

NATIONAL  
**Hazardscape**  
REPORT





## FOREWORD

As Chair of the Officials' Committee for Domestic and External Security Coordination (ODESC), I am pleased to introduce to you the National Hazardscape Report. ODESC has broad oversight roles in the area of emergency readiness and response. It is charged with providing strategic and policy advice to the Government for events of national importance, and it coordinates the activities of central government agencies in preparing for and responding to emergencies, natural disasters, and security crises.

The primary audience for the National Hazardscape Report is national and local decision-makers and emergency management stakeholders. I hope that the Report will also be a useful resource for a wider range of readers such as the education sector, international emergency management organisations, and the general public.

Hazard managers and decision-makers need to understand the range and nature of New Zealand's hazards, what their impacts could be in any given locality and how they can best be managed. The National Hazardscape Report takes the first steps towards meeting these needs.

The National Hazardscape Report provides a contemporary summary of New Zealand's hazardscape. Seventeen of our most significant hazards are discussed, along with their impacts, distribution, frequency, and how they are currently managed. New Zealand has a large and varied number of natural, technological, and man-made hazards, and we must understand them and the risks they pose.

I encourage you to read the National Hazardscape Report and consider the ways we can all reduce risks and make our communities safer.

Maarten Wevers  
Chair  
Officials' Committee for Domestic and External  
Security Coordination





## EXECUTIVE SUMMARY

New Zealanders are, and will continue to be, at risk from a broad range of hazards. Many communities, and much industry and infrastructure, are located in areas that are likely to be affected by hazards.

Flooding is the most common natural hazard in New Zealand, and earthquakes and tsunamis are potentially the most damaging and disruptive. Probably the most underrated natural hazard is volcanic eruption.

Accidental release of a hazardous substance, introduced organisms, and diseases may also affect New Zealand's environment, health and economy, and terrorism could become a threat to public safety and national security. Technological hazards and increasing reliance on key infrastructure, urbanisation, more intense land use generally, and climate change all compound New Zealand's exposure and vulnerability to damage, death and injury, and social and economic disruption.

Significant legislation and policy changes since 1994 include the increasing importance of hazard management in local authority plans and policy statements under the Resource Management Act 1991, the Civil Defence Emergency Management Act 2002, the Local Government Act 2002 and the Building Act 2004.

Emergency management arrangements have been strengthened by that legislation. Arrangements and responsibilities across local communities, local authorities, central government, the emergency services, and lifeline utility operators are now clearer.

Alongside these Acts, many other statutes set out further functions, roles and responsibilities of individuals and agencies for managing hazards and risks.

The *National Hazardscape Report* (NHR) does not set out to provide a comprehensive guide to all these arrangements. However, to inform discussion of a hazard or risk, references are made to some specific agencies and legislation.

The NHR is a non-statutory document aimed at informing policy makers, hazard managers and their advisors in carrying out hazard and risk management at the national and local level. It provides a contemporary summary of the physical nature, impacts, distribution, and frequency of occurrence of the 17 key hazards affecting New Zealand. The NHR also provides general information on the current management of hazards, through a focus on reduction and readiness initiatives. The hazards described in the NHR include geological, meteorological, biological, technological, and social hazards.

Additionally, four key factors that influence New Zealand's current hazardscape are discussed in the NHR: climate change, demographic and future development trends, reliance on technology, and human modification of the natural environment. These four factors, separately and collectively, will play a continuing role in determining the nature of hazards and risks that New Zealand faces, and their management.

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# INTRODUCTION

## Purpose and audience

New Zealand's citizens, businesses, hazard managers, and decision makers need to understand our hazards, the risks they pose, and how they are currently managed, if we are to improve our hazard and risk reduction, emergency readiness, and response and recovery arrangements. The Officials' Committee for Domestic and External Security Coordination (ODESC) is issuing the *National Hazardscape Report* (NHR) to help meet this need.

The central decision-making body of executive government that addresses emergency management is the Cabinet Committee for Domestic and External Security Coordination (DES). The DES committee is chaired by the Prime Minister, and includes those ministers responsible for departments that play essential roles in such situations. To support that process, the ODESC is the committee of government chief executives charged with providing strategic policy advice to the Prime Minister on such matters. ODESC provides oversight in the areas of emergency readiness, intelligence and security, terrorism, and maritime security. The chief executive of the Department of the Prime Minister and Cabinet chairs the committee, and members are the chief executives from relevant government agencies.

ODESC is issuing the NHR to assist ministers and those agencies at the national and local level with a direct role in hazard and emergency management. As everyone in the country is a stakeholder in emergency management, the NHR also contains useful information for the wider community.

The NHR does not place additional requirements on any individual or organisation beyond their existing responsibilities, roles and functions within any legislation and subordinate policy. However, the NHR will help identify priorities and effective courses of action to meet their obligations.

