



Growing for good

Intensive farming, sustainability
and New Zealand's environment



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Parliamentary Commissioner for the Environment
Te Kaitiaki Taiao a Te Whare Pāremata

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Preface

In a global context New Zealand can be described as being in the business of pampering the palates and passions of the world's more prosperous citizens. We do this through exporting our foods, fibres, wines, films and delivering great visitor experiences in our Gondwanan landscapes. New Zealanders are highly dependent on our natural capital – our waters, soils and biodiversity – for sustaining these wealth-generating capabilities.

In this report we examine the environmental sustainability of more intensive farming in New Zealand. That is, we look at how well the natural resource base of farming is being maintained. We do this by teasing out some of the complex economic, social, political, environmental and global forces that are shaping New Zealand's food and fibre businesses. Our starting position is an optimistic one. My team and I believe that New Zealand's farming sector will continue to play a vital role in our economy far into a distant future. We also believe in the ability of New Zealanders to innovate, to recognise when new directions are needed, and to redesign systems to meet new challenges and opportunities.

From these points of reference we have delved into many strands of farming from a paddock to plate context. We have looked at trends and challenges in the intensive farming systems in the United Kingdom, Netherlands and Australia. We have explored the market demands and the evolution of the Common Agricultural Policy in Europe to get a feel for what the shift from production subsidies to environmental protection might mean for New Zealand's farming and food futures. Closer to home, we have drawn on the wisdom of a great number of studies and people; farmers, local government staff and councillors, bankers, real estate agents, researchers, agribusiness folks, NGOs and members of central government agencies. This was done through visits to four regions and via discussions held in main centres. It was a deliberate process of embedding ourselves into the heart and soul of the farming sector to get a deeper understanding of what was going on. In particular, it involved questioning what is shaping the direction of farming in New Zealand and beyond, both now and in the foreseeable future.

This report synthesises many of the strands we explored. It focuses on the crucial part that two key inputs play in farming productivity – synthetic nitrogen fertiliser and irrigation water. We have zeroed in on these two because they are among the most important 'fuels' of the big increases in productivity over the last decade. They also have a major potential for adverse environmental impacts, as communities worldwide have found to their cost. In examining these two inputs we stress that we are not questioning the use of added nutrients and irrigation in agriculture, as they are both fundamental to farming productivity. However, we do examine the way in which they are being used, as there is mounting evidence that current models may be putting many farm systems at risk. For example the high, and still rising, use of synthetic nitrogen fertiliser appears to be leading to farming systems that are financially and environmentally 'brittle'. Financially brittle because synthetic nitrogen fertiliser relies on petroleum-based products for its manufacture and these products are likely to become increasingly expensive in real terms. Environmentally brittle because a high proportion of the nitrogen that is applied, directly or indirectly via livestock, reaches ground and surface waters and leads to the problems seen in Lake Rotoiti and other lowland water bodies in too many parts of New Zealand.

We have focused on the big shapers of New Zealand's farming and food systems. These are not largely physical, despite the fact that their expression is. Rather they are economic, institutional and political, and frequently originate far from our shores. An example is the enormous production subsidies paid in the European Union, USA and Japan that New Zealand is working hard to have reduced.

Over a decade ago, CSIRO researcher Barney Foran drew together some of the bigger issues that had emerged at an International Grasslands Congress in Palmerston North. He wrote:

The biggest challenge at the moment is to produce a vision of why we produce products from grasslands. If we are worried by the energy consumption of our developed economies, then we must develop low energy integrated pasture systems that give high quality products with no down stream pollution effects – a “cradle to grave” design concept. Our experimental methods must now be redesigned to reflect product quality rather than product quantity. We must re-examine why production per hectare is seen as a Holy Grail. In many areas, land prices have been distorted by government policy, and land is overvalued in terms of its productive worth, rather than limiting in amount. We could do better by helping to crash the land prices, rather than developing technologies to run the land harder to make it pay. This XVII Congress taught us that grasslands give much more than production. Using our grasslands are people who are real, and have life goals. Many of our landscapes are beautiful and biodiverse, and our technologies must accommodate these other uses.⁷

Eleven years later this synopsis is even more pertinent. Unfortunately, in the intervening years New Zealand has made glacial progress in addressing (or even fully acknowledging) the issues, opportunities and needs identified by the large cast of local and international participants. In particular the need for a new vision and to redesign farming systems seems to have gained little traction.

We cannot continue to respond so slowly and in such a piecemeal fashion. A much more strategic, long-term approach is needed. Such an approach should be developed from a wide stakeholder base, be sharply focused, and have clear goals to advance the sustainability of New Zealand's farming and food industries. We highlight the need for a forum for dialogue between all of New Zealand's farming, food and fibre stakeholders. This is not an original idea, as it was raised by a number of leaders during the course of our interviews. The nature of the forum needs to be discussed widely, but to be effective we believe it needs to be enduring, to sit outside government (but with local and central government partnered to it) and to have the capacity to enable all sectors to share strategic thinking. At present it is not easy for the various farming sectors to share ideas and experiences with other sectors. To remain competitive and to become more environmentally sustainable all sectors will need to develop collective understandings of

the major opportunities and threats to our biotic businesses and the natural capital underpinning them all.

We conclude our report by considering the opportunities for redesign, some initiatives already underway, and the resources needed to realise opportunities. We believe it is possible to transform many systems for the better if all players in our biotic futures are prepared to accept the challenges and to enter into dialogue about what is needed to address them. In this context, dialogue is an important word. It is about listening, building on the ideas of others, and working collectively towards agreed goals. My team and I trust that this report will make a contribution to that dialogue. As always, we welcome feedback on our efforts.

New Zealand can do it – let's get on with it!

A handwritten signature in black ink, reading "J. Morgan Williams". The signature is written in a cursive, flowing style.

Dr J. Morgan Williams
Parliamentary Commissioner for the Environment

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Guide to this report

This report examines the environmental impacts and sustainability of more intensive farming in New Zealand. It has been written for a broad range of people and organisations. Although it explores many complex issues, readers are not expected to be experts in any particular area.

Key messages

A separate 12-page pamphlet summarises the main messages from this report. Key points and summaries are also included at the end of each chapter, except for Chapters 1 and 7 as these are relatively short.

1 Introduction

The first chapter identifies the purpose of this report, what it does (and does not) cover and the methods that we used to research and write it.

2 Farming systems and sustainability

The second chapter sets the scene by explaining important concepts. It defines terms such as 'natural capital' and discusses why more intensive farming can be a cause for concern. It also identifies some key principles that have guided the thinking in this report.

3 Current trends

This chapter looks at some recent farming trends within New Zealand. Although the trends vary across each farming sector, it highlights that farming is generally becoming more intensive and that the environment is being damaged in many intensive farming areas.

4 Drivers and incentives

What is driving the development of more intensive farming in New Zealand? This chapter examines what is shaping farming in this country, focusing on the economic factors that tend to have the most influence.

5 Risks and challenges

This chapter examines some of the major risks that the environment and the farming sector face if current trends persist. In particular, it looks at the consequences of using more and more synthetic fertilisers and irrigation on fresh water in New Zealand.

6 Emerging trends

There is currently a lot of activity taking place to address the environmental impacts of farming in New Zealand. This chapter examines some existing approaches to 'redesign' farming and considers the scale of the challenges ahead.

7 Moving forward

Although many initiatives are already underway, more fundamental changes are needed to maintain and improve the quality of the environment and to avoid many risks to farming. The final chapter suggests some first steps towards change and provides recommendations for action.

Glossary

A glossary of terms, abbreviations and Maori words can be found at the end of the report.

Background reports

To support this investigation, more reports have been produced to provide additional analysis in key areas. These background reports are:

1. *Food market and trade risks*: assesses the effects of trade policies, supply trends, market access provisions and commodity prices on profits in the farming sector.
2. *Incentives for intensification*: uses in-depth farmer case studies to examine what is driving them to farm more intensively in New Zealand.
3. *The food production revolution — the search for a consumption efficiency policy*: examines the major economic factors that influence commodity producers and the potential to redesign these incentives to promote sustainability.
4. *International trends in farming and sustainability*: a literature review of farming trends, and policy responses to environmental issues, in the United Kingdom, Netherlands and Australia.

These reports were commissioned by the PCE to assist in this investigation. Any views expressed by the authors of these reports do not necessarily reflect the views of the Commissioner and his staff.

The background reports are available from www.pce.govt.nz or by contacting us directly.

CHAPTER

1

Introduction



The farming sector is very important for New Zealand and to maintain its viability the physical environment in which farming is based needs to be sustained in a healthy condition.¹ This report examines the trends toward more intensive farming systems in New Zealand and the impacts of these trends on 'natural capital', with a major focus on fresh water. It explores the driving forces behind these trends and identifies some major risks and challenges. It highlights a need to redesign many farming systems to promote better environmental, social and economic outcomes. Emphasis is placed on creating more resilient farming systems that are both economically viable *and* environmentally sustainable.

1.1 The importance of farming in New Zealand

Farming is a deeply ingrained part of contemporary New Zealand society. For most of the twentieth century, farming was considered the 'backbone' of the economy. New Zealand's temperate climate and fertile soils have supported almost every kind of farming—from sheep and cattle to cropping, horticulture and forestry. Farming has changed dramatically over time, and with it the shape of many rural communities. Although more than 85 percent of the population now lives in urban areas, the farming sector continues to play a fundamental role in New Zealand's economy. Farming products, excluding forestry, earn more than 40 percent of New Zealand's export income.²

Physically, farming dominates New Zealand's geography. There are about 70,000 farms in the country and over half New Zealand's land area is classified as farmland.³ Farming has also played an influential role in the development of New Zealand's national identity. Farming has long been associated with the innovative 'No. 8 wire' mentality that many people pride themselves on and the rural lowlands and rugged hills of New Zealand are still considered by many people, both urban and rural dwellers alike, to be the 'heartland' of this country.⁴

1.2 Background to this report

The Parliamentary Commissioner for the Environment (PCE) has had a long-standing interest in the farming sector of New Zealand. Several recent PCE investigations have examined elements of this sector, including:

- biosecurity
- the place of native plants on private land
- wetlands management
- progress with sustainable development in New Zealand since the 1992 Earth Summit.⁵

These investigations have highlighted many challenges for the environment and the sustainability of farming, such as the loss of lowland wetlands and biodiversity, the difficulties in managing non-point source pollution in waterways, potential pest and disease risks to monocultures, increased nutrient and energy inputs, and growing water demands for irrigation.

Many farming systems in New Zealand are currently becoming more intensive (as explained

in the following chapter, with the trends identified in Chapter 3). Intensification is born out of a drive to produce more from the same amount of land. The most visible manifestation of intensification in New Zealand over recent years has been in the dairy sector, with significant increases in dairy cows per hectare and milk production per cow. Intensive farming has contributed to declining water quality in many regions and challenges for water allocation. A variety of organisations and individuals have raised concerns about these trends with the Commissioner.

Internationally, there are also growing concerns about the environmental impacts and strategic risks of intensive farming systems (see Chapter 4). Farming in many parts of the globe has become much more intensive since around the 1940s. In Europe and North America in particular, the intensification of farming systems through the use of more materials and energy has led to increasing impacts on the environment. Against this backdrop, it was considered timely to review New Zealand's farming sector and to examine trends towards intensification.

1.3 Purpose of this report

This investigation was carried out pursuant to Sections 16(1)(a), (b) and (c) of the Environment Act 1986. Our terms of reference were to review:

- the characteristics of farming systems in New Zealand — particularly the more intensive forms of *food production* such as dairying, horticulture, and viticulture
- the impacts of farming on the environment — with a focus on *fresh water*.

More specifically, we have examined:

- *systems and trends* — characterising current farming systems and identifying trends, trajectories and driving forces in the farming sector
- *research and information* — reviewing available research, data and indicators to assess the state of New Zealand's natural capital in rural areas
- *impacts and effects* — identifying the links between farming and environmental sustainability
- *dialogue* — stimulating debate and reflecting the diversity of voices in the rural community around opportunities and ideas for the future of farming in New Zealand.

1.3.1 Our focus

This investigation looks at the development of more intensive farming in New Zealand, with a major focus on water. Although there are many elements of farming and sustainability that could have been explored, we decided to focus on water because of major concerns in many parts of New Zealand about the impacts of farming on waterways. Water quality is also a key indicator of ecosystem





health and therefore environmental sustainability. Consistent with this focus, we have looked at trends in nutrient inputs and water demand to explore the implications of these trends for fresh water quality and quantity. We have also examined the driving forces that are helping to shape farming trends in New Zealand, the risks and challenges associated with these trends, and areas where change is needed.

As Chapter 2 highlights, there are many different dimensions to sustainable agriculture. The central focus of this report is on *environmental* sustainability, as a core component of sustainable development — an unending quest to meet environmental, social, cultural and economic goals in ways that can be continued into a distant future.⁶ This environmental focus is consistent with the role and functions of the PCE.⁷ Nonetheless, environmental sustainability cannot be achieved without addressing the social

and economic factors behind unsustainable practices. Economically viable farms play an essential role in supporting rural communities in New Zealand. We have therefore examined some of the broader social and economic dimensions of sustainable agriculture as well. We have focused on opportunities to create more resilient farming systems that are both economically viable for farmers *and* environmentally sustainable.

1.3.2 What this report does NOT cover

This report does not intend to provide a comprehensive review of the entire farming sector. It focuses on intensive forms of farming for *food production*. It encompasses the dairy, intensive beef and sheep, deer, arable, horticulture and viticulture sectors, but *not* forestry and factory/shed farming.⁸ It does not cover urban, peri-urban and lifestyle-block areas, the conservation estate, or marginal lands.

There are some significant issues relevant for farming in New Zealand that have not been covered in this investigation. This investigation does *not*:

- include a review of agency performance or capacity to implement the *Resource Management Act 1991* (RMA) with respect to managing the environmental impacts of farming. This focus is outside the terms of reference and may merit an investigation in its own right. The PCE is planning a separate review of the RMA and these issues will be considered within the context of that investigation.⁹
- comment on *biosecurity*. This is a matter of considerable significance and poses some major risks for farming. However, the PCE has already completed a major investigation into biosecurity and is committed to on-going audits of New Zealand's biosecurity management.¹⁰
- explore the social and cultural dimensions of farming and rural communities in depth. Although it is essential to consider these dimensions in any discussion on sustainability, especially at a local level, our primary focus has been on environmental trends at a macro-level in New Zealand.

- explore the potential role of genetic sciences and one application of it – genetic modification (GM) in depth. This is because it is just one field of knowledge creation amongst many that could advance the sustainability of food production systems.

1.4 Methodology

Scoping (preliminary research) for this investigation began in September 2002. This consisted of desk-based literature reviews and information gathering. A small external reference group was then convened to assist with identifying issues and key questions for the investigation. This team consisted of:

- Don Ross — New Zealand Landcare Trust, Christchurch
- Gavin Sheath — AgResearch, Hamilton
- Anton Meister — Massey University, Palmerston North
- Stuart Morriss — Massey University, Palmerston North
- Jacqueline Rowarth — Unitec, Auckland.

Given the enormous size of the farming sector, we decided to use four regions as 'windows' into the world of farming in New Zealand. The four regions chosen were:

- *Canterbury* — for the trends in conversions to large-scale dairy farming, the size and diversity of the farming sector, the range of issues related to water allocation, irrigation proposals and the impacts of water extraction on the famous Canterbury rivers
- *Hawke's Bay* — for the range of intensive horticulture and viticulture in the region and the pressures on water in a region with low rainfall
- *Waikato* — for its long-established dairying sector and the current initiatives being undertaken to manage water quality issues in the Taupo basin and along the Waikato River
- *Southland* — for the trends in dairying conversions in this region.

The second major phase of the investigation consisted of interviews with a wide range of people with an interest in the farming sector (see Appendix 1). Most interviews were carried out in the four regions identified above. Additional visits were made to Auckland and we continued to hold discussions with a range of individuals and organisations throughout the research and writing phases of this project. To further inform our thinking and analysis, we commissioned research papers on financial and economic drivers relevant to farming in New Zealand. These documents are available as background reports to this investigation.

There is currently a lack of consistent and robust data on the environmental impacts and sustainability of farming in New Zealand. Although we assessed the available quantitative data, we took a more qualitative approach in our research.

CHAPTER

2

Farming systems and sustainability



This chapter sets the scene for the rest of the report. It explains important concepts associated with farming and sustainability. It defines key terms such as ‘natural capital’ and discusses why the development of more intensive farming systems can be a cause for concern. It also identifies some key principles of sustainable agriculture.

2.1 Farming systems

2.1.1 Taking a systems perspective

A farm is a place where agricultural activities occur to produce food and/or fibre from plants and/or animals. Each individual farm can be thought of as a system in its own right — a modified ecological system that includes people, crops and livestock within a broader environmental, social and economic context.¹ It is essential to take a systems perspective when examining farming and sustainability. This allows us to understand the reasons behind unsustainable practices and to develop long-term solutions to problems.

A systems perspective involves looking at the biophysical dimensions of farming (such as nutrient and water cycles) as well as socio-economic aspects (for example, social values and institutional structures). Farms can be analysed as systems from various points of view, depending on the scale of analysis. As Feenstra *et al.* note:

The system is envisioned in its broadest sense, from the individual farm, to the local ecosystem, and to communities affected by this farming system both locally and globally. An emphasis on the system allows a larger and more thorough view of the consequences of farming practices on both human communities and the environment. A systems approach gives us the tools to explore the interconnections between farming and other aspects of our environment.²

Farming systems, in the context of this report, therefore range from individual farms through to the broader social and economic structures and institutions linked to farming. Although the major focus of this report is on the farming end of the food chain (see Chapter 1), it is also important to consider the place of farms in broader food systems that include many other organisations and people, such as producer boards, retailers and consumers of food.

2.1.2 Intensive farming systems

Farming in New Zealand is becoming more intensive. ‘More intensive’ refers to the increasing use of inputs (e.g. fertiliser, energy, water for irrigation, knowledge or capital) into farming systems to produce more food from the same area of land.³ Intensive farming is usually characterised by the repeated cultivation and/or grazing of land and the addition of a large number of inputs per hectare to maintain or increase production every year.⁴

Over the last century, especially since the 1940s, there has been a general worldwide trend to increase food production through the addition of external human-made inputs into farming systems. These include petroleum-based fertilisers, chemical pesticides, animal

‘More intensive’ refers to the increasing use of inputs into farming systems to produce more food from the same area of land.

feedstuffs and machinery. These inputs have often taken the place of natural processes or resources (e.g. using synthetic fertilisers instead of legumes to 'fix' nitrogen into the soil). Although food production has increased remarkably through the use of these inputs, major concerns have been raised about the long-term environmental, social and economic costs of these farming methods. Prominent issues have included the erosion of topsoil, loss of soil fertility, water pollution, loss of biodiversity and dependence on non-renewable fossil fuels.⁵ Worldwide, there have also been growing concerns about the adverse impacts of intensive farming systems on food safety, human health, the viability of small family farms and the quality of life in rural communities.⁶

It is important to note that 'more intensive' is a relative phrase, in the sense that something is increasing in relation to what it was. While many farming systems are becoming more intensive in New Zealand (see Chapter 3), farming in this country is not generally as intensive as many farming systems in North America and Europe. Intensification occurs along a continuum from relatively low external inputs (such as pastoral farming systems that do not use synthetic fertilisers) to those that rely on very high external inputs (such as factory farming).

It is important to emphasise that there are many different ways in which farming systems can be designed to produce more food. For example, it is possible to make more use of human knowledge to increase food production while using less material and energy inputs.⁷ It is the particular way in which more intensive farming is carried out that needs to be considered in any discussion on sustainability.

It is the particular way in which more intensive farming is carried out that needs to be considered in any discussion on sustainability.

2.2 Sustaining natural capital

2.2.1 Natural capital and ecosystem services

The concept of 'natural capital' is pertinent to the sustainability of intensive farming in New Zealand. This concept has developed along with more widespread understanding of the fact that economic development does not just depend on financial capital — it ultimately relies on many other forms of 'capital' as well. These have been defined as:

- *natural capital* — the renewable and non-renewable stocks of natural resources that support life and enable all social and economic activities to take place. It includes rivers, lakes and aquifers, soil, minerals, biodiversity and the earth's atmosphere.⁸
- *economic capital* — the human-made means of production like machinery and equipment as well as infrastructure and financial assets.
- *social capital* — the networks of shared norms, values and understanding that facilitate co-operation and trust within and between groups.
- *human capital* — the knowledge, skills, competencies and attributes embodied in individuals that are developed through lifelong learning and experience, including through the formal education system.

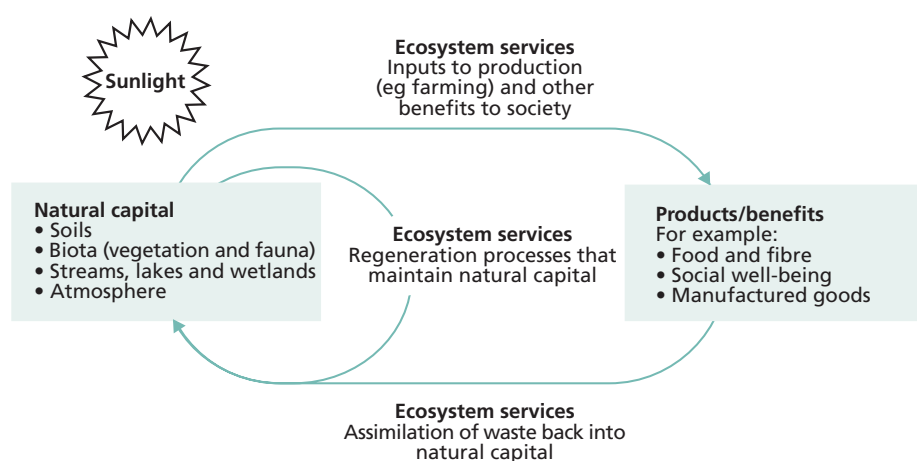


- *cultural capital* — the values, histories, traditions and practices that link a specific group of people together.
- *institutional capital* — the range of formal and informal civic, political, and legal arrangements that underpin economic activities and civic life.⁹

There are sometimes debates about the extent to which human forms of capital can take the place of natural capital.¹⁰ Nonetheless, natural capital provides many services that are essential to human life. These ‘ecosystem services’ include clean air and water, the creation and maintenance of fertile soils, pollination, the regulation of liveable climates, raw materials, genetic resources for harvesting and growing food and fibre, and processes to decompose and assimilate waste.¹¹ Although these services are often taken for granted, they have immense social and economic value. Many of these services are indeed priceless, as they have no known human designed substitutes.

Figure 2.1 highlights the relationship between natural capital and ecosystem services. Humans use natural capital, such as soil and water, for production purposes like farming and to provide things they value. To regenerate and to remain in a healthy condition, natural capital relies on sunlight and many ecosystem processes that are interdependent. Waste and by-products from production and consumption always remain within the environment. This waste can have a positive or a negative impact on the state of natural capital, depending on the type of waste and the capacity of the environment to assimilate it. In turn, this can affect the ability of natural capital to provide ongoing benefits to society.

Figure 2.1 Natural capital and ecosystem services



... human societies need to live off the ‘interest’ of natural capital, instead of using up or degrading the natural resource base

Source: Adapted from Binning *et al.* (2001).

It is also possible for humans to maintain or enhance the condition of natural capital. For example, soil fertility can be enhanced by recycling nutrients back into the soil. By thinking about the environment as a form of capital, the analogy is often made that human societies need to live off the ‘interest’ of natural capital, instead of using up or degrading the natural resource base that sustains human societies.

2.2.2 Criteria for environmental sustainability

The central focus of this report is on the *environmental* sustainability of farming in New Zealand—i.e. maintaining and enhancing natural capital and the services it provides. Environmental sustainability, as defined by the Organisation for Economic Cooperation and Development (OECD), has four specific criteria. These can easily be applied to thinking about the sustainability of farming systems, as listed below:

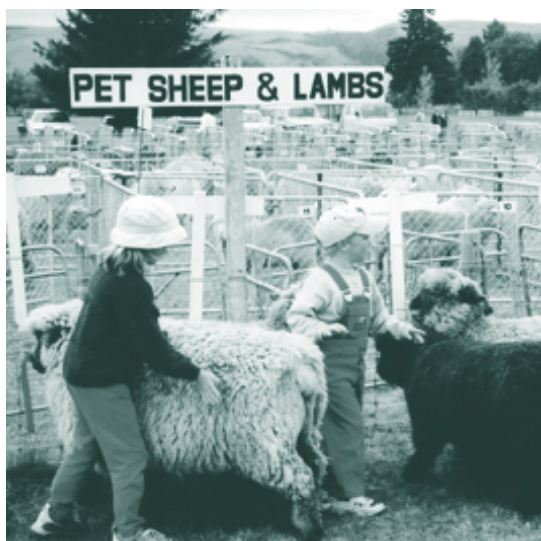
- *regeneration* — using renewable resources efficiently and not permitting their use to exceed their long-term rates of natural regeneration (e.g. taking water from an aquifer at a rate that does not exceed its recharge rate)
- *substitutability* — using non-renewable resources efficiently and limiting their use to levels that can be offset by substitution by renewable resources or other forms of capital (e.g. using fossil-fuel based fertilisers efficiently and developing human capital to find alternative ways of maintaining soil nutrients)
- *assimilation* — not allowing releases of hazardous or polluting substances to the environment to exceed the environment’s assimilative capacity (e.g. preventing excess nutrients entering waterways)
- *avoiding irreversibility* — avoiding irreversible impacts of human activities on ecosystems (e.g. ensuring that farming does not contribute to the extinction of a plant or animal species).¹²

Environmental sustainability is also essential for sustainable development—an unending quest to improve the quality of people’s lives and surroundings and to prosper without destroying the life support systems that current and future generations of people depend on. A detailed discussion on sustainable development can be found in the Commissioner’s investigation *Creating our future: Sustainable development for New Zealand*.¹³ As that report emphasises, it is important to recognise that there are ecological limits that ultimately constrain resource use and the ability of the environment to absorb the impacts of human activities.

2.2.3 Natural capital and farming

A farm is a modified ecosystem that exists within a broader environmental, social and economic context. Although farming in New Zealand is based on introduced species, it still relies on the services provided by natural capital to sustain production. Farming activities can have an impact on natural capital in many ways. As the OECD notes:

Agricultural activities can generate a range of environmental benefits. These include aesthetic value, recreation, water accumulation and supply, nutrient recycling and fixation, soil formation, wildlife protection and flood control, and carbon sequestration by trees and soil. However, major changes in farming practices in the past forty years have brought new pressures to bear on natural resources.¹⁴



Some potential negative effects of farming include:

- *declining soil fertility and integrity* — e.g. through erosion of soil or the loss of organic matter
 - *pollution of waterways and groundwater* — e.g. impacts on water quality from nutrient losses
 - *water scarcity* — e.g. through competition with other water users by extracting excessive amounts of water for irrigation
 - *reduced biodiversity* — e.g. becoming reliant on a small number of crop and livestock breeds through the development of monocultures that are more vulnerable to pests and diseases
- *climate change* — e.g. contributing to the loss of vegetation (important 'carbon sinks') or increases in greenhouse gas emissions.¹⁵

These impacts may occur across different scales of space and time. For example, nutrient runoff from one farm may impact on water quality and all other water users downstream, while the cumulative impacts of groundwater pollution from farming practices on lakes and waterways may only become slowly evident over time.

As farming relies so much on ecosystem services, it is important to have a basic understanding of some ecological processes that maintain natural capital. These include nutrient cycling, the water cycle, and energy flow, each explained briefly below.

Nutrient cycling — Nutrients are components required for normal growth and development. Plant roots take up nutrients such as nitrogen, phosphorus and potassium from the soil. Plants photosynthesise, converting water, carbon dioxide and minerals into organic material, using energy provided by the sun. Unable to utilise the sun's energy directly, animals depend on organic carbon sources for their energy, and hence consume plants or other animals. Energy flows one way through an ecosystem (see below), but materials like water, carbon dioxide and nutrients circulate within and between ecosystems. Decomposers, such as soil bacteria and fungi, break down dead plant and animal matter, absorbing some substances and releasing some back into the environment for uptake once more by plants. When plants or animals die in natural ecosystems, nitrogen and other nutrients are cycled back into the soil. However, in agricultural ecosystems, plant or animal biomass is removed with harvesting, and fertiliser is added to the soil to supply essential nutrients for plant growth.

The water cycle — Water cycles between the atmosphere and earth, condensing and falling as precipitation. It then flows over ground and into streams and lakes and out to sea, or filters down through the ground, nurturing plants and recharging groundwater. It moves back to the atmosphere *via* evaporation and plant transpiration, to be condensed again, thus continuing the cycle. Around 94 percent of the Earth's water is found in the oceans, four percent occurs as groundwater, 1.6 percent as ice at the Earth's polar caps, and 0.2 percent occurs either as water vapour, in clouds, in unsaturated soils, or in plants and animals. Only 0.2 percent occurs as surface water, i.e. in rivers and lakes. Fresh water, a finite resource, is essential to farming for pasture and crop growth and for livestock.

Energy flow — The lifeblood of any ecosystem, energy flow begins when sunlight is converted by photosynthesis into plant growth. It continues when animals consume plants or other animals and when micro-organisms consume dead plants and animals. Rather than relying wholly on the sun for energy (as would occur in a natural ecosystem), agricultural ecosystems also rely on energy inputs that are principally derived from fossil fuels. These are accumulated stocks of previous solar energy flows — energy rich compounds found below ground.¹⁶ Energy efficiency in agricultural systems can be examined by looking at the ratio of energy inputs to energy outputs. The lower the energy ratio, the more efficient the system and the lower the environmental impact, because the system relies more on natural ecosystem services and less on fossil fuel inputs. Energy efficiency declines when synthetic inputs are used instead of natural forms of pest control, fertiliser and water retention.¹⁷

It is essential to maintain natural capital in a healthy condition. If natural capital is degraded, the ongoing viability of farming may also be threatened. Degraded natural capital is currently contributing to decreasing farm productivity in many parts of the world, regardless of technological measures to try and alleviate these problems.¹⁸ As the Ministry of Agriculture and Forestry commented over a decade ago:

There is growing concern worldwide about the state of the natural environment and whether agricultural productivity can be sustained. It is not only good environmental practice, but sound economic sense to preserve the base on which our livelihood as a country depends.¹⁹

Many other economic sectors also rely on New Zealand's natural capital and the '100% pure' imagery that is used to sell New Zealand products or services to the world. The wealth generation capabilities of New Zealand as a whole will suffer if environmental realities do not meet the expectations of overseas consumers or tourists.

It is also important to recognise that the vast majority of New Zealanders value living in a high quality environment.²⁰ Natural capital provides many social and economic benefits beyond the farming sector. If farming has an adverse impact on water quality, this may affect drinking water supplies and fisheries. If other individuals, organisations or communities regard the environmental damage from farming as unacceptable, farmers are likely to lose their 'licence to operate' in society.

Soils: the central engine room

We can no more manufacture soil with a tank of chemicals than we can invent a rain forest or create a single bird.²¹

To illustrate how degraded natural capital can threaten the viability of farming, it is useful to consider the vital role of soil in farming systems. Soil provides the medium in which many of the ecological processes discussed in this section occur. It is a precious non-renewable (in human time scales) limited resource, holding life-supporting minerals, water,

If natural capital is degraded, the ongoing viability of farming may also be threatened.

The wealth generation capabilities of New Zealand as a whole will suffer if environmental realities do not meet the expectations of overseas consumers or tourists.

air and countless organisms—all of which facilitate plant growth. Soil ecosystems are extremely complex and small scale, and scientists still have much to discover in understanding how they function. As Young and Crawford note:

Given its importance, it is surprising how little we know about our most important natural resource. Indeed, much about soil remains a mystery, yet probably presents us with the most important clues as to how complex ecosystems become capable of self-organisation and sustaining functionality. Pick up a handful of soil and ask the question 'what is in it?' and an exciting new journey into inner space begins. In fertile garden or organic soil, there will be more individual organisms than the total number of human beings that ever lived.²²

After taking thousands of years for fertile soil to form, agricultural practices can undermine this most fragile yet fundamental form of natural capital in a short time *via* erosion, compaction, loss of organic matter, contamination and salinisation.

2.3 Sustainable agriculture

There has been considerable debate, over the last few decades in particular, about how farming can be conducted in ways that maintain natural capital.²³ 'Sustainable agriculture' is the term most commonly used to bring ideas and concepts from these debates together. The dialogue on the sustainability of farming has also focused on social and economic concerns such as the viability of small family farms, the quality of life in rural communities, animal welfare issues, poverty and food shortages in developing countries.

There is no single agreed upon definition of sustainable agriculture, but most definitions incorporate three main elements — environmental sustainability, social acceptability and economic viability. The definition of sustainable agriculture adopted by New Zealand's Ministry of Agriculture and Forestry is:

...the use of farming practices which maintain or improve the natural resource base of agriculture, and any parts of the environment influenced by agriculture. Sustainability also requires that agriculture is profitable; that the quality and safety of the food, fibre and other agricultural products are maintained; and that people and communities are able to provide for their social and cultural well-being.²⁴

One of the challenges in the quest for more sustainable agriculture is to make better use of internal resources, while being less dependent on external inputs.

One of the challenges in the quest for more sustainable agriculture is to make better use of internal resources, while being less dependent on external inputs. There has been a general trend over the last century to increase food production through the addition of external human-made inputs into farming systems. These external inputs have often taken the place of free services provided by natural capital. Table 2.1 compares farming systems that mostly use local resources with those that rely more on external inputs. Making better

use of internal resources does not mean that 'conventional' farming practices should be rejected — it merely highlights the importance of being discerning. At the level of an individual farm it may actually be more profitable to use fewer external inputs, even if overall production is lower, because external inputs are often very expensive.

Table 2.1 Comparison of internal and external resources/processes for farming

	<i>Internal</i>	<i>External</i>
<i>Sun</i>	Main source of energy	Supplemented by fossil fuels
<i>Water</i>	Mainly rain and small irrigation schemes	Large dams, centralised distribution and deep wells
<i>Nitrogen</i>	Fixed from the air and recycled in soil organic matter	Primarily from inorganic fertiliser
<i>Minerals</i>	Released from soil reserves and recycled	Mined, processed and imported
<i>Weed and pest control</i>	Biological, cultural, mechanical and locally available chemicals	With pesticides and herbicides
<i>Energy</i>	Some generated and collected on farm	Dependence on fossil fuel
<i>Seed</i>	Some produced on farm	All purchased
<i>Management decisions and information</i>	By farmer and community, gathered locally and regularly	Some provided by input suppliers, researchers, extensionists – assumed to be similar across farms
<i>Animals</i>	Integrated on farm	Production at separate locations
<i>Cropping system</i>	Rotations and diversity	Monocropping
<i>Varieties of plants</i>	Thrive with lower fertility and moisture	Need high input levels to thrive
<i>Labour</i>	Labour requirement greater – work done by family living on farm and hired labour	Labour requirement lower – most work done by hired labour and mechanical replacement of manual labour
<i>Capital</i>	Initial source is family and community; and accumulation invested locally	Initial source is external indebtedness or equity; and accumulation leaves community

Source: Pretty, 1995: 10

Sustainability can be thought of as an ethic or a general approach to farming — something to strive toward to promote the continuing health of the land and people. The actual *practices* of sustainable agriculture need to be tailored to the unique biophysical features (e.g. different climates and soil types) and the socio-economic characteristics and cultures of different communities. As Clay suggests:

There is no single ‘right’ way to practice more sustainable agriculture. Many farmers have found ways to reduce environmental damage, improve production, and increase profitability. How the farmers do this depends tremendously on where they live, what they produce, and where they sell the product. Broadly speaking, though, farmers are beginning to invent, adapt, and adopt a wide range of approaches that are usefully seen as ‘better management practices’. Such practices involve maintaining and building soils, maintaining the natural ecosystem functions on farms, working with nature and not against it to produce products, reducing total input use and using inputs more efficiently, and reducing waste or creating marketable by-products from materials that were previously considered waste.²⁵

... ‘strong sustainability’ requires people to address the underlying social, cultural, and economic reasons that rest behind environmentally unsustainable practices.

As highlighted in *Creating our future*,²⁶ ‘strong sustainability’ requires people to address the underlying social, cultural, and economic reasons that rest behind environmentally unsustainable practices. In particular, it is essential to avoid making trade-offs between environmental and economic objectives if short-term economic benefits later give rise to long-term damage to natural capital and associated costs to society. It is important to redesign social and economic systems if there is evidence that they are encouraging farmers to pursue environmentally unsustainable practices.²⁷ In contrast ‘weak sustainability’ is characterised by attempts to reconcile competing environmental, social, and economic objectives without questioning the prevailing socio-economic systems.

2.4 Summary and key principles to promote sustainable agriculture

We have identified some key principles to promote sustainable agriculture.²⁸ These principles have guided the thinking throughout this report. Ultimately, farming needs to be:

- *environmentally sustainable* — to maintain and enhance the natural capital on which farming depends as well as other ecosystems influenced by farming
- *socially beneficial* — to enhance the quality of life for people in rural communities and beyond, while addressing wider social and cultural concerns
- *economically viable* — to ensure farmers have a secure and rewarding livelihood.

These outcomes can be supported through the development of farming systems that are:

- *knowledge intensive* — investing in human knowledge to develop smart and productive farming systems that are less dependent on high levels of material and energy inputs
- *innovative* — experimenting and making greater use of farmers' knowledge, in combination with appropriate technologies developed through research
- *resource efficient* — using renewable and non-renewable resources efficiently and making the most effective use of natural processes and resources available on the farm
- *cyclical* — integrating natural processes such as nutrient cycling and soil regeneration into farming practices and using the by-products/wastes from farming as inputs into further production
- *high value* — producing high quality products from a quality environment
- *diverse* — developing and adapting farming systems so that they are appropriate for the local environmental, social, cultural and economic conditions
- *resilient* — developing the capacity of people to learn and adapt to changing circumstances, while ensuring that natural capital is still maintained.²⁹

Decision-making for the development of more sustainable farming systems should be based on:

- *systems thinking* — taking an integrated approach that considers the interactions and relationships among different elements. It is necessary to address the underlying reasons that rest behind unsustainable practices instead of just treating short-term symptoms.
- *futures thinking* — maintaining a long-term perspective and anticipating risks and challenges to farming systems, including the future implications of existing practices. Past trends do not dictate destiny, so it is important to explore different visions for the future and to constantly look for opportunities to improve sustainability.
- *participation* — actively involving farmers and other people in rural communities to develop more sustainable farming systems. It is also important to encourage individuals and organisations that are part of broader food systems, and those affected by farming, to take part in finding sustainable solutions.
- *leadership* — supporting good participation through good leadership. It is essential to help people see any issues and opportunities ahead and to develop their capacity to seek out solutions.

With regards to the actual *techniques* of sustainable agriculture, the application of these principles in practice needs to be *site specific* — i.e. adapted to a specific farm or catchment based on the particular characteristics of that area and its people. Farming systems, and the socio-economic structures and institutions that shape them, also need to be *redesigned* if it becomes clear that they are contributing to environmentally unsustainable outcomes.

CHAPTER

3

Farming trends



This chapter looks at some recent farming trends in New Zealand. It begins with a broad overview and examines trends within each farming sector. It then investigates the use of natural capital and takes a closer look at the state of the environment in intensive farming areas. New Zealand does not currently have a well developed set of indicators supported by comprehensive data in this area, so the trends identified in this chapter are based on available sources of data.

3.1 Overview of farming today

New Zealand's farming systems have developed through a significant modification of the original land cover and indigenous biodiversity. Over the past century, the area of land under pasture has increased from less than two million hectares to about 14 million hectares. More than half of New Zealand's land area is now classified as farmland.¹ In general, farming in this country has gone through a series of distinct phases, as summarised below:²

Pre-1840s *Exploitation of resources and early farming*

- birds and seafood provided the first settlers to New Zealand with an abundant source of food. Over time, hunting and harvesting depleted many of these sources.
- kumara gardening developed, particularly in the upper North Island.
- following the arrival of Europeans in New Zealand, native forests and populations of marine animals were further exploited and depleted before more widespread farming began.

1840s-1860s *Extensive pastoralism*

- animals were grazed on the grasslands of the East Coast of the North Island and tussock grasslands of the South Island.
- natural limits to further production were reached by the 1870s.

1870s-1920s *Expansion*

- forests across much of New Zealand were cut and burned for farming.
- a wheat boom in the 1870s contributed to the rapid depletion of soils.
- the development of refrigeration in 1882, and expansion of the railway system, enabled exports of meat, butter and cheese.
- a permanent grassland system began to evolve.

1920s-1940s *Early intensification*

- after World War I, farming settlements developed with varying success, often on unsuitable land.
- soil science and fertiliser technologies developed, and improved grass species for pasture began to be introduced.

1950s-1970s *Diversification*

- the development of suitable pasture species (such as perennial ryegrass and clover) contributed to the 'grasslands revolution'. Affordable sources of phosphate fertilisers also helped to lift soil fertility for grazing purposes.
- new mechanical and electrical technologies were introduced, including tractors, shearing plants, electric fences, milking sheds, milk tankers and planes for aerial topdressing.
- after World War II, about 90 percent of farm products were exported to Britain.
- Britain joined the European Community in 1973 and New Zealand's status as 'Britain's other farm' ended.
- new export products such as casein and milk powder were developed as well as new markets in countries such as America, Japan and Korea.
- improved stock breeding techniques, such as artificial insemination, were developed, as well as improved pest control methods.
- horticulture, deer and goat farming expanded rapidly in the 1970s.
- the role of producer boards was expanded.
- farm output roughly doubled between 1945 and 1970.
- the level of government support for farming increased significantly during the mid 1970s in response to falling agricultural prices.



1980s-today *Further intensification, diversification and development of certification schemes*

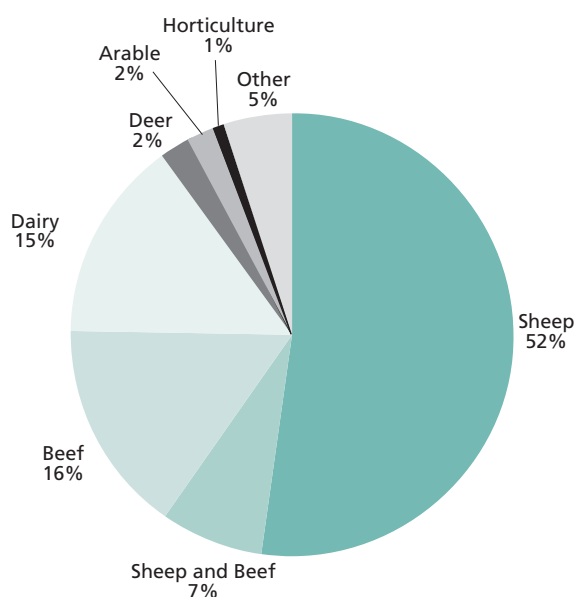
- amidst a period of massive change and upheaval in New Zealand society, the farming sector was deregulated from 1985 onwards, with all farming subsidies removed. Agricultural reforms encouraged farmers to aim for higher and higher levels of productivity (see also Chapter 4).
- farmers responded to deregulation in various ways. Since the 1980s there has been ongoing diversification into areas such as kiwifruit, forestry, viticulture and organics. As the rest of this chapter will highlight, there has also been further intensification in many farming sectors.
- the approaches taken toward intensification have differed significantly. In general, two dominant trends have emerged. While some sectors have mostly relied on more material and energy inputs to boost production volumes, others have focused on high value production and quality through various certification schemes.
- the dairy industry in particular has expanded substantially, with growing demand for dairy products as markets have globalised.

- new technologies are still being developed, including those from genetic sciences.

As this brief history suggests, farming has played a significant role in New Zealand's economy for over 100 years. Farming products, excluding forestry, earn more than 40 percent of New Zealand's export income.³ Dairy and meat products are New Zealand's biggest single export earners. Overall, farming contributes approximately six percent of gross domestic product (GDP) in New Zealand.⁴ If first-stage processing and manufacturing of products from farms are taken into account, farming contributes about 17 percent.⁵ Thus, the importance of farming in New Zealand's overall economy is substantial.

As noted in Section 1.1, there are approximately 70,000 farms in New Zealand today.⁶ More than half of New Zealand's land area is used for farming, excluding forestry. Figure 3.1 illustrates the land area used by different types of farming in 2002. The dominant land use for farming in New Zealand is sheep farming.

Figure 3.1 Land area distribution of different farming types in 2002 (excluding forestry)*



Source: Statistics New Zealand, 2003a

*Viticulture is included within horticulture, as vineyards make up only about 0.13 percent of the total land area farmed in New Zealand. The total area of land used for farming is approximately 14 million hectares.

Current farming systems in New Zealand vary according to climate, topography and soil types, and the farming activities undertaken. Table 3.1 details the hectares farmed and livestock numbers for the different farming sectors discussed in the report.

Table 3.1 Number of hectares farmed and livestock numbers by selected sectors of New Zealand farming, 2002.

Sector	Hectares farmed	Livestock numbers
Sheep & Beef cattle	10,348,291	39,545,609
Dairying	2,048,211	4,494,678
Deer	341,447	5,161,589
Cropping	123,176	1,643,938
Vegetable growing	52,721	-
Pipfruit orchards	12,680	-
Kiwifruit	12,000	-
Grape growing	17,400	-

Source: Statistics New Zealand, 2003a

3.2 Trends in farming sectors

New Zealand does not currently have a well-developed set of indicators supported by comprehensive data to thoroughly examine farming trends. The quality of information varies. Detailed data is available in some areas, but in other cases gaps are present. Some measurement systems have changed over time, making it difficult to develop a clear picture of any consistent trends. Our assessments are therefore based on the best available information. In some cases, regional data is used to illustrate a trend when national data is unavailable.

Although it has not been possible to build a complete picture, we have been able to identify the *broad* direction of trends within each farming sector. These trends are depicted as:



The focus for each sector is on:

- *scale* – hectares farmed, stock numbers, etc.
- *inputs* – nitrogen fertiliser urea,⁷ irrigation⁸
- *outputs* – production volumes
- *intensity* – outputs relative to scale and inputs.

We begin with a brief overview of each farming sector and then examine trends from the mid-1990s onward. The actual years of coverage vary according to the available data.

3.2.1 Dairying

Overview

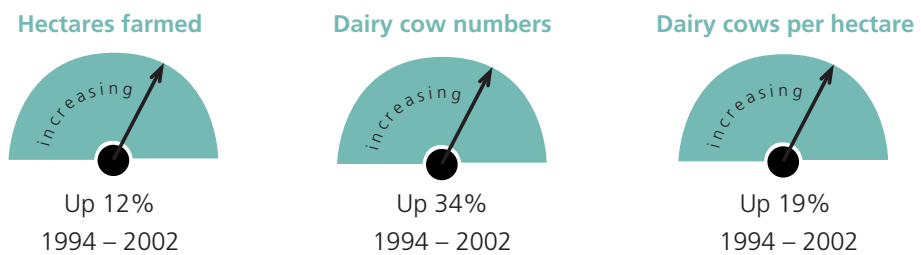
Dairying is the largest industry in New Zealand, accounting for 20 percent of export income.⁹ New Zealand’s dairy products make up almost a third of internationally traded dairy products.¹⁰ The vast majority of dairy herds (83 percent) are located in the North Island.¹¹ Most herds supply milk on a seasonal basis for manufacturing. Cows are milked in spring, summer and autumn, but dried off in winter when pasture production is lower. The remaining herds supply milk year-round for the domestic milk industry. The seasonal milk production system has historically relied on highly productive, rotationally grazed pasture and cow herds of high genetic merit.¹² The warm climate and productive pastures of New Zealand have enabled herds to graze on pasture year-round, avoiding the need for indoor housing and expensive feed supplements that characterise some overseas systems.¹³

Trends

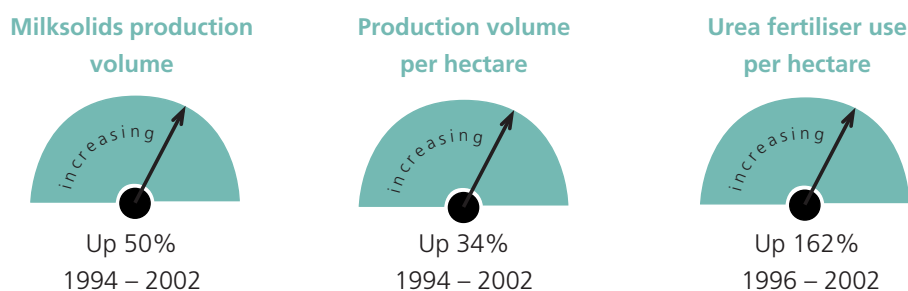
The dairy farming sector is clearly growing and becoming more intensive. Between 1994 and 2002, the number of dairy cows increased by 34 percent while the area of land directly used for dairy farming increased by only 12 percent.¹⁴ Over this same period, production of milksolids, on a per-hectare basis, increased by 34 percent, and milksolids production per cow also increased.¹⁵ While the size of the average dairy herd has been increasing, there has been a drop in the overall number of herds.¹⁶ This suggests a trend toward amalgamation of farms and expansions by individual farmers.

The dominant trend in this sector is a move away from traditional pasture-based systems toward systems that are highly dependent on inputs from outside the farm. A key feature is the increasing use of feed supplements such as maize and cereal silage. Maize silage is now the single biggest crop grown in the arable sector, with over a million tonnes produced in the year to June 2002 (see also Section 3.2.6).¹⁷

The use of synthetic fertilisers based on fossil fuels on dairy farms is also increasing. Total energy input into the average New Zealand dairy farm has doubled over the last 20 years, mostly due to the increase in nitrogen fertiliser usage.¹⁸ Dairying is also expanding into relatively dry regions such as Canterbury and Otago where significant irrigation is required to enable intensive dairy farming.



