activities on the land. These pollutants, particularly nutrients and faecal material, can quickly reach the water table and, once there, disperse over wide areas.

Nutrients (nitrate) in groundwater

Nitrogen is found in groundwater in the form of nitrate, and is monitored for health and environmental reasons. Excessive levels of nitrate in drinking water have been linked with blood disease in infants (commonly known as 'blue baby syndrome') (Davies, 2001).

From an environmental perspective, elevated levels of nitrate often indicate the potential presence of other pollutants from human activities, such as faecal pathogens and pesticides (that is, nitrate can be a good indicator of general groundwater degradation). In addition, groundwater that is rich in nitrate has the potential to elevate nutrient levels in the surface water it drains into.

Current nitrate levels

More than one-third (39 per cent) of groundwater monitoring sites in New Zealand have levels of nitrate that are elevated above natural background levels, probably as the result of human activities (Ministry for the Environment, in press b), such as the leaching of fertiliser and stock effluent. The median nitrate level in monitored groundwater in New Zealand is 1.3 milligrams per litre. Nitrate levels exceed the 2005 New Zealand drinking water standard of 11.3 milligrams per litre at almost 5 per cent of monitoring sites (see Figure 10.12). However, the proportion of bores at these sites used to supply drinking water for people is not known.

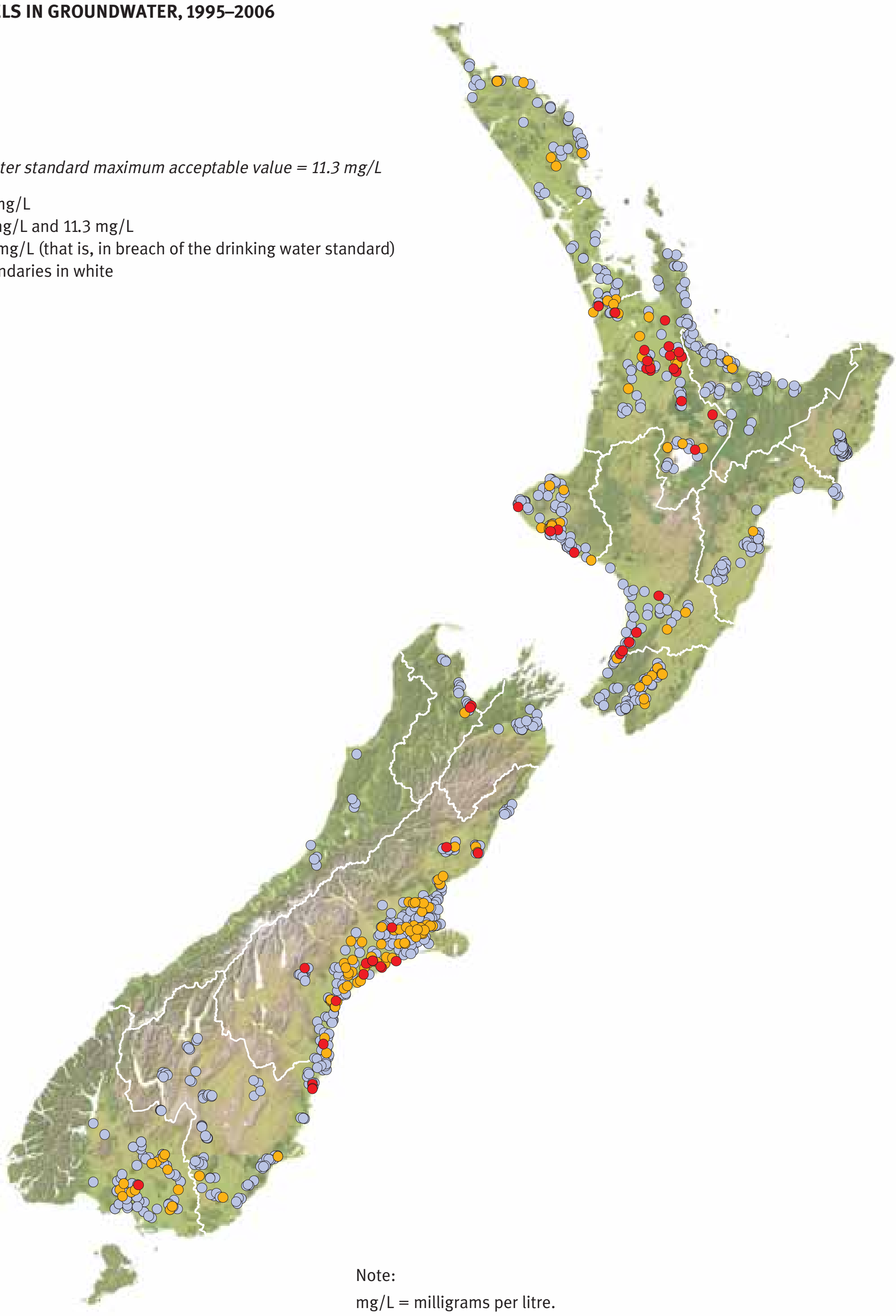
+ FIGURE 10.12:

MEDIAN NITRATE LEVELS IN GROUNDWATER, 1995–2006

NITRATE MEDIANS

New Zealand drinking water standard maximum acceptable value = 11.3 mg/L

- Sites less than 5.65 mg/L
- Sites between 5.65 mg/L and 11.3 mg/L
- Sites exceeding 11.3 mg/L (that is, in breach of the drinking water standard)
- Regional council boundaries in white



N

KILOMETRES

0 40 80 120 160

Note:

mg/L = milligrams per litre.

Source: Adapted from Ministry for the Environment, in press b.

In New Zealand, nitrate concentrations are highest in shallow, well-oxygenated groundwater in unconfined aquifers. The median nitrate concentration in this type of groundwater is 2.8 milligrams per litre, which is more than twice the average of all monitored groundwater (1.3 milligrams per litre).

Monitored groundwater with nitrate concentrations that breach health standards are found in most regions, but are most common in the Waikato and Manawatū regions (Ministry for the Environment, in press b). In the Waikato, elevated nitrate concentrations have been attributed to intensive land uses such as dairying and market gardening in areas where free-draining soils overlie a shallow water table (Environment Waikato, 1998).

As well as affecting drinking water quality, excessive levels of nitrate in groundwater can lead to nutrient enrichment of downstream surface water. This has important implications for regional freshwater management, particularly because there can be a lengthy time lag between groundwater being polluted and its emergence at a downstream water body. For example, nitrogen levels in a lake may increase long after the activity responsible for delivering nitrogen into a catchment (such as intensive farming) has declined or ceased. This is because the groundwater entering the lake is still polluted from historical farming practices.

Trends in nitrate

There has been no clear nationwide trend in nitrate concentrations over recent years. Approximately equal numbers of monitored groundwater sites have shown increasing concentrations of nitrate (13 per cent) and decreasing concentrations of nitrate (11 per cent) over 1995–2006 (Ministry for the Environment, in press b).

At a regional scale, increasing trends of nitrate are more widespread in some areas than others. Increasing nitrate concentrations have been reported in rural parts of Canterbury, probably due to the increasing intensity of human activities in the region, such as dairy farming and wastewater disposal (Environment Canterbury, 2002). Increasing concentrations of nitrate have also been recorded at some Waikato sites for which records are available from the 1950s (Environment Waikato, no date).

Faecal pollution (bacteria) in groundwater

There are 520 groundwater monitoring sites that have sufficient data on bacteria levels to derive medians. Eighty per cent of these sites comply with New Zealand guidelines for drinking water quality of 1 bacteria coliform unit per 100 millilitres of water sampled (Ministry for the Environment, in press b). However, it is not known how many of these monitored groundwaters are used to supply human drinking water. (Of the drinking water supplies that are registered with the Ministry of Health, about 2 per cent exceeded the guidelines for *E. coli* between 2002 and 2004 (Ministry of Health, 2006)).

The drinking water standard is breached most commonly in Northland, Southland, and Canterbury (Ministry for the Environment, in press b).

Only 2 per cent of the monitored sites exceed the guidelines for stock drinking water quality (100 coliform units per 100 millilitres of water sampled).

Like nitrate, bacteria concentrations are highest in shallow, unconfined groundwater (Ministry for the Environment, in press b); faecal bacteria generally do not survive the long travel times needed to reach deeper groundwater. However, bacteria can be widely dispersed within shallow groundwater systems because these aquifers typically have relatively fast-flowing water and porous sediments.

Elevated concentrations of bacteria in groundwater are commonly attributable to faecal matter leaching from stock dung on the land surface, or from human waste disposal facilities such as septic tanks. However, high bacteria counts do not always represent general groundwater degradation. For example, poor groundwater bore design may allow faecal material from a localised source at the land surface (such as a farm animal defecating near the well head) to leak directly down the shaft.

Ninety per cent of the monitored groundwaters showed no change in concentrations of bacteria over 1995–2006.

Other information on groundwater quality

Regional councils also assess the quality of our groundwater in other ways. In particular, minerals, chemicals, and metals, such as sodium, chloride, sulphate, dissolved iron arsenic, dissolved manganese, and total dissolved solids are measured. Table 10.1 summarises the medians and ranges for these elements in monitored groundwater.

+ TABLE 10.1:
NATIONAL MEDIANS AND RANGES FOR MINERALS, CHEMICALS, AND METALS IN MONITORED GROUNDWATER, 1995–2006

	SODIUM	CHLORIDE	SULPHATE	DISSOLVED IRON	DISSOLVED MANGANESE	ARSENIC	TOTAL DISSOLVED SOLIDS
Median	15	15.3	6.5	0.03	0.01	0	149
Range (5th–95th percentile)	4.6–117	2.8–142	0.1–44	0–5.5	0–3.6	0–0.24	64–950
Guideline level (maximum recommended level)	200	250	250	0.2	0.04 0.4*	0.01*	1,000
Percentage of sites exceeding guideline (%)	1.9%	2.5%	0%	26.5%	33% 15%*	10.2%	4.3%

Notes:

(1) Units are in milligrams per litre.

(2) Guideline levels are for aesthetic quality defined by the drinking water standards for New Zealand unless otherwise stated (Ministry of Health, 2005).

(3) Numbers with asterisks (*) relate to health guidelines (drinking water standards for New Zealand maximum acceptable value (Ministry of Health, 2005)) not aesthetic quality.

Source: Adapted from Ministry for the Environment, in press b.

Salinity

Concentrations of chloride, sodium, sulphate, and total dissolved solids are indicators of salinity. These exceed New Zealand drinking water standards for aesthetic quality at between 0 per cent and 5 per cent of the sites for which data is available (see Table 10.1).

High salinity, which may produce a salty taste, usually indicates that the groundwater is old, but it may also be associated with saltwater intrusion (the movement of salty water into fresh groundwaters) in low-lying coastal aquifers. Saltwater intrusion is a natural occurrence near the sea, but may worsen if too much water is withdrawn from coastal aquifers.

Although it is not widespread in New Zealand, saltwater intrusion is a serious resource management issue for local authorities in some coastal areas of Northland, Waikato (particularly in the Coromandel Peninsula), Manawatū, Tasman, and Canterbury (Ministry for the Environment, in press b).

Metals: iron and manganese

Dissolved iron and manganese concentrations exceed the New Zealand drinking water standards for aesthetic quality in 27 per cent and 33 per cent, respectively, of groundwater sites for which data is available (see Table 10.1).

Elevated concentrations of iron and/or manganese in groundwater are commonly caused by natural microbial processes (such as respiration by bacteria) or interaction with iron-rich sediments (such as peat), and can produce an unpleasant taste and stain and clog water supply pipes.

If ingested in high enough concentrations, manganese can also harm humans by damaging the respiratory tract and nervous system. Manganese concentrations exceed health-related guidelines at 15 per cent of monitored groundwater sites for which data is available (see Table 10.1).

Metals: arsenic

Arsenic concentrations exceed the drinking water standards of 0.01 milligrams per litre at 10 per cent of sites for which data is available (see Table 10.1). Adverse health effects such as skin cancers and lesions have been observed in populations that drink arsenic-contaminated water in countries such as Bangladesh and India. However, concentrations in these countries greatly exceed the concentrations encountered in New Zealand – sometimes being up to 350 times our national standard (Davies, 2001).

Arsenic in groundwater may originate from both human and natural sources. It is used in a variety of industries, including timber treatment (tanalising), agriculture (herbicides and insecticides), mining, smelting, and pulp and paper production.

Groundwater that spends a long time interacting with arsenic-rich rock, particularly in geothermal areas, may have high arsenic levels. The extent to which natural processes or human activities cause elevated concentrations of arsenic in New Zealand groundwater is not clear.

Other metals

Other trace metals (such as cadmium, chromium, copper, nickel, lead, and zinc) are generally present in low concentrations in New Zealand groundwater and do not pose a risk to human health (Ministry for the Environment, in press b).

Pesticides

Pesticides, including herbicides, insecticides, and fungicides, are commonly used in agricultural activities. Inappropriate use of these agrichemicals may result in groundwater contamination. Drinking water that is contaminated with pesticides can be harmful to both people and stock.

Five national surveys of pesticides in groundwater have been conducted since 1990, the most recent of them in 2006. Note that the limitations of groundwater monitoring are particularly relevant for pesticide surveys. These are described in the box 'Monitoring groundwater' at the beginning of the section 'Groundwater quality'. These surveys have focused on groundwater that is vulnerable to pesticide contamination; that is, shallow, unconfined groundwater in areas of known pesticide storage and application.

Of 163 groundwater bodies sampled in 2006, 19 per cent had detectable traces of pesticides. This proportion is comparable with earlier surveys, if differences between the survey methods are taken into account (Close et al, 2007).

The pesticide concentrations in all monitored groundwater in the 2006 survey, except one, complied with New Zealand drinking water standards and were similar to pesticide concentrations found during similar recent groundwater surveys in the United States (Close et al, 2007).

Groundwater in which pesticides have been detected usually also have elevated concentrations of nitrates. This further demonstrates the vulnerability of New Zealand's shallow unconfined aquifers to pollutants leaching from land that is intensively used.

Freshwater demand (allocation)

In this section, current consumptive allocation is compared with historical allocation, the overall size of New Zealand's renewable freshwater resource, and the amount of water flowing in our rivers.

Consumptive allocation does not include water used for electricity generation, because this water is normally returned directly to the water body from which it was taken; that is, it has a non-consumptive use.

More about allocation

Information on the amount of freshwater allocated from rivers, lakes, and groundwater aquifers is drawn from resource consents issued by regional councils (Ministry for the Environment, 2006c).

Allocation is usually granted as a maximum daily and/or weekly rate (that is, the maximum rate of water take (abstraction) that may be sustained in any given week), or as a maximum annual volume, or both. Weekly allocation rates are useful for understanding pressures on water demand that are related to seasonal activities (such as irrigation). Annual volumes are useful for understanding how much water is potentially used each year, irrespective of seasonal fluctuations in demand. In this report allocation figures are based on weekly rates.

Amount and use of allocated water

If all the water consents (see box ‘More about allocation’) are added together, the total allocation of water in New Zealand (in 2006) is 676 cubic metres every second (Ministry for the Environment, 2006c). The total allocation is equivalent to twice the average flow rate of the Waikato River. The Canterbury and Ōtago regions account for almost three-quarters of the total allocation, with 55 per cent and 18 per cent, respectively (Ministry for the Environment, 2006c).

On a per capita basis, it is estimated that the demand for water is two to three times higher in New Zealand than in most other OECD countries (Organisation for Economic Co-operation and Development, 2006). (This estimate is based on figures for total water use (including water used for economic development as well as domestic purposes) and is indicative only, because the methodologies for estimating water use differ between countries.)

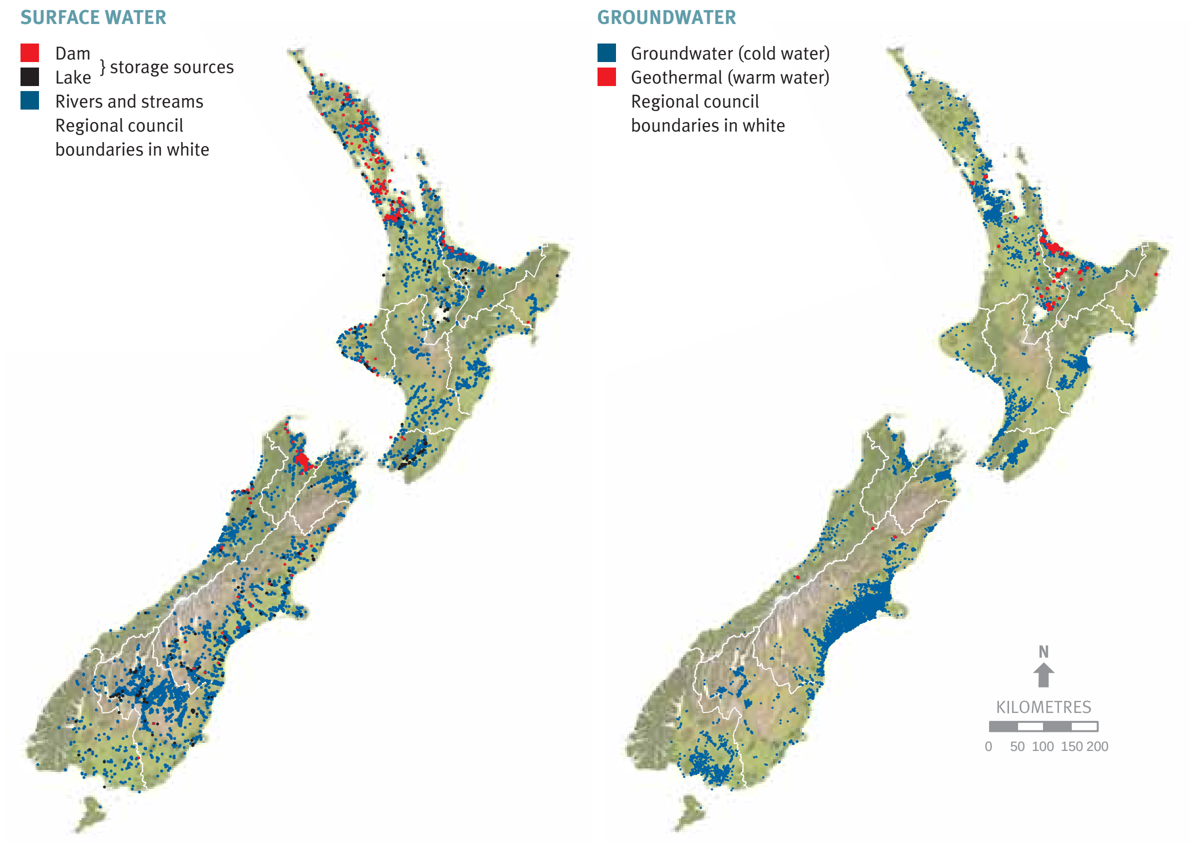
Source of freshwater supply

Almost 20,000 resource consents are in place for taking water, 66 per cent of which are for groundwater takes (Ministry for the Environment, 2006c).

Figure 10.13 (left) reflects the even distribution of the river and stream network across the country and the relative ease with which water can be taken from surface water systems.

In contrast, consents for groundwater takes tend to be grouped together in areas where the water table is shallow and/or aquifers yield relatively high volumes of water (such as the gravel aquifers on the Canterbury Plains or the Auckland volcanic aquifers); that is, where it is most cost-effective to take groundwater (see Figure 10.13, right).

+ FIGURE 10.13:
DISTRIBUTION OF RESOURCE CONSENTS FOR SURFACE WATER AND GROUNDWATER, 2006



Source: Adapted from Ministry for the Environment, 2006c.

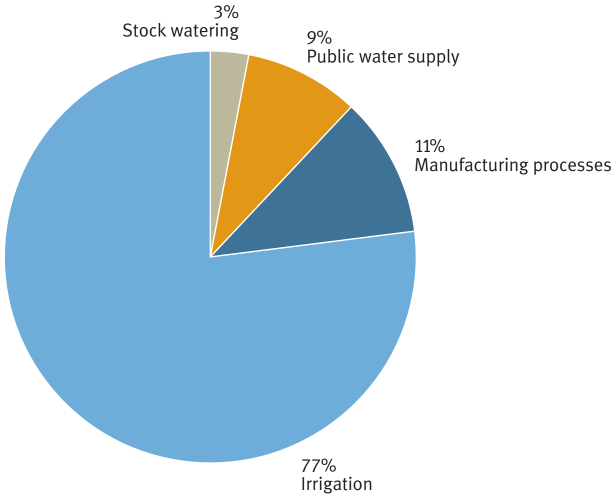
Although the majority of consents are for water from groundwater sources, the volume of water taken from surface water sources is higher. Sixty per cent of the total volume of water allocated comes from surface water sources, 34 per cent from groundwater, and 6 per cent from storage sources such as lakes and dam reservoirs.

There is considerable variation between regions in the proportions allocated from surface, ground, and storage sources. While storage sources contribute a relatively low proportion of the total national water allocation, in some regions (such as Auckland and Gisborne) reservoirs are the major source of supply.

Use of freshwater

As shown in Figure 10.14, on a national basis, 77 per cent of the total weekly allocation is used for irrigation, which is slightly higher than the global average of 70 per cent (Organisation for Economic Co-operation and Development, 2006). The remainder is shared among public water supply, manufacturing and industry, and stock watering. The use of water by manufacturing and industry and for public supply is generally low in New Zealand compared with more populous countries in Europe and North America, and represents a relatively small part of the overall demand in New Zealand.

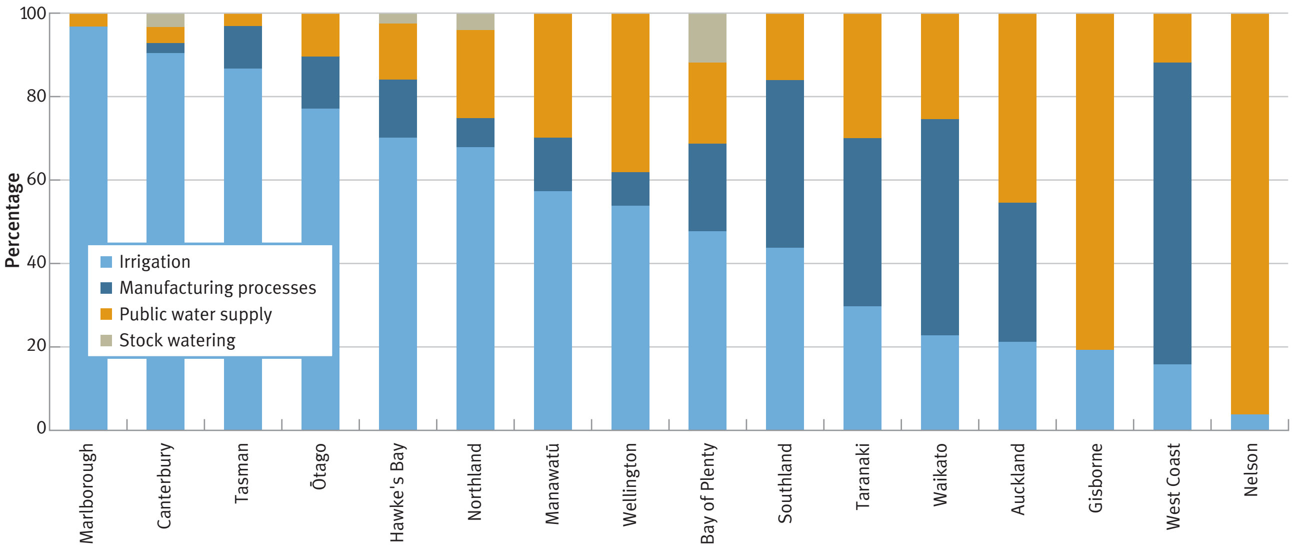
+ FIGURE 10.14:
USE OF ALLOCATED WATER IN NEW ZEALAND, 2006



Data source: Ministry for the Environment, 2006c.

Regional variations in the use of water are shown in Figure 10.15. In Canterbury, Marlborough, and Tasman, irrigation accounts for more than 80 per cent of water allocations. Water taken for industrial uses makes up a relatively large proportion of the total allocation in Auckland, Waikato, Taranaki, the West Coast, and Southland. Allocations for stock drinking water are underestimated in Figure 10.15, because this is generally a permitted activity under the Resource Management Act 1991 (that is, it does not require a resource consent), so full figures for stock drinking water allocations are not available.

+ FIGURE 10.15:
REGIONAL VARIATIONS IN THE USE OF ALLOCATED WATER, 2006



Data source: Ministry for the Environment, 2006c.

In most cases, consent holders do not use the full volume of water they are allowed under the consent. The proportion of actual water used is highly variable. Regional consents indicate that actual use typically ranges from 20 per cent to 80 per cent of the allocated volumes (Ministry for the Environment, 2006c). Demand for water varies according to factors such as the time of year, the crop type, and the growth stage of the crop. Use of allocated water often declines in the margins of the irrigation season (that is, early and late in the growing season).

Allocation compared with renewable freshwater resource

Compared internationally, New Zealand has an abundance of freshwater. It is ranked 12th out of 193 countries, on a per capita basis, for the size of its renewable freshwater resource (United Nations Educational, Scientific and Cultural Organization, 2006). Within New Zealand, allocated water comprises less than 5 per cent of its renewable freshwater resource (Ministry for the Environment, 2006c).

However, not all of the renewable resource is actually available to be used – much of it needs to be retained in the rivers, lakes, and aquifers to maintain the various values of these water bodies (such as ecological, recreational, and cultural values). Furthermore, water is not always in the right place at the right time for users. A large proportion of New Zealand's annual rainfall occurs in winter, when demand is relatively low.

Figure 10.16 shows the water allocated from surface water sources relative to the mean (average) annual low flow of rivers. The figure highlights the difference in water availability and demand between the western and eastern regions of New Zealand.

Several eastern regions (Hawke's Bay, Wairarapa, Marlborough, Tasman, Canterbury, and Ōtago) have surface water catchments that are highly allocated (that is, 20 per cent to 50 per cent of the river flow during low flow periods is allocated to users). Therefore, rivers in these catchments are likely to be under pressure during the drier parts of the year. In these regions, closer regard to managing water resources is required to ensure water takes do not adversely affect aquatic ecosystems or other water users. For example, resource consents may have conditions that restrict water take when river flows are low.

+ FIGURE 10.16:
ALLOCATION OF SURFACE WATER AS A PERCENTAGE OF AVERAGE ANNUAL LOW FLOW OF RIVERS, 2006

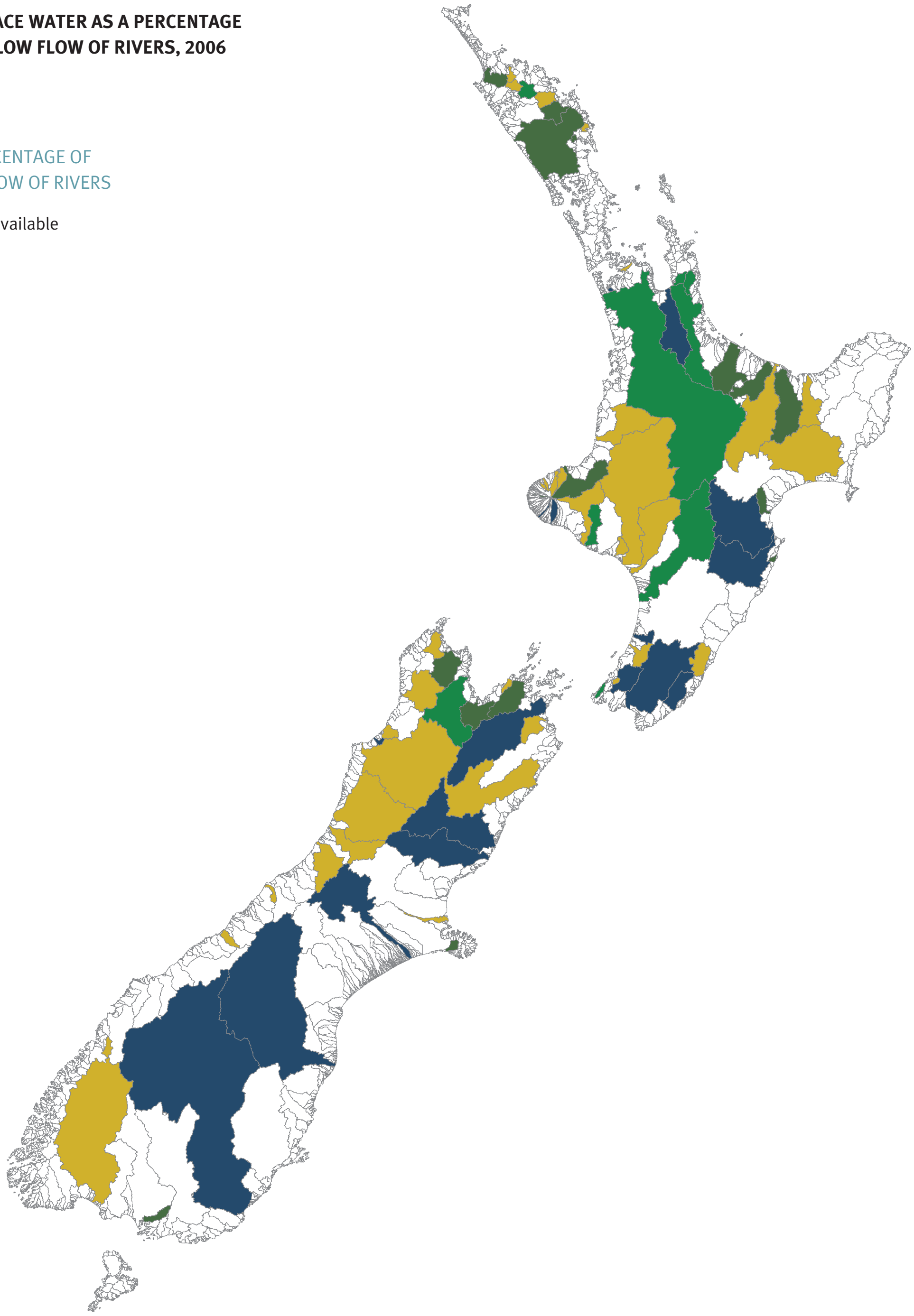
ALLOCATION AS A PERCENTAGE OF MEAN ANNUAL LOW FLOW OF RIVERS

- No data or data not available
- 1% – 5%
- 6% – 10%
- 11% – 20%
- 21% – 50%

N

KILOMETRES

0 40 80 120 160



Source: Adapted from Ministry for the Environment, 2006c.

Trends in allocation and irrigated area

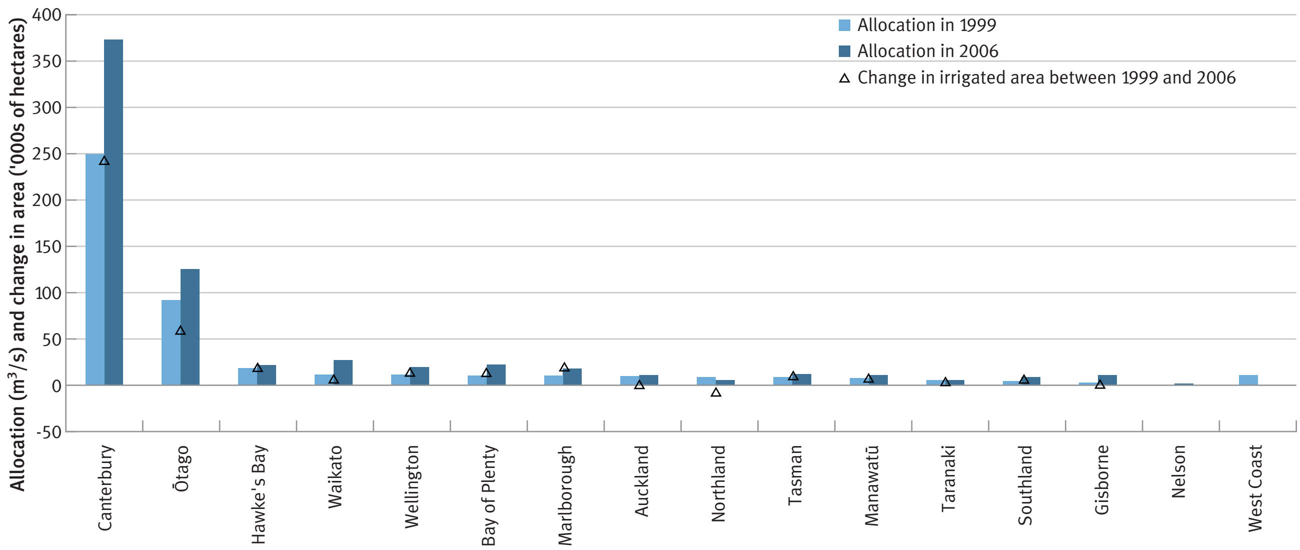
Total water allocation in New Zealand increased by 50 per cent between 1999 and 2006. Over this period, allocation increased by almost 80 per cent and 40 per cent from groundwater and surface water sources, respectively, while allocation from storage sources tripled (Ministry for the Environment, 2006c). Figure 10.17 shows that allocation increased in all regions except Northland. This is likely to reflect changes in the way resource consent information is held, rather than an actual reduction in demand for water in the Northland region.

The increase in total water allocation in New Zealand between 1999 and 2006 can largely be explained by the increase in demand for irrigation. The amount of consented irrigated land in New Zealand increased by 52 per cent over this period, which was an annual rate of increase of 7 per cent.

Figure 10.17 shows that in terms of total land area, the biggest increases in irrigation occurred in Canterbury, Ōtago, Hawke's Bay, and Marlborough. However, relative to the land irrigated in 1999, the regions with the biggest rate of growth are Southland, Wellington, Bay of Plenty, and the Waikato; irrigated land areas have at least doubled between 1999 and 2006 in these regions.

In 2006, the area of total consented irrigated land in New Zealand was just over 970,000 hectares, the majority of it in Canterbury (66 per cent) and the second largest amount in Ōtago (14 per cent).

+ FIGURE 10.17:
CHANGES IN ALLOCATION AND IRRIGATED AREA, BETWEEN 1999 AND 2006



Notes:

(1) Data was not available for Nelson or the West Coast in 1999.

(2) The consented irrigated area will differ from the actual irrigated area in any given year because land owners may not irrigate all the land for which they hold a consent.

(3) m^3/s = cubic metres per second.

Data source: Ministry for the Environment, 2000; Ministry for the Environment, 2006c.

GOVERNMENT ACTION to manage freshwater demand

The Sustainable Water Programme of Action

The Sustainable Water Programme of Action (see box 'Government action to manage freshwater quality') is presently developing policy to improve the management of freshwater demand and allocation.

A national policy statement on freshwater as well as two national environmental standards are under development in 2007: one standard will make the measurement of significant water takes (that is, metering of actual water use) mandatory and the other standard will ensure appropriate methods are used to allocate water so the health of aquatic ecosystems is safeguarded (that is, ensuring appropriate minimum flows remain in river, stream, and groundwater bodies).

LOCAL ACTION to manage freshwater demand

Allocation management in the Tasman region

Tasman District Council has taken an integrated catchment management approach to set allocation limits for many of its more highly used freshwater systems. This means numerical computer models and targeted flow investigations of both aquifers and rivers have been used together to set allocation limits that recognise the connection (that is, exchange of water) between surface and groundwater bodies.

Tasman District Council actively promotes and supports water user groups (whose members include farmers, growers, and other significant users) in the region during droughts and in the process of refining current water management plans.

Changes since the 1997 report

The 1997 report, *The State of New Zealand's Environment 1997*, concluded that:

> The main pressures on water flows have been from drainage and channelisation (which have reduced wetlands and altered the natural character of rivers including lowland aquatic habitats), deforestation (which has intensified flooding and sedimentation in steep catchments), and increasing demand for urban water supplies, livestock and irrigation. …
>
> Responses to water flow problems that historically focused on flood control and drainage works downstream and on increasing the supply of drinking and irrigation water are now looking more to whole catchment approaches involving afforestation and water conservation. …
>
> The main sources of pressure on water quality are non-point source pollution (from diffuse pasture runoff of animal wastes, fertiliser and sediments as well as runoff of pollutants from paved surfaces in urban areas) and point source discharges (e.g. from factories and sewage outfalls). …
>
> The quality of our water is high by international standards, except in some low-lying rural streams and small lakes, some shallow groundwaters, and some piped water supplies. …
>
> Responses to water quality problems have successfully focused on improving point source discharges (from sewage, factory, and dairyshed outfalls) but the more difficult and pervasive problem of non-point source discharges has yet to be addressed and will require changes in land management.

(Ministry for the Environment, 1997, chapter 10.)

Increasing demand for freshwater

Increasing demand for freshwater was identified in 1997 as one of the main pressures on water quantity and flows. Two national surveys since 1997 have confirmed that demand is increasing (it rose 50 per cent between 1999 and 2006), primarily in response to large increases in irrigation. This is particularly evident in areas that are already short of water.

While water is generally in good supply in most regions, many large river and aquifer systems are now fully allocated (that is, no further water can be taken from them without causing environmental harm or affecting existing users). The increase in demand has prompted consent authorities to put greater emphasis now than in 1997 on the management of water takes.

Protecting New Zealand's water bodies

Water conservation orders continue to be used as a mechanism to protect New Zealand's water bodies by placing restrictions or prohibitions on water takes, discharges, and other uses. Six water conservation orders have been gazetted since 1997, bringing the total to 14. Orders have been gazetted in the last decade for the Kawarau (1997), Mataura (1997), Buller (2001), Motueka (2004), Mōhaka (2004), and Rangitata (2006) rivers.

Pressures on water quality

Water quality in New Zealand is still generally good by international standards, and a large proportion of our water resources remain free of land-use pressures. Nevertheless, water quality continues to decline in areas that are dominated by agricultural and urban land use.

A key source of pressure on water quality in New Zealand in 1997 was identified as point-source pollution (for example, discharges from factories and wastewater treatment plants). While discharges from point-sources remain a significant influence on water quality in some areas, at the national level this source of pollution has largely been addressed through improved management of discharges from sewerage plants, meatworks, and farm effluent ponds. This is illustrated by a steady reduction in the levels of organic wastes in rivers.

Today, the primary pressure on the quality of our freshwater is intensive agricultural and urban land use. Increasing pollution from non-point-sources, such as diffuse run-off from pasture and from paved surfaces in urban areas, poses the greatest challenge for water management in New Zealand.

As was the case in 1997, the poorest water quality is found in streams and rivers, small lakes, and shallow groundwaters in modified catchments. While the levels of nutrients in our most polluted rivers are only about half the OECD average, nutrient enrichment has increased in some water bodies in catchments that are subject to intensive land use. In particular, there has been a nationwide pattern of increasing levels of total nitrogen and dissolved phosphorus in rivers in the national monitoring network.

Improving land and water management

In 1997, it was noted that management responses to the pressures on water quality from intensive land use and non-point-sources of pollution had been limited. Since then, local government, central government, and industry have invested significant resources in policy and education programmes and other initiatives that emphasise improved land and water management. The more important management responses of the last decade are discussed below.

Integrated approaches to freshwater management

Since 1997, there has been a shift at a regional level towards a more integrated approach to freshwater management. Many councils now have integrated land and water plans (within their regional plans), which put greater emphasis on protecting water quality and environmental flows through sustainable land use. For example, the Bay of Plenty Regional Council has a Land and Water Plan and the Manawatū–Wanganui Regional Council has a proposed 'One Plan'.

In the last decade, local government has also placed greater emphasis in freshwater management, developing partnerships with community groups (including land owners – see box 'Local action on riparian planting in Taranaki'), industry, and central government. Council-led programmes to protect and restore the water quality of Lake Taupō and the Rotorua Lakes are examples of this integrated approach (see box 'Local action to protect water quality in Lake Taupō and the Rotorua lakes' in the 'Current state and trends' section of this chapter).

LOCAL ACTION on riparian planting in Taranaki

Taranaki Regional Council is one of many councils working with farmers to develop sustainable land management and riparian planting plans. Up to June 2007, 12,400 kilometres of stream bank and 60 per cent of all dairy farms in the region were covered by riparian plans.

By the same date, more than 1 million plants had been provided to farmers by the Council, at cost, for land and riparian planting.

RIPARIAN PLANTING ON A STREAM IN TARANAKI.

Source: Courtesy of Taranaki Regional Council.

Sustainable Development Water Programme of Action

In 2003, the Sustainable Development Water Programme of Action was established by central government. The focus of the programme in 2007 is developing a national policy statement on freshwater, as well as two national environmental standards. One of these standards is intended to ensure appropriate methods are used to set ecological flows (that is, the minimum flow needed in a river to support aquatic ecosystems). The other standard will make measurement of significant water takes (that is, measurement of actual water use) mandatory.

Improved management by primary production sector

Since 1997, the main primary production sectors in New Zealand (dairy, horticulture, forestry, and the arable food industry) have produced or substantially revised their sustainable management strategies and environmental codes of practice. As well as setting targets and codes of practice for minimising ecosystem damage from sector activities, these strategies identify research and development needs within each sector to improve environmental sustainability.

Specific objectives for protecting water quality and flows include research into agrichemicals and nutrient run-off, on-farm mitigation and planning tools (such as nutrient and water budgeting), and forest harvesting techniques.

The 2003 Dairying and Clean Streams Accord is another example of an industry-led approach to improved land use and water quality management (see box 'More about the Dairying and Clean Streams Accord').

More about the Dairying and Clean Streams Accord

A voluntary agreement, the Dairying and Clean Streams Accord, was signed by Fonterra Co-operative Group (the largest dairy company in New Zealand), regional councils, and the Ministers for the Environment and of Agriculture and Forestry in May 2003. The accord's aim is to achieve clean, healthy waterways in dairying regions.