## Scope

The NHR summarises New Zealand's hazardscape and, to a lesser level, its risk exposure. Hazards are described by their physical nature, impacts, spatial distribution, frequency of occurrence, and current management arrangements.

Emergency management plans for local and central government were reviewed to help assess aspects of current hazard management and the national significance of hazards. While acknowledging the 4Rs approach – reduction, readiness, response, and recovery – the NHR focuses primarily on reduction and readiness. This focus recognises that reduction and readiness policy and programmes generally need to be specific to each hazard. In comparison, response and recovery policy and programmes are organised on 'generic' sets of consequences regardless of the hazard source.

Furthermore, core emergency readiness, response, and recovery operational arrangements are set out in emergency management strategies and plans at the national and local levels, including:

- CDEM Group plans
- the National Civil Defence Emergency Management Plan Order 2005 (National CDEM Plan) and the Guide to the National Civil Defence Emergency Management Plan 2006 (the Guide to the National CDEM Plan)
- the New Zealand Influenza Pandemic Action Plan
- the National Marine Oil Spill Contingency Plan.

## New Zealand's emergency management context

Central to emergency management in New Zealand is an all-hazards, all-risks, multi-agency, integrated, and community-focused approach. Risk management is based around various strategies that have evolved over the years. One generic template involves the 4Rs of reduction, readiness, response, and recovery.

The 4Rs are:

- **reduction** – identifying and analysing long-term risks to human life and property from hazards, and taking steps to eliminate these risks if practicable, or if not, to reduce their likelihood and the magnitude of their impact
- **readiness** – developing operational systems and capabilities before an emergency happens, including self-help and response programmes for the public as well as specific programmes for emergency services, lifeline utilities (infrastructure providers) and other agencies
- **response** – taking action immediately before, during or directly after an emergency to save lives and property, and to help communities recover
- **recovery** – using coordinated efforts and processes to bring about the immediate, medium-term, and long-term regeneration of a community following an emergency.

This report takes a broad interpretation of the term 'hazard'. Historically, natural hazards, and in particular flooding and earthquakes, were the main focus of emergency management. Technological development in New Zealand has created significant new hazards and risks, and increasing reliance on infrastructure has led to potentially greater community vulnerability. Hazardous substances, introduced organisms and diseases, and terrorism are included here as they may threaten public safety or adversely affect New Zealand's environment, health, and economy.

Individual agencies at the national and local level have a direct role in hazard and risk management, and operate under existing legislation and policies.

At a regional level, 16 regionally based CDEM Groups and their constituent local authorities and emergency services are responsible for implementing local risk management and civil defence emergency management. Legislation setting out these responsibilities includes the Resource Management Act, the Local Government Act, the Building Act, the Health Act, and the Civil Defence Emergency Management Act.

## Key terminology and definitions

Several key terms used in the report may need to be explained.

An event, for the purposes of the NHR, is an extreme occurrence of a natural process or a large-scale man-made incident.

Natural events may be:

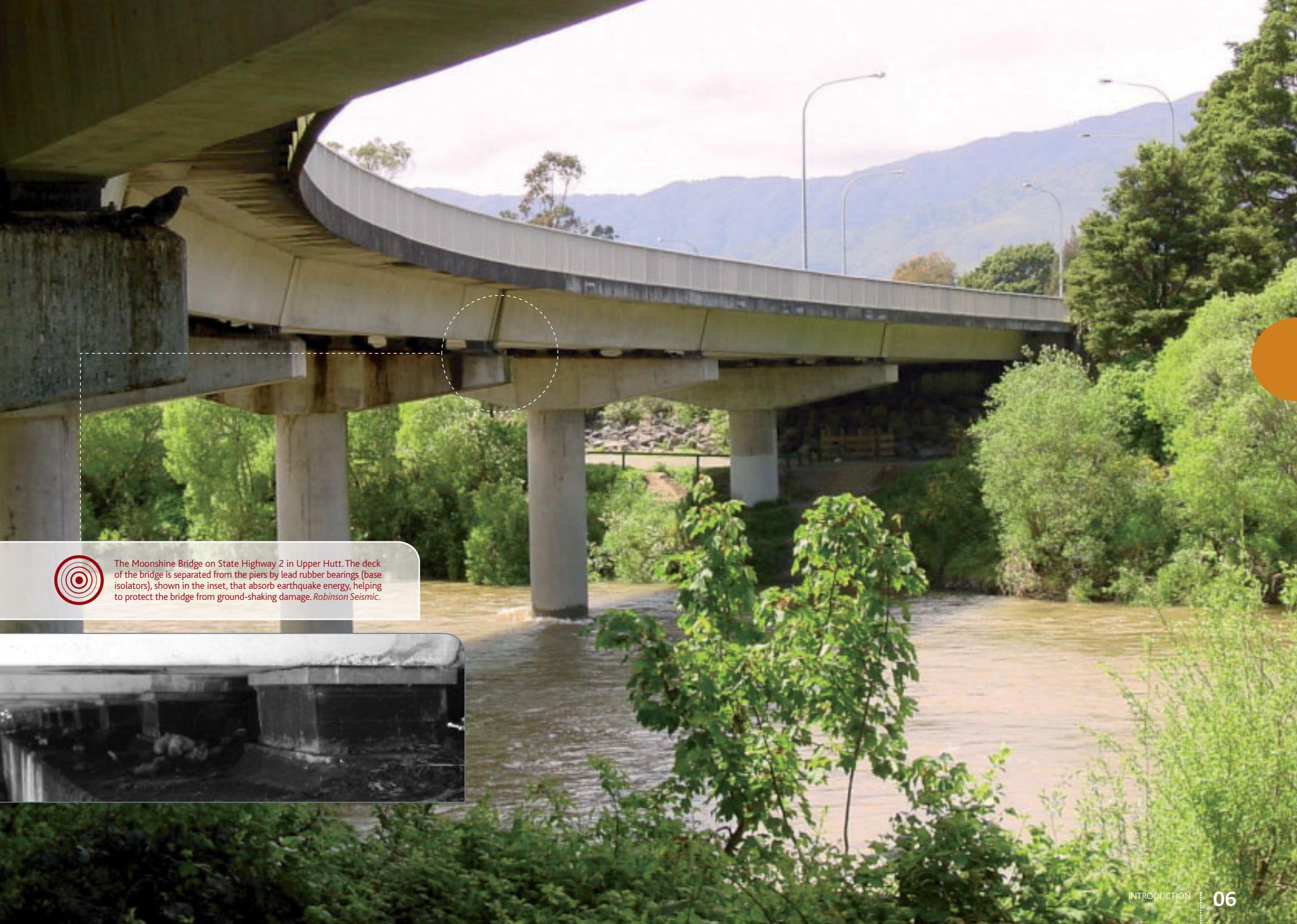
- meteorological (for example, strong winds, snow or heavy rain)
- geological (for example, earthquakes, tsunamis, landslides, and volcanic eruptions)
- biological (for example, animal and crop diseases, and human disease epidemics).

Man-made events can be classified into two main groups:

- technological (for example, major transport accidents and major infrastructure failures)
- social (for example, terrorism).

Some biological threats may also be considered to be man-made.





The Moonshine Bridge on State Highway 2 in Upper Hutt. The deck of the bridge is separated from the piers by lead rubber bearings (base isolators), shown in the inset, that absorb earthquake energy, helping to protect the bridge from ground-shaking damage. *Robinson Seismic.*



## Hazard and risk management

The focus of hazard and risk management in the NHR is reduction and readiness. Recovery can also include, for example, taking the opportunity to relocate people and property away from hazard-prone areas after an event.

There are three main ways to reduce risk from hazards – modifying the event, modifying the proneness to damage, and minimising the consequences through rapid intervention.

Reducing risk by modifying the nature of an event or by modifying a community's proneness to damage works by cancelling or reducing at least one of the two factors – an extreme event and human use of an area – that interact to create a hazard. Removing one of those factors removes the hazard itself.

For natural hazards, modifying an event includes measures such as building retaining walls for unstable slopes, stopbanks for flood control, and sea walls to control coastal erosion and inundation. Stopbanks prevent flooding up to a certain design level. Their appeal lies in the direct and specific protection they offer. However, stopbanks cannot be built high enough to protect against all floods, and the consequences of their overtopping or failure during a flood may be severe.

Avoiding places where an event is likely to occur and strengthening buildings are examples of modifying proneness to damage. Hazard maps can help planners make decisions on where development should take place and can be used for a wide range of land-use matters. An example of modifying a man-made risk is restricting the transporting of hazardous substances through urban areas.

Minimising the consequences of an event requires a wide range of planning. Response plans, part of readiness activities, are an example of a measure that provides a decision-making and coordination framework to help organisations respond efficiently and effectively to an event, and support the recovery of the community or affected facility. Exercises are valuable to test these frameworks and to highlight areas where they need to be amended or refined.

Readiness, response and recovery arrangements recognise that events may still happen that affect people, property and infrastructure, despite risk reduction measures that may have been taken. For example, there is always a risk that stopbanks and other flood mitigation structures may not contain a flood. Stopbanks can be breached or overtopped by floods larger than they were designed to cope with. In these cases, land-use controls and higher floor levels are effective ways to further reduce risk.