Source: Statistics New Zealand, 2003a



Source: Statistics New Zealand, 1996; Statistics New Zealand, 2003a; Livestock Improvement Corporation Limited, 2003

3.2.2 Sheep and beef¹⁹

Overview

The meat industry is one of New Zealand's oldest industries. Over 90 percent of sheep meat produced in New Zealand is exported, amounting to about 55 percent of the world's export trade.²⁰ Eighty-three percent of beef production is exported, which makes up around eight percent of world beef exports.²¹

There is a wide range of sheep and beef farm types and systems that vary according to land type, topography, climate, scale, and farmer preference. Many farms have both sheep and beef cattle, which complement each other in pasture-based grazing systems. Some farms also run deer or cultivate arable crops. Traditionally, sheep and beef farms have run on low input pasture grazing systems, sometimes supplemented with hay, silage and fodder cropping.²²

Trends

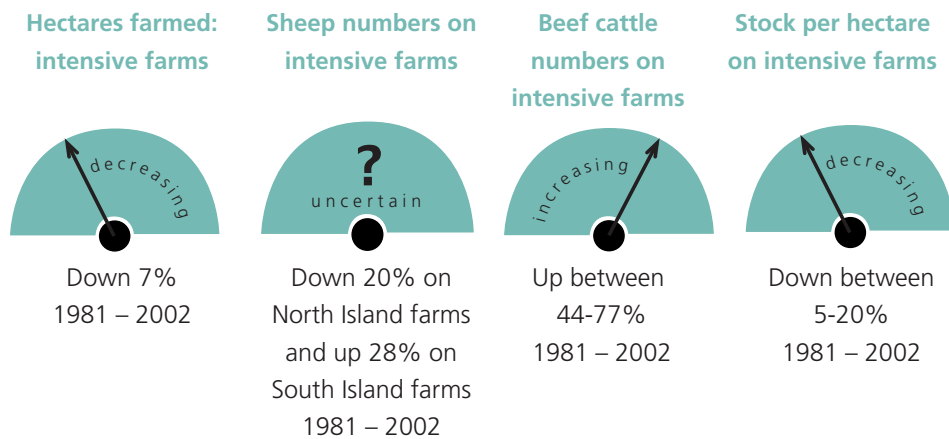
Sheep numbers nationally fell by 42 percent between 1980 and 2003.²³ Sheep numbers peaked in 1982 at 70.3 million.²⁴ Beef cattle numbers also decreased, by 13 percent between 1980 and 2003.²⁵ Beef cattle numbers peaked in 1975 at 6.3 million.²⁶ However on intensive sheep and beef farms, beef cattle numbers have risen between 44 percent and 77 percent in the same period.²⁷ Stock units per hectare on intensive farms have declined, from between 10.8 and 13.4 in 1981 to between 10.2 and 12.6 in 2002.²⁸

Despite the decline in livestock numbers, national production from sheep and beef farms has increased. Lambing rates nationally have increased 25 percent between 1980 and 2003.²⁹ Calving rates have remained relatively stable.³⁰ The most significant change has been the increase in livestock weights. The export carcass weight of lamb has increased 25 percent between 1980 and 2003. Similarly, mutton carcass weight has increased 18 percent and beef carcass weight has increased by 13 percent.³¹ Thus the increase in production in the sheep and beef sector has not been achieved through increased stocking

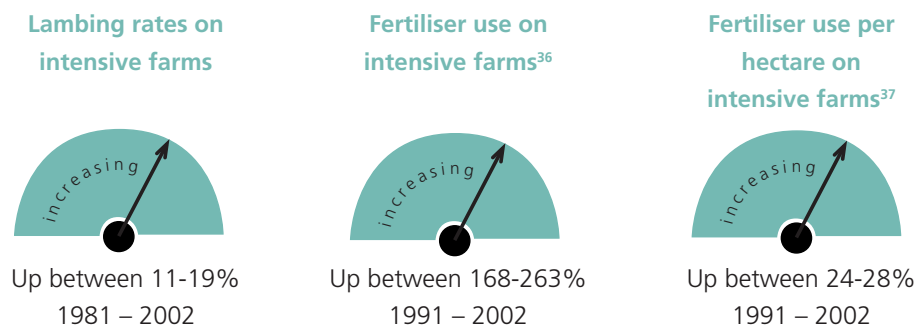


rates, but rather through increased lambing rates and livestock weights. Both improved lambing rates and livestock weights are partly a result of improved animal nutrition, which is largely due to an increase in fertiliser use by these sectors.³²

Fertiliser use in the sheep and beef sector generally has increased. Although fertiliser use per hectare is far below that of the dairy sector or some horticultural sectors, the sheep and beef sector covers a far larger land area. There has been an increase in fertiliser use in the intensive sheep and beef sector of between 24 and 28 percent between 1991 and 2002.³³ In the 2001-2002 year on North Island Hill farms an average of 309 kilograms per hectare of fertiliser was applied to pasture; on North Island Intensive Finishing farms, 352 kilograms per hectare; and on South Island Intensive Finishing farms 345 kilograms per hectare was applied.³⁴ The amount of nitrogen contained in the fertilisers used on intensive sheep and beef farms has also increased. For example between 1991 and 2002 on North Island Intensive Finishing farms the percent of nitrogen in the fertiliser applied to pasture increased from 1.3 percent to 4.2 percent.³⁵



Source: MWES, 1982; MWES, 2003a; MWES, 2004



Source: MWES, 1982; MWES, 1992; MWES, 2003a

3.2.3 Deer

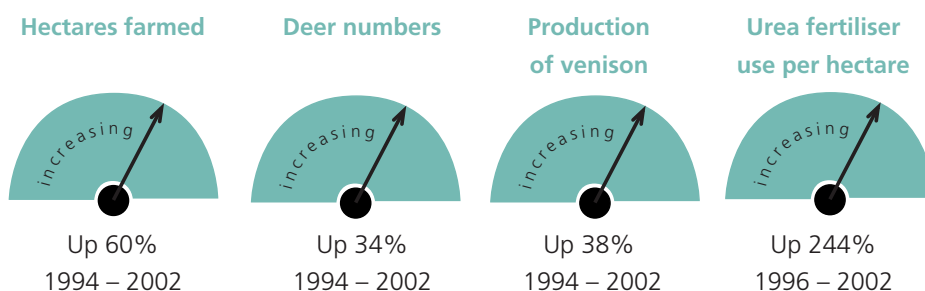
Overview

The New Zealand farmed deer industry began over 25 years ago, providing venison, velvet and other products for export. New Zealand is the world's largest producer and exporter of

farmed venison, 90 percent of which goes to Europe.³⁸ Deer are frequently run as a secondary enterprise in conjunction with other pastoral livestock, but there are nearly 2,000 farms where they provide over 50 percent of revenue.³⁹ These specialist farms carry 63 percent of all deer.⁴⁰ Deer are farmed in all regions of New Zealand, but are most common in Canterbury, the Bay of Plenty and Southland. Most deer graze on pasture, but supplementary feeds in winter may include silage, hay or grain.⁴¹

Trends

The number of hectares farmed, deer numbers, and the production volume of venison have all increased in recent years. Deer per hectare and production of venison per hectare vary from year to year, due in part to world prices. If prices are low farmers may keep their stock from slaughter until the following year, when prices hopefully improve. Urea fertiliser usage has also increased significantly in this sector.



Source: Statistics New Zealand, 1996; Statistics New Zealand, 2003a

3.2.4 Horticulture

Overview

Fruit growing accounts for about 40 percent of horticultural land use in New Zealand, with vegetable growing accounting for the remainder.⁴² Key fruit crops include kiwifruit and apples. Major vegetable crops include potatoes, onions, peas and beans, squash and sweet corn. Avocados, capsicums and carrots are emerging export earners.

Crops, orchards and market gardens are generally classified as intensive forms of land use, requiring high inputs of fertilisers, mechanical energy, labour, pesticides and herbicides.⁴³ Crop volumes produced can vary greatly from year to year due to factors beyond the control of growers, such as climate (e.g. frost and hail), pests, and levels of pollination.

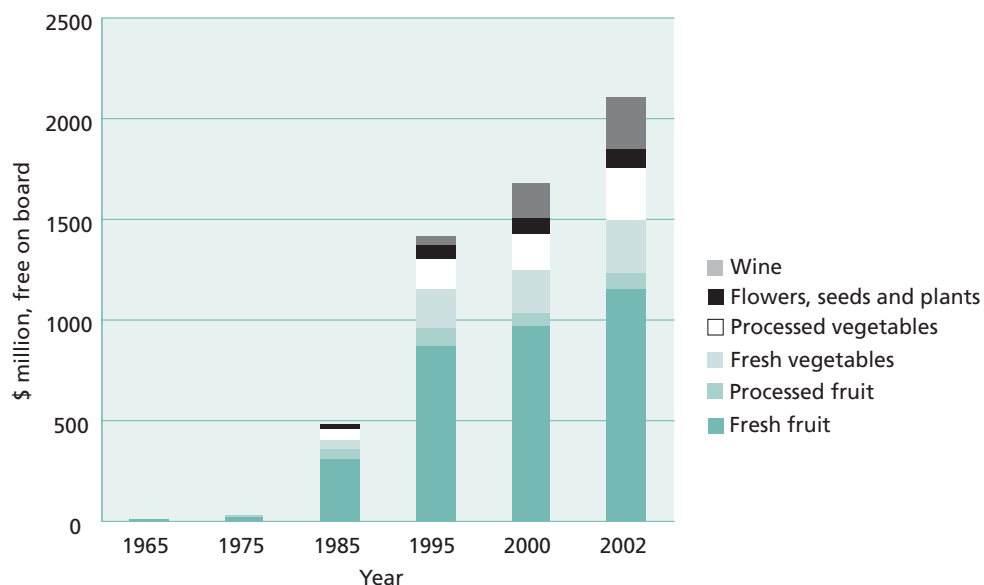
Trends

The overall size of the horticulture sector, in terms of hectares farmed, is gradually increasing—up six percent between 1994 and 2002.⁴⁴ Horticultural exports have increased phenomenally in the last 25 years (see Figure 3.2). Trends vary according to crop. For example, between 1994 and 2002 the change in *hectares farmed* for the following

crops were:

- *apples* – decreased by 24 percent
- *kiwifruit* – increased by 2 percent
- *onions and potatoes* – both increased by 12 percent
- *squash* – decreased by 12 percent
- *avocados* – increased by 121 percent.⁴⁵

Figure 3.2 Horticultural exports from New Zealand 1965 to 2002 (\$million, free on board).



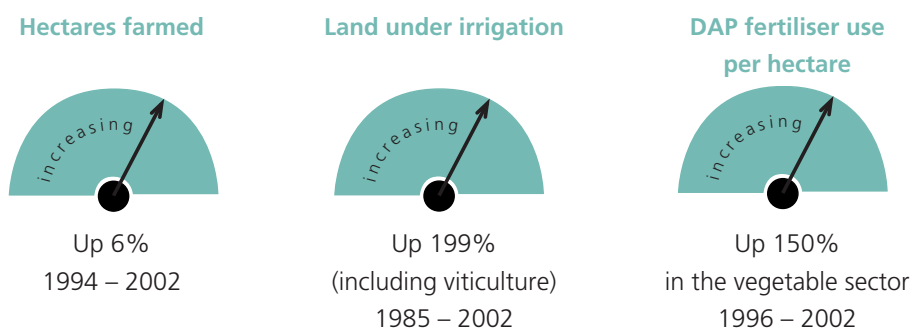
Source: HortResearch, 2002



The area of land under irrigation for horticultural use has increased markedly, from 26,623 hectares in 1985 to 79,692 hectares in 2002, including viticulture.⁴⁶ The intensity of nitrogen fertiliser use differs according to horticultural crop. For example, the vegetable sector applied an average of 167 kilograms of urea per hectare in 2002, whilst the kiwifruit sector applied 75 kg/ha, and the pipfruit sector applied 43 kg/ha.⁴⁷ Between 1996 and 2002, urea application per hectare increased by 49 percent in the kiwifruit sector and 3 percent in the pipfruit sector.⁴⁸

Unfortunately, 1994 urea figures were unavailable for the vegetable sector, so no comparison between years can be made. However, available figures for another nitrogen fertiliser, diammonium phosphate (DAP) between 1996 and 2002 show that there was a 150 percent increase in DAP application per hectare by this sector.⁴⁹

The broad trend in horticulture is toward environmental management systems that reduce pesticide use, though the picture varies according to crop type.



Source: Statistics New Zealand, 1996; Statistics New Zealand, 2003a; Lincoln Environmental, 2000c

3.2.5 Viticulture

Overview

Although vineyards only make up a small proportion of farming land in New Zealand, the wine industry has grown dramatically over the last two decades. Wineries are now found in ten out of 12 New Zealand regions. The three largest wine grape production areas are Marlborough, Hawke's Bay and Gisborne. New Zealand is a niche producer of quality wines, making up less than 0.5 percent of global wine production.⁵⁰ Average selling prices in major export markets are high by international standards. Most New Zealand wineries are small. Only 10 wineries produce more than 2 million litres of wine per year, 35 wineries produce between 200,000 and 2 million litres of wine and the remaining 376 produce less than 200,000 litres.⁵¹

Trends

There were 421 wineries in New Zealand in 2003, compared with 190 in 1994.⁵² The area of land planted in wine grapes grew by 142 percent between 1994 and 2002.⁵³ Much of this recent planting is just starting to come into production. Irrigated viticultural land has increased in the last 20 years, and is now more than 12,000 hectares (see Figure 3.3 – viticulture is included within horticulture data on the graph).⁵⁴



Source: Statistics New Zealand, 2003a; <http://www.nzwine.com/statistics>

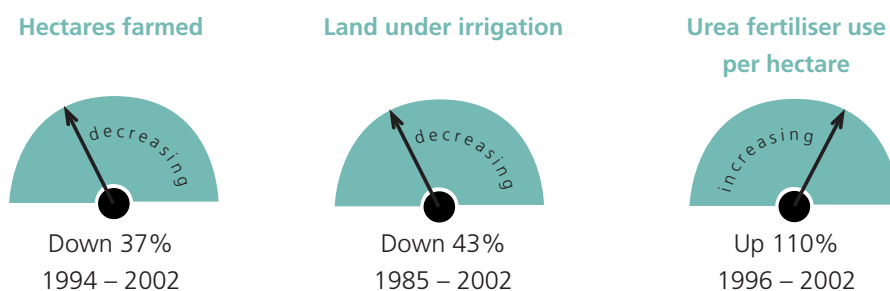
3.2.6 Arable crops

Overview

The arable industry produces milling, malting and feed grains, including wheat, barley, maize, oats and peas. New Zealand is a relatively small player in world grain production terms with less than 0.5 percent of world production.⁵⁵ The industry is located primarily in Canterbury, which produces 80 percent of the total crop, but production is also significant in Southland, Otago, Manawatu, Hawke's Bay and the Waikato.⁵⁶ Arable farms usually run a variable but significant number of livestock as well, including sheep, beef cattle, dairy cattle or deer.

Trends

The overall size of the arable sector is shrinking, and is becoming increasingly focused on producing silage for the dairy industry. Maize silage is now the single largest crop.⁵⁷ While arable land under irrigation has decreased, urea application on a per hectare basis by the arable sector has increased.⁵⁸



Source: Statistics New Zealand, 1996; Statistics New Zealand, 2003a; Lincoln Environmental 2000c

3.3 Trends in the use of inputs

This section examines some key inputs to farming in New Zealand. It looks at recent trends in water use for irrigation as well as nutrient/fertiliser inputs and energy use. The trends identified are based on available data and research.

3.3.1 Water for irrigation

The area of irrigated land in New Zealand has been increasing at a rate of about 55 percent each decade since 1965 (see Figure 3.3). Water abstraction from irrigation schemes is also increasing steadily. Most of New Zealand's irrigated land (70 percent) is located in the Canterbury region, and it is here that irrigation pressures are most obvious.⁵⁹

Water is an increasingly critical component of New Zealand's rural economy. The move to more intensive farming systems is usually accompanied by a demand for increased quantity and reliability in water supply. Irrigation undoubtedly supports farming, water being the key to plant growth and hence farm productivity. However, irrigation can also contribute to the development of farming systems that require higher inputs of fertiliser and energy as well as water. For example, irrigated dairy farms use nearly double the electricity of non-irrigated dairy farms (30.6 gigajoules per hectare compared to 16.9).⁶⁰ Similarly, nitrogen

fertiliser use is much greater on dairy farms with irrigation (135 kilograms of nitrogen per hectare compared to 68 on non-irrigated dairy farms).⁶¹ Chapter 5 looks at irrigation issues in much more detail.

Land under irrigation



Increasing at a rate of around 55% nationally each decade

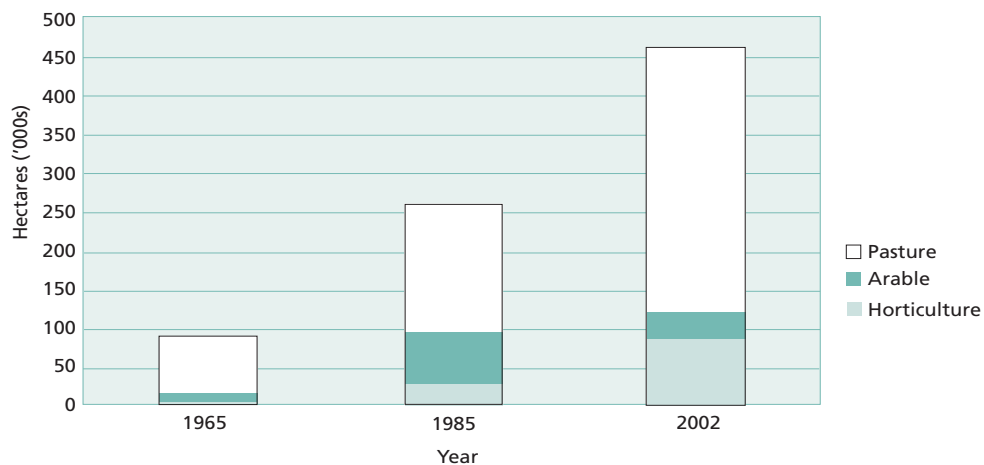
Water abstraction



Increasing for both surface and groundwater abstraction in the Canterbury region

Source: Lincoln Environmental 2000c; Statistics New Zealand, 2003a

Figure 3.3 Hectares under irrigation in New Zealand



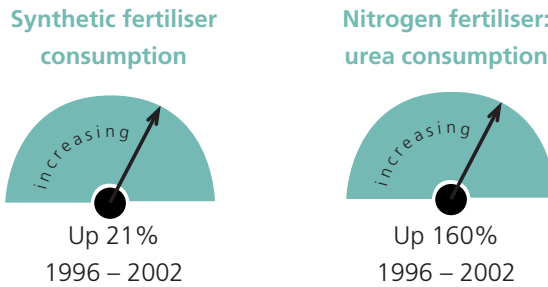
Source: Lincoln Environmental 2000c; Statistics New Zealand, 2003a

3.3.2 Nutrients and fertilisers

Synthetic fertiliser usage across most farming sectors has increased significantly in New Zealand in recent years.⁶² In particular, use of nitrogen fertiliser in New Zealand has soared, as has the proportion of total fertiliser being applied as nitrogen. This trend highlights a new technology that has moved from being innovative in the early 1990s to mainstream and widely adopted in 2001. The *intensity* of nitrogen fertiliser use, that is, the amount of fertiliser applied *per hectare* in New Zealand also increased in most sectors. For example, the intensity of urea use increased by 670 percent in the sheep and beef sector and by 160 percent in the dairy sector between 1996 and 2002.⁶³ Although there has been a huge increase in urea use by the sheep and beef sector, per hectare use is still *far below* that of the dairy sector or some horticultural sectors.

New Zealand is moving away from systems that use natural processes for providing nitrogen in soil to a greater reliance on synthetic substitutes.

In general, New Zealand is moving away from systems that use natural processes for providing nitrogen in soil (e.g. nitrogen-fixing clover in pasture) to a greater reliance on synthetic substitutes. Chapter 5 looks at nutrients and fertilisers in more detail and considers the risks and challenges associated with current trends.

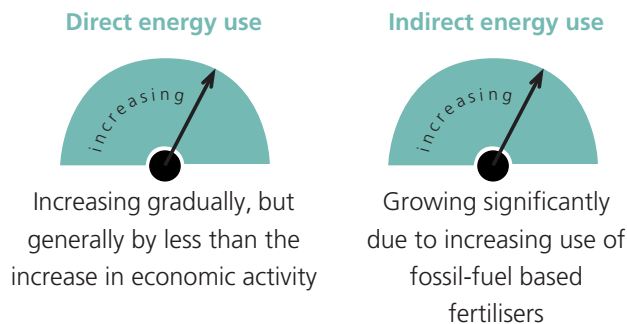


Source: Statistics New Zealand, 1996; Statistics New Zealand, 2003a

3.3.3 Energy

The energy required to produce a good or service is called *direct energy*, while *indirect energy* is the energy embodied in products that are consumed in producing the good or service. Overall, the amount of direct energy used by the farming sector increased by about 30 percent between 1992 and 2002.⁶⁴ More recently, direct energy use has increased in some farming sectors and decreased in others. For example, dairy farming used about one percent less direct energy in 2002 than it did in 1996, despite increased production during the period.⁶⁵

However, these figures do not account for all of the energy used in farming. Energy is used indirectly in the manufacture of farm inputs such as fertiliser and machinery. Given the significant increases in the use of fossil fuel derived fertilisers over recent years, New Zealand farmers are generally using much more energy to grow food on their farms.



Source: EECA, 2003; Statistics New Zealand, 2003a

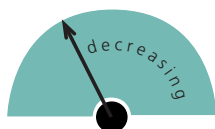
3.4 Trends in the state of natural capital

This section looks at the state of natural capital in intensive farming areas, based on available data and research. The primary focus is on water, although trends for soil and atmosphere are also discussed.

3.4.1 Water

Water quality in areas of intensive pastoral farming is poor relative to the Ministry for the Environment microbiological water quality guidelines and Australian and New Zealand Environment Conservation Council (ANZECC) water quality guidelines—a fact known for many years.⁶⁶ Water quality declines markedly in lowland streams and rivers in pasture-dominated catchments. Many rivers draining farmland are unsuitable for swimming because of faecal contamination from farm animals, poor water clarity, and nuisance algal growths caused by excess nutrients. Furthermore, groundwater quality in aquifers that exist under pastoral farming areas, in particular dairying areas, tend to have elevated nitrate concentrations sometimes exceeding drinking water standards.⁶⁷

Surface water quality



Most rivers in farming areas, particularly in lowlands, generally fail to meet recommended guidelines as a result of contamination from increased nutrients, turbidity and animal faecal matter.

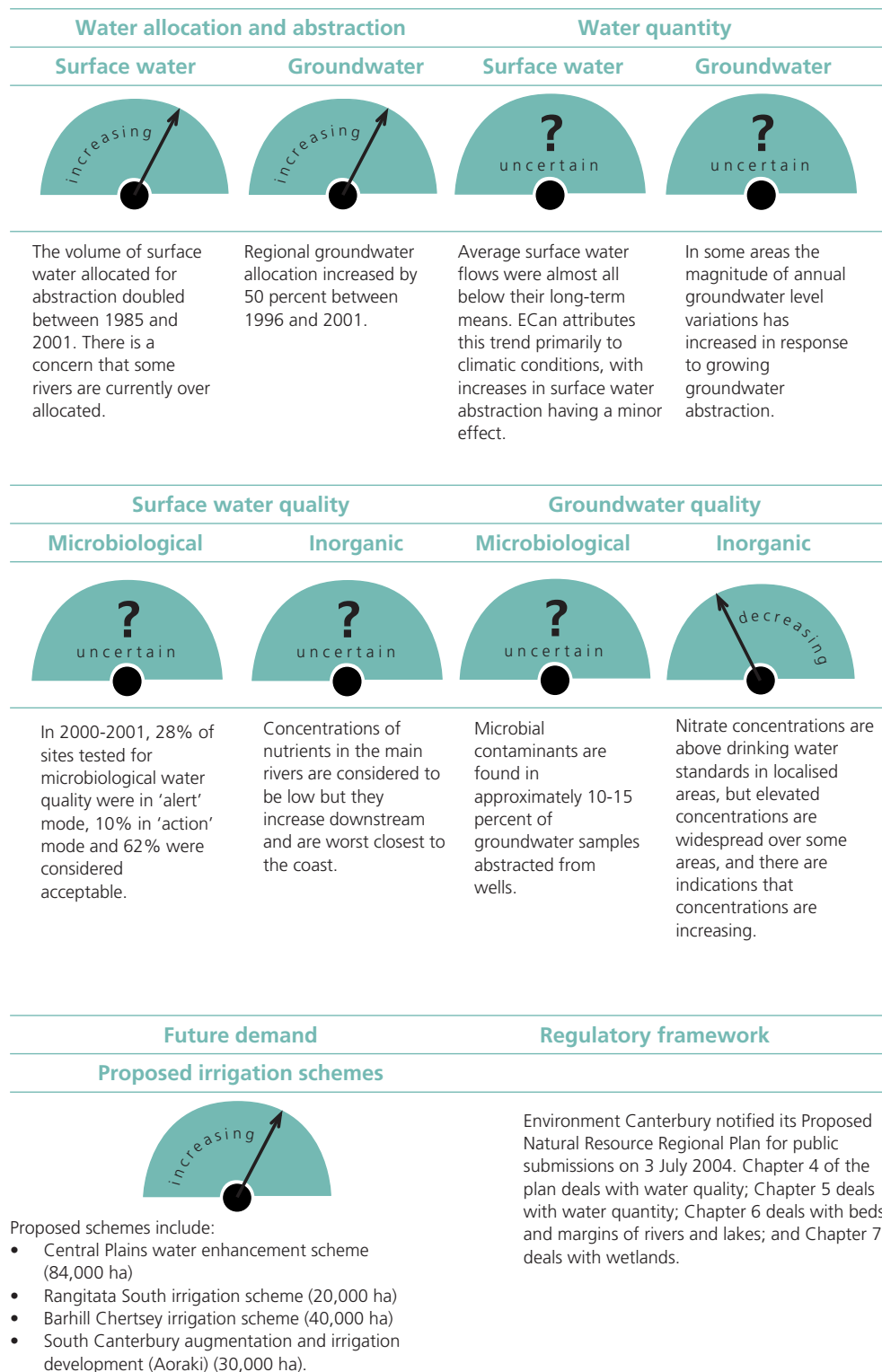
Groundwater quality






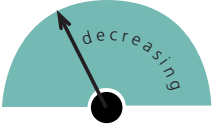




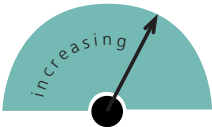
Although the state of groundwater quality is not known comprehensively at a national level, many shallow aquifers beneath dairying or horticultural land have elevated nitrate levels.

In those regions with intensive farming systems, such as Waikato and Canterbury, where data has been gathered, declining water quality has been confirmed in some areas. Chapter 5 looks at these issues in more detail. More detailed information on trends and issues relating to water in the Canterbury, Hawke's Bay, Southland and Waikato regions follows.

Water trends in the Canterbury Region



Water trends in the Hawke’s Bay Region




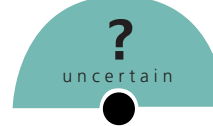
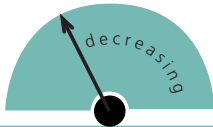
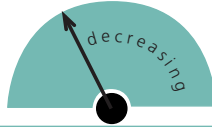

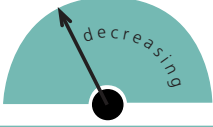
Water allocation and abstraction		Water quantity	
Surface water	Groundwater	Surface water	Groundwater
 <p>20% decrease in number of surface water consents, but 65% increase in number of hectares irrigated between 1995 and 2003. Although more water has been allocated, it is used over more hectares. This suggests an overall increase in efficiency.</p>	 <p>9% increase in the number of groundwater consents granted between 1996 and 2003, 89% of which have been for irrigation.</p>	 <p>Hawke’s Bay rivers are extremely variable. Up to 40 years of flow records and 100 years of rainfall records show no significant trends at either regional or sub-regional level. The variability in river flows is attributable to variability in climate patterns rather than increasing use, or climate-driven changes in trends.</p>	 <p>Generally sufficient to meet irrigation and domestic demands. However in some localised areas pressure on the resource may occur. Water levels in 51% of monitored wells are declining by less than 1 metre/10 years. 11% of wells are declining by between 1 and 2 metres/ 10 years. Water levels in 17% of wells are increasing.</p>
Surface water quality		Groundwater quality	
Microbiological	Inorganic	Microbiological	Inorganic
 <p>Microbiological water quality across the region is generally good and compares favourably with River Environment Classification standards. Data suggests that water quality in the region is decreasing over time. However, HBRC attributes this primarily to flow levels rather than human-induced changes.</p>	 <p>Inorganic water quality across the region is generally good, although there are some areas with elevated nitrate-nitrogen concentrations. Data suggests that water quality in the region is decreasing over time, however, HBRC attributes this primarily to flow levels rather than human-induced changes.</p>	 <p>Currently water in monitored wells is generally good across the region. Only one of the monitored wells exceeded the drinking water standards for faecal coliforms. No trend for microbiological determinants</p>	 <p>Currently water in a number of monitored wells exceeds drinking water standards. Median manganese concentrations exceed health standards at 7 wells (of 48 monitored). Aesthetic manganese and iron standards are commonly exceeded across Hawke’s Bay. Generally there have been increasing trends in pH, ammoniacal nitrogen, nitrate, manganese, iron, chloride and soluble reactive phosphorus in wells.</p>
Future demand		Regulatory framework	
Proposed irrigation schemes			
 <p>There is interest in developing irrigation schemes but no firm proposals. Individual users are increasingly aware of the greater certainty provided by groundwater</p>		<ul style="list-style-type: none"> Proposed Regional Resource Management Plan 1998 sets cap on amount of surface water for irrigation Minimum flow set for all streams and rivers Plan provides for what exists but does not provide for future demands, pressures and uncertainties. 	


Source: Hawke’s Bay Regional Council; Hawke’s Bay Regional Council, 2004

Water trends in the Southland Region

Water allocation and abstraction		Water quantity	
Surface water	Groundwater	Surface water	Groundwater
			
The volume of surface water allocated for abstraction has remained largely unchanged over the last decade.	Regional groundwater allocation has increased significantly (+100%) since 2000. Much of this increase has been for pasture irrigation.	Since 1998, average surface water flows were almost all below their long-term means. Environment Southland attributes this trend entirely to climatic conditions.	Current levels of groundwater allocation have had limited effect on the magnitude of seasonal groundwater level variation
Surface water quality		Groundwater quality	
Microbiological	Inorganic	Microbiological	Inorganic
			
In the decade prior to 2001, contamination levels had increased in the Maitaura River, but remained steady elsewhere. Recent trends uncertain. In 2003, 10 bathing sites were routinely monitored. In terms of suitability for recreation, four were 'good' or 'very good', five were 'poor' and one was 'very poor'.	In 2000, concentration of nitrogen in streams draining developed catchments generally exceeded periphyton guidelines. Levels appear to have remained steady since then. Phosphorus levels within guidelines, but some increase is evident due to anthropogenic and/or climatic factors.	Microbial contaminants are found in a significant number of bores however their occurrence is strongly correlated with the standard of bore construction and adequacy of wellhead protection. Some decrease in levels of contamination is indicated.	Groundwater quality in many areas shows some impact resulting from agricultural land use. Overall groundwater quality remains well below maximum drinking water standards at the majority of locations. Trends uncertain due to short record.
Future demand		Regulatory framework	
Proposed irrigation schemes		<ul style="list-style-type: none"> Environment Southland notified a Proposed Regional Fresh Water Plan (PRFWP) in October 2000. A Variation to the PRFWP was notified in July 2004. The purpose of the Variation is to incorporate a new framework for allocating groundwater into the Water Plan to address the increased demand for groundwater that has occurred in recent years. Environment Southland is currently considering initiating a Variation to the PRFWP to update the existing water quantity provisions of the Plan. 	
	While the demand for pasture irrigation continues, especially in northern Southland, there are no apparent plans for large scale irrigation schemes. The Southland Water Demand Study (2003) concluded that irrigation demand for water was likely to continue in a number of areas of Southland.		

Water trends in the Waikato Region

Water allocation and abstraction		Water quantity	
Surface water	Groundwater	Surface water	Groundwater
			
<p>In 2002, 560,000 m³/day of surface water was allocated for consumptive use such as irrigation and water supply. Many waterways in the region are reaching their allocation limits. Much of the recent pressure has come from irrigation takes.</p>	<p>In 2002 there were 339 consents to take groundwater amounting to 547,000 m³/day. 39% of the consents were for irrigation. However this amounted to only 9% of the groundwater allocated. There has been a 61% increase in amount of groundwater allocated between 1987 and 2002.</p>	<p>Changes in discharge are generally related to climate influences. There is natural variation from year to year in the range of plus or minus 40% of the long-term average discharge. The allocation limits in the Regional Plan limit the depletion effects due to surface water takes.</p>	<p>Most areas in the Waikato region have low stress from groundwater abstraction, with less than 10% of available groundwater being used. Thirteen areas are under high pressure, with more than 30% of available groundwater being used.</p>
Surface water quality		Groundwater quality	
Microbiological	Inorganic	Microbiological	Inorganic
			
<p>Water quality for contact recreation in rivers is generally good in the Upper Waikato River and in rivers and streams in the Taupo and Coromandel areas. It is poorer in areas where land use is more intensive. A 2002 study found that median <i>E. coli</i> concentrations in 53 of 73 stream and river sites sampled in the region, exceeded the guideline for freshwater recreation. 3 of 69 sites monitored across the region had increases in <i>E. coli</i> concentrations between 1998 and 2002. 62 sites showed no significant trends.</p>	<p>Water quality for ecological health is generally good across the region, however it is poorer in intensively farmed areas. More than 90% of streams in intensively farmed catchments in the region have moderate to high levels of nitrogen. Across the region as whole, monitoring between 1987 and 2002 indicates a general decline in water quality (increased total nitrogen, total phosphorus, decreased dissolved oxygen and pH).</p>	<p>Localised microbial contamination of groundwater is a problem in some coastal areas, due to septic tanks. At present there is little information about microbial contamination of rural groundwater, however a study of 40 wells in Matangi found that 12.5% were contaminated with faecal coliforms.</p>	<p>Nitrate contamination levels in groundwater commonly exceed drinking water guidelines. Nitrate concentrations are increasing in many areas. Pesticide residues at generally low levels have been detected in areas of frequent use. They commonly relate to historic practices.</p>

Future demand	Regulatory framework
<p>Proposed irrigation schemes</p> <div style="text-align: center;">  </div> <p>There are currently no proposed irrigation schemes. Future demand will come from individual takes and not from irrigation schemes.</p>	<ul style="list-style-type: none"> <li>• Proposed Waikato Regional Plan is the main planning framework for managing water resources in the Waikato Region. <li>• Environment Waikato proposes to address non-point source discharges through a combination of education and encouragement and conditions on permitted activities, to gradually change identified inappropriate farming practice. More stringent conditions and standards may be used in regulatory methods in the future if no improvement in water quality is detected. <li>• The Clean Streams project aims to encourage and support farmer efforts to reduce the impacts of farming on waterways. Advice and financial support of up to 35 percent of farmers' costs for fencing and planting waterway margins is available. The project runs for 10 years and EW has committed up to \$10 million. <li>• The Protecting Lake Taupo Project proposes regulatory control of non-point source discharges to the lake supported by education, advice, research on low nitrogen farm systems and land use and public funds to reduce nitrogen discharges to the lake.

NB: Environment Waikato measures water quality for contact recreation by assessing water clarity and *E.coli* levels in rivers and streams. It measures water quality for ecological health by assessing dissolved oxygen, pH, turbidity, ammonia, temperature, nitrogen and phosphorus levels in rivers and streams.

Source: Environment Waikato

3.4.2 Soil

New Zealand loses between 200 and 300 million tonnes of soil to the oceans every year.⁶⁸ This rate is about 10 times faster than the rest of the world, and accounts for between 1.1 and 1.7 percent of the world's total soil loss to the oceans, despite a land area of only 0.1 percent of the world's total.⁶⁹

Soil erosion is thus a significant issue across much of agricultural New Zealand – from extensive hill country grazing to more intensive types of farming such as horticulture.⁷⁰ This is partly because of the mountainous terrain and maritime climate. However, soil erosion can also be accelerated by land clearance and unsuitable land management practices (e.g. grazing on steep slopes, over-stocking). Farmed land in New Zealand has an average of only 15 centimetres of topsoil.⁷¹ Moderate to slight erosion affects over half of the country, and almost 10 percent of the country has severe to extreme erosion.⁷² The 1997 State of New Zealand's Environment report concluded that about 30 percent of New Zealand is able to sustain pastoral farming without significant erosion problems, and a further 28 percent can support limited livestock grazing provided it was accompanied by erosion management measures.⁷³

The annual economic cost to New Zealand of soil erosion and sedimentation was *conservatively* estimated at \$127 million in 1998.⁷⁴ However, it is unclear how much of this soil erosion can be attributed to farming given New Zealand's high background erosion rates reflecting tectonism and steep topography.

The loss of this precious, non-renewable resource is a major issue, and so too is the downstream effect that sediment has on waterways and estuaries. Sediment from farming activities can enter waterways and harm aquatic ecosystems by reducing light penetration and visual clarity, and by sedimentation. Chapter 5 discusses the effects of soil erosion on water quality and aquatic ecosystems in more detail.

3.4.3 Atmosphere

Certain gases present in the atmosphere trap heat from the sun and help to maintain the Earth's climate. This natural phenomenon is called the greenhouse effect. In the past 50 to 100 years, atmospheric concentrations of certain greenhouse gases such as carbon dioxide (CO₂), methane (CH₄) and nitrous oxide (N₂O) have been rising at an increasing rate. This is contributing to global warming, which is also affecting weather patterns and climatic conditions (i.e. it is leading to climate change).

In New Zealand, the farming sector contributes over half of the country's greenhouse gas emissions, compared to an average share of less than ten percent in other countries.⁷⁵ The main greenhouse gases emitted through farming are methane and nitrous oxide. Nearly all of New Zealand's methane emissions originate from the belching of ruminant animals (cattle, sheep, deer and goats).⁷⁶ Ruminants produce methane in their rumen (forestomach) as a by-product of digestion. Nitrous oxide emissions are produced by soil bacteria. The major source of nitrogen for these processes is animal waste (urine and dung). Nitrous oxide emissions are also associated with the use of nitrogen-based fertilisers.

The farming sector is responsible for around 90 percent of New Zealand's methane emissions and more than 90 percent of nitrous oxide emissions.⁷⁷ These two greenhouse gases are both more potent in terms of their global warming effect than carbon dioxide (methane is 21 times more potent and nitrous oxide 310 times).⁷⁸

According to the latest estimates, greenhouse emissions from New Zealand's farming sector are currently about 15 percent above 1990 levels.⁷⁹ The most significant changes have been in the dairy sector, where methane emissions have increased by 65 percent since 1990 due to the increase in stock numbers.⁸⁰

Greenhouse gases



Up over 15%
1990 – 2002

Source: New Zealand Climate Change Office, 2004a

3.5 Other trends

3.5.1 Social trends

Although the primary focus of this report is on natural capital, it is also important to consider some social trends in rural areas of New Zealand. There have been some substantial social shifts across rural New Zealand in recent decades. As a Ministry of Agriculture and Forestry report has commented:

Until recently, at least, most rural communities have functioned as close-knit groups, frequently focused around the activities of sporting clubs, churches, schools and pubs. Today, the characteristics of many rural communities have changed. Rural depopulation and a drop in traditional employment opportunities have resulted in a decline in the importance of the agricultural population relative to other rural residents...These changes have occurred in combination with the closure of many rural churches, schools, banks and other traditional facilities. Together these changes have had a fundamental effect on community dynamics.⁸¹

Some recent trends include:

- *schools* — rural schools often play a major role in holding the fabric of rural communities together. Many schools in rural areas are currently under threat of closure.⁸²
- *health services* — there are ongoing challenges to recruit and retain health professionals and to maintain high quality health services in rural areas.⁸³
- *population* — both depopulation and repopulation have occurred in rural areas over time. The rural population has decreased by about 12 percent over the last 50 years, but is now growing gradually (albeit much more slowly than the urban population).⁸⁴ It is often difficult to retain younger people in particular in rural areas.⁸⁵
- *employment* — employment opportunities in rural communities often fluctuate, but there has been a general increase in employment in the farming sector in recent years. However, there have also been significant labour and skill shortages in this sector, sometimes co-existing with substantial levels of local unemployment.⁸⁶

3.5.2 Human capital trends

The Ministry of Agriculture and Forestry commissioned a report in 2000 to examine student numbers in farming fields of study and to compare skill and knowledge requirements in the farming sector with the education opportunities available. The resulting report found that enrolments in farming and forestry courses declined overall during the 1990s — especially in universities.⁸⁷ If this trend continues, the development of human capital in the farming sector may be impeded.

3.5.3 Science and research trends

During interviews for this investigation, we found deep concerns about aspects of the contribution that science is making to the future of farming in New Zealand. For many farmers, processors, councils, investors and science teams, the concern is not so much about what *is* being done, which is generally regarded very highly. The concern is more about what is *not* being done and how what is being done is being communicated and implemented.

We conducted a review of Foundation for Research Science and Technology (FRST), Ministry of Agriculture (MAF), Marsden Fund and Ministry for the Environment (MfE) funding and research. Our initial analysis suggests that there is significantly less research into the natural resources necessary for farming (such as water and soil) than research into the manipulation of natural resources for farming and into farm management practices to improve production. It is important to acknowledge that some of the research into improving farm products will make a contribution to the understanding of the health and functioning of natural resources. There is some excellent work underway, such as research into land management practices and managing the environmental effects of those practices, supported by the MAF Sustainable Farming Fund.

Over the last year FRST has been revising its research investment portfolios to better reflect Government priorities for knowledge development and wealth creation. This is further discussed in Chapter 6.

3.6 Summary and key points

Farming in New Zealand has changed enormously over the past century. Trends during the last decade include:

- *dairy farming* — there is a general move away from traditional pasture-based systems towards systems that are highly dependent on external inputs. There has been a major increase in the use of urea fertiliser. Dairying is also expanding into relatively dry regions where significant irrigation is required.
- *sheep and beef farming* — although there has been an overall decrease in the number of sheep and beef cattle in New Zealand, stock numbers have increased on intensive sheep and beef farms. Lambing rates nationally have increased significantly. Livestock weights have also increased, partly due to improved animal nutrition. This has been enabled partly through the use of significantly more fertiliser to boost pasture growth.
- *deer farming* — deer numbers, hectares farmed and production volumes have all increased in recent years. Urea fertiliser use has also increased significantly in this sector.
- *horticulture and viticulture* — the overall size of these sectors, in terms of hectares farmed, is gradually increasing. The area of land under irrigation has also increased significantly. A positive trend in the horticulture and viticulture sectors is toward Environmental Management Systems that reduce pesticide use.

CHAPTER **4**

Drivers and incentives



The previous chapter highlighted trends toward more intensive farming systems in New Zealand. This chapter examines what is driving those trends. It identifies a range of driving forces and incentives that are shaping farming in New Zealand, with a major focus on international and national economic factors.

4.1 A range of driving forces

Farming, like any human activity, takes place within a very broad context. Decisions to develop more intensive farming systems, and to intensify production in different ways, are driven by a diverse range of motives, mindsets, values and assumptions that are held by people and embodied in social and economic structures and institutions. Farmers can choose to respond to these drivers in different ways, although individuals are often limited in their capacity to adopt sustainable practices if wider socio-economic systems do not support this goal. It is therefore important to examine the broad systems that help to shape farming practices and their impacts on the environment.

The OECD suggests that the most significant drivers affecting environmental sustainability are:

- *economic* — in particular economic growth and development, and trade and investment liberalisation
- *social* — demographic and labour force developments and consumption patterns
- technological innovation.¹

Figure 4.1 expands on these and identifies some major drivers shaping farming in New Zealand. Drivers at each level interact with drivers at all other levels. For example, the structure of the global market system impacts on institutions within New Zealand. Likewise, government policies and strategies pursued by major producer boards may have some influence on institutions overseas (although New Zealand is obviously only a

small country in the international trading system). It is also important to keep in mind that each individual farm and the natural capital that supports it underpins the entire farming system.



Figure 4.1 Significant drivers shaping farming in New Zealand



The rest of this chapter examines the major driving forces identified in Figure 4.1. Its primary focus is on the international and national economic drivers. This is because farmers tend to be very strongly influenced by economic factors as they seek to sustain their livelihoods or to protect their investments in various ways.²

4.2 International drivers

Much of the way farming operates in New Zealand is strongly influenced by how western market-based economic systems operate around the world. This section identifies some key features of the international trading system for agricultural products and considers their influence on New Zealand farming. More detailed information can be found in background papers to this report.³

4.2.1 Global markets and international trade policies

The vast majority of farming in New Zealand, with its relatively small population but large land area used for farming, is undertaken for export to world markets. Prior to the 1970s, the United Kingdom purchased most of New Zealand's agricultural products. When the United Kingdom joined the European Community in 1973, and access for New Zealand products became much more restricted, the New Zealand farming scene diversified significantly. Major export products and markets currently include:

- fresh chilled beef — particularly to the USA and Japan
- frozen beef — mostly to the USA
- sheep meat — to the European Union, and the United Kingdom in particular
- milk powders — to countries such as Malaysia and Mexico
- casein — especially the USA
- butter — in particular Belgium and the United Kingdom
- cheese — mostly to the USA, Japan and the European Union
- fruit and vegetables — especially Japan, followed by the European Union and Australia.⁴

Given the export-driven nature of most farming in New Zealand, international rules and regulations that govern trade play a critical role in driving change in New Zealand.

International trade rules and regulations

Over the last 50 years there has been a worldwide trend toward trade liberalisation—i.e. reducing national rules and regulations that restrict or manage trade and its impacts. This was initially fostered through the General Agreement on Tariffs and Trade (GATT) and a series of 'rounds' of negotiations. As a consequence of these negotiations, many countries have reduced tariffs (i.e. a tax on imports) for manufactured goods. However, farming products were effectively excluded from this process until the 'Uruguay Round' from 1986 to 1994. This has allowed countries to maintain high levels of protection for their farmers and to subsidise their production.

During the Uruguay Round, attempts were made to reduce tariffs and non-tariff barriers to trade for agricultural products. Non-tariff barriers are domestic policies that impact on trade. They include:

- *import quotas* — which limit the volume of agricultural products entering a country.
- *export subsidies* — government payments to domestic producers if they export their products. These schemes enable wealthy countries to ‘dump’ subsidised surpluses on world markets and contribute to lower world prices for agricultural products.⁵
- *other forms of producer support* — such as paying farmers for making environmental improvements.

The Uruguay Round led to new rules for agricultural trade and for domestic policies that impact on trade. However, agreement could not be reached on more significant agricultural reforms. Further negotiations are currently taking place as part of the ‘Doha Round’ of negotiations (discussed later in this section). Another outcome of the Uruguay Round was the establishment of the World Trade Organisation (WTO) to replace the GATT and to deal with rules of trade between countries.⁶ The WTO has a broader role than GATT, including an increased emphasis on trade and the environment.⁷

Restricted access for New Zealand and producer support in overseas markets

While trade negotiations continue, most countries have policies that restrict access for agricultural products from New Zealand. Governments in many developed countries also provide significant support for their farmers. Levels of restriction and support are highlighted in Table 4.1. This table identifies Producer Support Estimates (a measure of trade and policy intervention in farming) in significant export markets for New Zealand.⁸ Table 4.2 identifies the degree of restriction and support for selected agricultural products that New Zealand farmers trade in. As these tables highlight, New Zealand has a more open market-based system than any other member of the OECD. The level of government support to farming in New Zealand has remained the lowest in the OECD since the agricultural reforms of the mid-1980s.⁹ Farmers in New Zealand are in a unique position among developed countries in that they are almost totally exposed to world market forces.¹⁰

Table 4.1 Producer support estimates by country (percentage of the value of gross farm receipts)

	1986-1988	2001-2003
Australia	8	4
Canada	34	19
European Union	39	35
Japan	61	58
Mexico	0	21
Switzerland	76	73
United States	25	20
OECD average	37	31
<i>New Zealand</i>	11	2

Source: OECD, 2004

Table 4.2 Producer support estimates for commodities across OECD countries (percentage of the value of gross farm receipts)

	1986-1988	2001-2003
Milk	59	48
Beef and veal	32	33
Sheep meat	55	38
All commodities	37	31

Source: OECD, 2004

Recent developments in trade negotiations

The Doha Round of trade negotiations is currently taking place. The purpose of these negotiations is to increase market access for farming products, to eliminate export subsidies, and to reduce domestic support for farmers. They also allow for 'non trade concerns', such as environmental protection and food safety, to be taken into consideration.¹¹

Since the Uruguay Round, there has been a significant shift in focus in agricultural policies in many OECD countries.¹² For example, the European Union is placing increasing emphasis on rural development and environmental quality (see below). Some countries are also introducing new agri-environmental policies (measures that aim to address environmental issues related to farming) to address issues such as water quality, food safety and the promotion of less material intensive farming.¹³ The increasing attention given to environmental issues reflects many changing attitudes around the world about the wider impacts of free market policies on societies and the environment.

During the Doha negotiations there is also likely to be considerable debate about the acceptability of some trade restrictions. For example, the European Union appears to favour some restrictions based on production methods, such as beef produced with hormones or genetically modified organisms. However, it is currently very difficult to restrict trade for these sorts of reasons under existing WTO rules.¹⁴

European Union (EU) farming policies

The European Union is a significant market for New Zealand's agricultural products and an influential player in world trade negotiations.¹⁵ The Common Agricultural Policy (CAP) of the European Union has played a pivotal role since it commenced in 1963. The original objectives of the CAP were to:

- increase agricultural productivity
- ensure fair standards of living for those involved in farming
- stabilise markets and the availability of supplies
- ensure quality food production at reasonable prices.

... there has been a significant shift in focus in agricultural policies in many OECD countries.

New Zealand farmers enjoy some preferential access to the European Union, due to the loss of access to the United Kingdom market in the 1970s. Nonetheless, the CAP still places significant restrictions on trade and enables European countries to heavily subsidise their farmers' production. There have been various reforms to the CAP since the 1980s. For example, the 'McSharry reforms' in 1992 moved prices closer to world market levels and compensated farmers with direct payments based on past production patterns. They also increased funding for agricultural environmental schemes and allowed countries within Europe to provide additional funding for these schemes. Over time, the European Union has also introduced measures to promote the development of less material intensive farming.¹⁶

More recently, there has been significant reform of the CAP through *Agenda 2000*. The objectives of *Agenda 2000* are:

- increased competitiveness internally and externally
- food safety and food quality as a fundamental obligation toward consumers
- integration of environmental goals into the CAP
- creation of alternative job and income opportunities for farmers and families
- simplification of European Union legislation
- ensuring fair standards of living for the agricultural community and contributing to the stability of farm incomes.¹⁷

Environmentally sound production methods, high standards of animal welfare, and food safety and quality concerns topped the *Agenda 2000* list of priorities.¹⁸ These objectives differ significantly from the original objectives of agricultural policy in the European Union and reflect rising concerns among many European citizens and consumers about the health of their food and the environmental impacts of existing farming systems. In 2002, halfway through implementation of *Agenda 2000*, a Mid-Term Review of the CAP was conducted. Among other changes, this review strengthened policies encouraging food quality and improvements in animal welfare.

... the European Union has introduced measures to promote the development of less material intensive farming.

Environmentally sound production methods, high standards of animal welfare, and food safety and quality concerns topped the *Agenda 2000* list of priorities.

United Kingdom policy reform

Under recent CAP reforms, subsidies linked to environmental quality are becoming an important part of the direct payment system in the United Kingdom. There has been a steady increase in these subsidies over the last decade. Direct payments have become decoupled from production and more of the European Union's budget is aimed at environmental protection. In 2002, £245 million was spent on these schemes.

Existing schemes in the United Kingdom include:

- the *Environmentally Sensitive Areas scheme*, which covers all farming sectors and is aimed at conserving areas of high landscape, wildlife, or historic value

- the *Nitrate Sensitive Areas (NSA) scheme*, which identifies areas where water contains, or is at risk of containing, more than 50 mg/l of nitrate.

There are currently 22 Environmentally Sensitive Areas in the United Kingdom, covering ten percent of total agricultural land. Eight percent of England was designated as nitrate sensitive in 1996. However, land only received this designation under the NSA scheme if it directly affected drinking water catchments. In 2000, the European Union Court of Justice deemed that this was insufficient to fulfil the requirements of the NSA scheme. The United Kingdom must now find a way to comply with European Union directives.

Farming in the United Kingdom is also undergoing significant policy reform of its own. Internal drivers include the major food safety and animal welfare issues that arose at the end of the 1990s—namely BSE ('mad cow disease') and foot and mouth disease. After the foot and mouth outbreak, a Policy Commission on the Future of Farming and Food was set up. This Commission produced an influential report entitled *Farming and food: A sustainable future*, which called for a fundamental rethink of the whole food system to ensure the sustainability of farming and food in the United Kingdom. The government response, the *Strategy for sustainable farming and food*, embraces the challenges identified in the report and sets out how these ideas will be taken forward. It has a major emphasis on reconnecting people with the land, and consumers with farmers.

For more information see www.defra.gov.uk

Influence of international trade rules on New Zealand farming

Changes in agricultural trade rules and regulations have driven, and will continue to drive, many changes for farming in New Zealand. The growth in non-tariff barriers over time has increasingly affected New Zealand's trade with the rest of the world.¹⁹ Because New Zealand farmers compete with subsidised producers in other parts of the world, farmers in New Zealand often face strong pressures to intensify their production to remain competitive. These pressures are strongest in agricultural commodity systems (discussed in the following section) where food from New Zealand farms cannot be differentiated from products grown in other parts of the world. Some trade restrictions have also helped to drive environmental improvements in New Zealand. For example, environmental standards in overseas countries have driven some New Zealand exporters to change production methods to retain market access.