The accord sets practical targets for farmers; for example, that '50 per cent of regular stream crossing points are to have bridges or culverts by 2007 and 90 per cent by 2012'. This target has already been met, according to annual progress reports, while there has also been a steady increase in the number of waterways that stock have been excluded from (up from 67 per cent in 2003–2004 to 75 per cent in 2005–2006, with the same targets as for stream crossing points). However, the level of non-compliance of discharges of dairyshed effluent (33 per cent) falls significantly short of the target set (Ministry for the Environment, 2007).

Guidelines and standards for freshwater management

Various non-regulatory guidelines and standards have been published since 1997 to help resource managers assess the quality and quantity of New Zealand's freshwater. These include guidelines to protect ecosystems and the recreational and aesthetic values of freshwaters, guidelines to assess the risk of human disease from recreation (for example, swimming) in fresh and coastal waters, and drinking water standards to set maximum acceptable levels for chemicals and bacteria in drinking water (see box 'Government action to manage freshwater quality' in the 'Current state and trends' section of this chapter).

To incorporate Māori values more fully in freshwater management, a Cultural Health Index has been developed. The index provides additional information on stream health by drawing on local knowledge about waterways (see box 'More about iwi monitoring of freshwater: Cultural Health Index').

More about iwi monitoring of freshwater: Cultural Health Index

The Cultural Health Index for Streams and Waterways (CHI) is a tool developed by Ngāi Tahu, supported by the Ministry for the Environment, Te Rūnanga o Ngāi Tahu, and Ngāti Kahungunu. Its purpose is to facilitate the monitoring of waterways by Māori (Ministry for the Environment, 2003).

Developed as the result of research undertaken on the Taieri, Kakaunui, Hakatere (Ashburton), and Tukituki rivers, the CHI gives iwi/hapū the opportunity to assess and report on the cultural health of a catchment or stream in their area. The CHI provides a clear basis for iwi/hapū to assign priorities for the management or restoration of specific sites and monitor changes and improvements in them over time. It also provides a common platform for resource management agencies and iwi/hapū to discuss and incorporate Māori perspectives and values for stream health in management decisions.

The CHI works by assessing and providing a 'score' for three aspects of the monitored waterway:

- the significance of the freshwater site to Māori
- the cultural use values of the site
- the health of the stream or river.

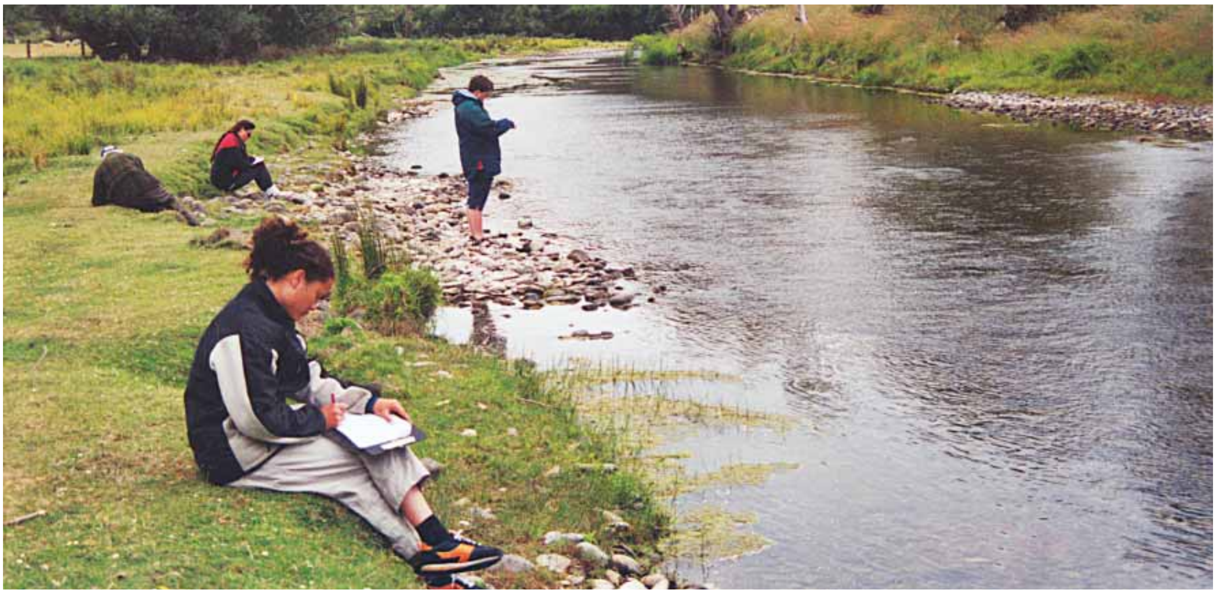
The first measure assesses whether the site is of traditional or contemporary significance to Māori. It also evaluates whether Māori would return to the site in the future given its present state.

The second measure assesses the ability of the site to sustain cultural use. To do the assessment, the CHI identifies mahinga kai species present at the site, compares them with traditional mahinga kai sourced from the site, evaluates how easy it is for Māori to access the site, and determines whether or not Māori would return to use the site in the future. The four elements are then averaged to produce a single score.

The third measure assesses stream or river health by considering eight different criteria: water quality, water clarity, flow and habitat variety, catchment land use, riparian vegetation, riverbed condition/sediment, use of riparian margin, and channel modification. The scores for each criteria are averaged to produce a final stream health score.

Training hui have been held throughout New Zealand to introduce whānau, hapū and iwi to the CHI system and to facilitate its use.

A TEAM MONITORING STREAM HEALTH USING THE CULTURE HEALTH INDEX.



Source: Courtesy of Gail Tipa.

Other national guidelines have been published to help promote best practice and increase consistency in freshwater monitoring and management across the country. These include guidelines for monitoring algae growth and the health of freshwater macroinvertebrate (insect) communities.

Expansion of freshwater monitoring

Ten years ago, many freshwater monitoring programmes had only recently been established by councils and other agencies. Relatively few monitoring records were available to show how water quality was changing over time. Today, several monitoring programmes yield data records of sufficient length to show trends and, most importantly, distinguish natural changes from those that are likely to have been caused by human activities.

Monitoring programmes have expanded to cover a wider cross-section of water environments than those monitored in 1997 (for example, the number of lakes regularly monitored has almost doubled since 1997).

There is also greater emphasis now on using measures of aquatic biology (such as the number and health of fish and macroinvertebrates) to assess overall freshwater ecosystem health, as well as using traditional chemical and physical measurements of water quality.

Future focus for freshwater management

In the future, water pollution from intensive urban and rural land use and water allocation will continue to be the focus of freshwater management in New Zealand. Balancing the competing needs of water users – recreational users, town water suppliers, hydro-electricity generators, tourist operators, and farmers – is likely to grow in urgency.

Climate change, recognised as a cause for concern to water managers in 1997, is also likely to feature more strongly in decision-making in some areas of New Zealand, particularly for water allocation (see box 'More about climate change and freshwater' in the Introduction to this chapter).

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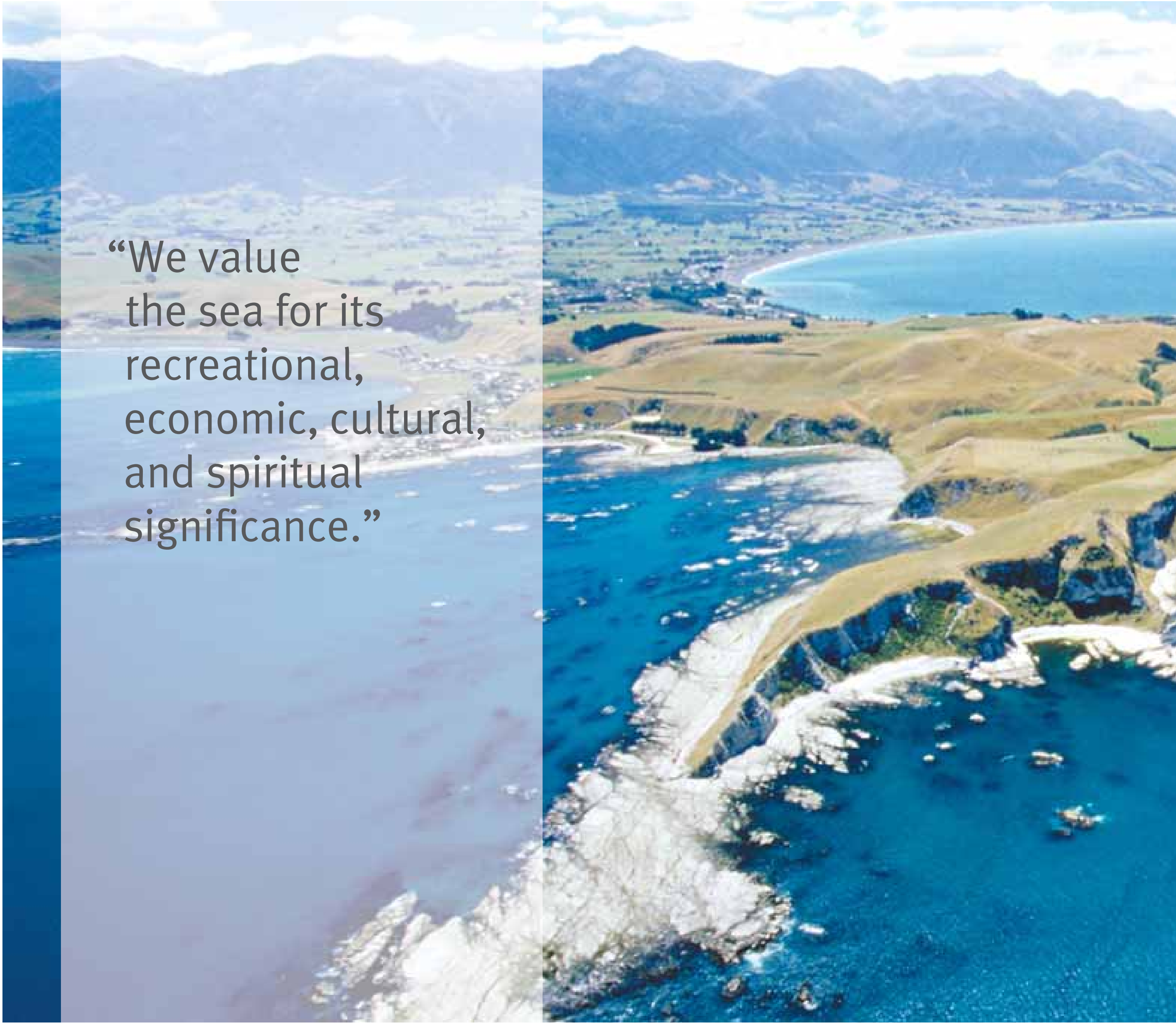
“We value
the sea for its
recreational,
economic, cultural,
and spiritual
significance.”

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Contents

At a glance

New Zealand's marine area

New Zealand administers the sixth largest marine environment in the world. At more than 4.4 million square kilometres, our marine environment is about 14 times larger than our land area. We use our marine area for many purposes, including transportation, fisheries, recreation, and tourism, and value it for its cultural and spiritual significance.

Our economy and the marine environment

Many of New Zealand's economic activities depend on our marine environment. More than 99 per cent of our exports are transported by sea. Our marine industries are worth an estimated $3.3 billion (about 3 per cent of gross domestic product), including $1.34 billion in fisheries exports.

Marine biodiversity

Our marine environment contains a diverse range of ecosystems, including subtropical and subantarctic waters, inter-tidal estuaries, and seabed trenches.

As much as 80 per cent of New Zealand's plant and animal species occurs in the marine environment and 44 per cent of these are not found anywhere else in the world. Little is known about many of New Zealand's marine species.

Impact of human activities

By international standards, New Zealand enjoys abundant marine resources and healthy marine environments offshore where much of the environment is not easily accessible. About 30 per cent of our marine environment, however, is thought to experience some degree of disturbance from human activities.

As our population and technological capability grow, so do the pressures we put on our marine environment. These pressures include:

- commercial fishing and trawling, which have the greatest impact on our oceans, both inshore and offshore
- increasing land development, which has increased discharges of land-based pollution, stormwater, nutrients, and sediments to the ocean
- marine spills which can put pressure on our marine environment in some areas
- climate change, which is expected to have a significant impact on our oceans and coasts.

Commercial fishing and trawling

In 2006, the commercial fishing industry caught about 525,000 tonnes of fish in New Zealand waters. Sixty-five per cent of this catch was from fish species that have been scientifically assessed. Of these species, 85 per cent have been sustainably fished. Fifteen per cent have been overfished and rebuilding strategies are in place.

Large commercial vessels conducted about 970,000 seabed trawls between 1990 and 2005. During this period, the area swept by trawls averaged around 55,000 square kilometres each year. Since 1998, the area trawled by large commercial vessels has reduced to about 50,000 square kilometres in 2005, probably due to reductions in the allowable catch for some high-value species. Between 1990 and 2005, an estimated 3.5 million dredges and trawls were undertaken by smaller vessels.

The environmental effects of trawling activity on our seabed are not well monitored.

Water quality at coastal swimming spots

Water quality at our coastal swimming spots is primarily affected by human activity on land. Over the 2006/2007 summer, 80 per cent of the 380 monitored beaches had safe levels of bacteria almost all the time. Only 1 per cent of sites breached bacterial guidelines regularly. Water quality at our beaches appears to have improved in recent years.

Threatened marine species

Of the almost 16,000 known marine species in New Zealand, 444 are listed as threatened. Well-known species of concern include the Hector's dolphin (both subspecies), New Zealand sea lion, southern right whale, Fiordland crested penguin, and New Zealand fairy tern.

By international standards, a high proportion (62 per cent) of our ocean-going seabirds are listed as threatened. Two species, the Campbell mollymawk and the black petrel, have shown signs of recovery in recent years. However, over the past three years, seven species have had their threatened species status upgraded.

Protecting our marine ecosystems, habitats, and species

A range of measures protect our marine ecosystems, habitats, and species, including marine reserves. Thirty-one marine reserves cover 7 per cent of our territorial sea – a high proportion by Organisation for Economic Co-operation and Development standards. Nearly half of these reserves have been established since 2000, and the area designated as marine reserve has nearly doubled in that same period. However, 99 per cent of our protected area is found in two offshore marine reserves, and some key habitats remain unprotected. Marine reserves are expected to play a significant role in protecting our marine biodiversity.

Fisheries closures are in place for sensitive habitats such as seamounts, and it has been agreed that 30 per cent of the Exclusive Economic Zone will be closed to seabed trawling. Customary restrictions and closures also play an integral part in fisheries management.

Present and future management

In recent years, management of New Zealand's marine environments has focused on:

- better understanding the wider ecosystem effects of human activities on our marine environment
- establishing a national network of marine protected areas.

Recent years have also seen the emergence of innovative local initiatives for coastal management such as in the Fiordland Marine Area.

In future, increasing attention is likely to be given to the impact of introduced species and climate change on our marine ecosystems, fisheries, and marine species.

Land-based pressures on the inshore marine environment and pressures on fisheries stocks are likely to continue to need careful management into the future. Balancing the competing needs of users of our marine area is likely to become more urgent in the future as our population increases and technology advances. Demand will increase for accurate information to help set priorities for the future use and protection of our marine area.

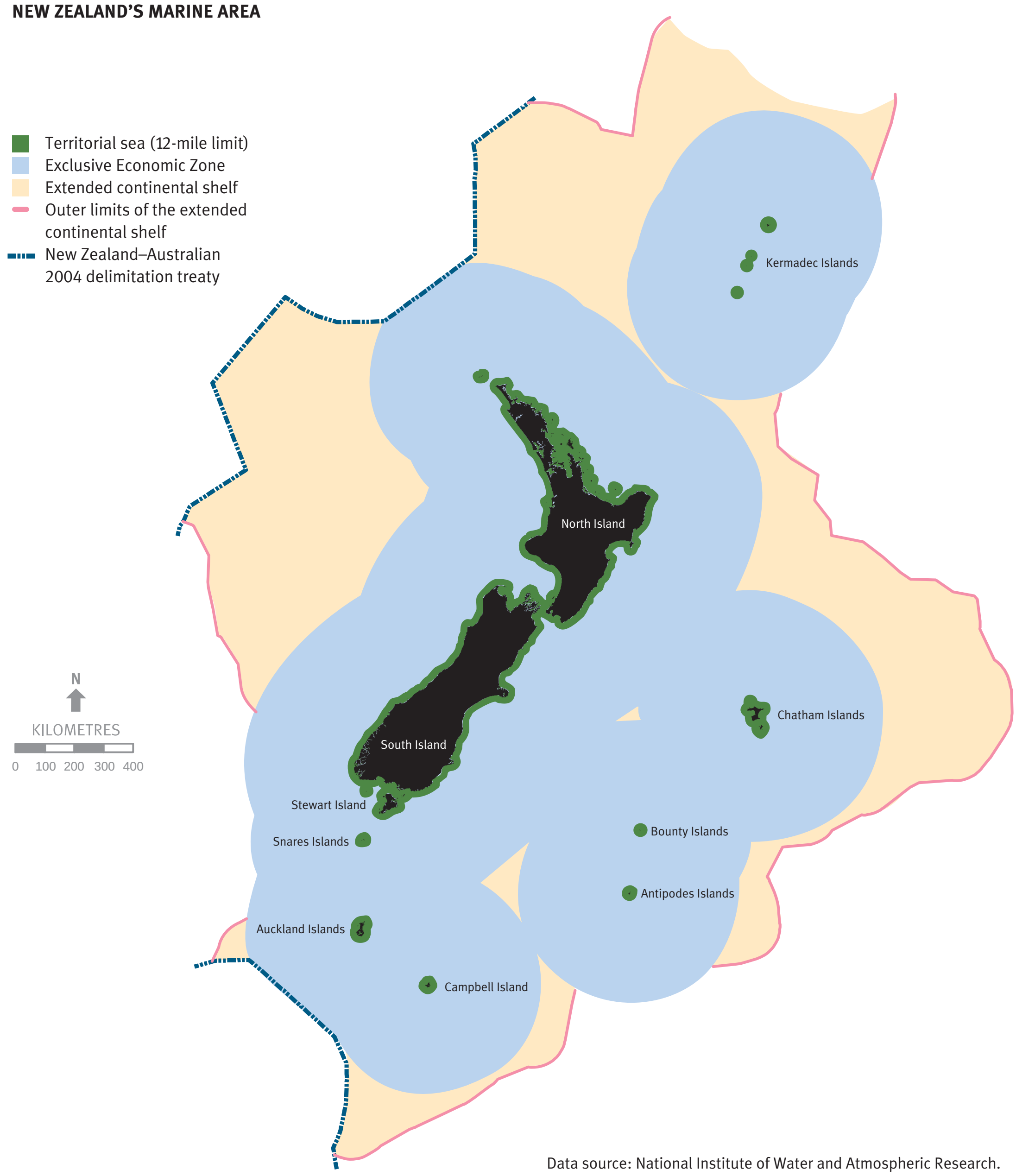
Introduction

New Zealand's marine area

New Zealand administers the sixth largest marine area in the world. At more than 4.4 million square kilometres, it is about 14 times larger than our land area (Organisation for Economic Co-operation and Development, 2007).

New Zealand contains an archipelago of more than 330 islands with 18,218 kilometres of coastline (Department of Conservation, 2007) extending from subtropical to subantarctic waters[7] over 30 degrees of latitude (see Figure 11.1).

+ FIGURE 11.1:
NEW ZEALAND'S MARINE AREA



Data source: National Institute of Water and Atmospheric Research.

7 This chapter does not discuss marine areas in New Zealand's Antarctic territory.

New Zealand's marine area has three key jurisdictional zones, each of which has a different legal regime. The territorial sea extends seaward from the coast to 12 nautical miles offshore. The Exclusive Economic Zone (EEZ) is the area of sea and seabed that extends from 12 to 200 nautical miles offshore. New Zealand has formally lodged the outer limits of its extended continental shelf – the 1.7 million square kilometres of seabed outside New Zealand's EEZ – with the United Nations Commission on the Limits of the Continental Shelf.[8] The commission is considering the submission. Once confirmed, the extended continental shelf boundary will be binding on other countries.

Biodiversity in the marine environment

New Zealand's vast marine area contains a diverse range of marine ecosystems, providing habitats for many species. Scientists have formally identified almost 16,000 marine species in New Zealand waters, although it is estimated that tens of thousands of species may still be undiscovered (Gordon, 2007). According to some estimates, the possible number of species in New Zealand waters could be as high as 65,000 (MacDiarmid, 2007). It is estimated that as much as 80 per cent of New Zealand's biodiversity occurs in the marine environment (Ministry for the Environment, 2006).

Because of New Zealand's geographical isolation, our marine area, by international standards, has a comparatively high level of endemism (species that do not occur elsewhere), particularly in isolated areas such as Three Kings Islands and our subantarctic islands (Gordon, 2007). Forty-four per cent of our known marine species are endemic (MacDiarmid, 2006). For example, over half of the 24 species of albatross breed in New Zealand and, of those, nine species breed only in New Zealand (MacDiarmid, 2007).

As a result, New Zealand is considered internationally to be an important contributor to global marine diversity. For example, endemic species include:

- about 95 per cent of the 733 known sponge species
- 84 per cent of bivalves and gastropods (types of marine molluscs)
- 75 per cent of ascidians (commonly known as sea squirts).

In addition, a comparatively high proportion of our seabirds (including half of our albatrosses) and a third of our seaweeds are endemic.

See Chapter 12, 'Biodiversity' for information on land-based and freshwater biodiversity.

Importance of our oceans

Most New Zealanders (90 per cent) live within 50 kilometres of the coastline. We use our marine area for many purposes, including transportation, fisheries, recreation, and tourism, and value it for its cultural and spiritual significance. Māori regard the ocean as a taonga (treasure) integral to their culture and identity. Many coastal areas contain culturally significant sites such as urupā (burial grounds) and tauranga waka (canoe landing sites). The ocean is also an important source of food to many New Zealanders.

Healthy oceans deliver a range of important environmental benefits: they absorb and transfer nutrients and sediments from the land, absorb carbon, and regulate heat transfer from the atmosphere. These functions are critical to sustaining life.

Many of New Zealand's economic activities are dependent on the sea. In 2006, 99.5 per cent of our exports (by weight) were transported by sea (Statistics New Zealand, 2006b). In 2002, the estimated economic value of marine industries was about $3.3 billion (about 3 per cent of gross domestic product), including earnings from shipping, fisheries and aquaculture, offshore minerals, and government and defence.

Considerable value is also generated from other marine activities, such as tourism, research and education, and marine construction (Statistics New Zealand, 2006a).

Fisheries and aquaculture

Export earnings for fisheries in 2006 were worth $1.34 billion, including $187 million in earnings from salmon and mussel aquaculture (Statistics New Zealand, 2007b). Fisheries and aquaculture employ more than 26,000 people, both directly and indirectly (Organisation for Economic Co-operation and Development, 2007).

In 2006, the asset value of fish species managed under New Zealand's quota management system was estimated to be $3.8 billion, a 40 per cent increase from 1996 (Statistics New Zealand, 2007a). However, New Zealand produces less than 1 per cent of global fisheries output, as much of our EEZ is commercially barren (Organisation for Economic Co-operation and Development, 2007).

8 The outer limits of New Zealand's extended continental shelf remain subject to the delimitation of boundaries with Fiji, Tonga, and possibly France (in respect of New Caledonia).

Natural factors that affect the marine environment

New Zealand's marine environment is influenced by its geological history, its isolation, and the action of major ocean currents. Marine life in New Zealand waters is influenced by the range and complexity of our marine habitats.

Longer-term weather cycles also affect New Zealand's oceans. Together, the atmosphere and the rotation of the earth drive major ocean circulation patterns and climate systems across the world, affecting deepwater and surface currents, sea temperature, sea levels, the productivity[9] of our oceans, and seawater chemistry.

Natural inflows of nutrients and sediments into coastal ecosystems are an important part of biological, physical, and chemical cycles in New Zealand's inshore area. Such cycles are the basis for productivity in these areas. The offshore ocean area is primarily influenced by major oceanic currents.

Human factors that affect the marine environment

By international standards, New Zealand enjoys abundant marine resources and healthy marine environments (Organisation for Economic Co-operation and Development, 2007). This is particularly so for our deepwater environments which are not readily accessible. It is estimated that about 30 per cent of New Zealand's marine environment experiences some degree of disturbance from human activities.

Fishing

New Zealand's inshore and offshore marine areas are generally subject to different human pressures. The largest single pressure on the marine environment in New Zealand is fishing.

In particular, large-scale commercial fishing can have a range of ecological effects, such as destroying habitats and removing large numbers of organisms from the area. Both of these effects have long-term impacts on marine ecosystems, including on the marine food chain. Bycatch (the unintended catch of species other than the target fish) also puts pressure on marine species in some fisheries.

Shipping

Other pressures result from the increasing levels of shipping in New Zealand waters. Shipping can bring new marine species into New Zealand waters. While most introduced species (see box 'More about introduced marine species') are harmless, some have had localised but significant effects on marine biodiversity (Dodgshun et al, 2007). For example, the sea squirt *Styela clava* is expected to have a significant negative impact on aquaculture around the Hauraki Gulf and Lyttelton areas unless it is controlled (Biosecurity New Zealand, 2006).

More about introduced marine species

By 1998, more than 140 introduced marine species had been recorded in New Zealand waters. Since 1998, surveys have confirmed at least 18 new species at 16 of New Zealand's high-risk ports and marinas (Biosecurity New Zealand, 2007). Most of these probably arrived as a result of shipping activity rather than by natural processes.

Changes to climate and ocean current patterns may bring more new species to New Zealand naturally. For example, rare tropical species are more likely to be observed (and survive) on offshore islands during warmer La Niña years (Evans, 2007). These changes may also allow a greater proportion of the new species that arrive as a result of shipping activity to survive.

Pollution

The past 60 years have seen increasing levels of pollutants, nutrients, and sediments in the inshore marine environment. This increase is the result of urban and agricultural run-off, road run-off, industrial discharges, and air pollution. Estuaries situated in heavily urbanised catchments often have high levels of chemical pollutants (Auckland Regional Council, 2004). Excessive nutrients, particularly nitrogen, from sewage and land run-off have also caused increased algae growth in many of our coastal areas (Robertson and Stevens, 2007). Litter and debris, both from vessels and land-based activities, can also affect marine organisms and pollute waters and coastlines.

9 Productivity is a measure of the amount of life that can be supported in an area. It is driven by the availability of nutrients and light (Pinkerton, 2007).

Because of land clearance in catchments, wetland drainage, and land development, average sedimentation rates in estuaries are typically at least 10 times higher than they were before Europeans arrived in New Zealand (Robertson and Stevens, 2007).

Marine mining

The mining of fossil fuels such as oil and gas from under the sea floor can put considerable pressure on marine ecosystems. Oil and gas have been produced from New Zealand's EEZ since the 1960s, from the oilfields in Taranaki, and new fields in the Great South Basin (Associate Minister of Energy, 2007; Ministry for the Environment, 2005).

To date, the extraction of minerals from the sea floor has not been a large pressure on the marine environment because such exploration has not been consistently economically viable. However, several prospecting licences to mining companies have recently been granted for areas on the Kermadec Ridge. These areas are now being explored (Ministry of Economic Development, 2007).

Coastal development

Habitat degradation or loss due to intensive coastal development is a pressure on the inshore marine area. Vulnerable coastal ecosystems including wetlands, mangroves, and coastal lagoons are most at risk from such habitat changes (United Nations Environment Programme, 2006). Many New Zealanders already live on the coastal margin, but previously undeveloped coastal areas have experienced significant development in the last decade.

More about climate change and the oceans

Climate change may significantly affect the marine environment. Increasing levels of atmospheric carbon dioxide are expected to have major implications for the distribution and health of marine biodiversity, because the absorption of carbon dioxide into the ocean increases the acidity of seawater. Organisms such as marine plankton, corals, and shellfish are particularly vulnerable to such a change because it may reduce their ability to form calcium-based shells and skeletons (Hays et al, 2005).

New Zealand waters have shown a small decrease in productivity of about 1 per cent each year in recent years (Pinkerton, 2007). Large-scale changes in productivity resulting from climate change would negatively affect New Zealand's marine ecosystems and fisheries.

In addition, the sea level has risen an average 0.16 metres in the last century at all four main ports in New Zealand (Hannah, 2004). The rate at which the sea level will rise is predicted to nearly double in the next century (Intergovernmental Panel on Climate Change, 2007).

Changes in sea level are likely to cause complex readjustments in coastal marine habitats and in the physical structure of beaches, estuaries, and sheltered foreshores. Changes to surface and subsurface temperatures could also affect how oceans circulate and the distribution of marine organisms.

National environmental indicators

See chapter 1, 'Environmental reporting', for more information on the core national environmental indicators and how they are used.

The four national environmental indicators for oceans are:

- fish stocks under the quota management system
- seabed trawling in deep waters
- water quality at coastal swimming spots
- marine areas with legal protection.

Understanding how these indicators change will allow us to respond better to existing and emerging pressures on our marine resources.

Fish stocks under the quota management system

The first indicator provides information on fish stocks under the quota management system. To report on this indicator, the following are measured:

- proportion of total commercial catch (by weight) from assessed fish stocks under the quota management system
- status of assessed fish stocks under the quota management system.

Assessed fish stocks

Assessed fish stocks are fish species for which there is enough information to scientifically determine the status of the stock.

Each year, some of New Zealand's fish stocks are assessed to determine the status of the stock relative to a target level and to ensure the total allowable catch for that stock is set at a sustainable level. Assessment of a fish stock requires significant amounts of data, so it is not always cost-effective or practical to conduct full assessments of all stocks. Therefore, the most valuable and most vulnerable species in any given year are prioritised for assessment.

Status of fish stocks

The Fisheries Act 1996 requires fish stocks to be managed so their numbers stay at or above a target level ('target biomass level'). Generally, the target level is set at the level that can produce the maximum sustainable yield; that is, the largest average annual catch that can be taken without damaging future stocks. The status of a fish stock is determined by how the stock compares with this target level.

Status classification

The status of New Zealand fish stocks are classified as:

- near or above target biomass levels: the stock is highly likely to have been sustainably fished
- probably near or above target biomass levels: the stock has probably been sustainably fished
- possibly near or above target biomass levels: the stock is more likely than not to have been sustainably fished
- below target biomass levels: the stock is likely to have been overfished, and recovery plans are in place
- unknown: there is not enough data to ascertain the status of the stock.

Seabed trawling in deep waters

The second indicator provides information on seabed trawling in deep waters. To report on this indicator, the following are measured:

- the area 'swept' (the area trawled over by a vessel towing gear along or near the seabed) by commercial trawlers, which are required to report their position by latitude and longitude
- the types of fish expected to be found in areas that have been swept.

This indicator shows only where there has been seabed trawling and the amount of trawl effort in those areas. It does not provide any information on the impact of the trawl on the sea floor environment.

Data collected from Trawl Catch Effort Processing Returns

Seabed trawling in deep waters is reported on using data collected from commercial forms called Trawl Catch Effort Processing Returns (TCEPRs) from 1990 to 2005. These returns are required from all commercial trawlers longer than 28 metres and some smaller vessels that are required to report their position.[10]

Most small vessels do not have to complete TCEPRs, so an estimated 3.5 million dredges and trawls are not reported over the same period. In some inshore areas, the effects of dredging and trawling by small vessels can be significant.

Data reported for 'fishing years'

Trawling effort is reported by 'fishing year', which runs from 1 October to 30 September of the next year. For ease of reference, a fishing year takes its name from the second of the two calendar years. For example, because most of the 1989–1990 fishing year is in 1990, it is referred to as the 1990 year.

Reporting on trawl effort

About 970,000 TCEPR trawls were reported in the 16 years from 1990 to 2005. These include bottom trawling and trawling using mid-water gear close to the seabed. The area swept for each trawl is estimated using the reported start and end positions of the trawl, and estimates of the 'doorspread' (effective width) of the trawl gear.

To report on trawl effort, the area inside the Exclusive Economic Zone (EEZ) is divided into a grid of 25-square-kilometre cells (National Institute of Water and Atmospheric Research, 2007). For each cell, the sum of the area swept (square kilometres) can be calculated. In a particular fishing year, a cell may have a total swept area of zero square kilometres (that is, it was untrawled) or, for example, 100 square kilometres, indicating that, on average, the area of the cell was trawled four times.

The trawl effort can then be analysed against the Demersal Fish Community Classification (see box 'More about the Demersal Fish Community Classification') to see what types of fish community are likely to have been most affected by seabed trawling in New Zealand.

More about the Demersal Fish Community Classification

The Demersal Fish Community Classification uses an extensive set of fisheries research trawl data to model the distribution of 122 fish species that live near the seabed (demersal fish species) (Leathwick et al, 2006b). These species include blue cod, hake, hoki, John dory, orange roughy, snapper, and tarakihi.

The classification shows the geographic distribution of particular demersal fish communities. It also shows the types of fish living in the communities and the environmental conditions in which the communities occur (Leathwick et al, 2006a).

Water quality at coastal swimming spots

The third indicator provides information on water quality at coastal swimming spots – referred to as 'recreational water quality'. To report on this indicator, concentrations of *enterococci* bacteria at coastal swimming spots are measured.

Enterococci indicate the presence of faecal material in coastal waters. During summer months, concentrations of *enterococci* are measured, usually once a week, at monitored beaches, and the results are compared with national guidelines.

Recreational water quality can be affected by effluent run-off from farmland and human wastewater discharges. Seawater that has been contaminated with human or animal effluent can carry a variety of disease-causing organisms. These can pose health risks to people using coastal beaches for activities like swimming, sailing, and surfing. Very young children, the elderly, or people with impaired immune systems are particularly vulnerable.

10 Fisheries (Reporting) Regulations 2001, Regulation 11(1).

Marine areas with legal protection

The fourth indicator provides information on marine areas with legal protection. To report on this indicator, the following are measured:

- the percentage of New Zealand's territorial sea in marine reserves
- the percentage of each class of the Coastal Biogeographic Regions Classification protected by marine reserve.

Marine reserves

Marine reserves are fully protected areas established under the Marine Reserves Act 1971. Until a Marine Protected Area network is established (see box 'Government action on protecting the marine environment' later in this chapter), this indicator will report on marine reserves within the territorial sea. Wider marine protection mechanisms, including those in the EEZ, are not reported on using this indicator.

Department of Conservation records are used to report on the size and location of marine reserves in New Zealand's territorial sea. By comparing this information with the Coastal Biogeographic Regions Classification (which divides New Zealand's territorial sea into 13 regions), we can show the percentage of each class of coastal biogeographic region protected by a marine reserve.

MILFORD SOUND MARINE RESERVE – ONE OF A NUMBER OF MARINE RESERVES IN NEW ZEALAND.

Source: Courtesy of the Department of Conservation.

Threatened marine species

Information on the state of New Zealand's threatened marine species is included in this chapter to present a more rounded picture of our oceans. This includes information about:

- marine species on New Zealand Threat Classification lists
- migratory marine mammals and seabirds on the International Union for the Conservation of Nature and Natural Resources (IUCN) Red List of Threatened Species.

New Zealand Threat Classification lists

The New Zealand Threat Classification lists classify all threatened and potentially threatened species that breed in New Zealand waters.

The classification uses information on population size, the range of the species, and population trends to determine the level of threat.

The classification system groups threatened species into the following three categories:

- acutely threatened: nationally critical, nationally endangered, or nationally vulnerable
- chronically threatened: in serious decline or gradual decline
- at risk: sparse or range-restricted.

International Union for the Conservation of Nature and Natural Resources Red List of Threatened Species

The IUCN Red List classifies threatened and potentially threatened species across the world. This chapter focuses on the species of marine mammals and seabirds on the IUCN Red List that migrate through New Zealand waters.

The IUCN Red List groups threatened species into the three categories of:

- critically endangered: considered to be facing an extremely high risk of extinction in the wild
- endangered: considered to be facing a very high risk of extinction in the wild
- vulnerable: considered to be facing a high risk of extinction in the wild.

Limitations of the indicators

The limitations of the indicators for oceans are explained below.

The two fisheries indicators do not measure:

- the environmental effects of fishing and trawling on marine ecosystems
- the effects from fishing activities on fish species that are not within the quota management system.

The recreational water quality indicator measures the water quality only at monitored beach sites, which may or may not be representative of recreational water quality elsewhere in New Zealand. In addition, beaches are often monitored only when there is a known problem with water quality.

The marine protection indicator does not measure how effective marine reserves are at protecting threatened marine species.

International agreements on the marine environment

New Zealand is a signatory to all key international agreements on managing the marine environment, including:

- the United Nations Convention on the Law of the Sea, which defines New Zealand's marine jurisdictional zones and specifies the rights and responsibilities within these zones, including obligations to protect the environment
- the International Convention for the Prevention of Pollution from Ships, which aims to eliminate the intentional pollution of the marine environment by ships, including from oil and other harmful substances
- the London Dumping Convention and Protocol, which aims to prevent the pollution of the sea from the dumping of waste.

Other international conventions relate to the conservation of marine living resources and biodiversity, including migratory fish stocks, marine mammals, and seabirds.

Current state and trends

Fisheries

Fishing is the most widespread human activity in the marine environment. Recreational, customary, and commercial fishing occur along a significant proportion of the New Zealand coastline and in several areas within our Exclusive Economic Zone (EEZ).

More than 1,300 commercial fishing vessels operate in New Zealand's marine environment (Ministry of Fisheries, 2007c). The commercial fishing sector accounts for the most significant proportion of the annual fisheries catch, catching 525,000 tonnes of fish in the 2006 fishing year. This includes fish caught both inside and outside of the New Zealand quota management system, including hoki, squid, jack mackerel, southern blue whiting, barracouta, and orange roughy. These species make up 60 per cent of the total catch by weight.

One hundred and thirty species are commercially fished in New Zealand. Of these, 96 species, comprising 618 fish stocks, are managed under New Zealand's quota management system (Ministry of Fisheries, 2007c). About 40 species have quota management system allowances for customary Māori fishers, and a similar number have allowances for recreational fishers (Ministry of Fisheries, 2007a).

While the quota management system ensures good information is collected about commercial fishing in New Zealand, recreational fishing catches are not formally reported. However, surveys are periodically conducted to estimate the quantity and type of species caught. For some fish stocks, the recreational take represents a large proportion of the total catch. For example, in the year ending 30 September 2005, the estimated recreational catch for blue cod in some management areas, such as the Marlborough Sounds, far exceeded the commercial landings (Ministry of Fisheries, cited in Statistics New Zealand, 2007a).

The quota management system also cannot track and report on unregulated and illegal fishing in New Zealand waters. Illegal fishing can limit the availability of fish for all fishers, particularly high-value species such as rock lobster and pāua.

FISHING IS THE MOST WIDESPREAD HUMAN ACTIVITY IN THE MARINE ENVIRONMENT.

Source: Nature's Pic Images.

Māori fisheries

Māori have a significant interest in New Zealand fisheries, controlling more than 35 per cent of the commercial fishing industry.

Māori also control the customary take of marine species provided for under the Fisheries (Kaimoana Customary Fishing) Regulations 1998 and Fisheries (South Island Customary Fishing) Regulations 1999.

Tangata kaitiaki or tiaki (customary-take guardians)

Iwi and hapū elect tangata kaitiaki or tiaki (customary-take guardians) for each area, whom the Minister of Fisheries then appoints formally.

Tangata kaitiaki may authorise any individual to take fisheries resources for customary use from within the rohe moana (coastal and marine area) for which the tangata kaitiaki have been appointed.

Iwi must report catches regularly to the Ministry of Fisheries so customary use can be factored in when annual catch limits are set.

Customary fisheries restrictions and closures

Provision for customary fisheries restrictions and closures is made under the Fisheries Act 1996 (Ministry of Fisheries, 2007a). This includes the use of rāhui, mātaitai reserves, and taiāpure.

Rāhui is a traditional marine management tool that temporarily closes an area. Tangata whenua may ask for mātaitai reserves (special management areas) and taiāpure (locally managed fishing areas) to cover some of their traditional fishing grounds or areas that have cultural and spiritual significance.

Within mātaitai reserves, tangata kaitiaki set the rules for customary and recreational fishing. Generally, commercial fishing is banned within mātaitai reserves. However, tangata kaitiaki may recommend that some types of commercial fishing be allowed (Taylor and Buckenham, 2003).

Taiāpure are local fisheries in coastal waters that recognise the special significance of the area to local iwi or hapū, either as a source of seafood or for spiritual or cultural reasons. Taiāpure give Māori greater say in the management of their traditionally important areas.

A major difference between mātaitai reserves and taiāpure is that commercial fishing is often allowed in taiāpure (Department of Conservation, 2007).

LOCAL ACTION to protect the marine environment

Central and local government are primarily responsible for decision-making, planning, and monitoring in the coastal marine area. However, local initiatives have become increasingly important for managing the coastal and marine environment.

In particular, a number of local initiatives for the better integration of management in the coastal marine area have been undertaken in recent years. These initiatives focus on the coastal margin and include marine management initiatives such as the Fiordland Marine Guardians and Kaiköura Coastal Marine Guardians (Te Korowai o Te Tai o Marokura).

The Fiordland Marine Guardians began as a local fisheries committee in Fiordland. It grew to include other commercial and recreational fishers, tourist and ecotour operators, dive clubs, and conservationists.