Minimising the consequences deals with the emergency that follows when a hazard becomes a reality. Response and recovery operations will address the consequences of the flood, and try to prevent an escalation of them. Damage and losses that are unavoidable (and uninsurable) are the residual risk associated with that event that individuals and the community must live with.



Stopbanks along the Hutt River protecting the Lower Hutt central business district during flooding in 1998. *Greater Wellington Regional Council.*



Part of the combined earthquake hazard map for Wellington City. Hazard maps help with planning decisions. *Greater Wellington Regional Council.*

## Legislative framework for hazard and risk management

The Resource Management Act 1991 (RMA), the Civil Defence Emergency Management Act 2002 (CDEM Act), and the Building Act 2004 are three key pieces of legislation influencing and promoting integrated environmental management and recognition of hazards and risks. None of these Acts has priority over the others. They sit alongside each other and other legislation.

Other Acts address other specific aspects of hazard and risk management, such as the Biosecurity Act 1993, the Soil Conservation and Rivers Control Act 1941, the Environment Act 1986, the Hazardous Substances and New Organisms Act 1996, the Local Government Act 2002, the Health and Safety in Employment Act 1992, the Maritime Transport Act 1994, the Health Act 1956, and the Forest and Rural Fires Act 1977.

### Resource Management Act 1991

The purpose of the Resource Management Act (RMA) is to promote the sustainable management of natural and physical resources. Under the RMA, both regional councils and territorial authorities have responsibilities to avoid or mitigate natural hazards.

Natural hazards must be considered in the preparation of regional policy statements, regional plans, and district plans. These documents are subject to preparation of a regulatory impact statement, and must allow the reasonable use of land. Regional councils identify significant environmental issues, and provide policy and certain regulatory controls. Territorial authorities are the principal consent authorities (through district plans) for subdivision and land-use approvals. Consideration of natural hazards by regional councils and territorial authorities is also achieved by monitoring the state of the environment and as part of a wide suite of considerations relevant to sustainable management and community well-being.

### Civil Defence Emergency Management Act 2002

The CDEM Act was enacted in 2002 to repeal and replace the Civil Defence Act 1983. The Act promotes the sustainable management of hazards and encourages communities to achieve acceptable levels of risk. It specifies the role and function of civil defence emergency management organisations, and also the responsibilities of government departments, lifeline utilities, and emergency services for the 4Rs (reduction, readiness, response, and recovery).

The CDEM Act required the formation of regional CDEM Groups by 1 June 2003 and the preparation of a CDEM Group plan by 1 June 2005. There are 16 CDEM Groups in New Zealand and each comprises a regional consortium of local authorities, emergency services, health organisations, and lifeline utilities.

A focus of the CDEM Groups is identifying hazards and mitigation activities (reduction), and identifying gaps in hazard knowledge and inefficiencies in mitigation. The implementation of actions and initiatives to address the gaps and inefficiencies is core work for CDEM Groups. Hazard and risk reduction requirements identified as part of this process will be implemented mostly through RMA and Local Government Act planning.

### Building Act 2004

The Building Act 2004 provides the means for ensuring the safety and integrity of structures. The Act is administered by the Department of Building and Housing and covers the performance requirements for the construction of buildings. The Act establishes a certification process to ensure compliance. The Building Code sets out specific criteria to which buildings and structures must conform.

The Act requires consideration of the nature of the land on which a building is to be built, as this may influence its structural requirements. Land that is, or is likely to be, subject to erosion, avulsion, alluvion, falling debris, inundation, or slippage may be the subject of a notice to ensure that all interested parties are informed.

# THE NEW ZEALAND SETTING

New Zealand is an island nation in the southwest Pacific. Its landscape has been shaped over millions of years by earthquakes, volcanoes, storms, and glaciers. Unique ecosystems evolved over this time in isolation from other land masses.