Further agricultural reforms are likely to lead to major economic benefits for New Zealand. However, in the absence of any other institutional changes, increasing prices for agricultural products on world markets may also provide some farmers with an incentive to further intensify their production.²⁰ While reforms are likely to lead to improved market access, it is also possible that further restrictions based on production methods will develop. These issues are returned to in Chapter 5.

While reforms are likely to lead to improved market access, it is also possible that further restrictions based on production methods will develop.

4.2.2 Commoditisation of production

Rising international trade in agricultural products has been facilitated through the development of global commodity systems. Over the last few centuries there has been a general shift away from local, small-scale, diverse production to larger-scale, specialised production by farmers and agricultural businesses. Many farmers throughout the world now sell their goods over long distances *via* complex distribution and processing networks.²¹ Most of the food produced on farms, and many of the inputs used for farming, are considered to be commodities. In economic terms, commodities are goods or services with qualities that enable them to be easily bought and sold through markets. Two major features of commodities are that they are:

- *standardised* — their characteristics are not strongly influenced by local environmental or social conditions. For example, it is usually very difficult to differentiate a tonne of milk powder produced and processed in New Zealand from a tonne of milk powder produced and processed in America.
- *substitutable* — because commodities are difficult to differentiate, traders and buyers can easily find substitutes around the globe. Buyers purchase commodities at the lowest possible price, often irrespective of where or how they were produced.²²

Over time, an ongoing process of ‘commoditisation’ has developed, in which there is a “tendency to preferentially develop things most suited to functioning as commodities.”²³ Agricultural commodities are easy to sell on markets and the transaction costs of buying and selling them are low.²⁴ Many farmers therefore produce goods and services that have the qualities of commodities, which contributes to the ongoing development of commodity systems. For example, it is usually easier to sell a generic kind of fruit or vegetable crop on world markets than it is to sell a specific crop variety that is unique to a particular area. Commodity systems have therefore developed that favour trade and farming in these generic crops.

Commodity production drivers

Because commodities are standardised and substitutable, farmers in commodity systems compete with many other producers to sell their products at the lowest possible price. If they can only compete on the basis of price, farmers in commodity systems tend to face limited choices when it comes to protecting their livelihoods or investments. They face three major driving forces:

- *efficiency boosting incentives* — to remain competitive, farmers face enormous pressures to seek ever greater efficiency. This can be achieved through cost savings, investing in technology, or cost externalisation (see Section 4.3.3).
- *expansion incentives* — farmers often aim to protect their viability in the future by expanding their production capacity and investing in more land.
- *demand growth loop* — when many farmers aim to sell the same commodity at the lowest possible price, there is a downward pressure on prices. If prices fall, consumption tends to increase and new uses for a product may develop, further

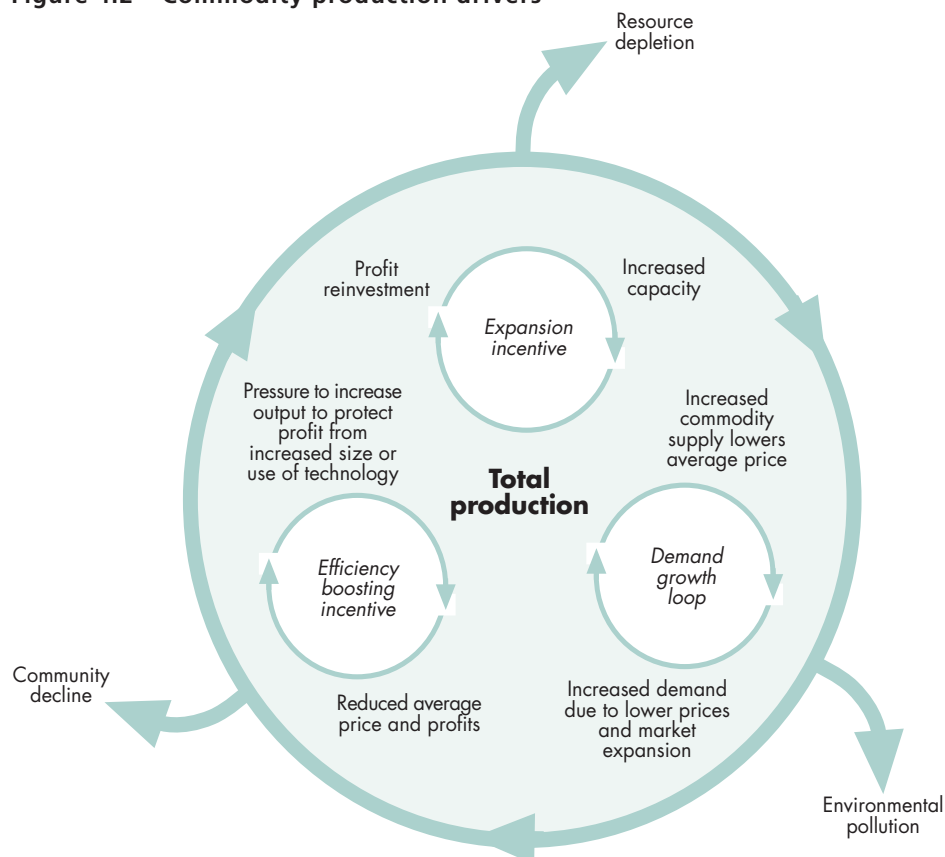
If they can only compete on the basis of price, farmers in commodity systems tend to face limited choices when it comes to protecting their livelihoods or investments.

fuelling demand. Increasing demand then puts upward pressure on prices, completing the cycle and reinforcing the efficiency and expansion incentives identified above.²⁵

As Figure 4.2 highlights, these processes reinforce each other. Taken together, they tend to drive farmers in a commodity system to increase their production *irrespective of high or low profits*. When profits are low, commodity producers face pressures to increase production through efficiency gains or expansion. When profits are high, farmers often invest in more production capacity to maintain their competitiveness in the future. Farmers may also try to capture a competitive advantage through innovation. However, this advantage is invariably lost over time through the innovation of many other farmers in New Zealand and, more significantly, overseas. It is this continuous process of competition that contributes to the emphasis on efficiency and/or expansion.²⁶

These major driving forces contribute to higher levels of production and help to keep the costs of commodities low. Commodity-based farming is often viewed as more productive than alternatives. However, productivity is usually measured in terms of capital and labour costs — not *land* productivity (the quantity of food that can be grown from a given amount of land). In their ongoing search for efficiency and/or expansion, these drivers can also encourage farmers to intensify their production in ways that lead to long-term problems such as resource depletion, pollution and community decline.

Figure 4.2 Commodity production drivers



Source: Sustainability Institute, 2003

Ultimately, these drivers contribute to the ‘treadmill effect’ that farmers often refer to. Ongoing pressures to increase production, combined with downward pressures on price, contribute to the sensation of ‘running to stand still.’²⁷ This is a core driving force behind the intensification of farming systems.

Influence of commoditisation on New Zealand farming

Much of the food grown on New Zealand farms is traded on global commodity markets. Examples of significant commodities include milk powder, casein and frozen beef. New Zealand commodity producers usually face strong incentives to intensify production to maintain their position as lowest cost producers. These pressures can be accentuated by low commodity prices in world markets, but high commodity prices can also provide farmers with incentives to intensify their production or to develop different farming systems (for example, converting from sheep and beef farming to dairy farming due to the high value of dairy commodities).

Because of the tendency for commoditisation to push prices down over time, some exporters have tried to break out of the ‘commodity cycle’ by producing high-value goods that can be differentiated on world markets. For example, the kiwifruit industry has developed the Zespri™ Green, Gold and Organic brands, in conjunction with stringent quality standards, to distinguish their fruit from competitors’ products in the rest of the world (see also Chapter 6).²⁸

4.2.3 Connections between consumers and producers

Distancing

As commodity systems have developed over time, and with increasing urbanisation, the distance between producers and consumers of food has grown significantly. Consumers today rarely know the source of their food or how it was produced, especially if it came from a farm in another country altogether. This trend of increasing separation between farmers and consumers of food is called ‘distancing’.²⁹

As distance increases, the connections between producers and consumers of food often break down. For example, consumers seldom see the impacts of farming on the environment and it is usually very difficult for them to find out how their food was produced. Separated by vast distribution and retail systems, it is also hard for consumers to provide any direct feedback to farmers about their preferences. Thus, as the Sustainability Institute notes:

Standardisation and substitutability have allowed commodity systems to be extraordinarily streamlined and productive. But as knowledge of the ecological and social context of the commodity is removed, producers are left with very few grounds upon which to compete. If buyers no longer know where or how a commodity was produced, it is impossible to reward producers for stewardship or good community citizenship.³⁰

Ongoing pressures to increase production, combined with downward pressures on price, contribute to the sensation of ‘running to stand still.’

... some exporters have tried to break out of the ‘commodity cycle’ by producing high-value goods that can be differentiated on world markets.

Consumers today rarely know the source of their food or how it was produced

Consumer values overseas

Over the last century, food has shifted from being a scarce resource to an extremely abundant resource in affluent countries around the globe. The proportion of household income spent on food in many developed countries has also been declining.³¹ More recently, however, there have been rising public concerns about the health of food produced in very intensive ways.³² Events such as the BSE ('mad cow disease') crisis in the late 1990s have also contributed to a loss of public faith in existing food production systems. Many consumers are now willing to pay a premium for certain attributes of food, particularly food safety and quality, but also animal welfare and environmental considerations.³³ These concerns are helping to drive the demand for high quality products, as well as influencing the agricultural policy reforms discussed in Section 4.2.1.

Many consumers are now willing to pay a premium for certain attributes of food.

Requirements of overseas retailers

The retail sector, especially supermarkets, now has closer links with customers than most farmers do. Retailers have therefore become much more influential in food systems. Many large retail chains are now insisting on particular farming standards and reporting as part of their supply chain management. For example, New Zealand fruit and produce suppliers need to satisfy strict environmental conditions to do business with some British supermarkets.³⁴ Over time, retailers have also gained an increasing share of the profits from food, relative to what farmers receive.

Retailers have become much more influential in food systems.

Influence of consumer and retail trends on New Zealand farming

Commodity systems tend to strip away knowledge of how food is produced. A wide variety of schemes have therefore been developed overseas and in New Zealand to improve product 'traceability'. As the Ministry of Agriculture and Forestry commented in 2003:

Markets are concerned not only with the nature of the product but how it is produced...Competing on the basis of production processes etc., means a greater emphasis on standards and on certification and verification regimes, and systems to track products from farm to consumer. The Government has a key role in verification and auditing regimes and in some cases in active facilitation.³⁵



Consumers in many overseas markets are therefore helping to drive changes in New Zealand, with some sectors of the farming community actively developing ways to verify the quality and safety of their production methods (see Section 4.3.3).

Super powers at the supermarket

Something is badly wrong with the way we feed ourselves. In rich countries food is cheaper than ever, yet premature deaths from diet-related diseases are soaring. Down on the farm, soil, water and biodiversity are under pressure as never before...Modern agriculture is set up to encourage one thing: produce more. Yet farmers clearly do many other things we value, such as managing the landscape, helping to fix carbon in the soil and preventing flooding.³⁶

Supermarket chains and processors now play an influential role in shaping 'food futures' and are dominating the food chain in many societies around the globe. In the United Kingdom, four supermarket chains make 70 percent of food and household good sales.³⁷ Two supermarket chains make most sales in New Zealand. These enormous businesses exert a massive amount of control on the supply chain for fresh and processed goods.

Large supermarket chains can often use their market power to drive down the costs they pay to suppliers. The 'virtuous circle' of their purchasing power, as characterised by buyers, is to reduce costs, increase quality, and increase the speed of supply.³⁸ These demands place significant pressures on all suppliers and food producers all the way back to farm paddocks. As highlighted at a recent international conference on food and farming, these pressures also contribute to environmental degradation, greater risks for food quality, and less choice for food consumers.³⁹

New Zealand's farming sector is striving for reductions in price distorting subsidies in many overseas markets. However, it is clear that there also needs to be a strong focus on the big supermarket players that shape the financial returns to New Zealand farmers. In a critique of the social impacts of the major UK supermarkets, it was argued that a 'cheap food' policy has contributed to poverty among many farmers as well as food poisoning, contamination and poor food quality.⁴⁰ This report argued that a 'fair price policy' would be a more appropriate approach to take, accounting for the true costs of production. To that view it could be added that the true *value* of our food — in nutritional, experiential and ecological terms — should be reflected in its *price*. Perhaps that is what the New Zealand kiwifruit and lamb industries are currently moving toward *via* sophisticated marketing of superior food products. Could their efforts be replicated and could they endure?

4.2.4 Other significant international drivers

There are several additional important international drivers. These include:

- *technology* — farming has always been characterised by continuous experimentation, innovation and the development of new technologies. These technologies have enabled farming systems to become more productive and have played a key role in driving intensification. New technologies often provide many benefits for farming and the environment, although they can also lead to significant adverse impacts that may have been unforeseen.

- *access to global energy sources* — the availability of inexpensive energy sources, particularly fossil fuels, has driven the development of more energy intensive farming systems around the world. Farming systems have become increasingly dependent on these energy sources for everything from the production of synthetic fertilisers to the running of farm machinery. Some of the implications of this growing dependence are explored in Chapter 5.
- *exchange rates* — these play a significant role in the price farmers receive for their products at the farm gate. As the value of the New Zealand dollar increases, the price received by farmers generally falls.⁴¹

4.3 National drivers

The previous section examined some major global forces driving changes in New Zealand farming. This section shifts the focus to a national level and looks at influential drivers within New Zealand.

4.3.1 Government policies, strategies and regulations

The government plays an important role in setting the institutional framework for farming in New Zealand. Policies, strategies and regulations can significantly influence the development of farming systems and help to manage their impacts on the environment.

New Zealand's agricultural trade policies

Since the mid-1980s, successive governments in New Zealand have promoted a market-oriented approach to farming, with a major emphasis on economic productivity. There has been little strategic direction provided by central government and, relative to other OECD countries, hardly any intervention into environmental issues related to farming.⁴² As noted above, the level of government support for farming in New Zealand has also remained the lowest in the OECD since this time. Given that New Zealand farmers compete with many other protected farmers around the globe, the government is a strong advocate of free trade in international negotiations. The Ministry of Agriculture and Forestry (MAF) and the Ministry of Foreign Affairs and Trade (MFAT) work together on agricultural trade negotiations with the following aims:

- to increase market access for New Zealand's products in key markets, through lowering all tariffs, increasing the quantity and quality of market access restricted by quotas, and removing all remaining non-tariff barriers
- to see the elimination of all forms of export subsidies
- to secure major reductions in trade-distorting domestic subsidies.⁴³

The existing round of international trade negotiations also provide for 'non-trade concerns', such as environmental sustainability and food safety, to be taken into consideration (see Section 4.2.1). The New Zealand government's position is that these concerns are important, but that issues such as standards should not be addressed in negotiations because "legitimate non-trade objectives can be met in ways which do not distort trade and which are consistent with a liberalised agricultural trading system."⁴⁴

There has been little strategic direction provided by central government and, relative to other OECD countries, hardly any intervention into environmental issues related to farming.

Government's other policies and goals

Within New Zealand, there are two key strategies that guide the current government's overall policies and goals:

- the *Growth and Innovation Framework* (GIF)⁴⁵
- the *Sustainable Development Programme of Action*.⁴⁶

The GIF is an overarching strategy with a primary objective to “return New Zealand’s per capita income to the top half of the OECD and to maintain that standing.”⁴⁷ The Ministry of Economic Development is responsible for implementing the GIF, while a Growth and Innovation Advisory Board provides key links between government agencies and the business sector.

To date, the government has primarily focused on growth in three sectors — biotechnology, information and communication technologies, and the creative industries.⁴⁸ The GIF does not have a strong focus on the farming sector, despite its significant role in New Zealand’s economy. To address this gap, the Growth and Innovation Advisory Board commissioned a report from the Ministry of Agriculture and Forestry in 2003. This report has a major emphasis on raising productivity in the farming sector. It also acknowledges the potential for future trade restrictions to be based on environmental considerations and recognises some of the benefits of moving away from low cost commodity production.⁴⁹

The *Programme of Action for Sustainable Development* aims to ensure that “the quality and durability of economic growth improves the well-being of all New Zealanders and the environment, now and for the future.”⁵⁰ It establishes a set of objectives and principles to guide all government activity and policy development. These principles require the government to take account of the economic, social, environmental and cultural consequences of its decisions by:

- *considering the long-term implications of decisions*
- *seeking innovative solutions that are mutually reinforcing, rather than accepting that gain in one area will necessarily be achieved at the expense of another*
- *using the best information available to support decision-making*
- *addressing risks and uncertainty when making choices and taking a precautionary approach when making decisions that may cause serious or irreversible damage*
- *working in partnership with local government and other sectors and encouraging transparent and participatory processes*
- *considering the implications of decisions from a global as well as a New Zealand perspective*
- *decoupling economic growth from pressures on the environment*
- *respecting environmental limits, protecting ecosystems and promoting the integrated management of land, water and living resources*

- *working in partnership with appropriate Maori authorities to empower Maori in development decisions that affect them*
- *respecting human rights, the rule of law and cultural diversity.*⁵¹

The Programme of Action focuses on four main areas — water quality and allocation, energy, sustainable cities, and child and youth development. As part of this work, a *Water Programme of Action* is being led by the Ministry for the Environment and the Ministry of Agriculture and Forestry. The three main focus points of the programme are water allocation and use; water quality; and water bodies of national importance.⁵² It remains to be seen what sort of tools will be developed by the government to improve water management.

Legal and regulatory frameworks

Beyond these strategies and goals, a wide variety of laws and regulations manage activities in the farming sector. These range from central government statutes and regulations to regional and district council bylaws and planning controls. Most regulations aim to control specific activities, such as:

- the production, sale and marketing of farming products
- land ownership and use
- animal ownership and animal welfare
- use of chemicals or animal remedies and biological hazard/pest control and management
- commercial and personal taxation issues
- natural resource use and conservation.

The most significant legislation for managing the impacts of farming on the environment is the Resource Management Act 1991 (RMA). The purpose of the RMA is to promote the sustainable management of natural and physical resources. It is based on a tiered planning framework from central through to local government. Central government can prepare national policy statements, environmental standards and regulations under the RMA to set environmental 'bottom lines' throughout the country. However, more than a decade after the RMA was introduced, only one national policy statement has ever been released and the first environmental standards, relating to air quality, were approved in 2004. To a large extent, regional councils set the context for development in their regions and provide a framework for district plans.

In the absence of much guidance from central government, there is considerable variability in the quality and focus of regional and district planning. This report has not reviewed the RMA or the performance of public agencies in implementing their responsibilities. The Parliamentary Commissioner for the Environment is planning to investigate some aspects of the RMA in a separate study. Nonetheless, it is very concerning that some regional councils still do not have their first RMA plans in operation. Some councils have clearly

coped with the transition to the RMA planning framework better than others.

4.3.2 Strategies of processing, marketing and exporting agencies

A recent regulatory trend in the farming sector has been the shift away from central government control and direction of producer and marketing boards toward similar organisations that are owned, controlled and directed by shareholding farmers.⁵³ Examples include Fonterra, which replaced the Dairy Board with a co-operative owned by 13,000 dairy farmers, and ENZA, which replaced the Apple and Pear Marketing Board.

Producer groups play a very influential role in the farming sector. Due to the large distances between New Zealand farmers and overseas consumers, and the very competitive nature of the global trading environment, farmers rely on these organisations to market and sell their products to the rest of the world. Producer groups can influence farming practices through measures such as:

- industry certification and standards programmes
- industry targets, such as ongoing targets to increase productivity
- supply contracts with processing companies
- levies on farmers for particular services or research.

Many consumers are becoming more discerning about the health of their food and how it is produced. Food regulations also require certain standards to be met and many large retail chains are increasingly requiring standards and reporting as part of their supply chain management. Some producer groups within New Zealand have responded to these concerns by developing quality assurance programmes and environmental management systems. Table 4.3 provides a list of examples, with more information available in the *Sustainable Management Systems Network* report released in 2004.⁵⁴ These programmes are most common in the horticultural sector, where a variety of integrated pest management (IPM) programmes have been developed for fruit and vegetables such as apples, kiwifruit, grapes, stonefruit, avocados, onions and brassica crops.⁵⁵



Table 4.3 Summary of EMS/QA programmes in New Zealand

Programme	Programme type					
	SMS	EMS	QA	IPM/ IFP	Standards	Codes of Practice
Greentick	x					
Organic standards	x					
Project Green ^a	x					
Smartplan ^a	x					
Sustainable Winegrowing	x					
Market Focused		x				
NOSLaM		x				
The Living Wine Group		x				
Merino Benchmarking Group		x				
Eco-Profit – Towards Sustainable Agriculture		x				
Enviro-Mark™		x				
Green Globe		x				
KiwiGreen ⁵⁶		x	x			
NZ Fresh Produce Supplier Programme			x			
DeerQA			x			
AFFCO Select			x			
FarmPride			x			
FernMark Quality Programme			x			
Olive Care™			x			
Pipfruit – Integrated Fruit Production				x		
AVO Green				x		
SummerGreen				x		
Agrichemical Code of Practice					x	
Fertiliser Code of Practice						x
FertMark						x
Spreadmark						x

KEY

SMS Sustainable Management Systems—components of these programmes encompass sustainability factors such as energy use, greenhouse gas budgets and a wide range of environmental issues such as biodiversity

EMS Environmental Management Systems—incorporate environmental issues not necessarily specific to food safety or quality

QA Quality Assurance Programmes—focus predominantly on food safety and quality issues

IPM Integrated Pest Management—focus mainly on pest management

IFP Integrated Fruit Production

Source: The AgriBusiness Group, 2004

Producer groups can also play an influential role in determining whether New Zealand farmers deal in commodity groups or higher value differentiated products. For example, some organisations have actively pursued high value strategies to break out of commodity cycles or to make the most of trade restrictions such as quotas (see Section 4.2.2).

Producer groups can also play an influential role in determining whether New Zealand farmers deal in commodity groups or higher value differentiated products.

4.3.3 Other national drivers

The ability to externalise costs

Farmers usually have strong incentives to increase their efficiency by reducing or avoiding costs. One strategy that farmers may pursue is to 'externalise' costs to the environment and society. For example, a farmer may aim to intensify their production in ways that (either knowingly or unintentionally) damage natural capital. If they are not required to pay for this damage, they are externalising costs beyond the farm and on to society.

The ability to externalise costs is not so much a driver as an 'enabling factor' that allows farmers to intensify their production in ways that damage the environment. These costs are often difficult to see or trace, and may only become evident slowly over time. Some farmers may deliberately aim to externalise costs, while others do it unintentionally. The use of cost externalisation as a deliberate strategy is influenced by factors such as:

- personal goals and values
- the degree of personal gain that is expected
- potential impacts on future production
- the expected probability of being caught, and the scale of any penalties.

The ability to externalise costs allows farmers to intensify their production in ways that damage the environment.

In some instances, it may be a common practice for farmers to externalise costs to the environment. Individual producers may therefore have a limited capacity to change practices if this creates a cost to them or market disadvantage. In the meantime, damage is likely to continue unless institutions exist to manage or restrict certain activities or require all farmers to pay the full social and environmental costs of their production.

Commoditisation of inputs for farming

Section 4.2.2 discussed some of the major driving forces and options that farmers face when they produce commodities. Farmers also use commodities as inputs for their production. Different inputs have different commodity potentials (i.e. the ease with which they can be bought and sold through market transactions). For example, synthetic fertilisers such as urea have a high commodity potential because they come in a standard form that can easily be applied by farmers, they are simple to package and transport, and there is an ongoing need to keep purchasing them. In contrast, many ecosystem services (see Section 2.2) are not priced in markets. They are unique to particular areas and depend on site-specific knowledge. Table 4.4 provides some examples of goods and services with high and low commodity potential.

Table 4.4 Goods and services with high and low commodity potential

High commodity potential	Low commodity potential
Proprietary hybrid patented seeds	Knowledge of climate, soil, local pests
Insecticides, pesticides, herbicides	Management techniques for pest control
Commercial fertilisers	Nutrient cycling and enhancement
Farm machinery	Soil protection and management
Fossil fuels and established forms of energy	Energy conservation and management
Farm management books and magazines	Rural networks of mutual aid

Source: Manno, 2002

Because it is easy to buy and sell goods and services with a high commodity potential, there are usually strong economic incentives for businesses to develop and market these inputs. However, goods and services with a low commodity potential often receive less attention and investment. Indeed, many institutions have evolved to support the development and production of farming commodities. Everything from research and development, information systems, physical infrastructure, financial and capital markets, and rules and regulations tend to support a commodity-based production model.⁵⁷ As Manno suggests, this is part of a worldwide trend in which:

Commoditisation operates on both the inputs and outputs of the production process, preferentially investing in commercial chemical fertilisers, pesticides, machinery, and standardised crops suited for long shelf life, transport, and branding while under-investing in the development of local site-specific knowledge and skills of soil management, site-specific agronomy and diverse crops...⁵⁸

Over time, changing commodity prices also play an influential role in driving intensification. For example, the increasing use of nitrogen fertiliser has, in part, been driven by the decreasing cost of nitrogen fertiliser relative to the prices farmers have been receiving for their products (see Chapter 5).

Science, research and information systems

The science and research sectors play an influential role in the development of farming practices and the longer-term direction of the farming sector. There is a long tradition of science contributing to innovation in New Zealand's farming community.⁵⁹ However, there are currently concerns about the ongoing contribution of science to farming in New Zealand (see Section 3.5.3). Funding for scientific research on natural resource and

environmental issues is declining, despite an increased need for understanding of sustainability issues.

The services provided to farmers by rural support businesses also play an important role in contributing to farmers' knowledge and influencing their practices. Service providers include veterinarians, farm consultants and advisers, farm suppliers, fertiliser companies, drain contractors, irrigation providers, farm machinery and equipment companies, stock agents, trucking and tanker services, pest control services, technology providers and other training or advisory services. Many advisory services used to be provided to farmers for free, *via* agencies such as the Ministry of Agriculture and Forestry.⁶⁰ These services are now often delivered for a fee by private consultants or contractors.

Land values

Land values are influential in driving land use changes. If land values are increasing, farmers who aim to increase their net wealth have an incentive to buy more land and expand their operations. Established farmers can also borrow more money to fund intensification if the value of their land is increasing. For new farmers, high land values may encourage them to aim for high levels of productivity to service their debts. As Table 4.5 highlights, there have been significant increases in the value of land used for farming in New Zealand over the last decade.



Rural financing agencies, banks, and lenders or investors can also influence farming practices through the terms and conditions attached to loans for land purchases and other investments made by farmers.

Table 4.5 National average pastoral and dairy land values 1990-2003⁶¹

Sector	Land value (\$ per hectare)				
	1990	1995	2000	2003	1990-2003
Pastoral	1,600	2,050	2,200	3,150	+ 98%
Dairy	6,950	13,500	12,750	19,200	+ 176%

Source: Background report *Incentives for intensification* (Watters *et al.*, 2004)

Land values and intensification

Farmers in many of the interviews conducted for this report often reflected on their own successes. However, many of those who were happy with their achievements also felt that they were under constant pressure to push themselves and their farming systems harder and harder to maintain their incomes. Many also commented on the ultimate physical limits of their farm—for example, how hard can a farm be worked before the system starts to break down or until it contributes to other undesirable impacts, such as water pollution?

One of the driving forces behind these pressures, as identified by farmers themselves, is ever-increasing land values — values that in reality have been the major contribution to farm wealth over the last decade. Many factors drive rising land values, such as land scarcity, its potential to generate income, and the perceived value of its site (e.g. its proximity to the coast). These factors have all been influential in New Zealand for many years and have contributed to the historically low rates of return from farming — approximately 4 percent per annum as a percentage of net operating capital excluding capital gain.⁶² At times, this has meant that many farmers have been asset rich but cash poor. However, some new dynamics appear to be emerging. New Zealanders and overseas buyers are increasingly buying farmland for purposes other than farming — often at prices that would far exceed its value for farming production. Some investors are also growing their economic wealth by buying land and converting it to other farming uses (such as dairying or vineyards), possibly encouraged by recent gains in commodity prices that may not be sustainable over the long term.

To some degree, these trends are being driven by international factors. Low interest rates in many countries have driven property prices to historical peaks. This has led to renewed concern among central banks about whether asset wealth is a 'sustainable' form of net wealth. As Otmar Issing commented:

As societies accumulate wealth, asset prices will have a growing influence on economic developments. The problem of how to design monetary policy under such circumstances is probably the biggest challenge facing central banks in our times.⁶³

There also appear to be some drivers specific to New Zealand influencing the recent increases in land values. Much to the despair of Reserve Bank Governors and Finance Ministers, New Zealanders frequently seek to grow their wealth from investments in land and property. This may be due to a lack of faith in New Zealand's share market, managed funds, and our superannuation system. The absence of a capital gains tax and relatively low interest rates in recent years have also provided incentives for New Zealanders to 'bank' in property and land. All these factors are contributing to higher land values, which are placing more pressure on farmers to intensify their production.

4.4 Individual responses at the level of the farm

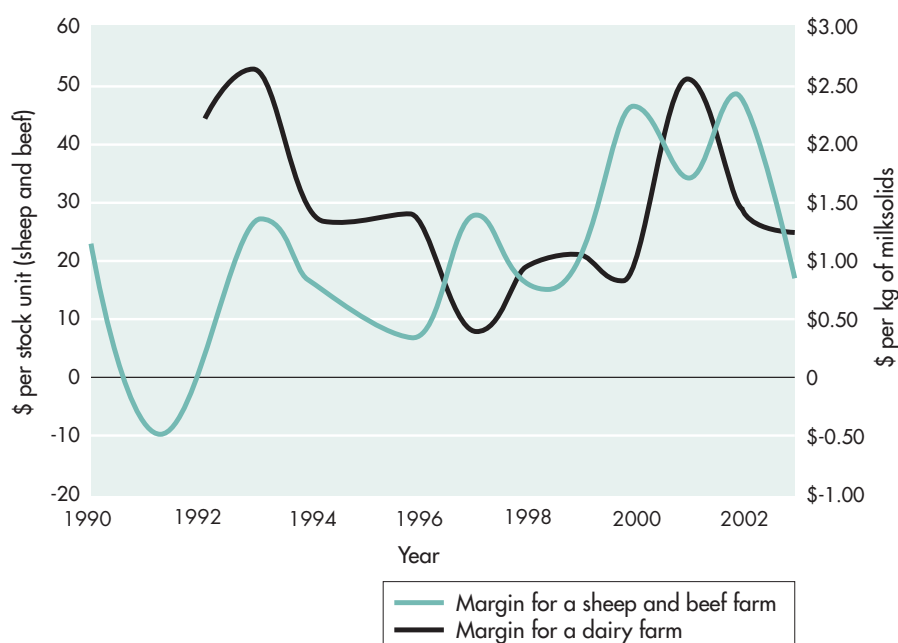
The major focus of this chapter has been on the broad systems that help to shape farming and its impacts on the environment. It is often difficult for individuals to adopt sustainable practices if wider socio-economic systems do not support this goal. Nonetheless, farmers respond to these drivers in many different ways and farmers often work together to achieve structural changes. The rest of this chapter looks at some other important influences at the level of the individual farm.

Economic priorities

Research suggests that New Zealand farmers tend to be most strongly influenced by economic factors.⁶⁴ Indeed, many of the farmers interviewed for this investigation commented that a key factor driving their decisions was the financial bottom line. Some of the participants in our research were financially comfortable, defined in such terms as their ability to fund their children's education at schools of their choice, to take good holidays and to invest in their houses and gardens. Others were still working hard to become established. Across the spectrum, the fundamental need to be financially viable was a common theme.

Profitability for farmers is variable and tends to fluctuate from season to season. This is highlighted in Figure 4.3, which illustrates the irregular profit margins for two different farmers over a decade. These margins are affected by such factors such as commodity cycles, exchange rate movements, climatic events and different stages of development on the farm.⁶⁵

Figure 4.3 Profit margins for a dairy farmer and a sheep & beef farmer 1990-2002



Although profitability tends to change from year to year, the last decade has been a period of enormous wealth generation for most New Zealand farmers. For example, the average net wealth of 12 farmers interviewed for a background report to this investigation increased from \$650,000 in 1990 to over \$3.6 million in 2003.⁶⁶ In part, increasing wealth has been generated through the increasing value of many farming commodities. Between 1998 and 2002 the value of New Zealand's farming commodities increased by 34 percent.⁶⁷ Some commodities increased their export value by more than 40 percent during this period.⁶⁸ However, significantly more wealth has been generated through the expansion of farms (i.e. buying more land) due to the dramatic rise in land values.

Agricultural reforms and other changes in the farming sector have encouraged farmers to aim for higher and higher levels of productivity. New Zealand farmers have been very successful in this regard, as the Ministry of Agriculture and Forestry noted in 2003:

Agricultural productivity has improved substantially over the last 15 years as a result of technological change, effective targeting of investment, cost cutting and efficiency gains, and scale economies through the expansion of the average size of farms and orchards.⁶⁹

At the level of the individual farm, the most productive farmers tend to set a benchmark for other farmers. Farmers with the highest levels of economic productivity provide a signal to other farmers that there could be significant opportunities to increase productivity. A background report to this investigation suggests that the difference between top farm production levels and average levels is over 150 percent for dairy farmers and 175 percent for sheep farmers at current profits.⁷⁰ The difference between 'top' and 'average' farms is usually based on managerial input (something with a high value but low cost) and relative advantages provided by natural capital, such as productive soils and a favourable climate.

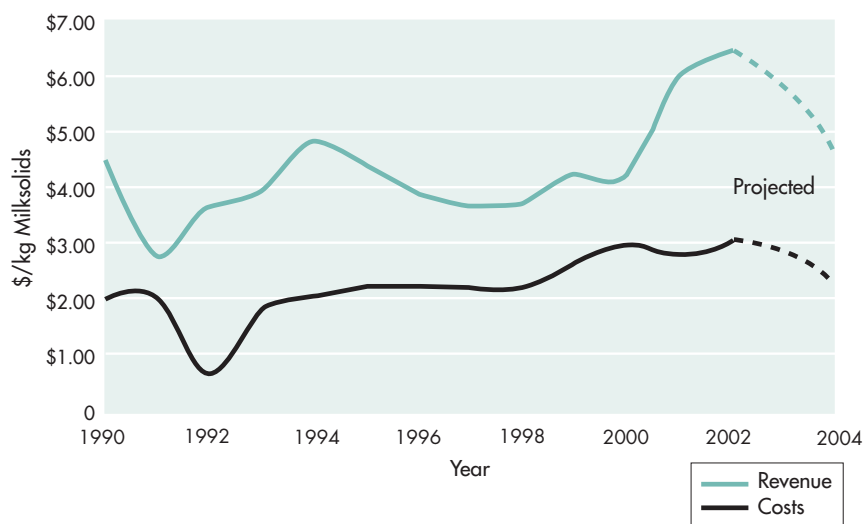
Farm development strategies

While economic concerns are very influential, individual farmers pursue different strategies for running their farms, depending on their personal mindsets and priorities. A background paper to this report discusses these strategies, which often change over time.⁷¹ Some general strategies include:

- *initial development* — increasing a farm's production capacity by improving its infrastructure and/or the quality of farm resources. Examples include drainage, land contouring, pasture renovation, irrigation, improving soil fertility, improving animal genetics, and the development of laneways or races for animals.
- *intensification* — following on from initial development, involves seeking ever higher levels of productivity.
- *asset growth* — focusing on expanding the size of the farm. In recent years, many farmers who have focused on expansion have done relatively better than those focused on intensification because of the large increases in land values.

- *profit maximisation* — optimising inputs and outputs. In New Zealand, the productivity of farmers with this type of strategy is generally between the top 25 percent and top 10 percent for their respective districts. Figure 4.4 highlights the profit margins from a case study for a farmer pursuing this approach. They are aiming to maximise profit from a grass-based system, only using grass silage from a runoff block.
- *production maximisation* — involves aiming for the top five percent of production, even though evidence suggests that this does not maximise profits. It is a high output, lower margin system. For example, a farmer in a background report case study appeared to be operating at levels of intensity beyond the level of profit maximisation (see Figure 4.5).⁷² The trend is toward a higher output, higher cost, and lower margin system with higher demands on the environment and with greater financial risk.
- *balance or 'enoughness'* — is a strategy pursued by farmers who are financially secure. Their farm supports their livelihood, but they are not strongly motivated by opportunities to increase production or profits.
- *producing within limits* — is when a farmer places a major emphasis on producing within environmental and social limits. For example, this may imply placing some limits on stocking rates and the use of certain inputs.

Figure 4.4 Maximising profits on a dairy farm



Source: Background report *Incentives for intensification* (Watters et al., 2004)

CHAPTER **5**

Risks and challenges



This chapter considers the major risks to natural capital, and farming itself, if current trends persist. The major focus is on water. It examines trends in nutrient inputs and water demand to explore the implications of these trends for fresh water quality and quantity in New Zealand.

5.1 Intensification through external inputs

There are many different ways farming systems can be designed to produce more food. It is the particular way in which more intensive farming is carried out that needs to be considered in any discussion on sustainability. Nonetheless, intensive farming systems are often characterised by an increasing use of external inputs to maintain or increase production every year. Indeed, as Chapter 3 highlighted, farming systems in New Zealand are generally becoming more intensive through the use of additional material and energy inputs. This is clearly evident in trends relating to the increased use of synthetic fertilisers, increasing demands for irrigation, and the purchase of additional stock feed (such as maize silage) in the dairy sector to boost production.

Although a variety of external inputs are being used to develop more intensive farming systems in New Zealand, this chapter focuses on two key inputs:

- nutrients
- water from irrigation.

We have examined these inputs to explore implications for fresh water quality and quantity and the sustainability of intensive farming in New Zealand (see also our focus in Section 1.3.1).

5.2 Nutrient inputs

5.2.1 Overview of nutrients and potential effects on the environment

In natural ecosystems when plants or animals die, nutrients are cycled back into the soil (see Chapter 2). However, in farming ecosystems, plant or animal biomass is removed with harvesting. Thus to supply essential nutrients for plant growth, farmers add nutrients (particularly nitrogen, phosphorus and potassium) to the soil in a number of ways.

Farmers have been using natural fertilisers to replace nutrients for centuries, relying on such things as guano (bird and bat droppings), bone, compost, human waste and seaweed. As the world's population grew in the 19th century, more nutrients were needed to meet human dietary needs, and processes for manufacturing synthetic fertilisers were developed, with profound effect on farming practices across the globe. Since then, synthetic fertilisers have been added to soils in farming systems the world over to make up for nutrient removal and to increase food production.¹

In New Zealand most soils developed beneath forests, and hence are acidic and naturally low in nutrients.² Therefore, it is common for farmers to add lime (calcium oxide) to soils to reduce acidity, and to add nutrients to aid the growth of pasture grasses and crops. The addition of lime to reduce soil acidity in farming is generally considered environmentally

benign or beneficial.³ Conversely, if nutrients are applied to pasture and crops at a rate beyond which plants are able to assimilate, they will leak to the wider environment causing harm. Damage to the environment may result from nutrients running off into surface waters, leaching into groundwater, or entering the atmosphere. The rest of this section discusses the effects of nitrogen and phosphorus on the environment, particularly in terms of non-point source pollution.

Nitrogen

...today, around the globe, more than half the atoms of nitrogen that are incorporated into green plant material come from fossil fuel energy subsidised fertilisers, rather than from natural biogeochemical processes.⁴

The input of nitrogen in farming systems is a key focus in this investigation because of:

- the increasingly important role it plays in New Zealand farming
- its mobility in the environment (*via* ground and surface waters and the atmosphere)⁵
- the potential damaging effects that it has.

Plants, animals and humans all need nitrogen for survival, and nitrogen, like other nutrients, cycles through ecosystems.⁶ Although we live in a nitrogen-rich atmosphere, most ecosystems rely on nitrogen-fixing bacteria, fungi and algae to access this atmospheric nitrogen.⁷ Nitrogen fixation is the conversion of non-reactive atmospheric nitrogen by bacteria, fungi and algae into reactive nitrogen for use by plants and animals.⁸ Most natural nitrogen fixation is carried out by symbiotic bacteria, such as the bacteria *Rhizobium*, which penetrate the root hairs of clover and other legumes.⁹ In New Zealand the main pasture species, ryegrass, needs large amounts of nitrogen, and is therefore planted alongside clover.¹⁰ Nitrogen, once utilised by animals, is excreted as waste products, primarily as urea (excreted by mammals), ammonia (by fish), or uric acid (by birds, reptiles, insects and mammals). To complete the cycle, denitrifying organisms convert reactive nitrogen to atmospheric nitrogen.¹¹

In pre-industrial times nitrogen fixation and denitrification were approximately equal, but this changed with human creation of reactive nitrogen through:

- the advent of a synthetic process for fixing nitrogen¹²
- combustion of fossil fuels (that contain nitrogen)
- the increased cultivation of nitrogen-fixing plants.¹³

These activities have greatly increased the cycling of reactive nitrogen through the atmosphere, hydrosphere, and biosphere and, in the past few decades, production of reactive nitrogen by humans has been greater than reactive nitrogen production from all natural terrestrial systems.¹⁴ As a result, reactive nitrogen is accumulating in the environment because reactive nitrogen creation rates are greater than conversion rates of

reactive nitrogen back to non-reactive atmospheric nitrogen.¹⁵

Nitrogen is easily dispersed by way of hydrologic (water) and atmospheric (air) transport processes.¹⁶ If nitrogen application in farming is not balanced by plant uptake it can create considerable problems.¹⁷ Nitrogen can enter streams (directly, as surface runoff, or indirectly, *via* contaminated groundwater) or leach through the soil into groundwater, eventually ending up in lakes, rivers and coastal waters.¹⁸ This can result in deterioration of groundwater quality and drinking water supply, with risks to human health, and the eutrophication of fresh waters and coastal waters. A recent report by the United Nations Environment Programme (UNEP) has identified the increase of oxygen-starved zones in the world's oceans and seas as an emerging issue that needs urgent attention. These oxygen-depleted zones (termed 'dead zones') are linked to nutrients, mainly nitrogen, originating from agricultural fertilisers, vehicle and factory emissions and wastes.¹⁹

Leached nitrate can carry with it alkaline elements (such as calcium, potassium and magnesium) from topsoil, lowering soil pH and resulting in acidified soils. Nitrogen in the soil can also be converted to the greenhouse and ozone-depleting gas, nitrous oxide.

Klaus Toepfer, Executive Director of the United Nations Environment Programme recently stated:

Humankind is engaged in a gigantic, global, experiment as a result of the inefficient and often over-use of fertilisers, the discharge of untreated sewage and the ever-rising emissions from vehicles and factories. The nitrogen and phosphorus from these sources are being discharged into rivers and the coastal environment or being deposited from the atmosphere, triggering these alarming and sometimes irreversible effects.²⁰



Once nitrogen is leached to the environment there is no effective way to remove it – it is simply too late, and the consequences must be dealt with. Figure 5.1 lists the effects of reactive nitrogen on human health and ecosystems.

Figure 5.1 Effects of reactive nitrogen on human health and ecosystems

Direct effects of reactive nitrogen on human health include:

- nitrite and nitrate contamination of drinking water leading certain types of cancer and to the 'blue-baby syndrome'²¹
- blooms of toxic algae, with resultant harm to humans
- respiratory and cardiac disease induced by exposure to high concentrations of nitrous oxides, ozone and fine particulate matter.

Direct effects of reactive nitrogen on ecosystems include:

- increased productivity of reactive nitrogen-limited natural ecosystems
- ozone-induced injury to crop, forest, and natural ecosystems and predisposition to attack by pathogens and insects
- acidification and eutrophication effects on forests, soil, and fresh water aquatic systems
- eutrophication and hypoxia in lakes and coastal ecosystems
- nitrogen saturation of soils
- biodiversity losses in terrestrial and aquatic ecosystems and invasions by nitrogen-loving weeds
- changes in abundance of beneficial soil organisms that alter ecosystem functions.

Indirect effects of reactive nitrogen:

- depletion of stratospheric ozone by N₂O emissions
 - global climate change induced by emissions of N₂O and formation of tropospheric ozone
-

Adapted from Galloway and Cowling, 2002.

Phosphorus

Plant growth in many farming systems is limited by the absence of phosphorus, hence its addition as fertiliser.²² Clover requires a large amount of phosphorus for growth, thus phosphorus fertiliser has traditionally been popular in New Zealand, predominantly as superphosphate.²³

Phosphorus is far less susceptible to leaching to the environment than nitrogen. This is because it is absorbed by organic matter within the upper metre of the land surface, and it dissolves slowly in water through time.²⁴ However, as phosphorus is readily mobilised by soil erosion (in particulate form), loss of phosphorus from farmed land is an issue for New Zealand. Soil loss is typically higher in extensive sheep and beef farming than in other farming sectors, due to the steeper slopes farmed and propensity for erosion. However, soil erosion is also an issue in more intensive farming sectors (see Section 5.3.3). Eroded soil enters waterways and soil-bound phosphorus slowly dissolves in water. Phosphorus also enters waterways *via* farm runoff. Increases in phosphorus levels in natural waters in

New Zealand can contribute to eutrophication. Phosphorus from farming sources also contaminates groundwater – the most common source in New Zealand is from agricultural fertiliser.²⁵

Aquatic plant growth is typically limited by the absence of phosphorus and/or nitrogen. In lakes overseas, it is predominantly the absence of phosphorus in the water that limits aquatic plant growth.²⁶ In New Zealand it is noteworthy that plant growth in Lake Taupo and lakes in the Rotorua district tends to be limited by the absence of nitrogen, rather than phosphorus.²⁷ Plant growth in rivers and coastal waters and estuaries also generally tends to be limited by the absence of nitrogen. But even where nitrogen-phosphorus ratios for waters suggest that the absence of phosphorus is the issue, addition of nitrogen usually promotes growth of plants or algae. Therefore *both* nitrogen and phosphorus addition to natural waters needs to be strictly controlled so as to avoid eutrophication with (usually undesirable) increases in plant growth.²⁸ If it were the case that phosphorus was the issue, then nitrogen 'leakage' from farming to the environment would not be so much of a concern, because it would be biologically irrelevant. The fact is that plant growth in many lakes and most rivers and estuaries is more likely to be limited by the absence of nitrogen than phosphorus.

... *both* nitrogen and phosphorus addition to natural waters needs to be strictly controlled so as to avoid eutrophication

5.2.2 Nutrient inputs to New Zealand's farming systems

There are a number of ways that nutrients are added to farming systems in New Zealand, for example *via*:

- spreading fertiliser²⁹
- planting nitrogen-fixing clover
- animal excreta, particularly urine
- spraying whey and effluent (both dairy shed and human) onto pasture.

The following sections discuss each of these points in turn.

Nutrient input from synthetic fertilisers

Nutrients are essential for life and growth. In the rural context, nutrients, in the form of fertiliser, are important because of economics and the ability they give farmers to correct soil imbalances and significantly increase productivity. However, if used incorrectly, they are polluters not only of our soils but also of our waterways.³⁰

Synthetic fertiliser use in New Zealand has generally increased through time.³¹ Of the more than 2.3 million tonnes of synthetic fertiliser used in New Zealand farming for the year ending June 2002, 52 percent of that was phosphate fertiliser, 33 percent nitrogen fertiliser, and 15 percent potassic fertiliser.³² Breaking it down on a sector basis, 46 percent of synthetic fertilisers were used in sheep and beef farming, 44 percent in dairy farming, and two percent each in deer farming and vegetable growing.³³ Table 5.1 presents the

Table 5.1 Tonnes of nitrogen fertiliser urea and phosphate fertiliser spread by selected farming sectors in New Zealand for the years ending June 1996 and 2002

Sector	Nitrogen fertiliser urea*			Phosphate fertiliser**			Hectares farmed			Livestock numbers		
	1996	2002	% change	1996	2002	% change	1996	2002	% change	1996	2002	% change
Sheep & Beef cattle	7,444	59,192	+695	616,112	778,789	+26	10,036,076	10,348,291	+3	47,393,907	39,545,609	-17*
										4,852,179	4,494,678	-7
Dairying	78,201	207,805	+166	661,413	349,749	-47	2,017,755	2,048,211	+2	4,165,098	5,161,589	+24
Deer	858	3,456	+303	30,761	27,963	-9	291,596	341,447	+17	1,192,138	1,643,938	+38
Cropping	17,156	20,235	+18	24,663	16,757	-32	219,470	123,176	-44	-	-	-
Vegetable growing	-	8,816	-	27,274	11,989	-56	59,107	52,721	-11	-	-	-
Pipfruit orchards	652	498	-24	3,147	1,025	-67	16,970	12,680	-25	-	-	-
Kiwifruit	603	900	+49	7,026	2,389	-66	11,640	12,000	+3	-	-	-
Grape growing	-	146	-	943	1,017	+8	7,627	17,400	+128	-	-	-
TOTAL##	119,688	311,400	+160	1,507,395	1,223,612	-19	14,863,897	13,769,543	-7	-	-	-

Source: Statistics New Zealand, 1996; Statistics New Zealand, 2003b

* Because of changes to the way that fertiliser statistics have been categorised between 1996 and 2002, it was not possible to compare *all* nitrogen fertilisers, thus urea figures only were used. Nor could potassic fertiliser comparisons be made.

** Since 1996 use of phosphate fertilisers in New Zealand farming has decreased by 19 percent, with 1.2 million tonnes applied in the year ending June 2002. However, use of diammonium phosphate (DAP), which contains 18 percent N and 40 percent P but is *statistically counted as a nitrogen fertiliser*, has increased dramatically over the last 20 years.

Although sheep numbers declined in this period, lamb and sheep production rose by 2 percent, due to an increase in the lambing rate and in the average weight of lambs processed.

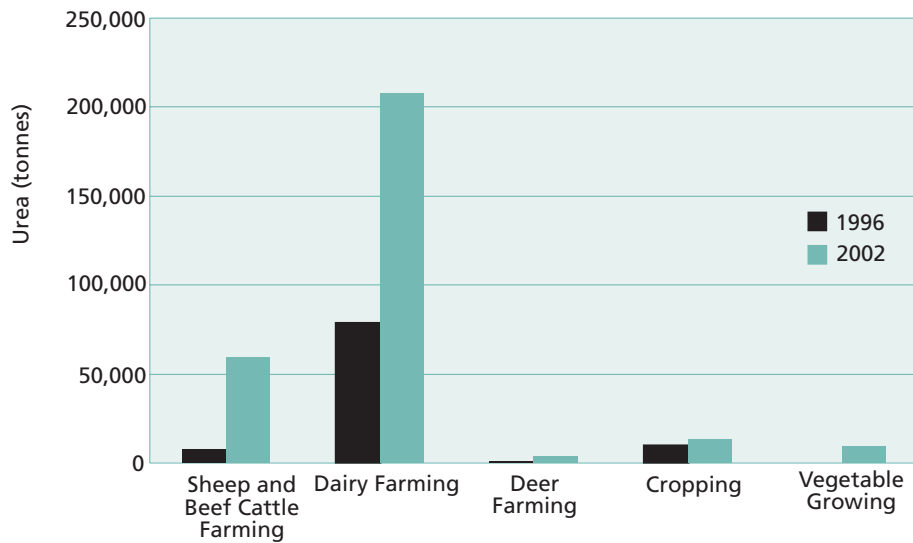
These totals include *all* farming sectors; forestry is excluded.

change in nitrogen fertiliser urea and phosphate fertiliser spread by selected farming sectors in New Zealand between 1996 and 2002. Hectares farmed and livestock numbers are taken into account as well.