The Fiordland Marine Guardians developed a community-initiated resource management plan to protect and sustain the unique marine environment in Fiordland. This plan included agreement that:

- commercial fishers would fish only in the open sea and outer fiords
- recreational fishers would limit their daily bag to three cod per person
- Ngäi Tahu would not fish under customary right.

This agreement was cemented through the Fiordland (Te Moana o Atawhenua) Marine Management Act 2005. The Act brought into being the Fiordland Marine Area, which extends from Awarua Point to Sand Hill Point, covering about 928,000 hectares. Within the marine area, the Act established eight new marine reserves of 9,520 hectares, in addition to the two pre-existing marine reserves.

Other important council and community initiatives include beach clean-ups, dune restoration programmes, wetlands and habitat restoration, and stormwater management initiatives.

Status of commercial fish stocks

In 2006, 65 per cent by weight of all commercial catches were from fish stocks where enough information was available to assess the stock status (99 fish stocks).[11]

The remaining 35 per cent comprised 519 stocks, the status of which could not be assessed because of insufficient information. For many of these fish stocks, there is presently no way to assess their status, as long-term data is needed for a meaningful assessment. Many of these stocks record catches of less than 10 tonnes each year, so they are not considered at risk of over-fishing.

Table 11.1 shows that of the 99 assessed fish stocks, 85 per cent (84 fish stocks) are near or above target biomass levels. This includes all stocks in the 'near or above', 'probably near or above', and 'possibly near or above' target level categories.

The remaining 15 per cent of assessed fish stocks are below target levels. Rebuilding strategies are in place for these fish stocks. They include, for example, orange roughy in the Puysegur area (which has been closed to fishing since 1997) and rig (a shark-like species) in areas where the allocated catch has been reduced.

Seabed trawling

Trawling on or near the sea floor is the most widespread fishing activity in the New Zealand marine area that physically affects the seabed. From 1990, trawl effort by vessels required to report accurate fishing locations (TCEPR vessels) increased from fewer than 40,000 sweeps by trawls per year by about 127 vessels to a peak in 1998 of almost 80,000 sweeps per year by 173 vessels. In 2005, this number had dropped to nearly 55,000 sweeps per year by 94 vessels.

At the same time, the total area swept increased from 35,000 square kilometres in 1990 to a peak of more than 67,000 square kilometres in 1998. On average, the total area swept remained between 55,000 and 62,000 square kilometres in subsequent years until 2004 (see Figure 11.2). By 2005, the area swept had decreased to about 50,000 square kilometres, probably due to reductions in the total allowable catch for some species.

On average, around 55,000 square kilometres were trawled each year between 1990 and 2005.

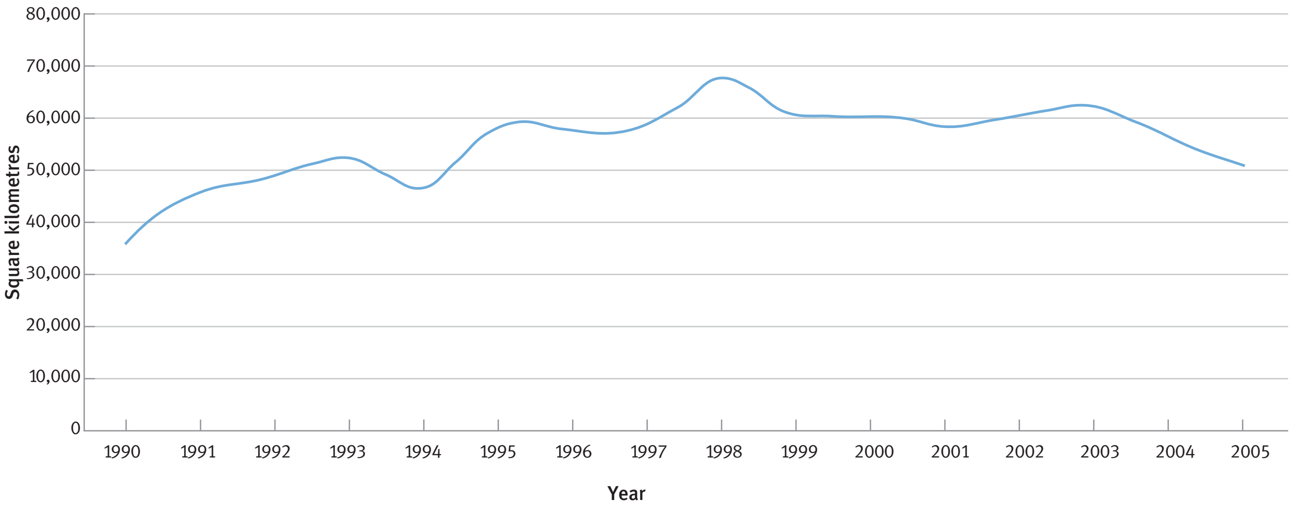
+ TABLE 11.1:
STATUS OF ASSESSED FISH STOCKS UNDER THE QUOTA MANAGEMENT SYSTEM RELATIVE TO TARGET LEVELS, 2006

STOCK STATUS	NUMBER OF ASSESSED STOCKS	PERCENTAGE OF ASSESSED STOCKS (%)
Near or above target biomass levels	51	52
Probably near or above target biomass levels	23	23
Possibly near or above target biomass levels	10	10
Total fish stocks near or above target biomass levels	84	85
Below target biomass levels	15	15

Data source: Adapted from Ministry of Fisheries, 2007b.

11 The 65 percent excludes arrow squid, the annual catch limit for which is more than 100,000 tonnes. The unusual life cycle of the arrow squid prevents a meaningful stock assessment being made. However, current levels of fishing are expected to be sustainable (Ministry of Fisheries, pers comm).

+ FIGURE 11.2:
COMMERCIAL TRAWLING EFFORT (TOTAL AREA SWEPT IN SQUARE KILOMETRES) BY TRAWL CATCH EFFORT PROCESSING RETURNS (TCEPR) VESSELS, 1990–2005



Data source: National Institute of Water and Atmospheric Research.

Figure 11.3 reports on where commercial trawling effort occurred in New Zealand by showing the total area swept (in square kilometres) in each 25-square-kilometre 'cell' fished. Sixty-four thousand of these cells are in fishable depths (less than 1,600 metres deep). Overall, 58 per cent of cells at fishable depths were crossed by at least one trawl over the 16 years for which there is data.

Trawling effort by year rose from 20 per cent of fishable cells in 1990 to 30 per cent in 2002, and then decreased to 25 per cent in 2005. The data shows the majority of the fished cells have had less than 1 square kilometre swept by trawls over the 16 years.

Figure 11.3 shows that many areas in the EEZ are not targeted by trawling. Even if the area is of a fishable depth, catches may not be high enough to be economic.

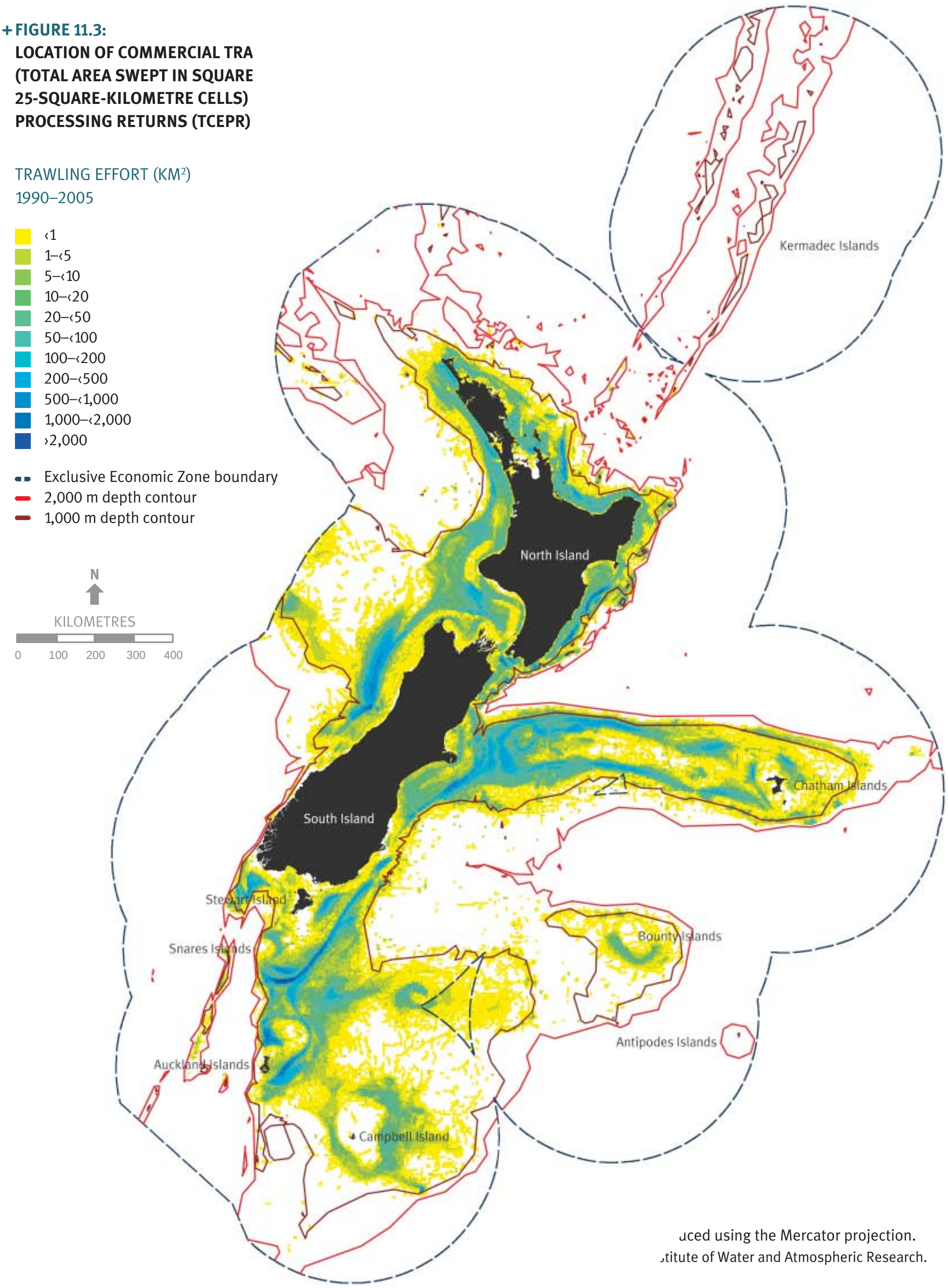
Areas of higher trawling intensity are those where hoki, squid, orange roughy, scampi, or snapper are targeted.

The distribution of trawl effort changes from year to year, but the data does show a pattern of initial expansion of trawl effort to the east and south of New Zealand. This initial expansion is mainly due to trawl effort targeted at hoki, although this has contracted in recent years (as the hoki catch has decreased).

Demersal Fish Community Classification

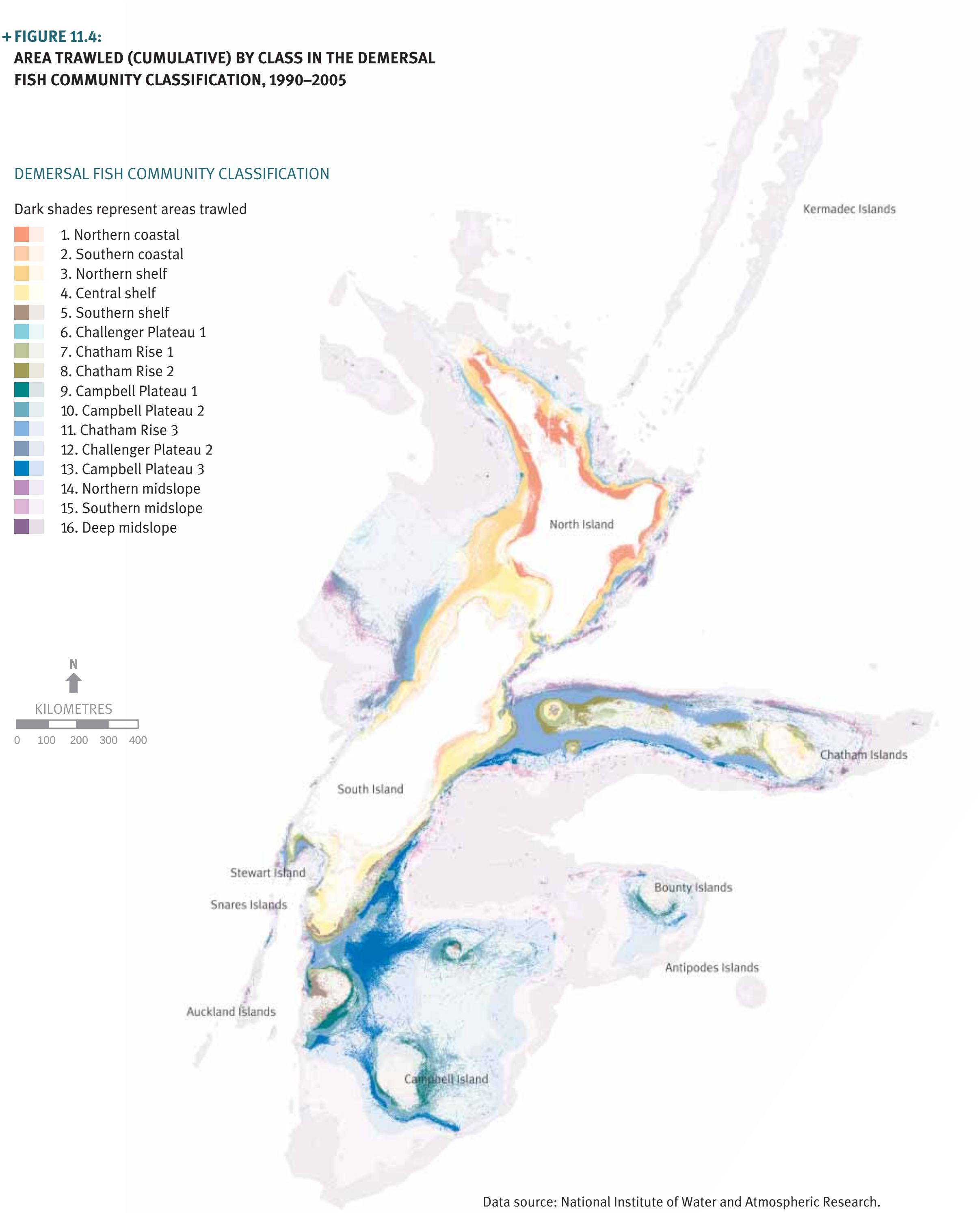
Demersal fish live near the seabed. Figure 11.4 shows the 16 classes in the Demersal Fish Community Classification. Each class represents a different demersal fish community and is shown by a different colour in Figure 11.4. The darker shades show where the various classes (and their fish communities) have been affected by trawling.

+ FIGURE 11.3:
LOCATION OF COMMERCIAL TRA
(TOTAL AREA SWEPT IN SQUARE
25-SQUARE-KILOMETRE CELLS)
PROCESSING RETURNS (TCEPR)



uced using the Mercator projection.
stitute of Water and Atmospheric Research.

+ FIGURE 11.4:
AREA TRAWLED (CUMULATIVE) BY CLASS IN THE DEMERSAL FISH COMMUNITY CLASSIFICATION, 1990–2005



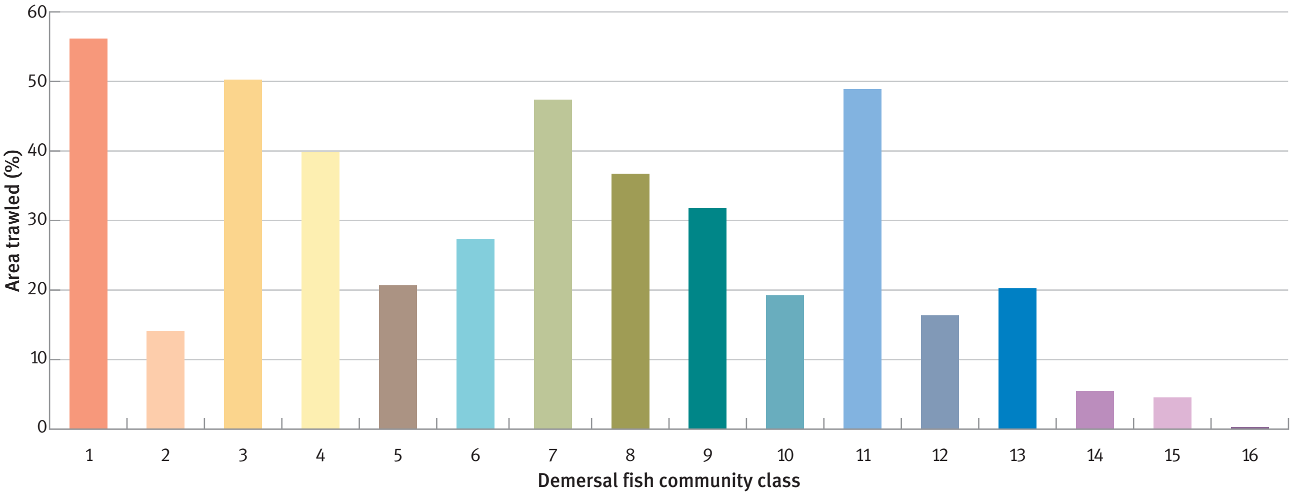
Data source: National Institute of Water and Atmospheric Research.

Figure 11.5 shows the percentage of cells within each class of the Demersal Fish Community Classification trawled at least once between 1990 and 2005. That some of these classes have a higher proportion of trawled cells than others may indicate that the associated demersal communities may also have been exposed to a greater extent of fishing.

Note that inshore classes are comparatively under-represented in Figure 11.5. This is because smaller vessels that do not use Trawl Catch Effort Processing Returns (TCEPRs) are more likely to fish inshore.

Demersal fish communities in the northern coastal, northern shelf, central shelf, Chatham Rise 1, and Chatham Rise 3 classes have had the highest proportion of their area (40–56 per cent of their cells) trawled by TCEPR vessels at some time in the 16-year period (see Figure 11.5). This does not necessarily reflect a higher level of trawling, as a trawled cell may have been trawled only once in the past 16 years.

+ FIGURE 11.5:
NUMBER OF CELLS TRAWLED AT LEAST ONCE AS A PERCENTAGE OF THE NUMBER OF CELLS IN EACH CLASS IN THE DEMERSAL FISH COMMUNITY CLASSIFICATION, 1990–2005



Note:
Refer to key in Figure 11.4 for the Demersal Fish Community Classification represented by each colour.
Data source: National Institute of Water and Atmospheric Research.

More about seabed fishing

Fishing effort on or near the seabed is known to affect the seabed environment (Cryer et al, 2002; Thrush et al, 1998). In Foveaux Strait, oyster dredging since 1863 has caused continuous reef modification and disturbance. This dredging has reduced oyster density (Cranfield et al, 1999). Dredging is known to remove epifauna (animals living on top of the seabed sediment) and damage reef systems. Analysis of oyster fisheries on three continents suggests that this pattern of impact is common in areas trawled (Kirby, 2004).

We still have large gaps in our understanding of the wider ecosystem effects of seabed fishing. Historically, most fisheries management and research has focused on individual species and stocks. While this remains important, efforts have increased in recent years to gain a better understanding of the long-term and ecosystem impacts of trawling and other seabed fisheries activities.

Water quality at coastal swimming spots

Monitoring swimming spots

Throughout the country, 380 beaches are monitored for recreational water quality. These are sites where water-based activities such as swimming, water-skiing, surfing, and diving are common.

Water samples are typically taken once a week over the summer (November to March) and tested for *enterococci* bacteria, which is the indicator of faecal pollutants in sea water. The 380 sites monitored include only those beaches where at least 10 water quality samples are taken over the summer; another 26 beaches are monitored, but less frequently.

When *enterococci* levels are higher than those recommended by the *Microbiological Water Quality Guidelines for Marine and Freshwater Recreational Areas* (Ministry for the Environment and Ministry of Health, 2003), councils liaise with health authorities to ensure the public is warned (by signs or other means) that there is an unacceptable health risk if they enter the water.

OVER THE SUMMER SEASON, POPULAR SWIMMING AND RECREATION BEACHES THROUGHOUT NEW ZEALAND ARE REGULARLY TESTED FOR WATER QUALITY.

Source: Ministry for the Environment.

Figure 11.6 shows that over the 2006–2007 summer, water quality at 80 per cent of the 380 monitored beaches met the New Zealand guidelines for contact recreation almost all the time (at least 95 per cent of samples taken at these sites had safe *enterococci* concentrations). One per cent of sites breached guidelines regularly (more than 25 per cent of samples were non-compliant), indicating these beaches are often unsafe for swimming.

Figure 11.6 shows that more beaches met the guidelines in the 2006–2007 summer season than in previous summer seasons for which we have national data (2003–2004 and 2005–2006). While this is encouraging, the period for which we have data is not long enough to show whether the improvements in recreational water quality are a trend, or merely annual variations.

Several factors may cause variations in recreational water quality. For example, during a wet summer, more faecal matter is carried from the land into rivers and streams and out to the coast. Therefore, bacteria levels in coastal waters during wet summers are often high compared with levels in dry summers. Windy or stormy conditions can also lead to elevated bacteria levels, because increased wave action lifts sediment from the seabed, which may release faecal matter.

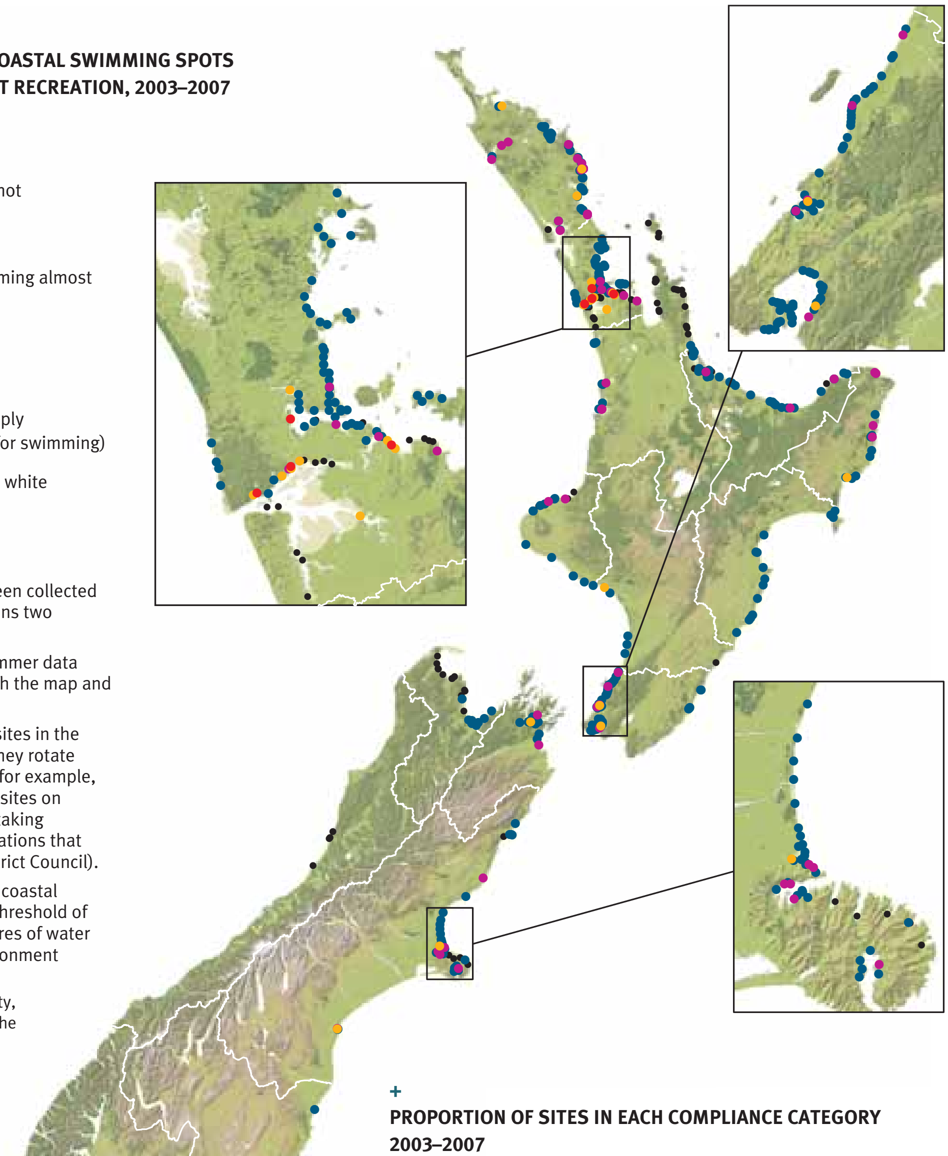
Coastal beaches generally have lower background levels of bacteria and/or shorter lasting bacterial contamination events than river and lake swimming spots. This difference is largely due to pollutants being more rapidly diluted and dispersed by currents and the large volumes of water at the coast.

+ FIGURE 11.6:
COMPLIANCE OF MONITORED COASTAL SWIMMING SPOTS WITH GUIDELINES FOR CONTACT RECREATION, 2003–2007

COMPLIANCE WITH GUIDELINES

- Not sampled in 2006–2007 or not sufficiently sampled
- 95–100% of samples comply (Water quality is safe for swimming almost all the time)
- 90–95% of samples comply
- 75–90% of samples comply
- Less than 75% of samples comply (Water quality is often unsafe for swimming)

Regional council boundaries in white



Notes:

(1) Data shown in the graph has been collected over the summer period so spans two calendar years.

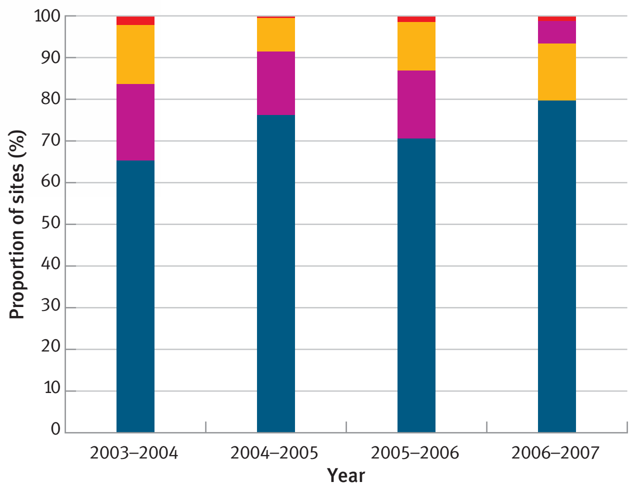
(2) The map shows 2006–2007 summer data only. The legend applies to both the map and the graph.

(3) Some councils did not sample sites in the 2006–2007 summer because they rotate their monitoring programmes (for example, Environment Waikato samples sites on alternate years) or were undertaking targeted water quality investigations that year (for example, Tasman District Council).

(4) Compliance with guidelines for coastal water is based on the 'action' threshold of 280 *enterococci* per 100 millilitres of water sampled (Ministry for the Environment and Ministry of Health, 2003).

Source: Data collected by regional, city, and district councils and collated by the Ministry for the Environment in 2007.

+ PROPORTION OF SITES IN EACH COMPLIANCE CATEGORY 2003–2007



More about marine pollution

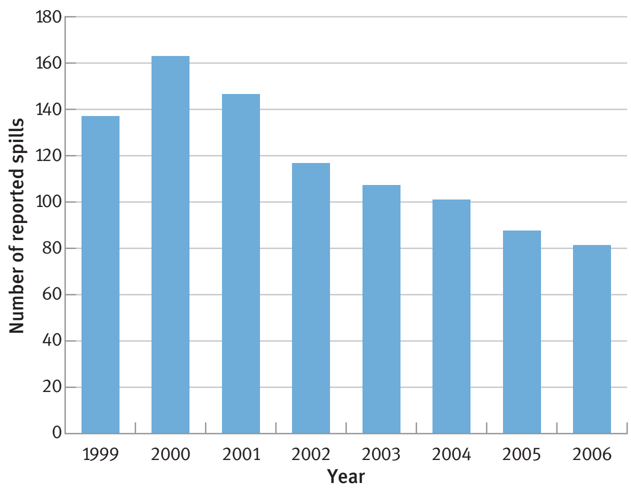
Marine pollution, from various sources, has the potential to affect marine biodiversity and habitats. Pollution includes marine debris, litter from land, run-off from land into coastal ecosystems, and oil spills.

Most oil spills occur in ports and harbours as a result of the high volume of shipping traffic. The spill rate for ports is about three times higher than the spill rate for all other coastal areas. Although oil spills from ships must be reported by law, most marine oil spills are from unknown sources and the volume of oil cannot be measured.

Figure 11.7 shows a decrease in the number of reported spills since 1999, possibly due to improving practices in the fishing and shipping industries. It is notable that in spite of a significant increase in shipping and tourism activities in recent years, there has been no large-scale marine spill in New Zealand since 2002.

It is possible that some spills continue to go undetected or are unreported.

+ FIGURE 11.7:
TOTAL NUMBER OF REPORTED MARINE SPILLS, 1999–2006



Note:
Spills of all sizes, sources, and types are aggregated.
Source: Maritime New Zealand, 2007.

Threatened marine species

Several of New Zealand's marine species are on the New Zealand Threat Classification lists (Hitchmough et al, 2007). In addition, several migratory marine mammals and seabirds that pass through New Zealand waters are on the IUCN Red List (International Union for the Conservation of Nature and Natural Resources, 2007).

Table 11.2 shows the number of species that breed in New Zealand waters that have a threat ranking in the New Zealand Threat Classification System (Hitchmough et al, 2007; Molloy et al, 2002).

Table 11.2 shows the high proportion (62.3 per cent) of seabirds (excluding waders and shorebirds) that are threatened. Sixteen of the 22 acutely threatened species or subspecies and eight of the 14 chronically threatened species or subspecies are endemic to New Zealand.

Table 11.2 also highlights that, of the threatened species, certain marine fish groups such as sharks, skates, dogfish, and rays are particularly vulnerable to fishing pressures. This vulnerability results from their long lives and low reproductive rates. The great white shark and basking shark are the only marine fish in the chronically threatened category (Hitchmough et al, 2007). Sharks, skates, and dogfish are also a significant proportion of the species in the at risk category.

Both the North and South Island subspecies of Hector's dolphin are acutely threatened.[12]

12 The North Island subspecies is also known as Maui's dolphin.

+TABLE 11.2:
NUMBER OF MARINE SPECIES AND SUBSPECIES IN THE NEW ZEALAND THREAT CLASSIFICATION SYSTEM, 2005

GROUP	ACUTELY THREATENED	CHRONICALLY THREATENED	AT RISK	TOTAL NUMBER OF KNOWN SPECIES IN THREAT CATEGORIES	TOTAL NUMBER OF KNOWN SPECIES[1]	PERCENTAGE OF TOTAL NUMBER OF KNOWN SPECIES IN THREAT CATEGORIES (%)
Marine fish (sharks, bony fish)	0	2	50	52	1,246[2]	4.2
Marine invertebrates (crabs, corals, starfish, shellfish, limpets, octopus, and squid)	13	19	238	270	11,255	2.4
Marine mammals (seals, sea lions, dolphins, and whales)	6	0	2	8	48	16.7
Macroalgae (seaweeds and algae)	1	0	37	38	847	4.5
Seabirds (excluding waders and shorebirds)	22	14	40	76	122	62.3

Notes:
(1) Information from D Gordon, National Institute of Water and Atmospheric Research, pers comm, number of known marine invertebrates, mammals, and macro-algae in New Zealand.
(2) Information from A L Stewart, Te Papa Tongarewa, pers comm, number of known marine fish in New Zealand (inclusive of estuarine species).
Data source: Adapted from Hitchmough et al, 2007.

Changes in threat classification

The New Zealand Threat Classification lists are updated every three years. In 2005, several hundred species were added to the lists. For marine species, the total number of species in the acutely threatened, chronically threatened, or at risk categories has increased by one for marine fish, one for marine mammal, two for macroalgae, and 26 for marine invertebrates.

In general, this increase is likely to reflect better information and a growing understanding of the threat status of species in the New Zealand marine environment, rather than a real change in threat status. However, there are some genuine declines and recoveries.

Two species of seabird, the Campbell mollymawk and black petrel, have shown enough recovery to have their threat classification lowered. However, the threat status of seven species of seabird has worsened since 2004 (Hitchmough et al, 2007).

Table 11.3 shows the species of migratory marine mammals and seabirds in New Zealand waters that are on the IUCN Red List.

The New Zealand species on the IUCN Red List are the sei, blue, and fin whales (classified as endangered); and the humpback and sperm whales, snowy albatross, and southern giant petrel (classified as vulnerable).

+ TABLE 11.3:
MIGRANT SEABIRDS AND MARINE MAMMALS IN CRITICALLY ENDANGERED, ENDANGERED, AND VULNERABLE IUCN RED LIST CATEGORIES, 2005

	CRITICALLY ENDANGERED	ENDANGERED	VULNERABLE	TOTAL NUMBER OF SPECIES IN THREAT CATEGORIES
Seabirds	0	0	2	2
Marine mammals	0	3	2	5

Data source: Adapted from International Union for the Conservation of Nature and Natural Resources, 2007.

Causes of population loss within species

Fishing bycatch (the accidental capture of non-target species during fishing activities) is a significant cause of the decreasing numbers of many seabird species worldwide. In New Zealand, bycatch is a serious threat to New Zealand-breeding albatrosses and some petrels (Wilson, 2006).

Commercial and recreational set-net fishing also pose an unquantified threat to Hector's dolphins and some penguins, shearwaters, and shags.

Recent initiatives to minimise the harm from bycatch include a national action plan to reduce seabird mortality and regulatory measures to address dolphin mortality.

Pest species and loss of habitat also present significant risks to breeding and nesting sites for many of our rare marine species.

Loss of genetic diversity is another risk faced by some species. Genetic diversity is an important factor in a species' resilience. A significant reduction in population, from human or natural pressures, may affect a species' ability to adapt to further environmental changes, especially large-scale variations such as climate change.

Marine areas with legal protection

Marine reserves

Around the world, marine reserves are widely considered to be useful for achieving marine conservation goals, including:

- conserving habitats
- maintaining marine communities
- fostering the recovery of some species.

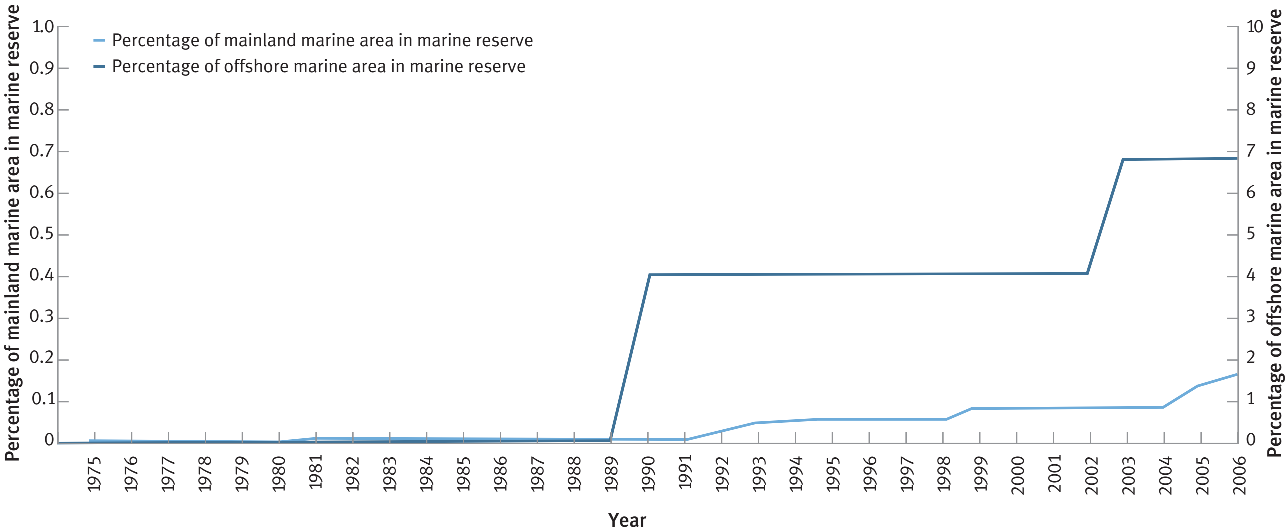
Marine reserves cover slightly more than 7 per cent of New Zealand's territorial sea. Ninety-nine per cent of this area is in two remote offshore marine reserves – the Kermadec Islands Marine Reserve and Auckland Islands Marine Reserve.

New Zealand's first marine reserve (Cape Rodney–Okakari Point Marine Reserve) was established in 1975. There are now 31 gazetted marine reserves in New Zealand's territorial sea, 15 of which have been established since 2000. The area designated as marine reserve has also increased significantly in the last decade, from 7,602 square kilometres in 1997 to 12,764 square kilometres in 2007.

Figure 11.8 shows the increase of marine reserve area in the territorial sea since 1974. There have been two large increases of marine reserve area, which can be attributed to the establishment of marine reserves in the two remote offshore island groups mentioned above. In 1990, 7,280 square kilometres were protected around the Kermadec Islands, and in 2003, 4,980 square kilometres were protected around the Auckland Islands. These two reserves make up 99 per cent of the total area protected by marine reserve.

Less than 1 per cent of marine reserve area lies around the three main islands of New Zealand (the North, South, and Stewart Islands).

+ FIGURE 11.8:
PERCENTAGE OF TERRITORIAL SEA IN MARINE RESERVES, 1975–2006



Data source: Department of Conservation.

Marine reserve recovery

Monitoring of marine reserves in New Zealand has provided us with useful insights into the effectiveness of protection and the changes that have occurred in New Zealand waters. It has also helped us understand how species targeted by fishing respond to protection.

Research has been carried out in three of New Zealand's oldest and most-studied reserves situated in the northeast of New Zealand (Cape Rodney–Okakari Point Marine Reserve, Cathedral Cove–Te Whanganui a Hei Marine Reserve, and the 'no-take' Tāwharanui Marine Park). Results of this research show the recovery of previously overfished populations and the re-establishment of natural ecosystems (Langlois and Ballantine, 2005; Langlois et al, 2006).

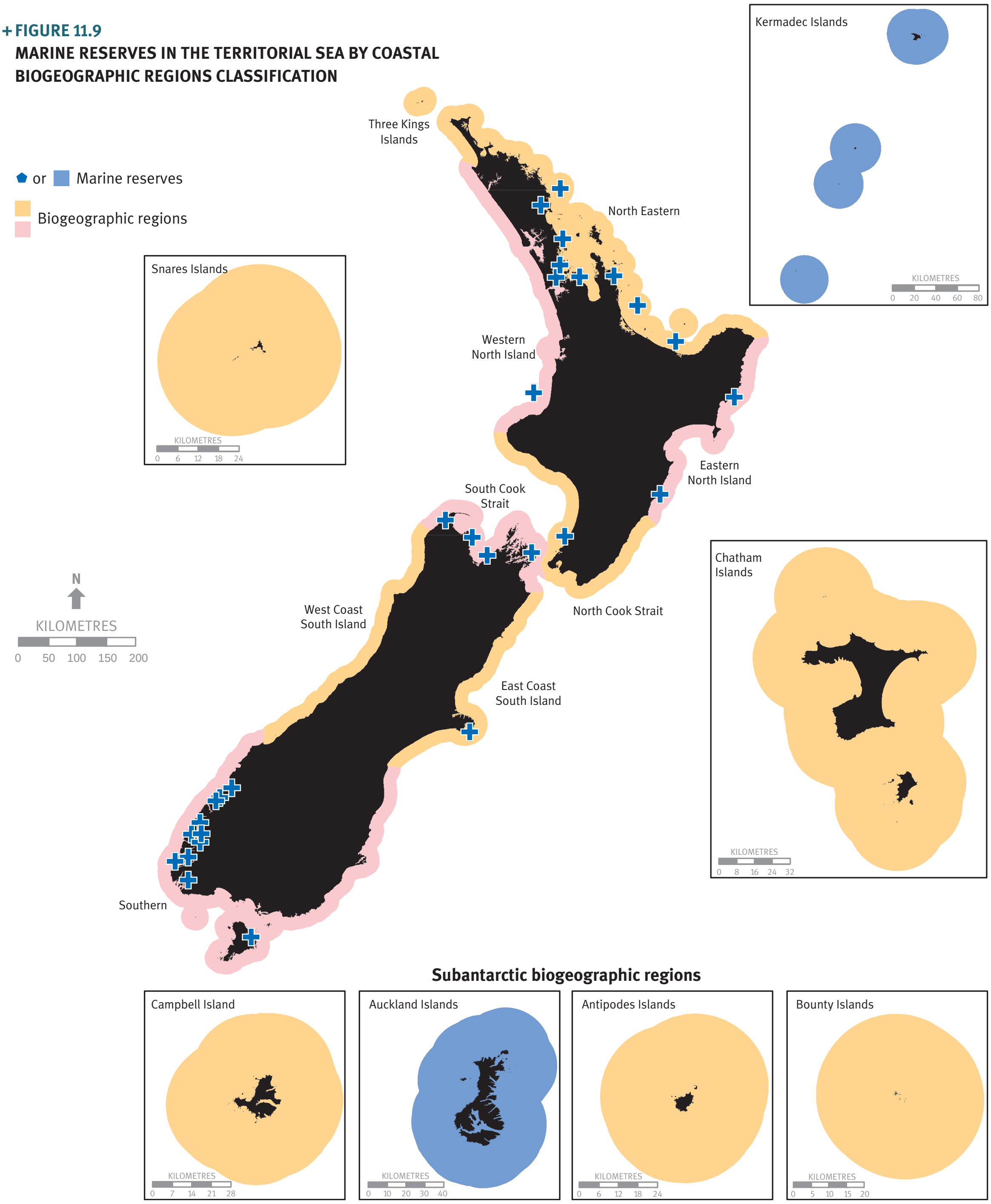
Coastal Biogeographic Regions Classification

The Coastal Biogeographic Regions Classification divides New Zealand's territorial sea into 13 regions. Figure 11.9 shows the location of these regions and compares them with marine reserves around New Zealand.