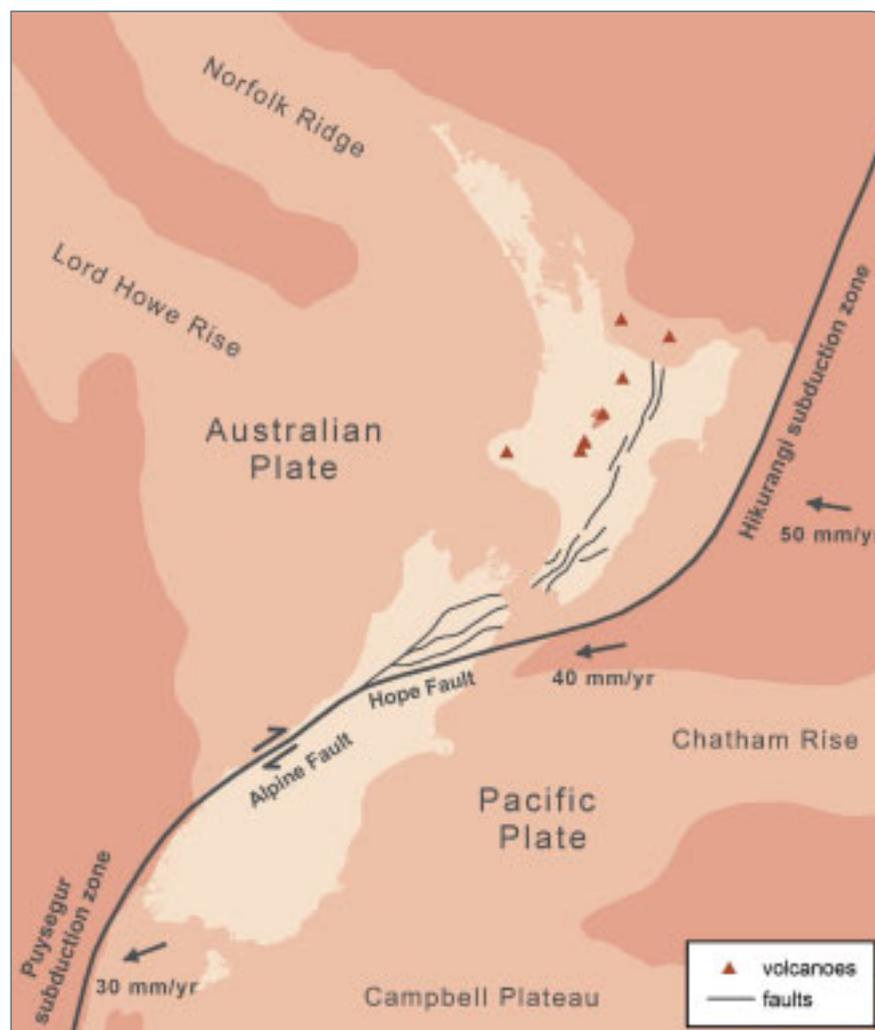
People arrived in New Zealand several hundred years ago and soon realised the destructive potential of these natural processes. By modifying the landscape and introducing many new species, people have altered some of these natural processes and New Zealand's ecosystems.

## Geography

New Zealand lies midway between the equator and Antarctica, about 2600km east of Australia. Its three main islands, the North Island (113 729km<sup>2</sup>), the South Island (150 437km<sup>2</sup>), and the much smaller Stewart Island, stretch 1500km across latitudes 34° to 47° south and are the visible parts of an extensive, mostly submarine continent.

New Zealand lies across the boundary of the Australian and Pacific tectonic plates. To the east of the North Island, the Pacific Plate is being subducted under (pushed under) the Australian Plate. To the southwest of the South Island the opposite is happening – the Australian Plate is being subducted under the Pacific Plate. These two subduction zones are connected by the Alpine Fault and several smaller faults that run through the South Island.

The tectonic setting of New Zealand showing the generalised plate boundary between the Australian and Pacific tectonic plates. The Pacific Plate is moving towards the Australian Plate at around the same rate that fingernails grow. *University of Canterbury.*



Volcanoes, fed by melting of the subducted Pacific Plate, rise in the centre, north, and west of the North Island. Lake Taupo, New Zealand's largest lake, fills the depressions left by several extremely large eruptions of the Taupo volcano, and is overlooked by Mt Ruapehu, the North Island's highest point at 2797m. The remainder of the North Island is mainly rolling hill country, much of which is farmed. A series of narrow ranges – Tararua, Ruahine, Kaimanawa, and Raukumara – runs along the eastern side of the island.



Farmland near Raglan, in the western Waikato region. This rolling hill country is typical of much of the North Island. *GNS Science*.

The geography of the South Island is dominated by the Southern Alps, rising to more than 3000m, created by uplift along the plate boundary over several million years. To the west and north, short, steep rivers flow through rainforest to the Tasman Sea. To the east, the Canterbury Plains are dissected by large braided rivers that flow to the Pacific Ocean. To the south are long glacial lakes that drain through inland basins and rich farmland.



The Rakaia River and the Southern Alps. The Rakaia is one of many large braided rivers that run from the mountains across the Canterbury Plains farmland to the east coast of the South Island. *GNS Science*.