Nitrogen fertiliser

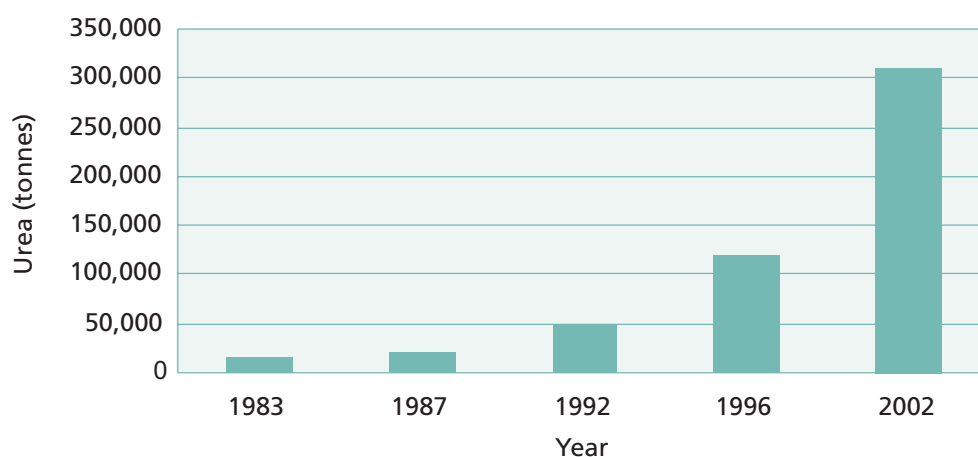
The use of nitrogen fertiliser in New Zealand has soared in recent years (Figures 5.2 and 5.3 illustrate the increase in urea application). In all, more than 770,000 tonnes of nitrogen fertiliser was applied in New Zealand in the year ending June 2002 – more than ten times that used in 1983.³⁴ The proportion of total fertiliser being applied as nitrogen in New Zealand farming is also increasing – for example in 1996, urea made up six percent of all fertiliser use, and by 2002 accounted for 13 percent of the total.³⁵ Fifty-four percent of nitrogen fertiliser applied in 2002 was used in dairy farming, 19 percent in sheep farming, eight percent in beef cattle farming, four percent in sheep-beef farming, four percent in vegetable growing and two percent in deer farming.

Figure 5.2 Tonnes of nitrogen fertiliser urea spread by selected farming sectors in New Zealand for the years ending June 1996 and 2002*



Source: Statistics New Zealand 1996; Statistics New Zealand 2003b

*Because of changes to the way that fertiliser statistics have been categorised between 1996 and 2002, it was not possible to compare all nitrogen fertilisers, thus urea figures only were used.

Figure 5.3 Tonnes of urea fertiliser applied in New Zealand 1983–2002

Source: Statistics New Zealand, 2003b; Statistics New Zealand INFOS service

Between 1983 and 2002, there was an 18-fold increase in the amount of urea fertiliser applied in New Zealand agriculture, to 311,000 tonnes (Figure 5.3). Use of diammonium phosphate (DAP) has increased more than four-fold since 1983 to almost 183,000 tonnes, and use of ammonium sulphate has doubled since 1983 to 43,000 tonnes. The sectoral change in kilograms of urea spread per hectare is illustrated in Table 5.2.

Table 5.2 Kilograms of urea fertiliser spread per hectare, by sector, for the years ending June 1996 and 2002*

Sector	1996	2002	% change
Sheep and beef	0.7	5.7	+ 670
Dairy	38.8	101.5	+ 160
Deer	2.9	10.1	+ 240
Cropping	78.2	164.3	+ 110
Vegetable growing	-	167.2	-
Pipfruit	41.2	42.6	+ 3
Kiwifruit	51.8	75.0	+ 45
Grape growing	-	8.4	-

Source: Statistics New Zealand 1996; Statistics New Zealand 2003b

*These figures have been assessed by dividing the 'kilograms of urea spread by each sector' by the 'number of hectares farmed by each sector' for 1996 and 2002. A similar methodology was used by Holland and Rahman (1999) to assess sectoral pesticide use in New Zealand on a per hectare basis for 1998. It is important to note that figures have been rounded to 1 decimal place. The '% change' column was calculated from these figures before rounding.

Why has there been such a large increase in nitrogen fertiliser application in the past decade? Reasons include:

- nitrogen fertiliser application enables an increase in farm productivity and profitability – for example, in the dairy sector the resulting provision of extra feed throughout the year allows the farmer to increase stocking rate, calve earlier, and make more high quality silage (thus extending lactation)
- the tactical use to overcome seasonal feed shortages, and ensure a steady supply of forage
- the cost of nitrogen fertiliser as a percentage of milk fat price (or farm income) has decreased³⁶
- the loss of clover in pasture due to clover root weevil.³⁷

As dairying in New Zealand has become more intensive over the last decade and stocking rates have increased, nitrogen fertiliser has been increasingly added to pasture to supplement nitrogen supplied by clover, and provide increased grass growth so as to produce more milk. Some farmers are reported as using nitrogen fertiliser to replace clover entirely, rather than to supplement it (see next section). Intensity of nitrogen fertiliser use has also increased in deer farming, cropping and kiwifruit growing.³⁸

The huge increase in nitrogen fertiliser use in sheep and beef farming, and the resultant increase in pasture growth, is attributed in part to the growing trend in lamb and beef fattening systems, an approach that is more intensive than the more traditional forms of sheep and beef farming.³⁹ Also, high lamb prices have led to a focus on lamb production, with farmers increasing lamb live weight, and thus average lamb carcass weight. There also has been a 25 percent increase in the lambing rate.⁴⁰ Although there has been a huge increase in urea use by this sector, per hectare use is still *far below* that of the dairy sector or some horticultural sectors (Table 5.2).

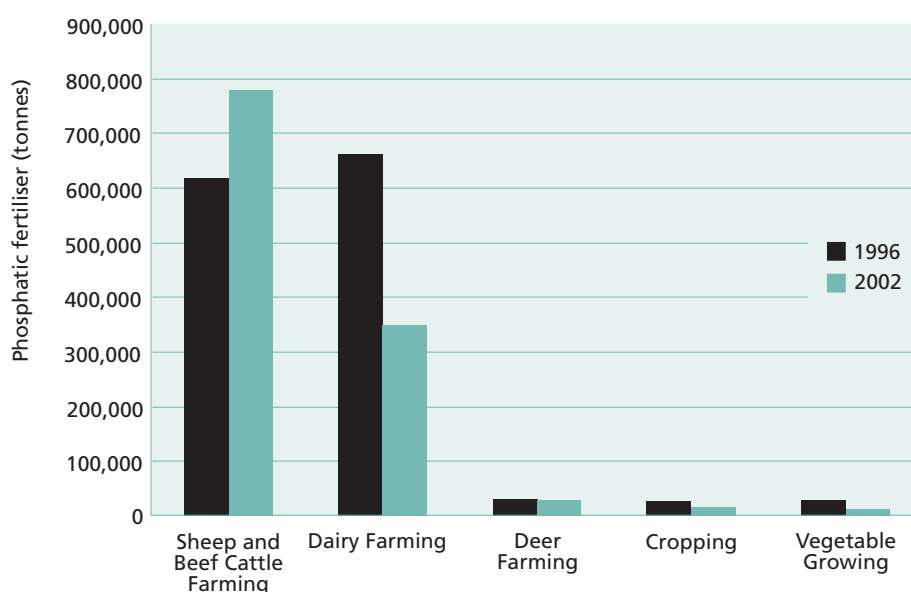
However, results of sheep grazing trials undertaken over two years in Hawke's Bay hill country, in which very high rates of nitrogen fertiliser were applied (400 kg N/ha annually, in 8 x 50 kg applications), suggest that there is potential for greatly increasing production levels.⁴¹ Consequently, there was a 25 kg/ha increase (to 31 kg/ha) in nitrogen leaching annually, or six percent of the total fertiliser N applied (compared to the 'control' paddocks which received no nitrogen fertiliser and leached 6 kg N/ha). The authors expressed caution about adopting this approach commercially without undertaking further investigation to determine whether high nitrogen input rates would affect long-term sustainability of the farming system, due to the potential on- and off-site impacts such as effects on nitrate and greenhouse gas emissions, soil and pasture condition, and nutrient cycling. This caveat is significant given the huge amount of grazed hill country in New Zealand, and the potential for cumulative negative environmental effects.

Phosphate fertiliser

Since 1996 use of phosphate fertilisers in New Zealand farming has decreased by 19 percent, with 1.2 million tonnes applied in the year ending June 2002. However, use of

diammonium phosphate (DAP), which contains 18 percent nitrogen and 40 percent phosphorus but is statistically counted as a nitrogen fertiliser, has increased dramatically over the last 20 years. Figure 5.4 provides a sectoral breakdown of phosphate fertiliser application comparing 1996 with 2002.

Figure 5.4 Tonnes of phosphate fertiliser spread by selected farming sectors in New Zealand for the years ending June 1996 and 2002.



Source: Statistics New Zealand 1996; Statistics New Zealand 2003b

Nitrogen input from clover

Annual nitrogen fixation by clover in New Zealand is estimated at 1.57 million tonnes, and valued at \$1.49 billion,⁴² but the discovery of the clover root weevil, *Sitona lepidus*, in the Waikato in 1996 threatens this productivity. The clover root weevil is now one of New Zealand's most serious pasture pests. It is rapidly spreading throughout the country, feeding on clover nodules and roots, causing root loss, disease and a reduction in nitrogen fixation.⁴³ Broadcast insecticide treatments to control the larvae in the soil are untenable for environmental and economic reasons.⁴⁴ A research programme for pest control is underway – possible control options include a small parasitic wasp and a fungus that both attack the weevil. Unfortunately, the weevil's spread across New Zealand may encourage further increases in nitrogen fertiliser application to maintain grass growth.

Nutrient input from animal excreta

With the addition of nitrogen fertiliser by the farmer comes the ability to increase stocking rates. Increased stocking rates lead to greater inputs of animal excreta into the farming system, placing greater pressure on the environment. It has been estimated that "the waste generated by the 3000 dairy herds in the Waikato River catchment is equivalent to the waste from about five million people or nearly 50 cities the size of Hamilton."⁴⁵

With the addition of nitrogen fertiliser by the farmer comes the ability to increase stocking rates. Increased stocking rates lead to greater inputs of animal excreta

Although animals graze grass-clover pastures, they do not convert the nitrogen they ingest efficiently. Thus, the largest input of nitrogen in New Zealand pasture-based farming is from animal excreta, *particularly urine*. O'Hara *et al.* note that:

On average only 10.5 percent of the nitrogen in grass, silage or other feedstuff is converted into milk, meat, eggs or wool. The remainder is excreted in dung and urine. Thus the bulk of the nitrogen added to New Zealand soils comes from the excreta of animals, which contributes to nitrogen leaching.⁴⁶

Cattle urine, in particular, has high concentrations of nitrogen, and urine patches swamp plants' nitrogen uptake capacity, which then results in nitrate leaching.⁴⁷ Although not nearly as significant as urine, animal dung is a contributing factor in nitrate leaching, and cattle dung has the greatest nitrogen content compared to other livestock.⁴⁸

The suitability of intensive dairy farming on pasture where tile and mole drains⁴⁹ have been laid underneath has been questioned in Waikato, Southland and South Otago. The drains provide a fast route to waterways for nitrogen:

...tile drains are commonly used on many poorly drained pasturelands in the Waikato watershed and can rapidly transport nitrogen to stream channels with little removal by natural attenuation processes.⁵⁰

Nutrient input from dairy shed effluent application

In recent years effluent has increasingly been spread onto pasture in New Zealand as a way to add nutrients for pasture growth *and* dispose of waste.⁵¹ Effluent was sprayed onto almost 170,000 hectares of pasture in New Zealand in the year ending 2002,⁵² and almost 80 percent of dairy farms in the Waikato apply effluent to land.⁵³ In some parts of New Zealand, whey, a by-product of milk powder processing, is also sprayed onto dairy pasture as fertiliser.

It is estimated that the dairy shed effluent from 100 cows is worth \$1,200 to \$1,500 in fertiliser value a year.⁵⁴ Applying agricultural effluent to land, rather than discharging it directly into water, can help reduce the impacts of farming on water quality, as well as retaining nutrients on the farm. However, there are concerns over the safety of spraying raw effluent onto pasture without any pre-treatment of the effluent. Risks associated with this practice include nutrients entering groundwater and surface water in bad weather. Also, care must be taken that the effluent is applied over sufficient area and at a rate that does not allow runoff or seepage into water systems.⁵⁵ Soil, slope and climatic combinations in several areas of New Zealand do not favour land disposal. Even where land disposal *is* favoured by environmental conditions, it is much safer to spray irrigate pond-treated effluent than raw wastewater from the milking shed wash-down with its high microbial contaminant content and high biochemical oxygen demand (BOD) (see Section 5.3.2).⁵⁶

5.2.3 Nitrogen contamination of New Zealand's environment

There is evidence that nitrogen from farming sources enters and contaminates New Zealand's surface waters, groundwater, soils, and atmosphere. Unfortunately, there is little nationally consistent data available on *levels* of nitrogen contamination in New Zealand. Section 5.3 looks at nitrate contamination of rivers, lakes and groundwater in detail. The rest of this section looks at nitrogen contamination of New Zealand's soil and the atmosphere.

Nitrogen saturation of soils

Scientists at Landcare Research have identified nitrogen saturation of soils as an emerging issue.⁵⁷ There are limits to any soil's capacity to store nitrogen and once reached, nitrate leaching is expected to increase markedly if nitrogen continues to be applied at the same rate. Research indicates that the nitrogen storage capacity of agricultural soils in New Zealand is declining with time. The rate of this decline is dependent on a number of factors, including soil type, soil carbon to nitrogen ratio, current soil nitrogen levels, the nitrogen storage rate of the soil, and land use (particularly fertiliser and effluent application, urine input, and nitrogen fixation). Further work will focus on defining some of these factors to more accurately assess the extent of the issue, but it is expected to have implications for long-term nitrogen budgeting for different land uses.⁵⁸ Land managers need some indication of how long soils can continue to store nitrogen so that fertiliser is not wasted and risks to groundwater are minimised.⁵⁹

Nitrogen pollution of the atmosphere

Greenhouse gas emissions contribute to global warming and climate change, and the farming sector contributes more than half of New Zealand's greenhouse gas emissions – nitrous oxide and methane in particular. The farming sector is responsible for more than 90 percent of New Zealand's nitrous oxide (N₂O) emissions. The global warming potential of nitrous oxide is 310 times that of carbon dioxide (based on a hundred-year horizon).⁶⁰ Nitrous oxide is emitted from soil when soil bacteria convert nitrogen from animal urine and fertiliser. Nitrate lost *via* leaching or surface runoff can also be converted to nitrous oxide in water bodies. Nitrous oxide is also converted from volatilised ammonia (originating from animal excreta and fertiliser) that has been deposited back to land.⁶¹

5.3 Risks for fresh water quality and aquatic habitats

Intensive farming poses risks to fresh water quality and aquatic ecosystems. It must be noted that the following risks arise from farming in general, but the more intensive a farming system is in terms of external inputs, such as fertiliser and irrigation (and any consequent increases in stocking rates), the higher are the risks.⁶² This is because the key water quality concerns stemming from farming relate to the three major non-point (or 'diffuse') pollutants:

- nutrient contamination from livestock wastes and fertiliser application
- microbial contamination from livestock faeces

- sediment impacts (reduced water clarity and sedimentation).⁶³

These three pollutants and their effect on water quality in New Zealand are examined in more detail later in this section, after a more general discussion on water quality.

New Zealand's waters are a limited, fragile resource coming under increasing pressure from farming activities

New Zealand's waters are a limited, fragile resource coming under increasing pressure from farming activities, both in terms of the effects on water quality *and* the increasing demand for water (see Section 5.4). Although pollution of rivers from point sources, such as factory outfalls, has declined over the last 20 to 30 years, pollution from non-point sources is a major and increasing problem. Farming has been identified as the main source of pressure on water quality in New Zealand. Research indicates that rivers in lowland areas with intensive farming are in particularly poor condition, and that groundwater quality is also compromised. As the Ministry for the Environment notes:

Agricultural runoff...is difficult to measure and control. Unlike point source discharges (those discharging through a single point, such as a stormwater or effluent pipe), non-point source discharges (pollution from wide areas such as runoff from pastures or hillsides) are relatively complex systems to measure and control. Most agricultural sources of contamination are from non-point discharges.⁶⁴

As noted in Chapter 3, water quality in areas of intensive pastoral farming is poor relative to standards in the RMA⁶⁵ and supporting guidelines prepared by MfE and ANZECC, a fact known for many years.⁶⁶ Water quality is particularly poor in lowland stream and river catchments dominated by pasture. Many lowland rivers are unsuitable for swimming due to faecal contamination from farm animals, poor water clarity, and nuisance algal growths caused by excessive nutrients (eutrophication). Nutrient enrichment of lakes from farming activities is a growing concern, and is not only affecting shallow lakes but deeper lakes too, such as those in the Rotorua area. The lag time taken for nutrients to enter these lakes suggests that the problem will get worse before it gets better, even if measures are put in place to reduce nutrient inputs. Furthermore, groundwater quality in aquifers that lie under pastoral farming, in particular under dairying, tend to have elevated nitrate concentrations.⁶⁷ The Ministry for the Environment notes that:

... the problem will get worse before it gets better, even if measures are put in place to reduce nutrient inputs.

Urban and agricultural runoff is lowering the water quality and degrading aquatic ecosystems in New Zealand. A significant source of contamination in our streams, rivers, lakes, wetlands and coastal waters is runoff from agricultural land. This is a major impediment to achieving the sustainable management of water resources.⁶⁸

A 2002 review of the environmental effects of farming on New Zealand's fresh waters noted that the proportion, intensity, and types of farming within a catchment are all factors that affect stream health.⁶⁹ Arable and horticultural activities can have severe impacts on local water quality (with regard to sediment loss and nitrate leaching to groundwater), but pastoral grazing has the greatest impact on water quality in New

Zealand because of the scale of the sector and the volume of water affected.⁷⁰ It is acknowledged that streams in areas of sheep, beef and intensive dairy farming are in poor condition, and are faecally-contaminated to the extent it may be unsafe for livestock to drink. A decade ago, Smith *et al.* noted that:

Intensive dairying areas are typified by rivers in poor condition. The most common problems are excessive nutrient concentrations and faecal contamination. The extreme case is the Waikato region while areas within Taranaki, Southland and Northland are additional examples. Lowland rivers in these areas are naturally more productive than those in sparsely developed regions. Agricultural development has accentuated pre-existing differences in water quality.⁷¹

Recent work on national and regional river water quality trends carried out by NIWA on behalf of the Ministry for the Environment confirms these earlier findings on the poor state of lowland rivers.⁷² This work notes:

Water quality in low-elevation source-of-flow [river] classes in Canterbury, Southland and Waikato regions generally failed to meet recommended guidelines; median *E. coli* concentrations in all low elevation classes in each region exceeded the guideline value, and median DRP, NO_x and NH₄ concentrations⁷³ exceeded the guidelines in all low-elevation [river] classes but one.⁷⁴

Another recent report prepared for MfE by NIWA on the effects of rural land use on water quality stated quite simply:

Unless mitigation measures are simultaneously put in place to prevent (so far as possible) entry of pollutants to waters, intensification of land use will further degrade water quality.⁷⁵

In a recent assessment of the state of water quality in low elevation rivers across New Zealand, median concentrations of *E. coli* and dissolved nitrogen and phosphorus exceeded guidelines recommended for the protection of aquatic ecosystems and human health.⁷⁶ These parameters were two to seven times higher in pastoral and urban classes than in native and plantation forest classes, and water clarity was 40 to 70 percent lower.⁷⁷ The study highlighted the lack of a *nationwide* assessment of the links between low-elevation land cover and water quality in lowland rivers in New Zealand, despite land use pressures on these rivers. It noted that:

Such an assessment would entail examining... whether water quality is improving or getting worse over time, and whether such trends are occurring in catchments dominated by particular land uses.⁷⁸

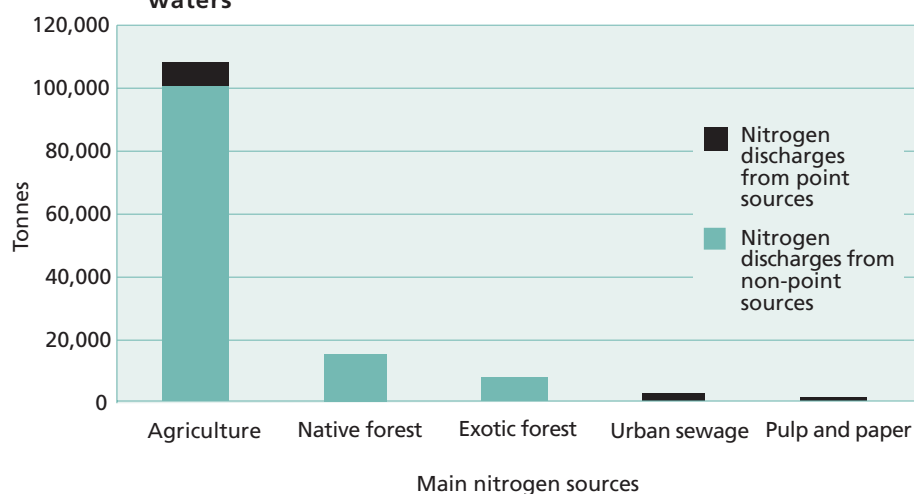
5.3.1 Nutrient contamination of water

Low-level inputs of nutrients from farmed land may have a beneficial impact on natural aquatic communities by increasing primary and secondary production.⁷⁹ However, higher levels of nutrient input into waterways and groundwater cause ecosystem stress to develop. There may also be risks to human health, particularly where groundwater aquifers used as sources of drinking water become contaminated with nitrates. This section focuses on nitrate-nitrogen contamination of ground and surface water in New Zealand.

Nitrate contamination of rivers and streams

It is estimated that 75 percent of the total nitrogen input to surface waters in New Zealand is from agricultural non-point source pollution (Figure 5.5).⁸⁰ More than 90 percent of streams in intensively farmed catchments in the Waikato region have moderate to high levels of nitrogen.⁸¹ There is a strong relationship between the number of cows stocked per hectare and nitrogen loss from dairy land (Figure 5.6).

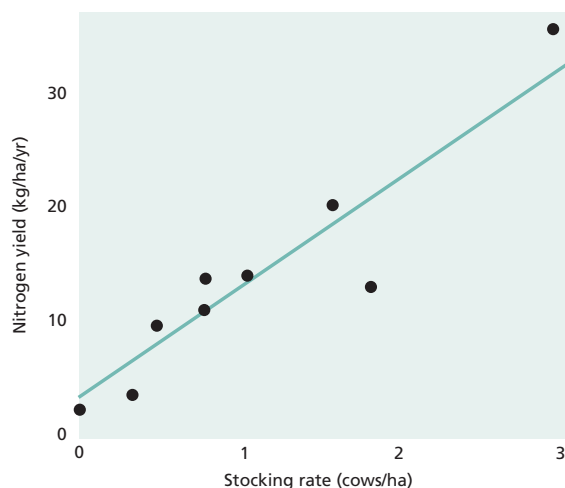
Figure 5.5 Estimated yearly nitrogen loadings to New Zealand surface waters



Source: Cooper, 1992 in MfE, 1997a

In a study of the trends in river water quality in the Waikato region between 1987 and 2002, data from 110 sites were analysed.⁸² Ten of these sites were situated along the Waikato River (19 water quality variables were investigated); the other 100 sites were situated along other regional rivers and streams (14 water quality variables were investigated). Along the Waikato River there were improvements in some aspects of water quality – ammonia, BOD, arsenic, and boron levels declined significantly at nine or more of the ten sites. These improvements are attributed to decreases in *point source* pollution along the river. Total nitrogen and nitrate-nitrogen declined at four of the 10 sites, representing an improvement in water quality. In three of the four cases this decline occurred at sites along the upper river, and thus may be the result of land use changes.

Figure 5.6 Relationship between dairy cow stocking rate and nitrogen loss



Source: Environment Waikato, 2003a

Results for the other rivers and streams revealed patterns across the region as a whole between 1990 and 2002. The majority of the trends indicate a decline in water quality (increased total nitrogen, total phosphorus and conductivity, decreased dissolved oxygen and pH). Some trends indicate an improvement (increased visual clarity, decreased turbidity and ammonia levels). Environment Waikato suggests that the significant decline in ammonia levels at 20 of the sites may be the result of the move to land disposal of dairy shed effluent, and that the significant increase in total nitrogen at 46 of the sites may be the result of increased stock numbers and farming intensity over the past decade or more. The magnitudes of the trends in total nitrogen, ammonia, total phosphorus, dissolved reactive phosphorus and visual clarity were significantly correlated with the proportion of the catchment area that was in pasture.

Nitrate contamination of lakes

... more than 700 lakes [in New Zealand] are shallow and between 10 percent and 40 percent of these are nutrient enriched (eutrophic). Most of the eutrophic lakes are in the North Island and in pasture dominated catchments. A number are subject to fish kills or are no longer capable of supporting fish life...development of their catchments, primarily for agriculture, is almost certainly responsible, due to the substantially increased nutrient loads that result.⁸³

New Zealand's larger, deeper lakes are also at risk of becoming eutrophic – the amount of nitrogen entering Lake Taupo from rural and urban sources has increased considerably over the past 50 years. As discussed in Section 5.2.1, Lake Taupo is extremely sensitive to nitrogen – the addition of nitrogen (rather than phosphorus⁸⁴) results in aquatic plant growth – and monitoring trends indicate that water quality is gradually worsening.⁸⁵ Add to this the fact that groundwater transporting much of the nitrogen from the land to the

lake is stored underground for several decades before entering the lake, and it appears that things will get worse before they get better.⁸⁶ Chapter 6 includes discussion of the *2020 Taupo-Nui-a-Tia Action Plan*, which aims to reduce the manageable sources of nitrogen flowing into Lake Taupo by 20 percent over the next 15 years. Environment Waikato states that:

Scientists agree that the lake is under threat from increasing nitrogen leaching from land uses in the catchment. To just maintain the lake's current water quality, we need to reduce the amount of nitrogen coming from farmland and urban areas by 20 percent.⁸⁷

Also of national significance, the Rotorua Lakes are experiencing similar issues with declining water quality, but the situation there is even more critical. Nutrients from farming practices and septic tanks are entering the lakes, reducing dissolved oxygen levels, and in some lakes triggering toxic blue-green algal blooms. The lakes have been in decline for 30 to 40 years and suffer the same time delay issues as Lake Taupo between land use and its effects on water quality.⁸⁸ A strategy for protection and restoration of the Rotorua Lakes has been developed by Environment Bay of Plenty, Rotorua District Council and Te Arawa Maori Trust Board. It sets out 14 goals with regards to protection, use, enjoyment and management of the lakes,⁸⁹ and in June 2004, the Government committed \$7.2 million toward improving Lake Rotoiti's water quality.⁹⁰ Water quality is declining in many other New Zealand lakes because of increased nutrient levels from farming practices – Lake Omapere, Lake Brunner and Waikato's peat lakes to name just a few. Chapter 6 discusses the importance of taking a catchment-scale approach in attempting to work through these kinds of complex issues.

Nitrate contamination of groundwater

Nitrogen in the form of nitrate from rural land use is a principal contaminant of New Zealand's groundwater.⁹¹ Around 50 percent of New Zealand's population depends totally or partially on groundwater as a source for drinking water.⁹² For example, Christchurch City sources its drinking water, which is untreated, from underground aquifers.

Over 30 years ago, Baber and Wilson reported that some groundwater supplies in the Waikato were badly polluted by nitrate originating from the 'highly productive clover/grass' farming system of the region.⁹³ Many shallow aquifers beneath dairying or horticultural land have elevated nitrate levels. Shallow groundwater (down to 60m) commonly shows an accumulation of nitrate concentrations especially in areas where stock densities are high and groundwater is vulnerable to contamination from surface drainage.⁹⁴

Around 50 percent of New Zealand's population depends totally or partially on groundwater as a source for drinking water.

Irrigation can exacerbate the situation:

The addition of water to farm systems can have greater adverse effects on water quality than the taking of water for irrigation. This is because additional water input such as irrigation of grazed dairy pasture accentuates nitrate leaching by increasing annual hydrological recharge. Careful assessment of the need for and potential impacts of irrigation can therefore help reduce adverse effects on water quality.⁹⁵

As rivers recharge groundwater, so groundwater discharges to rivers providing their baseflow (i.e., the flow between rainfall events).⁹⁶ Nitrates, being very mobile, move between surface and groundwaters.

Nitrate levels in Canterbury groundwater

In 2002, Environment Canterbury (ECan) carried out a review of nitrate concentrations in Canterbury groundwater, using existing data in ECan's water quality database.⁹⁷ Concerns over the suitability of Canterbury plains groundwater as a continued source of drinking water were expressed in the 1980s, because of a predicted increase in nitrate concentrations due to new irrigation schemes and more intensive land use.⁹⁸ More than 14,000 samples were taken from 2,350 wells. The range of nitrate-nitrogen concentrations found in samples was below detection levels (0.05 to 0.1 mg/L) up to 89 mg/L⁹⁹:

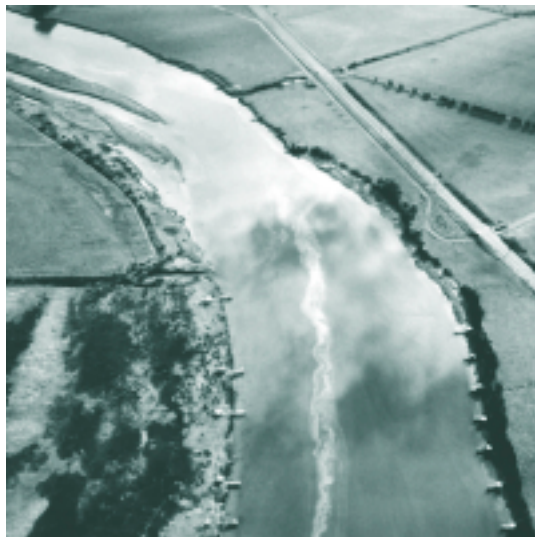
- 942 or 6.7 percent had nitrate-nitrogen concentrations higher than the maximum accepted value (MAV) of 11.3 mg/L¹⁰⁰
- More than a third of samples had nitrate-nitrogen concentrations higher than 5.65 mg/L (half the MAV)¹⁰¹
- More than a quarter of samples had nitrate-nitrogen concentrations less than 1 mg/L.¹⁰²

In an analysis of long-term trends, 17 percent of wells included in the test (43 out of 255 wells) had increasing nitrate concentrations through time.¹⁰³ These wells were distributed across the Canterbury Plains, but mostly on the lower, seaward, half of the plain. Land use in these areas includes intensive farming activities, e.g. effluent spreading, dairy farming and horticulture.¹⁰⁴

A subsequent study of nitrate contamination of Canterbury groundwater was published by ECan in 2004, testing groundwater in the vicinity of a well in the Chertsey-Dorie area, south of the Rakaia River, which has shown increasing levels of nitrate-nitrogen since testing began at the well in 1991.¹⁰⁵ An increase in irrigation in the area over the last 25 years has allowed more intensive cropping and pastoral farming. Dairying in the area has increased markedly in the last five years, and there are at least 20 consented discharges of effluent to land.

Overall, the nitrate contamination extended over several square kilometres, generally increasing toward the coast, reaching levels of between 15 and 20 mg/L.¹⁰⁶ ECan concludes that “there are no large point-source discharges that are likely to generate such widespread contamination in the area”, and that the “contamination is likely to be the result of a range of agricultural activities in the area” such as fertiliser use, cultivation and pastoral farming, and may be exacerbated by increased irrigation.¹⁰⁷ The council also stated “if current land uses are more intensive with greater potential to leach nitrates, concentrations in groundwater can be expected to increase further.”¹⁰⁸

The report states that groundwater in the Ashburton-Rakaia area, widely used for private drinking water supplies, is now no longer suitable for human consumption in some parts without treatment.¹⁰⁹



Nitrate levels in Waikato groundwater

Environment Waikato monitors nitrate levels in regional groundwater, sampling 112 wells less than 30 m deep.¹¹⁰ Results show that:

- nitrate concentrations commonly exceed drinking water guidelines
- high nitrate concentrations are related to intensive land use, particularly market gardening (e.g. Pukekohe area) and livestock farming (e.g. Hamilton area)
- nitrate concentrations are increasing in many areas.

Across the region, 17 percent of groundwater samples had excessive nitrate levels (i.e. exceeding the 11.3 mg/L National Drinking Water Guideline), 15 percent had elevated levels (5.65-11.3 mg/L, requiring increased monitoring) and 68 percent had low¹¹¹ levels (less than 5.65 mg/L). In the sub-region of Hamilton-Mangaonua, 49 percent of groundwater samples had excessive nitrate levels, 21 percent had elevated levels and 30 percent had low levels. The data was also broken down by land use (see Table). Environment Waikato also found low nitrate-nitrogen concentrations:

The low category may still include some land uses that may affect sensitive environments. For example, in the Lake Taupo catchment even slightly raised nitrate concentrations will affect water quality.¹¹²

Groundwater nitrate levels in the Waikato region, 2002

Land use	% Low	% Elevated	% Excessive
Market gardening	46.2	30.8	23.1
Dairying	68.5	22.2	9.3
Drystock farming	76.2	14.3	9.5
Orcharding	100	0	0
Domestic and other use	90	10	0

Source: Environment Waikato, 2004d

The council lacks long-term records to indicate nitrate trends across the region, but data collected since the 1950s from some school water supplies show a steady increase in nitrate at these sites.¹¹³

5.3.2 Faecal contamination of water

In a 1993 report on the influence of farming on fresh water quality, faecal contamination was identified as the most prevalent problem,¹¹⁴ and current research indicates that it is widespread.¹¹⁵ Faecal contamination of waters poses a public health risk. Illnesses may be contracted as a direct result of ingesting bacterial, viral, and protozoal pathogens in

faecally contaminated waters. Faecal contamination of waterways can stem from a number of sources such as:

- direct deposition of faecal matter in streams by livestock
- faecal matter from livestock entering waterways *via* surface and sub-surface flows
- wild animals and waterfowl
- point-source discharge of wastewater from sewage treatment and meat processing plants
- discharge of effluent to land contaminating soil and soil water, which could flow to surface waters.¹¹⁶

A wide range of pathogens may be present in waters contaminated by livestock faeces, and one of particular concern in New Zealand is the bacterium *Campylobacter*. *Campylobacter* is the most commonly notified disease in New Zealand, accounting for nearly 50 percent of notifications in 2001.¹¹⁷ New Zealand has the highest reported incidence of campylobacteriosis in the developed world (at about 400 cases per 100,000 people per year), with the annual economic cost of the disease estimated to be \$61.7 million (1999 \$NZ).¹¹⁸ The risk of infection exists in fresh waters used for recreational purposes and for human consumption. Shellfish in downstream estuaries can also become contaminated.¹¹⁹ Faecal contaminants are also a potential health risk to livestock, and their consumption of contaminated waters may result in reduced growth, morbidity or mortality.

In recent years, the contamination of New Zealand's fresh waters by a range of indicator and pathogenic micro-organisms has been studied under the Freshwater Microbiological Research Programme carried out by the Ministry of Health, the Ministry of Agriculture and Forestry, and the Ministry for the Environment.¹²⁰ This programme confirms that microbial contamination of lakes and rivers is widespread. A high proportion of samples in this survey contained *Campylobacter* (60 percent) and viruses (59 percent). The results of this and earlier studies indicate that concentrations of the faecal indicator *E. coli* often exceed 1000 colony forming units (cfu) per 100 ml,¹²¹ which far exceeds the *E. coli* guideline for fresh water recreation (median of 126 cfu/100ml).

The results of the research programme formed the basis of a risk assessment, the main outcomes of which were that:

- of the pathogens assessed in the study, *Campylobacter* and human adenoviruses are most likely to cause human waterborne illness to recreational fresh water users
- using data from all sites, an estimated four percent of notified campylobacteriosis in New Zealand could be attributable to water contact recreation
- *Campylobacter* is moderately correlated with *E. coli*, and the critical value for *E. coli* as an indicator of increased *Campylobacter* infection is in the range of 200-500 *E. coli* per 100ml
- infection risks of other pathogens examined have not been able to be related to *E. coli* concentrations in fresh waters.¹²²

Faecal contamination in the Ashburton district

The Institute of Environmental Science and Research Ltd (ESR) recently carried out a three-year pilot investigation for the Ministry of Health on the transmission routes of human campylobacteriosis.¹²³ The study was undertaken in the Ashburton area, within the South Canterbury Health District where the incidence of campylobacteriosis is higher than average. The study's aim was to advance the understanding of potential reservoirs and transmission routes, from the environment to humans, in order to help prioritise the development of risk management strategies. The main conclusion drawn was that "for the population sampled, bovine animal contact, direct or indirect, was the highest risk factor identified."¹²⁴

The study results indicate that cattle may be an important reservoir and source of infection in New Zealand. ESR note some limitations to the study, such as a small sample size and rural location, and recommend caution in applying the results throughout New Zealand. Urban dwellers are far less likely to be exposed to farm animals, untreated water and unpasteurised milk – identified sources of infection in the study – and thus urban sources of *Campylobacter* will likely differ. However, it does highlight the risks to people of water contamination caused by increasing cattle numbers.

Faecal contamination in Waikato

Research based on data from 73 stream sites across the Waikato region found that median *E. coli* concentrations ranged from 1 to 1300 cfu/100ml and 53 of the 73 sites sampled exceeded the guideline for fresh water recreation (median of 126 cfu/100ml).¹²⁵

*The pattern of [E. coli] contamination across the Waikato is dominated by the presence of grazing livestock and the highest median E. coli concentrations are associated with the most intensive dairy farming in the centre of the region. Conversely, the lowest median values are found in forested catchments, although E. coli concentrations are always measurable, indicating contamination by wild animals.*¹²⁶

This research also established a relatively strong relationship between the median *E. coli* concentration and the percentage of poorly drained soil in the catchment:

*This is probably attributable to the generation of a relatively large volume of surface runoff on these soils that is able to entrain faecal material and quickly transport it to the stream network. It is also probable that the installation of sub-surface drains and drainage ditches in poorly drained soils accelerates the transport of faecal microbes to streams. The bacterial water quality of streams draining such soils is likely to be particularly sensitive to livestock grazing and the application of effluent to land.*¹²⁷

Water quality and public health

On August 7, 2003, it was confirmed that the water supply for Masterton, the Wairarapa town of 19,000, was infected by the parasitic micro-organism *Cryptosporidium*. *Cryptosporidium* causes gastroenteritis and is transmitted by ingestion of oocysts excreted in human or animal faeces. It is potentially lethal, particularly to people with weakened immune systems. In this instance there were only two reported cases of cryptosporidiosis. The town's residents had to boil their drinking water until October, when the water supply was declared safe to drink. It could have been a lot more serious – a *Cryptosporidium* outbreak in the U.S. city of Milwaukee's drinking water in 1993 claimed 53 lives and caused 403,000 cases of intestinal illness.

5.3.3 Sediment contamination of water

Soil erosion is an issue across much of agricultural New Zealand, from extensive hill country grazing to more intensive types of farming such as horticulture.¹²⁸ This is due to the physical nature of New Zealand's terrain and the maritime climate, and is accelerated by land clearance and unsuitable land management practices.¹²⁹ In May 1996 a severe storm hit Pukekohe, south of Auckland – one of New Zealand's chief horticultural areas. Rain washed away valuable top soil from cultivated land, damaging property and infrastructure. Manukau Harbour and streams flowing into it were also damaged.¹³⁰ In February 2004, storms lashed the Manawatu region with widespread soil loss – some 63,000 irrecoverable landslips affected 20,000 hectares of land. The effects of this storm were reminiscent of Cyclone Bola, which severely affected the East Coast of the North Island in 1988. There is concern at the move toward more intensive cattle grazing systems on rolling and hill land in the North Island, and the implications for soil and pasture damage from treading, including increased sediment loss.¹³¹

The effects of soil erosion from farmland in New Zealand are twofold – a precious resource is lost from the farm and the downstream effect of eroded sediment entering waterways is enormous.

The effects of soil erosion from farmland in New Zealand are twofold – a precious resource is lost from the farm and the downstream effect of eroded sediment entering waterways is enormous. Thus, sediment 'pollution' and sedimentation are *major* water quality issues in New Zealand. Sediment yields from farmland in New Zealand vary strongly with geological factors, but studies of sedimentation rates in 'sediment traps' such as estuaries and lakes suggest that yields are typically about ten times greater than from the pre-existing native forest.¹³² Sediment from farming activities can enter waterways and harm aquatic ecosystems by reducing light penetration and visual clarity (suspended sediment), and by sedimentation.¹³³

Reduced light penetration and visual clarity

Suspended sediment in waterways affects the optical quality of water, reducing light penetration and visual clarity, thus causing harm to aquatic ecosystems. Water becomes cloudy due to light being scattered by the particles (a phenomenon called turbidity). Environmental effects of suspended sediment include:

- reduced vision for aquatic animals especially visual predators e.g. fish and semi-aquatic birds

- reduced plant photosynthesis and growth
- reduced visual and recreational amenity
- reduced safety for contact recreation.¹³⁴

There are also non-optical effects associated with high levels of suspended sediment including plant abrasion and damage to the respiratory structures of animals, e.g. fish gills.¹³⁵

Sedimentation

Sedimentation in waterways destroys in-stream habitats by smothering animals, plants and streambeds, and affecting animal lifecycles and food supply. Downstream lakes and estuaries can also be affected. Environmental effects of sedimentation include:

- *degradation of substrates for bottom-dwelling organisms*
- *reduced food quality for bottom-dwelling organisms (in streams)*
- *clogging of fish spawning gravels*
- *smothering of estuarine animals*
- *shoaling of estuaries*
- *infilling of lakes and reservoirs*
- *siltation of water supply intakes.*¹³⁶

Recovery from the impacts of sediment can take years, or be essentially irreversible as in the case of estuary shoaling or lake infilling. Sedimentation can also affect domestic water supply.¹³⁷

5.3.4 Aquatic habitats

In addition to impacting on water quality, farming in New Zealand also has a potentially detrimental effect on aquatic habitat and stream ecology. The more intensive the farming system in terms of external inputs the greater the effect. For example, increasing fertiliser application and introducing irrigation enables a higher stocking rate, which results in the discharge of more contaminants to waterways.

Farming-related activities that increase the risk to New Zealand's aquatic ecosystems, such as rivers and lakes, include:

- the widespread clearance of riparian vegetation
- the entry of livestock into stream channels
- the drainage of swamps and seepage zones
- the installation of mole and tile drains in poorly draining soils
- the clearance of watercourses to promote rapid transmission of floodwaters and the channelisation of rivers for the same purpose

... increasing fertiliser application and introducing irrigation enables a higher stocking rate, which results in the discharge of more contaminants to waterways.

- contaminant discharge (faecal matter, nutrients, pesticides) entering surface and groundwaters.¹³⁸

These activities have a number of consequences for aquatic habitats and their biotic communities:

- increased water temperature, increased algal growth, and the possible elimination of cool-water organisms, due to reduced shade
- reduction in inputs of organic matter such as leaves (used for food and habitat)
- reduced native biodiversity – pollution intolerant species may disappear
- nuisance algal growth and downstream eutrophication due to increased nutrients
- increased sediment load and turbidity from trampling and grazing of stream banks, resulting in stream bed siltation, reduced food quality, and reduced visual clarity (see Section 5.3.3)
- reduction in stream length and habitat diversity, and increase in stream gradient, caused by stream channel deepening and straightening
- increased flow yield, variability and surface runoff.¹³⁹

5.4 Water allocation risks

5.4.1 Overview of water use and allocation

Water is becoming an increasingly critical component of New Zealand's rural economy. The move to more intensive farming systems is usually accompanied by a demand for increased quantity and certainty in water supply. Projections indicate that the dairy, horticulture and viticulture sectors will all expand in the future, and it follows there will be growing demands for water *via* irrigation.¹⁴⁰

Water consumption in New Zealand is estimated to be nearly 2,000 million cubic metres per year. More than half of our consumption is for irrigation purposes as shown in Table 5.3.¹⁴¹

Table 5.3 Estimated annual water consumption in New Zealand¹⁴²

Sector	Water use (million cubic metres)
Households	210
Industry	260
Livestock	350
Irrigation	1,100
TOTAL	1,920

Source: Statistics New Zealand, 2002

Counsell notes in *Achieving efficiency in water allocation* that:

...as New Zealanders, we often take our water resources for granted. New Zealand is relatively well endowed with rainfall and water resources. Despite this, increasing demands on water from competing in-stream and abstractive users, and an uneven distribution of both rainfall and water resources, combine to make the efficient allocation of water an increasingly critical issue.¹⁴³

Opinions vary as to whether water is scarce in New Zealand. A key problem is inadequate information to make an informed assessment. However, "where there has been a strategic look at increased demand for irrigation water, results indicate that many surface water resources have reached their limit for reliable run-of-river irrigation."¹⁴⁴ Some rivers are clearly over-allocated.

The use of water for irrigation, mainly for pasture purposes, is the main pressure on water availability throughout New Zealand and, in particular, on some South Island rivers and aquifers.¹⁴⁵ The most recent quantitative analysis of water allocation, based on council consent database information found that:

- *70.5 percent of all water allocated in New Zealand is allocated from surface water, 29.5 percent is allocated from groundwater.*
- *77 percent of water allocated is for irrigation, 16 percent is for community, municipal and domestic uses, and 7 percent is for industrial takes.*
- *58 percent of water allocated in New Zealand is allocated from the Canterbury region. The North Island accounts for 17 percent of water allocated.*
- *19 percent of the current weekly allocation has been allocated since 1990. The majority of water in New Zealand was therefore initially allocated under legislation predating the RMA.*
- *There is approximately 500,000 hectares of irrigated land in New Zealand, 350,000 hectares of which is in Canterbury.*
- *41 percent of the irrigated land area is irrigated from groundwater.*
- *The area of irrigated land is increasing at around 55 percent each decade.*
- *The 'at farm gate' value of irrigation water is estimated to be around \$800 million.*¹⁴⁶

The study also found that groundwater allocation, although only representing 29.5 percent of water allocated, was increasing at a faster rate than surface water allocation. Half the water allocated since 1990 has been allocated from groundwater.¹⁴⁷

As the information for the study came from council consent databases it may not present an entirely accurate picture of actual water usage. The study notes that when actual water use was compared to allocated amounts on a weekly basis, the total take from a water

resource was seldom more than 40 percent of allocated volume.¹⁴⁸ Thus actual water usage may be less than the consented allocations. However, because water meters are not mandatory in many places, there is no certainty that water takes are not exceeding the amount allocated. In the absence of water meters there is no accurate way to measure how much water is in fact being taken.

Water allocation has become a significant issue because water is a finite resource and the demand for water for a variety of uses continues to increase. The farming sector requires water both for stock drinking water and for irrigation. Water is vital to many community functions such as power generation, health, industrial processes, recreation, and protection of natural heritage and fisheries, cultural values and mahinga kai. Water is essential for sustaining aquatic ecosystems and biodiversity.

Water allocation and consequent abstraction has the potential for significant environmental impacts. Both surface water, such as rivers and lakes, and groundwater sustain ecosystems. Any removal of water from those water bodies will have an impact on those ecosystems. Generally, the greater the abstraction the greater the likelihood of adverse environmental impact. The environmental effects of water allocation are twofold – the effects of the reduction of water in the water bodies *and* the effects the use of that water may have on water quality.

Abstraction of water from surface water or groundwater, will have an impact on the ecosystems reliant on that water, for example, by reducing the flow of a river, or increasing the temperature of the water. Thus a reduced flow may mean that the river is no longer a suitable habitat or breeding ground for a type of fish.

Water that is abstracted is often used for irrigation. Irrigation enables farmers to grow more pasture, which in turn enables them to have higher stocking rates. To assist with the pasture growth, fertilisers are applied. Thus water used for irrigation enables intensification and diversification of land use. As discussed previously in this chapter, intensification has impacts on water quality, through increased fertiliser use and higher stocking rates. Thus water abstracted for irrigation can lead to impacts on water quality and soil quality through allowing intensification of land use. It also in turn impacts on ecosystems reliant on the water.

A significant issue related to water allocation is the quality and extent of knowledge about groundwater and surface water resources held by councils. The quality of the information can have impacts on the quality of decisions made by councils in setting rules in plans and in granting resource consents. For example if long term records have not been kept in relation to the flow of a river, it can be very difficult to set a minimum flow for that river, or grant water takes that are sustainable.

A study by Lincoln Environmental on water allocation found that the greater pressure being placed on water resources by the increasing demand for water concerned environmental sector groups.¹⁴⁹ The major concerns arose from:

- consent based planning which does not provide a catchment overview and consequently makes it difficult to manage cumulative effects

A significant issue related to water allocation is the quality and extent of knowledge about groundwater and surface water resources held by councils.

- the inadequacy of information on relevant values associated with a resource, on which to base in-stream flows
- a number of technical issues associated with setting minimum flows.¹⁵⁰

The same study found that abstractive users were concerned:

- that their uses were inadequately considered by councils in setting minimum flows
- about the impact of water allocation processes on the reliability of their water supply
- about the complex and legalistic nature of the planning process and the lack of consistency in the application and interpretation of the RMA between regions.¹⁵¹

Water allocation issues are currently the focus of a number of policy development initiatives led by central government such as the Water Programme of Action covered in Chapter 4 and the Resource Management (Waitaki Catchment) Amendment Bill.¹⁵²

The Waitaki River and Project Aqua

The issues surrounding water allocation were brought into sharp focus in the debate surrounding Meridian Energy Limited's Project Aqua and the Waitaki River. In the upper part of the Waitaki River, Meridian currently operates eight hydro electricity stations. Project Aqua proposed to divert approximately two thirds of the mean flow of the Waitaki River, at Kurow, down a 60 kilometre long canal. Six power stations were to be built along the canal to allow production of about 524 MW of electricity.¹⁵³

A large number of applications for consent to take water for irrigation were made before and after Meridian's applications for Project Aqua. Environment Canterbury did not have a plan for water allocation from the Waitaki River. The Minister for the Environment used her call-in powers under the Resource Management Act and called all the applications in. The Government then introduced special legislation, the Resource Management (Waitaki Catchment) Amendment Bill. The Bill proposed to appoint a Board to create a water allocation plan for the Waitaki River. The individual applications for resource consent would then be assessed against this plan. The Bill recognised the current difficulties with the RMA in terms of water allocation, for example: first-in-first-served granting of consents and the lack of ability to compare consents on the basis of merit; what happens to resource consents where there is no operative plan for water allocation; and whether the national interest should be taken into account when considering applications for resource consent.

The debate around water allocation in the Waitaki River highlighted the fact that there is insufficient water to allocate to all those who would seek to use it. In this case the competing abstractive uses were irrigation and hydroelectricity. While most of the debate was focused around whether Project Aqua should proceed, there were some who raised the issues of sustainability and the effect the abstractions, both hydro and irrigation, would have on river flows, ecosystems, and also on water quality.

Meridian Energy announced in March 2004 they would not proceed with Project Aqua, however, it has not withdrawn its applications for consent and the many irrigation applications remain outstanding. The amended form of the Resource Management (Waitaki Catchment) Amendment Bill was passed in September.

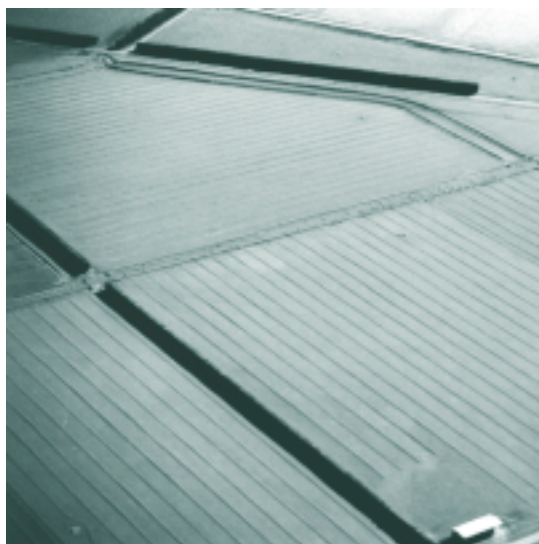
An important issue related to water allocation is the use of water meters. In some regions, water metering is not mandatory. As a result, the following questions can be raised: do farmers know how much water they are applying in the absence of water meters, can councils then accurately determine compliance with resource consents, and are the water resources in fact under more demand pressure than we think? We need more information about actual water use – easily obtained *via* water metering. Without this information, water allocation will continue to be *ad hoc*.