Of the 13 regions, nine have at least one marine reserve. However, only two have a significantly large area protected in a marine reserve: the Kermadec Islands and the Subantarctic Island regions. With 100 per cent and 41.9 per cent of their respective territorial sea ecosystems protected, these two regions are recognised internationally as unique ecosystems.

+ FIGURE 11.9

MARINE RESERVES IN THE TERRITORIAL SEA BY COASTAL BIOGEOGRAPHIC REGIONS CLASSIFICATION



Note:

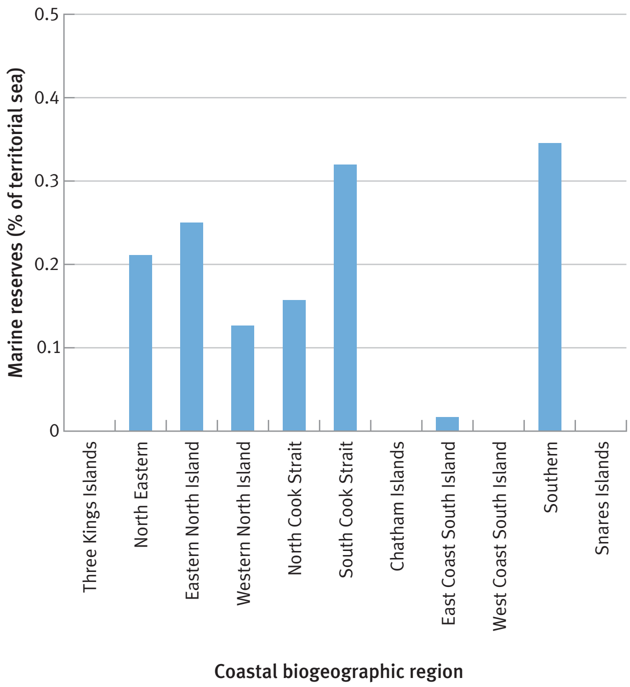
Some marine reserves appear to be on land, but they are in bays or fiords, such as the 10 marine reserves in the Fiordland Marine Area.

Data source: Department of Conservation.

Figure 11.10 shows the proportion of mainland coastal biogeographic regions in designated marine reserves (none has more than 0.4 per cent). Four regions (Three Kings Islands, West Coast South Island, Snares Islands, and Chatham Islands) do not contain any marine reserves.

+ FIGURE 11.10:

PERCENTAGE OF MAINLAND COASTAL BIOGEOGRAPHIC REGIONS CLASSIFICATION REGIONS IN MARINE RESERVES, 2007



Note:

No mainland region has more than 0.4 per cent of its total area in marine reserve.
Data source: Department of Conservation.

GOVERNMENT ACTION on protecting the marine environment

A number of cross-government initiatives aim to protect the New Zealand marine environment.

Oceans Policy

The Oceans Policy emphasises taking a coordinated and integrated approach to marine management. The Government has prioritised improving the regulation of environmental impacts in the Exclusive Economic Zone. In August 2007, the document, *Improving the Regulation of Environmental Effects in New Zealand's Exclusive Economic Zone*, was released for public consultation.

Marine Protected Areas Policy and Implementation Plan

The Marine Protected Areas Policy and Implementation Plan aims to expand the network of Marine Protected Areas, so it covers a fully representative range of New Zealand's coastal and marine ecosystems and habitats (Department of Conservation and Ministry of Fisheries, 2005). A key objective is to have at least one example of each identified marine habitat and ecosystem in the marine reserves.

A wide range of tools may contribute to a network of Marine Protected Areas (for example, marine reserves, special legislation, marine sanctuaries, and fisheries closures). Whether an area becomes part of the network will depend on how effectively the biodiversity values in the area are already protected.

Strategy for Managing the Environmental Effects of Fishing

The Strategy for Managing the Environmental Effects of Fishing sets out approaches to regulate the effects of fisheries to help achieve the sustainable use of fish stocks and ecological sustainability (Ministry of Fisheries, 2005), as defined under the Fisheries Act 1996.

Biosecurity Strategy

The Biosecurity Strategy sets out an overall direction for monitoring and managing biosecurity in New Zealand (Biosecurity Council, 2003).

New Zealand Marine Oil Spill Response Strategy

The New Zealand Marine Oil Spill Response Strategy aims to minimise the impact of oil pollution on the marine environment within New Zealand's area of responsibility (Maritime New Zealand, 2006).

New Zealand Biodiversity Strategy

New Zealand's Biodiversity Strategy sets out a vision for coastal and marine biodiversity protection. The strategy lists four desired outcomes for the marine environment by 2020.

- New Zealand's natural marine habitats and ecosystems are maintained in a healthy, functioning state. Degraded marine habitats are recovering. A full range of marine habitats and ecosystems representative of New Zealand's indigenous biodiversity is protected.
- No human-induced extinctions of marine species occur within New Zealand's marine environment. Rare or threatened marine species are adequately protected from harvesting and other human threats, enabling them to recover.
- Marine biodiversity is appreciated, and harvesting or marine development is done in an informed, controlled, and ecologically sustainable manner.
- No new undesirable introduced species is established, and threats to indigenous biodiversity from established exotic organisms are being reduced and controlled.

The strategy includes the goal of having 10 per cent of the marine environment in a network of Marine Protected Areas by 2010 (Department of Conservation and Ministry for the Environment, 2000).

Changes since the 1997 report

The 1997 report, *The State of New Zealand's Environment 1997*, concluded that:

> New Zealand's environmental information needs considerable upgrading if the state of the nation's environment is to be accurately described and trends detected. …
>
> The main pressures on indigenous biodiversity today are insufficient habitat in lowland areas, declining quality of many of the remaining land and freshwater habitats, the impacts of pests and weeds and, for some marine species and ecosystems, human fishing activities. …
>
> The main responses to biodiversity decline have focused on ecosystem and species recovery programmes on offshore islands and extensive pest control operations on the mainland, but the need for partial restoration of the representative indigenous lowland and coastal ecosystems and for wider protection of marine ecosystems has yet to be addressed. …
>
> The status of more than half the commercially exploited fish stocks is unknown but, of the stocks whose status is known, about 10 percent are considered to be below the level of Maximum Sustainable Yield and measures have been set to rebuild these stocks. …
>
> Pressures on marine life from fishing include direct harvesting pressure as well as indirect pressures from trawling and dumping of offal on nursery ecosystems (e.g. coral communities, seamounts, bryozoan mats), and bycatch of non-target species (e.g. 1,000 marine mammals, several hundred seabirds, and many non-target fish per year). …
>
> The new Fisheries Act 1996 recognises that environmental sustainability requires more than just sustaining the yield from target stocks but also requires the maintenance of marine biodiversity and ecosystems. …
>
> Protected marine areas can act as both reservoirs of biodiversity and nurseries for some commercial fisheries yet, apart from the Kermadec and Auckland Islands, protected marine areas are under-represented in both our coastal and our deep water ecosystems, e.g. seamounts.

(Ministry for the Environment, 1997, chapter 10.)

Progress since 1997

Since 1997, considerable effort has been made to strengthen marine information systems and put in place more extensive monitoring to improve the management of New Zealand's marine area. Government strategies, research funding, and management policies have collectively focused on improving our understanding of the marine environment, its ecosystems, and its biodiversity.

Limited knowledge of long-term impacts

In recent years, marine research in New Zealand has increased its emphasis on improving its understanding of the:

- wider ecosystem effects of human activities on our marine area
- distribution and structure of our marine ecosystems
- interdependence between marine species and ecosystems.

Despite this shift, our knowledge of the long-term ecosystem impacts of human activities in the New Zealand marine environment remains somewhat limited. Bringing together land, freshwater, and marine research will be particularly important in studying the resilience of our inshore ecosystems to land-based pressures.

More about Māori indicators for marine protection

In 2004, Ngāti Konohi, the Department of Conservation, and the Ministry for the Environment worked together to establish a framework for marine protection for the rohe moana (coastal area) of Ngāti Konohi of Whangarā. The rohe extends from Waihau Bay in the north to Tatapouri Heads in the south, and includes Te Tapuwae o Rongokako Marine Reserve, established in 1999.

Identifying the indicators (tohu)

The project aimed to:

- define a process to identify Māori marine indicators (tohu) that would measure the health of the rohe moana
- pilot the implementation of tohu
- test how marine reserves contribute to iwi conservation objectives.

The project involved members of Ngāti Konohi who regularly used the rohe moana to gather kaimoana (seafood). The project identified traditionally important locations and species and collected information on traditional catch techniques and customs relating to management of kaimoana. Using this information, tohu were developed by Ngāti Konohi to monitor changes in the health of their rohe moana and address problems using customary management practices.

Primary and secondary tohu

Ngāti Konohi established primary and secondary tohu.

Primary tohu were divided into species-focused and process-focused tohu. Species-focused tohu monitor the availability, accessibility, abundance, and quality of species of traditional importance. For example, tohu indicate whether kaimoana can be readily harvested to provide for customary needs.

Process-focused tohu monitor the condition and presence of processes that indicate a healthy marine environment. For example, seasonal observations of 'bait fish' feeding or predators (such as marine mammals or sea birds) were categorised as process-focused tohu.

Secondary tohu included:

- a series of plots established at various locations in the rohe moana to quantify the size and location of key indicator species
- data on water quality, shellfish health, and beach bathing standards from marine environmental monitoring undertaken by Gisborne District Council
- a series of land-based tohu, which were defined to aid management of the rohe. These include the flowering seasons of the kōwhai, pōhutakawa, and tī kouka (cabbage tree) as indicators of ripeness of kina for harvesting.

The identification of marine environmental tohu has proven to be a catalyst for heightened interest in and awareness of marine protection in the area.

New tools to improve understanding

Since 1997, new marine databases and national coordination tools such as the National Aquatic Biodiversity Information System have become important aids to understanding our marine environments and their associated biodiversity.

New ecological classification systems have also helped us to better understand our marine environment. These classification systems include:

- the Marine Environment Classification
- the Marine Environment Classification optimised for demersal fish
- the Demersal Fish Community Classification
- the Coastal Biogeographic Regions Classification.

Marine monitoring programmes that have been implemented since 1997 include:

- the non-indigenous marine species monitoring programme
- regional monitoring of the quality of beach bathing water
- regional monitoring of wastewater and stormwater discharges into the coastal marine area
- estuarine and coastal monitoring of sedimentation, nutrients, and other pollutants
- monitoring of Māori marine indicators (see box 'More about Māori indicators for marine protection')
- the Ocean Survey 20/20 mapping initiative.

In addition, research funding was allocated in 2007 to gather more detailed information on commercial fish catches in coastal waters. The aim of this funding is to ensure that inshore fisheries are managed sustainably. The research aims to increase our understanding of interactions between target fish stocks, bycatch species, and fishing effects on the wider inshore environment, with a view to improved planning and management of inshore fisheries. The research is also expected to inform coastal planning decisions on marine protection and aquaculture development.

Biosecurity

The protection of New Zealand's marine environment will continue to require a focus on biosecurity. Increased marine-based trade and travel as well as climate change are expected to add to the existing pressures of pests, diseases, and pathogens. Controlling these threats is important for protecting our fisheries and Marine Protected Areas as well as for preserving wider coastal amenity values (Ministry of Research, Science and Technology, 2007).

State of our fisheries

The Fisheries Act 1996 has been in place for more than a decade. Of the 99 fish stocks for which sufficient information is available to assess stock status, 85 per cent have been fished sustainably and 15 per cent have been overfished and are now being rebuilt.

It is difficult, however, to compare the 15 per cent of stocks overfished in 2007 with the 10 per cent of stocks overfished in 1997. The number of species in the quota management system has increased from 42 species in 1997 to 96 species in 2007, and the number of assessed fish stocks has increased from 74 to 99 over the same period. Furthermore, methodologies for assessing stocks have improved. Even so, it is clear that pressures on our fisheries stocks remain and our fish stocks will continue to need careful management into the future.

The pressures identified for our fisheries in the 1997 report remain important environmental issues in fisheries management today: bycatch, habitat destruction, and indirect and wider ecosystem impacts. Initiatives to address these issues include:

- the Strategy for Managing the Environmental Effects of Fishing
- the National Plan of Action to Reduce the Incidental Catch of Sea Birds in New Zealand Fisheries
- industry-initiated benthic protection areas.

See box 'Government action on protecting the marine environment' for more information on government initiatives to protect the marine environment.

However, more monitoring and research into the effects of fisheries, including seabed trawling, on the wider ecosystem is warranted, because we have significant gaps in our understanding of the impacts of human activity on the marine environment.

Marine protection

Since the 1997 report, monitoring and research have conclusively demonstrated the positive effect of marine protection on both the size and abundance of marine life and the recovery of ecosystems under pressure.

In 1997, almost 7,602 square kilometres of New Zealand waters were protected in marine reserves. This area has increased by about 5,162 square kilometres in the last decade. Thirty-one marine reserves now comprise 7 per cent of our territorial sea, a high proportion by Organisation for Economic Co-operation and Development standards. Nearly half of these have been established since 2000, and the area designated as marine reserves has nearly doubled in this time. However, 99 per cent of our protected area is in two offshore marine reserves, and some key habitats remain unprotected.

Progress on classifying the marine environment and developing and implementing a 10 per cent Marine Protected Area network throughout the Exclusive Economic Zone (EEZ) (targeted for 2010) has been slow. However, the Marine Protected Areas Policy and Implementation Plan is expected to increase momentum to expand the network to fully represent the range of New Zealand's coastal and marine ecosystems and habitats (see box 'Government action on protecting the marine environment').

Other initiatives to protect important marine habitats from disturbance include:

- proposed benthic protection areas (which will close 30 per cent of the EEZ to seabed trawling)
- seamount closures (which will close 100,000 square kilometres to seabed trawling).

In addition, customary closures and restrictions are an integral part of fisheries management.

Recent years have also seen the emergence of innovative local initiatives for coastal management, such as the coastal management plan proposed by the Fiordland Guardians and supported by the Government.

Looking ahead

New Zealand's marine environment will continue to face pressures from fishing activities. In the light of improved information over time about fish stocks and the broader effects of fishing on marine ecosystems, the challenges will be to ensure fisheries are utilised in a sustainable way and to allow the recovery of stocks that have been overfished in the past.

Land-based pressures on the inshore marine environment will continue to challenge the health of our marine environment. Discharges of pollution, stormwater, nutrients, and sediments to the sea from land development appear unlikely to ease, given our increasing population and shift towards more intensive land use.

Balancing the competing needs of the users of our marine area will continue to be important and may become increasingly difficult as our population increases and technology advances. The need for accurate information to help set priorities for future use and protection of our marine area will increase.

In the future, greater attention is likely to turn to the significant changes to our oceans and coasts that climate change is expected to bring, and how New Zealand will respond.

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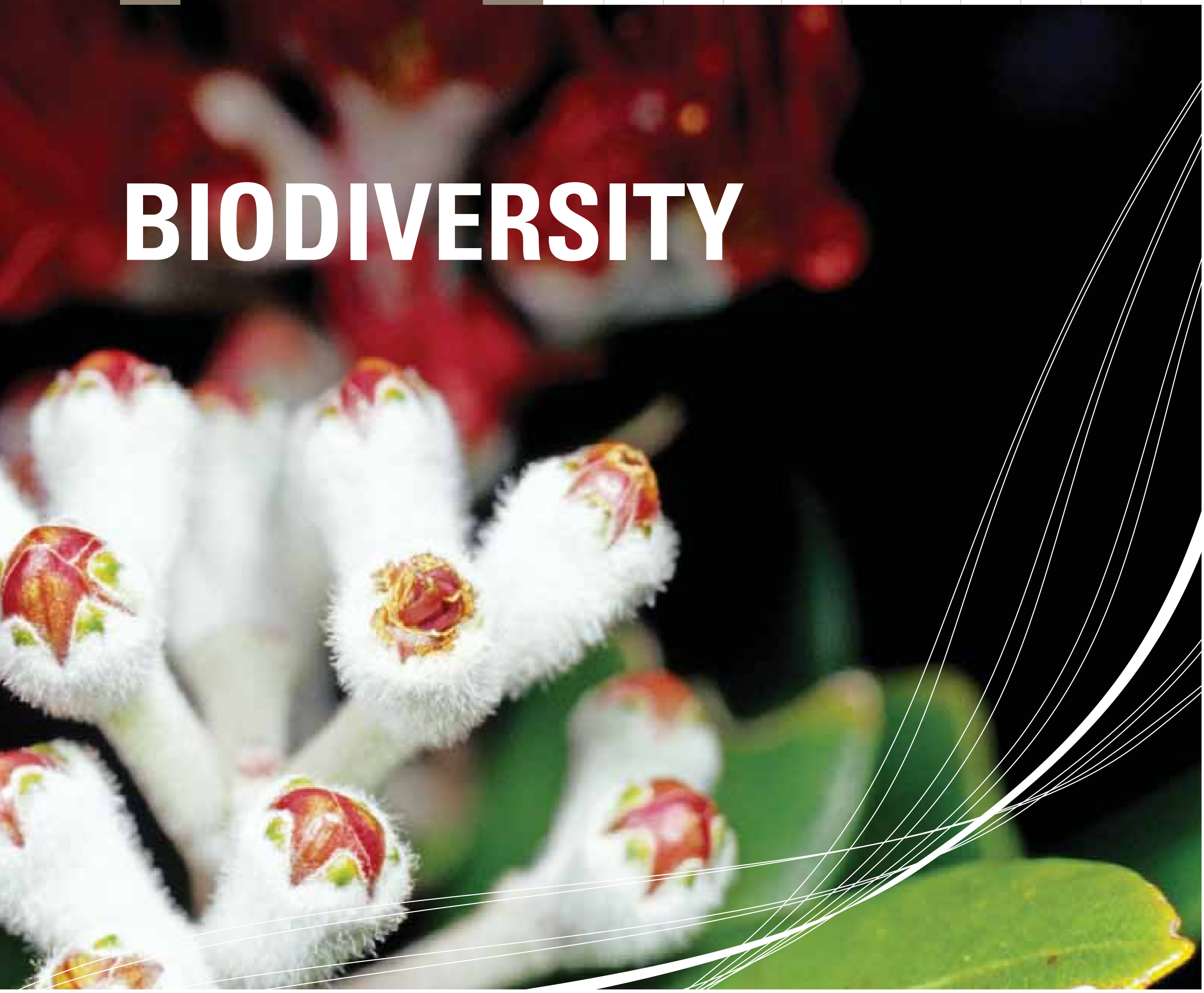
"Our distinctive plants and animals have strongly shaped our national identity."

BIODIVERSITY



Contents

At a glance

Biodiversity in New Zealand

New Zealand's varied landscapes and unique native plants and animals have helped shape our national character and cultural identity. Biodiversity helps to sustain the ecosystems that support the country's primary production and tourism sectors.

Internationally, New Zealand is regarded as a significant contributor to global biodiversity, with an estimated 80,000 species of native animals, plants, and fungi. A comparatively large proportion of these are endemic – they do not occur naturally anywhere else on earth.

Pressures on biodiversity

Since humans arrived in New Zealand, the country has experienced one of the highest species extinction rates in the world, due to the loss of habitats and the introduction of pest plants and animals. Today, almost 2,500 native land-based and freshwater species are listed as threatened. The effects of climate change may further exacerbate pressures on our most endangered species.

Freshwater biodiversity is affected by surrounding land use and water quality. Invasive freshwater species such as the alga didymo (*Didymosphenia geminata*) pose risks for freshwater biodiversity.

Native land cover

About 44 per cent of New Zealand's land area is covered by native vegetation, most of which is in hill country and alpine areas. Less native vegetation remains in lowland areas; this has implications for species that need this type of habitat to survive.

Between 1997 and 2002, it is estimated that native land cover decreased by 16,500 hectares (0.12 per cent). This total decrease included an increase of 700 hectares of non-vegetative native cover, such as sand and gravel, and a decrease of 17,200 hectares of native vegatative cover. These changes either occurred through conversion of land to other uses, or as a result of natural processes.

It is estimated that wetland areas have reduced by 90 per cent from their original area. New Zealand has designated six wetlands as having global importance under the Ramsar Convention on Wetlands (an inter-governmental treaty signed in 1971). Together, these Ramsar wetlands cover a surface area of 39,068 hectares.

Legally protected areas

By international comparison, a large proportion (just over 32 per cent) of New Zealand's land area is legally protected for conservation purposes, either as public conservation land (8.43 million hectares) or through conservation initiatives on private land (221,473 hectares). The area of public conservation land has increased by 4.56 per cent between 2004 and October 2007. Private land under legal protection has increased by just over 51 per cent between 2004 and 2006.

However, some of our land environments and the ecosystems they contain, for example wetland and lowland ecosystems, are not well represented among the legally protected areas.

Distribution of selected native species

The distribution of the selected native species discussed in this chapter (the lesser short-tailed bat, kiwi, kōkako, kākā, mōhua, wrybill, and dactylanthus) has decreased over time on a national scale.

Some of our more common native birds have shown an increase in distribution in recent years (27 out of 96 observed species). The same percentage (28 per cent) reduced in distribution between 1985 and 2004. Ninety-three per cent of these were endemic species.

Decreases in distribution since the 1970s are largely due to the impacts of introduced pest species, rather than habitat loss.

Present and future pest management

Pest management efforts have intensified over the last decade, and areas receiving ongoing management have increased for all major targeted pests. For instance, between 2000 and 2006, areas targeted for possum management by the Department of Conservation increased by 60 per cent. Areas targeted by the Animal Health Board have increased by 40 per cent since 2001. Together, areas targeted by the Department of Conservation and the Animal Health Board for possum management equate to around 37 per cent of New Zealand's land area.

Introduced animal pest and weed species remain a serious threat to New Zealand's endangered native plants and animals. Over the last decade, increasing priority has been given to controlling pests in the habitats of the most threatened native species, and to stopping unwanted species coming into the country.

While offshore island reserves continue to protect many of our rarest species, sanctuaries on the mainland are increasingly aiming to match that level of protection. Attention has also turned to the protection of endangered native species and ecosystems on private land.

In the future, conservation priorities are likely to continue to focus on improved pest control and biosecurity, and on increasing legal protection for the land environments and ecosystems that are currently under-represented.

Introduction

Biological diversity, or biodiversity, is the variety of biological life on earth. Biodiversity comprises:

- genetic diversity – the genetic variety among individuals of a single species
- species diversity – the variety of species within a particular geographical area
- ecological diversity – the variety of ecosystems (such as forests, deserts, wetlands, grasslands, streams, lakes, and oceans), the communities within these, and the interactions between them.

This chapter covers native land-based and freshwater biodiversity. Marine biodiversity is discussed in chapter 11, 'Oceans'.

Biodiversity in New Zealand

Given the wealth and uniqueness of New Zealand's biodiversity, the country is internationally regarded as 'one of the richest and most threatened reservoirs of plant and animal life on earth' (Conservation International, 2007).

New Zealand makes an important contribution to global biodiversity, with an estimated 80,000 species of native animals, plants, and fungi. We have comparatively few native flowering plants and land-based vertebrates (animals with backbones).

High proportion of endemic species

As a result of 80 million years of evolution in isolation from other land masses, a large number of New Zealand's native species are endemic – meaning they do not naturally occur anywhere else in the world (Organisation for Economic Co-operation and Development, 2007). All our frogs and reptiles, more than 90 per cent of our insects, about 80 per cent of our vascular plants (plants other than mosses, liverworts, and hornworts), and a quarter of our bird species are found only in New Zealand. By comparison, Great Britain, which separated from continental Europe only 10,000 years ago, has only two endemic species – one plant and one animal.

Cultural importance

New Zealand's biodiversity is important for other reasons as well. Our natural landscapes and unique native plants and animals have strongly shaped our national identity. For many, our distinctive flora and fauna contribute to our sense of belonging to this land. New Zealanders take pride in calling themselves 'Kiwis' after one of the country's most well-known native birds.

Our native species are culturally important to Māori. For example, Māori have traditionally used a variety of native berries, roots, and fruits for food, for dyes and stains, and as medicines. The flowering and fruiting of some native species guided traditional planting and harvesting times and rāhui (periods when harvesting is restricted to allow a resource to regenerate).

Why biodiversity matters

New Zealand's ecological biodiversity performs a number of important services: our ecosystems provide clean air and water, help decompose wastes and recycle nutrients, maintain healthy soils, aid pollination, regulate local climates, and reduce flooding. These ecosystem services help sustain the country's primary production – farming, forestry, viticulture, and horticulture. One study valued the ecosystem services provided by nature each year at $46 billion (Patterson and Cole, 1999). Tourism in New Zealand depends largely on the conservation of our ecosystems.

To many people, the variety of natural life also has an 'intrinsic value' in its own right, independent of its usefulness to human society.

More about New Zealand's known native species

There are an estimated 80,000 native species in New Zealand. Almost 55,000 of these have been identified, and about 30,000 have been scientifically described, named, and classified. Table 12.1 shows the number of native species currently known[1] in New Zealand.

+ TABLE 12.1:
NUMBER OF KNOWN NATIVE SPECIES IN NEW ZEALAND, 2007

GROUP	MARINE	LAND-BASED	FRESHWATER
Bacteria[2]	40	309	341
Protozoa (single-celled eukaryotes – organisms whose cells have membrane-bound nuclei)	1,663	671	465
Chromista (group of eukaryotes other than protozoa)	855	158	922
Plants	626	5,165	1,107
Fungi[3]	3	6,781	255
Animals	12,637	20,337	2,410
Total[4]	15,824	33,421	5,500

Notes:
(1) This includes the numbers of described species plus known species that have not yet been described.
(2) The numbers given for bacteria are based mainly on cultured species in New Zealand. Some of these have not been broken down according to their environment; most are land-based.
(3) The numbers given for aquatic species of fungi are approximate.
(4) The totals provided do not equal the sum of the rows as there is some overlap due to different life-history stages in different environments (for example, aquatic larval stages and land-based adult stages).
Data source: Adapted from Gordon (ed), 2007.

Factors affecting biodiversity

New Zealand has experienced one of the highest extinction rates in the world (Hitchmough et al, 2002). Today, almost 2,500 known land-based and freshwater species of animals, plants, and fungi are classified as threatened in New Zealand.

Human settlement and landscape transformation

Before human settlement, New Zealand was largely forested below the alpine tree line. However, in little more than 1,000 years, much of the country's landscape and ecosystems have been transformed. Fires, land clearance, intensive use of natural resources, and introduced plants and animals have had a cumulative effect on New Zealand's native biodiversity.

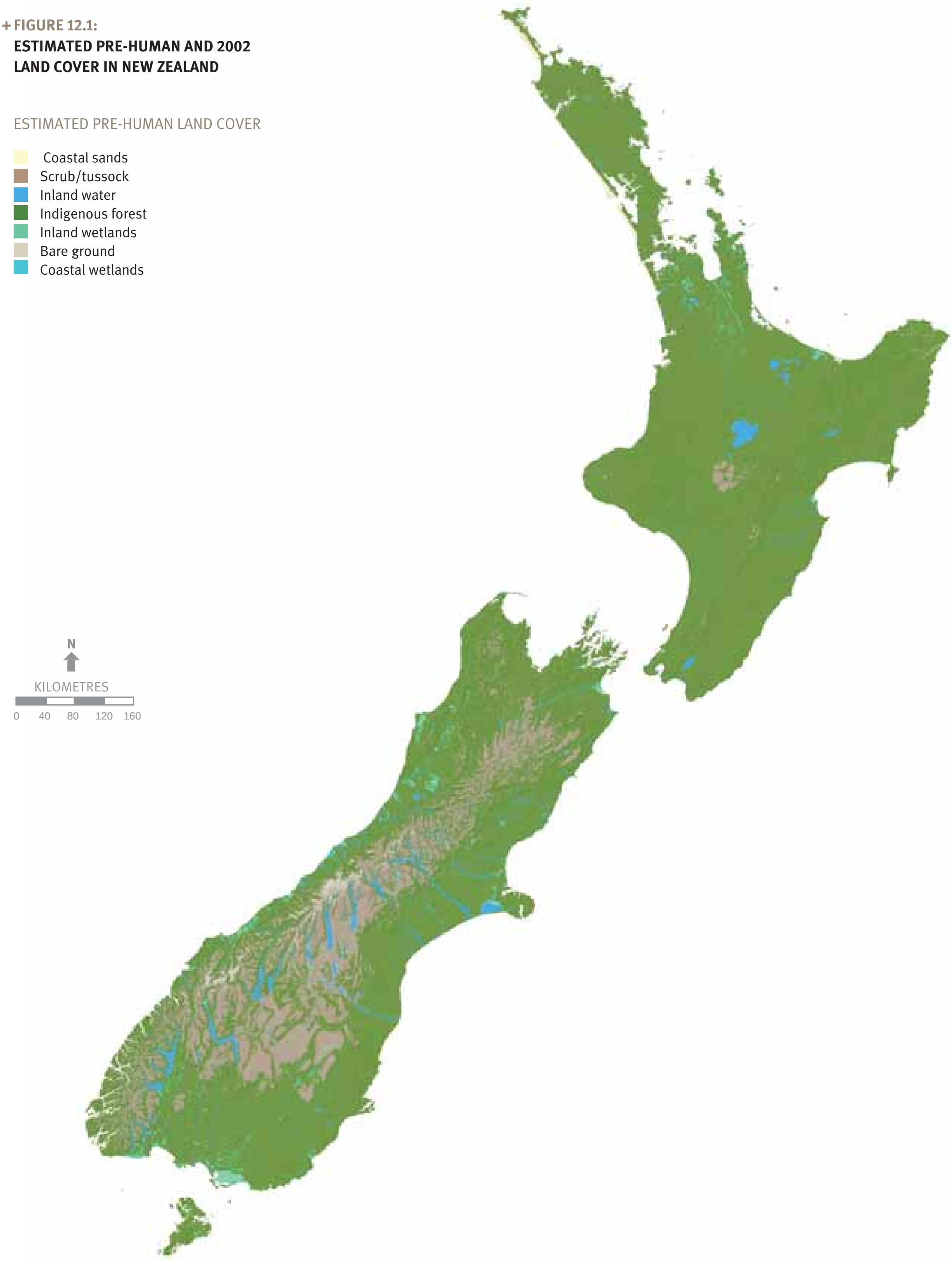
While almost half of the native habitats and ecosystems that existed before human settlement remain in some form today, many of them have been modified. Most of the remaining unmodified habitats are in remote or mountainous areas or on offshore islands (Ministry for the Environment, 2004). Many of them have been (or still are) under pressure from introduced animal pests and weeds.

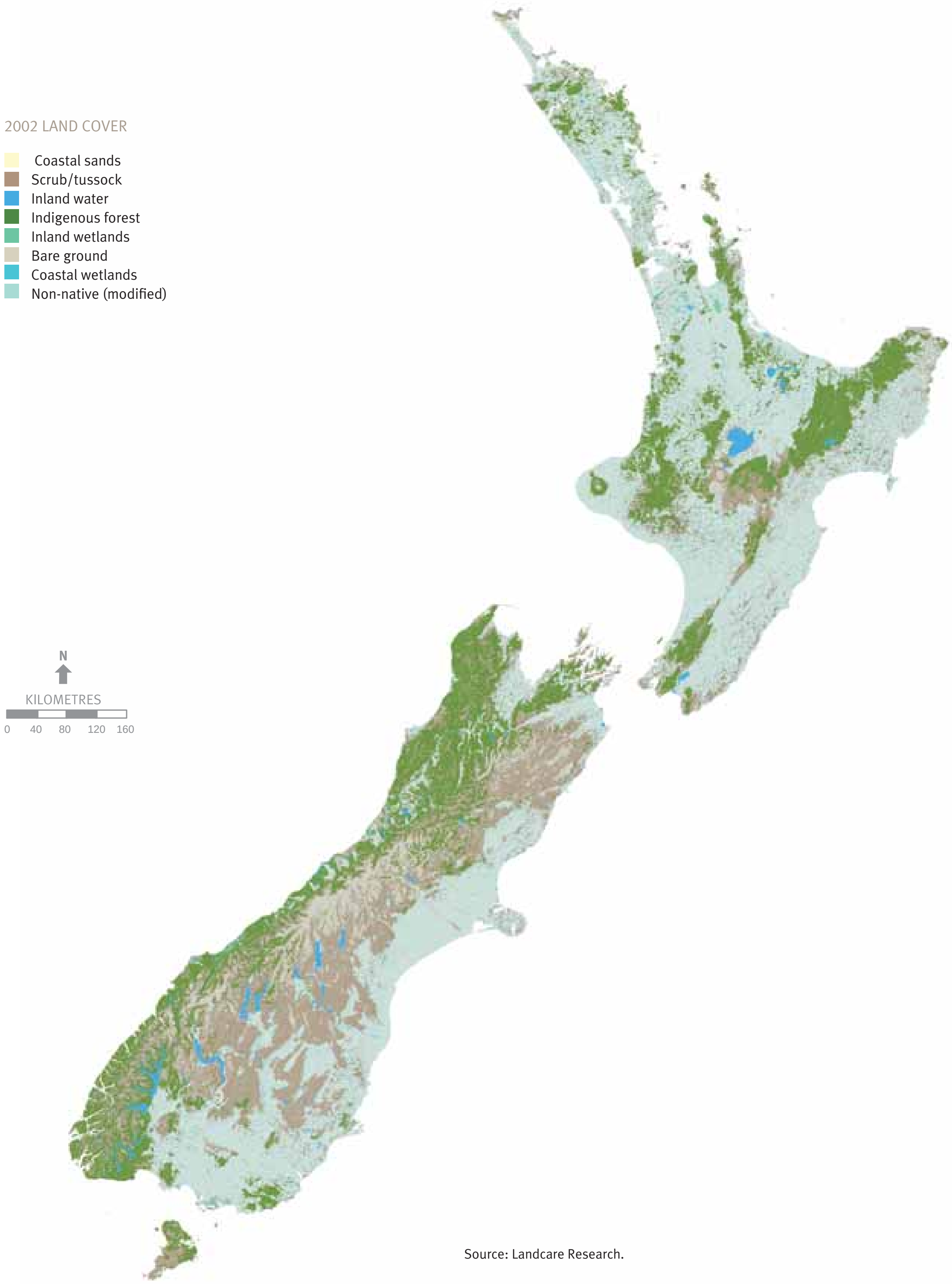
Over the past 200 years, much of New Zealand's most accessible and productive land has been cleared or modified for a range of different land uses, such as agriculture, horticulture, roading, and human settlement. As a result, many of our lowland and coastal forests, lowland grasslands, wetlands, dune lands, and estuaries have been modified. These habitats and ecosystems are particularly at risk of being modified further if they occur on, or are adjacent to, prime agricultural and horticultural land (Ministry for the Environment, 2004).

Many of our lakes, rivers, and streams have been modified by dams, drainage, and irrigation schemes. Some of them are also affected by pollution from agricultural and urban areas, which alters the ecological processes that support downstream freshwater biodiversity.

Changes in land cover can illustrate the impact of human settlement on native habitats and ecosystems. Figure 12.1 compares the estimated land cover before human settlement with the type of land cover in New Zealand today. It shows the significant changes to land cover that have occurred in the intervening period. See chapter 9, 'Land', for further discussion of the changes in land cover in New Zealand.

+ FIGURE 12.1:
ESTIMATED PRE-HUMAN AND 2002 LAND COVER IN NEW ZEALAND





Source: Landcare Research.

Introduced species

The isolated evolution of New Zealand's native species means many of them lack strategies to co-exist with or defend themselves against introduced competitors and predators (Atkinson, 2001). Introduced pest animals and weeds can therefore pose a serious threat to New Zealand's biodiversity in both land and freshwater environments (Organisation for Economic Co-operation and Development, 2007).

Introduced pests, coupled with the loss of native habitats and ecosystems, have caused a substantial decline in New Zealand's native plant and animal species (Saunders and Norton, 2001).

More than 25,000 plant species, 54 mammal species, and about 2,000 invertebrate species have been introduced to New Zealand since it was settled. Nearly 2,000 exotic plant species are now established in the wild. Of the mammals introduced to New Zealand, a group of 31 species now dominates many of our landscapes.

While some of these introduced species, such as sheep and cattle, are cornerstones of New Zealand's agricultural industry, others pose a threat to our native biodiversity. Browsing pests such as goats, deer, and Australian brushtail possums, which also prey on native animals (Atkinson et al, 1995), change the structure and composition of our forests and grasslands. Predators like rats, stoats, and cats hunt some of our rarest native animals. Introduced weeds can smother or overshadow native plants.

Without sustained control of such pests, many of New Zealand's protected ecosystems are at risk of continued biodiversity loss.

New Zealand's biodiversity is not only at risk on land. All freshwater ecosystems, such as streams, lakes, and wetlands, and the freshwater species within them, are influenced by the human activity that occurs on adjacent land and within estuarine areas. Pest species, reduced water quality, and sedimentation can adversely affect biodiversity in these ecosystems.

As an example, wetlands represent some of New Zealand's most diverse ecosystems, but 90 per cent of their original area has been lost through changing land use. Wetlands currently cover fewer than 2,500 square kilometres.

Climate change

Whether plants and animals are native to New Zealand or introduced, most can only survive within a certain climate zone. While most species are able to cope with normal climatic variations, climate change is expected to place additional pressure on many species, particularly those already at risk.

A changing climate is expected to disrupt sensitive food-chain relationships in some ecosystems. For example, there is already evidence in the northern hemisphere that as temperatures grow warmer, some bird species are hatching earlier in the year, when the flower or fruit on which they depend for nourishment may not yet be ready.

Climate-influenced shifts in habitat may also lead to changes in the distribution of species. For example, migration patterns may alter, and the available habitat for sensitive alpine species may diminish with the gradual recession of glacial or snow systems.

As temperatures and climate patterns change, New Zealand may also develop new biosecurity risks, with new tropical pests and diseases potentially becoming established here.

Threatened species

Since human settlement, many of New Zealand's unique native species, such as all species of moa, the Haast's eagle, and the huia, have become extinct. Many more of our native species are currently threatened, with our levels of threatened species rated among the highest in the world (Hitchmough et al, 2007).

Extinction risk is determined by classifying species using the Department of Conservation's Threat Classification System, which takes into account national distribution and abundance, as well as other variables. Table 12.2 shows the threat status of native species in this classification system.

In some species groups, a large proportion of native species are threatened. For example, all of New Zealand's native frog species are threatened as a result of loss of habitats and predation. Diseases are probably also responsible for declines in some species, with a chytrid fungus and a ranavirus recently detected in some native frogs. Five out of six New Zealand bat species are endangered because of predation and loss of the large trees they require as roosts.

Table 12.2 indicates that not enough is known about some groups to reliably determine their threat status. For example, many fungi and plants are listed as 'data deficient', which means insufficient information is available to determine whether they are endangered.

+ TABLE 12.2:
DISTRIBUTION OF THREAT RANKING BY NATIVE SPECIES GROUP ACCORDING TO THE DEPARTMENT OF CONSERVATION'S THREAT CLASSIFICATION SYSTEM, 2005

GROUP		THREATENED			TOTAL THREATENED	DATA-DEFICIENT[1] SPECIES
		ACUTELY THREATENED	CHRONICALLY THREATENED	AT RISK		
Bats		4	0	1	5	1
Birds		62	25	66	153	50
Reptiles		10	23	34	67	12
Frogs		3	0	1	4	0
Freshwater fish		6	14	6	26	21
Invertebrates	Freshwater	14	3	97	114	29
	Land-based	237	52	654	943	1,541
Plants	Bryophytes[2]	88	0	87	175	8
	Vascular plants	175	108	585	868	155
Fungi		49	11	5	65	1,445
Total		648	236	1,536	2,420	3,262

Notes:

(1) Species for which data is deficient may be rare or threatened, but not enough is known to classify them that way.

(2) Bryophytes are non-vascular plants: mosses, liverworts, and hornworts.

Data source: Adapted from Hitchmough et al, 2007.

National environmental indicators

See chapter 1, 'Environmental reporting', for more information on the core national indicators and how they are used.

It is neither practical nor possible to measure the distribution and health of every native plant and animal species or ecosystem, to assess the state of New Zealand's native biodiversity. Instead, the monitoring of New Zealand's land environments and a selected range of native species, habitats, and ecosystems can provide an indicative measure of the state of and changes to native biodiversity.

There are two national environmental indicators for biodiversity.

The first provides information on the area of land covered by native vegetation, including the area under legal protection.

The second indicator provides information on the distribution of selected native species.

The distributions of the following species are measured to provide information for reporting on this indicator:

- lesser short tailed bat
- kiwi
- kākā
- kōkako
- mōhua
- wrybill
- dactylanthus.

Further details on the indicators follow.

Other information is included in this chapter to present a more rounded picture of New Zealand's native biodiversity as follows:

- changes in native land cover, as classified by the Land Cover Database, a satellite map of New Zealand's land cover which describes the types of features present on the surface of the earth
- the location of protected areas
- the extent of wetland areas
- conservation efforts on private land
- the extent and type of pest management on public conservation lands
- the extent of some freshwater weed invasions
- observed changes in the distribution of some common native birds.