New Zealand has around 18 000km of coastline. Of that, 11 000km are exposed to the open ocean and the remainder are sheltered in harbours and estuaries. The western and southern coasts are exposed

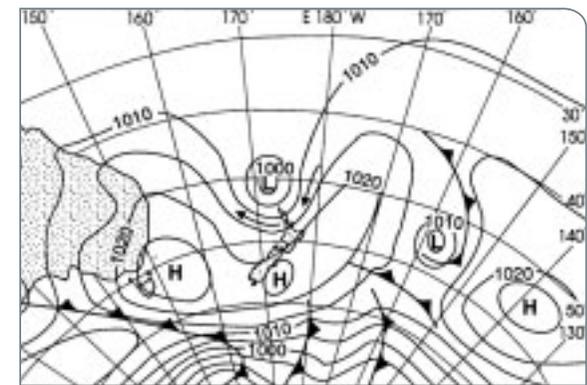
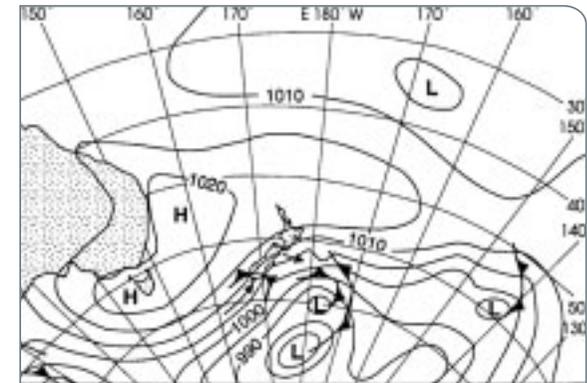
to persistent swells, while the northern and eastern coasts are more sheltered. Warm, salty, subtropical currents exist in the north and west of New Zealand, with cold, less saline, subantarctic currents in the south. Summer water temperatures range from about 21°C in the north to 14°C in the south.

## Climate

New Zealand lies in the mid-latitude zone of westerly winds, known as the 'roaring forties', which flow around the Southern Hemisphere. The weather is typically dictated by an irregular succession of anticyclones and troughs of low pressure on a 6- to 7-day cycle. Anticyclones (high-pressure systems) generally track eastwards across the North Island and bring settled weather with little or no rain. The intervening troughs of low pressure, often containing cold fronts, extend northwards over the country from low-pressure systems that track eastwards to the south of the South Island. The cold fronts bring rain, followed by showers.

The prevailing wind direction is westerly. This wind pattern is modified by the blocking effect of the Southern Alps and North Island ranges. Wind strength decreases on the western side of the ranges, but increases through any gaps in the ranges such as Foveaux Strait, Cook Strait and the Manawatu Gorge. Air is also forced upwards over the ranges (orographic lift), which creates a warm, dry (föhn) wind in the lee areas to the east of both islands.

New Zealand's climate is influenced by the El Niño/Southern Oscillation, a Pacific-wide oscillation that affects air pressure, wind, sea-surface temperature, and rainfall. New Zealand generally experiences stronger than normal southwesterly airflows in El Niño phases, which results in drier conditions in northern and eastern areas, and stronger than normal northeasterly airflows in La Niña phases.



Typical synoptic maps for the New Zealand area during La Niña (top) and El Niño (bottom) phases of the El Niño Southern Oscillation. *Mosley and Pearson, 1997*.

The mountain ranges also control the distribution of rainfall, which varies greatly over short distances. The highest rainfall occurs in the west of both islands where mountains are exposed to westerly winds. More than 8000mm of rain is recorded each year in the Southern Alps. The areas of lowest rainfall are in the lee of the main ranges, such as Central Otago where average annual rainfall is as low as 300mm. However, average annual rainfall in most of the country is between 600 and 2000mm.

Average temperatures decrease from about 15°C in the Far North to about 10°C in the south of the South Island. January and February are the warmest months of the year and July is the coldest. The highest temperatures are recorded east of the main ranges; 42°C has been recorded in the Awatere Valley (Marlborough), Christchurch, and Rangiora (Canterbury). The lowest recorded temperature is -22°C at Ophir (Central Otago).

The North Island has a small permanent snowfield above 2500m on the central plateau, but the snowline rarely descends below 600m. In the South Island, the snowline varies from 2000m in summer to around 1000m in winter. Snow commonly falls to around 300m, and occasionally to sea level in the south and east of the South Island in the winter, but the snowline rarely remains below 1000m for extended periods.

## New Zealand society

New Zealand has a population of about 4.23 million. Its population density, of around 15 people per km<sup>2</sup>, is relatively low by world standards. About 75 per cent of the population live in the North Island and almost 86 per cent of New Zealanders live in urban areas. New Zealand's population is projected to reach about 5 million by 2050.

New Zealand's population is ageing. This is the result of a surge in the birth rate after the Second World War (the 'baby boomer' generation) and the influx of immigrants who arrived at that time and started families. In 1971 children aged below 15 made up 32 per cent of the population; by 2001 this figure had dropped to 23 per cent. Life expectancy at birth in 2000 was 81 years for females and 76 for males.