We need more information about actual water use – easily obtained *via* water metering.

5.4.2 Irrigation

Irrigation changes the nature of farming. It can be used in virtually all forms of farming, although the irrigation system used and management of its use depends on a number of factors, the most important being crop type and climate. Irrigation enhances the reliability of any farming system and improves profitability. It also makes possible types of farming in areas previously difficult or impossible to carry out under normal climatic conditions. Irrigation has thus allowed diversification of farming and is a key component of intensification in drier regions. As Doak *et al.* note:

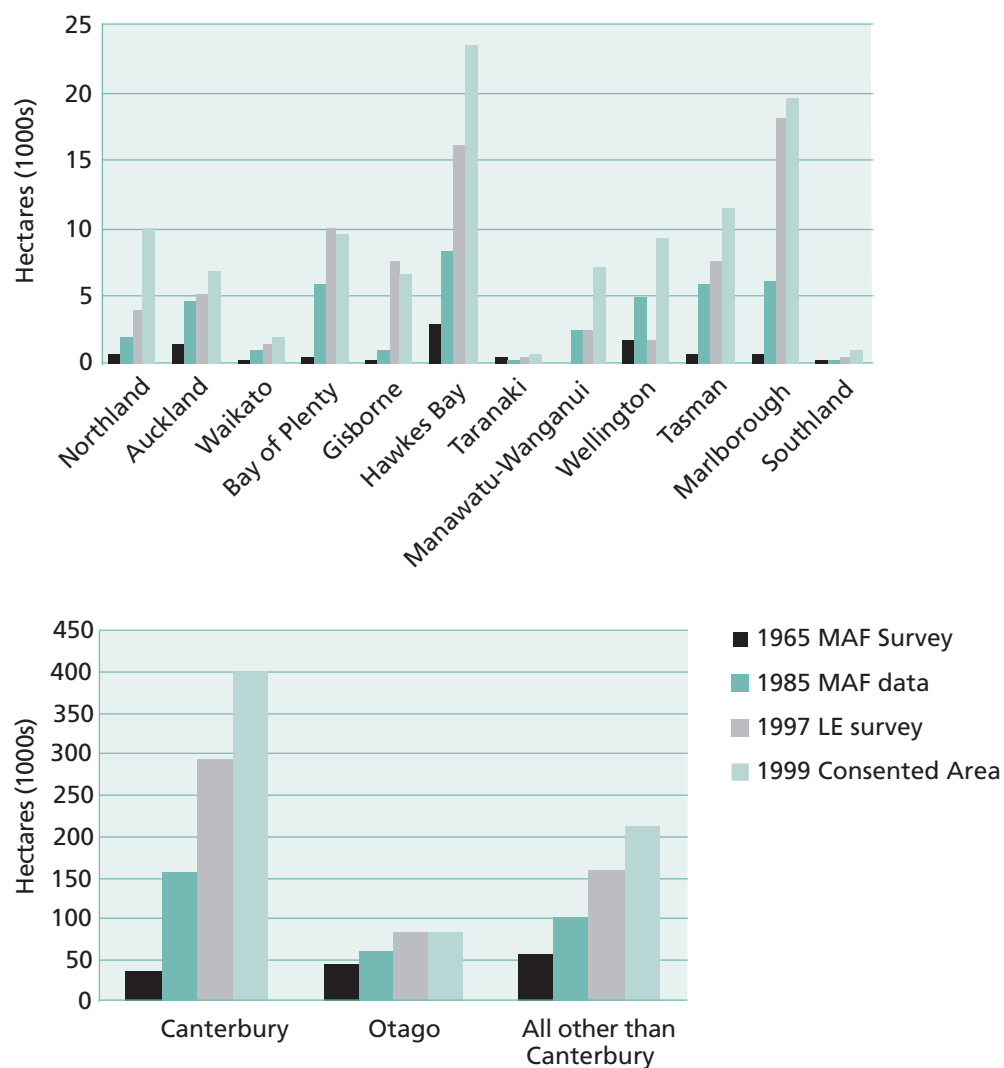
*The role of irrigation has also changed from drought proofing or insurance to being the means by which farmers and therefore the economy can diversify, and meet market expectations for quality and quantity of produce because of the increased control irrigation provides over a major production variable.*¹⁵⁴



Irrigation is used extensively in the drier regions of New Zealand such as Canterbury and Hawke's Bay for horticulture, dairying and arable production. It is estimated that 509,797 hectares of land in New Zealand are irrigated.¹⁵⁵ Thirty-one percent of this is dairy pasture, 34 percent other pasture, 22 percent arable, 11 percent horticulture and 1 percent viticulture.¹⁵⁶ Eighty-one percent of irrigated land is in Canterbury and Otago.¹⁵⁷

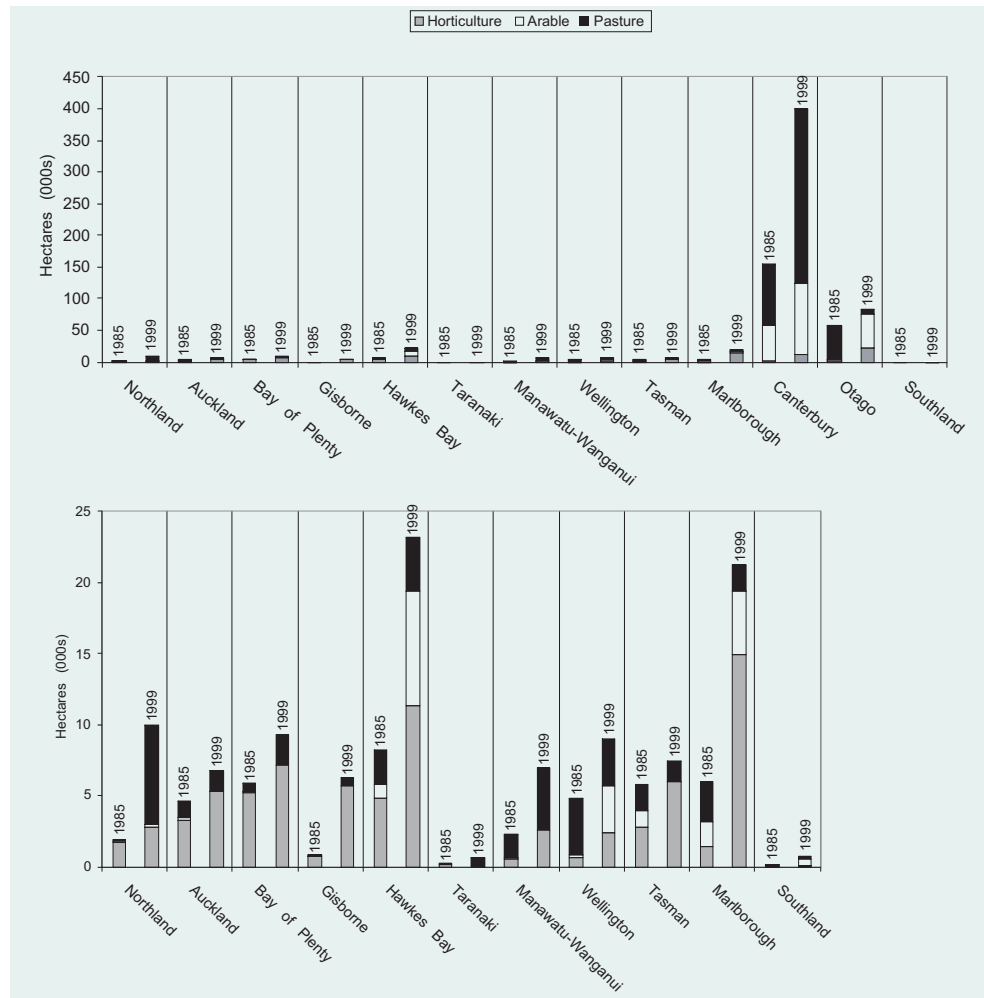
Figure 5.7 shows the regional trends in irrigated area in New Zealand over the last 40 years. Figure 5.8 notes the sectoral trends in irrigated area by region between 1985 and 1999.

Figure 5.7 Regional trends in irrigated area in New Zealand



Source: Lincoln Environmental, 2000c

Figure 5.8 Sectoral trends in irrigated area by region (1985-1999)*



Source: Lincoln Environmental, 2000c

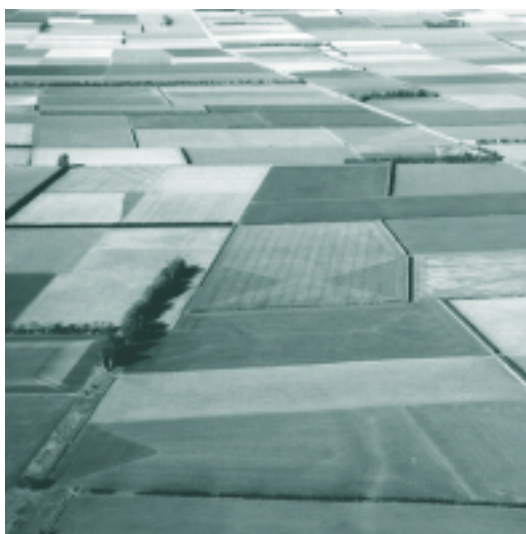
*The second graph portrays the same data as the first, but at a different scale (0-25,000 hectares compared to 0-450,000 hectares)

One recent study has estimated that irrigation demand is projected to increase 28 percent in the period to 2010, on current levels.¹⁵⁸ This would bring the total irrigated area to an estimated 650,000 ha. The same study did, however, note:

*The projected growth in demand for water resources will increase the competition between agricultural, amenity, industrial and recreation uses raising calls for further environmental preservation. Rising concerns over water quality and the impact of various intensive land uses will undoubtedly act as a counter to the increased agricultural demand.*¹⁵⁹

Land use and social change

Research indicates that eventually irrigation leads to significant land use and social change in rural areas through changes in farm type and ownership. The Waitaki area experienced a 16 percent population gain as a result of the development of the community irrigation scheme.¹⁶⁰ Irrigated farming is much more demanding and highly technical than dry land farming. It requires extra work and the development of new farming systems to maximise its usefulness. Recent research based on



community case studies has developed a descriptive model of the successive waves of interlinked changes in land use and farm ownership under irrigation.¹⁶¹

Benefits of using irrigation

There are a number of factors which encourage the use of irrigation, including:

- improving reliability of existing production systems, i.e. controlling the risks associated with climate particularly in dry areas
- providing for diversification or intensification
- increasing profitability
- producing a more constant income flow from one season to the next
- wanting greater control of production inputs and therefore outputs
- improving viability of the farming business so other members of the family can become involved.¹⁶²

Irrigation generally provides substantial economic benefits for farmers, which also flow through other parts of the farming sector and related economic sectors. The higher returns to individual farmers from irrigated production are undoubtedly a key driver behind decisions to move to irrigated farming. A recent study by MAF suggests that the net contribution of irrigation to GDP at the farm gate in the 2002/2003 year was \$920 million.¹⁶³ This amounts to 11 percent of the total contribution of primary production to GDP in that year. Table 5.4 identifies estimates of the contribution of irrigation in different regions, and from different types of farming.

Table 5.4 Farm gate GDP value of currently irrigated land uses by region (2002/03)

Region	Irrigated area (hectares)	Dairy benefit (\$m)	Pasture benefit (\$m)	Arable benefit (\$m)	Hort benefit (\$m)	Viticulture benefit (\$m)	Undefined land use benefit (\$m)	Total (\$m)	\$/ha irrigated (\$m)
Northland	7,000	1.7	0.0	0.0	21.0	0.0	6.0	\$28.7	\$4,106
Auckland	7,900	-8.8	0.0	0.0	63.1	0.1	0.0	\$54.4	\$6,883
Waikato	14,500	-3.0	0.0	0.0	58.5	0.2	0.0	\$55.7	\$3,840
Bay of Plenty	11,400	0.0	0.0	0.0	39.3	0.0	0.0	\$39.2	\$3,441
Gisborne	5,600	0.0	-1.5	0.0	27.8	-1.0	0.0	\$25.3	\$4,525
Hawke's Bay	18,100	1.6	0.0	-0.9	83.2	8.3	7.0	\$99.2	\$5,479
Taranaki	2,900	2.6	0.0	0.0	2.3	0.0	1.1	\$6.0	\$2,072
Manawatu-Wanganui	8,000	1.2	-0.6	0.0	12.8	0.0	7.6	\$21.0	\$2,622
Wellington	9,600	6.2	0.0	-0.2	7.3	1.9	6.5	\$21.8	\$2,268
Tasman	10,000	0.9	0.3	-0.8	32.2	2.3	11.7	\$46.6	\$4,656
Marlborough	20,200	3.8	0.0	2.9	10.2	54.0	15.0	\$85.9	\$4,250
Canterbury	287,200	241.9	-21.9	23.2	91.1	0.5	0.0	\$334.7	\$1,166
Otago	68,900	26.8	29.8	0.6	23.5	1.4	5.4	\$87.4	\$1,269
Southland	4,100	-0.1	0.0	-0.1	8.7	0.0	4.5	\$13.0	\$3,173
TOTAL	475,400	\$274.6	\$6.0	\$24.8	\$481.0	\$67.6	\$64.8	\$918.9	\$1,933

Source: Doak et al., 2004: 55

However, it is important to note that the MAF report has a narrow focus and does not consider any costs to the environment associated with irrigation use in its assessment of the economic value of irrigation. As the forward to the report notes:

...the contribution of water to the national interest has many forms. The socio-economic value of irrigation is only one of them. There are also important conservation, environmental, recreational and cultural values of water. The use of water for irrigation can impact on all these values in various ways, some positive and some negative.¹⁶⁴

5.4.3 Irrigation and the environment

While irrigation provides many benefits to farmers, its use also has the potential to create adverse environmental effects. These adverse effects are summarised in Section 5.4.1. Irrigation does not have to create adverse environmental effects – it is *how* and *where* the technology is used that matters. The fundamental question is whether the land use requiring irrigation is environmentally sustainable. A land use dependent upon irrigation in a naturally water limited area may not be sustainable. For example, is dairying in Canterbury, a region with low natural rainfall, light permeable soils, and dependent upon irrigation, sustainable?

Irrigation sits within the context of the hydrological resource for a whole catchment or even wider in some cases (see Figure 5.9). Thus the potential for a range of complex impacts on other parts of the environment, activities and the hydrological resource always exists.

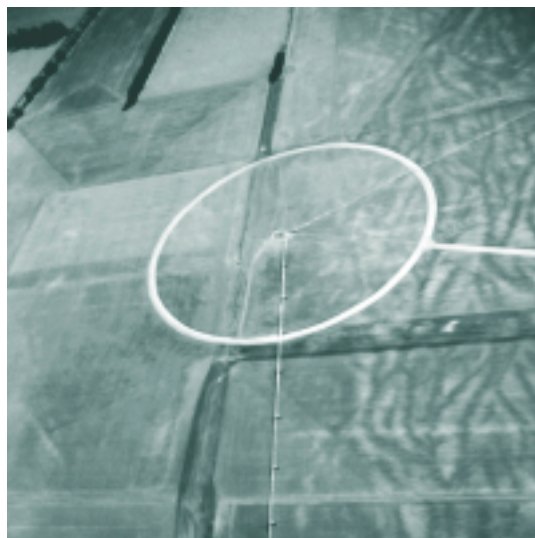
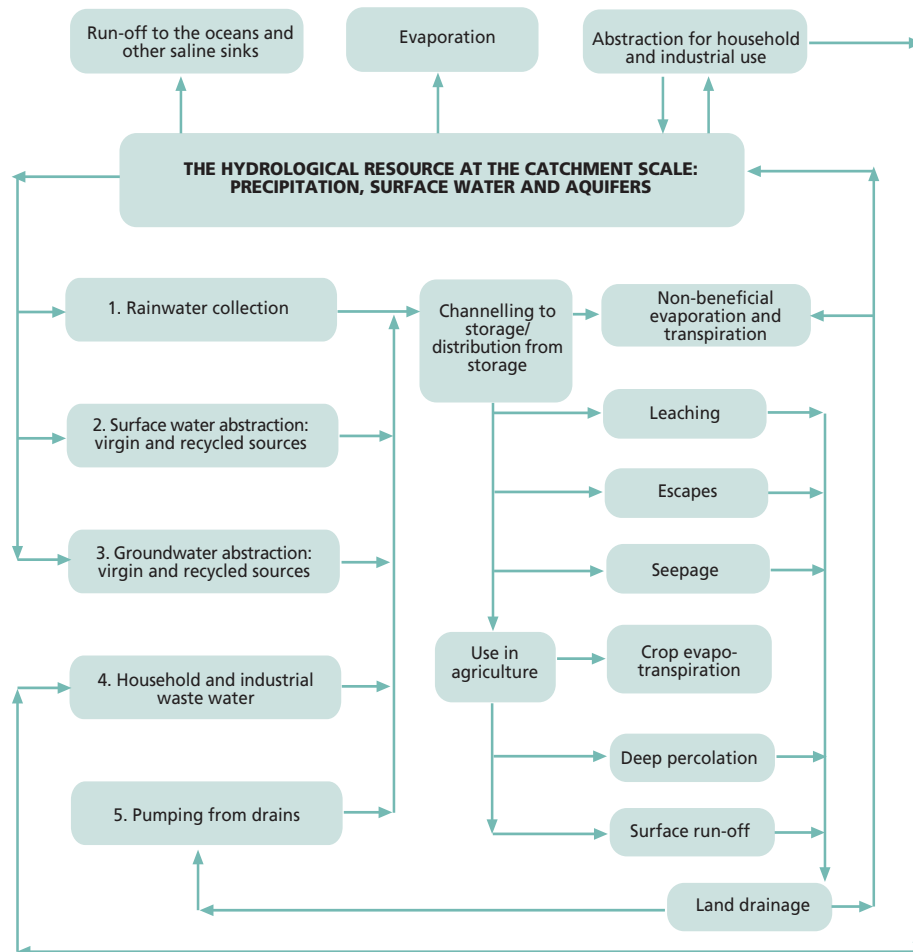


Figure 5.9 The irrigation cycle



Source: Merrett, 2002

Common potential impacts on the environment from irrigation include changes to river flow rates and lowering of groundwater levels as a result of water extraction. Surface water such as rivers and lakes, and *also* groundwater, sustain complex ecosystems.¹⁶⁵ The removal of water from these systems has adverse impacts on those ecosystems, in some cases modifying the ecosystem significantly. Irrigation can also act as a conduit for contaminants (sediment, agricultural chemicals, effluent discharges and fertiliser discharges) from land to surface water and groundwater. It may also change the content of dissolved salts in soils. As irrigation enables higher stocking rates per hectare it can also indirectly lead to impacts on soil, such as soil compaction and soil erosion.

So just how sustainable is irrigation over the long-term? Given appropriate management, it may well be sustainable both environmentally and economically. However, experience overseas suggests that water takes in excess of recharge rates, along with leaching of contaminants, may mean it is neither environmentally nor economically sustainable and in the end will not be socially sustainable either. The example of the Ogallala Aquifer in the US Midwest should serve as a warning.

The Ogallala Aquifer

...it's like a lot of people sticking straws into a big common pot of water and sucking up as much as they want.¹⁶⁶

The Ogallala Aquifer (also known as the High Plains aquifer) covers 174,000 square miles and underlies parts of Texas, New Mexico, Oklahoma, Kansas, Colorado, Wyoming and Nebraska.¹⁶⁷ The amount of water stored in the aquifer in each state varies. One fifth of all US cropland is irrigated by 90 percent of water from the Ogallala. This amounts to thirty percent of all groundwater used for irrigation in the US. Irrigation is used for crops such as cotton, corn, alfalfa, soybeans and wheat. Some of these crops are used for cattle feed for cattle farms in the Midwest. The Midwest supplies 40 percent of feedlot beef produced in the US.

The use of the Ogallala began in 1900, but increased in the late 1940s with the development of efficient deep-well pumps and low cost energy to run them. At the same time there was an improvement in associated irrigation technology.

Irrigation on the High Plains was not merely a response to climate, but its replacement. While in the beginning the farmer tapped groundwater only as a last resort when the rains failed, and often applied water when it was too late, by the 1960s irrigation was integrated into the farming routine as the single most important activity to guarantee big yields. Most consumer of the High Plains groundwater treat it as a 'free good' available to the first-taker at no cost for the water itself.¹⁶⁸

It has been conservatively estimated that water has been extracted from the aquifer over the last 30 years at 10 times the rate of natural recharge. As a result there has been a decline in the water level within the aquifer. As the water table drops, more energy is required to pump the water to the surface, thus reducing the profitability of irrigated crop production. The continued decline of the aquifer is threatening the future of irrigated farming in the area and thus impacts on the economy in the area. A study conducted in 1978-80 into the economic life of the aquifer under the Oklahoma Panhandle predicted a conversion to dry land farming as a result of the decline of the aquifer. It concluded that "the eventual economic exhaustion of the aquifer appears inevitable unless dramatic and unforeseeable output price increases or institutional or technological changes occur."¹⁶⁹

There is, however, disagreement as to the level of decline in the aquifer and whether it can be mitigated. Research and policy development are ongoing.¹⁷⁰

A Faustian bargain with the water is now coming due; it created a prosperous irrigation economy based on levels declining ten times faster than any recharge. But we have no historical experience from which to predict the future of high-production industrial agriculture or the small-time farmer on the High Plains without the continuous massive infusions of groundwater. Nor have pragmatic alternatives been devised, much less tested. Pumping the Ogallala remains a one-time experiment.¹⁷¹

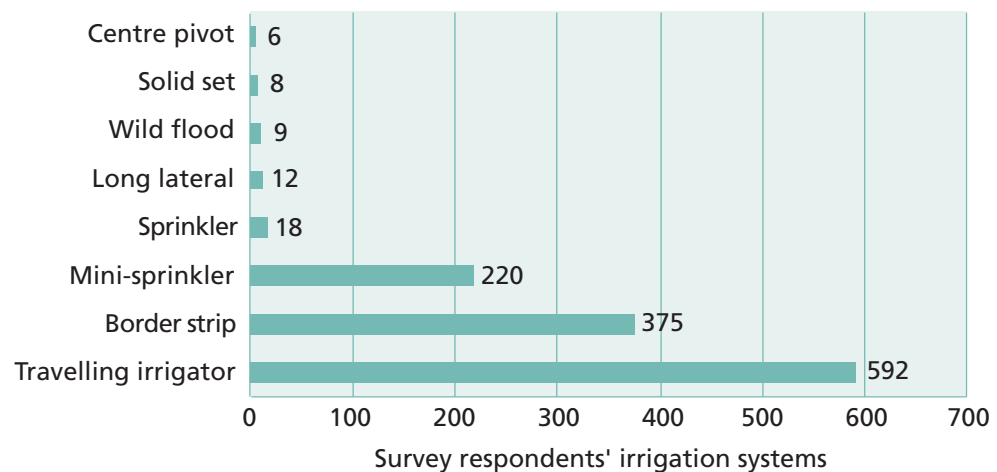
5.4.4 Managing irrigation

Irrigation management is complex and involves assessment of a number of variables, including the irrigation system used, distribution uniformity, uniformity of site, soil type, crop type, climate (including rain and evapotranspiration rate), and soil moisture content. Determining when irrigation should be applied should involve consideration of all these variables. However, this rarely occurs in practice.

Irrigation systems

A variety of different irrigation systems are used in New Zealand. A Lincoln Environmental survey found eight types (Figure 5.10).¹⁷² Travelling irrigators are the most common, followed by border strip and mini-sprinkler.¹⁷³

Figure 5.10 Types of irrigation application systems



Source: Lincoln Environmental, 2000a: 7

Farmer experiences

A survey of farmers' approaches to and perceptions about irrigation management carried out by Lincoln Environmental on behalf of MAF found that:

- *a significant majority of farmers perceive they have few problems with deciding when to irrigate, how much water to apply, and which crops to irrigate.*
- *most farmers appear to recognise the need to base operational irrigation management decisions on soil moisture and crop conditions.*
- *while most farmers claim to monitor soil moisture or evapotranspiration, only a small proportion base their decisions on measured data (probably less than 10 percent).*
- *few farmers know how much water they are using.*
- *the most frequently stated irrigation problem was an insufficient water supply. This is due to either insufficient on-farm capacity or water supply restrictions when river flows or groundwater levels are too low.*

- *the most frequently stated concern was continued access to water for irrigation, under the RMA and in the face of urban needs and opinions.*
- *the most frequently stated constraint on overcoming irrigation problems was cost, or insufficient profitability.*
- *the issue uppermost in the minds of most farmers who irrigate is the effectiveness of irrigation, not the efficiency. This is driven by the desire to maximise production and achieve financial viability.¹⁷⁴*

In the same survey it was found that farmers did not consider leaching and runoff of nutrients (particularly nitrogen) to be a significant problem (apart from dairy farms).¹⁷⁵ However farmers did express some concern about the effect of irrigation on soils including, salinity in limited areas and soil structure under big guns (a form of travelling irrigator).¹⁷⁶

The survey concluded that "sustainability of irrigation is not high on farmers list [sic] of priority issues, except where access to water resources is limited."¹⁷⁷

Irrigation efficiency

Irrigation efficiency has multiple definitions.¹⁷⁸ As noted below:

True measures of irrigation efficiency take account of the spatial uniformity of application depth, the average application depth, and the soil's capacity to store more water at the time of irrigation. Irrigation efficiency varies with each water application throughout the season, and with site, soil type and application system.¹⁷⁹

There are many ways to measure the efficiency of irrigation, for example, application efficiency (how much of the applied water is retained in the root zone after irrigation); farm distribution system efficiency (how much of the water supplied to the farm reaches the irrigator); energy use efficiency; and hydraulic efficiency.¹⁸⁰

A study by Lincoln Environmental into designing effective and efficient irrigation systems found that:

Overall there is a paucity of information relevant to the design of effective and efficient irrigation systems in New Zealand. The lack of accepted performance criteria, particularly related to the efficiency of water use, puts New Zealand agriculture in a weak position with respect to renewing, or obtaining, permits to take water under the Resource Management Act. It also represents a major oversight in the development of information about water resource management in New Zealand, considering that agriculture is the largest consumptive user of water in New Zealand, by a substantial margin.¹⁸¹

One key aspect of irrigation management is knowing when to irrigate and how much water to apply. This requires an assessment of soil moisture content directly or assessing the evapotranspiration rate and calculating how much water has been lost from the soil.¹⁸²

A Lincoln Environmental survey of farmers' approaches to irrigation management found that:

*The survey results leave the impression that a large majority of farmers know that soil moisture and evapotranspiration data is the basis of good irrigation management but that for most the monitoring is qualitative. It is likely that respondents included visual inspection in 'measurement' and 'monitoring'. The conclusion is that between 10 percent and 12 percent of respondents regularly measure soil moisture.*¹⁸³

If farmers are not monitoring soil moisture and evapotranspiration data, it is likely that they are not using irrigation efficiently.

If farmers are not monitoring soil moisture and evapotranspiration data, it is likely that they are not using irrigation efficiently, i.e. they are applying either too much or too little water. As water is a finite resource and is coming under increasing pressure from irrigation, irrigation efficiency is vital to ensure sustainable use of our water resources.

While the picture painted by the Lincoln Environmental survey is grim, there appear to be some changes amongst some farmers to use irrigation more efficiently. In some cases this is probably driven by regional councils that require applicants to show they are using the water efficiently and employing models such as Soil-Plant-Atmosphere System Model (SPASMO) in order to gain consent (see Chapter 6). There is also a growing use of professional irrigation consultants who provide advice on irrigation systems and scheduling. This is particularly true in viticulture, where water use is closely tied to wine quality. But it is unclear how widespread is the use of consultants in other farming sectors.

5.5 Other major risks and challenges

Although the focus of this chapter is on the risks and challenges of current nutrient and water demand trends, there are many other risks for natural capital and farming that need to be addressed. This section briefly identifies some further looming issues for the sustainability of farming in New Zealand.

5.5.1 Agricultural policy reforms overseas

As noted in Section 4.2, changes in international trade rules and regulations will continue to drive the direction of farming in New Zealand. Trade negotiations and agricultural reforms are currently taking place, so it is difficult to predict the precise impacts of these changes. Nonetheless, it is useful to explore some different scenarios for what the future may hold. For example, as part of a background report to this investigation Saunders *et al.* estimated the impacts of European Union policy reforms on New Zealand's dairy farming sector.¹⁸⁴ Estimates for four scenarios were undertaken. These scenarios differed according to the degree of reform under Agenda 2000 and the Mid-term review (discussed in Section 4.2.1). The scenarios were:

- *Agenda 2000 reforms implemented* — leading to changes in the prices of milk and dairy products in the European Union and an increase in production quota.
- *Mid-term review reforms implemented* — leading to further changes in the prices of milk and dairy products in the European Union and an increase in production quota.
- *Agri-environmental policies implemented* — leading to a 15 percent decrease in European Union dairy farm production, due to restrictions on stocking rates and constraints on inputs such as fertiliser.
- *Agri-environmental policies implemented* — leading to a 30 percent decrease in European Union dairy farm production, due to restrictions on stocking rates and constraints on inputs such as fertiliser.

The two different scenarios for agri-environmental policies were chosen due to the difficulties involved in establishing the likely impacts of these policies. The authors used the Lincoln Trade and Environment Model to simulate the impacts of these policies until 2010.¹⁸⁵ Estimates for each scenario are identified in Table 5.5.

Table 5.5 Estimated impacts of changes in European Union policy¹⁸⁶

	Agenda 2000	Mid term review	Agri-environment 15% reduction	Agri-environment 30% reduction
Milk: Producer price (US\$/tonne)				
EU	\$285	\$280	\$305	\$340
NZ	\$225	\$220	\$240	\$260
Butter: Trade price (US\$/tonne)				
NZ	\$2,030	\$2,025	\$2,130	\$2,300
Milk: Production (000 tonnes)				
EU	120,325	122,745	109,545	95,330
NZ	12,275	12,155	12,925	13,875
Producer returns (US\$)				
EU	\$34,050	\$34,245	\$33,190	\$32,220
NZ	\$2,760	\$2,700	\$3,090	\$3,620

Source: Saunders *et al.*, 2004

As these figures suggest, different scenarios would have significantly different impacts on dairy farmers in New Zealand. According to these estimates, New Zealand farmers would benefit most from the third and fourth scenarios. In these cases, environmental constraints in Europe would lead to a decrease in production in the European Union and an increase in the price of dairy products, benefiting New Zealand producers significantly.¹⁸⁷

Although future agricultural reforms are likely to lead to many opportunities for the farming sector, New Zealand farmers also risk losing access to lucrative markets if some existing trends persist.

Although future agricultural reforms are likely to lead to many opportunities for the farming sector, New Zealand farmers also risk losing access to lucrative markets if some existing trends persist. As Section 4.2 highlighted, it is possible that future trade restrictions will develop on the basis of production methods. The increasing use of nitrogen fertiliser for farming in New Zealand, as highlighted in this chapter, contrasts remarkably with the focus in the European Union and other OECD countries on reducing nitrogen use. It is important to consider what would happen if New Zealand farmers were required to comply with European standards to gain access to these markets. Recent research suggests that many of New Zealand's waterways would already fail to meet European Union water quality standards for nitrogen and further intensification could exacerbate this situation.¹⁸⁸

5.5.2 Energy futures

Farming in New Zealand is generally becoming much more energy-intensive (see Section 3.3). Primarily, this is due to the increasing use of fossil-fuel derived synthetic fertilisers. However, the sector also relies heavily on fossil fuels for running farm machinery and for transporting farm products around the globe. Sooner or later, an increasing reliance on fossil fuels is likely to lead to major challenges for farming in New Zealand.

Fossil fuels are non-renewable energy resources. There is currently a major debate occurring worldwide about the economic viability of remaining oil reserves. Some forecasters suggest that global oil production will peak within the next 20 years or less – *not* because there will be no oil left, but because world demand for oil is growing higher and higher and the limited stocks of remaining oil will be more expensive to extract.¹⁸⁹ When world oil production 'peaks' (i.e. when the demand for oil outstrips the capacity to extract it) oil prices will rise significantly. Although this peak will probably be softened by the availability of alternative petroleum sources and some new extraction technologies, the effect of such a peak, when it occurs, will be felt the world over. This is not a matter that New Zealand has any control over – although it is not inevitable for New Zealand to pursue an energy-intensive future. In the meantime, New Zealand farmers are currently becoming more dependent on an energy source that will become much more expensive.

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Access to energy sources within New Zealand is also becoming more expensive. For example, there is limited capacity to generate further low-cost electricity in New Zealand, especially if all environmental effects are taken into account. There are limited sites for further hydro generation, gas reserves are finite, and it is likely that future gas discoveries will not match past discoveries enough to sustain current and projected consumption patterns.¹⁹⁰ The price of electricity will therefore rise as more expensive sources of energy are utilised. Electricity is a major cost input for some farmers, especially those who rely on irrigation. For example, the cost of electricity for one farmer in a 2003 case study increased

from approximately \$200/ha to \$650/ha in one season when electricity prices hit an unusual peak.¹⁹¹ Although this single case does not indicate a trend, it does illustrate the risk and the potential vulnerability of farmers to rising electricity prices.

Although electricity prices will rise, it is important to keep in mind that farmers may not necessarily need to pay more for energy services. After all, farmers do not require electricity *per se* – they merely want the *services* that electricity is often used to provide.¹⁹² For example, while irrigation systems with pumping consume a lot of electricity, gravity fed systems do not. Similarly, it may be possible for many farmers to generate electricity on-site instead of becoming more reliant on electricity provided *via* the national grid. On-site generation, or other forms of ‘distributed generation’, is likely to become more common as 2013 approaches. From that date, electricity line companies will no longer be legally required to service their customers, including remote rural users, from this year onward.¹⁹³

5.5.3 Climate change impacts

While worldwide energy consumption continues to grow, carbon dioxide and other greenhouse gases are building up in the atmosphere and contributing to global warming (see also Section 3.4.3). This is affecting weather patterns and contributing to climate change.¹⁹⁴ For New Zealand, climate change is likely to lead to drier conditions in eastern regions and wetter conditions in the west. In combination with other climate changes, this is likely to lead to more ‘climate events’ such as floods and droughts.¹⁹⁵

A report prepared for the Ministry for the Environment in 2001 highlighted some major risks and challenges for farming over the next two decades.¹⁹⁶ Some of the main findings of this report are that:

- climate change will probably have the greatest impact on farming through changes in climate variability and climate extremes. New Zealand farmers and growers will increasingly need to manage risks associated with climate events.
- eastern regions could experience more frequent, and potentially more severe, droughts through a combination of higher average temperatures, reduced average rainfall, and greater variability of rainfall.
- western regions, and possibly some eastern regions, could be more prone to flooding and erosion from high rainfall events.
- pasture production will generally increase, particularly in southern New Zealand. There may be a reduction in feed quality in pastures as far south as Waikato and feed quality may also decrease further in dry eastern regions.
- arable crops may generally benefit from warmer conditions and higher carbon dioxide levels in the atmosphere. However, potential yield increases may require higher fertiliser inputs. There may also be increasing demand for irrigation to increase yields, particularly in Canterbury where there will be increased drought risk.
- Hayward kiwifruit may become uneconomic in the Bay of Plenty in the next 50 years under mid to high climate warming scenarios. Apple production is unlikely to be

adversely affected, although there could be greater risk of heat damage in future and availability of water for irrigation may be an increasingly critical issue.

- within the farming sector, there are major uncertainties about the impacts of climate change scenarios related to changes in pest and disease profiles in different regions, changes in soil fertility, and changes in water availability.

This report also suggests that the most effective strategies for adapting to climate change in the farming sector are likely to involve “developing a more integrated approach to land management that considers climate change alongside other important issues such as biodiversity, biosecurity, land degradation, and water resource use.”¹⁹⁷

5.5.4 Biodiversity loss

Biological diversity, or biodiversity, describes the richness, diversity and variability among all living organisms and ecosystems. Biodiversity is commonly considered at three levels: genetic (diversity within species), species (diversity between species and within an ecosystem) and ecosystem (diversity between ecosystems).¹⁹⁸

New Zealand’s indigenous biodiversity is important for many reasons.¹⁹⁹ Due to its isolated position in the South Pacific, New Zealand has a high proportion of endemic species (those found nowhere else in the world).²⁰⁰ This makes New Zealand’s native biodiversity special as well as vulnerable. New Zealand’s biodiversity also provides many ecosystem services to the farming sector (see Section 2.2.1), even though these services are usually taken for granted. Although the vast majority of farming in New Zealand is based on introduced species, its success still relies on natural biological systems. For example, it was estimated that the total economic value from New Zealand’s biodiversity on land was \$44 billion in 1994.²⁰¹ This compares to national gross domestic product (GDP) of \$84 billion that year.

Biodiversity can easily be damaged when farming becomes more intensive. If so, this may also put the ongoing viability of farming at risk. In 1997, the decline in biodiversity was identified as New Zealand’s most pervasive environmental issue.²⁰² The main threats to indigenous biodiversity were identified as:

- habitat destruction – deforestation, grazing, fires, development, wetland drainage, fragmentation and degradation of ecosystems and unsustainable use of resources
- introduced pests and weeds – competing with and preying upon indigenous plants and animals.

As noted in a previous PCE investigation, there is a vital need for indigenous biodiversity on private lands to be sustained and enhanced to improve the sustainability of farming in New Zealand.²⁰³

5.6 Summary and key points

This chapter has highlighted how natural capital can be degraded as farming becomes more intensive, leading to social and environmental harms that place the future of farming at risk. The main focus has been on fresh water. New Zealand’s surface waters (streams,

rivers and lakes) and groundwater systems are coming under more and more pressure from intensive farming, with trends of decreasing water quality and increasing demands for water for irrigation.

Many farms are becoming more intensive through the use of two external inputs – synthetic fertilisers and water for irrigation. Farmers add synthetic fertilisers, which contain nutrients such as nitrogen and phosphorus, to the soil to increase plant and pasture growth. Over time, there has been a major increase in the use of synthetic fertilisers to provide these nutrients and to intensify production. In particular, the use of nitrogen fertiliser in New Zealand has soared in recent years. Nutrients can also be added to soil *via* clover, the spraying of effluent onto pasture, and animal excreta (particularly cattle urine).

Nutrient inputs need to be very carefully managed. If excessive nutrients are applied to pasture and crops, they leak into the wider environment. Nitrogen is highly mobile and can easily enter streams or leach through the soil into groundwater, eventually ending up in rivers, lakes and coastal waters. This can lead to the eutrophication of fresh waters and coastal waters and the deterioration of groundwater quality. This can result in contaminated drinking water supplies, with risks to human health. Once nitrogen enters the environment there is no effective way to remove it. Although phosphorus is far less susceptible than nitrogen to leaching into the environment, phosphate fertilisers can also contaminate water.

There are now major concerns about New Zealand's waterways and lakes becoming nutrient enriched and degraded. The lag time taken for nutrients to enter these water bodies suggests that any problems will get worse before they eventually improve. The longer it takes to address these problems, the more likely it is that serious degradation will result.

Faecal matter and eroded sediment from farming sources are other major contaminants of water and aquatic ecosystems in New Zealand. Many of New Zealand's lowland rivers are now unsuitable for swimming due to faecal contamination. Sediment can detrimentally affect water bodies in two ways: sediment can be suspended in water affecting light penetration and visual clarity; and sedimentation in waterways can destroy in-stream habitats by smothering animals, plants and streambeds, and affecting animal lifecycles and food supply. The more intensive the farming system, the more at risk the environment is to contamination from these sources as well.

Water allocation has also become a significant issue in New Zealand. Although water is a finite resource, the demand for water continues to increase. Most of this pressure is coming from the farming sector. There are significant demands for water for irrigation, mainly for pasture purposes, and much of this water is being used inefficiently. While irrigation provides many benefits to farmers, it can also contribute to adverse environmental effects. Both surface waters and groundwater sustain complex ecosystems. Any removal of water from those water bodies will impact on those ecosystems. Irrigation can also act as a conduit for contaminants (such as sediment, farming chemicals, effluent discharges and nutrients) from the land to surface water and groundwater.

By using more synthetic fertilisers and/or using irrigation, farmers can grow more pasture

and increase the number of stock on each hectare of land. This can exacerbate many of the environmental impacts discussed above. For example, higher stocking rates in the dairy sector lead to more cow urine (and thus nitrate) leaching to the environment.

The farming sector is likely to face rising public pressure to adequately address the trends.

There are clearly major risks to New Zealand's waters and these are likely to become more critical if current trends persist. The farming sector is likely to face rising public pressure to adequately address the trends. Many New Zealanders rely on secure sources of uncontaminated water for drinking, and they value waterways maintained in a healthy condition. Water is vital to many community functions, and other important economic sectors, such as tourism, rely on high quality water to meet New Zealand's 'clean and green' reputation.

Other looming risks for farming, which are likely to become more serious if current trends continue, include:

- the potential loss of access to lucrative overseas markets if trade becomes restricted on the basis of production methods, including environmental impacts
- a growing dependence on fossil-fuel based fertilisers even though these inputs are likely to become much more expensive in the future
- ongoing loss of biodiversity and the essential ecosystem services provided to farming.

From all of this, it is clear that New Zealand's farming sector faces some enormous challenges. Fortunately, as the next chapter highlights, some attempts are already being made to redesign existing farming systems for the better.

CHAPTER **6**

Emerging trends



Previous chapters have discussed the dominant trends in farming and the state of New Zealand's natural capital in intensively farmed areas, examined the drivers and incentives, and identified a number of risks and challenges for farming. This chapter focuses on emerging activity, particularly that related to managing the adverse effects of farming on the health of the environment and redesigning farming for environmental sustainability. For our purposes here, this activity has been described as 'redesign' activity – redesign in the sense of creatively developing new ways of farming which address problems created by previous and current systems.

6.1 Redesigning farming

Much of the emerging activity draws on a long tradition in the farming sector of both innovation and stewardship of the land. Analysis suggests it ranges along a spectrum from tools for remedy and mitigation of adverse environmental impacts, to the development of new farming systems which deliver environmental sustainability and economic wealth (i.e. more sustainable agriculture), to approaches which promote sustainable agriculture and seek to integrate farming into the wider environment (see Figure 6.1). The impetus for change may come from individual efforts (by farmers), sector wide initiatives by industry groups, or government (local and central) promoted programmes. It is acknowledged that not all of the tools and approaches discussed fit simply into one place on the spectrum. Some tools have components that range across it while others may illustrate progress along it. Importantly, tools at the remedy and mitigation end of the spectrum can be used in combination to develop systems approaches that are toward the other end of the spectrum.

A constructive way of examining and appreciating the potential for redesign in the farming sector is to look at examples of what is happening now.

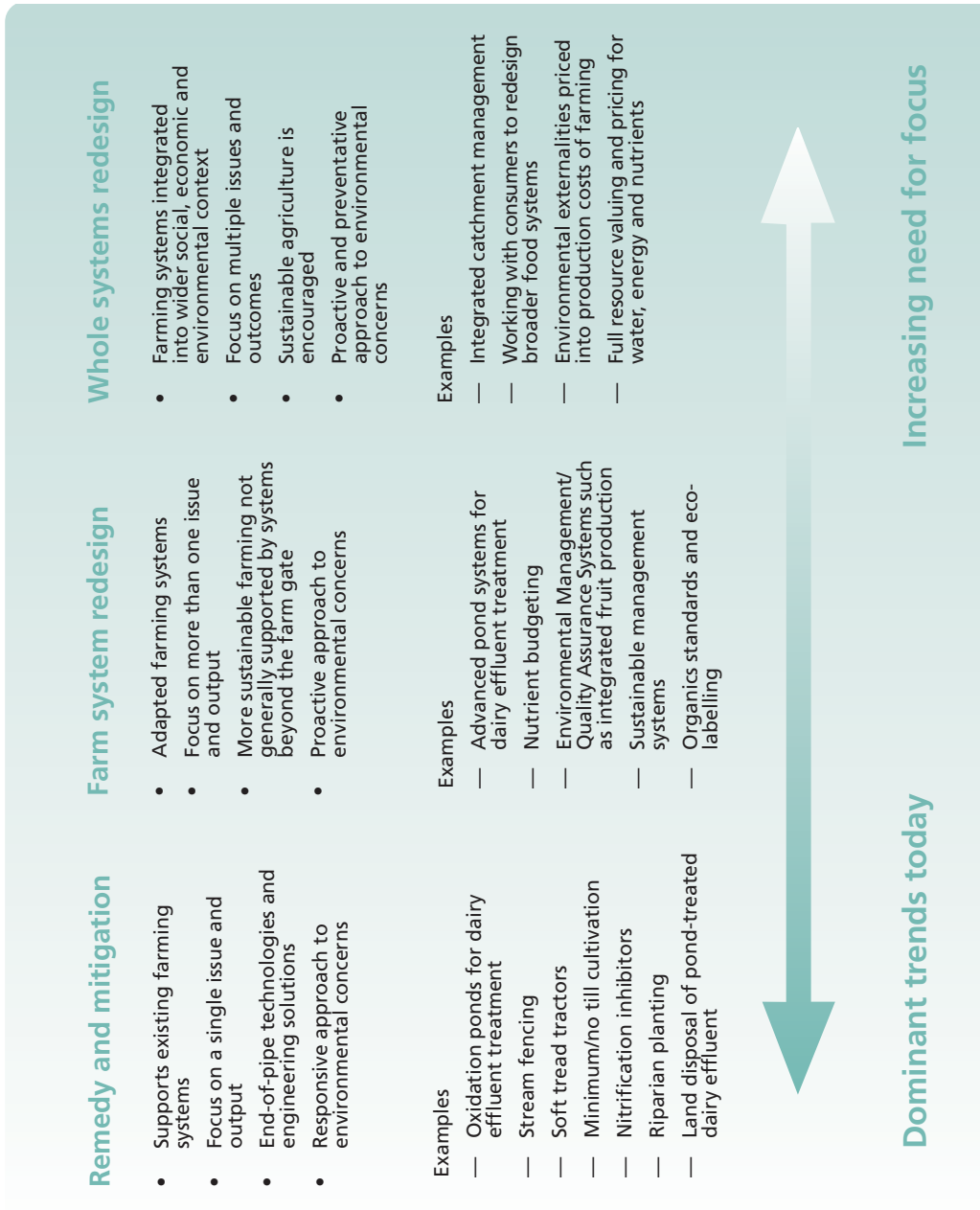
A constructive way of examining and appreciating the potential for redesign in the farming sector is to look at examples of what is happening now. The following sections explore some current approaches and achievements. This is not intended to be comprehensive, but rather illustrative of the range of possibilities.

6.1.1 Remedy and mitigation

Tools for remedy and mitigation of adverse environmental impacts tend to be 'end of pipe' technologies. They are aimed at reducing the adverse impacts on the environment of various outputs from farming systems. The *status quo* in terms of the functioning of the overall farming system, that is, the focus on increasing production as supported by commodity production drivers, is maintained (see Figure 4.2). No fundamental changes are being made to develop new systems that do not produce the adverse environmental impacts in the first place.

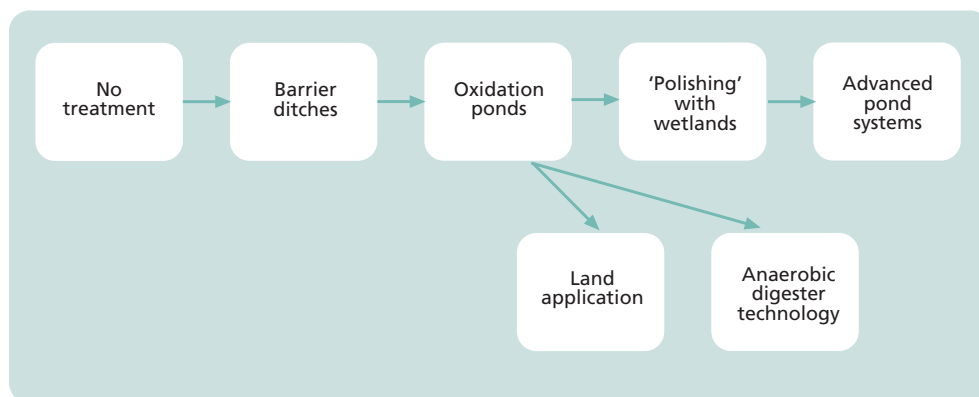
Most practices tend to be sector-specific – that is, related to the nature of the impacts and activities of that particular sector. Such activity may seek to address a particular output from a farming system – for example, dairy shed effluent treatment by discharge to land. These approaches are often well understood scientifically and some (for example, oxidation pond treatment of dairy shed effluent) have played an important role in mitigating adverse environmental effects over the years. They perform a vital function in the overall system.

Figure 6.1 Redesign activity in farming



Managing dairy shed effluent

Agricultural pollution (particularly nutrients and pathogens) poses a serious threat to the health of the environment in New Zealand. Over the years, the preferred methods of treating dairy shed effluent have changed as more information has become available on the effects of this effluent in the environment, as new technology has been developed, and as regulation has required different or higher standards of treatment.¹ Most of these tools seek to initially isolate dairy shed effluent from the environment and treat it to a certain standard before discharging it into the environment. Figure 6.2 outlines the stages in the improvement of treatment options.

Figure 6.2 Progress in dairy shed effluent treatment systems

Source: Developed by the PCE with assistance from Rob Davies-Colley, NIWA

Before the advent of on-farm oxidation treatment ponds in the 1970s, dairy shed effluent was discharged into waterways untreated, or into barrier ditches (which provided some degree of treatment) before being discharged to waterways. Once oxidation ponds were widely adopted, effluent was treated to a higher degree before discharge. Unfortunately, pond performance can be inconsistent and poor quality effluent is sometimes discharged to receiving waters. As a result of this, regional councils began to encourage the application of dairy shed effluent to land. However, not all dairy shed effluent is treated before it is sprayed to land. Some is sprayed directly onto pastures. Spraying treated effluent onto land, even from 2-pond systems, is safer (for humans and the environment) than spraying raw effluent onto land.

Further options for improved treatment of dairy shed effluent include oxidation ponds followed by discharge through wetlands. Wetlands remove more of the contaminants and 'polish' the effluent.² Tools currently under development include advanced pond systems (APS) and anaerobic digester technology. APS³ is an advance on conventional oxidation ponds, producing higher quality effluent that is safe for spraying onto pasture or assimilation into streams, and providing opportunities for resource recovery. Nutrients are recovered as settled algal biomass (a non-noxious material which can be used as a soil conditioner). The high quality effluent may be re-used as wash-down water (the subject of current research). Biogas may be recovered from the first (anaerobic) pond of the APS for energy generation (the subject of current research). Anaerobic digester technology also presents possibilities for resource recovery (non-toxic fertiliser and biogas for energy) and is particularly suitable for dairy shed effluent that has been collected by mechanical scraping rather than flushing with water.

These tools are vital in terms of reducing the adverse impacts of dairy effluent on the environment. However, they also tend to support the high input-output approach to intensification in the dairy sector because the focus is end-of-pipe, that is, on making existing technology work better while the overall farming system continues as usual.

Managing non-point source dairy effluent

Unfortunately, improved dairy shed effluent treatment has failed to halt a general decline

in water quality in dairy farming areas in New Zealand. One of the main reasons for this seems to be the effluent produced by grazing cows which contains both nutrients and faecal contamination (see Section 5.3.1 for a discussion of the impacts of nitrate pollution and faecal contamination on water quality).