NEW ZEALAND'S DIVERSE LAND ENVIRONMENTS HOST MANY DIFFERENT ECOSYSTEMS AND SPECIES.

Source: Courtesy of the Department of Conservation.

Land area with native vegetation

This indicator shows the proportion of land environment covered by native vegetation. It also illustrates the proportion of various native ecosystem types under legal protection.

Data on native vegetation can indicate changes in habitats that are suitable for various native species. Overlaying a map of native vegetation with a map of New Zealand's land environments shows which areas have lost the most native vegetation, and what remains, according to its ecosystem type.

For this mapping and analysis, two reporting tools are used: the New Zealand Land Cover Database, which maps all land cover for mainland New Zealand based on satellite imagery; and the Land Environments of New Zealand classification, an environment-based classification of ecosystems, mapped across New Zealand's landscape. See chapter 1, 'Environmental reporting', for a more detailed explanation of these tools.

To illustrate the vegetation that has been safeguarded and the types of environments protected nationally, we combine data on native vegetation and land environment with the total number of hectares legally protected as public conservation land, regional parks, and covenants on private land.

Distribution of selected native plants and animals

This environmental indicator shows whether selected native species are present or absent in areas where they might be expected to be found, and the change in distribution of these species over time.

Monitoring the quality and extent of suitable native habitats for a selection of 'indicator species' is a practical way of assessing changes in New Zealand's native biodiversity.

Changes in the distribution of a small number of indicator species over specific periods are used to illustrate the changing extent of native habitats over time. The three periods used are: before human settlement; during the 1970s and 1980s; and the present.

Seven indicator species have been selected from the national biodiversity indicator programme currently under development by the Department of Conservation. These species are all managed by the Department under recovery plans, and they were selected for their usefulness as indicators, their habitat requirements, the availability of data for them, and their level of threat. Table 12.3 shows the selection of indicator species and their descriptions.

+ TABLE 12.3:
SELECTION OF NATIVE SPECIES USED TO ILLUSTRATE CHANGES IN NEW ZEALAND'S NATIVE BIODIVERSITY

NAME	WHAT IS IT?	WHY IS IT AN INDICATOR?
Lesser short-tailed bat/pekapeka (*Mystacina tuberculata)* Referred to as lesser short-tailed bat in this report	Endemic bat. Bats are our only native terrestrial mammal	Shows the general health and structure of forested ecosystems in many parts of New Zealand.
Kiwi (*Apteryx* spp.) (five species)	Endemic, flightless bird	A good indicator of the abundance of key mammalian predators in a range of forest types in many parts of the country.
Kākā (*Nestor meridionalis)*	Endemic forest parrot	A good indicator of possum and stoat abundance in a range of forest types in the North and South Islands.
Kōkako (*Callaeas cinerea)*	Endemic New Zealand wattlebird	An indicator of rat and possum densities in North Island forests. The kōkako, because of its sensitivity, only exists in managed sites.
Mōhua/yellowhead (*Mohoua ochrocephala*) Referred to as mōhua in this report	Endemic insectivorous forest bird	A very sensitive indicator of stoat and rat densities in South Island beech forest.
Wrybill/ngutu pare (*Anarhynchus frontalis*) Referred to as wrybill in this report	Small, endemic shorebird that is highly specialised for breeding in braided rivers	These birds depend on South Island braided rivers for their breeding habitat and provide a good indicator of various threats degrading this ecosystem, such as pest predators and direct human impact, including water extraction and four-wheel-drive activities.
Dactylanthus/Woodrose/pua o te rēinga (*Dactylanthus taylorii*) Referred to as dactylanthus in this report	Endemic, parasitic flowering plant	Indicates aspects of forest health in parts of the North Island, including densities of introduced browsers, presence of native pollinators, seed dispersers, and host trees.

Source: Ministry for the Environment.

Limitations of the indicators

The indicators used to report on biodiversity assess only native land-based and freshwater ecosystems. They do not include marine ecosystems. Refer to chapter 11, 'Oceans', for information on marine biodiversity.

The indicators do not provide information on ecosystems at a community or habitat level – that is, the distribution and number of various species in an ecosystem or habitat cannot be determined on the basis of the indicators in this chapter. Neither do the indicators provide information about the quality of the habitats or ecosystems.

Legal protection of native vegetation does not indicate the condition of an ecosystem or habitat – that is, it does not show how effective the legal protection is. Conversely, active pest management on land contributes to biodiversity goals, even if the land is not formally protected.

Information about the indicator species discussed in this chapter illustrates changes in the distribution of these species, but does not illustrate the abundance or stability of populations.

United Nations Convention on Biological Diversity 1993

The United Nations Convention on Biological Diversity has 190 parties and although it is largely descriptive it is considered the primary international convention on biodiversity. New Zealand's 1993 ratification of the convention confirmed our commitment to international efforts to conserve global biodiversity and use it sustainably.

Under the convention, governments are required to develop national biodiversity strategies and action plans, and to integrate these into broader national plans for sustainable development. These requirements are met in New Zealand through domestic environmental policy and initiatives, including the New Zealand Biodiversity Strategy 2000.

New Zealand Biodiversity Strategy 2000

The New Zealand Biodiversity Strategy reflects New Zealand's commitment to the United Nations Convention on Biological Diversity. The strategy sets out the Government's response to declining native biodiversity in broad terms. It identifies national goals and principles for managing New Zealand's biodiversity, and action plans for achieving the goals.

The biodiversity indicators and environmental classifications presented in this report form part of the strategy's action plan for Theme 9 ('Information, knowledge and capacity') (Department of Conservation and Ministry for the Environment, 2000).

Current state and trends

Native vegetation cover and legal protection

This section reports on the area of native vegetation cover in New Zealand and the legal protection it receives.

Each native land cover class is shown by area (measured by data from the Land Cover Databases 1 (LCDB 1) and 2 (LCDB 2)), and by land environment type (as classified by Land Environments of New Zealand, a land-based classification tool).

Table 12.4 shows the estimated change in area of New Zealand's native land cover between 1997 and 2002, as well as the extent of legal protection each native cover class received.

Past and present land cover

In 2002, more than 13.3 million hectares of New Zealand's land was covered by native land cover, as estimated by the Land Cover Database 2 (Table 12.4). This equates to 49.6 per cent of New Zealand's total land area (26.9 million hectares). The area of native vegetation (excluding other native land cover, such as permanent snow and ice) equates to 43.7 per cent (11.7 million hectares) of New Zealand's total land area.

Between 1997 and 2002, it is estimated that native land cover decreased by 16,500 hectares (0.12 per cent). This total decrease included an increase of 700 hectares of non-vegatative native cover, such as sand and gravel, and a decrease of 17,200 hectares of native vegetative cover. These changes either occurred through conversion of land to other uses, or as a result of natural processes.

The vegetation types that have experienced the greatest loss are broadleaved native hardwoods, mānuka and/or kānuka, tall tussock grassland, and native forest. Changes recorded by the Land Cover Database 2 show broadleaved native hardwood land cover was mainly converted into exotic forestry (83 per cent), or cleared for pasture (12.5 per cent). Similarly, mānuka and/or kānuka stands were converted into exotic forestry (52.5 per cent), or pasture (46 per cent).

The changes in native forest cover shown in Table 12.4 were largely due to harvesting (82.5 per cent) and some conversion to exotic forestry (11 per cent). All the tall tussock grassland cover that experienced land-use change was converted into exotic forestry.

Legal protection

Table 12.4 shows that in 2006, about 62.4 per cent (8.3 million hectares) of New Zealand's total native land cover was legally protected. This represents 35 per cent of New Zealand's total land area. Of our native vegetation (excluding other native land cover, such as permanent snow and ice), 63.7 per cent is legally protected.

Some native vegetation types receive comparatively high levels of protection. For example, in 2006, 79.6 per cent of the remaining native forests, 81.5 per cent of the remaining sub-alpine shrublands, and 80.7 per cent of the remaining alpine grass/herbfields were protected. Other vegetation types are represented to a lesser degree in legally protected areas.

+ TABLE 12.4:

ESTIMATED CHANGE IN NATIVE VEGETATION AND OTHER NATIVE LAND-COVER CLASSES (1997 AND 2002) USING SATELLITE IMAGERY (LCDB 1 AND LCDB 2) AND THE EXTENT OF LEGAL PROTECTION FOR EACH LAND COVER CLASS

NATIVE LAND COVER CLASS	AREA (HECTARES)		PERCENTAGE DIFFERENCE (%)	AREA LEGALLY PROTECTED IN 2006	
	1997	2002		HECTARES	PERCENTAGE OF 2002 AREA (%)
Alpine grass/herbfield	224,400	224,400	0.00	181,100	80.72
Broadleaved native hardwoods	546,200	539,600	–1.22	199,500	36.97
Depleted grassland	250,500	250,500	0.00	33,300	13.29
Fernland	51,800	51,700	–0.15	8,200	15.82
Flaxland	6,500	6,500	0.00	3,600	55.83
Grey scrub[1]	72,500	72,400	–0.06	9,800	13.52
Herbaceous freshwater vegetation	88,800	88,700	–0.13	41,400	46.71
Herbaceous saline vegetation	19,300	19,200	–0.45	6,700	34.8
Native forest	6,459,400	6,457,000	–0.04	5,136,600	79.55
Mangrove	26,000	26,000	0.00	2,600	9.8
Mānuka and/or kānuka	1,191,600	1,186,200	–0.45	362,800	30.59
Matagouri[2]	29,500	29,500	–0.02	3,100	10.32
Sub-alpine shrubland	385,400	385,400	0.00	314,200	81.53
Tall tussock grassland	2,397,100	2,394,600	–0.10	1,175,500	49.09
Total native vegetation cover	11,748,900	11,731,700	–0.15	7,478,300	63.74
Alpine gravel and rock	698,000	698,100	0.01	506,400	72.53
Coastal sand and gravel	51,300	51,300	–0.07	18,900	36.8
Estuarine open water	92,500	92,500	0.00	3,600	3.86
Lake and pond	356,800	357,500	0.20	121,500	33.98
Landslide	17,000	17,000	–0.26	11,600	68.16
Permanent snow and ice	111,000	111,000	0.00	109,200	98.43
River	81,900	81,900	0.00	18,100	22.09
River and lakeshore gravel and rock	179,700	179,700	0.00	45,900	25.56
Total other native land cover	1,588,400	1,589,100	0.04	835,100	52.56
Total native land cover	13,337,300	13,320,800	–0.12	8,313,446	62.41

Notes:

(1) Grey scrub is a classification for areas covered with small-leaved shrubs such as small-leaved *Coprosma* species.

(2) Matagouri (*Discaria toumatou*) is a thorny shrub found in open, moist areas, which is known to invade pastures.

(3) Figures rounded to the nearest 100 hectares. Percentages are calculated from unrounded figures.

(4) Any discrepancies between hectares shown for land-cover classes and totals shown on this table are due to rounding.

Data source: Landcare Research.

The Resource Management Act 1991 and biodiversity

The Resource Management Act 1991 has a key role in managing New Zealand's terrestrial and freshwater biodiversity. Because almost all forms of resource use affect native biodiversity, biodiversity is recognised in the Act in many ways:

- All plants and animals come within the definition of natural resources (section 5).
- Section 6(c) refers to the protection of areas of significant native vegetation and significant habitats of native fauna.
- Section 7(d) refers to the intrinsic value of ecosystems.
- Section 30(1)(c)(iiia): Regional councils are responsible for controlling the use of land for the purpose of maintaining and enhancing ecosystems in water bodies and coastal waters.
- Section 30(1)(ga): Regional councils are responsible for establishing, implementing, and reviewing objectives, policies, and methods for maintaining native biological diversity.
- Section 31(b)(iii): Territorial authorities are responsible for controlling the effects of land use to maintain native biological diversity.

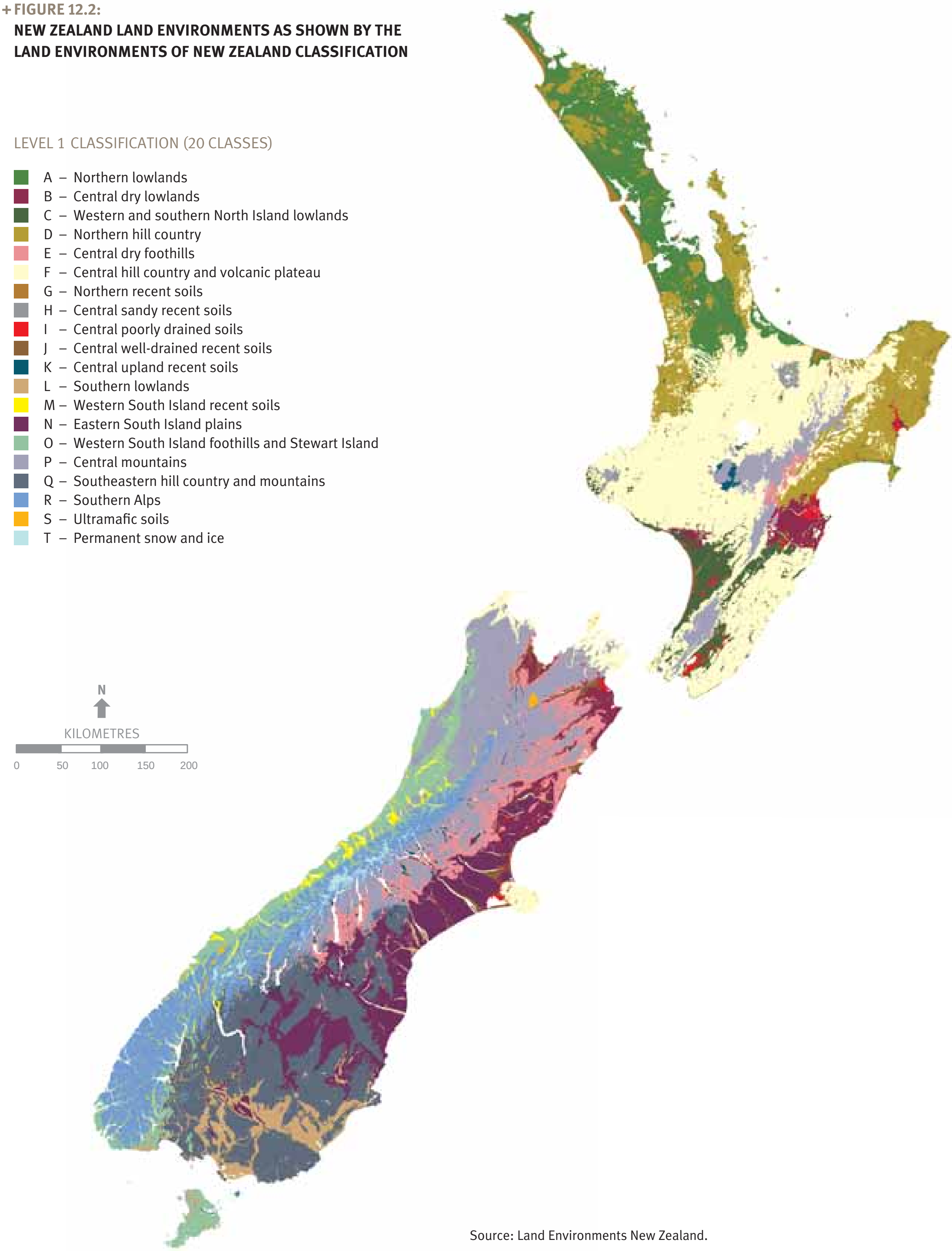
Amendments to the Act in 2003 clarified that regional councils and territorial authorities are responsible for managing native biodiversity. Local authorities must consider the consequences of all effects on native biodiversity, not simply the significance of a species or habitat.

Figure 12.2 maps New Zealand's land environments into 20 classes, as identified in the Land Environments New Zealand classification. Table 12.5 shows the area and percentage of native land cover (both vegetative and non-vegetative) for each of the 20 land environments mapped in Figure 12.2. It also shows how much of these areas were legally protected in 2006. By combining the information shown in Table 12.4 and Table 12.5, we can see which areas have lost most native land cover, what the type of land cover was, and to what extent the remaining native land cover is legally protected.

+ FIGURE 12.2:
NEW ZEALAND LAND ENVIRONMENTS AS SHOWN BY THE LAND ENVIRONMENTS OF NEW ZEALAND CLASSIFICATION

LEVEL 1 CLASSIFICATION (20 CLASSES)

- A – Northern lowlands
- B – Central dry lowlands
- C – Western and southern North Island lowlands
- D – Northern hill country
- E – Central dry foothills
- F – Central hill country and volcanic plateau
- G – Northern recent soils
- H – Central sandy recent soils
- I – Central poorly drained soils
- J – Central well-drained recent soils
- K – Central upland recent soils
- L – Southern lowlands
- M – Western South Island recent soils
- N – Eastern South Island plains
- O – Western South Island foothills and Stewart Island
- P – Central mountains
- Q – Southeastern hill country and mountains
- R – Southern Alps
- S – Ultramafic soils
- T – Permanent snow and ice



Source: Land Environments New Zealand.

+ TABLE 12.5:
NATIVE LAND COVER BY LAND ENVIRONMENT, AND LEGALLY PROTECTED NATIVE LAND COVER, 2006, WITHIN EACH LAND ENVIRONMENT

LAND ENVIRONMENT	TOTAL AREA (HECTARES) OF LAND ENVIRONMENT	PERCENTAGE OF TOTAL LAND AREA (%)	AREA (HECTARES) OF LAND ENVIRONMENT WITH NATIVE LAND COVER	PERCENTAGE OF LAND ENVIRONMENT WITH NATIVE LAND COVER (%)	AREA (HECTARES) OF NATIVE LAND COVER WITH LEGAL PROTECTION	PERCENTAGE OF NATIVE LAND COVER WITH LEGAL PROTECTION (%)
A – Northern lowlands	1,849,768	7.05	337,759	18.26	84,754	25.09
B – Central dry lowlands	691,023	2.64	70,437	10.19	6,526	9.26
C – Western and southern North Island lowlands	636,039	2.43	27,014	4.25	5,783	21.41
D – Northern hill country	2,100,703	8.01	927,561	44.15	469,804	50.65
E – Central dry foothills	1,323,134	5.05	591,154	44.68	229,675	38.85
F – Central hill country and Volcanic Plateau	5,241,257	19.99	1,901,125	36.27	999,483	52.57
G – Northern recent soils	336,969	1.28	56,205	16.68	18,274	32.51
H – Central sandy recent soils	135,305	0.52	47,804	35.33	31,187	65.24
I – Central poorly drained soils	120,999	0.46	6,159	5.09	2,390	38.80
J – Central well-drained recent soils	292,689	1.12	20,779	7.10	3,277	15.77
K – Central upland recent soils	160,758	0.61	63,831	39.71	19,936	31.23
L – Southern lowlands	801,869	3.06	104,945	13.09	59,356	56.56
M – Western South Island recent soils	220,444	0.84	121,532	55.13	98,584	81.12
N – Eastern South Island plains	2,044,301	7.80	163,565	8.00	8,780	5.37
O – Western South Island foothills and Stewart Island	1,412,650	5.39	1,279,893	90.60	1,161,159	90.72
P – Central mountains	3,247,880	12.39	3,029,280	93.27	2,313,193	76.36
Q – Southeastern hill country and mountains	3,276,038	12.49	1,780,287	54.34	622,273	34.95
R – Southern Alps	1,929,739	7.36	1,927,944	99.91	1,816,279	94.21
S – Ultramafic soils	33,485	0.13	32,513	97.10	31,059	95.53
T – Permanent snow and ice	157,144	0.60	157,128	99.99	153,603	97.76
Unspecified	211,114	0.81	116,986	55.41	29,486	25.20
Total	26,223,310	100.00	12,763,904	48.67	8,164,862	63.97

Notes:

(1) This report uses a total land area for New Zealand derived from the Land Environments of New Zealand classification tool. It results in a smaller total land area than that derived by other means.

(2) Ultramafic soils are derived from molten rock (magma) that are rich in iron and magnesium and have a low silica content.

Data source: Landcare Research.

Table 12.5 shows that it is generally lowland environments, some recent soils, and the eastern South Island plains that have lost substantial native land cover since human settlement. Where native land cover does remain within these land environments, there is mostly low to medium legal protection for conservation purposes (between 5 per cent and 40 per cent). This has implications for the threatened species that require unmodified lowland habitats to survive.

As an example, the western and southern North Island lowlands and eastern South Island plains have lost 95.8 per cent and 92 per cent of their respective original native land cover. Of these land environments, 21.4 per cent and 5.4 per cent, respectively, are legally protected.

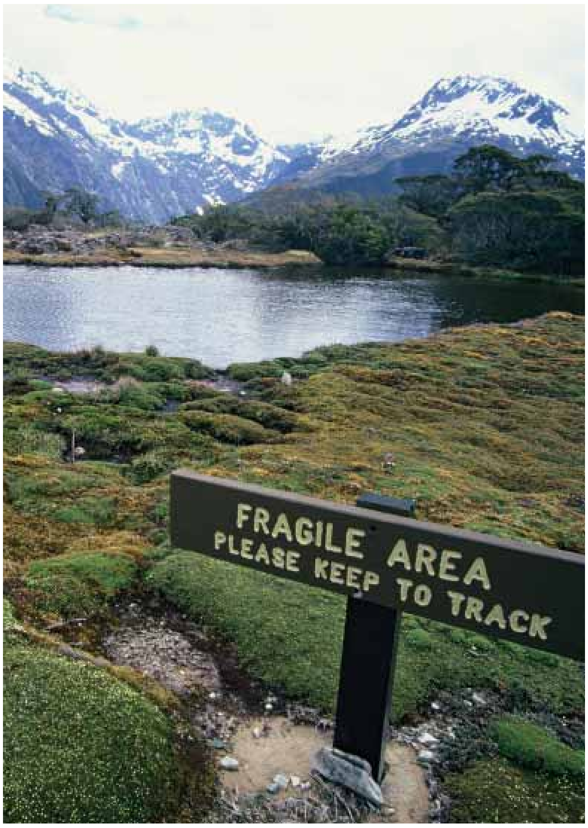
In contrast, the central mountains and Southern Alps have lost less than 6.7 per cent and 1 per cent, respectively, of their original native land cover. Of this, 76.4 per cent and 94.2 per cent, respectively, of the remaining native land cover is under legal protection.

Wetlands

Wetland ecosystems, where land and freshwater meet, often support particularly high levels of biodiversity. They provide the water and nutrients that countless species of plants and animals depend on for survival (Ramsar Convention, 2007). However, increasing demand for accessible land has led to the conversion or modification (including drainage) of a large proportion of New Zealand's wetland areas to provide pastoral land cover.

Figure 12.3 shows the estimated original and current extent of wetland areas. Just over 10 per cent of the original wetland environment remains across New Zealand (4.9 per cent of the original area in the North Island, and 16.6 per cent in the South Island). Of this amount, less than half is legally protected. Many of the remaining wetlands are situated on private land.

WETLANDS CUSHION BOG AT KEY SUMMIT, FIORDLAND NATIONAL PARK.

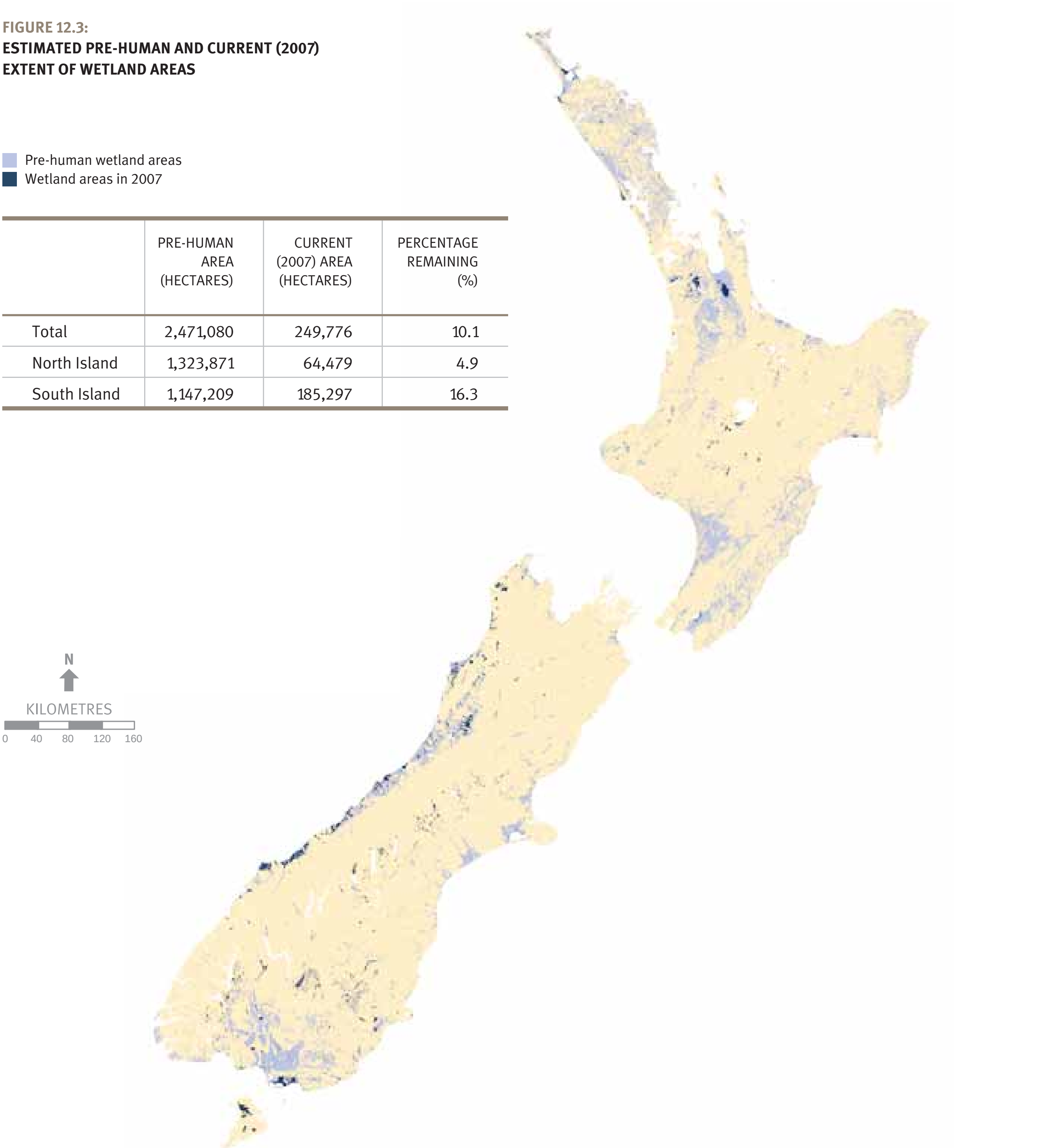


Source: Courtesy of the Department of Conservation.

+ FIGURE 12.3:
ESTIMATED PRE-HUMAN AND CURRENT (2007) EXTENT OF WETLAND AREAS

Pre-human wetland areas
Wetland areas in 2007

	PRE-HUMAN AREA (HECTARES)	CURRENT (2007) AREA (HECTARES)	PERCENTAGE REMAINING (%)
Total	2,471,080	249,776	10.1
North Island	1,323,871	64,479	4.9
South Island	1,147,209	185,297	16.3



Data source: Department of Conservation.

New Zealand has designated six wetlands as having global importance under the Ramsar Convention on Wetlands, 1971 (Table 12.6). Together, these wetlands cover a surface area of 39,068 hectares.

+TABLE 12.6:
WETLANDS DESIGNATED UNDER THE RAMSAR CONVENTION ON WETLANDS

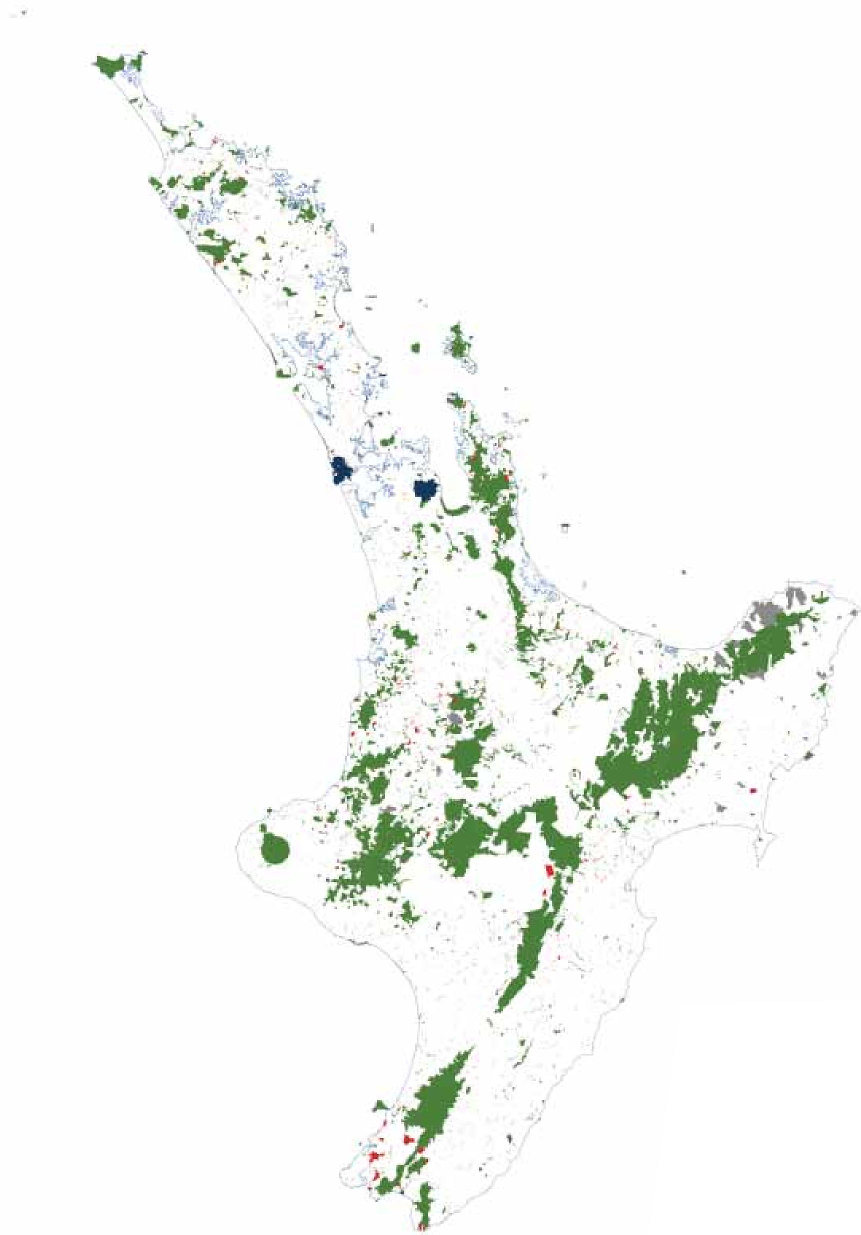
SITE NAME AND LOCATION	DATE OF DESIGNATION	SURFACE AREA IN HECTARES	DESCRIPTION
Farewell Spit, South Island	1976	11,388	Nature reserve; shorebird network site A 30-kilometre long sand spit and inter-tidal area with a dune complex giving way to mudflats on the south. Particularly important as a staging area for shorebirds. Also supports several notable plant species.
Waituna Lagoon, South Island	1976	3,556	Scientific reserve A coastal lagoon, peatlands, saltmarsh, gravel beach, ponds, and lakes. These habitats provide important areas for waders and various other waterbirds. Endemic butterfly species and two species of endangered fish occur. The site supports numerous native plant species, some typical of alpine regions.
Kopuatai Peat Dome, North Island	1989	10,201	Stewardship area; wildlife management reserve The largest unaltered raised bog in New Zealand, surrounded by mineralised swampland and associated lagoons. Important area for threatened birds and plants, and notable invertebrates. A spawning site for threatened fish.
Whangamarino, North Island	1989	5,923	Stewardship area The second largest peat bog and swamp complex on the North Island. The most important breeding area in New Zealand for matuku (*Australasian bittern*) and habitat for wintering birds and endangered species of plants and fish.
Firth of Thames, North Island	1990	7,800	Coastal reserve; shorebird network site A large coastal reserve consisting of shallow marine water, mud and grass flats, mangrove swamp, saltmarsh, and swampland. Includes a globally rare land formation of graded shell beach ridges that support grazing. Important site for roosting, wintering, and staging wading birds.
Manawatū River mouth and estuary, North Island	2005	200	Estuarine system An estuary retaining a high degree of naturalness and diversity, important as a feeding ground for migratory birds, including wrybill. The saltmarsh–ribbonwood community is the largest in the ecological district and contains its southernmost and biggest population of fernbirds (*Bowdleria punctata*). A high diversity of fish is supported, including some that are threatened. Archaeological signs of the semi-nomadic moa hunter culture dating from AD1400–1650 support Ramsar designation.

Source: Adapted from Ramsar Convention, 2007.

Legal protection of land

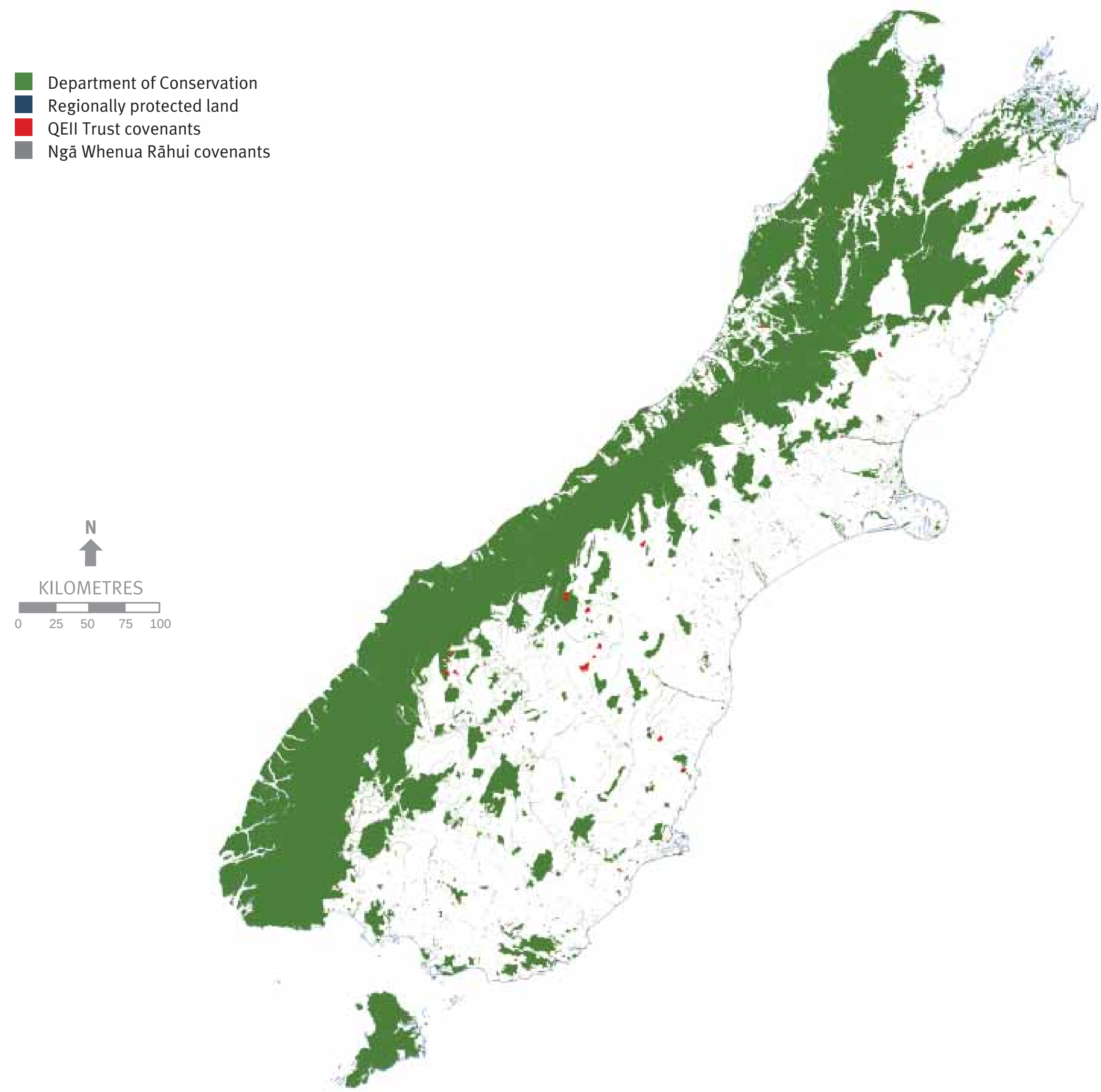
Land under legal protection for conservation purposes includes public conservation lands managed by the Department of Conservation, parks managed by regional authorities, and private land protected under covenant by the Queen Elizabeth II National Trust (QEII Trust) and Ngā Whenua Rāhui. Figures 12.4 and 12.5 show the location and extent of New Zealand's land-based legally protected areas.

+ FIGURE 12.4:
LEGALLY PROTECTED AREAS – NORTH ISLAND, 2006



Data source: Landcare Research.

+ FIGURE 12.5:
LEGALLY PROTECTED AREAS – SOUTH ISLAND, 2006



Data source: Landcare Research.

TONGARIRO WAS THE FIRST NATIONAL PARK IN NEW ZEALAND, ESTABLISHED IN 1887.

Source: Courtesy of the Department of Conservation.

Most legally protected land is part of the public conservation lands that cover large tracts of native forest and alpine areas. The Department of Conservation is responsible for preserving and protecting these areas, including managing threats from invasive pests and diseases.

By October 2007, 8.43 million hectares of land were legally protected for conservation purposes in New Zealand. This includes public conservation lands managed by the Department of Conservation and councils, and private land protected under covenants by the QEII Trust and Ngā Whenua Rāhui.

What is Ngā Whenua Rāhui?

Ngā Whenua Rāhui is a contestable fund that was established in 1991 to promote the voluntary protection of native ecosystems on Māori-owned land. To date, about 146,800 hectares of native ecosystems have been protected through this fund.

Public conservation lands

Public conservation lands (Crown conservation land and council-protected land) have also increased. In 2004, 8.06 million hectares were set aside in New Zealand for public conservation land (Ministry for the Environment, 2004). By the end of 2006, a total of 9.27 million hectares were legally protected, which is an increase of 14.95 per cent.

The increase in public conservation land has been partly achieved through the buy-back of Crown-owned land that was formerly leased or licensed to others. The Crown Pastoral Land Act 1998 authorised the review of 304 state-owned properties totalling 2.37 million hectares in the South Island high country, which had been leased to farmers for livestock grazing since the 1940s. The review's objectives are to promote ecologically sustainable land management, protect land that has significant inherent value, secure public access to and enjoyment of the land, and dispose of any surplus land.

By September 2006, 226,000 hectares had been transferred to full government ownership to create a network of high-country parks and reserves.

Private conservation of land

While most of the effort to protect New Zealand's native vegetation occurs on legally protected land, efforts to protect native vegetation on private and council-owned land are increasing.

In 2004, a total of 146,280 hectares were registered as formally protected private land (Ministry for the Environment, 2004). By June 2006, registered QEII National Trust and Ngā Whenua Rāhui covenants formally protected a total of 221,473 hectares. The area on private land that is legally protected through these two mechanisms has increased by 51.4 per cent over this two-year period.

As an example, the number of covenants processed through the QEII Trust has continuously increased since 1977. By June 2007, 82,933 hectares were legally protected through more than 2,600 QEII Trust covenants. Figure 12.6 shows the location of QEII Trust covenants, as well as the number of registered QEII Trust covenants and the total land area protected by June 2006.

Private conservation initiatives

What is the Landcare Trust?

The Landcare Trust was established in 1996, with the vision of promoting sustainable land management. There are currently more than 250 landcare groups operating around New Zealand. Their level of activity and pace depends on the community they are based in and the specific issues they are trying to address.

Landcare groups are particularly numerous and active in some regions. Major initiatives are prominent where regional councils have set up active programmes for biodiversity protection and offer incentives or assistance to landholders (Davis, 2002).

Karori Wildlife Sanctuary

The Karori Wildlife Sanctuary, located 2 kilometres from Wellington city and run by a charitable community trust, has been developed as a major educational, research, and recreational site for the benefit of all New Zealanders.

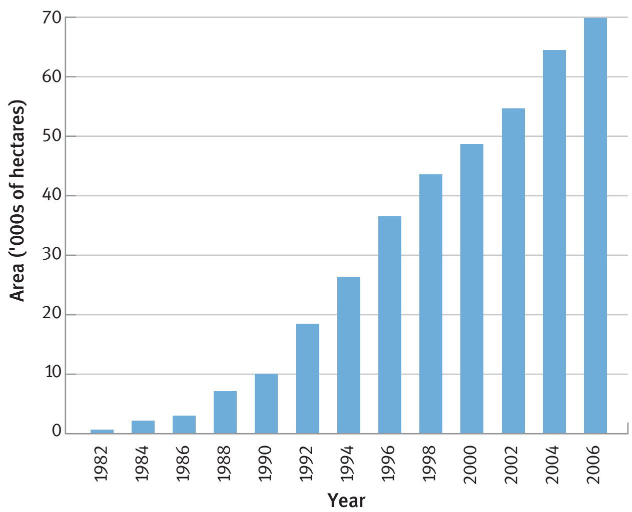
The sanctuary is a 252-hectare haven for endangered native birds and other wildlife. A predator-proof fence, specifically designed to exclude 14 species of non-native mammals ranging from possums to mice, encircles the 8.6-kilometre perimeter.