New Zealanders of Māori origin account for around 16 per cent of the population, 90 per cent of whom live in the North Island. Just over two-thirds of New Zealand's population is European in origin, largely because between the early 1800s and the mid-1970s immigrants came mainly from Europe. More recent immigrants have come mainly from the Pacific Islands and Asia, and now each of those groups makes up around 7 per cent of the population.

The most notable contrasts in population are between Auckland, where one-third of the population lives, and the rest of the New Zealand. Auckland has a higher percentage of Asian and Pacific Island people than the rest of the country.

New Zealand has a very mobile population – about half the resident population aged five or over moves house at least once every 5 years. The fastest growing regions are currently Auckland, Bay of Plenty, Nelson/Tasman, Northland, and Waikato. However, much of this growth is the result of immigration, and higher Māori and Pacific Island birth rates in the northern North Island, rather than internal migration.

## New Zealand's economy

New Zealand's economy is based on market forces. The Government provides a framework of commercial law in which transactions occur. In some sectors, most notably education and health, the Government

is the most important funder and provider. Although the market mechanism has been dominant ever since European settlement, the balance between government involvement and voluntary market transactions has varied.

The tertiary (service) sector dominates production and employment, and the share of secondary (manufacturing) and primary (resource) industries is decreasing. Most industries are technologically sophisticated by world standards, relying on a skilled workforce.

### Primary sector

The primary sector includes agriculture, fishing, forestry, energy, and mining and quarrying. The most important forms of farming are dairy, sheep, beef, deer, goats, pigs, poultry, bees, crops, fruit and vegetables, and vineyards. The primary sector has historically been a strong contributor to the New Zealand economy. It continues to be influential, directly contributing 8 per cent of gross domestic product (GDP) and indirectly 17 per cent of GDP through flow-on effect into manufacturing, processing, education, technology, communications, and transport businesses.

Most of New Zealand's agriculture remains internationally competitive, partly because animals are largely grass-fed, but also because New Zealand farming is technologically innovative and sensitive to market opportunities and changes.

Being a resource-based industry, much of the primary sector is strongly influenced by meteorological conditions.

Because New Zealand is highly dependent on its land-based industries, inadequate hazard management, along with climate change and human modification of the natural environment, poses a real threat to New Zealand's economic sustainability. Hazards to property –

farms, forestry plantations, vineyards, orchards, farm animals, and on-farm infrastructure – pose a significant risk to the economic viability of individuals, communities, and industries.

### Secondary sector

In 2001 the manufacturing sector contributed about 16 per cent to GDP, down from the 25 per cent that was typical of much of the 1900s. In part this decrease reflected the trend occurring in other developed countries, but it was also a result of the elimination of all import licensing and of most tariffs from the mid-1980s.

The largest sub-sectors are food, beverages, and tobacco, followed by machinery and equipment. Auckland was the largest centre for manufacturing in 2001, with 53 per cent of the 235 000 manufacturing labour force.

### Tertiary sector

Transport, communications, commercial services, and tourism are New Zealand's main tertiary sectors. Transport plays an important role because of New Zealand's long and rugged terrain, its thinly spread population, and its distance from other countries.

New Zealanders have had choice and technological sophistication in communications since the late 1980s. New Zealanders have also quickly accepted telecommunications developments, especially cell-phones and the internet. The information and communications technology (ICT) sector is thriving, and New Zealand exports hardware, software, and services.

Other significant commercial services include wholesale and retail trade, banking, and insurance. More and more New Zealand companies provide services offshore using broadband internet. New Zealand is also developing a significant role in the world biotechnology industry.

Tourism is New Zealand's largest industry. During the 1990s, overseas tourist numbers doubled and tourism became the country's leading earner of foreign exchange.

### Exports

New Zealand has had a high level of trade since becoming part of the world economy in the 1800s.

Before 1960 more than 90 per cent of New Zealand's exports were farm products, mostly wool, meat, butter, and cheese, two-thirds of which went to Britain. Farm exports today are much more sophisticated and involve more processing beyond the farm. Dairy products account for 21 per cent of New Zealand's exports by value but most dairy products are exported as milk powder rather than as butter or cheese. Meat exports have dropped from 30 per cent in the mid-1960s to 10 per cent today. Exports now also include timber, cut flowers, kiwifruit, apples, vegetables, and wine. Primary products continue to be New Zealand's biggest and most consistent revenue earner.

The manufacturing sector is a major exporter, either by processing and adding value to the primary sector exports, or by general and specialist products in their own right. Among the range of goods sold overseas are whiteware (fridges and dishwashers), electric fences, newsprint, and furniture.