Strategies for mitigating faecal contamination of waterways include:

- reducing access of grazing livestock to streams and near channel areas *via* the establishment of riparian zones, through permanent fencing and stock exclusion from the area⁴ and through bridging of stream crossings.⁵ (It is acknowledged that quantifying the effectiveness of permanent fencing is difficult. Unfortunately, the relative contribution to faecal contamination of water by overland flow from the wider catchment, compared to direct and near-channel faecal deposition is not clear.⁶)
- alternatives to permanent fencing which include temporary fencing, rest-rotation grazing, off-stream watering, off-stream shade and shelter.

Nitrification inhibitors offer a method of managing excess nitrogen produced by grazing animals as well as from fertiliser applications. They have only recently been commercialised in New Zealand, so it is too early to assess the full range of impacts they might have. They certainly have the potential to contribute to a reduction in the impacts of nitrogen in the environment. However, use of this tool needs to be part of a whole systems approach (such as reducing fertiliser application, monitoring impacts on soil ecology, and taking a catchment scale approach). There is concern that they may support the on-going use of nitrogen fertiliser rather than encourage the development of farming systems that are not as dependent on nitrogen fertiliser in the first place. There may also be wider impacts on the health of the environment (e.g. soil bacteria) that only become evident as time goes by.

Nitrification inhibitors

In addition to efforts aimed at refining and reducing nutrient inputs into agricultural systems, a number of efforts are underway aimed the other end of the system, that is, treating the output by enhancing soil capacity to retain nutrients. Lincoln University researchers in partnership with fertiliser company Ravensdown, have recently developed a spray, called 'eco-n', aimed at the dairy sector.⁷

Eco-n is a liquid chemical containing the nitrification inhibitor, dicyandiamide (DCD), which reduces nitrate leaching from cattle urine and emissions of the greenhouse gas nitrous oxide. It is designed to be sprayed onto pasture twice a year to slow down the action of soil bacteria, which work to convert the ammonia in cow urine into nitrate. The slower pace of nitrate conversion slows leaching from the system, and enables the pasture to absorb the ammonia as it grows, thus increasing pasture production.

DCD can also be used in conjunction with nitrogen fertilisers. Fertiliser company Ballance Agri-Nutrients has recently developed 'n-care', a urea fertiliser containing DCD, designed for use in late spring and early

autumn, when the risk of nitrate leaching is highest.⁸ In a similar vein, fertiliser company Summit-Quinphos has developed a fertiliser 'Sustain' that contains a urease inhibitor called Agrotain®. Agrotain® inhibits or reduces the rate that urease (a soil enzyme) converts urea (from both fertiliser and urine) into ammonium, thus reducing nitrogen volatilisation to the atmosphere and the conversion of ammonium into easily leached nitrate.⁹

These products are only recently available to New Zealand farmers, and their effectiveness, practicality, and cost benefit will no doubt have a bearing on their popularity. A review of nitrification and urease inhibitors has recently been released by Environment Waikato (2004f). It expresses some caution and the need for substantive research under New Zealand field conditions.

Managing nitrogen fertiliser use

Nitrate losses to the environment have been identified as a key challenge for farming. Tools and practices for managing nitrogen fertiliser that help keep nitrates out of waterways include:

- matching total nitrogen applied to attainable yield goals to avoid excess applications
- only applying during suitable weather conditions. For example, late autumn and winter fertiliser applications have the greatest risk of direct leaching loss of nitrogen fertiliser¹⁰
- timing nitrogen applications to fit pasture and crop needs, e.g. multiple (smaller) applications to fit high nitrogen demand periods by crops
- monitoring soil nitrate so fertiliser rates can be appropriately adjusted
- using nitrogen stabilisation techniques to slow formation of nitrate
- specific placement of nitrogen-containing fertilisers
- applying fertilisers with irrigation water for controlled plant uptake
- balancing fertility to maximise nitrogen use efficiency¹¹
- the application of nitrification inhibitors.

Specific nutrient management tools used in New Zealand include the *Code of Practice for Fertiliser Use*, funded by the New Zealand Fertiliser Manufacturers' Research Association Inc (Fert Research) and endorsed by Federated Farmers, central government, and regional councils.¹² The *Code* outlines best practice techniques for fertiliser use, with a focus on meeting production goals in an environmentally sustainable way. It takes a non-prescriptive, site-specific, effects-based approach to fertiliser application, and takes growers' responsibilities under the RMA into account. These techniques can be used singularly as forms of remedy and mitigation. They can also be integrated into whole systems approaches to redesigning farming (see discussion later in chapter).

Protecting soil fertility

A variety of techniques are being developed in the horticulture and arable sectors to enhance the health of soils through protecting soil structure. These include using machinery which is less damaging such as soft tread tractors and developing minimum till or no till methods of planting crops. The LandWISE project in Hawke's Bay is a good example of this. The arable sector often uses crop rotations to maintain and enhance soil health. In the grape growing sector, cover crops are often grown under vines to prevent soil loss.

Minimum tillage and LandWISE

Soil is a precious non-renewable limited resource. A medium for growing plants, soils hold life-supporting minerals, micro-organisms, water and air. Soils have been utilised for cultivation for more than 10,000 years.¹³ Throughout this period, there has been an ongoing struggle to retain these arable soils in a healthy state, and past civilisations have collapsed when they have failed to do so. It is an ongoing challenge. The World Bank notes that:

...erosion, salinisation, compaction, and other forms of soil degradation affect 30 percent of the world's irrigated lands, 40 percent of rainfed agricultural lands, and 70 percent of rangelands.¹⁴

As discussed in Chapter 3, soil erosion is a significant issue in New Zealand, and can be accelerated by land clearance and unsuitable land management practices. Conventional tillage of arable land is financially costly, damages soil structure and increases erosion risk.¹⁵ The practice of minimum tillage¹⁶ on arable lands avoids unnecessary cultivation, while aiming to maintain or improve crop yields. It minimises soil disturbance, thus reducing soil erosion. It also assists in maintaining good soil structure, reducing soil nutrient loss, and reducing water loss by evaporation. Other benefits include reduced labour requirements and fuel savings.

No-till farming integrates ecology into the farming system design and considers the complex biological web that is at work in a system of healthy and efficient soils, plants and animals. It recognises that management decisions affect the habitats and food sources of organisms important to regulating biological processes, and therefore agricultural productivity.¹⁷

Hawke's Bay group, LandWISE, co-ordinate and develop on-farm research. They have a three-year programme underway, involving a number of trials, to develop and refine strip tillage systems for process and arable crops in New Zealand. Strip tillage involves cultivating only about a third of a crop row width, rather than the entire row width, thus minimising soil disturbance and retaining crop residues – valuable as organic matter. They are also undertaking no-tillage trials, where the crop seed is drilled directly into the soil. The programme monitors soil quality, crop development and financial indicators, and compares the outcomes with conventional tillage systems. An aim of the programme, funded largely by the MAF Sustainable Farming Fund, is to establish the reliability of strip tillage and to develop a set of best practice guidelines.

...it is a win-win-win approach that resulted in greater net returns to farmers (through reduced labour, fuel and equipment costs), increased crop yields, and watershed benefits such as cleaner streams and lakes and less road damage.¹⁸

Old habits die hard – ‘a maintenance fertiliser’ story

Improving crop yields as knowledge advances would seem to be a straightforward process – apply the new knowledge by modifying or replacing current practices based on *past* knowledge. However, it appears that the ongoing improvement of production systems, in productivity terms and input costs, is not quite so straightforward. A sobering story by Dr Nick Pyke, CEO of the Foundation for Arable Research, indicates farmers may be better at adopting new ideas than phasing out superseded ones. His story is one about the efforts of arable soil fertility researchers to convince pea growers that annual maintenance applications of superphosphate were unnecessary – producing no increases in yields on well-managed farms and in fact under some conditions actually depressing pea yields. Despite many talks and articles about the lack of production response from the standard 250 kilograms per hectare fertiliser dressing regime, many pea growers, in some cases encouraged by their fertiliser representatives, continued application as an ‘insurance’. The applications persisted until a leading grower got up at a field day and said he’d worked out how many overseas holidays he and his wife had potentially missed because of the years of fertiliser applications for no apparent benefit. And the number – 10! Putting the message this way – in terms of personal experiences forgone – had a much greater impact than hard data on crop yields with and without the fertiliser.

Using sector agreements



Beyond the context of specific regulatory approaches under the RMA (largely confined to effluent disposal and water takes and discharges), remedial strategies for mitigating adverse environmental effects in the dairy sector have tended to be voluntary and focused on good practice, that is, “education is more appropriate than legislation.”¹⁹ By way of example, fertiliser use is not regulated as occurs in some European countries. Rather nutrient budgeting is encouraged as good practice through the provision of tools such as the *Code of Practice* and OVERSEER. The *Dairying and Clean Streams Accord*²⁰ signals a more active approach that incorporates a number of tools covered in this report. The Accord is also a more comprehensive approach using a suite of tools including improved treatment, protection of sensitive environments and reduction of fertiliser inputs through efficiency.

Dairying and Clean Streams Accord²¹

Fonterra Co-operative Group, regional councils, the Ministry for the Environment, and the Ministry of Agriculture and Forestry signed the Dairying and Clean Streams Accord on 26 May 2003. The purpose of the Accord is to provide a:

...statement of intent and framework for actions to promote sustainable dairy farming in New Zealand. It focuses on reducing the impacts of dairying on the quality of New Zealand streams, rivers, lakes, groundwater and wetlands.

The Accord sets out priorities of action and performance targets. It also establishes the roles and responsibilities of the organisations that are party to the Accord. The goal of the Accord is to “have water that is suitable, where appropriate, for:

- fish
- drinking by stock
- swimming (in areas defined by regional councils).”

The Accord sets priorities for action and performance targets (minimum targets to be achieved on a nationally aggregated basis):

- *Dairy cattle are excluded from streams, rivers and lakes and their banks:*
 - *fencing may not be required where natural barriers prevent stock access*
 - *the type of fencing will depend on factors such as terrain, stock type and costs*
 - *streams are defined as deeper than a “Red Band” (ankle depth) and “wider than a stride”, and permanently flowing.*
 - o *Performance target: dairy cattle excluded from 50% of streams, rivers and lakes by 2007, 90% by 2012.*
- *Farm races include bridges or culverts where stock regularly (more than twice a week) cross a watercourse.*
 - o *Performance target: 50% of regular crossing points have bridges or culverts by 2007, 90% by 2012.*
- *Farm dairy effluent is appropriately treated and discharged.*
 - o *Performance target: 100% of farm dairy effluent discharges to comply with resource consents and regional plans immediately.*
- *Nutrients are managed effectively to minimise losses to ground and surface waters.*
 - o *Performance target: 100% of dairy farms to have in place systems to manage nutrient inputs and outputs by 2007.*
- *Existing regionally significant or important wetlands (as defined by regional councils) are fenced and their natural water regimes are protected.*
 - o *Performance target: 50% of regionally significant wetlands to be fenced by 2005, 90% by 2007.*
- *Fonterra and regional councils develop regional action plans for the main dairying regions to implement the Accord by June 2004.*

By August 2004, nine of the 13 regional councils have developed clean water action plans under the Accord. The plans cover 84 percent of Fonterra’s farmer suppliers.²²

6.1.2 Farming systems

Further along the spectrum (see Figure 6.1), redesign innovations seek to address a number of issues. Parts of the farming system may be modified and a new system effectively developed.

Nutrient budgeting

Nutrient budgeting is a tool for estimating nutrient requirements and potential losses to the environment. It involves measuring nutrient inputs, such as fertiliser, nitrogen fixation by clover, effluent and purchased feed, and then estimating nutrient outputs, in the form of products (milk, wool or meat), nutrient leaching, nutrients retained by the soil and greenhouse gas emissions.²³ The software packages OVERSEER and SPASMO are examples.

Nutrient budgeting indicates the balance sheet of inputs and outputs and quickly identifies situations of nutrient surplus or deficit that can then be rectified with appropriate management changes.²⁴ Provided that farmers do alter management practises, fertiliser losses should be reduced and the result should be more environmentally friendly and economically effective farming systems.

In practice, nutrient budgeting can be used in a variety of ways ranging from little change to existing systems through to optimisation of fertiliser use. An example of the latter is the use of GPS²⁵ and farm environment mapping to deliver different amounts of fertiliser to different parts of a single paddock based on calculations of actual requirements (for example, the Sustanza nutrient management system produced by Summit Quinphos).²⁶ Nutrient budgeting can be optimised for different purposes as well (for example, maximum pasture growth, least cost application, minimum nutrient loss), thus producing different outcomes.

OVERSEER

The OVERSEER nutrient budgeting model, developed by AgResearch and released in 1999, is available free to farmers.²⁷ The computer programme provides a summary of nutrient inputs into and outputs from a farm or orchard. Nutrient input levels in terms of fertilisers, animals, crop, and crop residues are entered into the programme, and a nutrient budget is produced. The budget includes a breakdown of the fate of nutrients such as nitrogen, phosphorus and potassium in kilograms per hectare per year. It also calculates greenhouse gas emissions for methane, nitrous oxide and carbon dioxide. The programme is designed for a number of sectors: pastoral farming (dairy, sheep, beef and deer), wheat, potatoes, apples and kiwifruit.

Irrigation management

Irrigation has a significant capacity to fuel intensification and contribute to adverse environmental impacts on the environment. However, it is not irrigation *per se* that is the issue. It is *how* and *where* it is used. Effective and efficient management of irrigation can minimise adverse impacts on the environment. Current developments in this area include the development of a code of practice, certification and training, and tools such as SPASMO.

On-farm irrigation evaluation: Code of Practice, certification and training

A number of research programmes funded by the MAF Sustainable Farming Fund have looked at improving the efficiency of irrigation. A recent example of this is a project looking at on-farm irrigation evaluation, funded by NZ Pipfruit, Veg Fed, FAR, ECan, and Hawke's Bay Regional Council, and undertaken in conjunction with farmers, industry sector groups and regional councils.

The project involves pipfruit, vegetable crops, wine grapes, and arable crops and is suitable for pasture, turf and landscape irrigation as well. It aims to develop a national code of practice for the evaluation of irrigation systems and to train and certify people to conduct evaluations. The aim of the on-farm evaluations is to assess irrigation systems by analysing on-farm measurements and observations against a range of key performance indicators, including water distribution uniformity and irrigation application efficiency. Systems and their management are assessed and recommendations made for improvement if required.

The benefits of the evaluation for farmers are improved irrigation performance and profitability through increased irrigable area, better crop yield and quality, and reduced operational and marginal costs. The benefits for the environment are that water is used more sustainably and the potential for drainage (and leaching) resulting from poor uniformity or scheduling is minimised.²⁸

Soil Plant Atmosphere System Model (SPASMO)

Soil Plant Atmosphere Model (SPASMO) is a computer modelling system developed by Hort Research. It is designed to deliver dependable science based information about the risks associated with different types of land use and management practices, particularly the effects on soil and water quality.

The model has a number of applications. It can predict what will happen to leached fertilisers, pesticides, and effluent. It also allows farmers to work out irrigation requirements in particular areas. The model integrates many variables. For example, in the irrigation context it uses weather, soil, irrigation system, and crop data to determine the irrigation requirements of that crop on that site. It has been used by a number of regional councils to assist in determining water allocation consents.²⁹

Other on-farm resources for managing irrigation include the *Irrigation Guide*.³⁰ The environmental checklist attached to this guide includes the following vision for farmers:

- *developed state of the art irrigation systems that allow efficient use of water*
- *significantly improved their soil, its biological activity and ability to sustain plant life*
- *contributed to the rural environment through extensive tree planting, fencing of sensitive areas and enhancement of waterways.*³¹

Adapting whole farm systems

While many dairy farms operate in a conventionally acceptable and economically successful manner, some farmers have developed management systems that place greater emphasis on understanding and avoiding adverse impacts and aim to increase productivity without compromising the environment.

The Pencarrow Farm story provides an interesting study in the types of management information required for the operation of such dairy farming systems. The approach might be termed an 'enhanced' conventional approach. A notable new component of the management system is detailed monitoring of soil health, water use and water quality over a long timeframe, data that then feeds into farm operations.

... some farmers have developed management systems that place greater emphasis on understanding and avoiding adverse impacts and aim to increase productivity without compromising the environment.

Pencarrow Farm, Canterbury

Pencarrow Farm has been recognised as a leader in environmental management by receiving the Canterbury 2003 Supreme Ballance Farm Environment Award.

Farm statistics:

- 207 hectare milking unit with 27 hectare support block
- Sharemilker runs the dairying operation with 680 cows.

Farm vision:

To develop a farming operation with scale that is in the top bracket for:

- profitability
- efficiency in conversion of resources to productivity
- environmental management
- aesthetics and landscape value.

Objectives include:

- achieve 1,500kg milksolids without excessive use of purchased feed



- achieve top 10 percent earnings before interest and tax (EBIT) per hectare for Canterbury irrigated dairy
- have all farm paddocks at least partially sheltered from winter NW or SW wind
- integrate trees and landscape features into the farm environment successfully
- integrate wastewater management into the farm environment successfully, while improving soil productivity, moisture and nutrient holding capacity
- continue to improve efficiency of water use while retaining trees, as measured by pasture production per mm of water (>10kg dry matter per mm water) and milksolids production per mm water (>1kg milksolids per mm water)
- achieve more family time once core development is completed.

Andy Macfarlane has monitored and recorded all data relating to soil and water management for 15 years. He is able to justify fertiliser and water management programmes and calculate leaching potential from different management approaches using the Nitrate Leaching Model developed at Lincoln University. The farm is experimenting with the use of Eco-N, a nitrification inhibitor, to further reduce nitrate leaching by enhancing plant available nitrate in the root zone.

The farm distributes effluent efficiently over 50 percent of its land, diluted with fresh water *via* a "rotorainer" rotating boom. When fresh water for irrigation is not being pumped, waste water is applied via a specialized effluent irrigator. In case of power failure, overflow waste water can be applied to a border dyke (flood irrigated) area.

Worm activity and organic matter content is measured as an indicator of soil health, along with conventional soil test analysis. Data recorded is used in setting and achieving goals from year to year. Integrated planting is carried on a regular basis. Production is measured per millilitre of water, including rain and irrigation. Management achieves a high output per labour unit. The Dairy Monitoring System used by Macfarlane Rural Business Ltd and Baker & Associates benchmarks efficiency of pasture conversion into milk. The system accurately measures feed consumed and hence allows accurate comparison of milk produced relative to utilisable pasture consumption, fertiliser and water inputs.

An example of farm system redesign in the sheep and beef sector is the Whatawhata sustainable land management project.³² This project is notable for the development of a new farming system providing for multiple economic and environmental outcomes. The research process used is also a good example of linking farmers, researchers and regulators to develop solutions, i.e. participatory action research or 'putting ideas into action' and 'learning by doing'.

Whatawhata Sustainable Land Management Project

Research to improve hill-land farming has been going on for over 50 years at AgResearch's Whatawhata Research Centre, between Hamilton and Raglan. More recently, 280 hectares in the headwaters of the Mangaotama catchment have been used to develop ways to sustainably manage hill country used for farming and forestry. In 1998/99 the farm was only returning about 2 percent on capital, or a farm surplus of \$25,000 as an owner-operator unit. Environmental problems associated with farming on steep hill country included soil erosion and degradation of stream habitat and water quality.

A catchment management group (CMG) was formed, comprising farmers, resource management agency staff (regional and territorial authorities and DOC), researchers (AgResearch, Landcare Research and NIWA) and local iwi. The CMG identified the following environmental, economic, and community goals for the farm:

- having viable businesses
- controlling erosion
- having healthy stock
- improving on-farm native tree vegetation
- having healthy streams, good water quality and an attractive environment.

Fundamental to the farm planning was the ability to demonstrate environmental performance so that the products from the farm could be marketed as *sustainably* produced and obtain a market advantage. Land management changes included:

- converting the steeper, eroding, and poorly producing land (55 percent of the farm catchment) into radiata pine plantations.
- establishing fenced, regenerating scrub/forest riparian buffers to protect streams
- changing stock management practices on the remaining better grazing land. Stock management changed to a higher cattle-to-sheep ratio and from breeding cows to a bull-beef system.
- planting poplars on pasture land for soil conservation in erosion risk areas.
- replanting seven hectares in native shrubs and trees in an experiment on biodiversity restoration and native tree timber production.

An extensive monitoring programme has been established covering a range of biophysical and economic indicators (e.g. farm economics, stock health, sediment control and stream health). The timeframes for responses to the changes were predicted to vary from the short term (e.g. faecal coliform reductions in stream water following stock exclusion) to the longer-term (e.g. stream temperature declines as riparian areas grow). There are already improvements in the annual farm economic surplus – from \$25,000 in 1998/99 to \$45,000 in 2001/02.³³

Developing healthy soils

The soil foodweb approach is another example of a systems redesign philosophy and approach.

The Soil Foodweb Institute

Founded by US soil scientist Dr Elaine Ingham in the 1990s, the Soil Foodweb Institute's principle is that healthy, productive soils lead to healthy, productive plants. The Institute takes a systems, ecological approach to soil management by using beneficial soil organisms that make up the soil food web, such as bacteria, fungi and nematodes.³⁴ In doing so, nutrient cycling is improved, nutrient loss from the soil is reduced, weeds and disease are eliminated, water use is reduced, and the need for pesticides and inorganic fertilisers is reduced.

The Institute has a number of soil testing laboratories around the world, including one recently established in Waikato by former BioGro auditor Cherryle Prew. She analyses the biology of soil samples sent to her from around the country, measuring bacterial and fungal biomass, protozoa and nematode numbers, and mycorrhizal root colonisation. Levels indicate soil nutrient recycling and release, and plants' ability to take up nutrients from the soil. She then recommends organic ways to get the right balance of soil biology through the application of compost and compost teas that match the requirements of the plant being grown.

Quality assurance and sustainable management programmes

The farming sector has developed a range of quality assurance and sustainable management programmes at an industry/organisation level in response to demands by both international and national markets for assurances about food safety and the sustainability of food production (see Section 4.3 and Table 4.3).³⁵ These programmes are, in part, a response to some of the drivers discussed in Section 4.2.3, particularly the separation between farmers and consumers and the desire of consumers to influence food safety and quality. In most cases the primary focus of these programmes is food safety with a more limited focus on environmental sustainability. However, there are benefits for environmental sustainability and the programmes certainly provide a platform to build on.

Integrated Pest Management (IPM) aims to be a sustainable approach to managing pests by combining biological, cultural, physical, and chemical tools in a way that minimises economic, health, and environmental risks.³⁶ IPM seek to integrate the use of pesticides with other pest control methods and avoid the traditional practice of calendar spraying, which can result in pesticide overuse.

Although aspects of IPM have been used in farming for centuries, modern IPM evolved as an improved method of pest control in the 1950s, in response to both the limitations of synthetic pesticides (e.g. pest resistance) and the environmental consequences of pesticide overuse. IPM is a sophisticated, holistic, and knowledge intensive system of managing pests that depends on an understanding of the entire production system. Its goals include:

- ensuring abundant, high quality food and fibre
- increasing net profits
- maintaining or improving environmental quality
- reducing production risks.³⁷

IPM aims to be proactive and preventative. The use of tools that avoid pest problems and monitoring for pests are an important part of IPM. IPM tools include:

- biological, e.g. protecting, enhancing or importing natural enemies of pests
- cultural, e.g. crop rotation, using locally adapted or pest resistant/tolerant varieties, sanitation, manipulating planting/harvest dates to avoid pests
- physical, e.g. cultivation, trapping, pest exclusion
- chemical, e.g. pesticides.³⁸

IPM is one component of farming that has been fundamentally redesigned. It takes a *systems approach*, where decisions are made in the context of the ecology of the farming system. A systems approach is highly relevant in efforts to improve agricultural sustainability, and there are opportunities to apply it much more broadly across farming sectors in New Zealand.³⁹

An Integrated Fruit Production (IFP) programme for the management of pests and disease was introduced to New Zealand apple growers in 1996 and became a minimum export standard in 2000/01.⁴⁰ The programme, involving all commercial apple growers in New Zealand, entails:

- monitoring of pests
- threshold-based applications of selective insect growth regulator insecticides
- limited use of organophosphate insecticides.



Since implementation, overall insecticide use has declined by 50 percent, organophosphate pesticide use has declined by 93 percent and dithiocarbamate fungicide use has declined by 30 percent.⁴¹

The KiwiGreen programme

In 1992 ZESPRI™ Group Ltd introduced the KiwiGreen programme, an integrated pest management approach developed by HortResearch.⁴² It aims to produce fruit with minimal or no chemical residues. A key driver was retaining market access.

Adopted by conventional kiwifruit growers, it involves increased monitoring of orchard pests, a decrease in the use of organophosphates and synthetic pyrethroids, and the use of 'soft' pesticides for pest control (for example, Bt-based products⁴³ and mineral oils). The aim is to provide an environmentally and ethically responsible production system that ensures safe fruit for consumers. All kiwifruit growers now comply with the KiwiGreen programme.

ZESPRI™ Group Ltd broadened the KiwiGreen programme in 2000 into an environmental management system called the 'ZESPRI™ System', moving beyond on-orchard processes, to encompass environmental, social, and financial aspects of kiwifruit production throughout the supply chain, from the grower (and shareholder) through to the consumer.

Of the programmes mentioned in Table 4.3, Project Green™ is particularly interesting for its focus on sustainable agriculture and the alignment between its aims and goals and the concepts discussed in Chapter 2. A key to the success of the project has been the involvement of producers from the outset. They were heavily involved in the development and on-farm testing of the three plans that make up the package. Thirty draft plans have been developed and the audit system tested. Over the last six months the farmers involved have established a Project Green Charitable Trust to manage the intellectual property and provide governance. They are also currently developing a business arm "NZ farmsure" to deliver the package on-farm. It is in the early stages of implementation and uptake is limited so far, but if adoption of the standard becomes widespread it could make a significant contribution to the redesign of sheep and beef farming systems for environmental sustainability.

Project Green™

The Project Green™ concept evolved through the input of a number of parties interested in establishing a significant supply base to satisfy international, particularly UK, demand for organic meat.⁴⁴ Richmond Ltd, MAF Sustainable Farming Fund and the New Zealand Business Council for Sustainable Development supported development of the concept. Over time the focus on organics shifted to the establishment of an integrated/sustainable production goal that set out:

To achieve a standard of food safety, animal welfare and sustainable resource management that is defensible in all countries of the world.

The project has involved 50 predominantly sheep and beef farmers

from Hawke's Bay, Manawatu, Wanganui, Taranaki, Waikato and Bay of Plenty. Land managers from six Regional Councils have also been involved, along with expertise from AgResearch and Manawatu Veterinary Services. It was agreed from the start that the input from producers was critical in the development of the on-farm specification. It was also agreed that to be credible the standard would require the development of an audit system, with independent verification.

The standard, developed for sheep, beef cattle, deer and goat farmers, aims to enhance farm production, provide future proofing for the farming business and demonstrate that farmers are 'clean and green' by providing the basis for an internationally recognised Quality Assurance (QA) system. Like many such standards, it is voluntary and based on best practice farming.

Project Green™ defines 'sustainable agriculture' as meaning:

An integrated system of plant and animal production practices having site-specific application that will, over the long term:

- (a) satisfy human food and fibre needs*
- (b) enhance environmental quality and the natural resource base upon which the agricultural economy depends*
- (c) make the most efficient use of non-renewable resources and on-farm resources and integrate, where appropriate, natural biological cycles and controls*
- (d) sustain the economic viability of farm operations*
- (e) enhance the quality of life for farmers and society as a whole.⁴⁵*

The principles of the standard are as follows:

- a supply capability based on sustainability principles must consider economic, environmental, and social aspects of production.*
- conditions for supply are based on factual information with a scientific basis wherever practical. However, consumer views and perceptions on acceptable practice are considered and are adopted wherever proven to be important.*
- builds on Base Farm Assurance for conventional supply, which includes animal welfare and food-safety requirements.*
- integrated management between animal livestock species, animal age groups and/or through cropping/pasture rotation is encouraged as an effective means of reducing challenge from pests.*
- overall, chemical intervention is minimised by application of the management plan strategies including adherence to a demonstrated need principle.⁴⁶*

The standard requires development of three plans for individual farms, which together cover a complex range of issues:

- the *land and environment plan* is a structured approach to land use planning based on a standardised resource analysis. The plan covers soil health, water quality, shelter and shade, pasture, biodiversity, biosecurity and greenhouse gases. The plan is developed in consultation with an approved land management professional and is unique to each property, to reflect the farm resources, local issues and challenges.⁴⁷
- the *social responsibility plan*, prepared by the farm manager, seeks to maintain protection of those involved on the farm and in the community. It includes staff, community and heritage issues, as well as a commitment to sustainable development.⁴⁸
- the *animal management plan* covers both animal welfare and animal health. It is developed in consultation with an approved veterinarian and requires a current level of 'Base Farm Assurance' as a prerequisite.⁴⁹

Amongst other things the standard requires that farms comply with the Biosecurity Act, the Resource Management Act, the Fertiliser Code of Practice, Growsafe and Spreadmark and that an approved land management professional must endorse the Land and Environment Plan.⁵⁰ With respect to the Land and Environment Plan, a minimum entry compliance level of 10 percent work or protection already complete of the total planned for is required. This should include erosion control, perennial waterways, shelter and shade, native bush and wetlands and compliance should increase to 50 percent in five years and 80 percent in 10 years.

6.1.3 Beyond the farm

Further along the redesign spectrum shown in Figure 6.1, initiatives move beyond the farm to address connections with wider parts of the system. This can encompass both the wider physical environment (the catchment) and the wider food chain (processors, marketers and consumers, both national and international).

Integrated catchment management

Integrated catchment management (ICM) moves beyond redesigning farming at a farm scale. It provides an opportunity for linking and integrating individual farms with other farms and other land use activities in a catchment⁵¹ (the appropriate unit for planning, ecologically speaking). It offers a way of addressing and understanding the cumulative effects on the environment of all activities within a catchment, only some of which may be farming. ICM integrates land use planning with water and soil planning enabling a better match between activity and environment.

Further along the redesign spectrum, initiatives move beyond the farm to address connections with wider parts of the system. This can encompass both the wider physical environment and the wider food chain

Many definitions of ICM are available. For the purposes of this investigation ICM is defined as:

*a process through which people can develop a vision, agree shared values and behaviours, make informed decisions and act together to manage the natural resources of their catchment. Their decisions on the use of land, water and other environmental resources are made by considering the effect of that use on all those resources and on all people within the catchment.*⁵²

The actual range of visions and activities will vary from place to place and project to project.

ICM may be approached in at least three basic ways:

- systematic consideration of water resources, surface and groundwater, quantity and quality. The important aspect is the acceptance that water comprises an ecological system that is made up of a number of interdependent components which need to be managed in the context of the inter-relationships.
- seeing water as an interconnected system that interacts with other systems. Interactions between water, land and the environment are considered, recognising that changes in one will have consequences for the others.
- considering the inter-relationships between water and social and economic development. At this level, ICM closely reflects approaches to sustainable development.⁵³

ICM is a philosophy that recognises the environment as a complex system of interacting resources at a broad scale – the catchment. It is issues-driven – the issues provide the focus for activity, be it sediment, water or nutrients.⁵⁴ The key ingredient is integration – among science disciplines, across spatial and temporal scales, from science through to policy, management, and education, and among knowledge providers, users and purchasers.

Physical boundaries are usually based on the catchment in recognition of the central role of water as a critical resource and of catchments as the source of that water. Water provides transportation for nutrients and pollutants across land within the catchment and out to sea.

ICM recognises the vital importance of involving all people in the catchment in decisions made about management within the catchment. There is a strong focus on encouraging and developing participation and understanding between resource users and resource managers both in terms of the drivers and activities causing the adverse environmental impacts and on the actions necessary to address the issues. ICM research requires interdisciplinary involvement ranging from ecology right through to civil engineering.

In recent times, the focus on ICM has grown within New Zealand. Many projects have developed at the community level out of concern for the health of parts of the local environment. These groups commonly encompass a variety of people from the local

community, including farmers.⁵⁵

The ICM projects discussed in this section have used distinct but related approaches to finding solutions to the impacts of farming. The Taieri Trust and Whaingaroa Harbourcare initiatives are predominantly community-based projects (bottom-up and grass roots). These communities have identified a decline in the natural capital of their catchments and have initiated a range of educational and ecological restoration projects to raise awareness and actively halt this decline. The Fonterra Dairy Catchments project and the 2020 Taupo-nui-a-Tia project are driven predominantly by either industry or local government with varying degrees of landholder, community group or iwi buy-in (top down, agency-led projects).

Community-based catchment plans allow those with a stake in the local environment to incorporate their visions, knowledge and experience into the policy development process. Local and traditional knowledge can then assist the sustainable management of the catchment alongside scientific data. In particular, catchment plans assist with prioritising areas or issues. These plans can also highlight how joint activities between different catchment groups with similar goals can be more productive, for example, the work of Whaingaroa Harbourcare.

Best Practice Dairying Catchments for Sustainable Growth

This project is an initiative by the dairy industry to integrate environmentally safe practices into dairy farming, against the background of rapid conversion of dry-stock farms to dairying, and the industry's policy of increasing output by 4 percent per annum. It is funded by the dairy industry and MAF's Sustainable Farming Fund and has been running since 2000.

Its objectives are to:

- *encourage adoption of practices that meet industry and regulatory authority requirements and address local issues*
- *monitor changes in farm practice, adoption of new practices and waterway condition to establish the success of the project and identify areas where the system is not responding as expected*
- *publicise the results of the study as it progresses to demonstrate industry commitment to change, sustainable management and to encourage other farmers to consider these issues and adopt improved management practices.*⁵⁶

Four catchments are being used in the project: Toenepi Stream (Waikato), Waikakahi Stream (Canterbury), Bog Burn (Southland) and Waiokura (Taranaki).

In the spring of 2001, farms in the catchments were surveyed to provide benchmark data on current farm practice and performance. Information collected included stock numbers, fertiliser use, soils and environmental management. The majority of farmers expressed the intention of increasing per cow performance as a key objective for future growth through increasing feed brought into the farm or improving pasture quality (i.e. intensification).

Soil quality assessments carried out in the spring of 2001 indicated that soil quality attributes were generally good though some sites were below optimal. Soil organic matter levels were good. Poor physical condition (compaction) was an issue at some sites.

Monitoring indicates poorer water quality in all streams in the four catchments compared to that in less intensively farmed catchments. All streams have moderate levels of nutrients (nitrogen and phosphorus) and intermittently high concentrations occur. Faecal pollution is in all streams but was most elevated in the Taranaki catchment. Surveys show that nitrate inputs occur uniformly down the stream lengths; whereas, inputs of faecal bacteria were associated with specific sites.⁵⁷

The Taieri Trust

The Taieri River is the third longest river in New Zealand (318 kilometres). It drains a 5,659 square kilometre catchment (18 percent of the Otago Region) before entering the sea. The Taieri catchment is a highly diverse landscape. The upper Taieri is one of the driest areas of New Zealand. Intensive farming in the area is dependent on irrigation. The lower Taieri Plains are different, with a healthy rainfall and many areas lying around sea level or even below. These plains were once a large swamp and today water must be actively pumped from the area to allow for intensive farming. Water extraction, runoff from farms, septic systems and urban storm water are adversely affecting water quality in the river.

The Taieri Trust (TT) project evolved from a community orientated participatory action research initiative in the Taieri catchment between 1999 and 2001.⁵⁸ This initiative⁵⁹ brought together people in the Taieri catchment to discuss river health and ecological issues. Later, community members approached the researchers and asked them to develop a project that would help improve communication among stakeholders in the catchment and give the community a voice to allow it to tackle environmental problems more quickly. An ICM project was formulated and commenced on 1 July 2001 funded through the Ministry for the Environment's Sustainable Management Fund.

The TT comprises five trustees – four landowners from different geographic areas of the catchment and one University of Otago representative. There is also a wider management group consisting of community members and local iwi and resource managers from Otago Regional Council (ORC), DOC, and Fish and Game. The project is co-ordinated by the New Zealand Landcare Trust, which provides a project co-ordinator, mentoring, group facilitation and financial management assistance.

Project objectives include:

- enhancing stakeholder partnerships (particularly between communities, researchers and agencies)
- establishing an information exchange system for effective communication

- implementing actions for environmental improvement
- designing reflection and evaluation strategies to enable ongoing review and dissemination of the catchment approach.

The TT has established an information exchange system which includes a project website,⁶⁰ newsletters, workshops, A&P show exhibits and extensive media coverage. A considerable amount of effort has been spent working with primary school students and teachers, including development of a curriculum kit and video on the Taieri River. Actions for environmental improvements have included prioritisation of catchment areas/issues, facilitating ORC and DOC regulatory actions, development of model restoration sites, field days and planting days and university research on riparian management. Many TT actions are supported by science.

Many catchment residents believe that the TT has been highly successful in its efforts to improve working relationships among stakeholders. The TT is seen as a key motivating influence on Otago Regional Council and DOC in relation to water quality monitoring and the remediation and enforcement of wetlands protection.⁶¹ The TT is generally seen as neutral because it has no regulatory function.⁶² Despite this success, future funding is uncertain threatening the sustainability of TT project activities.⁶³

Whaingaroa Environment Catchment Plan

The Whaingaroa catchment includes all the land that drains into the Whaingaroa (Raglan) Harbour, approximately 525 square kilometres. Whaingaroa Harbour is located on the west coast of the North Island, approximately 40 km from Hamilton. The land in the catchment has been cleared of forest, scrub and wetlands in the past 150 years and most has been developed for farming. The main land use has been dry stock farming (sheep and beef cattle) but dairying production has increased with changing economic conditions. Because of the inherently unstable geology and lack of indigenous forest cover, steep catchment slopes are prone to erosion. Many of the streams and larger rivers draining the catchment carry high sediment loads and high faecal bacteria levels into the harbour. Over time there have been concerns about sedimentation in Raglan Harbour and the decline in both the fresh water and saltwater fisheries.

This concern has prompted the local community to develop a catchment plan to protect and restore the special qualities of this harbour environment.⁶⁴ Actions recommended in the plan include:

- supporting Whaingaroa Harbourcare and other landcare groups working with farmers to fence and plant streams and harbour margins
- building partnerships between government agencies and locals to preserve key natural areas

- creating a range of different learning opportunities for the community about catchment wildlife and sustainable land and waste management techniques.

Whaingaroa Harbourcare (WH) is an incorporated society established in 1995. They operate a native plant nursery and undertake riparian plantings throughout the Whaingaroa (Raglan) catchment. WH propagates and plants up to 100,000 trees each year and is coming up on their 650,000 tree planting. WH offers a free planting service to landholders in the catchment. It has specifically targeted the Wainui Reserve as a focal point for riparian restoration. The Reserve is the gateway to Raglan's beach and receives 200,000 visitors a year.

The Waikato District Council manages the Wainui Reserve as farm park. Despite retiring and planting gullies and wet and steep areas, the farm now runs almost double the number of cows it used to. It acts as model for farmers. WH is now working with key farmers in other parts of the catchment to spread the concept. Over 90 percent of farmers in the catchment participate in the project with more farmers wanting to become involved each year. Community locals have reported significant improvements in shellfish numbers, recreational sea fishing and whitebait runs.

Many of these ICM projects occur at a local scale – a sub-catchment level rather than connecting the whole catchment. They make valuable contributions locally and provide opportunities for learning about ICM. There are fewer examples of fully developed ICM programmes operating at a whole catchment though some initiatives underway embody components of a whole-of-catchment approach – for example, the Whatawhata Research Centre's work on hill country catchments (the Whatawhata Sustainable Land Management Project), the Taieri Trust and the Whaingaroa (Raglan) Harbour initiative.

ICM can be complex – legally, environmentally *and* socially. It involves multiple layers and relationships over long time frames. Despite, or perhaps because of, that it can also provide successful, durable solutions to the impacts of land use on the environment. It is a promising framework for effective and efficient collaboration on issues of regional and national significance, including the effects of farming on environmental sustainability. This is vital considering that no one agency, person or community has sole responsibility for achieving a particular land management outcome for New Zealand. ICM by its very nature requires integration and interdisciplinary research. So it is particularly encouraging to see the active collaboration between research providers and end users in the Fonterra Dairy Catchments, Whatawhata and Taieri ICM projects.

The strategy developed to protect Lake Taupo is notable for the use of a range of tools, partnerships and collective action.

Collective action and strategic partnerships

The strategy developed to protect Lake Taupo is notable for the use of a range of tools, partnerships and collective action. The apparent success of this strategy in creating collective agreement on the action required to manage the threats to the lake suggests the value of applying lessons learned elsewhere in New Zealand.

Protecting Lake Taupo: a long term strategic partnership

The process used to develop the strategy for Lake Taupo shows four distinct phases:

- communication of information from Lake Taupo's long-term water quality monitoring programme to various forums by Environment Waikato (EW) (the community is informed about the current state of the catchment/lake)
- a debate and discussion within the community about what it wants for Lake Taupo (an improved future state)
- agencies and the community working out how to achieve this future state
- development of a robust planning framework to ensure actions are taken to protect Lake Taupo.

EW raised the issues of declining lake health with the community in May 2000. This was followed shortly by the development of the 2020 Taupo-nui-a-Tia project. This was a three-year Ministry for the Environment Sustainable Management Fund project focused on understanding a wide range of community and iwi values and aspirations for the lake and its catchment, and developing an action plan to protect them. Values and aspirations include: clear water, high quality inflowing water, a weed-free lake, safe swimming and safe drinking water (amongst others).⁶⁵ The 2020 project combined the second and third phases noted above.

The 2020 project provides an overarching framework for the future resource management of Lake Taupo. It is long-term, takes a wide range of management issues into account, and involves significant participatory work with the community and agencies with resource management responsibilities for the catchment and lake. In essence, it is an example of a more comprehensive approach to ICM described above.

Fundamental to the 2020 project was engaging the Taupo community in identifying issues (or problems/concerns) that posed a threat to the most highly valued features of the lake and its catchment, including:

- increasing human use and activities
- increased nutrients entering the lake
- increased faecal organisms in lakes and streams
- boating (affecting safe swimming, introducing weeds, littering and discharge of waste)
- lake level changes
- lack of effective management by councils and other organisations.

A risk assessment designed to identify priorities for future action was carried out in five categories: ecological, human health, cultural/iwi, economic and quality of life. Two aspects were key to the process:

- determining what were the most serious threats affecting the community values

- determining what were the best solutions to most effectively deal with these threats.

Importantly, the risk assessment process identified nutrient enrichment from farm runoff as a high risk to the lake.

The fourth part of the strategy has been the Protecting Lake Taupo project focused on the development of a new planning framework for protecting the water quality of the lake. The principal target of the planning framework is “over the next 15 years, to reduce the manageable sources of nitrogen flowing into Lake Taupo by 20%.” Actions include:

- establishment of a joint public fund from local and regional rates and Government taxes to help convert pastoral land to low-nitrogen land uses in the most cost-effective way. The joint fund has been set up to ensure that 20 percent of the nitrogen from pastoral land is permanently removed. This could be achieved through land purchase, covenanting, joint ventures or direct purchase of nitrogen discharges where land cannot be sold. For example, some of the private land in the catchment could be purchased from willing sellers. The land could then be:
 - changed to a low-nitrogen land-use, then on-sold with nitrogen restrictions
 - retained as a public forestry investment
 - retained for public use, recreation and biodiversity.
- using Regional Plan rules to restrict but not reduce current levels of nitrogen being lost from land in the catchment.
- upgrading community sewage systems and requiring landowners with septic tanks to improve maintenance of their older systems.
- assisting in research and development of low-nitrogen farming practices, and providing information and advisory services for landowners.
- building strong partnerships between Ngati Tuwharetoa and local and central Government.
- exploring other low-nitrogen land use options, such as native forest, to meet biodiversity goals, and low-impact tourism and recreation facilities.

This is a combination of measures that identify opportunities to reduce nitrogen and underpin them with regulation.⁶⁶ The total cost of the programme is estimated to be \$81.5 million over 15 years of which the Government will contribute \$36.7 million and EW and Taupo District Council the rest.⁶⁷ EW released a draft variation to the Proposed Waikato Regional Plan for discussion on 30 September 2004, which incorporates many of the actions discussed above.

This initiative also considers the appropriateness of certain land use activities in the catchment. An analysis of four future economic scenarios for the Lake Taupo catchment has been important in identifying development pathways that are economically viable yet ensure minimum nutrient flows to the lake.⁶⁸ At a macro scale, forestry or tourism development scenarios provide the greatest economic growth opportunities with least nitrogen emissions compared with agricultural development pathways. The information shows several sustainable development options are available to the Lake Taupo community in the face of nitrogen restriction policies to protect lake water quality. A cost benefit analysis using the economic information available shows that the benefits of restricting nitrogen emissions to Lake Taupo exceed costs by a factor of three.⁶⁹

Trends in food systems

It is important to consider the wider food system and emerging trends in food consumption, and how these trends are driving change through the food supply chain.

As people get richer they tend to be more prepared to pay for food with attributes that stress *quality*, especially in terms of food safety and environmental factors (although there is obviously not a strict relationship between rising financial wealth and having these concerns). Table 6.1 identifies some 'income elasticities'⁷⁰ related to demand for various food attributes. It shows that the demand for food products with positive nutritional and food safety attributes tends to increase as income increases. The demand for basic food commodities usually does not increase as income increases. Therefore, if New Zealand wishes to target high value markets in rich overseas markets, it is important to give attention to the attributes of food these markets demand rather than focusing on basic commodities.⁷¹

Table 6.1 Food attributes as income elasticities of demand

Calories	Close to zero; negative for many
Fat and cholesterol	Low; strongly negative for many, (low fat: 42%)
Nutritional/Health value	Positive; high for many (69%)
Food safety	High
Greenness and sustainability	High; especially for some
Natural	High for some
Taste	Very high for practically everyone (97%)
Experience	High; especially for some
Status and prestige	High; especially for some
Value (quality/price)	Desired even at high incomes (cost/price: 74%)

Source: Saunders *et al.*, 2004



A number of the attributes of agricultural products with relatively high-income elasticity are related to the way in which products are produced. It is important to understand that these attributes are ones that are *perceived* to exist by the consumer and are often derived from how farming is carried out. These include healthiness, food safety, greenness and sustainability, naturalness and taste. The motivation for purchasing food products with low input production methods may

be derived from either ethical or environmental concerns. However, most studies have identified that perceived health benefits are more likely to motivate purchase. Most consumers are unable to discern the presence of these attributes at the point of purchase unless information is provided. Labelling of some kind is important for this.⁷²

Thus, while the percentage of income spent on food has fallen, the evidence suggests that consumers (especially in developed markets) are willing to pay a premium for certain food attributes. These include food safety, quality, the manner in which the food is produced, and its impact on the environment. Targeting these markets and emphasising these attributes of New Zealand food provides a wide range of potential opportunities for the farming sector.

Some farming sectors have already responded to this challenge by targeting niche and high value markets and increasing the premium on their products – the kiwifruit sector being a good example. This approach holds real potential for increasing the value of farming output in a sustainable manner.

Eco-labelled products

It is generally accepted that some consumers are willing to pay a premium for food that is 'green' in origin. The labelling of such food provides consumers with the capacity to identify and choose such food. The willingness to pay varies from country to country and across different food products. Although it is difficult to determine the precise size of any premiums, some empirical studies combined with a variety of 'intentional' studies do support the argument that many consumers are willing to pay a premium for eco-certified and labelled products.⁷³

The *willingness* to pay a premium for 'green' produce is reflected in the actual prices paid. Price premiums vary across commodities and also according to what 'green' attributes are claimed for it. Information regarding actual price premiums paid is most readily available for organic produce. Table 6.2 shows the range of premiums. The Danish organic milk market story also highlights the possibilities.

Table 6.2 Price premium for organics in key demand centres

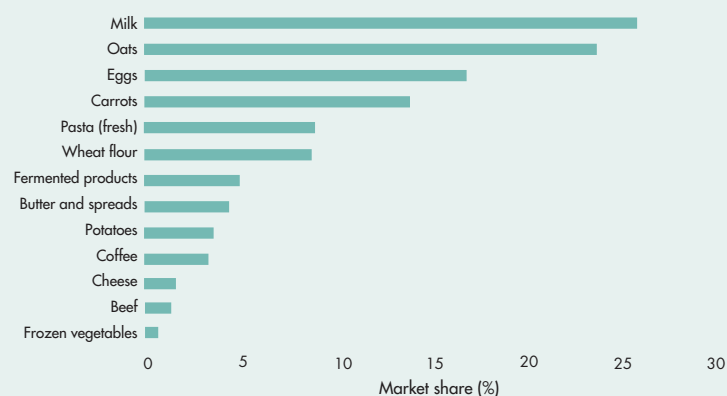
Market	Price premium (% above conventional price)
Austria	25-30
Denmark	20-30
France	25-35
Italy	35-100
Germany	20-50
Netherlands	15-20
Sweden	20-40
Switzerland	10-40
United Kingdom	30-50
Japan	10-20
United States	10-30

Source: Saunders *et al.*, 2004: 63

While organics⁷⁴ is used here as an example of more sustainable agriculture, it is likely that a range of different systems could deliver environmental sustainability *and* economic wealth.

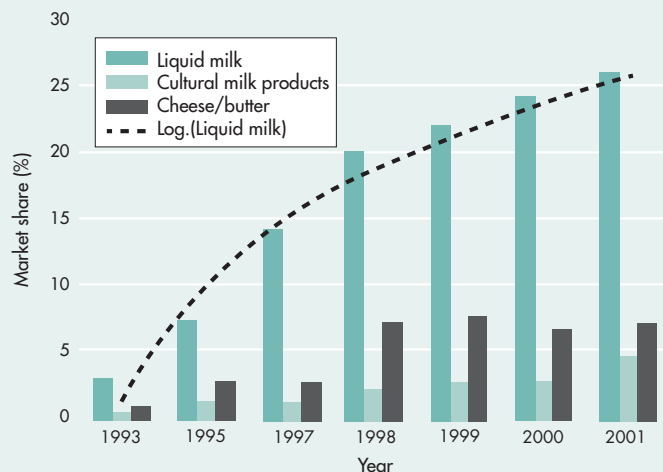
The Danish organic dairy market

Overall, Denmark has one of the highest consumption rates of organic products in the world. Dairy products dominate in the Danish organic retail sector accounting for 45 percent of total organic sales followed by meat (13%), bread (12%) and eggs (8%). The domestic market share for organic products is shown in the figure below. A quarter of all liquid milk consumed in Denmark is organic. Furthermore, organic oats, eggs and carrots have relatively large market share as well.



Source: OrganicDenmark, 2002

The market for organic liquid milk has grown rapidly from 3 percent of consumption in 1993 to nearly 26 percent in 2001. Markets for processed organic dairy products such as cheese and butter are also developing but at a slower pace (see figure below).



Source: Danish Dairy Board, 2002

The Danish retail price premium for organic liquid milk is 18-20 percent. This shows that it is possible to have both a considerable organic premium (18-20%) and a large market share (above 25%). There are several explanations for this. The difference in conventional and organic liquid milk price may be insignificant when considering the proportion of liquid milk relative to the total household expenditure.



Another reason may be that organic liquid milk is easily accessible in the retail-chain stores. In addition, Danish retail-chain stores and dairies continuously run marketing campaigns to promote their organic products.

If demand in other markets follows the Danish trends there will be potential for organic dairy sales. Moreover, this market seems to be sustainable with premiums.⁷⁵

Value versus volume

The two broad strategic development options available to farming in New Zealand are encapsulated in the value versus volume debate: *is profitability best derived from producing high value quality products or is it derived from producing large volumes of products?*

In a simple way, Table 6.3 illustrates the contrasts between these two strategies. In practice these strategies have produced different approaches to development and intensification. As discussed in Chapter 3, intensification in the horticulture sector has tended to focus on higher value production with the adoption of EMS and QMS schemes resulting in controlled use of external inputs. In the dairying sector intensification has meant increasing stock numbers, more synthetic inputs, expansion and greater volumes of production. These strategies also have fundamentally different implications for environmental sustainability. Dialogue around the implications of these strategies and the relationships to the risks and challenges identified in Chapter 5 are critical to the future development of farming in New Zealand.