Many threatened species of native wildlife are expected to be reintroduced to the sanctuary as appropriate habitats recover. The little spotted kiwi, stitchbird (hihi), weka, saddleback (tīeke), kākā, bellbird (korimako), whitehead (pōpokatea), and tuatara have already been released there.

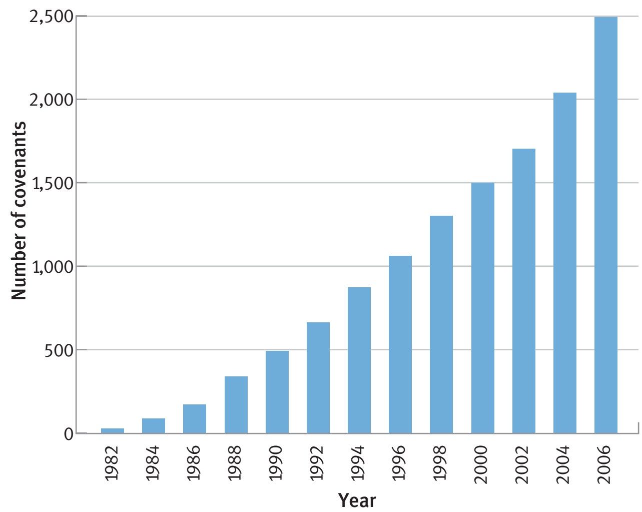
+ FIGURE 12.6:
LOCATION OF QUEEN ELIZABETH II NATIONAL TRUST COVENANTS AND REGISTERED COVENANTS, AND AREA PROTECTED, JUNE 2006

Data source: Queen Elizabeth II National Trust.

TOTAL AREA PROTECTED BY QEII COVENANTS, 1982–2006



TOTAL NUMBER OF REGISTERED QEII COVENANTS, 1982–2006



More about the Queen Elizabeth the Second National Trust

The Queen Elizabeth the Second National Trust (QEII Trust) is a statutory organisation, independent from government, which was established in 1977 under the Queen Elizabeth the Second National Trust Act 1977.

The QEII Trust was established at the request of New Zealand farmers to protect open space on private land for the benefit and enjoyment of the present and future generations of New Zealanders.

A covenant is generally requested by the landowner and registered against the title of the land in perpetuity. The values of each covenant are identified in the covenant document. Each registered covenant is monitored every two years to ensure the land is managed in accordance with the covenant document. More than 95 per cent of covenant owners meet or exceed covenanting requirements with a resulting increase in biodiversity and sustainability of land and resources.

Over the past 10 years, landowners have increasingly recognised a QEII covenant as a mechanism to protect areas of land they value. Councils see QEII covenants as a cost effective method to manage and improve biodiversity in their regions.

The QEII Trust generally contributes to the cost of fencing, surveying, and registration on the title, often with the help of local or regional councils or conservation groups.

As a result of increases in the area protected by covenant, many of New Zealand's ecosystem types that have become uncommon due to human activity are now represented in the QEII Trust covenanted areas. The number of covenants that include these rare habitats and ecosystems, such as wetlands and lowland forests, has increased. Table 12.7 shows the increase in QEII covenants for lowland forest and wetland systems since the late 1990s.

+ TABLE 12.7:
REGISTERED COVENANTS BY THE QUEEN ELIZABETH II NATIONAL TRUST, AND THE ECOSYSTEM TYPES WITHIN THEM

ECOSYSTEM TYPE	NUMBER OF REGISTERED COVENANTS THAT INCLUDE THIS ECOSYSTEM TYPE				
	1977–1986	1987–1996	1997–2007	TOTAL NUMBER OF COVENANTS	TOTAL AREA (HECTARES) OF COVENANTS
Lowland forest	124	595	820	1,539	34,963
Non-lowland forest	21	196	372	589	28,593
Wetland, stream, bog, river, lake	16	77	209	302	8,496
Saltmarsh, estuarine, dune, sandplain	1	9	18	28	502
Montane saline plain	0	0	2	2	166
Tussock system	2	12	31	45	11,741
Archaeological, such as pa or other historical site	3	8	25	36	1,670
Geological feature such as rock, bluff, scree, cliff, outcrop, limestone	6	23	22	51	2,668

Note:

Ecosystem types listed here follow the 'ecotypes' the QEII National Trust uses to classify specific habitat, ecosystem, landform, and landscape types.

Data source: Queen Elizabeth II National Trust.

Some of New Zealand's most endangered species find refuge in QEII Trust covenanted areas. For example, Table 12.8 shows that 51 QEII Trust covenants are home to at least one of the native indicator species shown in Table 12.3.

+ TABLE 12.8:
OCCURRENCE OF SPECIES COVERED IN THIS REPORT THAT ARE FOUND IN QUEEN ELIZABETH II NATIONAL TRUST COVENANTS, 2007

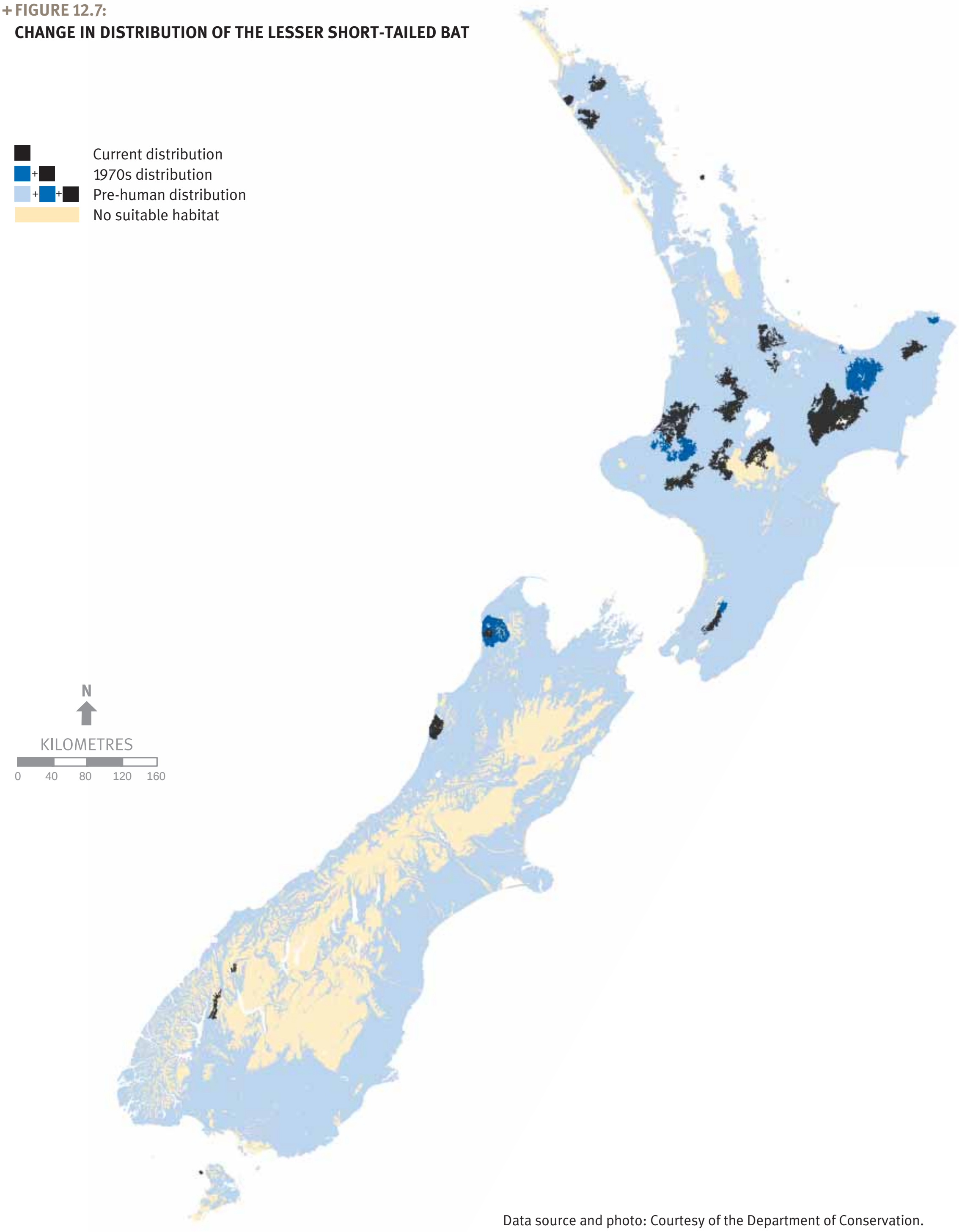
SPECIES	NUMBER OF COVENANTS WHERE SPECIES IS PRESENT	TOTAL AREA (HECTARES) OF COVENANTS WHERE SPECIES IS PRESENT
Kiwi (North Island brown)	38	2,329
Kākā	10	339
Wrybill	1	1
Mōhua	1	8
Dactylanthus	1	39
Total	51	2,716

Data source: Queen Elizabeth II National Trust.

Distribution of selected native species

The following maps provide information on the distribution of the seven selected native species used as indicators of biodiversity levels. All seven species show a marked decrease in their range since human settlement, due to loss of habitats and the impacts of introduced pests.

+ FIGURE 12.7:
CHANGE IN DISTRIBUTION OF THE LESSER SHORT-TAILED BAT



Data source and photo: Courtesy of the Department of Conservation.

SHORT-TAILED BAT (*MYSTACINA TUBERCULATA*).

There are three subspecies of the lesser short-tailed bat: the northern short-tailed bat, which is nationally endangered; the central short-tailed bat, which is range restricted; and the southern short-tailed bat. The Tararua Ranges population of the southern short-tailed bat is nationally critical and its southern populations are nationally endangered.

The bats live in indigenous forests where they roost in hollow trees. They forage for extended periods on the forest floor, using their folded wings as 'front limbs'. Their diet consists of insects, fruit, nectar, and pollen, and they are an important pollinator of the plant dactylanthus.

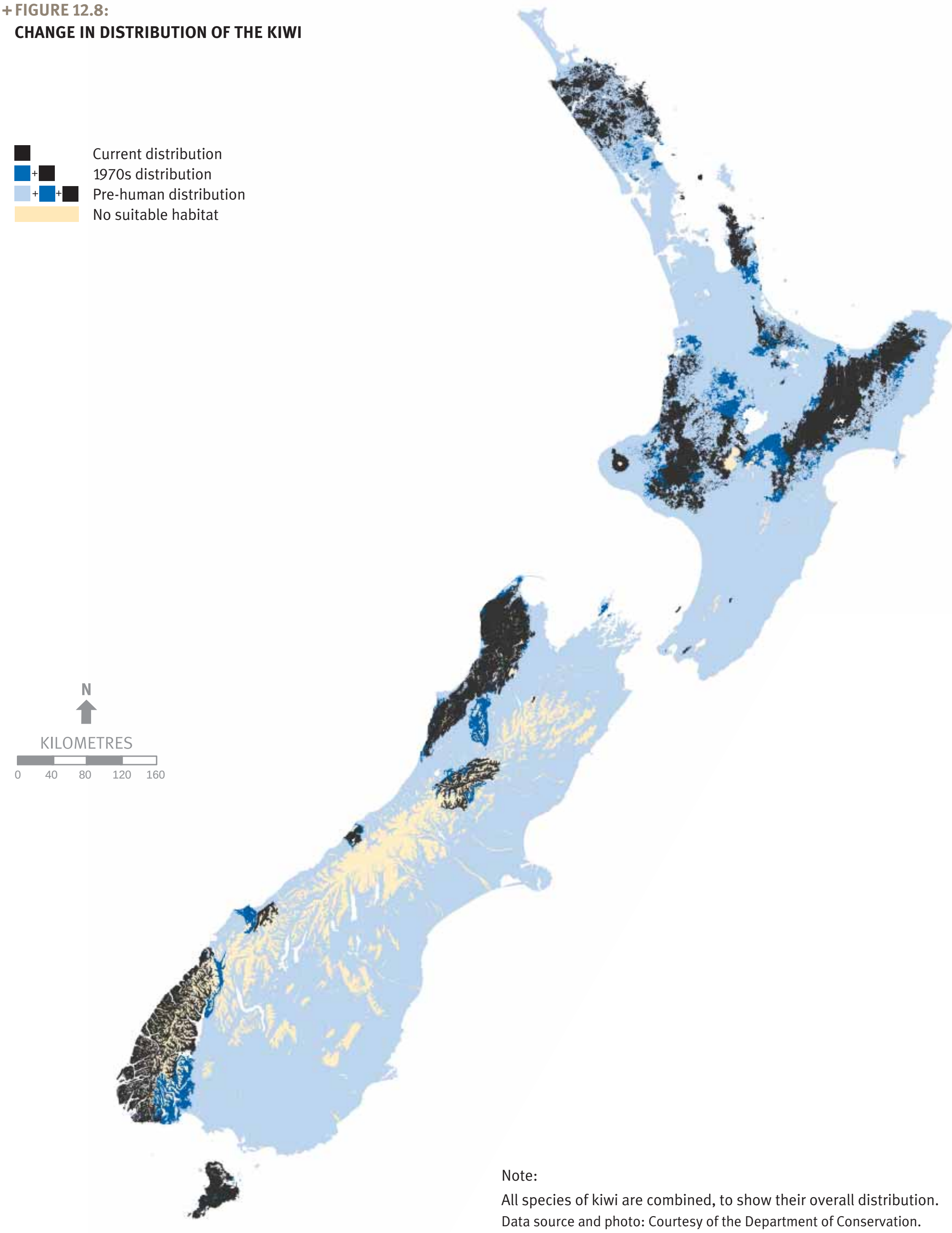
Pressures include introduced predators such as rats, stoats, and cats as well as browsers and wasps. Some of their habitat is threatened by selective logging of large trees, which results in a loss of roost sites.

The management of the bats is guided by a recovery plan that includes protecting their roost sites from destruction or disturbance, introducing predator control programmes at important sites, and monitoring key populations. Attempts are being made to establish 'insurance populations' of short-tailed bats in predator-free environments in case they do not survive in their present habitats. Captive husbandry and breeding have also been used.

The lesser short-tailed bat currently occupies less than 5 per cent of the range it was estimated to have before human settlement. Its current distribution is about 75 per cent of its range in the 1970s.

The northern lesser short-tailed bat is found at two sites in Northland and one on Little Barrier Island. The central lesser short-tailed bat is found in Northland, the central North Island, and Taranaki. The southern lesser short-tailed bat is found in the Tararua Ranges, on Codfish Island, in northwest Nelson, and in Fiordland.

+ FIGURE 12.8:
CHANGE IN DISTRIBUTION OF THE KIWI



Note:
All species of kiwi are combined, to show their overall distribution.
Data source and photo: Courtesy of the Department of Conservation.

KIWI (*APTERYX SPP.*).

Kiwi are flightless, nocturnal birds, which feed largely on invertebrates. They lay a single, very large egg. Currently, the populations of the five kiwi species total about 70,000.

All kiwi species are in decline and considered threatened. Their rates of decline depend on the densities of introduced predators, especially dogs, ferrets, stoats, and cats. The fastest rate of decline is in lowland areas, with slower declines or stable populations at high-altitude sites, where predators are absent or scarce.

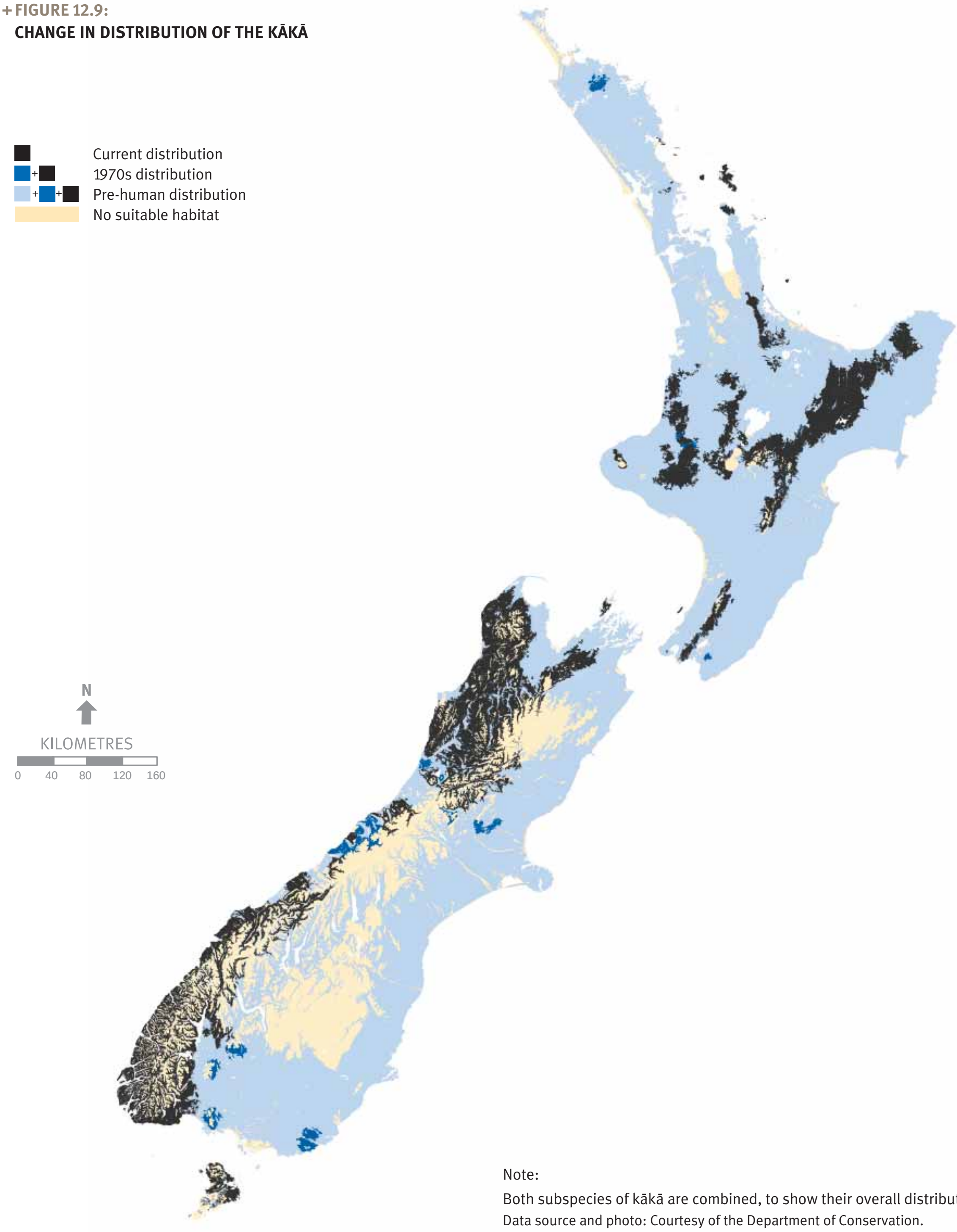
Guided by a recovery plan, the Department of Conservation's strategy includes:

- protecting nests, chicks, and adults from predators in the wild
- collecting eggs or chicks from the wild and raising them in captivity for release back into the wild when they are able to defend themselves from stoats and cats
- undertaking research into their genetics, breeding ecology, and habitat requirements
- empowering iwi and community groups to manage kiwi populations, especially where kiwi are still found on private land.

The brown kiwi is still widespread in the central and northern North Island. Rowi are found only at South Ōkarito on the West Coast, but distinct populations of tokoeka (formerly believed to be brown kiwi) are present at Haast, Fiordland, and on Stewart Island. Great spotted kiwi can be found in the northwestern South Island, while little spotted kiwi are restricted to five offshore islands and the Karori Wildlife Sanctuary in Wellington.

Kiwi now occupy about 17 per cent of their estimated original range, as a result of habitat loss and predation. Since the 1970s, their range has decreased by about 20 per cent.

+ FIGURE 12.9:
CHANGE IN DISTRIBUTION OF THE KĀKĀ



Note:
Both subspecies of kākā are combined, to show their overall distribution.
Data source and photo: Courtesy of the Department of Conservation.

KĀKĀ (*NESTOR MERIDIONALIS*).

The käkä is a large, endemic forest parrot whose diet includes berries, seeds, nectar, and invertebrates. The käkä plays an important role in native forests by pollinating flowers and breaking up rotten wood, speeding its decay.

There are two subspecies; the North Island käkä (*N. meridionalis septentrionalis*), and the South Island käkä (*N.m. meridionalis*). Both are classified as nationally endangered due to the loss of their habitat in the past, coupled with the current pressure from predators like possums and stoats.

In areas without predator control, most käkä nests do not produce young and many nesting females are killed. Predator control in protected forest blocks has resulted in a rapid increase in käkä numbers in those areas.

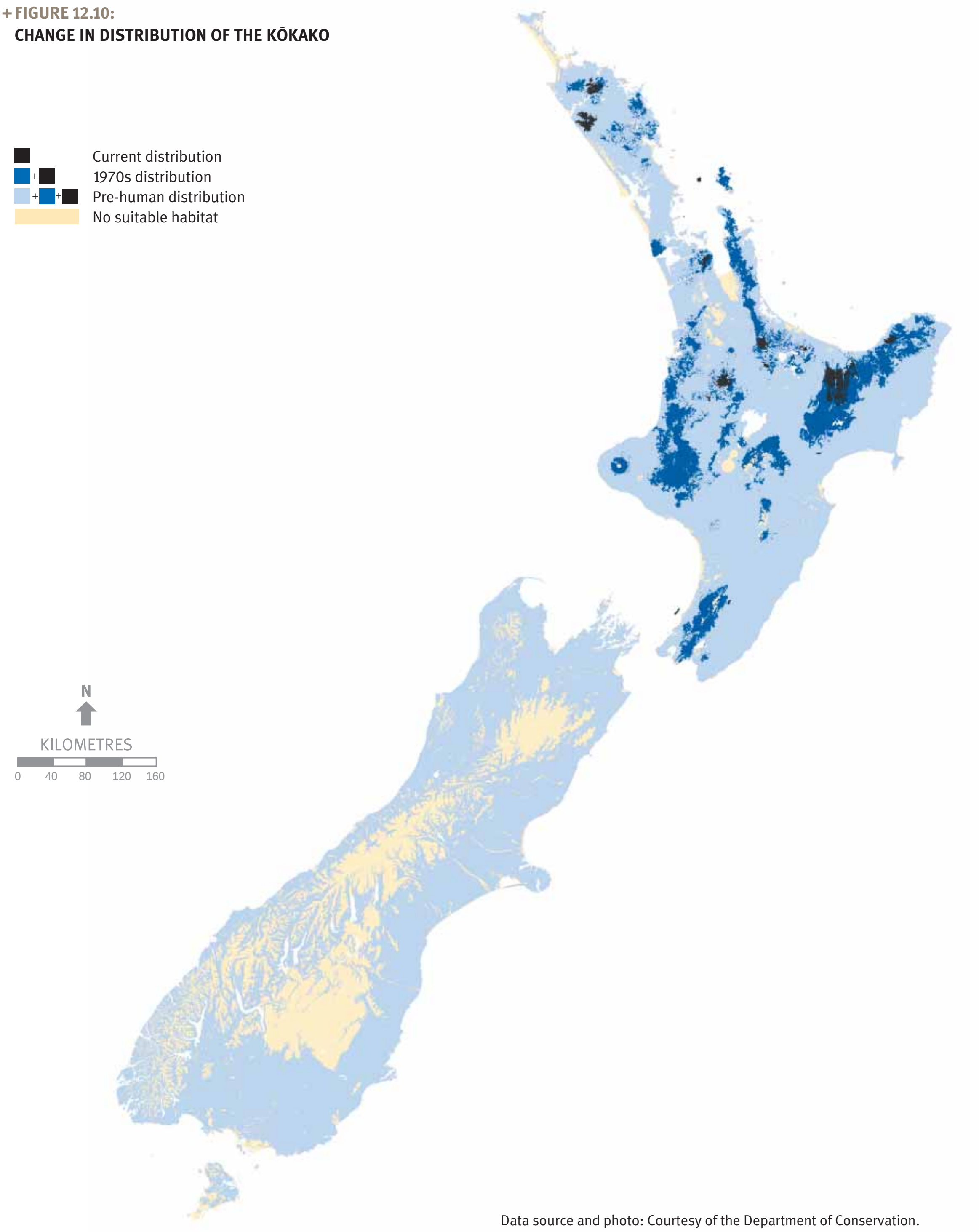
With effective predator control, about 80 per cent of the nests produce young, which is a marked increase in breeding success, and far more breeding females survive.

In the 19th century, kākā were abundant throughout forests in the North and South Islands, but by 1930 they had become more localised. North Island kākā are now almost absent from many large forested areas with high levels of predators. They are still common in some central North Island forests, but even within these strongholds kākā are thought to be declining. They are still also common on some larger offshore islands.

The South Island subspecies is still widespread, although low in number, and has become progressively more common on the West Coast of the South Island to Fiordland, and on Stewart Island.

Kākā currently occupy less than 20 per cent of their original range, and recent evidence suggests that most populations without predator control are declining and remaining populations may consist of predominately males (Moorehouse et al, 2003). Since the 1970s, the kākā's range has contracted a further 6 per cent.

+ FIGURE 12.10:
CHANGE IN DISTRIBUTION OF THE KŌKAKO



Data source and photo: Courtesy of the Department of Conservation.

NORTH ISLAND KŌKAKO (*CALLAEAS CINEREA*).

The kökako belongs to the endemic New Zealand wattlebirds, an ancient family that includes the North and South Island saddlebacks and the extinct huia. The kökako feeds on foliage, fruits, and invertebrates, and is well known for its beautiful song.

Currently, about 750 pairs of kökako occur in several isolated populations in the central and northern North Island, mainly in podocarp hardwood forests. The North Island kökako (*C. cinerea wilsoni*) is classified as nationally endangered. The South Island kökako (*C. c. cinerea*) is classified as extinct.

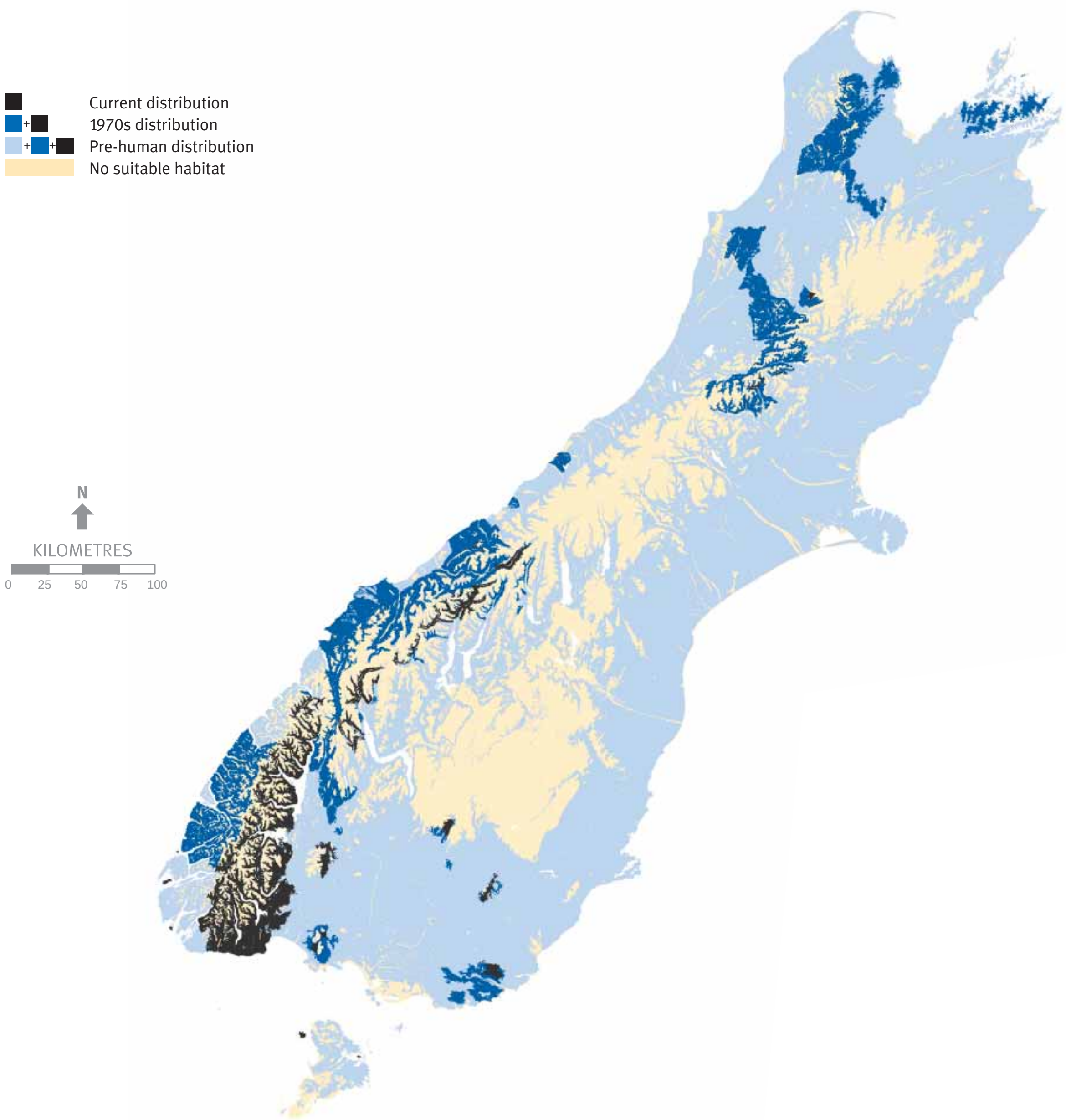
Although deforestation in the past centuries has resulted in a substantial loss of habitat, possums, rats, and stoats are the main threat to kökako populations at present.

The management of kökako is guided by a recovery plan, and recent management of the remaining North Island populations has reversed their overall decline. For kökako populations to increase, possums and rats need to be controlled to low levels.

Before human settlement, kōkako were widespread and common. Until 1995, there was a marked decline in kōkako numbers, but recent management of the remaining populations has reversed that trend and the national population is increasing.

Kōkako are currently present in 2 per cent of their estimated natural range. Since the 1970s, their range has been reduced by a further 90 per cent. There have been successful transfers to offshore islands.

+ FIGURE 12.11:
CHANGE IN DISTRIBUTION OF THE MŌHUA



Data source: Department of Conservation. Photo: Michael Eckstaedt.

MŌHUA (*MOHOUA OCHROCEPHALA*).

Small, insectivorous forest birds, möhua are members of the genus that includes the whitehead and brown creeper. They nest in holes, usually high in beech trees, and are a host of the long-tailed cuckoo.

Möhua are found only in South Island forests. In the 1800s, they were one of the most abundant and conspicuous forest birds, inhabiting all forest types across the South Island and Stewart Island. Deforestation and the introduction of mammalian predators caused their decline, and the population has declined by 90 per cent since European settlement. The möhua is currently classified as nationally endangered.

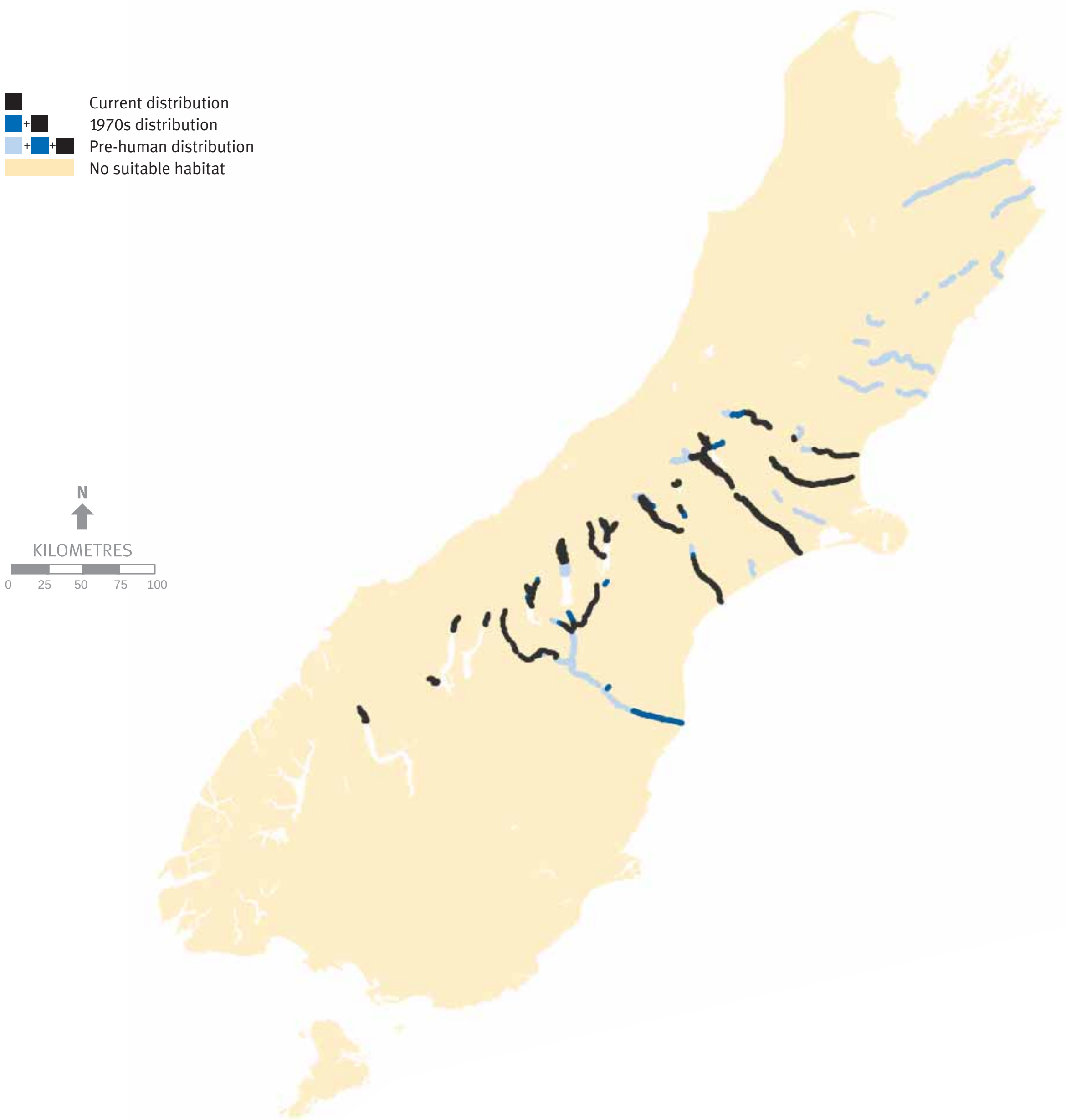
The management of the species is guided by a recovery plan that includes controlling rats and stoats following beech masts (these are the infrequent fruiting events of native beech trees). Möhua have been introduced to several predator-free islands, where their numbers have increased rapidly.

Mōhua are found only in South Island forests. Their distribution has become very fragmented and the species is now confined to beech forest.

They are present in 5 per cent of their estimated natural range. Since the 1970s, their range has contracted by almost 70 per cent, and in areas where there is no predator control, mōhua numbers are continuing to decline.

+ FIGURE 12.12:

CHANGE IN DISTRIBUTION OF THE WRYBILL



Note:

Coloured areas indicating wrybill presence have been thickened to improve visibility.

Data source and photo: Courtesy of the Department of Conservation.

WRYBILL (*ANARHYNCHUS FRONTALIS*).

Wrybills are small endemic shorebirds that are highly specialised for breeding in braided rivers. Their unique bill is adapted to finding mayfly and caddisfly larvae under riverbed stones. They migrate north each year, with most wrybill wintering in the large harbours around Auckland.

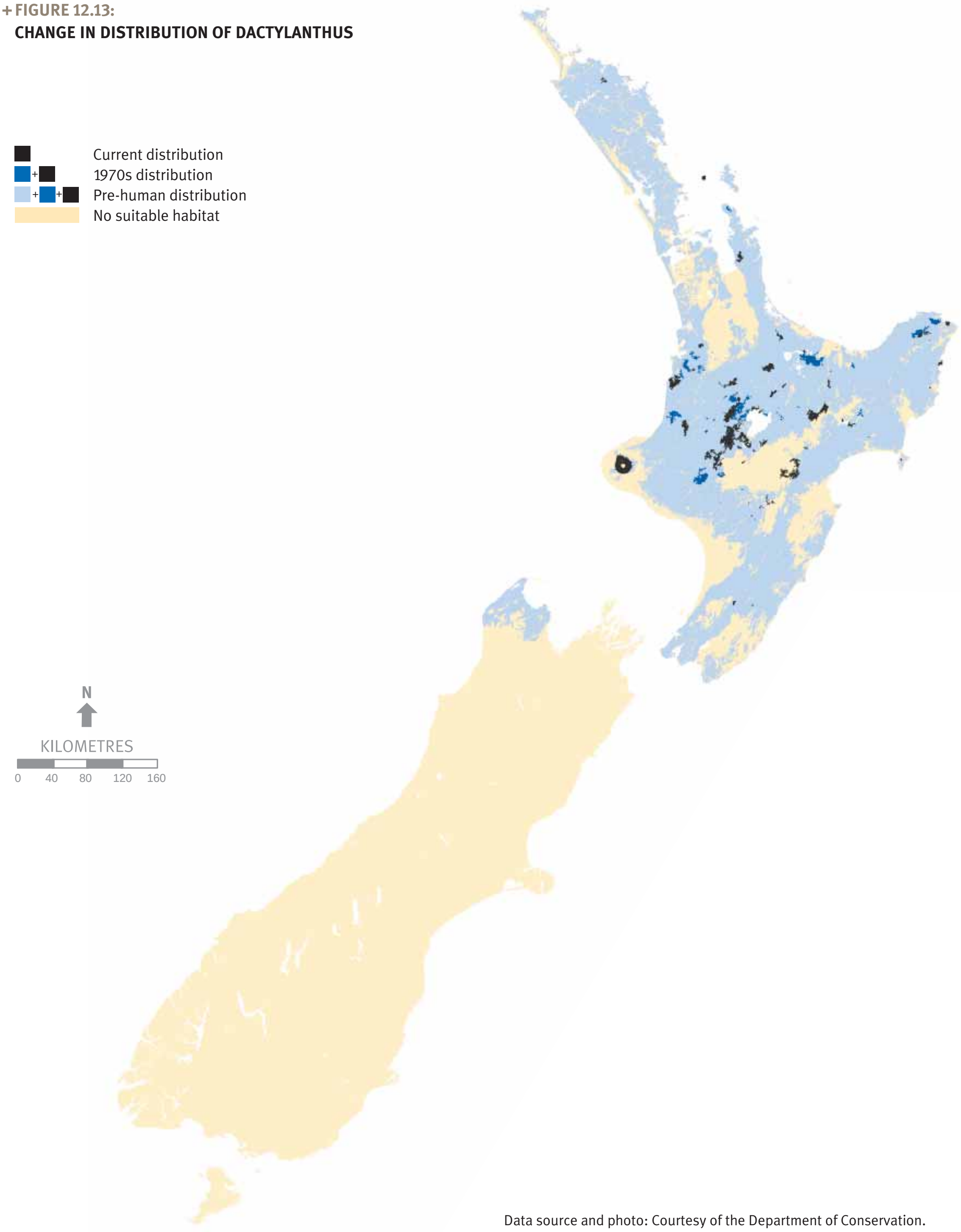
Within their current breeding range, wrybill have disappeared from most small rivers, and are now confined to several large catchments. About 5,000 remain, and the species is classified as nationally vulnerable. The main threats to wrybill include mammalian predators (particularly stoats), flooding, and the loss and degradation of suitable habitats.

The maintenance of this species' range in the long term will require predator control, coupled with a reduction in the many human impacts on riverbeds.

Wrybills currently breed only in braided rivers east of the main divide in Canterbury and northern Ōtago. They previously bred in a number of Marlborough rivers, but their range has contracted southwards in the past 100 years.

They now occupy about 60 per cent of their estimated original range.

+ FIGURE 12.13:
CHANGE IN DISTRIBUTION OF DACTYLANTHUS



Data source and photo: Courtesy of the Department of Conservation.

DACTYLANTHUS *(D. TAYLORII)*.

Dactylanthus is New Zealand's only fully parasitic flowering plant. It grows a root-like stem that is attached to the root of a host tree. The host root moulds into the shape of a fluted wooden rose, giving the plant its common name, woodrose. It is pollinated by the lesser short-tailed bat.

This plant has never been considered common, and occurs in widely scattered sites. Currently there are likely to be only a few thousand remaining. Dactylanthus has the threat classification of serious decline. Threats to it include deforestation, collectors, and browsing by possums, rats, and pigs. Declines in species that are its natural pollinators and seed-dispersers probably also have an impact.

The management of dactylanthus is guided by a recovery plan that incorporates the exclusion of predators by using simple cages, and by the hand-pollination of flowers.

Dactylanthus is found from Northland to the Wairarapa, with the largest populations in East Cape and on the Central Plateau. There is also a small population on Little Barrier Island. However, the distribution and number of plants has declined recently, and there are likely to be only a few thousand remaining.

Dactylanthus is currently distributed in only 4 per cent of its former range, with its range decreasing 32 per cent since the 1970s.