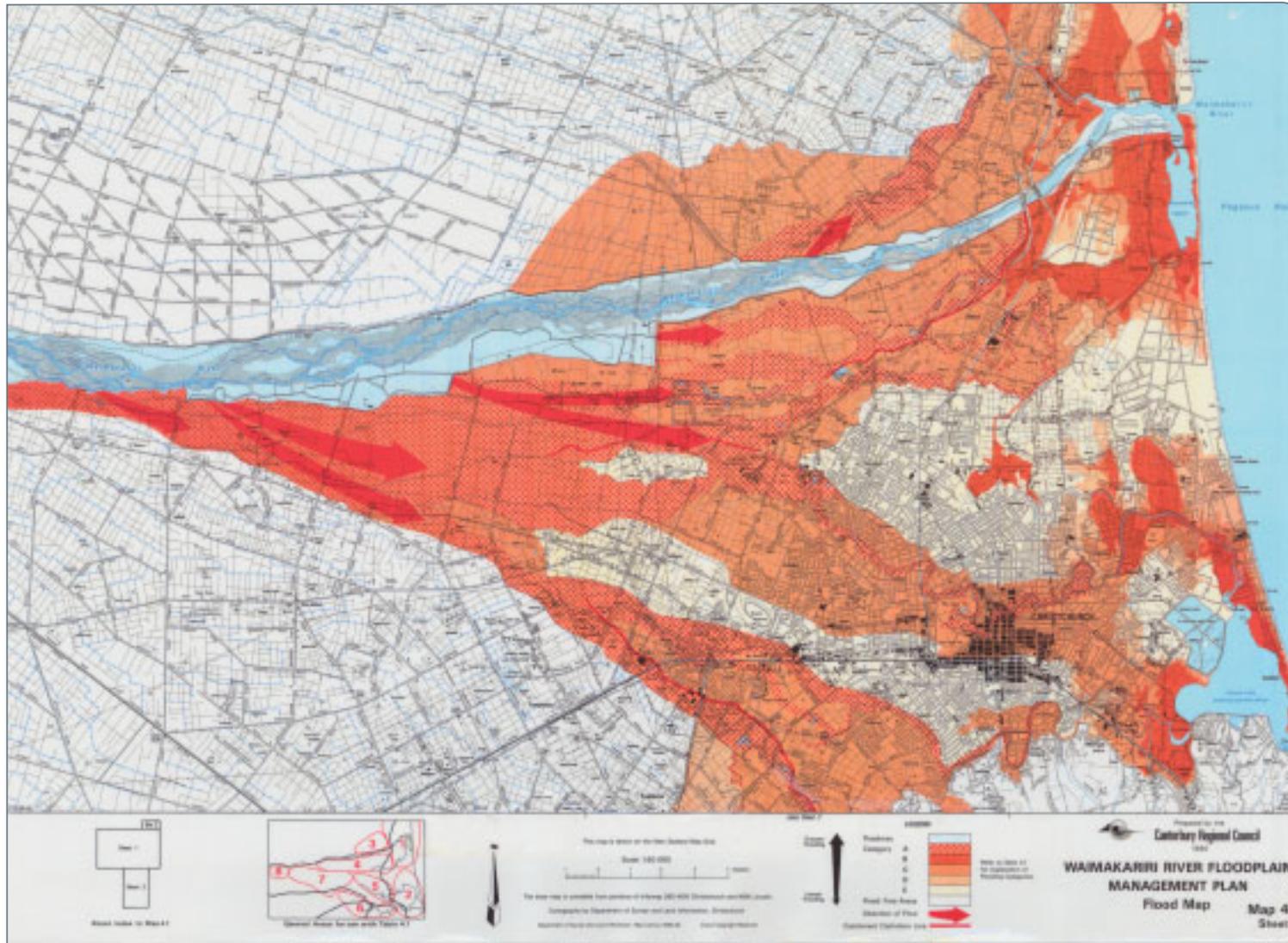
The biggest change in exporting has been providing services, which by 2001 were contributing about a quarter of the country's exports. This was largely a result of the rise of international tourism to New Zealand, although other service activities, most noticeably the film industry, also made a considerable contribution.

Export destinations have changed dramatically. Australia is now New Zealand's single largest export market with more than 22 per cent of exports in 2006, followed by Japan, the United States of America, China, and Korea. Asia takes about a third of all New Zealand exports.

## FURTHER INFORMATION

### GENERAL INFORMATION

MOSLEY, M P AND PEARSON, C P (EDS), 1997, FLOODS AND DROUGHTS. New Zealand Hydrological Society, Christchurch.



Flood hazard to Christchurch from the Waimakariri River, 1990. Flood protection works costing about \$30 million are proposed. The existing flood protection works and proposed improvements are expected to contain flood flows of 6500 m<sup>3</sup>/s – a one in 10 000 year event. Environment Canterbury estimates a major flood could inundate residential and industrial areas, causing up to \$2 billion worth of damage and affecting up to 300 000 people. *Environment Canterbury.*