... is profitability best derived from producing high value quality products or is it derived from producing large volumes of products?

Table 6.3 Value versus volume

Value in the kiwifruit sector	Volume in the dairy sector
<p>ZESPRI™ Group Ltd is recognised for its innovative marketing and promotion strategies.⁷⁶ These include:</p> <ul style="list-style-type: none"> • strong branding • environmental and quality assurances • promotional programmes linking kiwifruit with good health • meeting year-round demand by contracting kiwifruit growing to northern hemisphere countries, e.g. Italy, Iran and the United States • programmes to ensure good tasting fruit reaches the market • product range development.⁷⁷ 	<p>Fonterra’s strategy for achieving global dairy industry leadership focuses both on commodity dairy products (protecting its competitive advantage as lowest cost supplier) and on innovation into high-value markets with the development of specialty milk components and nutritional milks. Commodity products were 83.5% of production in the 2002/03 year, but returned only 54.1% of sales value. A key goal of the dairy industry is a 4% increase in productivity each year. The Strategic Framework for Dairy Farming’s Future extrapolates this to a 50% total productivity gain by 2014.⁷⁸</p>
<p>The focus on food safety and quality assurances has resulted in 100% of kiwifruit growers complying with the KiwiGreen programme. This may be expected to also lead to better environmental outcomes as fewer chemicals are used. However, this picture is not straightforward – the new Gold kiwifruit variety requires fertiliser inputs in the order of 40% higher than the green variety. Thus we see nitrogen fertiliser urea use in the kiwifruit sector increased by 49% between 1996 and 2002 (see Section 5.2.2 and Table 5.3).</p>	<p>The focus on increasing production each year is aligned with the increasing intensity of production in the dairy industry with associated environmental impacts discussed in Chapter 5.</p>

Learning from other industries

Other industries, particularly internationally, have already begun grappling with redesigning business systems for sustainability and can therefore shed light on what is involved. Many of these businesses have gone on to be extremely successful so they also demonstrate the benefits that can accrue from innovation and change. One of these businesses is Interface Inc, a carpet manufacturer.

Other industries, particularly internationally, have already begun grappling with redesigning business systems for sustainability

Sustainable business: the Interface story

Interface Inc, an American carpet manufacturer, is a global company with headquarters in Atlanta. It has 23 manufacturing sites and sales in more than 100 countries. In 1994 the CEO of Interface, Ray Anderson committed the company to becoming a "restorative enterprise, first to reach sustainability and then to become restorative – putting back more than we ourselves take and doing good to Earth, not just no harm – by helping or influencing others to reach toward sustainability."⁷⁹

The company manufactures carpet and carpet tiles. As such, its products are heavily dependant on petroleum, thus its challenge to become sustainable was significant. The company sought to achieve sustainability on seven fronts:

1. Eliminating waste (anything that did not add value to their customers)
2. Eliminating harmful emissions into the biosphere
3. Using renewable energy resources
4. Creating self-sustaining, closed-loop products and processes
5. Developing alternatives to the physical movement of people and material, using resource-efficient means of transportation
6. Creating a culture that integrates the principles of sustainability into what we do everyday
7. Creating a new model for business (redesigning it) by pioneering sustainable commerce.

Interface subscribes to the Natural Step Principles (<http://www.naturalstep.org.nz/>). It has also achieved ISO 14001 certification for some of its plants (65 percent of its products are produced from these plants) and it aims to have its remaining plants achieve this standard by 2004. ISO 14001 is an international standard for environmental management systems. Interface also published what is believed to be the first corporate sustainability report in 1997. Interface has developed a set of metrics against which to measure its sustainability.

Interface has taken many measures to become a more sustainable business. Some examples include:

- 46 percent reduction in CO₂ emissions since 1996
- 28 percent reduction in the use of petroleum based materials since 1994
- increased use of non-petroleum based materials
- constructing carpets so they can be recycled
- recycling carpets to create new carpets
- using used carpet that is unsuitable for recycling to generate electricity
- increased use of renewable energy
- decreased total energy use
- decreased water consumption (up to 78 percent in modular carpet)
- \$231 million saved since 1995 by waste elimination activities
- research on manufacturing carpets requiring less material and less energy and on making carpets from renewable resources
- sought to influence suppliers by holding conferences explaining Interface's sustainability vision, and seeking sustainable products from them.

One of the most radical ideas the company has created is the Evergreen Service Contract. Under this contract a building owner leases a carpet from Interface. Interface owns the carpet and provides regular maintenance and replacement services to the owner. When worn areas of carpet are replaced, they can then be recycled by Interface. The owner pays a monthly fee for the lease.⁸⁰

Within New Zealand, these ideas are being put into practice by an initiative called *Redesigning Resources*.⁸¹ Eight organisations are involved: Snowy Peak/Untouched World; Manaaki Whenua, Landcare Research; Macpac; the Christchurch City Council; the Recovered Material Foundation; Orion; the Warehouse; and the Shire of Yarra Ranges, Australia. This group is committed to business redesign that takes account of social and environmental matters alongside the purely financial, that is, putting sustainable development into practice. They are aiming to 'create new value' based on a balanced score card or Triple Bottom Line approach to their business models. Landcare Research has become a leader in sustainability reporting and introduced EBEX21 to enable other companies to reduce and offset greenhouse gases by restoration of native forests. The Warehouse and Orion have focused on energy efficiency in innovative ways.

Transforming drivers

Given the strength of economic drivers (see Chapter 4) in influencing the broad direction of the farming sector, some of those drivers may need to be transformed if the trends are to be changed. The strong reliance on market based policies appears to create incentives

that lead farmers toward unexpected adverse outcomes for the natural capital. Ultimately, the negative environmental outcomes constitute a strategic risk to the future growth in value of New Zealand's farming systems, particularly in a sustainability context.⁸²

Future policy development and institutional change will need to address ways in which the drivers can be adapted to avoid current risks and support positive environmental and economic outcomes. Current matters that need to be addressed include:

- the propensity to externalise pollution and costs to the environment and society, that is, we need more tools for addressing non-point source pollution (Ontario's Nutrient Management Act 2002 and the International Nitrogen Initiative are examples of international approaches)
- the relative paucity of feedback loops and information on the state of the environment that would identify the need for change much earlier.

Ontario's Nutrient Management Act 2002

A bill nervously anticipated by Ontario's farmers became law Wednesday, paving the way for the province to set and enforce standards for the spreading and disposal of potentially lethal animal manure. Spawned by the Walkerton E. coli tragedy two years ago in which cattle waste poisoned the town's water, the Nutrient Management Act aims to protect the province's waterways from farm-animal contamination.⁸³

In May 2000, the water supply for the small Canadian town of Walkerton, Ontario became contaminated with the bacterium *E. coli*. Seven people died and 2,300 became ill from drinking contaminated water. The contamination originated from manure spread on a farm near one of the town's wells, and was exacerbated by a large rainfall event. An inquiry into the matter exposed numerous system failures that culminated in Canada's worst *E.coli* outbreak, including the falsification of records and inadequate water testing regimes.

Prompted by this tragedy, two years later Ontario's Nutrient Management Act 2002 came into force:

- to provide standards with respect to the management of materials containing nutrients used on lands
- to provide for the making of regulations with respect to farm animals and lands to which nutrients are applied
- to make related amendments to other Acts.

The purpose of the Act is to "provide for the management of materials containing nutrients in ways that will enhance protection of the natural environment and provide a sustainable future for agricultural operations and rural development."

The International Nitrogen Initiative and the Nanjing Declaration

In 1998 the first International Nitrogen Conference, held in the Netherlands, focused on the high levels of reactive nitrogen in the environment. A second conference was held in the United States in 2001, and a third will take place in Nanjing in China in October 2004. Following the 2001 conference, the International Nitrogen Initiative (INI), a project of the Scientific Committee on Problems of the Environment and the International Geosphere/Biosphere Programme was launched. This international focus on nitrogen is taking place because of the widespread recognition of the adverse environmental effects associated with nitrogen (see Chapter 5).

The international community considers agreements are urgently needed to combat the nitrogen problem – hence the proposal for a Nanjing declaration at the October conference. The proponents of this Declaration are suggesting an action plan that starts with governments accepting the importance of the issue and then formally charging the International Nitrogen Initiative with creating scientific and political paths that would lead to measures limiting production of reactive nitrogen.⁸⁴ This approach is similar to the Convention on Long Range Transboundary Air Pollution agreed 25 years ago to deal with acid rain.

It will be important that New Zealand engages in this global focus on nitrogen management and the development of international conventions, given the pivotal role of nitrogen in our economy and the influence it is already having on the quality of our environment.

Public policy in terms of the management of adverse environmental effects has tended to rely on a narrow range of tools, principally education and a limited amount of regulation under the RMA. In actual fact, a much wider range of possibilities already exists either here or overseas (see Table 6.4). The range of public policy tools used needs to be broadened and developed into integrated packages. Existing redesign initiatives in the farming sector need to be supported and encouraged, but they also need to be backed up by appropriate public policy initiatives and regulation.

Existing redesign initiatives in the farming sector need to be supported and encouraged, but they also need to be backed up by appropriate public policy initiatives and regulation.

Table 6.4 Typology of environmental policy instruments

Non-market based instruments:

- *output or performance based standards* set limits on performance or output (e.g. limits on effluent load or concentration).
- *input, practice or process based standards* can involve:
 - o setting limits on input level (e.g. IPM, SMS)
 - o specifying a particular technology be used in production (e.g. minimum till, treating dairy shed effluent)

- o development and zoning regulations.
- *education* seeks to influence behaviour by educating those who contribute to the adverse environmental impacts.

Economic (price-based) instruments attempt to influence environmental performance by pricing negative externalities or subsidising mitigation actions:

- *environmental charges* relate to the level of environmental externality (e.g. discharge fees for effluent) or inputs related to the environmental externality.
 - *incentive payments* subsidise the cost of actions to mitigate an externality.
 - *tendering* involves distributing funds by tender or auction as an alternative approach to distributing incentive payments.
-

Economic (quantity-based) instruments set standards for mitigation efforts (emissions standards) and allow trade amongst those providing mitigation:

- *tradeable permits* set individual rights to input levels, outputs levels or performance standards (e.g. allowable level of emissions). Individuals are only allowed to exceed the standard if they purchase additional permits.
 - *environmental offsets* involve actions taken to meet a standard somewhere other than where the adverse environmental impacts occur.
 - *market barrier elimination instruments* seek to improve environmental outcomes by increasing consumer awareness of the attributes of products (e.g. product labelling schemes) or by removing barriers to market activity.
-

Source: Hatton MacDonald *et al.*, 2004

As noted in Chapter 3, New Zealand does not have an established programme of state of the environment indicators or agri-environmental indicators. The information from such indicators is critically important for the development of future public policy. The OECD work on agri-environmental indicators demonstrates a way forward for New Zealand.

OECD Agri-environmental indicators

The OECD work on agri-environmental indicators (AEIs) is primarily aimed at policy makers and the wider public interested in the development, trends and the use of agri-environmental indicators for policy purposes.

The general objectives are to:

- provide information on the current state and changes in the conditions of the environment in agriculture
- assist policy makers to better understand the linkages between the causes and impacts of agriculture, agricultural policy reform, trade liberalisation and environmental measures on the environment, and help to guide their responses to changes in environmental conditions

New Zealand does not have an established programme of state of the environment indicators or agri-environmental indicators. The information from such indicators is critically important

- contribute to monitoring and evaluating the effectiveness of policies addressing agri-environmental concerns and promoting sustainable agriculture, including future looking perspectives of agri-environmental linkages.

OECD work on AEIs covers four main areas:

- *agriculture in the broader economic, social and environmental context* – setting the AEIs in a broader context by considering contextual information and indicators, that is, the influence on agri-environmental relationships of: economic forces (e.g. farm production, employment), societal preferences (e.g. rural viability), environmental processes (e.g. interaction of agriculture with biophysical conditions) and land use changes (e.g. agricultural land use). One of the key contextual issues concerns farm financial resources and their relation to environmental outcomes in terms of farm level income and public and private agri-environmental expenditure.
- *farm management and the environment* – examining the relationship between different farming practices and systems and their impact on the environment, covering whole farm management practices that encompass overall trends in farming methods, including organic farming, as well as nutrient, pest, soil and irrigation management practices.
- *use of farm inputs and natural resources* – tracking trends in the use of farm inputs, covering nutrients (e.g. fertilisers, manure), pesticides (including risks), and water use intensity, efficiency, stress and the price of water paid by farmers relative to other users in the economy.
- *environmental impacts of agriculture* – monitoring the extent of agriculture's impact on the environment covering: soil quality, water quality, land conservation, greenhouse gases, biodiversity, wildlife habitats and landscape.

This programme included an Expert Meeting, (held in Palmerston North in March, 2004), on Farm Management Indicators for Agriculture and the Environment which sought to develop policy-relevant and feasible indicators that can track the current state and trends in farm management practices and approaches. New Zealand (through MAF) has undertaken to provide data on the indicators to the OECD. Full data for all AEI's will not be provided because of availability and relevance issues.⁸⁵

Research innovations advancing sustainability

Major improvements in the sustainability of New Zealand farming will require significant redesign of current farming systems that in turn will require innovative research.

Over the last year FRST has been revising its research investment portfolios to better reflect Government priorities for knowledge development and wealth creation. The basic framework for investment is derived from the Government's Growth and Innovation Framework (GIF).⁸⁶ In September 2004, FRST released a public discussion document proposing an investment strategy for the period 2004/05 to 2010/11.⁸⁷

The current dialogue on this investment strategy is a critical one. A number of questions arise:

- how much should New Zealand invest in the farming sector as a major contributor to economic wealth, versus new non-biologically based economic development?
- what should the balance be between investment in enhancing the production and product innovation of the farming sector versus improving knowledge of the natural capital that underpins the sector?

It is essential that, during the selection of these investment priorities, the risks and challenges raised in this report are addressed so that knowledge can be developed to redesign many parts of the farming, food and fibre sectors.

In addition to the FRST process, a range of innovative research is already underway. The following three initiatives are examples of the way in which new farming systems are being advanced and the types of research that will feed into such systems.

Agriculture Research Group on Sustainability (ARGOS)

The group is a joint venture involving the AgriBusiness Group, Lincoln University and the University of Otago. It has been formed to undertake a six-year research programme aimed at comparing different land management systems in lowland sheep/beef, high country sheep, kiwifruit and in selected Maori owned farmland. Dairying may be added as the study progresses.

The research programme commenced in October 2003 and is funded by FRST and some industry partners. It will include up to 36 properties in each sector allowing investigation of the environmental, social and economic effects of different systems (i.e. Kiwi Green, Kiwi Gold IPM and Kiwi Organic) or levels of intensity within a system.

This is a 'ground breaking' research programme in that it is the first large scale study that aims to investigate the character of sustainable systems and the dynamics associated with the various drivers. It is a study that is taking place against a background of growing pressure in our world markets for paddock to plate QA systems and evidence of the environmental integrity at the start of the food chain – the farm. The research is designed to accommodate ongoing innovation in the systems being compared – this is a critical aspect given the dynamic nature of innovation in practice on a farm – innovation that is often primarily driven by the farmer team drawing on component knowledge from research organisations, agribusiness and farm produce buyers. An example of a 'component' contribution to farm sustainability system development and interpretation work by this study is the OVERSEER nutrient budgeting model developed by AgResearch Ltd.⁸⁸

Organic-Conventional Dairy Systems Study

This research, established in 2001, is a linear comparison of two dairy farm systems – one conventional, the other organic (as defined by the International Federation of Organic Movements, IFOAM). Its strength lies in the insight it will provide into how the two farm systems evolve over time from pre-conversion to conversion and ‘mature’ states. While the methodology used i.e. two farming systems on one site comparison, does not have the scope to yield insights into dynamic innovation within a farm system, it will ultimately provide significant insights into the difference in ecosystem functioning between the two and its contribution to environmental sustainability. Some of the changes and the potential sustainability gains are expected to take several years, particularly in areas such as soil ecology and nutrient balances. It will therefore be important that the two trials run for a sufficient length to allow the influence of the changing system variables to emerge. This means not just the ecological parameters, but also those relating to animal health and economic viability.⁸⁹

Pastoral Genomics - a consortium undertaking clover genomics research and development for the benefit of New Zealand pastoral farmers.

Clovers have traditionally been at the heart of New Zealand’s pastoral systems producing the essential nitrogen for good pasture growth. Clovers’ contribution to the global competitiveness of pastoral farming has been significant given the historically low dependencies on artificial sources of nitrogen. The decline of clovers as a source of nitrogen and the now high dependence on artificial sources is one of the major issues highlighted by this investigation. The research by Pastoral Genomics may have the potential to drive a renaissance in clover based pastoral systems and a return to a ‘solar powered’, more sustainable system.

Pastoral Genomics is applying molecular mapping and functional genomics to characterise key traits associated with improved productivity in clover. Measurements of productivity traits are being integrated with molecular analysis of gene sequences. Discoveries will be used to support the production of new clover cultivars through the application of conventional plant breeding.

Given that nutrient flows are the lifeblood of farming systems, research that advances ecological sources of supply are a key contribution to the redesign of farming systems. In addition to improving overall clover performance, *via* increased dry matter, this research also aims to increase the persistence of clovers in swards and the production of condensed tannins. This is aimed at improving the efficiency of utilisation by animals of the metabolisable energy from digestion, which would decrease methane production – a major component of agricultural greenhouse gases.⁹⁰

Genetic sciences in New Zealand's agri-food futures

For a country so dependent on wealth generation from its natural capital, science that advances our understanding of the building blocks of living organisms is important. There has been an expansion of gene science capacity over the last decade and growing enthusiasm in science and agribusiness circles for its application in the genetic modification (GM) of organisms and understanding genetic resources.

There has also been public concern about GM leading to a moratorium and the Royal Commission on Genetic Modification in 2000, the findings of which have been widely reported and largely adopted by Government.⁹¹ This debate is still alive as many people worldwide are unsure of the benefits or safety of products derived from GM crops or animals.⁹²

As part of the PCE's submission to the Royal Commission, a review of lessons to be learnt from the history of the introduction of new sciences and technologies was commissioned.⁹³ Over the last 200 years the pattern has typically been enthusiasm for early applications of a new science or technology, opposition and resistance to calls for caution, then modification when undesirable effects emerge. It is no surprise that the gene sciences are following a similar pathway. However for this science the potential unknowns are probably greater than any previous area of human discovery – hence the global debate about its application to areas such as food production (which is about wellness) versus wider acceptance of specific medical applications (which is about illness).

Genetic research and applications of the science have continued on a precautionary pathway in New Zealand. No organisms have yet been released for commercial production, though field trials have been approved. A Biotechnology Strategy⁹⁴ has been produced, labelling requirements for genetically modified foods have been introduced, and studies of market acceptance for GM foods have been commissioned. A European focused market study concluded that:

we should defer commercial release of genetically modified organisms (GMOs) in farm animals for meat or milk production, and probably for pasture and animal feed, until such time as this technology becomes widespread in European markets.⁹⁵

It also commented that "great caution should be exercised in approving commercial GMO release in any crop situation."⁹⁶ However GMO-based technology in non-food areas such as mammalian pest control, bioremediation, methane emissions, forestry and biopharmaceuticals was reported as unlikely to affect acceptability of New Zealand foods in European markets.⁹⁷

All evidence to date indicates that gene sciences will have a significant influence on our agri-food futures. Lessons from history indicate some of them will be beneficial in economic terms and hopefully in sustainability terms while others will be detrimental in both dimensions. Beneficial applications will potentially emerge from efforts to map the genetics of New Zealand's dairy herd, the work on clovers (see box) and possum bio-



control using gene sciences. Development of GM food crops in contrast appear to have few, if any, benefits for New Zealand in terms of market acceptability.

Ultimately this science, and the technologies that flow from it, will have to be factored into the strategic future for New Zealand's agri-food sector. However, in light of new knowledge, the impacts of early applications, public views, market acceptability and environmental sustainability, constant reassessment is essential.

6.2 Discussion

The redesign initiatives discussed above represent a variety of approaches aimed at addressing the risks and challenges discussed in Chapter 5. Figure 6.1 is indicative of the spectrum that exists. However, not all activity fits tidily into one place on the spectrum. Some tools may have elements that range across it and others may illustrate progress along the spectrum.

Keeping in mind the different approaches to intensification discussed in previous chapters, the examples discussed in this chapter suggest that the pastoral sectors (dairy, sheep and beef) have tended to favour tools at the remedy and mitigation end of the spectrum. However, as evidence of environmental damage and pressure from external groups grows, more fundamental systemic tools are being developed. In contrast, the horticulture sector has favoured the development of farm system tools such as IPM and SMS. These are tools that are further along the spectrum toward (and incorporate more of the principles of) sustainable agriculture.

6.2.1 Characteristics

These redesign initiatives have some or all of the following characteristics of sustainable agriculture:⁹⁸

- *idea/vision* – a desired outcome which seeks some capacity to be more environmentally sustainable, economically viable and socially beneficial. A focus on being strategic and recognising that maintaining natural capital is a long term business.
- *knowledge intensive* – sophisticated knowledge of the physical environment and the farm management system and on-going feedback and adaptation. For example, this could include detailed knowledge over time of inputs, outputs and losses (i.e. nutrients and discharges to water) from the farm system leading to minimisation or prevention of the losses.

- *systems thinking* – an acknowledgement of interconnections, an approach based on integration, for example, catchment based, paddock to plate or incorporating a number of facets of the farming system. Integration with other farmers, resource managers, researchers, and community members is also important.
- *site specific* – the initiative is adapted to a specific farm or catchment and derives from the particular characteristics of that area and its people.
- *multiple benefits* – the practice will have multiple benefits, financial and social as well as improving the quality of natural capital.
- *manageability* – the scale of activity, costs and perceived costs are seen as manageable.
- *builds on existing practice* – and on the tradition of innovation in New Zealand farming.
- *enhances social capital* – through sharing experiences, discussion groups, etc.

6.2.2 Drivers

A variety of factors encourage the uptake of initiatives. Some are based on the responses of individuals at the farm level, including:

- capacity to think strategically and independently (see into the future)
- individual values and mindsets, for example, belief in sustainability and concepts of 'balance/sufficiency' which shape choice of production models and quality of life goals
- the pain of failure or disaster encouraging new approaches, for example, crossing environmental thresholds such as watching soil blowing away and changes in economic conditions
- how well the changed management practice taps into the traditions of New Zealand farming culture, for example, independence and pragmatism.

These initiatives are also clearly a response to, and an outcome of, some of the driving forces discussed in Chapter 4. These include:

- market and consumer expectations and requirements including an increasing awareness and concern about food safety, and to a lesser extent the environment, and consequent demands for food that is produced in a healthy and sustainable way (Section 4.2.3)
- the requirements of government – the statutory provisions of the RMA and other legislation, policies and procedures of government agencies. For example, regulation for improved dairy shed effluent management and the requirements of the industry itself (Sections 4.3.1 and 4.3.2)
- ideas, methods and attitudes of other farmers, neighbours, local rural communities and local farmer discussion groups

- ideas, advice and other messages from industry advisory and extension agencies such as Dexcel or FAR
- news about science and research developments, and messages from research agencies about the trends, discoveries and directions of science and technology in relation to farming and environmental sustainability.

6.2.3 Barriers

While acknowledging and understanding emerging redesign activity, it is also important to recognise barriers. Why do some practices get uptake when so many do not? Why are these changes not more wide spread? An essential part of moving forward is understanding the nature of the barriers which make it difficult for change to occur. Barriers include:

- *lack of acceptance of the need for change* – people may not understand or accept the effect their activities are having on the environment and the potential risks for the future. Alternatively they may feel that what they are already doing is quite sufficient to deal with any problems.
- *the lack of an industry-wide strategic focus on the future of farming* – this may also contribute to limited acceptance of the need for major changes to farming systems. There is no pan-sector forum in which to debate the risks, challenges and opportunities associated with farming systems and maintaining natural capital.
- *the benefits of change are not immediately obvious* – many sustainability innovations take some years to show the benefits. The current system does not provide an immediate reward. For example, minimum till can take up to 10 years to show obvious improvements in soil structure.⁹⁹
- *influencing the wider system is very difficult* – many of the drivers discussed in Chapter 4 are not under the direct control of New Zealand let alone an individual farmer. It will take collective agreement to make some changes.
- *the impetus for change is not sufficiently strong* – New Zealand tends to rely on voluntary approaches rather than regulation. The carrot is not very big and neither is the stick.
- *capacities* – sometimes the necessary skills and knowledge are lacking in New Zealand's rural communities/farming sectors. The training to build up and support the human capital needed to shape, lead, and organise change in farming may not be available.
- *the technology necessary to implement the change is not readily available* – minimum till cultivation, for example, requires specialised machinery that has been hard to get in New Zealand. Enthusiasts have sourced it from the USA, or made or adapted their own. A disincentive exists for all but the most passionate.

More detailed discussion of the principal barriers follows.

Recognising that change is required

An initial barrier can be lack of acceptance of any reason or cause for change. This can occur at any level of the overall system.

On the ground, a key factor is the need to be sensitised to the early signs of degradation in order to see it. Many farmers, and many other rural and urban dwellers, are not. In Australian studies, Barr and Cary¹⁰⁰ observed that farmers needed to reach three conclusions before they were motivated to react to environmental damage (in that case, salinity). Farmers had to conclude that salinity was a serious problem in itself, it was spreading, and they would be affected by the spread. The farmer had to pass each of these thresholds of awareness before being motivated to action.¹⁰¹

Many local ICM projects get their start from the people involved 'seeing the degradation.' For example, the Lake Ellesmere/Te Waihora issues group coalesced around concerns over water quality, turbidity and the loss of fish in Lake Ellesmere.¹⁰² Farmers in the group highlighted the recognition that streams on their farms were degraded by comparison to their childhood memories as being an important impetus to getting involved. In ecosystem terms, the indications of degradation would have been there well before they became obvious.

However, it is also important to acknowledge that other parts of the wider system do not always encourage and support farmers and local decision-makers¹⁰³ to recognise early signs of degradation. New Zealand does not have an established framework of state of the environment indicators or indicators for sustainable farming that would make such information more transparent and widely available.

Even when robust scientific evidence of environmental degradation is available, recognition of the need to change does not necessarily follow. Causality is resisted or ignored. The issues are minimised and evidence dismissed. Responsibility is considered to lie elsewhere in the system. Declining water quality in the Rotorua lakes, for example, has been documented for two to three decades.

There are complex issues associated with translating science into policy and/or information that is understood by non-scientists.¹⁰⁴ Those institutions with statutory responsibilities for maintaining and enhancing the environment are still grappling with these issues. Other considerations include, who or what conveys information to farmers and other players in the system and whether the message carriers are respected? Credibility would appear to be critical.

Benefits

Research shows that the costs to farmers of environmentally sustainable practices may exceed the on-farm benefits on a short-term (and possibly even long-term) basis. Interviews with farmers bear this out. Section 4.4 and Table 4.4 highlight the fact that some aspects of these practices (for example, nutrient cycling and enhancement and soil protection and erosion) are not valued by markets. This contributes to the lack of an

immediate financial incentive which, in a dynamic farming sector, may result in farmers *not* adopting these practices or adopting them slowly.

Furthermore, in situations involving environmental externalities, the costs of remediation and new practices incurred by an individual farmer may produce benefits that accrue on adjoining or distant properties. Relative advantage could thus be diffused and considerably reduced for the individual adopting improved management practices. Changing farming systems to reduce impacts on water quality is a good example. The benefits accrue to the whole community and may seem quite limited to the individual farmer. In this situation, promoting a perception of profitability for farmers will not be sufficient to produce a high level of adoption of new technologies.¹⁰⁵

That said, there are some benefits to farmers from these initiatives, including:

- building and maintaining access to markets
- demonstrating good stewardship of the land and protecting their 'licence to operate'
- improved profitability from reducing expenditure on inputs such as fertiliser.

The carrot and the stick

In many regions, the use of regulation under the RMA has been relatively light-handed. The farming sector has been resistant to this approach to managing the environmental effects of farming. Regional councils have found it politically more palatable to rely on non-regulatory instruments such as raising awareness through education¹⁰⁶ and extension services and limited financial incentives, to promote better environmental outcomes.¹⁰⁷ Central government, through MAF, has also favoured a voluntary individual and industry based response to concerns about the environmental impacts of farming.¹⁰⁸

Thus the range of tools used so far to promote more environmentally sustainable outcomes has been rather limited. The carrots are not always obvious and the stick has been relatively non-existent.¹⁰⁹

Remedy and mitigation

In the short-term remedy and mitigation initiatives seem to work by providing a single 'engineering' solution to a problem, for example, land disposal of dairy shed effluent. They may convey the impression that the matter has been resolved. However, in the longer term, because they tend to support *status quo* land uses and existing farming systems, the underlying environmental issues are usually not resolved. More fundamental changes in practices and land uses are not undertaken.

Remedy and mitigation enables an ongoing focus on production, growth, and various monetary/economic drivers because it is assumed that any difficulties will be managed. It may be based on unfounded optimism and confidence in research/science/technology to provide solutions. Further, remedy and mitigation can itself contribute to environmental problems by creating unintended consequences and unpredictable outcomes.

That said, remedy and mitigation is *vitaly important* and must be strengthened and

supported. In the first instance, it is valuable for fixing yesterday's problems. The current generation has inherited a considerable legacy of adverse impacts from long-term land uses – soil erosion and groundwater pollution eventually entering lakes and rivers for example.

6.2.4 Catalysing change

Addressing the threats and challenges and moving toward sustainable agriculture will require change at many levels of the overall system from behind the farm gate through to institutional structures and how commodity markets operate. Change will need to occur on a scale not currently being seen in New Zealand.

Part of catalysing this change is the need for dialogue and discussion in the farming sector and institutional structures to support this into the future. The barriers to greater progress should not be minimised and the key to overcoming them is likely to be widespread agreement on a vision for the future of farming in New Zealand and the range of actions needed to move towards it.

One way of looking at how to bring about change is recognising that there are a number of factors that influence the rate of adoption of new innovations. These include:

- *relative advantage to the farmer* – particularly relative financial advantage, as innovations that have a clear net financial cost are rarely adopted
- *complexity* – increases the risk of failure and the costs of gaining knowledge to make the innovation work
- *compatibility* – innovations are more likely to be adopted if they fit easily into existing production systems and accepted social/cultural practice
- *trialability and divisibility* – innovations which can be trialled on a small scale first are more likely to be adopted, for example, minimum till cultivation of one paddock rather than the whole farm
- *observability* – innovations whose advantages are observable are more likely to be adopted. Water quality controls often fail this test.¹¹⁰

Implementation should recognise these factors and develop strategies to address them.

6.3 Summary and key points

This chapter has reviewed emerging trends in the farming sector focused on sustaining the health of the environment and maintaining natural capital. There are many positive initiatives underway, certainly many more than could be touched upon here. We suggest these trends constitute *redesign* in farming, redesign in the sense of creatively developing new ways of farming which address problems created by previous and current systems. We have placed examples of the trends along a spectrum (see Figure 6.1) ranging from remedy and mitigation tools to whole systems redesign. This spectrum is intended to assist with identifying the characteristics of the variety of tools and approaches. However, its limitations are acknowledged. Not all activity fits tidily into one place on the spectrum.

Change will need to occur on a scale not currently being seen in New Zealand.

Some initiatives have elements that range across the spectrum. Tools when used in combination can illustrate progress along the spectrum.

Many of these initiatives share a number of characteristics, which are consistent with aspects of sustainable agriculture.¹¹¹ *Remedy and mitigation tools* tend to support existing farming systems and focus on a single issue or output, for example, treating dairy shed effluent. They can be described as end-of-pipe technologies. These tools are generally developed as a response to obvious environmental concerns. *Farming system redesign* involves adapting farming systems to avoid adverse environmental outcomes. The focus is more complex, expanded to include more than one issue and output, for example, implementing an environmental management/quality assurance system. It is generally proactive. *Whole system redesign* expands the focus still further to include what is happening beyond the farm, for example, integrated catchment management. It seeks to integrate farming into the wider social and environmental context either at a catchment level or through the food chain. The focus is on multiple issues and outcomes. It is both proactive and preventative.

Remedy and mitigation tools are often well understood and use engineering solutions. Farm system redesign is fairly well developed too, drawing on a long tradition of research and innovation. Examples of whole system redesign are more difficult to find. This end of the spectrum is moving toward sustainable agriculture. It is here that the PCE believes the focus needs to be in the future. There needs to be a much greater investment in whole systems redesign for sustainable agriculture.

These emerging trends are also, at least partly, a response to several of the risks and challenges raised in Chapter 5 and consequently to the drivers identified in Chapter 4. Unfortunately, there are a number of barriers to making further progress, the principal one being a lack of widespread acceptance of the need for change. Catalysing change and moving forward will require widespread dialogue, building on existing initiatives, and developing new farm systems and whole systems approaches.

The current trends are not inevitable. It is possible to choose new strategic directions, to create new outcomes. The decline in natural capital can and should be halted and reversed, for the sake of the environment itself and the sake of farming if it is to continue to be economically and socially sustainable over the long term.

CHAPTER

7

Moving forward



Although changes are already underway to address the environmental impacts of farming, there is little evidence that existing efforts will be sufficiently profound or widespread enough to maintain and enhance New Zealand's natural capital. The trends in the health of the environment continue downward. The trends in use of more material and energy inputs into farming systems continue to increase. Questions remain:

- will the types of innovations highlighted in Chapter 6 be sufficient to turn around the decline in environmental health and natural capital?
- or will they simply soften the curve and slow the decline?
- if they are only slowing the decline, are New Zealanders prepared to accept declining environmental quality?

7.1 The need for more fundamental changes

The evidence gathered in this report shows that more fundamental redesign of farming systems is required to address the depth of the problems identified. Farming systems need to be developed which deliver environmental sustainability *and* economic wealth, *not* short-term economic wealth at the expense of environmental sustainability. Moving forward will require drawing on and nurturing current activities *and* designing and implementing new approaches. All of the tools and approaches discussed in Chapter 6 have something to offer. It is not so much about finding a 'silver bullet' as using a variety of tools that in combination will contribute to improved outcomes.

It will not be enough to focus on change at the on-farm/local level only. Many powerful drivers originate from beyond the farm and will need to be addressed. A broad systemic approach is required – one that defines goals, removes barriers and develops strategies to support a transition to more sustainable agriculture within local and global environmental, economic, political and market contexts. This will include improving access to appropriate information, resources and technologies; the development of new skills and technologies; the provision of a range of institutional supports; the development of strategies for

sustainability and empowering people and organisations to take the necessary action.¹



Farming systems need to be developed which deliver environmental sustainability *and* economic wealth, *not* short-term economic wealth at the expense of environmental sustainability.

7.2 Redesign for sustainable farming

Most of the changes we must make are in our economic life. The systems of taxes, subsidies, regulations and policies through which governments motivate the behaviour of individuals and corporations continues to 'incent' unsustainable behaviours.²

In order to achieve sustainable environmental outcomes, redesign needs to occur more extensively at multiple levels of the whole farming/food system:

- *on the farm*, through the development of sustainable farming systems
- *regionally*, via approaches that integrate the activities of many farms, such as integrated catchment management
- *nationally*, through the development of central government policies, farming sector policies and codes of practice, new institutions and structures, market instruments and other measures which alter some of the drivers to ensure that environmental impacts are appropriately costed and valued and that changes made on the farm and regionally are supported
- *internationally*, through ensuring that international trade negotiations and rules support environmentally sustainable outcomes.

So what is needed to encourage these changes? Making changes will necessitate:

- widespread understanding and acceptance of the *strategic risks* involved in current farming systems
- understanding of the drivers that are shaping current farming systems and agreement on *adapting, changing and modifying some of the drivers* to ensure support for new farming systems
- understanding of the *farming systems research* needed to empower major redesign, and investment in the necessary research capabilities
- understanding of the *ecosystems research* and environmental monitoring at a catchment scale needed to maintain and enhance natural capital over long enough time scales, and investment in the necessary research capabilities
- provision of *strategic leadership and vision for environmentally sustainable farming* from within the farming/food sector
- implementing redesign for *environmentally sustainable farming* through integrated catchment management programmes
- widespread *participation and commitment* to developing new farming systems.

... redesign needs to occur more extensively at multiple levels of the whole farming/food system

7.2.1 Strategic leadership and vision

In the first instance, the most pressing requirement is for the farming sector to engage in an extensive dialogue on the issues raised in this report. The strategic risks identified during the course of this investigation (see Chapter 5) do not appear to be either widely understood *or* accepted within the farming sector. As Chapter 4 highlights, leadership in the sector, as indicated by some government policies and industry strategies, is strongly focused on production and productivity gains. Progress of a sufficient scale to address the cumulative damage to natural capital and loss of resilience in farming will not occur without widespread commitment from all parts of the farming sector. This includes farmers, rural communities, consumers, processors, exporters, service industries, financial institutions and government.

In terms of structures, this investigation identified a gap in the farming sector: a forum or place for a dialogue/discussion and synthesis of ideas and knowledge about the strategic opportunities, risks and directions for New Zealand's farming, food, and fibre businesses. People interviewed for this investigation also identified this gap. They want the opportunity to share in the on-going development of strategic ideas and innovations for farming *across* the various sectors not just within each one.

In short, there is a need for an organisation that can:

- stimulate a constructive dialogue around the future of New Zealand's farming sector and broader food systems
- facilitate wide engagement in that dialogue
- create a vision and direction for New Zealand farming which is more environmentally, economically, and socially sustainable
- facilitate research to support the dialogue and promote strategies to address changing needs.

In terms of organisational structure, one approach might be along the lines of a foundation or trust, collectively owned by many partners (i.e. the whole farming sector), and outside of Government (local and central) but partnered with it.

To be effective, a new vision and strategy for the future would need to be developed from within and owned by the farming sector. It would also need to recognise the interests of the general public and other industries (e.g. tourism) in maintaining the health of natural capital in New Zealand. Hence the need for an organisation that is capable of openly and freely engaging the diverse variety of individuals, groups and sectors involved in farming, with a view to developing collective strategic thinking.

This report is a contribution to the dialogue and discussion necessary to develop this understanding, but much more will be required. Widespread participation of the farming sector will be critical to fully understanding the risks *and* essential in getting commitment to change.

Proposal for Action:

In summary:

- the farming sector would benefit from the development of a strategic vision for the future which addresses the risks, challenges and opportunities raised in this report
- a new pan-sector institution may need to be developed to support this dialogue. At the present time no such structure exists.

The PCE will organise a workshop to promote this dialogue in the first half of 2005.

7.2.2 Sustainable farming systems

The shape and form of sustainable farming systems will depend on the nature of the vision for the future of the farming sector. Given the valuable work that is already occurring, it will be a matter of building on it while developing an understanding of the *farming systems research* needed to empower major redesign and investment in the necessary research capabilities.

More effort needs to go into research and development of tools and systems that contribute to sustainable farming systems. The characteristics of farming systems redesigned for sustainability have been discussed in Chapters 2 and 6. The focus needs to be moved along the redesign spectrum from tools for remedy and mitigation to approaches that adapt the whole farm system.

The on-going development of sustainable management systems in the farming sector shows considerable promise.³ However, two key issues need to be addressed. The primary focus of a number of these schemes is food safety, which, while critical, does not automatically lead to improved outcomes for the environment. Such schemes need to place more emphasis on environmental outcomes. The other issue is the need for independent certification and verification and systems to track products from farm to consumer. As noted in Chapter 4, the Government has a key role to play in verification and auditing regimes and facilitating the establishment of such schemes.

Proposal for Action:

In summary:

- enhance the investment in farming systems research to empower major redesign
- continue the development of sustainable management systems, with a particular emphasis on independent verification and auditing regimes.

It is *recommended* that:

- a) the Minister of Research, Science and Technology pay particular attention to farming systems research requirements during the development of the Foundation for Research, Science and Technology's investment strategy for 2004/05 to 2010/11.⁴
- b) the farming sector, assisted by the Ministry of Agriculture and Forestry, increase investment in developing and implementing sustainable management systems with a



particular emphasis on independent verification and auditing regimes.

7.2.3 Integrated catchment management

ICM provides a catchment wide organising framework for integrating redesign efforts on individual farms with activity beyond the farm. Much of the adverse environmental impacts we see are the end result of the cumulative impacts. An integrated framework is required in order to understand the relationships between all the activities and the environment,

and to ensure that individual redesign efforts cumulatively lead to the maintenance of natural capital. The capacity to integrate land use planning with water and soil planning is vital for providing the capacity to match activity to the environment and recognising that some activities may not be appropriate for the sensitivity of the surrounding environment.

Some of the necessary conditions to promote ICM are already in place through the provisions of the RMA and non-statutory project based efforts of the type discussed in Chapter 6. However, understanding what needs to happen at a catchment scale to maintain and enhance natural capital over long term time scales will require greater investment in ecosystem research, regular monitoring, and the necessary associated research capabilities.

In order to take ICM to the next level, consideration should be given to forming some type of Cooperative Research Centre (CRC) for ICM in New Zealand.⁵ The CRC approach involves partnerships between central and regional government, research providers, industry and the community. This ensures the specifically appropriate research outcomes to particular geographic areas (where the research is conducted) will have national transferability and relevance. It also ensures that regionally applied research funding is leveraged by contributions from central government for the national good.⁶

What is also required is a way of taking best practice management models and using them to inform a strategic approach to ICM. The process needs to be led and funded by central government.⁷ In particular, these best practice models have the potential to:

- clearly define ICM for a New Zealand context
- identify frameworks for environmental issue identification and prioritisation
- inform multi-stakeholder catchment management planning
- identify the causes of environmental pressures and evaluate the effectiveness of environmental responses

- evaluate the implementation of sustainable land practices including environmental and socio-economic costs and benefits
- evaluate the suitability of land use activities (farming) in relation to the natural and physical resources available
- raise public and stakeholder awareness of integrated catchment management
- establish trust between government, industry, science and the community.

Funding is a critical barrier to developing ICM more extensively in New Zealand.⁸ Much of the funding for either research or implementation is limited and/or short-term and the benefits of ICM will not show over the short-term. A key to the development of whole farm systems is greater investment in long-term research trials (taking the Whatawhata sustainable land management project⁹ as an example).

Proposal for Action:

It is *recommended* that:

- a) the Minister of Research, Science and Technology pay particular attention to ICM research requirements during development of the Foundation for Research, Science and Technology's investment strategy for 2004/05 to 2010/11.¹⁰
- b) local government pays particular attention to supporting and resourcing ICM initiatives when developing plans under the RMA, and annual plans and long-term council community plans under the LGA.

7.2.4 Transforming drivers

Creating commodity systems that serve a broader range of goals will require incorporating those other goals into the structure of the rules and incentives that shape the behaviour of commodity systems. Sustainable commodity systems will need to be much richer in information, full of the details that have been so intentionally stripped away in the process of commodification.¹¹

For the reasons outlined in Chapter 4, commodity markets do not tend to account for damage to natural capital and community decline that can occur as a result of intensified farming production. The dialogue proposed in Section 7.2.1 will need to incorporate a discussion on how commodity markets can be adapted to address these issues and seek agreement on transforming drivers. Given the strength and complexity of the drivers, collective action will offer the greatest likelihood of success.¹²

A variety of policy instruments already exist that can be used to adapt drivers (see Chapter 6). New Zealand has tended to rely on non-market based instruments. The 'stick' has not been very big and neither has the 'carrot'. There is a need to broaden the range of instruments used. More comprehensive packages need to be trialled to develop understanding of the most useful combinations for New Zealand conditions. The Lake

Taupo initiative is a potentially successful example of a package using combinations of regulation, economic instruments, education and partnerships.

Proposal for Action:

The PCE will monitor the impact of the Sustainable Development Programme of Action, which may be expected to address some of these issues.

The PCE may also carry out an investigation into the use of economic instruments.¹³

7.3 Other research needs

This investigation has been broad-based and focused at a high level. A number of potentially important issues could not be addressed adequately (see Chapter 1 for what the investigation does not cover). In this context a number of matters have been identified which may merit further research either to understand drivers more fully or to understand the nature of the redesign required to move toward more sustainable farming.

Soil is one area where there are a number of issues which require better understanding if soils are to continue to have the capacity to support farming. These include:

- intensification and soil functioning – the ability of soils to provide ecosystem services while under pressure from intensive farming
- managing land use change – the capacity to predict the performance of new farming systems on soils not traditionally used for that type of farming
- valuing the natural capital of soils and methodologies for assessing such value
- soil functioning and soil ecosystem behaviours.¹⁴

As this report goes to print, a research proposal to address some of these issues, from four CRIs and funded by FRST, is being finalised. This is welcome recognition of the importance of soil and land use research to our ecological and economic futures.

Other issues include:

- understanding what type of farming system is appropriate (i.e. will not compromise natural capital) to a particular catchment and recognising when the receiving environment in a catchment is too sensitive for farming to occur
- the effect of rising farming asset values on how the overall farming system functions
- the effect of the rising dominance in the food system of supermarkets.

The likelihood of major degradation to natural capital is too high to postpone action.

7.4 Areas for focus

While there is clearly need for dialogue in the farming sector before further actions are identified and agreed to, some matters require immediate progress. The likelihood of major degradation to natural capital is too high to postpone action. Three of these are discussed briefly in the sections below.

7.4.1 Non-point source pollution

This investigation has clearly identified non-point source pollution from farming systems as a significant risk to New Zealand's environment and to the future of farming itself.

Remediating, mitigating and ultimately avoiding non-point source pollution must be a priority for the farming sector and a key focus for farm system redesign in order to maintain and enhance natural capital, specifically fresh water and soils.

Nutrient management

Nutrient management stands out as the area requiring *significant, immediate* focus, particularly in respect of nitrogen fertiliser use.

In the short-term, New Zealand needs to move rapidly to a situation where all farmers are using nutrient management plans and tools which balance nutrient inputs with plant uptake and minimise nutrient outputs which cause environmental damage. A suite of tools, management practises and policy instruments are available (some of which have been discussed in Chapter 6). Given the declining trends in the quality of the environment, particularly fresh water, it would appear the voluntary approaches used to date are not sufficient. Regulation will probably be required. The exact type of approach would be best developed with the characteristics of individual catchments in mind.

In the medium and long-term, research needs to focus on developing highly productive farming systems which do not require high levels of synthetic fertilisers in order to achieve that productivity. Expansion of soil research will be a critical part of this farm systems research.

Faecal contamination from animals

The other key risk to the quality of the environment and to the health of people is contamination arising from animal faecal matter. A variety of tools discussed in Chapter 6 help reduce the discharge of these contaminants into waterways. However, it is unclear whether these approaches will be sufficient. Further research is required.

Proposal for action:

Further work is required to advance the management of non-point source pollution, ranging from changes on-farm, to new planning provisions, to new research. A number of institutions can be expected to take a lead:

- farming industry organisations
- regional councils
- research institutions
- research funding agencies such as FRST
- MAF through the Sustainable Farming Fund.

7.4.2 Fresh water

Many New Zealanders highly value clean fresh water but there is strong evidence that fresh water quality is declining in farming areas (see Chapter 5). If left unchecked, over time New Zealanders will lose access to clean fresh water in the wider environment.

Farming clearly contributes to declining fresh water quality, although many other land use activities do as well. Managing fresh water requires an integrated approach across rural and urban areas and at national, regional and local levels.

Major fresh water issues that must be addressed include:

- water quality and water pollution
- abstraction and allocation
- valuing and pricing
- efficiency of water use, particularly irrigation
- poor stakeholder awareness of issues
- indicators for fresh water quality and quantity.

Proposal for action:

The current Government's Water Programme of Action is a vital policy programme that is addressing some of these issues. The PCE will monitor and report on the impact of this programme over the next few years.

7.4.3 Indicators for sustainable agriculture and the state of the environment

An area for immediate focus is the selection and implementation of indicators that will provide information on the sustainability of farming systems and the state of our natural capital (see Appendix 2 for a summary of sustainable agriculture indicators). As noted in Chapter 3, New Zealand does not currently have a well-developed national set of environmental and social indicators for farming. The farming sector generally has a variety of established economic and production indicators and good data ranging over long time sequences for those indicators. The dairy sector, for example, carries out detailed monitoring related to milk production while the sheep and beef sector monitors lambing rates and carcass weights. The farming sector needs similar information about the state of its natural capital which farmers can then use to adapt farming systems accordingly.

Benefits would include:

- early identification of trends in the health of the environment and potential threats to natural capital
- reliable data which informs and demonstrates the need for change to farming systems
- the capacity to clearly identify environmental quality and sustainability and demonstrate it to consumers, internationally and nationally.

This is an area of focus in which it would be appropriate for the Government to take the lead. A national framework will need to be developed and implemented. Indicators for sustainable farming will also need to be integrated with the indicators programme for the state of the environment (SOE).¹⁵ SOE information is vital for placing farming within the broader environmental context. Both of these areas of focus will of course need to be integrated into the Government's work on monitoring progress toward sustainable development.¹⁶

Proposal for action:

It is *recommended* that:

- a) the Minister of Agriculture and Forestry take the lead on the development and implementation of a programme of indicators for sustainable farming
- b) the Minister for the Environment ensure that the SOE indicators programme is completed and implemented as soon as possible with a focus on a limited suite of key indicators.

7.5 Further PCE involvement

The usual practice of the PCE is to back-up the release of a report by carrying out workshops and speaking engagements that provide opportunities for people to engage in the findings of the investigation. In the case of this report, this phase will be particularly vital because of the need for dialogue in the farming sector about the risks, challenges and opportunities identified in this report. In the first instance, the PCE will organise workshops in the four regions originally visited: Southland, Canterbury, Hawke's Bay and the Waikato. Other opportunities will be taken-up as and when they arise.

Some issues have been identified as matters that the PCE may investigate further. These include:

- the system of science funding and provision and how it contributes to the maintenance and enhancement of the natural capital of farming
- the Government's Water Programme of Action and other fresh water related issues
- aspects of the implementation of the RMA particularly in relation to the environmental outcomes arising from farming.¹⁷

A number of the themes raised in this report with respect to the need for research and environmental policy making have also been canvassed in a recent PCE report *Missing links: Connecting science with environmental policy*.¹⁸ *Missing links* focuses on the complex issues that face environmental policy makers, and analyses ways in which science, research and technology can be used more effectively to address such issues. In doing so, it examines how the links between science, policy-making and the public interest can be strengthened to engender confidence in the way policies are developed and what they will achieve. It highlights some approaches to improving science-policy-stakeholder links, relationships and communication. Approaches such as adaptive management, integrating scientific perspectives, participatory and learning systems in the policy cycle, and the role

of 'boundary organisations' are explored. *Missing links* concludes with suggestions for forging better links and developing better processes to deal with complex environmental policy issues. Recommendations for further action are directed towards environmental policy makers in general, and the Minister for the Environment and the Minister of Research, Science and Technology in particular.