More about New Zealand's common native birds

Some of our more common native birds have shown an increase in distribution in recent years, particularly in certain urban areas (Robertson et al, 2007). It is thought that this increase is due to intensive local pest control efforts and plantings of native plants in gardens to attract these species.

For example, tūi, bellbird/korimako and New Zealand pigeon/kererū are important pollinators and seed dispersers for many of New Zealand's trees and shrubs. These are among the 27 native species that have increased in distribution since 1985, as shown in Table 12.9 (or 28 per cent of the 96 observed species).

Table 12.9 also shows that, despite some gains with our more common birds, the same percentage (28 per cent) of New Zealand's birds have also decreased in distribution since 1985. However, 93 per cent of these are endemic species (those that do not naturally occur elsewhere in the world).

+ TABLE 12.9:
SUMMARY OF OBSERVED CHANGES IN DISTRIBUTION OF BIRDS, 1985–2004

TREND	ENDEMIC SPECIES	NATIVE SPECIES	TOTAL
Increase	15	12	27
No change	26	16	42
Decrease	25	2	27
Total	66	30	96

Source: Adapted from Robertson et al, 2007.

TŪI
(PROSTHEMADERA NOVAESEELANDIAE).

BELLBIRD/KORIMAKO
(ANTHORNIS MELANURA).

NEW ZEALAND PIGEON/KERERŪ
(HEMIPHAGA NOVAESEELANDIAE).

Source: Courtesy of the Department of Conservation.

Pest management in New Zealand

Following the initial large-scale deforestation of New Zealand before and during the 19th century, the habitat for many threatened vertebrate species in New Zealand has largely come under legal protection.

However, introduced predators and competitors such as stoats, rats, and possums continue to reduce the populations of some of our most at-risk bird species. They do so by feeding on eggs, chicks, and adults, and by competing for food and nesting sites.

Protecting native species from predation and competition by introduced animals and weeds is therefore critical if we are to sustain the remaining populations and avoid further biodiversity loss. Protection largely relies on ongoing control of animal pests and weeds.

Pests are unwanted organisms that adversely affect ecosystems and directly compete with native or commercial species. Established introduced pest species are the single largest threat to New Zealand's remaining biodiversity (Department of Conservation and Ministry for the Environment, 2000), and substantial efforts are directed towards controlling and eradicating them.

New Zealand's biosecurity system is a multi-agency programme that aims to exclude unwanted organisms at the border, and to control incursions and growth of pest populations within the country. It aims to exclude and control the invasive species that threaten our natural species and ecosystems, and those species that underpin our primary production sector.

Biosecurity efforts include pest management for conservation and animal health purposes. Because bovine tuberculosis (Tb) – a disease affecting livestock and humans – is transmitted by possums, the control of possum numbers has benefits for both conservation and New Zealand's farming industry.

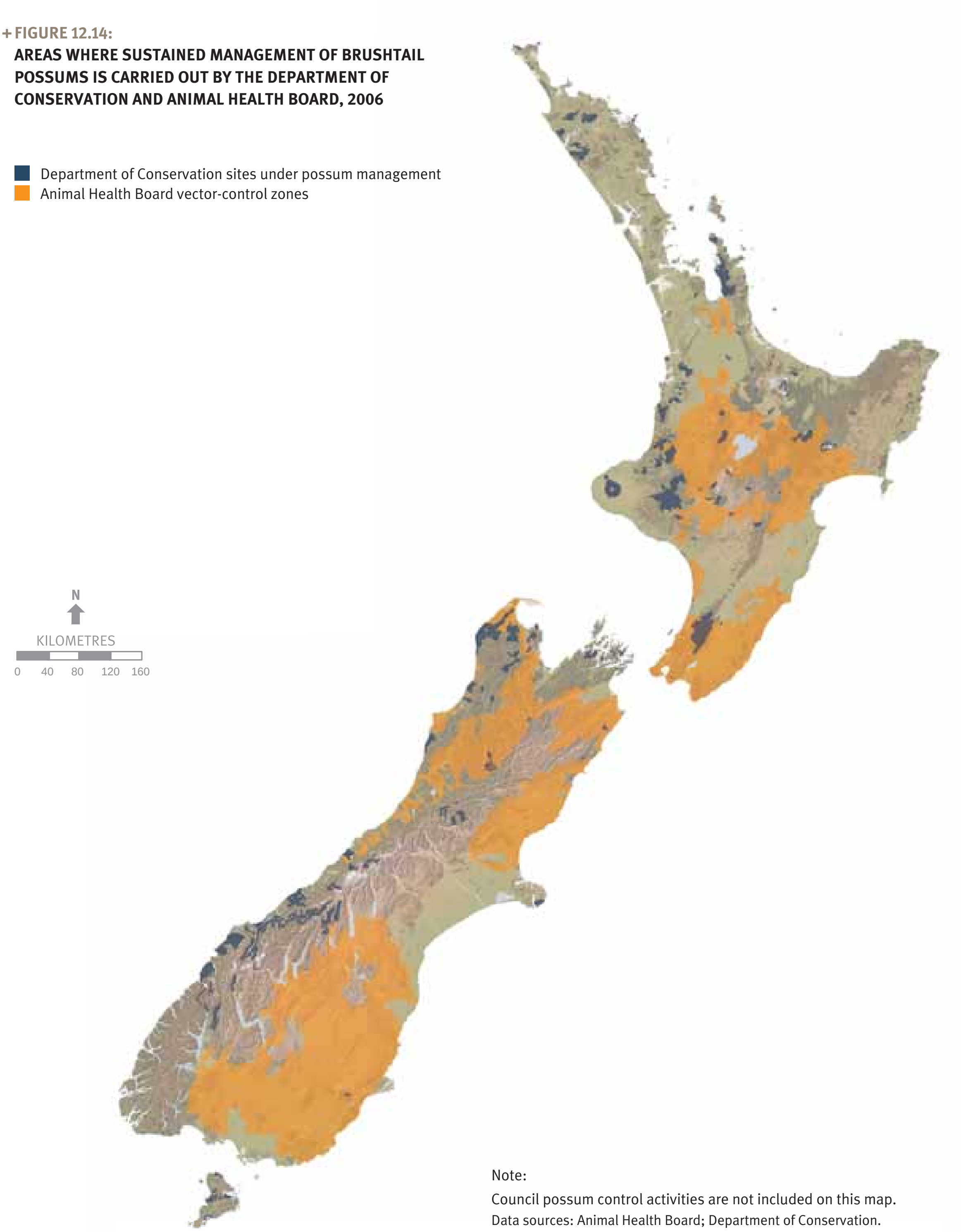
However, reducing the risk of Tb-transmission from possums to cattle may not be enough on its own to protect our native biodiversity. In addition, when low Tb levels have been achieved, and possum management ceases, biodiversity gains may be reversed in some areas.

Figure 12.14 shows the areas of the country where possum control or surveillance is carried out by the Animal Health Board (the organisation responsible for managing and implementing the National Pest Management Strategy for bovine Tb) and the Department of Conservation. Other pest groups such as rodents, mustelids (primarily stoats), cats, hedgehogs, pest grazers (including rabbits), and weeds are also managed in some of these areas.

THE AUSTRALIAN BRUSHTAIL POSSUM HAS BECOME ONE OF THE GREATEST THREATS TO NEW ZEALAND'S BIODIVERSITY. IT WAS INTRODUCED IN 1837 TO ESTABLISH A FUR TRADE.

Source: Courtesy of the Department of Conservation.

+ FIGURE 12.14:
AREAS WHERE SUSTAINED MANAGEMENT OF BRUSHTAIL POSSUMS IS CARRIED OUT BY THE DEPARTMENT OF CONSERVATION AND ANIMAL HEALTH BOARD, 2006



Note:
Council possum control activities are not included on this map.
Data sources: Animal Health Board; Department of Conservation.

In the past decade, animal pest and weed control efforts have significantly increased in their extent and intensity. Table 12.10 shows the area managed for pest groups within mainland public conservation lands. Figure 12.15 shows the trend in the land area receiving sustained control for possums, deer, goats, thar, and weeds.

As an example, since 2000, the area of Department of Conservation land under sustained management for possums has increased by 60 per cent, from 669,000 hectares to 1,069,000 hectares in 2006. Within sustained pest control areas, targeted pest treatment also increased from 40,000 hectares in 1991 to 302,000 hectares in 2006.

The area controlled for possums by the Animal Health Board has also increased by 40 per cent, from 6,153,200 hectares in 2001 to 8,870,000 hectares in 2006.

This results in a total of 9,939,000 hectares under sustained possum management in 2006, which constitutes about 37 per cent of New Zealand's total land area. The figure excludes all council and private management activities.

Control methods (for example, trapping, culling, and poisoning), the ease of access to affected ecosystems, the threat to biodiversity, the range of pests present, the severity of a pest's impact on native species, and the available resources largely determine the pest control effort and which pest group is targeted.

+ TABLE 12.10:
PEST MANAGEMENT ON PUBLIC CONSERVATION LANDS BY PEST GROUP AND AREA UNDER MANAGEMENT (2005/2006)

PEST GROUP	AREA MANAGED (HECTARES)
Rodents	312,676
Mustelids/cats	417,618
Pest herbivores[1]	4,859,498
Weeds	2,635,405
Possums	1,078,053

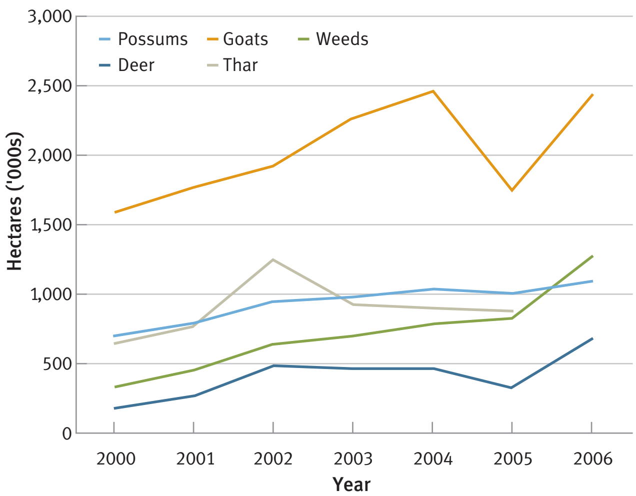
Notes:

(1) Pest herbivores include deer, goats, pigs, thar, chamois, wallabies, rabbits, sheep, and cattle.

(2) Areas do not total, as in some cases more than one pest is managed in the same area.

Data source: Department of Conservation.

+ FIGURE 12.15:
LAND AREA UNDER SUSTAINED MANAGEMENT OF PEST SPECIES BY THE DEPARTMENT OF CONSERVATION, 2000–2006



Data source: Department of Conservation.

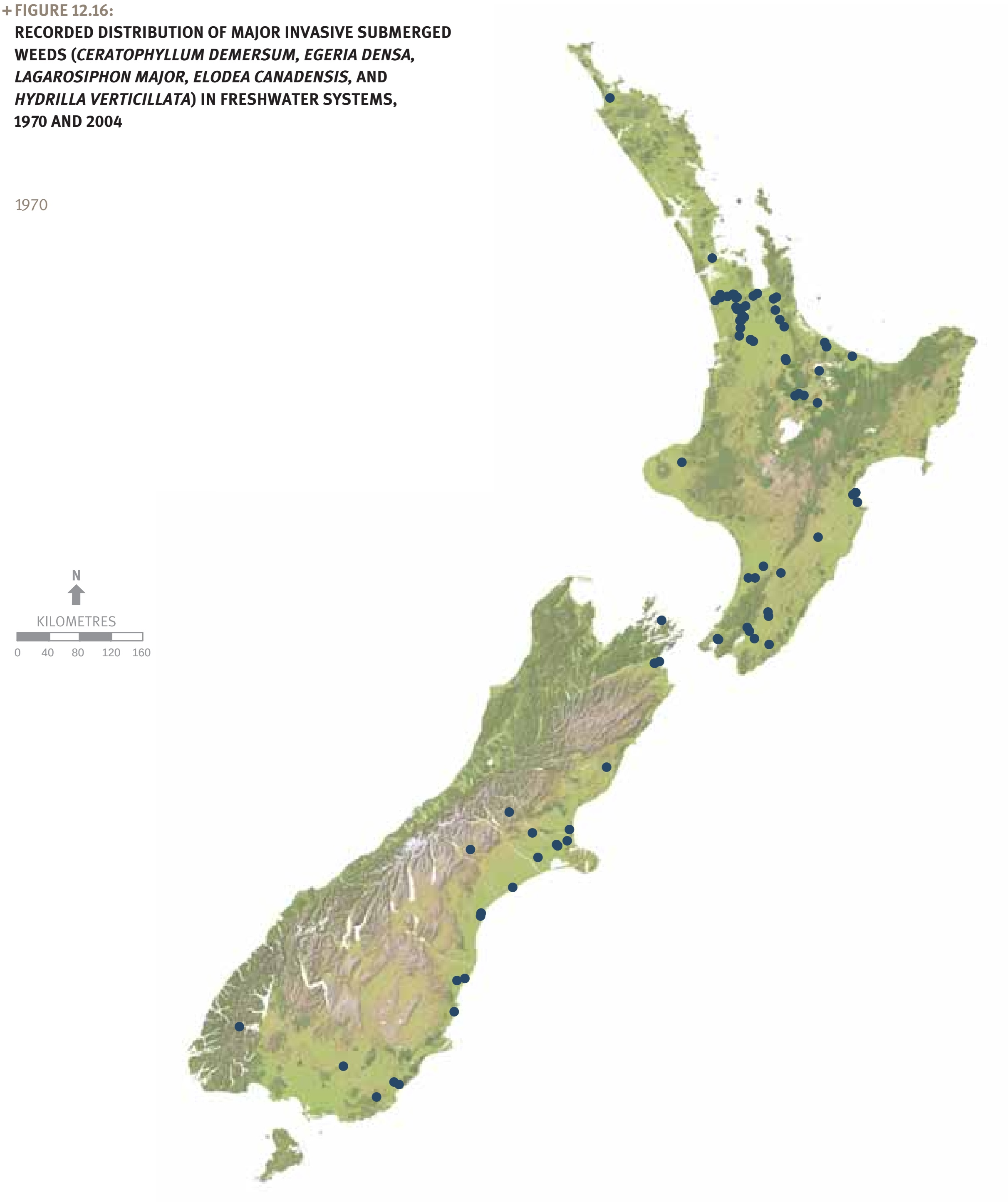
Freshwater pests

Freshwater resources face pressures similar to land-based areas. Introduced fish and aquatic weeds and algae compete with and displace our native aquatic plants and animals. Pest aquatic plants have invaded 61 per cent of lakes in New Zealand (National Institute of Water and Atmospheric Research, pers comm).

The monitoring of five major aquatic weeds (*Ceratophyllum demersum*, *Egeria densa*, *Lagarosiphon major*, *Elodea canadensis*, and *Hydrilla verticillata*) shows a jump in recorded incidences of these pest species, from 95 sites in 1970, to 778 sites in 2004 (Figure 12.16).

+ **FIGURE 12.16:**
RECORDED DISTRIBUTION OF MAJOR INVASIVE SUBMERGED WEEDS (*CERATOPHYLLUM DEMERSUM, EGERIA DENSA, LAGAROSIPHON MAJOR, ELODEA CANADENSIS,* AND *HYDRILLA VERTICILLATA*) IN FRESHWATER SYSTEMS, 1970 AND 2004

1970



2004

Data source: National Institute of Water and Atmospheric Research.

What is didymo ('rocksnot')?

Didymosphenia geminata – known as didymo, or 'rocksnot' because of its slimy appearance – is an introduced freshwater alga.

While it does not pose a risk to human health, didymo can form large algal mats on the bottom of rivers and streams and, occasionally, on lake edges. As these mats smother rocks, they can reduce the availability of suitable habitats for freshwater fish, invertebrates, and plant species. The presence of didymo may also affect riverbed bird species, such as the wrybill, by reducing their prey numbers and access to waterways.

As a result, didymo has been classed as an unwanted organism (pest species) under the Biosecurity Act 1993.

Didymo occurs naturally in northern parts of the northern hemisphere. It was first identified in New Zealand in October 2004 in the Lower Waiau River in Southland and was the first recorded occurrence in the southern hemisphere.

Since then, it has spread to a number of other river catchments in the South Island. By June 2007, it was found in 55 South Island rivers (Biosecurity New Zealand, 2007), but North Island rivers remain free of the pest. However, many rivers in the North Island, particularly around the central Volcanic Plateau, have environments that are suitable for didymo to take hold.

Didymo is easily spread between waterways on boating, fishing, or other equipment that has not been thoroughly cleaned. It is estimated that up to 50 per cent of all waterways in New Zealand are at risk of didymo incursion (Kilroy et al, 2005).

Intensive biodiversity conservation efforts

Conservation on offshore islands

Pest eradication, as opposed to pest control, can be accomplished in isolated areas that have low risk of reinvasions. Offshore islands that have remained free or have been cleared of introduced predators have been invaluable for the survival of many of New Zealand's most threatened species (Atkinson, 2001). In these environments, species may establish new populations in safe havens, free of introduced pests.

Conservation on the mainland

Habitat limitations mean New Zealand's threatened native biodiversity cannot be sustained on offshore islands alone. On the mainland, a number of areas have undergone intensive pest control to hold pest numbers at low thresholds (Table 12.11). These include the Department of Conservation's 'mainland island' projects (1995–1996), kiwi sanctuaries, Operation Ark (2003), and other projects initiated by community groups.

Table 12.11 shows that over 500,000 hectares of land are under intensive pest management by the Department of Conservation on offshore islands and the mainland.

+ TABLE 12.11:
AREA UNDER INTENSIVE PEST MANAGEMENT BY THE DEPARTMENT OF CONSERVATION, 2006

TYPE OF AREA	AREA (HECTARES)
Offshore islands	153,895
Operation Ark	208,579
'Mainland islands'	64,182
Kiwi sanctuaries	59,000
Kōkako mainland sites	15,000
Total	500,656

Data source: Department of Conservation.

GOVERNMENT ACTION on biodiversity

Mainland islands

Six 'mainland island' projects were initiated by the Department of Conservation in 1995 and 1996. These are not actual islands surrounded by sea, but areas that are intensively managed on mainland New Zealand to restore native ecosystems. In total, more than 64,000 hectares and a range of native species are intensively managed at these six sites.

In less than five years, significant reductions of targeted pests were achieved, resulting in the recovery of many native species, as well as building organisational capability, and providing opportunities for learning.

The 'mainland island' projects have produced some measurable conservation outcomes over the last decade. These include:

- confirming that pest management enhances the recovery of targeted native species and revitalises ecological processes
- demonstrating that biodiversity declines can be halted on the mainland
- providing opportunities for the public to visit and participate in conservation management and to interact with rare species
- improving conservation practices through:
  - increasing the effectiveness of predator management techniques and practices
  - improving bird translocation techniques
  - providing flagship sites that have paved the way for other similar projects.

Kiwi sanctuaries

Much of the work on biodiversity protection is funded by central government in support of the New Zealand Biodiversity Strategy. This includes the Kiwi Sanctuaries programme, aimed at halting the decline of kiwi populations and decrease in their range in most mainland areas.

There are three kiwi sanctuaries in the North Island and two in the South Island. Each of these sanctuaries protects a different kiwi species or special population. Intensively managed sanctuaries and kiwi zones now play a key role in turning around the decline in kiwi numbers on New Zealand's mainland.

Operation Ark

The Department of Conservation's Operation Ark projects were established after the populations of orange-fronted käkäriki and möhua more than halved, following rodent and stoat plagues in South Island beech forests in 2000 and 2001.

The areas selected span more than 200,000 hectares throughout the South Island. They include four of the most important sites for möhua and blue duck/whio populations, sites containing the last two populations of the lesser short-tailed bat, and the key sites for orange-fronted käkäriki.

The operation involves progressively expanding possum control and setting tens of thousands of stoat and rat traps in permanent trap lines throughout the 11 'Ark' areas.

LOCAL ACTION on biodiversity

Regional councils and territorial authorities use a range of tools to support native biodiversity. These include:

- conservation covenants and help with establishing QEII National Trust covenants
- subdivision controls
- incorporation of biodiversity protection in management plans and agreements
- rates relief for land under private conservation covenant
- education and advice for land owners
- support for volunteer community groups, landcare groups, and conservation trusts, and waiving consent fees.

Since 1997, the extent of council effort and expenditure on biodiversity protection has increased. Regional councils now invest more than $4.26 million per year in contestable biodiversity funds. Many of these funds support on-the-ground activities such as covenants, landcare groups, education, and land owner advice.

One example is the Biodiversity Condition and Advice Fund, which aims to enhance the management of native biodiversity outside public conservation lands. By May 2006, these funds had directly benefited 4,800 private land owners, either through advice received or work undertaken on their property to protect biodiversity.

Some other examples of regional council approaches to protect local biodiversity are:

- provisions for native biodiversity in the regional policy statements for Taranaki, Hawke's Bay, Wellington, Canterbury, and Ötago
- extensive biodiversity programmes in Auckland Regional Council's regional parks, such as:
  - protection programmes (including predator control) for threatened shorebirds in many coastal regional parks (such as Whakanewha, Wenderholm, and Mahurangi), many of them in conjunction with community groups
  - the Ark in the Park initiative, a joint programme with the Royal Forest and Bird Protection Society to restore birds to the Waitäkere Ranges
  - a joint programme with the Department of Conservation to conserve kökako in the Hünua Ranges Regional Park
  - a sanctuary ('mainland island') established at Tawharanui in 2004
- coastal care groups operated by several regional councils (such as Waikato and Bay of Plenty).

Local plant and animal pest control also plays an important role in maintaining New Zealand's native biodiversity. All regional councils help control the animals and weeds that have been identified as pests in their regions, although land owners have the primary responsibility for pest management on their properties.

Much of the pest control work undertaken for the benefit of agriculture, such as the control of bovine Tb, also has direct benefits for biodiversity. Most of these programmes are aligned or integrated with biodiversity pest control carried out by the Department of Conservation, the QEII National Trust, and community groups.

Changes since the 1997 report

The 1997 report, *The State of New Zealand's Environment 1997*, concluded that:

> Biodiversity decline is New Zealand's most pervasive environmental issue, with 85 per cent of lowland forests and wetlands now gone, and at least 800 species and 200 subspecies of animals, fungi and plants considered threatened. …
>
> The main pressures on [native] biodiversity today are insufficient habitat in lowland areas, declining quality of many of the remaining land and freshwater habitats, the impacts of pests and weeds and, for some marine species and ecosystems, human fishing activities. …
>
> The main responses to biodiversity decline have focused on ecosystem and species recovery programmes on offshore islands and extensive pest control operations on the mainland, but the need for partial restoration of representative [native] lowland and coastal ecosystems and for wider protection of marine ecosystems has yet to be addressed. …
>
> Pest control, especially possums, is now a vital means of protecting our environment as well as being important for our economy. Pest control will need to become increasingly safe, humane and cost-effective to remain economically and socially sustainable.

(Ministry for the Environment, 1997, chapter 10.)

New Zealand's biodiversity profile

New Zealand continues to be regarded as a significant contributor to global biodiversity. A comparatively large proportion of our estimated 80,000 species of native animals, plants, and fungi do not occur naturally anywhere else on earth.

While many populations of some of our most threatened species have now stabilised under conservation management, the task of halting biodiversity loss is still a challenge in New Zealand today, as it was in 1997.

Almost 2,500 native land-based and freshwater species remain listed as threatened. All 10 threatened indicator species discussed in this chapter have shown a continuing decline in their habitat range.

In 2007, New Zealand's biodiversity faces the same pressures as 10 years ago. Introduced animal and plant pest species remain a serious threat to New Zealand's biodiversity. Native plants and animals that survived the initial habitat modification caused by human settlement continue to be threatened by introduced predators and competitors.

Native vegetation

Although 11.7 million hectares (44.8 per cent) of New Zealand's land mass is in native vegetation in 2007, it is largely restricted to hill country and alpine areas.

Wetlands and lowland forests remain among New Zealand's most threatened habitats and ecosystems. While these areas are now receiving greater conservation attention, they remain under-represented in legally protected areas. This has implications for the threatened species that require unmodified lowland habitats to survive.

Between 1997 and 2002 native land cover decreased by an estimated, 16,500 hectares (0.12 per cent). This total decrease included an increase of 700 hectares of non-vegetative native cover, such as sand and gravel, and a decrease of 17,200 hectares of native vegetative cover. These changes either occurred through conversion of land to other uses, or as a result of natural process.

Since 1997, the clearance of native forests has reduced to low levels as a result of sectoral initiatives and stronger legislation, such as the New Zealand Forest Accord 1991 and the amendments to the Forests Act 1949, the latter of which stopped the clear-felling of native forest. However, other types of New Zealand native land cover, such as broadleaved native hardwoods, mānuka and kānuka, and tall tussock grassland, continue to be modified.

While climate change is expected to have a significant impact on some aspects of New Zealand's biodiversity, climate-change policies are likely to reinforce current efforts to protect native vegetation.

Land conservation

By international comparison, a high proportion of land in New Zealand is now set aside for conservation purposes. Just over 32 per cent of our total land area is legally protected, either as public conservation land or through conservation initiatives on private land, such as the QEII Trust covenants.

The amount of public conservation land has increased significantly since 1997. For example, 8.06 million hectares were set aside in New Zealand for public conservation land in 2004. By October 2007, a total of 8.43 million hectares were legally protected. This represents an increase of 4.56 per cent in less than three years, which has been achieved partly through the buy-back of Crown-owned land that was formerly leased or licensed to others.

Conservation efforts on private land have also increased significantly. In 2004, a total of 146,280 hectares were registered as formally protected private land. By June 2006, the QEII Trust and Ngā Whenua Rāhui protected a total of 221,473 hectares – an increase of 51.4 per cent over this two-year period.

Introduced species and pest control

Since 1997, controlling pest animals and weeds has received greater attention as a conservation tool. The extent and intensity of pest control effort has increased significantly on both public and private land, driven partly by the increased local funding for pest management made available by regional councils and other agencies. At present, priority is given to controlling pests in the habitats of New Zealand's most threatened species.

The area managed for targeted pests by the Department of Conservation has increased significantly since 1997. For instance, between 2000 and 2006, areas targeted for possum management by the Department of Conservation increased by 60 per cent. Those targeted by the Animal Health Board have increased by 40 per cent since 2001. Together, areas targeted by the Department of Conservation and the Animal Health Board for possum management equate to around 37 per cent of New Zealand's land area.

Since 1997, pest control has become more effective as technology and knowledge have improved. The recent introduction of new Department of Conservation traps for stoats, as well as enhanced control regimes on the Department's offshore and 'mainland island' projects, show how pest control is evolving in New Zealand. These efforts have been invaluable in securing habitats for threatened populations and improving conservation techniques and practices.

Stringent pest control to the point of excluding introduced species from areas is a comparatively new conservation strategy. This has enabled endangered species to be successfully reintroduced to reserves on the mainland.

Increased biosecurity is now recognised as a key measure to protect New Zealand from new pest plants and animals. This is important not only for our native biodiversity, but also for the introduced species on which much of our economy depends.

Focus on ecosystems

Conservation efforts on New Zealand's offshore islands have been invaluable in securing habitats for threatened populations and for improving conservation techniques and practices. Increasingly, habitat with adequate protection for threatened species on the mainland is provided through various initiatives.

Since 1997, our conservation efforts have extended from species-specific conservation, towards ecosystem conservation that enables whole communities of species to survive. This focus on ecosystems recognises the high level of interdependence between some species within the same ecosystem, and is reflected in recently developed national policies (for example, the New Zealand Biodiversity Strategy, 2000).

Attention has also turned to protecting the endangered native species and ecosystems on private land.

Future priorities

As a result of our experience in trying to halt the serious decline in some of our native species, New Zealand is now considered a world leader in conservation and restoration efforts (Saunders and Norton, 2001).

In the future, conservation priorities are likely to continue to focus on improved pest control and biosecurity protection, and on increasing the legal protection for those land environments and ecosystems that are not well represented in areas legally protected for conservation purposes. Attention is also likely to focus on the impacts of climate change on our native biodiversity.

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Glossary

%EPT	An index that measures the abundance of three **macroinvertebrate** groups, Ephemeroptera, Plecoptera, and Trichoptera. These groups are particularly sensitive to water pollution.
Acidification	The process of a substance becoming more acid (below **pH**7).
Aesthetic/amenity values	The natural or physical features of an area or thing that contribute to people's appreciation of it, such as its visual appeal. Aesthetic quality of freshwater refers to whether the water's appearance is appealing to a drinker or user of it (that is, whether it looks clear and clean).
Afforestation	The process of establishing a forest on land that is not a forest, or has not been a forest for a long time, by planting trees or their seeds for commercial use or any other purpose.
Aggregate (of soil)	Mixture of fine soil particles held together in a single mass.
Aggregate stability	The stability of soil **aggregate**s or particles.
Agrichemical	A synthetic substance used in agricultural and horticultural activity to eradicate, modify, or control selected plants and animals.
Algae	Small, often microscopic plants. Freshwater algae grow in the water or on rocks on river and lake beds and shores. Large quantities of algae can cause **algal bloom**s.
Algal bloom	A rapid increase in the population of **algae** in an aquatic system. Blooms can reduce the amount of light and oxygen available to other aquatic life and may be toxic if ingested by humans (or an irritant to skin and eyes).
Allocation	The maximum volume of water that may be taken from freshwater sources by resource consent holders. See also **consumptive water use**.
Ambient air quality	The quality of the air in the surrounding outdoor environment.
Ammoniacal nitrogen	Covers two forms of nitrogen: ammonia and ammonium. Animal **waste** (particularly from humans and farmed animals such as sheep and cows) is the major source in New Zealand waterways.
Aquaculture	The commercial farming of fish, shellfish, or aquatic plants.
Aquifer	An underground rock formation that stores water, most commonly one that stores sufficient quantities of water for people to use. See also **confined** and **unconfined aquifer**.
Arable cropping	Cultivation activities on **arable soil**.
Arable soil	Soil that is suitable for cropping.
Ascidian	A group of marine animals, which includes sea squirts. These soft, boneless filter feeders are found all over the world.
Assessed fish species/stocks	Fish **species** for which there is enough information to quantitatively measure the **status** of the stock.
Atmospheric deposition	The process by which particles suspended in the air are transported and deposited on a distant land or water surface.
Bacteria	Micro-organisms, some of which are harmful to humans.

Beneficial reuse	The reuse of a material or substance that would otherwise be disposed of to a **landfill** or **cleanfill**.
Benthic	Found in or on the bottom **sediment**s of a stream, river, lake, or ocean.
Biocapacity	The supply of resources from a given area of biologically productive land or sea (contrasted with the **ecological footprint**, which is a measure of the demand on those resources). Biocapacity can be varied by physical conditions and by human actions, including changing ecosystem management and agricultural practices, technology improvements (such as fertiliser use and **irrigation**), ecosystem degradation, and weather.
Biochemical oxygen demand (BOD_5)	A measure of the amount of **organic pollution** in water.
Biodiesel	A fuel that can be produced from vegetable oil or animal fat and used as a substitute or partial substitute for diesel.
Biodiversity	Variation of life at all levels of biological organisation on earth, including diversity of genes, species, and **ecosystem**s.
Biofuel	Fuel that is derived from **biomass** (recently living organisms such as wood) or their metabolic by-products (such as tallow from cows). Biofuels are a **renewable energy** source.
Biogas	Energy produced from the anaerobic digestion of **sewage** and industrial **waste**, including **landfill** gas and sewage.
Biogeographic region	An area that is defined according to patterns of ecological and physical characteristics in the seascape.
Biomass	Total weight of the organisms of a population inhabiting a given area.
Biophysical	The biological and physical features of the environment.
Biosecurity	Measures taken to protect a nation's food supply, agricultural resources, and natural environment from introduced **pest species** and other unwanted organisms.
Biosolids	A by-product of **sewage** collection and treatment processes that is treated and/or stabilised so it can be beneficially reused. Also known as **sewage sludge**.
Bivalve	Marine animal with paired shells that protect the soft animal inside. Bivalves include mussels, scallops, cockles, oysters, and clams.
Bovine tuberculosis (TB)	Tuberculosis in cattle, caused by the aerobic bacterium *Mycobacterium bovis,* which can jump **species** to cause the disease in humans.
Breach	Where the concentration of a pollutant fails to meet what a national environmental standard permits.
Browsing animals	Herbivorous animals that generally feed on high-growing plants rather than grasses.
Brush-weed	Usually a shrub or small tree such as gorse that is undesirable for **livestock consumption** or timber production.
Bryozoan mat	A colony of bryozoans, certain **species** of very small aquatic **invertebrate** animals.
Bycatch	Fish, birds, and marine mammals that fishers catch unintentionally.

Canopy	A layer of **vegetation** in a forest, often formed by trees.
Carbon footprint	A measure of the effects of human activities on the climate in terms of the total amount of **greenhouse gas**es they produce (measured in units of carbon dioxide).
Carbon monoxide	A colourless and odourless gas produced by incomplete burning of carbon-containing fuels such as wood, coal, petrol, and diesel.
Carbon sink	An area where the rate of carbon uptake by living organisms exceeds the rate of carbon released from other parts of the carbon cycle. The main carbon sinks are the world's oceans and forests. See also **forest sink**.
Carcass weight	The weight of an animal after skinning and gutting, when it is ready for **consumption**.
Carrying capacity	The maximum population that a particular area of land or sea is able to support indefinitely.
Catchment	An area of land from which water from rainfall drains toward a common watercourse, stream, river, lake, or estuary.
Cells (in relation to trawling)	The 25 km^2 divisions of New Zealand's **Exclusive Economic Zone (EEZ)** used to report accurately on **trawl effort**.
Chain-linked series	A data series that has been chain-linked – a method of linking individual data figures together using a regularly re-weighted system, to produce a long-term time series.
Chlorofluorocarbons (CFCs)	**Halocarbon** chemical carbons that contain only chlorine, fluorine, and carbon atoms. CFCs are both ozone-depleting substances and **greenhouse gas**es.
Cleanfill	A **waste disposal** site that accepts only inert **waste**s such as clay, soil, rock, concrete, and bricks which, when buried, will have no adverse effect on people or the environment.
Climate change	Statistically significant long-term changes in climatic conditions on a regional or global scale. The term refers to changes in the natural pattern of climatic variability over time periods ranging from decades to millions of years.
Coastal and marine habitat and ecosystem classification	A combination of the **Coastal Biogeographic Regions** and **Marine Environment Classification** systems, used to report on the state of New Zealand's marine environment.
Coastal Biogeographic Regions Classification	A classification dividing New Zealand into 13 **coastal biogeographic region**s based on large variations in physical and biological characteristics. It is used for the coastal marine environment (that is, waters less than 200 metres deep).
Coastal margin	The transition area between ocean and land, such as shallow coastal waters, beaches, dunelands, lowland rivers, estuaries, saltmarsh, and adjacent land areas.
Coastal waters	Seawater extending from the coast to 12 nautical miles offshore. Coastal waters also include seawater in estuaries, fiords, inlets, harbours, and bays.
Cogeneration	The simultaneous or sequential production of two or more forms of useful **energy** from a single primary energy source – for example, electricity and thermal energy such as heat or steam for industrial or commercial heating or cooling.
Commercial waste	**Waste** generated by the activities of a commercial business or industry.
Community	A group of organisms sharing an environment.

Community recycling facilities	**Recycling** services provided by local authorities for a community, including kerbside collections and drop-off facilities.
Compaction	The destruction of **soil structure** by heavy vehicles (such as tractors) or by **livestock**.
Concentration	The measure of how much of a given substance there is mixed with another substance. Usually related to fluids, it is the amount of material in a solution in relationship to the amount of solvent, expressed as the ratio.
Confined aquifer	An **aquifer** that is 'closed' to the land surface; that is, it has a low-permeability upper layer such as clay or silt that prevents it from being directly replenished by rainfall. See also **unconfined aquifer**.
Conservation	Preserving, guarding, or protecting a resource, and/or keeping it safe or intact. The term also refers to the wise use of natural resources.
Constant price	See **real**.
Construction and demolition waste	**Waste** generated from building activities, including the preparation and/or clearance of a property or site. Materials such as clay, soil, and rock are excluded when they are associated with infrastructure such as road construction and maintenance, but building-related infrastructure is included.
Consumer energy	The amount of **energy** consumed by final users. It excludes energy used or lost in the process of transforming energy into other forms and in bringing the energy to the final consumers. For example, natural gas is a primary energy source, some of which is transformed into electricity of which some is lost in transmission to consumers.
Consumption	The acquisition and/or use of materials, goods, and services to provide utility. In an environmental context, the use of ecological resources in the production of goods and services and their final use by individuals or organisations. A consumed good or service embodies all the resources, including energy, that were needed to provide it to the consumer.
Consumptive water use	Water that is consumed or not returned directly to the source from which it was taken (for example, drinking water or **irrigation** supply). Non-consumptive uses do not result in significant losses of water (for example, the water used in hydro-electric power generation, which is returned downstream from where it is taken).
Contact recreation	Recreational activities that bring people physically in contact with water, involving a risk of involuntary ingestion or inhalation of water.
Contaminant	Any substance (including gases, odorous compounds, liquids, solids, and micro-organisms) or energy (excluding noise), or heat, that results in an undesirable change to the physical, chemical, or biological environment. Also called pollutant.
Contaminated land or site	Land or a site that has been exposed to a hazardous substance that has the potential to damage the environment.
Continental shelf	Underwater land that runs from the shore to where the sea floor drops away sharply to the deep ocean floor.
Cultivation	The agricultural preparation of soil for growing crops.

Cultural landscape	A landscape that has been modified by people and is associated with heritage or **aesthetic/amenity values**.
Customary authority	Customary rights, prestige, and authority over land. For the purposes of the **Resource Management Act 1991**, **mana whenua** means customary authority exercised by an **iwi** or a **hapū** in an identified area.
Customary fishing	Non-commercial fishing (that is, the fish caught may not be traded) within a customary use area managed by **iwi** and **hapū**. Guardians appointed by iwi, hapū, and the Minister of Fisheries can issue anyone a permit to fish in their customary use area.
Customary restrictions	Restrictions requested by **tangata whenua**, including **rāhui**, **mātaitai,** and **taiāpure** reserves.
DDT	Dichloro-diphenyl-trichloroethane, an insecticide that is also toxic to humans, it may no longer be legally used in New Zealand.
De-couple	The term for decreasing the dependency between **variables**. Often used in reference to economic production and environmental quality, to mean the ability of an economy to grow without corresponding increases in environmental pressure.
Deepwater	In technical terms, water that is 200 metres deep or deeper.
Deforestation	The removal of forest from a **landscape**.
Demersal	Living on or near the bottom of a body of water.
Demersal Fish Community Classification	The geographic distribution, composition, and environmental conditions of particular demersal fish communities. This classification was developed using an extensive set of research data about **trawling**.
Demography	The combined characteristics of a population, such as average age, sex ratio, marital status, family size, education, occupation, and geographic location.
Design for the environment	Products that are designed and managed to cause minimal environmental impact through their manufacture, use, recovery, and disposal. See also **greener design**.
Didymo or 'rocksnot' *(Didymosphenia geminata)*	A **species** of single-celled **algae** that grow in warm and shallow freshwater. It can form large mats on the bottom of lakes, rivers, and streams, affecting stream **habitat**s and fish food sources, and making recreational activities unpleasant.
Diesel boiler	A boiler fuelled by diesel oil.
Diesel oxidation catalyst	A device that breaks down pollutants in the exhaust stream of diesel vehicles into less harmful components.
Dioxins	The by-products of various industrial processes (such as bleaching paper pulp, and chemical and **pesticide** manufacture) and combustion activities (such as burning rubbish, forest fires, and **waste** incineration).
Dissolved oxygen	The oxygen content of water.
Dissolved reactive phosphorus	The soluble form of the nutrient phosphorus, which is readily available for use by plants.
Distribution	In biology, the geographical area within which a **species** can be found. Also referred to as *range*.

Diversion	In reference to **waste**, diverting from **landfill** or **cleanfill** to other destinations, typically for reuse, **recycling**, or to recover materials.
Dobson unit	A measure of atmospheric ozone, specifically ozone in the stratospheric **ozone layer**. One Dobson unit refers to a layer of ozone that is 10 μm thick under standard temperature and pressure.
Domestic recycling	Materials **recycled** by householders through kerbside collection or at drop-off facilities.
Domestic transport	Road, off-road, and rail land transport, coastal shipping, and national air transport. International transport is excluded.
Doorspread	The distance between the two trawl doors of a fishing **trawler** – effectively, the width of a single trawl **sweep**.
DPSIR model	Driving force-Pressure-State-Impact-Response model, which shows how human activity (also known as a driver or driving force) exerts pressure on the environment and, as a result, changes the state of the environment. It includes human responses to these changes to alter the driving force in some way. (See chapter 1, 'Environmental reporting'.)
Dredge/dredging	A means of harvesting bivalve molluscs such as oysters, clams, and scallops from the seabed. The fishing vessel tows a metal-framed basket (dredge), raking the catch from the sea floor into the basket.
Drop-off facilities	Specific sites provided for local communities to drop off materials for **recycling**.
Dry bulk density	Natural density, the weight of dry soil per unit of volume, usually expressed in g/cm^3.
Drystock pasture	Sheep, beef, deer, and other farming activities that occur on pasture.
E. coli (Escherichia coli)	**Bacteria** that indicate the presence of **faecal matter**, and therefore risk of disease, in freshwater. See also **recreational water quality**.
Earth flow erosion	A slow-flowing mass of fine-grained soil particles saturated with water.
Ecological balance of trade	The difference between the **ecological footprint**s of exported and imported goods and services.
Ecological diversity	The variety of ecosystems in a particular geographic area, and the communities within them and actions between them.
Ecological footprint	A measure of how much biologically productive land and sea area is needed by an individual, population, or activity to compensate for all the resources consumed and to absorb the carbon dioxide emissions it generates as **waste**. This is calculated using prevailing technology and resource management practices, and is usually measured in global hectares. Because trade is global, an individual's or a country's footprint includes contributions that have been imported from all over the world.
Ecosystem	All plants, animals, and micro-organisms in a particular area, interacting with all of that environment's non-living physical factors. Ecosystems may be small and short-lived (for example, water-filled tree holes or logs rotting on a forest floor), or large and long-lived (such as forests or lakes).
Ecotoxic	An element that is **toxic** to the environment, or to a particular ecosystem; and, for substances, capable of harming the environment.

Ecotoxicity	Harmful to **ecosystems** or to the wider environment.
Effluent	**Liquid waste** that enters the environment from a farm, factory, commercial establishment, or **household**. It can refer to **livestock**'s urine or manure, but generally refers to **wastewater** from a **sewage** treatment plant.
Electricity generation	The process of producing electricity by transforming other forms of **energy**.
Electronic waste	Any electrical or electronic appliance that is unwanted and/or unvalued, and discarded or discharged.
El Niño	During an El Niño phase of **ENSO**, New Zealand tends to experience stronger or more frequent winds from the west in summer, typically leading to drought in east coast areas and more rain in the west.
Emission	A **pollutant** that is released into the atmosphere; its **concentration** will depend on how the pollutant disperses in the atmosphere.
Emissions inventory	An estimate of the quantity of pollutants being released into the atmosphere.
Endangered species	A **species** that is at risk of becoming extinct because it is either few in number or threatened by changes in the environment.
Endemic	In biology and ecology, something that is found *only* in its own place or region, and does not naturally occur anywhere else. The place must be a discrete geographical unit – often an island or island group, but sometimes a country, **habitat** type, or other defined area or zone. (The term 'endemic' may sometimes be applied to **species** that *breed* only within a specified locality/region and are unique to that area, such as species that breed only in New Zealand, but disperse to other countries at certain stages of their life cycle.)
Endemism	The occurrence of plant or animal species (termed **endemic**) which are naturally found only in a specified area or locality.
Energy	Power derived from physical or chemical resources to produce light, heat, or movement.
Energy efficiency	The ratio of total useful output to energy input.
Energy transformation	The process of transforming energy from its initial state (**primary energy**) into a more convenient, useable state (**consumer energy**).
Engineered liners	Used to minimise leachate from entering and contaminating surface and groundwater systems.
ENSO	El Niño Southern Oscillation is synonymous with the El Niño/La Niña cyclical weather patterns. An interaction between the tropical Pacific Ocean and the global atmosphere that results in irregular (two to seven years) oscillations in ocean and atmospheric conditions, often with significant impacts, such as altered marine **habitat**s, rainfall changes, floods, droughts, and changes in storm patterns. See also **El Niño** and **La Niña**.
Enterococci	**Bacteria** that occur naturally in the gut of humans and animals, including mammals, birds, fish, and reptiles, which are useful indicators of the extent of faecal contamination of recreational waters.

Environmental indicator	A physical, chemical, or biological variable (or set of **variables**), generally quantitative, that may be used to describe complex environmental information, including trends and progress over time.
Environmental reporting	Providing information on the environmental **status** of an area, or a particular environmental aspect, such as air, **waste**, or water.
Erosion	The wearing away of land by the actions of water, wind, or ice.
Estuary	A semi-enclosed coastal body of water with an open connection to the sea and within which sea water mixes with freshwater from land **run-off**, usually a river.
Exceedence	Where the concentration of a pollutant exceeds a national environmental standard or a guideline.
Exclusive Economic Zone (EEZ)	The area of sea and seabed beyond coastal waters, from 12 to 200 nautical miles offshore.
Exotic	Introduced from another country.
Exotic conifers	Introduced cone-bearing trees.
Exposure	Contact with a chemical, physical, or biological agent that can have either a harmful or beneficial effect.
Extended continental shelf (ECS)	An extension of the **continental shelf** that includes some of the deep ocean floor. The extent of New Zealand's ECS is currently being considered by the United Nations Commission on the Limits of the Continental Shelf.
Extinction	In biology and ecology, the demise of a **species** that results in **biodiversity** being reduced. The moment of extinction is generally considered to be marked by the death of the last individual of that species.
Faecal matter	Particles of animal dung or human faeces, which carry **bacteria** that can be harmful if ingested. See also **sewage** and ***E. coli*.**
Farm plastics	Chemical containers and silage wrap used on farms; these are dangerous to burn or bury on the farm, and if not properly managed can be **hazardous** if disposed of to **landfill**s.
Fauna	All animal species present, especially in a particular country, region, or time.
Fibrous mat	A mat made up of plant root fibres.
Fish stock	Any fish, seaweed, or other aquatic life of one or more **species** that are treated as a unit for the purposes of **fisheries** management.
Fisheries	A general term that covers the fishers, vessels, and fishing gear involved in catching fish from a particular fish stock. It also refers to the fishing grounds and catch.
Fishing year	From 1 October to 30 September of the following year.
Floodplain	A plain that borders a river and is subject to flooding.
Flora	All plant species present, especially in a particular country, region, or time.

Food chain	The feeding relationships (also called food webs and food networks) between **species** in an ecological **community**. It graphically represents the transfer of material and energy from one species to another within an **ecosystem**.
Forest sink	The ability of a forest to remove a **greenhouse gas** from the atmosphere. In New Zealand, forests are the primary **carbon sink**.
Fossil fuel	Coal, natural gas, liquefied petroleum gas (LPG), crude oil or a fuel derived from crude oil (including petrol and diesel), so called because they have been formed from ancient **organic matter** over long periods of time.
Fuel combustion	The controlled burning of solid, liquid, or gaseous **fossil fuel**s to generate heat or energy.
Fugitive emission	An emission that escapes during the production and processing, transport, storage, transmission, and distribution of **fossil fuel**s such as coal, oil, and natural gas.
Gaseous exchange	The exchange of oxygen (O_2) and carbon dioxide (CO_2) that occurs in the respiratory system.
Gastropod	A soft-bodied animal, which is often protected by a shell. Marine gastropods include sea snails, sea hares, limpets, abalones, turbans, and tritons.
Gazetted	Published in the *New Zealand Gazette* as an official record, which may appear before a change (such as the creation of a national park) takes effect legally.
Gazetted airshed	An area, formally notified in the *New Zealand Gazette*, that is likely or known to have unacceptable levels of **pollutant**s, or may require air quality management.
Genetic diversity	The genetic variety found among individuals of a single **species**.
Geographically spatial (geospatial) data or information	Data and information that can be related to a specific location or set of points on land, in water, in air, or in the atmosphere, and represented on a map. **Geospatial** data is used in a geographic information system (GIS), which is a software programme for analysing data and creating maps.
Geology	The study of the earth's outer layer, including the minerals and rocks it is made of, and the physical forces that affect its development and appearance.
Geospatial	Spatial representation of geographic information.
Glacial action	The action of glaciers.
Global hectare (gha)	A local hectare that is adjusted to allow comparisons of **ecological footprint**s with other countries, such as its ability to produce resources and absorb **waste**s in a given year against a world average. For example, a hectare of New Zealand grazing land is 2.5 times more productive than the global average. The use of global hectares recognises that different land types have different **productivity** – for instance, a hectare of highly productive land represents more global hectares than the same amount of less productive land.
Green waste	**Waste** produced by both commercial and domestic gardening activities, also known as garden waste.
Greener design	The design of products to be environmentally sustainable, which conform to environmentally sound principles of building, material, and energy use.

Greenhouse gas	Atmospheric gas such as water vapour, carbon dioxide, tropospheric ozone, nitrous oxide and methane, transparent to incoming solar radiation but opaque to reradiated long-wave radiation.
Gross domestic product (GDP)	The value of all goods and services produced in New Zealand during a specified time period.
Ground level ozone	A colourless and odourless gas that is a **secondary pollutant**. It differs from atmospheric ozone (see chapter 8, 'Atmosphere') as it occurs at ground level. Examples of **pollutant**s that form ozone are oxides of nitrogen and volatile organic compounds caused by transport, home heating, and industrial processes.
Groundwater	Water that flows beneath the land surface through pores and fissures in rock and soil. Permeable underground zones where groundwater accumulates are known as **aquifer**s. See also **confined aquifer** and **unconfined aquifer**.
Groundwater bore (well)	A pipe installed vertically in the ground through which **groundwater** is pumped to the surface.
Gully erosion	Erosion caused by **run-off** water accumulating in narrow channels and creating large gullies.
Habitat	The area where a particular **species** lives – essentially, the natural environment that surrounds, influences, and is used by a species population.
Halocarbon	A chemical compound containing carbon atoms and one or more atoms of the halogens chlorine, fluorine, bromine, or iodine. Used widely in fire extinguishers, as propellants, and in solvents. Halocarbons have negative environmental effects such as ozone depletion and are also **greenhouse gas**es.
Halon	Chemical compounds containing bromine that have long lifetimes and, when broken down in the atmosphere, are known to cause depletion of ozone.
Hapū	A Māori sub-tribal group made up of **whānau** groups that share a common ancestor.
Hazardous	Having the capacity to adversely affect either health or the environment.
Hazardous activities and industries list (HAIL)	A compilation of activities and industries that are considered likely to contaminate land through their use, storage, or disposal of **hazardous substance**s.
Hazardous substance	Includes but is not limited to any substance defined in section 2 of the Hazardous Substances and New Organisms Act 1996 as **hazardous**.
Hazardous waste	Materials that are flammable, explosive, oxidising, corrosive, **toxic**, **ecotoxic**, radioactive, or infectious. Examples include solvents and cleaning fluids, medical **waste**, unused agricultural chemicals, and many industrial wastes.
Herbaceous	A plant with soft rather than woody tissues.
Heritage protection authorities	An authority that can direct local councils to protect the special heritage qualities of a place or structure under the district plan.
High-producing exotic grassland	An area of introduced grass **species** used for production processes that create a high level of value or wealth.

Household	The European Environment Agency has referred to this term as including all the people who occupy a housing unit. According to Statistics New Zealand, a household includes any number of people usually residing together in a private dwelling, including members who are temporarily elsewhere, but not including visitors. Note that the national accounts data used in chapter 3, 'Household consumption', for **household consumption expenditure**, and the number of households in New Zealand, also includes non-private dwellings such as hospitals and boarding houses.
Household consumption expenditure	The amount of money spent by **household**s on goods and services.
Hybrid vehicle	A vehicle with an internal combustion engine (using petrol or diesel) providing power to the wheels while also charging a battery. An electric motor then uses the stored energy in the battery to move the vehicle at low speeds and while accelerating. The dual or 'hybrid' drive train uses less fuel than a conventional vehicle.
Hydrographic area	A defined area of water and its associated marginal land or underlying sea floor, river bed, or lake bed.
Indigenous	**Native**, or belonging naturally to a given region or **ecosystem**, as opposed to **exotic** or **introduced** (can be used for people, animal, or plant species or even mineral resources).
Inert	Not affecting other substances when in contact with them, chemically inactive.
Inflation	An increase in the general or average level of prices of goods and services over a period of time.
Inshore area	The area extending from the shore out to deep waters.
Integrated catchment management	Decisions on the use of land, water, and other environmental resources based on the effect of that use on all those resources, and on all the people within a designated catchment boundary.
Intensification	In agriculture, an increase in the **stocking rate** of animals, or an increase in the level of production from a given area of land.
Inter-tidal	The area where land and sea meet, which is covered by seawater at high tide, and exposed at low tide.
Intrinsic value	Value that is not dependent on monetary value or usefulness, but a natural part of the item itself.
Introduced species	A **species** that is not **native** to a given place, but has been transported there as a result of human activity.
Invasive species	Non-**indigenous species** of plants or animals that adversely affect the **habitat**s they invade either economically, or environmentally, or in another way.
Invertebrate	An animal that has no backbone or spinal column. Opposite of **vertebrate**.
Irrigation	In horticulture and agriculture, water provided by a sprinkler system to promote plant growth.
IUCN red list	The International Union for the Conservation of Nature and Natural Resource (now the World Conservation Union) produces a Red List of Threatened Species with information about animal species groups, including their **conservation** status. Its main purpose is 'to catalogue and highlight those groups that are facing a higher risk of global **extinction**'.

Iwi	A Māori tribal group.
Jurisdictional zone	A zone governed by a specific legal regime. Each of New Zealand's three marine jurisdictional zones – **territorial sea**, **Exclusive Economic Zone**, and **extended continental shelf** – has its own different legal regime.
Kaitiaki	An **iwi**, **hapū**, or **whānau** group with responsibility for **kaitiakitanga**.
Kaitiakitanga	The guardianship of natural and physical resources by the **iwi** or **hapū** of an area, in keeping with **tikanga Māori**.
Kerbside facilities	Recycling services provided to local communities through the collection of recycled materials directly from **household**s.
La Niña	A weather pattern that frequently affects New Zealand, typically bringing stronger winds and warmer than normal temperatures to much of the country. See also **ENSO** and **El Niño**.
Lambing percentage	The proportion of lambs born to the breeding stock (ewes).
Land cover	The physical material at the earth's surface, including grass, asphalt, trees, bare ground, and water.
Land information memorandum (LIM)	An official document that gives information about land within a territorial authority's district. LIM information will include any building consents or other authorisations applying to buildings on the land, and any special features it has, including potential erosion, subsidence or inundation, or the likely presence of hazardous contaminants.
Land-use control	Control of activities on the land through regulatory methods (such as resource consents) or non-regulatory methods (such as voluntary agreements between land owners and resource managers).
Land-use intensity	The extent to which, or intensity with which, land is used.
Landfill	An area for the controlled disposal of **solid waste**.
Landform	Any feature of the earth's surface with a characteristic shape that has been produced by natural causes.
Landscape	The visible features of an area of land, including physical **landform**s, living **flora** and **fauna**, abstract elements such as light and weather conditions, and human effects.
Landslip	Ground movement, the downward movement of relatively dry masses of rocks and earth or a combination of the two.
Leaching	The process by which dissolved materials are filtered through soil by a liquid (usually water) and often end up in rivers, streams, lakes, and **groundwater**.
Light vehicle fleet	Private and commercial vehicles weighing less than 3.5 tonnes, which together account for 93 per cent of all licensed vehicles on New Zealand roads (excluding motorcycles).
Liquefied petroleum gas (LPG)	A colourless and odourless gas that burns readily in air and is used for heating, cooking, and transport.
Liquid waste	**Waste** that is generated in, or converted to, a liquid form for disposal. It includes point source and non-point source discharges such as **stormwater** and **wastewater**. See also **point-source pollution** and **non-point source pollution**.

Livestock	Domesticated animals, which may be kept or raised in pens, houses, on pastures, or on farms as part of an agricultural or farming operation, for commercial or private use.
Local hectare (lha)	The basic building block of an **ecological footprint**. A local hectare (also referred to as actual land area) shows the biological **productivity** (or **biocapacity**) of one **real** hectare within a specified region or country, in one year. The value of local hectare is limited because it assumes all land to be equally valuable or biologically productive.
Lower-waste goods	Products that result in less **waste**, both in terms of their packaging and their disposal at the end of their useful life.
Low-producing exotic grassland	An area of introduced grass **species** used for production processes that create a low level of value or wealth.
Macroalgae	Large **algae**, including seaweeds, which are visible to the naked eye.
Macroinvertebrate (freshwater)	Aquatic invertebrate animals such as insects, worms, and snails which are visible to the naked eye. Populations of macroinvertebrates are sampled to provide an indication of stream **water quality**. See also **%EPT**.
Macropore	A pore greater than 0.05 millimetres within soil that is usually air-filled and contains water only when the soil is saturated or draining.
Mana whenua	Customary authority exercised by an **iwi** or **hapū** in a particular area.
Managed site	A site containing **hazardous substance**s that is managed so it no longer meets the definition of 'contaminated land' contained in the **Resource Management Act 1991**.
Management areas	Defined areas within New Zealand's **Exclusive Economic Zone** that have a specific management system or rules. These rules apply to recreational fishers and may vary across management areas.
Marine Environment Classification (MEC)	A combination of physical factors used to classify and map deepwater (at least 200 metres deep) marine areas of similar ecological character.
Marine protected area (MPA)	A geographically defined area that is protected primarily for **conservation** purposes and to maintain biodiversity values. It includes **marine reserve**s and **mātaitai**.
Marine reserve	Specified areas of the sea or **inter-tidal** areas that are protected under the Marine Reserves Act 1971, and managed to preserve their natural state as the **habitat** for marine life. All marine life within them is protected.
Marine sanctuary	A defined marine area where certain activities are prohibited to prevent particular **species** from being harmed.
Mass land movement	The bulk movement (**erosion**) of soil.
Mass movement soil erosion	Extreme **landslip**, **tunnel gully**, gully, and earth-flow forms of soil **erosion** in which bulk soil slips away or is gouged away from the land surface through actions of water.
Mast	Fruits or nuts used as a food source by animals following regular or irregular fruiting events of tree species.

Mātaitai	**Marine reserve**s established in areas of traditional importance to Māori for customary food gathering. Usually recreational and **customary fishing** are allowed within the reserve, but not commercial fishing.
Material resources	Physical resources used in the production of goods, as distinct from resources such as energy.
Mauri	A Māori concept, which translates as 'life force'.
Maximum sustainable yield	The largest average annual catch that may be taken sustainably.
Mean annual low flow (MALF)	A statistic that describes the average amount of water in a river during times of low flow.
Median	In statistics, the middle score in a range of samples or measurements (that is, half the scores will be higher than the median and half will be lower).
Micrograms per cubic metre ($\mu g/m^3$)	A measure of concentration. A microgram is one-millionth of a gram.
Milligrams per cubic metre (mg/m^3)	A measure of concentration. A milligram is one-thousandth of a gram.
Mineral deficiency	The lack of particular minerals which are essential for normal nutrition or metabolism.
Mineral matter	Matter formed from naturally occurring compounds, such as rocks. Contrasts to **organic matter**.
Mixed cropping	Several crops growing at the same time on the same area of land.
Monitoring network	A network of rivers, streams, lakes, and **groundwater bore**s from which water is tested at regular intervals (say, once a month) to determine its quality.
Mudstone	Soft, sedimentary rock formed from material that contains a large proportion of clay.
National accounts	A condensed set of information about the national economy, which is compiled according to internationally agreed concepts, definitions, classifications, and accounting rules.
National environmental standards	Regulations produced by central government under the **Resource Management Act 1991**, which are binding on local authorities.
Native	Occurring naturally in New Zealand (**indigenous**).
Natural cleanfill	Uncontaminated gravel, clay, rock, silt, and other inorganic inert materials.
Natural landscape	A landscape that has not been modified by people or is dominated by natural processes and native plants and animals.
New Zealand threat classification lists	Lists identifying **species** that are at risk of extinction, and providing information about the level and nature of the risk.
Nitrate	A soluble/dissolved form of the nutrient nitrogen that can be readily used by plants.
Nitrate leaching	The transport of **nitrate** through soil by water, often to water bodies.
Nitrogen dioxide	A reddish-brown, pungent gas that is produced mainly from the combustion of **fossil fuel**s (coal, gas, and oil) and some industrial processes. It is one of the **greenhouse gas**es.

Nitrogen-fixing plants	Plants (such as clover) that fix nitrogen (a soil **nutrient**) into the soil. Legume plant roots contain *Rhizobium* bacteria that convert the air's nitrogen into soil nitrates. These can be absorbed by other plants, such as pasture grasses.
Nitrogenous fertiliser	Nitrogen-based plant **nutrient**s added to the soil by humans.
Nominal	As used in chapter 3, 'Household consumption', refers to figures that have not been adjusted for price change (that is, **inflation** or deflation); also referred to as actual current figures.
Non-point source pollution	Pollution that does not have a single point of origin – for example, pollutants that are carried from agricultural or urban land into rivers by rainfall **run-off**, or that soak through soil into **groundwater**. See also **point-source pollution**.
Non-renewable	Matter that is unable to be replaced or regenerated over time.
Nutrient	Chemicals needed by plants and animals for growth, especially nitrogen and phosphorus.
Nutrient cycling	The continuous cycling through an **ecosystem** of minerals, compounds, or elements which promote biological growth or development.
Nutrient run-off	**Nutrient**s that are not absorbed by soil and drain into bodies of water, either in surface or **groundwater** flows.
Olsen P	Olsen phosphate, the phosphate that is available for plant uptake.
Organic carbon	Carbon that is, or has been, part of a living organism.
Organic matter	Matter that has come from a recently living organism; that is capable of decay or the product of decay; or that is composed of organic compounds. Contrasts to **mineral matter**.
Organic pollution	In freshwater, pollution from organic **waste**, such as **sewage** from **wastewater** treatment plants; and discharges of carbohydrate and protein material from timber treatment plants, meat works, and dairy factories. Does not include **persistent organic pollutants** for the purposes of this report.
Organic waste	**Waste** from once-living organisms, including garden waste (**green waste**), food scraps, **biosolids**, and commercial organic wastes. It can sometimes include wastes that may biodegrade in **landfill**s, such as paper, cardboard, and untreated wood.
Organisation for Economic Co-operation and Development (OECD)	This organisation works to address the economic, social, and environmental challenges of globalisation. It has 30 member countries.
Organochlorine	A chemical that contains carbon and chlorine atoms joined together. Some organochlorines are persistent (remain chemically stable) and present a risk to the environment and human health, such as dioxin and polychlorinated biphenyls (PCBs).
Ozone-depleting substances	Chemical substances that cause a net loss of ozone in the stratosphere, usually long-lived man-made gases, such as CFCs.
Ozone layer	The layer of ozone gas that lies 20–25 kilometres above the earth. It plays an important role in protecting the earth from some harmful effects of the sun.
Parent material	Material from which soil develops.

Parent rock	The rock from which soils are derived through weathering.
Particle density	The density of soil particles, used to calculate its porosity and water availability.
Pastoral hill country	Hilly **landscape**s that are covered in pasture.
Pellet fire	An enclosed heating appliance with a controlled feed of compressed wood pellets.
Percentile	A statistic that indicates the relative rank of a value (or measurement) among a range of values. For example, the 95th percentile is the value below which 95 per cent of all values in a range will lie (and only 5 per cent of values will exceed).
Perennial crop	A crop from plants that live for more than one year, such as nuts and berryfruit.
Persistent organic pollutants (POPs)	Pollutants composed of polychlorinated biphenyls (PCBs), **dioxins**, and certain **organochlorine pesticide**s that remain in the environment for long periods of time. They can be highly **toxic** and are widely dispersed, usually by water or wind.
Pest control	The regulation or management of a **species** defined as a pest, usually because it is believed to be detrimental to human health, the ecology, or the economy.
Pest species	An organism that has characteristics regarded as injurious or unwanted, most often because it causes damage to agriculture by feeding on crops or acting as a parasite on **livestock**. An animal may also be a pest when it causes damage to a wild ecosystem or carries germs within human **habitat**s.
Pesticide	A chemical substance used to kill unwanted animals and plants, including herbicides (which kill **vegetation**), insecticides (which kill insects), and fungicides (which kill fungi). See also **agrichemical**.
Petajoule (PJ)	The unit used to measure **energy** production on a national scale. One petajoule is a million billion joules (10^{15} J) and roughly equivalent to a coastal tanker load of 25 million litres of oil, or all the electricity used in Nelson in a year, or more than 10 days' output from the Huntly Power Station when it is operating at full capacity.
pH	The degree of acidity or alkalinity as measured on a scale of 0 to 14 where 7 is neutral, less than 7 is more acidic, and more than 7 is more alkaline.
Plantation forestry	Forest that is grown for an economic return; can be either exotic, or intensively managed indigenous species.
PM_{10} particulates	Airborne particles that are smaller than 10 µm in diameter (about a fifth of the thickness of a human hair). They are produced by the combustion of wood and **fossil fuels**, as well as by various industrial and natural processes.
$PM_{2.5}$ particulates	Airborne particles that are smaller than 2.5 µm in diameter and mostly come from combustion sources (see **PM_{10} particulates**). Most particulate matter from natural sources is larger than 2.5 µm in diameter.
Point source pollution	Discharge of pollutants from a single fixed point, such as a pipe. Examples include discharges from **wastewater** treatment plants and factories. See also **non-point source pollution**.
Pollinator	The biotic agent (vector) that moves pollen from a flower's male anthers to the female stigma of a flower to accomplish fertilisation. The most recognised pollinators are bees.

Pollutant	See **contaminant**.
Potentially mineralisable nitrogen	The amount of soil organic nitrogen converted to plant-available forms under specific conditions of temperature, moisture, aeration, and time. It is a measure of biological activity and indicates the amount of nitrogen that is relatively rapidly available.
Predator	An organism that feeds on another living organism (its prey).
Primary energy	The amount of energy available for use in New Zealand for energy supply and end use. It includes coal, **indigenous** oil, and natural gas, imported oil and oil products, and hydro. It takes into account imports and exports, and allows for changes in energy stocks. By convention, fuels used for international transport are excluded.
Primary production	The production of goods and services from the primary sector, such as agriculture, horticulture, and forestry.
Private land	Land in private ownership – that is, land not managed by the Department of Conservation or any other public body.
Product stewardship	A product-centred approach that helps reduce the environmental impact of manufactured products, by having producers, brand owners, importers, retailers, consumers, and other parties accept responsibility for the environmental effects of their products, from the time they are produced until they are finally disposed of.
Production rate	The speed at which value or wealth is created by producing a good or service.
Productive capacity	The productive yield per unit of land.
Productivity	In environmental terms, the measure of the amount of life that can be supported in an area. It is determined by the availability of **nutrient**s and light.
Proxy measure	A measure of something that is used instead of a more exact measure that may not be practical or possible.
Quota management system (QMS)	A system introduced in 1986 to manage New Zealand commercial **fisheries**, based on individual transferable property rights. It allocates each commercial fisher a share of the total allowable commercial catch, which the fisher may catch or trade the right to. Allowances for recreational and customary Māori catch are made before the total allowable commercial catch is set. **Species** outside the QMS are managed under a permit system that provides no tradeable rights.
Rāhui	Temporary protection of a place or resources by restricting access or harvest. It is set in place by an **iwi** or a **hapū** and may be voluntary or **gazetted**.
Real	In statistics, figures that have been adjusted to remove the impact of price change (that is, **inflation** or deflation).
Recovered materials	Materials that have been collected for **recycling** and reprocessed to create a new material.
Recreational water quality	**Water quality** that is defined by the microbiological health risk it poses to swimmers or others undertaking contact recreation on or in the water. See also **bacteria** and ***E. coli***.
Recycled	**Waste** that has been processed into a new material.

Recycling	The act of collecting and depositing materials that can be **recycled** (such as glass, plastic containers and bottles, aluminium and steel cans, paper, and card), and the processes involved in reusing the materials.
Refrigerants	A range of gases used in refrigerators, cool stores, air conditioning units, and dehumidifiers.
Remediate	Action taken to remove contamination from a site.
Remediation	The removal or destruction of **hazardous substance**s from a site so it is no longer '**contaminated land**' according to the definition in the **Resource Management Act 1991**.
Renewable energy	Energy from sources that do not become depleted or degraded for following generations, such as solar, wind, hydro, biomass, tidal, wave, and ocean currents power. Geothermal energy is considered renewable, although these fields can be depleted if fluids are extracted at a higher rate than they are replenished.
Renewable freshwater resource	The total amount of water flowing into a region (mainly as rainfall), minus any natural losses (mainly through evaporation) before it flows into the sea.
Residual waste	**Waste** remaining after activities undertaken to reduce, reuse, recycle, recover, and treat materials.
Resource efficiency	Effective use of materials and energy to produce goods and services. This may be achieved, for example, through improved manufacturing processes, updating equipment, and technological advancements.
Resource intensity	Using high quantities of materials and energy to produce goods and services. Contrasts to **resource efficiency**.
Resource Management Act 1991	New Zealand's main piece of environmental legislation, which provides the framework for managing the effects of human activities on the environment.
Retrofitting	Updating older systems with new technology or features. That is, to install, fit, or adapt a device or system for use with an original or existing system.
Requiring authorities	An authority that can have areas of land designated under the district plan for a public work or project.
Riparian areas/margin	A strip of land, usually of varying width, that is directly adjacent to a waterway.
Riparian planting	Revegetating the **riparian margin** to reduce erosion and pollutant **run-off** to the waterway.
Rohe	The geographical territory of an **iwi** or a **hapū**.
Rohe moana	A coastal and marine area over which an **iwi** or a **hapū** exercises its mana and its **kaitiakitanga**.
Ruminant animal	**Livestock** (cattle and sheep) with a complex digestive system consisting of a four-part stomach where microbes break down food. Methane, a **greenhouse gas**, is a by-product of the microbial activity (enteric fermentation) and mostly released when the animal exhales.
Running average	An average of measurements taken for a specified duration of time, which moves over time. Every new measurement taken after the initial period replaces the earliest measurement in the periodic sequence, and the average is recalculated.
Run-off	Water that is not absorbed by soil but drains off the land into bodies of water.

Rural subdivision	The division of rural land into separate lots.
Saltwater intrusion	The movement of saltwater (seawater) into freshwater (usually **groundwater** near the coastline).
Sandstone	Sedimentary rock consisting of compressed or cemented sand-sized particles.
Saturation	The point at which soil can no longer accept external inputs, such as water.
Screening survey	A low-cost monitoring method used to make an initial assessment of air quality.
Seabed trawling	A fishing method that involves towing trawl nets along the seafloor. It can be carried out from one vessel or from two vessels fishing cooperatively.
Seabed trench	A deep, elongated depression or valley in the ocean floor.
Seamount	A mountain rising from the seafloor, but not reaching the sea's surface.
Secondary pollutant	A pollutant not directly emitted from a source, but formed by a subsequent chemical reaction. For example, **ground level ozone** requires precursor pollutants in order to form.
Secondary treatment	The treatment of **sewage sludge** to degrade its biological content, usually by aerobic biological processes.
Security of supply	Also known as energy security, this has two key dimensions: reliability and resilience. Reliability means users can access the **energy** services they require, when they require them. Resilience is the ability of the system to cope with shocks and change.
Sediment	Particles or clumps of particles of sand, clay, silt, or plant or animal matter carried in water.
Sedimentation	The accumulation of **sediment**.
Septic tank	An underground tank that receives, treats, and disposes of human **sewage** and other **wastewater** into the surrounding soil. Such tanks usually service houses that are not connected to municipal **sewerage** treatment stations (such as houses in rural areas).
Sequestration	In forestry, the uptake of carbon dioxide by trees.
Set-net fishing	A fishing method where a net is placed in water with floats at the top and weights on the bottom. Fish are caught as they swim into the net.
Sewage	**Liquid waste** formed from human excreta (faeces and urine) and other **household wastewater** from cooking, washing, cleaning, and so on.
Sewage sludge	A by-product of **sewage** collection and treatment processes, also known as **biosolids**.
Sewerage	A network of underground pipes (sewers) that carries **sewage** and **wastewater** to and from treatment stations.
Shelter belt	Trees or shrubs that are planted in a row to provide stock or human dwellings with shelter and protection from the wind.
Short-rotation croplands	**Arable cropping** such as the cultivation of grains, fodder crops, and vegetables.
Siltation	The deposition or accumulation of silt.
Silviculture	The science and practice of growing, establishing, and maintaining forests.

Soil	Soil is the layer of minerals and organic matter that forms the earth's crust. It is formed over time by the interaction of climate and living organisms on parent material, which can be a mixture of inorganic and organic materials.
Soil acidification	A gradual increase in a soil's acidity (**pH**) due to both natural processes and land management.
Soil compaction	Deterioration of soil structure (the size, shape, and stability of soil particles and the spaces between and within these particles). See also **compaction**.
Soil conservation	Measures taken to preserve a **soil resource**.
Soil fertility	The ability of a soil to provide enough **nutrient**s for plant growth.
Soil health	Synonymous with both the quality and condition (biological, chemical, nutrient, and physical) of a soil type, relating to its natural characteristics or sustained use.
Soil intactness	Expresses whether soils are staying in place on the land surface and what factors may contribute to soil movement or loss (that is, soil **erosion**).
Soil nutrient enrichment	The addition of soil nutrients by the application of fertilisers or other **agrichemical**s, and organic matter such as compost, or through the use of nitrogen-fixing plants such as clover.
Soil resource	The soil that occurs naturally and is of use to humans.
Soil structure	The way soil particles are arranged together (aggregated).
Soil type	The classification of a soil, based on its chemical and physical properties.
Solid waste	All **waste** generated as a solid or converted to a solid for disposal, including paper, plastic, glass, metal, electronic goods, furnishings, and **organic waste**s.
Solid waste analysis protocol	A baseline measurement programme to provide generic **solid waste** composition data for New Zealand.
Special waste	**Waste**s that pose particular management and/or disposal problems, and need special care, such as **used oil**, tyres, end-of-life vehicles, batteries, and electronic goods.
Species	One of the basic units of biological classification. A species comprises individual organisms that are very similar in appearance, anatomy, physiology, and genetics, due to having relatively recent common ancestors; and can interbreed.
Species diversity	The variety (or number) of **species** within a particular geographic area.
Sponge	Animal belonging to a group of sedentary filter-feeding **invertebrate**s.
Status	In reference to **fish stock**s, their condition; in technical terms, how a stock compares with the **target biomass level**.
Stewardship	The duty of care placed on everyone – government, business, and the **community** – to prevent **waste** and recover resources. See also **kaitiakitanga**.
Stocking rate	The number of **livestock** per unit area of land (such as per hectare).
Storage sources	Lakes and reservoirs (including reservoirs created by the damming or diversion of rivers).

Stormwater	Rainwater **run-off** that is channelled through drains from roads and urban properties into waterways and the sea.
Sulphur dioxide	A colourless gas with a pungent smell, produced during the combustion of fuels containing sulphur, such as coal and diesel.
Sulphur hexafluoride	A non-**toxic**, non-flammable gas, which is chemically very stable. Its predominant commercial use is in the electrical sector as an insulant.
Surface mine	An area of land where minerals are extracted from its surface.
Surface water	Water on the land surface that flows in channels (rivers and streams) and lies in depressions (lakes). Note that, in this report's discussions of water allocation, lakes are not included in the definition of surface water.
Sweep	In fishing, the area trawled over by a vessel towing gear along or near the seabed.
Taiāpure	Fishing areas with special importance to local Māori, managed by the **community** with involvement from local **iwi** and **hapū**.
Tangata kaitiaki/tiaki	Customary-take guardians elected by **iwi** and **hapū**, and appointed by the Minister of Fisheries. These guardians are called tangata **kaitiaki** in the North Island and tangata tiaki in the South Island. They can issue permits to allow the harvest of aquatic life within **rohe moana** and recommend additional bylaws to influence the use of the resource.
Tangata whenua	People of the land; the **indigenous** people of New Zealand. In relation to a particular area, it means the **iwi** or **hapū** that holds **mana whenua** over that area.
Tāonga	A resource or object that is highly valued by Māori; a treasure.
Tapu	A Māori concept of 'sacred' or 'forbidden'.
Target biomass level	The Fisheries Act 1996 requires that **fish stock**s are managed so their numbers stay at or above the target **biomass** level. Generally, this is set at the level that can produce the **maximum sustainable yield**.
Tauranga waka	Canoe landing sites.
Taxonomy	The practice and science of classification of living organisms into taxonomic units known as taxa.
Technology taker	An entity that receives technology that has developed elsewhere and adapts it for its own needs, rather than developing its own unique technology.
Temperature inversion	A layer of warm air that sits over a layer of cooler air near the ground. Because cool air is heavier than warm air, it often remains trapped close to the ground. Air pollution that gets trapped beneath the inversion layer can build up, causing air pollution concentrations to increase.
Territorial sea	Area of sea extending seaward from the coast to 12 nautical miles offshore.
Tertiary treatment	The final stage in treating **wastewater**, typically involving the removal of substances such as nitrates and sometimes including disinfection of the water.
Threatened species	Any animal or plant **species** that is vulnerable to **extinction** if factors causing its vulnerability are not reversed.

Threshold	The dose or exposure, below which a significant adverse effect is not expected.
Tikanga Māori	Māori customary values, practices, and traditions.
Topography	The natural surface features of a land area, including its shape and relief.
Topsoil	The uppermost layer of **soil**, which has the highest concentration of **organic matter** and micro-organisms; this is where most of the earth's biological soil activity occurs.
Total allowable catch	The total amount of fish allowed to be harvested each year by both commercial and non-commercial fishers.
Total carbon content	The amount of carbon present in a soil, measured from the **status** of the soil's **organic matter**.
Total nitrogen content	The amount of nitrogen present in a soil, measured from the soil's organic nitrogen reserves.
Toxic	The quality or degree of being poisonous or harmful to plant, animal, or human life.
Trace gas	A minor constituent of the atmosphere.
Trade waste	**Liquid waste**s generated by industry and business and disposed of through the **sewerage** system. It includes a range of **hazardous** materials resulting from industrial and manufacturing processes.
Transfer stations	Facilities where waste collections are deposited and sorted into recyclable and non-recyclable **waste**. Recyclable waste is then transferred for processing and non-recyclable waste is transferred to **landfill**s.
Trawl catch effort processing returns (TCEPR)	Forms completed by commercial fishers, providing information to the Ministry of Fisheries.
Trawl effort	The amount of **trawling** undertaken, expressed in either area terms (square kilometres swept) or number of trawls.
Trawler	A fishing boat that uses a trawl net or dragnet for fishing.
Trawling	Fishing methods where a single vessel or pair of vessels tow a large netting bag (trawl net).
Treated timber	Wood that contains preservative chemicals (such as copper, chrome, or arsenic) and requires careful disposal to avoid harming the environment.
Tree line	The edge of the **habitat** at which trees are capable of growing. Beyond the tree line, usually at high altitude, trees are unable to grow because environmental conditions are inappropriate.
Triple bottom line (sustainability) reporting	A reporting technique that allows organisations to assess their performance against economic, environmental, and social criteria.
Trophic level index	A six-category index used to monitor and report on the **nutrient** status of lakes in New Zealand, using measures of nitrogen, phosphorus, **algal biomass**, and visual clarity.
Tunnel gully	An **erosion** process in which water percolates through subsoils, forming caves or tunnels that often cause surface subsidence.
Tussock grasslands	**Native** land cover of tussock grasses.
Typology	The organisation of items into groups based on their shared characteristics.

Unconfined aquifer	**Aquifer**s that are 'open' to the land surface – that is, there is no low-permeability confining layer between them and the land surface. Typically shallow, they are normally composed of permeable surface sands and gravels and recharged directly by rainfall percolating from the land surface. See also **confined aquifer**.
Urupā	Māori traditional burial grounds.
Used oil	Oil contaminated through use with substances that can be **hazardous** to human health and the environment.
UV index	An index used to inform the public about the intensity of ultraviolet (UV) radiation. The larger the number, the higher the risk of skin damage.
Variables	Properties of objects that take on different values that can be measured or counted.
Varroa mite	An Asian mite (*Varroa jacobsoni* syn. *V. destructor*) that is a parasite of honeybees.
Vegetation	A general term for the plant life of a region; the ground cover provided by plants.
Versatile soil	A soil that is suited to a variety of uses, including those that are demanding on soil structure, such as cultivation and cropping.
Vertebrate	An animal that has a backbone or spinal column. Opposite of **invertebrate**.
Viticulture	The cultivation of grapes for use in the production of wine.
Wāhi tapu	Special and sacred sites for Māori.
Waste	Any material (solid, liquid, or gas) that is unwanted, unvalued or both, and discarded or discharged.
Waste disposal	The final placement of **waste**.
Waste electronic and electrical equipment	Products that are dependent on electric currents or electromagnetic fields to work, and which are no longer required and due for disposal. Examples include fridges, fluorescent lamps, toasters, computers, and mobile phones.
Waste hierarchy	The order of preferred **waste** management options. The most preferred option is to reduce, followed by reuse, recycle, recover, treat, and lastly, dispose of.
Waste management plans	Plans produced by territorial authorities outlining the **waste** management and minimisation activities undertaken in their area.
Waste minimisation	All activities aimed at preventing, reducing, reusing, or **recycling waste**.
Waste prevention	Practices that avoid and reduce the generation of **waste**.
Waste recovery	The extraction of materials or **energy** from **waste** for further use or processing, including making materials into compost.
Waste sector	The collective term for industries and businesses that are specifically involved in the collection, disposal, or, reprocessing of **waste** and **recycled** materials.
Wastewater	A by-product of **sewage**, liquid **trade waste** collection, and treatment processes.

Water column	The volume of water between the seabed and the sea's surface. Regional councils are responsible for the sea's water column from the foreshore to the outer limits of the **territorial sea**.
Water quality	The 'health' of freshwater, as defined by measures of its physical, biological, and chemical properties, as well as other attributes valued by users (such as its aesthetic quality). See also **aesthetic/amenity value**.
Weed	A plant that is considered to be unwanted or a nuisance. The term is often used to describe **native** or non-native plants that grow and reproduce aggressively.
Wetlands	Wet areas of land or shallow water that support plants and animals that have specifically adapted to living in those conditions.
Whakapapa	Māori genealogy; ancestry.
Whānau	Māori family group.
Wood burner	An appliance designed for or capable of burning wood, generally to provide heat for **household**s.

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