Glossary and acronyms

Acidification	The process of becoming acid or being converted into an acid
Adenovirus	Viruses associated with a variety of mammalian respiratory infections including the common cold
Agenda 2000	An action programme launched in 1999 to provide the European Union with more effective policies and a financial framework over the period 2000 to 2006. It includes a package for further agricultural reform.
Agri-environmental policies	Policy measures that aim to address environmental issues in agriculture. These policies may be specific to the agricultural sector, or they may be part of broader national environmental programmes that affect many sectors including agriculture.
Agronomy	The science of soil management and crop production
Anaerobic digester	A biochemical degradation process by which complex organic matter such as animal manure is converted into methane and other by-products
ANZECC	Australia and New Zealand Environment Conservation Council
APS	Advanced pond system
Atmosphere	The layer of gases and dust surrounding the earth
Benthic algae	Algae that live on or near the bottom of a water body
Biodiversity	The variety of all biological life (plants, animals, insects, fish, birds, invertebrates and micro-organisms), the genes they contain, and the ecosystems and habitats in which they live
Biomass	The total quantity of matter in an organism
Biopharming	Growing genetically modified plants to be used in creating pharmaceuticals
Biosphere	That part of the earth and its atmosphere inhabited by living organisms
BOD	Biological oxygen demand. The amount of dissolved oxygen consumed in a water sample by

	micro-organisms as they decompose organic matter. BOD is used as an index of organic pollution, such as sewage – the higher the BOD reading, the more polluted the waterway.
BSE	Bovine Spongiform Encephalopathy; Mad Cow disease
CAP	Common Agricultural Policy of the European Union
Catchment	The area of land drained by a river and its tributaries
Codes of Practice	Set out best management practices, usually on specific issues or for specific sectors. They are usually voluntary, although they may form the basis for standards or other regulatory systems.
Commodity	An object that is produced for the purpose of being exchanged through markets (usually for money)
Commodity potential	The potential of a good or service to carry the qualities of a commodity
Commoditisation	The process of preferentially developing goods and services that are most suited to functioning as commodities.
Cost externalisation	Contributing to environmental degradation and/or harming other individuals or groups in society and not paying for these costs of production. In such a case, the private costs of production tend to be lower than their actual 'social' cost.
CRC	Cooperative Research Centre
CRI	Crown Research Institute
Dairying and Clean Streams Accord	A framework between Regional Councils, the Ministry for the Environment, the Ministry of Agriculture and Forestry and Fonterra to promote more sustainable dairy farming in New Zealand
DAP	Diammonium phosphate
DCD	Dicyandiamide, a nitrification inhibitor
Direct energy	The energy required to produce a good or service
DM	Dry matter

DoC	Department of Conservation
Doha Round	Multilateral trade negotiations that are currently taking place in Doha, Qatar. The negotiations cover agricultural reforms.
DRP	Dissolved Reactive Phosphorus
EBIT	Earnings before interest and tax
ECan	Environment Canterbury
<i>E. coli</i>	<i>Escherichia coli</i> . A bacterium.
Ecosystem	A dynamic complex of plant, animal and micro-organism communities and their non-living environment interacting as a functional unit
Ecosystem services	The transformation of natural capital (soil, plants and animals, air and water) into things that people value
Embodied energy	Energy required directly and indirectly in the production of a good or service
End of pipe	Technologies that reduce emissions of pollutants after they have formed
EMS	Environmental Management Systems. A set of procedures developed and used by businesses to reduce environmental risk and impacts on the environment. The nature of EMS will vary depending on the organization and its requirements.
EU	European Union
EUREP-GAP	Euro-Retailer Produce Working Group – Good Agricultural Practice
Eutrophication	A naturally occurring, slow process of ageing of water bodies such as lakes, slow moving streams, and estuaries, whereby nutrient levels increase and the water body gradually fills in. Unfortunately, some human activities increase the rate of nutrient input into waterways and eutrophication is greatly accelerated. These activities include the application of agricultural fertilisers, leaking septic tanks, and urban runoff. Eutrophication occurs when elevated nutrient levels over-stimulate algal growth, reducing water clarity, and levels of oxygen in the water. These conditions affect the

	health and diversity of indigenous fish, plant, and animal populations, and also affect recreational water use.
Evapotranspiration	The total water loss from a particular area, being the sum of evaporation from the soil and transpiration from vegetation
EW	Environment Waikato
Export Subsidies	Government payments or other financial contributions provided to domestic producers or exporters if they export their goods and services (i.e. contingent on export performance)
FAR	Foundation for Arable Research
Farm gate price	The price farmers receive for their products
GATT	General Agreement on Tariffs and Trade
GDP	Gross domestic product
GPS	Global Positioning Systems
FRST	Foundation for Research Science and Technology
GIAB	Growth and Innovation Advisory Board
GIF	Growth and Innovation Framework
GMO	Genetically modified organism
Grasslands revolution	A term used to describe the period after 1919 in New Zealand when there was a huge increase in farming output as a result of increased fertiliser use and planting of exotic pastures.
Hapu	Family or district groups, communities
HSNO	Hazardous Substances and New Organisms Act 1996
Hydrosphere	The collective mass of water that is found under, on and over the surface of the earth.
Hypoxia	Absence of oxygen
ICM	Integrated Catchment Management
IFP	Integrated Fruit Production
Indirect energy	Energy embodied in products that are consumed in producing a good or service

Integrated catchment management	A process through which people can develop a vision, agree shared values and behaviours, make informed decisions and act together to manage the natural resources of their catchment. Their decisions on the use of land, water and other environmental resources are made by considering the effect of that use on all those resources and on all people within the catchment.
IPM	<p>Integrated Pest Management.</p> <p>This focuses on a careful consideration of all available pest control techniques and the subsequent integration of appropriate measures that:</p> <ul style="list-style-type: none"> discourage the development of pest populations keep pesticides and other interventions to the levels that are economically justified reduce or minimise risks to human health and the environment
Iwi	Tribal groups
Kaitiaki	Iwi, hapu, or whanau group with the responsibilities of kaitiakitanga
Kaitiakitanga	The ongoing necessity for tangata whenua to look after taonga, both physical and intangible, that are their heritage.
Leaching	The process by which solids are dissolved and filtered through the soil by a percolating fluid (e.g. water)
LGNZ	Local Government New Zealand
MAF	Ministry of Agriculture and Forestry
MAV	Maximum acceptable value
MFE	Ministry for the Environment
Mid Term Review	A review of reforms to Europe's Common Agricultural Policy conducted halfway through implementation of Agenda 2000
MS	Milksolids
Natural capital	The renewable and non-renewable stocks of natural resources that support life and enable all social and economic activities to take place

Non point source pollution	Diffuse sources of pollution
Nr	Reactive nitrogen
Nutrient budget	Budget of nutrient inputs and outputs
OECD	Organisation for Economic Co-operation and Development
ORC	Otago Regional Council
OVERSEER	A nutrient budgeting model created by AgResearch
Pasture	Mixed communities of plant species adapted to being grazed
PCE	Parliamentary Commissioner for the Environment
Periphyton	Benthic algae that grow attached to surfaces such as rocks or larger plants
pH	Measure of acidity or alkalinity
Planktonic algae	Algae that float passively in water, that is they are not attached to rocks or plants
Point source pollution	A single identifiable source of pollution
Producer support estimate	A measure of government trade and policy interventions in farming
QA	Quality Assurance programmes. These have a focus on ensuring the quality of the product meets consumer requirements. Safety is a key component of food based QA systems. While such programmes may include components that address wider issues, such as environmental matters, this is subsidiary to the focus on a quality product.
R & D	Research and development
RAMSAR	RAMSAR Convention on Wetlands, 1971
Rangatiratanga	The right of iwi, hapu and whanau to make their own decisions about things that concern them
Redesign	Purposefully changing or adapting practices, and the broader systems that shape those practices, to meet specific goals or values
Rohe	Geographical territory of an iwi or hapu

RMA	Resource Management Act 1991
Salinisation	Process of the build up of salts within soil
SMS	Sustainable Management Systems
SPASMO	Soil Plant Atmosphere System Model
Standards	A standard may be a required set of principles or practices which have a degree of regulatory force – that is a set of criteria that must be met. A standard may be an industry developed set of protocols which establish ‘best practice’ and are a benchmark for the industry but are not necessarily required or legally have force.
Stratosphere	The atmospheric layer that is between 15 and 50 kilometres above the earth’s surface
Stratospheric ozone	Ozone that is found in the stratosphere
Synthetic	A substance or material that is made artificially by chemical reaction
System	A group of elements, which are interdependent (either directly or indirectly) with each other
Takiwa	Area
Tangata whenua	People of the land, Maori people
Tariff	A tax levied on imports of goods as they cross the border
Taonga	Valued resources, assets, prized possessions both material and non-material
Tectonism	Plate tectonic activity
Terrestrial	Of the land
Tikanga	Customary correct ways of doing things
Tile and mole drain	A form of subsurface drainage, used under pasture
Trade liberalisation	The process of lowering national rules and regulations that restrict or manage trade in goods, services and intellectual property
Troposphere	The lower part of the Earth’s atmosphere
Tropospheric ozone	Ozone found in the troposphere
UNEP	United Nations Environmental Programme

Uruguay Round	Multilateral trade negotiations from 1986 to 1994 that brought about massive changes to the world's trading system
Waahi tapu	Special and sacred places
Whakapapa	Genealogy, ancestry, identity with place, hapu and iwi
Whanau	Family groups
WTO	World Trade Organisation

Endnotes

Preface

¹ Foran, 1993

Chapter 1

- ¹ For the sake of simplicity, the term 'farming' is used in this report to refer generically to animal farming, horticulture, fruit growing, viticulture and arable crop growing—the principal forms of intensive farming that have been the focus of this investigation. Farming is also used synonymously with similar terms like 'agriculture' and 'primary production'.
- ² Statistics New Zealand, 2004
- ³ Statistics New Zealand, 2003a
- ⁴ 'No. 8 wire' is a metaphor for Kiwi innovation, based on the myth that almost anything on the farm can be fixed with a piece of number eight wire and a bit of ingenuity.
- ⁵ See PCE (2000a); PCE (2001a); PCE (2002a) and PCE (2002b).
- ⁶ PCE, 2002a
- ⁷ For more information see www.pce.govt.nz or PCE (2003a).
- ⁸ Initially we did not focus on the sheep and beef sector, as it is generally considered to be an extensive (in contrast to intensive) form of farming. However, as work on this report progressed it became clear that sheep and beef farming is also becoming more intensive, so we undertook further research in this sector.
- ⁹ See PCE (2003a) for an outline of the Commissioner's work programme. The investigation into the RMA will commence after existing amendments to this legislation have been finalised.
- ¹⁰ See PCE (2000a).

Chapter 2

- ¹ An ecosystem is a dynamic community of plant, animal and micro-organism populations and their environment, which interact together as a whole. Human, crop and livestock populations are an integral part of farming ecosystems and are not external to the functioning of the ecosystem.
- ² Feenstra *et al.*, 1997. See also MAF (2000c).
- ³ The focus of this report is on *food* production, as highlighted in Chapter 1, although more intensive farming systems have obviously developed for fibre production as well.
- ⁴ Johnston *et al.*, 2000
- ⁵ For example see Pretty (1998); Johnston *et al.* (2000); Feenstra *et al.* (1997) and Sullivan (2003).
- ⁶ For example, more food can often be produced by fewer and fewer farmers, with reduced labour demands (and associated impacts on employment and rural communities).
- ⁷ For example see Matson *et al.* (1998) for a discussion on fertiliser management.
- ⁸ Human populations are not usually included as a 'stock' within this category. Renewable *flow* resources, such as solar radiation and wind resources, are not included as part of the stock of natural capital either—they can be considered as *services* of natural capital (Perman *et al.*, 1999).
- ⁹ Based on Statistics New Zealand (2002a).
- ¹⁰ For examples see Perman *et al.* (1999).
- ¹¹ For much more detailed information on ecosystem services and how they relate to farming see Binning *et al.* (2001) and Cork *et al.* (2001).
- ¹² OECD, 2001b
- ¹³ PCE, 2002a
- ¹⁴ OECD, 2003: 7
- ¹⁵ For more detail see Gold (1999).
- ¹⁶ For further summaries see Sullivan (2003) and Neher (1992).
- ¹⁷ Moseley and Jordan, 2001
- ¹⁸ See for example Hawken *et al.* (1999).
- ¹⁹ Ministry of Agriculture and Fisheries, 1993: iii. This Ministry was later restructured into the

Ministry of Agriculture and Forestry.

- ²⁰ For example see Growth and Innovation Advisory Board (2004).
- ²¹ Donald Worster quoted in Hawken *et al.*, 1999
- ²² Young and Crawford, 2004. One handful of soil may contain 10^{12} bacteria, 10^4 protozoa, 10^4 nematodes, 25km of fungi, and countless other species.
- ²³ For discussion on the contested meanings of sustainable agriculture in the early 1990s, see Olson (1992).
- ²⁴ Ministry of Agriculture and Fisheries, 1993: v. This Ministry was later restructured into the Ministry of Agriculture and Forestry.
- ²⁵ Clay, 2004: 62
- ²⁶ PCE, 2002a
- ²⁷ *ibid.* See also Hill (1992).
- ²⁸ See also OECD (2003); PCE (2002a); Pretty (1995); Pretty (1998); MAF (1993); Feenstra *et al.* (1997); Clay (2004) and Olson (1992). This list of principles is not intended to be exhaustive and, as noted in Chapter 1, the major focus of this report is on sustaining natural capital.
- ²⁹ As Holling and Walker (2003: 1-2) note, "Resilience, *per se*, is not necessarily a good thing. Undesirable system configurations (e.g. Stalin's regime, collapsed fish stocks) can be very resilient, and they can have high adaptive capacity in the sense of re-configuring to retain the same controls on function. Building resilience of a desired system configuration requires increasing the adaptive capacity of structures and processes (social, ecological, economic) that help maintain this configuration."

Chapter 3

- ¹ Statistics New Zealand, 2003a
- ² Adapted from Glasby (1991) and Belich (2001).
- ³ Statistics New Zealand, 2004
- ⁴ MAF, 2004a
- ⁵ *ibid.*
- ⁶ Statistics New Zealand, 2003a
- ⁷ In the absence of data for all nitrogen fertilisers, urea fertiliser data has been used to illustrate trends in New Zealand farming.
- ⁸ For irrigation we have based the trends on land under irrigation instead of the actual amount of water used in a given year. This provides a more reliable picture, as actual water use is strongly influenced by climatic factors that are highly variable over time.
- ⁹ Statistics New Zealand, 2003a
- ¹⁰ MAF, 2000a
- ¹¹ Livestock Improvement Corporation (LIC), 2003
- ¹² MAF, 2000a
- ¹³ *ibid.*
- ¹⁴ Statistics New Zealand, 2003a
- ¹⁵ *ibid.*
- ¹⁶ LIC, 2003
- ¹⁷ Statistics New Zealand, 2003a
- ¹⁸ Wells, 2001
- ¹⁹ Initially we did not focus on the sheep and beef sector, as it is generally considered to be an extensive (in contrast to intensive) form of farming. However, as work on this report progressed it became clear that sheep and beef farming is also becoming more intensive, so we undertook further research in this sector.
- ²⁰ Meat and Wool Economic Service (MWES), 2003b
- ²¹ *ibid.*
- ²² MAF, 2000a
- ²³ MWES, 2004b
- ²⁴ MWES, 2000
- ²⁵ MWES, 2004b
- ²⁶ Statistics New Zealand, 2003a

- ²⁷ MWES, 1982; MWES, 2003a. We have used data from the Meat and Wool Economic Service's Annual Farm Surveys. This survey classes New Zealand Sheep and Beef farms into eight classes, based on geographical location and land type. The eight classes are: South Island High Country; South Island Hill Country; North Island Hard Hill Country; North Island Hill Country; North Island Intensive Finishing farms; South Island Finishing-Breeding farms; South Island Intensive Finishing farms and South Island Mixed Finishing farms (Further information on the farm classes can be found in the MWES 2003a: 8). As the focus of this report is on intensive farming, we have used data from the Annual Farm Surveys from the three classes which are more intensive in nature than the other classes: North Island Hill Country, North Island Intensive Finishing and South Island Intensive Finishing. These three classes generally have farms with smaller land area, and higher stocking rates per hectare than farms in other classes, which may be regarded as being more extensive in nature. While recognising that there may be intensification occurring in other classes, this is the best available data.
- ²⁸ MWES, 1982; MWES, 2003a. A stock unit the equivalent of one breeding ewe, weighing 55 kilograms. Thus a cow is 5.5 units. For further discussion of calculation of stock units see MWES 2003a: 12
- ²⁹ MWES, 2004b
- ³⁰ MWES, 1982; MWES, 2003a
- ³¹ MWES, 2003a; MWES, 2003b
- ³² Bray, 2004. The increased lambing rate is also due to a number of other factors such as better feeding of ewes prior to mating, greater use of scanning of pregnant ewes and subsequent better feeding and care, increased use of fertility drugs, increased selection of flocks for fertility, and changes in breed type (MWES, 2004a).
- ³³ MWES 1992; MWES, 2003a
- ³⁴ MWES, 2003a
- ³⁵ MWES 1992; MWES, 2003a
- ³⁶ Note that these statistics encompass *all* fertiliser use (N, P, K and S) by *intensive* sheep and beef farms. Urea fertiliser data was not available for intensive sheep and beef farms. Fertiliser statistics used in Section 3.3.2 and in Chapter 5 are for the *entire* sheep and beef sector.
- ³⁷ *ibid.*
- ³⁸ MAF, 2003a
- ³⁹ MAF, 2000a
- ⁴⁰ *ibid.*
- ⁴¹ *ibid.*
- ⁴² Hegarty *et al.*, 2001
- ⁴³ MfE, 1997a
- ⁴⁴ Statistics New Zealand, 2003a
- ⁴⁵ *ibid.*
- ⁴⁶ Lincoln Environmental, 2000c; Statistics New Zealand 2003a
- ⁴⁷ Statistics New Zealand, 2003a
- ⁴⁸ Statistics New Zealand, 1996, 2003a
- ⁴⁹ Statistics New Zealand, 1996, 2003a
- ⁵⁰ Statistics New Zealand, 2003a
- ⁵¹ <http://www.nzwine.com/statistics>
- ⁵² *ibid.*
- ⁵³ Statistics New Zealand, 2003a
- ⁵⁴ *ibid.*
- ⁵⁵ MAF, 2003b
- ⁵⁶ *ibid.*
- ⁵⁷ Statistics New Zealand, 2003a
- ⁵⁸ Statistics New Zealand, 1996; Statistics New Zealand, 2003a
- ⁵⁹ Lincoln Environmental, 2000c
- ⁶⁰ Wells, 2001. One gigajoule = 1,000,000,000 joules or 1000 megajoules. A joule is a unit of measure for work and energy.
- ⁶¹ *ibid.*
- ⁶² Statistics New Zealand, 2003b. Of the more than 2.3 million tonnes of synthetic fertiliser used in New Zealand agriculture for the year ending June 2002, 52 percent of that was phosphate fertiliser, 33 percent nitrogen fertiliser, and 15 percent potassic fertiliser.

- ⁶³ Statistics New Zealand, 1996; Statistics New Zealand, 2003b
- ⁶⁴ The data for this figure come from the Ministry of Economic Development's Energy Data Files, which use the category of 'agriculture and hunting.' In 1992 this sector used 10.30 PJ/annum and in 2002 13.46 PJ/annum.
- ⁶⁵ EECA, 2003
- ⁶⁶ See, for example, Baber and Wilson, 1972; Smith *et al.*, 1993; MfE, 1997a; Parkyn *et al.*, 2002.
- ⁶⁷ Lincoln Environmental, 2001a
- ⁶⁸ New Zealand Herald, 2002
- ⁶⁹ *ibid.*
- ⁷⁰ Whilst recognising that soil erosion is a major issue in New Zealand, it has not been the focus of this report.
- ⁷¹ Williams, 2001
- ⁷² MfE, 1997a
- ⁷³ *ibid.*
- ⁷⁴ Krause *et al.*, 2001. See Chapter 5 for further discussion about soil erosion and sedimentation.
- ⁷⁵ MAF, 2002a
- ⁷⁶ *ibid.*
- ⁷⁷ MED, 2000
- ⁷⁸ *ibid.*
- ⁷⁹ New Zealand Climate Change Office, 2004a
- ⁸⁰ New Zealand Climate Change Office, 2004b
- ⁸¹ MAF, 2000b
- ⁸² For more information see <http://www.minedu.govt.nz/index.cfm?layout=document&documentid=8689&indexid=8697&indexparentid=6088>
- ⁸³ MOH, 1999
- ⁸⁴ Data is available from the 2001 census.
- ⁸⁵ MAF, 1994
- ⁸⁶ Department of Labour, 2004; Morriss *et al.*, 2001
- ⁸⁷ Morriss *et al.*, 2001. However, as the authors of this report note, a lack of clear and consistent data in New Zealand makes it very difficult to analyse student and graduate numbers with any certainty. Furthermore, while University and Polytechnic enrolments have declined in recent years, there has been a significant rise in trainees registered for industry training in the farming sector. This suggests that some people may be pursuing training programmes instead of more in-depth and expensive University or Polytechnic courses.

Chapter 4

- ¹ OECD, 2001a
- ² For example see Wilkinson (1996) and Townsley *et al.* (1997).
- ³ See background reports *Food market and trade risks* (Saunders *et al.*, 2004); *The food production revolution* (Saunders and Ross, 2004); and *Incentives for intensification* (Watters *et al.*, 2004).
- ⁴ For more information see background report *Food market and trade risks* (Saunders *et al.*, 2004).
- ⁵ Export subsidies are considered to be the most distorting trade policies. They depress world prices and undermine unsubsidised exporters such as New Zealand by allowing uneconomic producers to export. The European Union is currently the largest user of export subsidies (approximately 2 billion Euro per year).
- ⁶ GATT still exists as the WTO's umbrella treaty for trade in goods, updated as a result of the Uruguay Round negotiations.
- ⁷ However, the WTO does not currently intend to set environmental standards. The WTO states that it is only competent to deal with trade issues and that it only studies environmental issues that arise when environmental policies have a significant impact on trade. See www.wto.org for more information.
- ⁸ Producer Support Estimates measure the monetary value of transfers from consumers and budgetary payments to farmers.

- ⁹ OECD, 2004. Price support occurs only for poultry and eggs (due to border measures). Most other support is for general services, such as basic research and for the control of pests and diseases.
- ¹⁰ There are also no mechanisms in place to purchase the ecological services provided by farms.
- ¹¹ See www.wto.org for more information.
- ¹² OECD, 2001a
- ¹³ Background report *Food market and trade risks* (Saunders *et al.*, 2004)
- ¹⁴ Under existing rules, a WTO member cannot unilaterally restrict trade because of the environmental effects of its production in the exporting country.
- ¹⁵ The USA is obviously a very important export market for New Zealand and an influential player in world trade negotiations as well. However, for purposes of brevity, we have not discussed the USA's agricultural policies in this report. The spotlight on the European Union was chosen to illuminate the magnitude of changes in agricultural environmental policies in this part of the world over recent years. Further information is available in background report *Food market and trade risks* (Saunders *et al.*, 2004).
- ¹⁶ Background report *Food market and trade risks* (Saunders *et al.*, 2004)
- ¹⁷ *ibid.*
- ¹⁸ See www.europa.eu.int/pol/agr/overview_en.htm for more information.
- ¹⁹ See MAF and MFAT (2002).
- ²⁰ As noted in Chapter 2, the impacts of further intensification on natural capital will depend on how farming systems intensify (e.g. using more materials and energy compared with developing human capital and expertise).
- ²¹ Sustainability Institute, 2003
- ²² Sustainability Institute, 2003; Manno, 2002
- ²³ Manno, 2002: 70
- ²⁴ For more information see Manno (2002) and background report *The food production revolution* (Saunders and Ross, 2004).
- ²⁵ Sustainability Institute, 2003
- ²⁶ Sustainability Institute, 2003; Background report *The food production revolution* (Saunders and Ross, 2004)
- ²⁷ Sustainability Institute, 2003
- ²⁸ See www.zespri.com for more information.
- ²⁹ Princen, 2002
- ³⁰ Sustainability Institute, 2003: 5
- ³¹ Background report *Food market and trade risks* (Saunders *et al.*, 2004)
- ³² See for example Schlosser (2002).
- ³³ Background report *Food market and trade risks* (Saunders *et al.*, 2004)
- ³⁴ All growers of fresh fruit, vegetables and flowers that wish to do business with supermarket Tesco in the United Kingdom need to meet strict rules protecting wildlife and the land. These rules are being introduced to suppliers around the world, including New Zealand. These rules may also cover produce from livestock in the future. See www.tesco.com for more information.
- ³⁵ MAF, 2003d: 14
- ³⁶ Webb *et al.*, 2004
- ³⁷ These supermarkets are ASDA Wal-Mart, Tesco, Sainsbury and Safeway. See Hird (2000).
- ³⁸ A. Watters, Nuffield Fellow, pers. comm., 4 June 2004.
- ³⁹ Royal Institute of International Affairs and New Scientist Conference. *Consumers, farmers and food: Reconciling the future*. Chatham House, 5-6 July 2004.
- ⁴⁰ Hird, 2000
- ⁴¹ Background report *Food market and trade risks* (Saunders *et al.*, 2004)
- ⁴² See for example the discussion on Europe and the United Kingdom in Section 4.2.1 and OECD (2003).
- ⁴³ MFAT, 2003
- ⁴⁴ <http://www.mfat.govt.nz/foreign/tnd/wtonz/agricultural.html>. See also MAF (2003d).
- ⁴⁵ New Zealand Government, 2002
- ⁴⁶ Department of Prime Minister and Cabinet, 2003
- ⁴⁷ New Zealand Government, 2002: 12

- ⁴⁸ Ministry of Economic Development, 2003
- ⁴⁹ MAF, 2003d
- ⁵⁰ Department of Prime Minister and Cabinet, 2003: 6
- ⁵¹ Department of Prime Minister and Cabinet, 2003: 10
- ⁵² See www.mfe.govt.nz/issues/water/prog-action/index.html for more information.
- ⁵³ Another example of this type of restructuring can be seen in the wine industry where the Wine Act 2003 replaced the Wine Makers Act 1981 and Wine Makers Levy Act 1976.
- ⁵⁴ For more information on these programmes see The AgriBusiness Group (2004).
- ⁵⁵ Brassica is a group of plants belonging to the mustard family. It includes broccoli, brussel sprouts, cabbage, cauliflower, collards, kale, kohlrabi, mustard, rape, rutabaga and turnip.
- ⁵⁶ KiwiGreen, in its current form is essentially a Quality Assurance programme, but the addition of EUREP-GAP requirements extends the scope of issues for consideration and is more inclusive of Environmental Management System approaches in the revised format.
- ⁵⁷ For more information see background report *The food production revolution* (Saunders and Ross, 2004).
- ⁵⁸ Manno, 2002: 83
- ⁵⁹ For example, see Pawson and Brooking (2002) for a discussion on science and the grasslands revolution.
- ⁶⁰ Or previous organisations that existed before this Ministry was restructured into its present form.
- ⁶¹ Dollars have been rounded to the nearest fifty.
- ⁶² Nicola Shadbolt, Agricultural and Horticultural Management Systems Group, Massey University, pers. comm., August 2004.
- ⁶³ Issing, 2004
- ⁶⁴ For example see Wilkinson (1996) and Townsley *et al.* (1997).
- ⁶⁵ For more information see background report *Incentives for intensification* (Watters *et al.*, 2004).
- ⁶⁶ Net wealth equals assets (land and stock at market value, other assets at book value) less liabilities (term debt plus current liabilities). See background report *Incentives for intensification* (Watters *et al.*, 2004).
- ⁶⁷ Measured in terms of the free on board price (the border price before any transport costs or tariffs have been added to it).
- ⁶⁸ Background report *The food production revolution* (Saunders and Ross, 2004)
- ⁶⁹ www.maf.govt.nz/mafnet/rural-nz/statistics-and-forecasts/sonzaf/2003/2003-sonzaf-11.htm#P568_75231
- ⁷⁰ Background report *Incentives for intensification* (Watters *et al.*, 2004)
- ⁷¹ *ibid.*
- ⁷² *ibid.*
- ⁷³ *ibid.*

Chapter 5

- ¹ Food production is now highly dependent on manufactured nitrogen fertilisers, “indeed 40 percent of the world’s population would not be alive but for this massive alteration of the natural nitrogen cycle (Smil, 2001).”
- ² MfE, 1997a
- ³ OMRI, 2002
- ⁴ Lord May, 2002
- ⁵ In the Waikato, it is estimated that of the nitrogen input into dairy farms, 30 percent is leached to groundwater and 26 percent returns to the atmosphere *via* denitrification, while 13 percent is retained in soil and 31 percent ends up in milk.
- ⁶ The nitrogen cycle is referred to as a biogeochemical cycle – *chemical* element nitrogen involves *biological* organisms and their *geological* (atmosphere or lithosphere) environment (Kormondy, 1996).
- ⁷ See next section for discussion of synthetic nitrogen fixing in the manufacture of fertilisers – an energy intensive process.

- ⁸ The term reactive nitrogen includes all biologically active, photochemically reactive, and radiatively active N compounds in the Earth's atmosphere and biosphere. Therefore, reactive nitrogen includes inorganic forms of N (e.g. ammonia NH_3 , ammonium NH_4 , nitrogen oxides NO_x , nitric acid HNO_3 , nitrous oxide N_2O , and nitrate NO_3) and organic forms of N (e.g. urea – the chief nitrogenous waste of mammals, amines, and proteins) (Galloway *et al.*, 2002).
- ⁹ Kormondy, 1996
- ¹⁰ MfE, 1997a
- ¹¹ Denitrification is the process carried out by various soil bacteria *via* respiration that results in the release of gaseous nitrogen into the atmosphere.
- ¹² In the early 20th century a process for synthetically converting reactive nitrogen from atmospheric nitrogen was developed (the Haber-Bosch process) (Galloway *et al.*, 2002). The human body needs about two kilograms of nitrogen per year to survive; yet globally, humans create 20 kilograms of nitrogen per person per year for food production, *via* the Haber-Bosch process (Galloway and Cowling, 2002).
- ¹³ Galloway *et al.*, 2002; Galloway *et al.*, 2003
- ¹⁴ Galloway *et al.*, 2003. The creation and accumulation of reactive nitrogen is predicted to continue to increase in the future, due to increases in human populations and per capita resource use. As a single human generated reactive nitrogen atom circulates in sequence through the atmosphere, hydrosphere, and biosphere, it can have multiple effects on ecological and human health. This sequence of effects is called the *nitrogen cascade*. These effects are magnified through time, with many undesirable consequences.
- ¹⁵ *ibid.*
- ¹⁶ In a 'fertiliser factory to mouth' analysis, for every 100 nitrogen atoms produced as synthetic fertiliser, only four atoms end up being consumed in a carnivorous diet (14 are consumed in a vegetarian diet) with the remaining atoms lost along the way. The largest loss occurs in the field. Of the 94 nitrogen atoms applied (six are already lost between the factory and the field), the crop takes up 47 atoms. The *remaining 47 are emitted to the atmosphere or lost to groundwater or surface water*, mostly as nitrate (Galloway and Cowling, 2002).
- ¹⁷ Galloway and Cowling, 2002
- ¹⁸ MfE, 1997a
- ¹⁹ UNEP, 2004
- ²⁰ Vidal, 2004
- ²¹ Blue-baby syndrome is the disease Methemoglobinemia, in which amounts of methemoglobin in the blood are so high that the skin turns a bluish colour – this is because the presence of nitrite (converted from nitrate by bacteria) in the blood oxidizes iron in the hemoglobin of red blood cells to form methemoglobin, which lacks hemoglobin's oxygen-carrying ability. The disease is commonly known as blue-baby syndrome because infants are more susceptible to it.
- ²² Phosphorus is a nutrient vital for life. Unlike nitrogen, phosphorus does not have a gaseous phase. Most of the world's phosphorus is bound up in sedimentary rock, and is naturally released (in an inorganic form) by weathering processes, becoming available for uptake by plant roots. As with nitrogen, phosphorus moves through the food chain, until it is returned to the soil in an organic form, *via* animal excreta or decomposing plant and animal tissue. Guano deposits have been mined for phosphorus for centuries. Phosphorus rock deposits are also mined and manufactured into fertiliser.
- ²³ Superphosphate is phosphate treated with sulphuric acid to form an agricultural fertiliser.
- ²⁴ Rosen, 2001. Also, phosphate readily binds with clay particles, iron and aluminium oxides, and organic matter in soil and aquifer materials.
- ²⁵ *ibid.*
- ²⁶ This is due to phosphorus-removal processes within lakes.
- ²⁷ This is because relatively abundant phosphorus is provided from geochemical sources
- ²⁸ Including planktonic algae in lakes, benthic algae (periphyton) in rivers, and both benthic and planktonic algae in estuaries.
- ²⁹ This investigation has focused on synthetic fertilisers not organic fertilisers (which are derived from animal or vegetable matter, e.g. fish meal), for a variety of reasons related to the relative potential for adverse environmental impacts. Nutrients – nitrogen in particular – are released more quickly from synthetic fertilisers than from organic fertilisers.
- ³⁰ Tuckey, 2003
- ³¹ Fertiliser subsidies for farmers were introduced in 1963 and then removed in 1984 (Saunders, 2002). This subsidy removal resulted in a dramatic drop in the total amount of fertiliser applied between 1985 and 1988. Since then, fertiliser application has steadily increased.

- ³² Statistics New Zealand, 2003b. Common nitrogen-based fertilisers used in New Zealand include ammonia, urea, ammonium nitrate and ammonium sulphate. Common phosphorus-based fertilisers include superphosphate and diammonium phosphate. Common potassium-based fertilisers include muriate of potash and potassium nitrate.
- ³³ *ibid.*
- ³⁴ Statistics New Zealand, 2003b; Statistics New Zealand INFOS service.
- ³⁵ Statistics New Zealand, 2003b
- ³⁶ The ratio of milk price to nitrogen price (data sourced for Lincoln Farm Budget Manuals) has changed by a factor of nearly 2.5 in favour of nitrogen use over the past 20 years. For a standard sheep and beef farm, the change has been more dramatic. In 1982 the average gross income was \$27.50 per stock unit, lifting to \$67 per stock unit in 2001/02. The ratio of stock unit income to nitrogen price has moved in favour of nitrogen use by a factor of 3.3
- ³⁷ O'Hara *et al.*, 2003; Bolan and Podila, 1996; Watters *et al.*, 2004
- ³⁸ The mid- to late-1990s saw a conversion of Hayward (green) variety kiwifruit orchards to the new Hort16A kiwifruit variety (gold). Because of its different growth and yield habits, fertiliser inputs are in the order of 40 percent higher than the Hayward variety. Average yield per hectare over the whole industry continues to increase as growers look to maximise their profitability. These yield increases are supported in both Hayward and Hort16A orchards by increases in fertiliser use (Shane Max, pers. comm.).
- ³⁹ See for example background report *Incentives for intensification* (Watters *et al.*, 2004).
- ⁴⁰ There are several reasons for the increase: increased use of scanning for pregnant ewes, and subsequent better care and feeding of those ewes (through greater pasture growth in Spring due to increased applications of fertiliser); increased use of fertility drugs; selection of flocks for fertility; and changes in breed type. See Chapter 3: Sheep and beef.
- ⁴¹ Lambert *et al.*, 2003
- ⁴² Gerard and Goldson, 2004
- ⁴³ *ibid.*
- ⁴⁴ *ibid.*
- ⁴⁵ Environment Waikato, 2003c
- ⁴⁶ O'Hara *et al.*, 2003
- ⁴⁷ Ledgard and Thorrold, 2003
- ⁴⁸ In a chemical analysis undertaken by Williams and Haynes (1995), cattle dung was found to have a much higher nutrient concentration compared to that of sheep and deer. The nitrogen content of cattle dung was 27 milligrams per gram of dry matter, compared to 15 mg for sheep and 12 mg for deer (other nutrients P, K and S were also more concentrated in cattle dung). This, and the fact that cattle produce large dung deposits, which are less evenly spread across the paddock than sheep and deer dung, indicates that nutrients are more likely to be leached to the environment by cattle dung, than by that of sheep and deer.
- ⁴⁹ Tile and mole drains drain water from what, under natural conditions, would be swampy land, in order to farm.
- ⁵⁰ Alexander *et al.*, 2002 drawing on Wilcock *et al.*, 1999
- ⁵¹ This practice is not suitable in some areas with poor soils such as Northland and Westland (Rob Davies-Colley, pers. comm.).
- ⁵² Statistics New Zealand, 2003b
- ⁵³ Environment Waikato, 2003d
- ⁵⁴ Dexcel, 2004
- ⁵⁵ MfE, 1997b
- ⁵⁶ BOD – biochemical oxygen demand. The amount of dissolved oxygen consumed in a water sample by micro-organisms as they decompose organic matter. BOD is used as an index of organic pollution, such as sewage – the higher the BOD reading, the more polluted the waterway.
- ⁵⁷ Schipper and Percival, 2003
- ⁵⁸ Schipper, 2001
- ⁵⁹ *ibid.*
- ⁶⁰ One kilogram of N₂O emitted into the atmosphere has the same contribution to the greenhouse effect as about 310 kilograms of CO₂ (MED, 2002).
- ⁶¹ O'Hara *et al.*, 2003
- ⁶² In the context of this section, risk refers to the likelihood of environmental contamination from farming activities and the consequences this may have for fresh water quality and aquatic habitats.

- ⁶³ Davies-Colley *et al.*, 2003
- ⁶⁴ MfE, 1997b
- ⁶⁵ See sections 69, 70 and 107, and the Third Schedule of the RMA.
- ⁶⁶ Baber and Wilson, 1972; Smith *et al.*, 1993; MfE, 1997a; Parkyn *et al.*, 2002
- ⁶⁷ Lincoln Environmental, 2001b
- ⁶⁸ MfE, 1997b
- ⁶⁹ Parkyn *et al.*, 2002
- ⁷⁰ Davies-Colley *et al.*, 2003
- ⁷¹ Smith *et al.*, 1993
- ⁷² Larned *et al.*, 2003
- ⁷³ DRP = dissolved reactive phosphorus; NO_x = nitrate + nitrite; NH_4 = ammonium.
- ⁷⁴ *ibid.*
- ⁷⁵ Davies-Colley *et al.*, 2003
- ⁷⁶ Larned *et al.*, 2004
- ⁷⁷ The *E. coli* guideline was exceeded at 96% of pastoral sites, and dissolved reactive phosphorus, ammonia, and oxidised nitrogen exceeded at 88%, 78%, and 64% of pastoral sites respectively.
- ⁷⁸ Section 7.4.3 discusses indicators for sustainable agriculture and the state of the environment.
- ⁷⁹ Smith *et al.*, 1993
- ⁸⁰ For example, Environment Waikato monitors four regional rivers to identify sources of nitrogen and phosphorus. Nitrogen loads are highest in areas of intensive dairy farming. In the intensively farmed Piako River catchment, 85% of the average annual input of nitrogen is attributed to agricultural non-point source discharge (17.2 kg/ha/yr). By comparison, the average annual input of phosphorus is much lower, and a higher proportion is from point source discharge (63%, or 1 kg/ha/yr), thus nitrogen is dominated by non-point sources, phosphorus by point sources (Environment Waikato, 2004e).
- ⁸¹ Environment Waikato, 2003a
- ⁸² Environment Waikato, 2004b. This report looks at *trends*, that is, the *change* in levels between 1987 and 2002. It *does not* discuss whether the *actual levels* are high or low, compared to what might be expected in a river unaffected by anthropogenic land use.
- ⁸³ MAF, 1993
- ⁸⁴ Phosphorus levels in Lake Taupo are significant. The phosphorus source is natural, and likely leached from fresh rhyolitic pumice (Rosen, 2001).
- ⁸⁵ Environment Waikato, 2004a; Rosen, 2001
- ⁸⁶ Environment Waikato, 2004a
- ⁸⁷ Environment Waikato, 2003e
- ⁸⁸ See PCE report *Missing links: Connecting science with environmental policy* (2004) for discussion on the availability of scientific information on Lake Rotoiti's water quality and delay by policy and decision makers. Also the PCE will be scoping an investigation into the Rotorua Lakes in the second half of 2004.
- ⁸⁹ Hamilton, 2003
- ⁹⁰ Up to \$4 million is to be spent in the next two years on urgent remedial engineering works, and \$3.2m will be used to address related sewage disposal issues through the Sanitary Works Subsidy Scheme.
- ⁹¹ Davies-Colley *et al.*, 2003
- ⁹² Davies, 2001
- ⁹³ Baber and Wilson, 1972 cited in Close *et al.*, 2001
- ⁹⁴ Smith *et al.*, 1993
- ⁹⁵ MfE, 1997b
- ⁹⁶ Thorpe, 1992
- ⁹⁷ Environment Canterbury, 2002b
- ⁹⁸ Environment Canterbury, 2002b drawing on Bowden *et al.*, 1983; Burden, 1982; Burden, 1984
- ⁹⁹ This sample was taken from a paddock used for land disposal of effluent from a meat processing plant.

- ¹⁰⁰ The maximum acceptable value (MAV) of nitrate-nitrogen in drinking water in New Zealand is set at 11.3 milligrams per litre (mg/L) in the Ministry of Health's Drinking Water Standards (based on international standards) (MOH, 2000). (There has been recent international debate about the appropriateness of this drinking water standard – see, for example, Close *et al.*, 2001). Specific sources can be identified for many of the samples with the highest concentrations e.g. land disposal of effluent from meat processing plants, Burwood landfill.
- ¹⁰¹ The Drinking Water Standards advocate increased monitoring if this concentration is reached in a water supply. Several areas had numerous wells above this level, most likely reflecting land use such as agriculture, lifestyle blocks and small communities.
- ¹⁰² These were generally from groundwater samples taken alongside rivers and streams (the main source of recharge) and/or taken from confined coastal aquifers between the Rakaia and Ashley Rivers. Beyond these sampling areas, nitrate-nitrogen levels were generally above 3 mg/L, which likely indicates contamination from human activities (Environment Canterbury, 2002b).
- ¹⁰³ Eight percent (or 21 wells) had decreasing concentrations. Land use in areas of decreasing nitrate trends includes a higher proportion of grazing and residential land.
- ¹⁰⁴ Environment Canterbury, 2002b
- ¹⁰⁵ Haywood and Hanson, 2004. The study focused on three discrete areas of concern in the Ashburton-Rakaia plains. Groundwater nitrate contamination in the other two areas (not discussed in detail in this report) was associated with effluent disposal at meat processing plants.
- ¹⁰⁶ Groundwater from 24 of the 37 wells tested had nitrate levels higher than half the MAV (5.65 mg/L). These levels of nitrate-nitrogen were found at up to 70 metres below the water table, indicating vertical dispersion of the nitrate contamination. Groundwater from 5 of the 37 wells tested had nitrate levels higher than the MAV (11.3 mg/L) – four of these are used for domestic drinking water supply. These five wells were all shallow and within 5 km of the coast. Background nitrate levels were also quite high – seven of the nine wells tested northwest of Fairton had nitrate-nitrogen concentrations higher than half the MAV.
- ¹⁰⁷ Haywood and Hanson, 2004
- ¹⁰⁸ *ibid.*
- ¹⁰⁹ This situation is unlikely to be acceptable to the community and is inconsistent with objectives in ECan's Policy Statement and draft Regional Plan. As a result of this report, ECan has recommended a detailed investigation into current and past land uses in the Ashburton Rakaia plains to help understand the sources of nitrate contamination, particularly in the Chertsey-Dorie area.
- ¹¹⁰ Environment Waikato, 2003b
- ¹¹¹ The term 'low levels' used here is relative. In this case it relates to values less than half the maximum acceptable value (MAV) of nitrate, but 'low' in terms of baseline environmental levels is less than 1 mg/L.
- ¹¹² Environment Waikato, 2003b
- ¹¹³ Smith *et al.*, 1993
- ¹¹⁵ Collins *et al.*, 2002
- ¹¹⁶ Collins *et al.*, 2002; Davies-Colley *et al.*, 2003
- ¹¹⁷ Institute of Environmental Science and Research Ltd, 2002
- ¹¹⁸ Klana, 2001; Scott *et al.*, 2000
- ¹¹⁹ Parkyn *et al.*, 2002
- ¹²⁰ MfE and MOH, 2002
- ¹²¹ Collins *et al.*, 2002
- ¹²² MfE and MOH, 2002
- ¹²³ Institute of Environmental Science and Research Ltd, 2002
- ¹²⁴ *ibid.*
- ¹²⁵ Collins *et al.*, 2002
- ¹²⁶ *ibid.*
- ¹²⁷ Collins *et al.*, 2002. See also Collins and Rutherford (2004).
- ¹²⁸ Whilst recognising that soil erosion is a major issue in New Zealand, it has not been the focus of this report.
- ¹²⁹ Such as grazing on steep slopes and over-stocking.

- ¹³⁰ Out of this event, the Franklin Sustainability Project was established by the Pukekohe Vegetable Growers Association, Auckland and Waikato Regional Councils and Agriculture New Zealand. The Project's main goal was to improve the overall sustainability of vegetable growing in the particular soils, climate and location of Franklin District.
- ¹³¹ Mackay *et al.*, 2002
- ¹³² Davies-Colley *et al.*, 2003
- ¹³³ *ibid.*
- ¹³⁴ *ibid.*
- ¹³⁵ *ibid.*
- ¹³⁶ *ibid.*
- ¹³⁷ Environment Waikato, 2004c
- ¹³⁸ Smith *et al.*, 1993
- ¹³⁹ Parkyn *et al.*, 2002
- ¹⁴⁰ Hegarty *et al.*, 2001
- ¹⁴¹ Statistics New Zealand, 2002
- ¹⁴² These figures do not include the use of water for hydro-electric generation, which exceeds 100,000 million cubic metres per day and is recyclable (i.e. not a consumptive use).
- ¹⁴³ Counsell, 2003
- ¹⁴⁴ Lincoln Environmental, 2001a: 8
- ¹⁴⁵ MfE, 1997a
- ¹⁴⁶ Lincoln Environmental, 2000c: Summary
- ¹⁴⁷ Lincoln Environmental, 2000c
- ¹⁴⁸ *ibid.*
- ¹⁴⁹ Lincoln Environmental, 2001a
- ¹⁵⁰ *ibid.*
- ¹⁵¹ *ibid.*
- ¹⁵² The terms of reference of this investigation did not allow for an in-depth analysis of water allocation issues. It is a significant matter, however, with major implications for environmental sustainability. The PCE may undertake an investigation in the future.
- ¹⁵³ Meridian Energy Limited, 2001
- ¹⁵⁴ Doak *et al.*, 2004: 4
- ¹⁵⁵ Lincoln Environmental, 2000c
- ¹⁵⁶ *ibid.*
- ¹⁵⁷ *ibid.*
- ¹⁵⁸ Hegarty *et al.*, 2001
- ¹⁵⁹ *ibid.*
- ¹⁶⁰ Ford, 2002
- ¹⁶¹ For further information see Taylor *et al.* (2003).
- ¹⁶² McIndoe *et al.*, 2002
- ¹⁶³ Doak *et al.*, 2004
- ¹⁶⁴ Doak *et al.*, 2004: Forward
- ¹⁶⁵ G. Fenwick, NIWA, pers. comm.
- ¹⁶⁶ Proulx, 2002: 95
- ¹⁶⁷ Guru and Horne, 2000
- ¹⁶⁸ *ibid.*
- ¹⁶⁹ Guru and Horne, 2000: 14 citing Mapp, 1980.
- ¹⁷⁰ See <http://www.kgs.ukans.edu/HighPlains/index.html> for more information.
- ¹⁷¹ Opie, 1993
- ¹⁷² Lincoln Environmental, 2000a
- ¹⁷³ More information on irrigation technology is available in *The irrigation guide: a guide to decision-making when going irrigating* (McIndoe *et al.*, 2002).
- ¹⁷⁴ Lincoln Environmental, 2000a
- ¹⁷⁵ *ibid.*
- ¹⁷⁶ *ibid.*

- ¹⁷⁷ Lincoln Environmental, 2000a: 19
- ¹⁷⁸ It has been estimated that there are more than 30 definitions (Lincoln Environmental, 2000b).
- ¹⁷⁹ Lincoln Environmental 2000b: 4
- ¹⁸⁰ Lincoln Environmental 2000b and Lincoln Environmental 2002
- ¹⁸¹ Lincoln Environmental, 2000b: 21
- ¹⁸² Lincoln Environmental, 2000a: 16
- ¹⁸³ *ibid.*
- ¹⁸⁴ Background report *Food market and trade risks* (Saunders *et al.*, 2004)
- ¹⁸⁵ The Lincoln Trade and Environment Model (LTEM) is a multi-country, multi-commodity, partial equilibrium trade model which focuses on the agricultural sector. It is calibrated with 1997 as the base year.
- ¹⁸⁶ Estimates have been rounded to the nearest \$5 and 5 tonnes.
- ¹⁸⁷ For more detailed information see background report *Food market and trade risks* (Saunders *et al.*, 2004).
- ¹⁸⁸ Background report *The food production revolution* (Saunders and Ross, 2004)
- ¹⁸⁹ See for example Heinberg (2003).
- ¹⁹⁰ For a more in depth discussion on the electricity sector, see PCE, 2003b.
- ¹⁹¹ Background report *Incentives for intensification* (Watters *et al.*, 2004).
- ¹⁹² PCE, 2003b
- ¹⁹³ *ibid.*
- ¹⁹⁴ For more information see www.climatechange.govt.nz
- ¹⁹⁵ Wratt *et al.*, 2004
- ¹⁹⁶ Kenny, 2001
- ¹⁹⁷ Kenny, 2001: vii
- ¹⁹⁸ PCE, 2001a
- ¹⁹⁹ See PCE (2001a).
- ²⁰⁰ For more information see www.biodiversity.govt.nz
- ²⁰¹ Patterson and Cole, 1999
- ²⁰² MfE, 1997a
- ²⁰³ PCE, 2001a

Chapter 6

- ¹ These tools deal with dairy shed effluent only, i.e., point source pollution, which constitutes a lesser amount of the total amount of dairy effluent. The rest is spread on pastures while cows graze, and receives no treatment. This contributes to non-point source pollution.
- ² Guidelines are available for their construction and operation.
- ³ Craggs *et al.*, 2000. See www.niwa.co.nz/rc/pollution/aps for more information.
- ⁴ Collins *et al.*, 2002
- ⁵ Davies-Colley *et al.*, 2004
- ⁶ Collins *et al.*, 2002
- ⁷ Ravensdown Fertiliser Cooperative Ltd, 2003
- ⁸ Ballance AgriNutrients Ltd, 2004
- ⁹ Summit-Quinphos Ltd, 2004
- ¹⁰ Ledgard and Thorrold, 2003
- ¹¹ IFO, EFMA & PPI, 1992
- ¹² Fert Research, 2004. For more information see www.fertresearch.org.nz/fertiliser.cfm?folderid=40§ionid=18&parentid=18.
- ¹³ Pringle, 1998
- ¹⁴ World Bank, 2002
- ¹⁵ Hamilton-Manns *et al.*, 1999
- ¹⁶ Minimum tillage encompasses reduced tillage, strip tillage, direct drilling, no-tillage and zero-tillage.
- ¹⁷ Pieri *et al.*, 2002: vii

- ¹⁸ *ibid.*
- ¹⁹ Ledgard *et al.*, 1996
- ²⁰ Fonterra Co-operative Group, LGNZ, MfE and MAF, 2003
- ²¹ *ibid.*
- ²² MAF, 2004b
- ²³ Environment Waikato has nutrient budgeting worksheets available online for both dairy farmers and dry stock farmers, for the application of nitrogen and phosphorus, developed by the Waikato Farm Environment Award Trust with SFF, EW and Dexcel funding. They can be accessed *via* the following web page: <http://www.ew.govt.nz/enviroinfo/land/management/nutrients/index.htm> [Accessed 13 April, 2004].
- ²⁴ Tuckey, 2003
- ²⁵ Global Positioning Systems
- ²⁶ See www.sq.co.nz/sq/website.nsf/vwWebPages/GANN-5SKULT for more information.
- ²⁷ See www.agresearch.co.nz/overseerweb/ for more information.
- ²⁸ Dan Bloomer, Page Bloomer Associates Ltd, pers. comm., 15 April 2004.
- ²⁹ See www.hortresearch.co.nz/products/bioremediation/SPASMO for more information.
- ³⁰ McIndoe *et al.*, 2002
- ³¹ Eaton, 2001: 12
- ³² While this type of extensive farming is largely outside the terms of reference for this investigation, Whatawhata is still considered relevant because of the systems redesign focus and the move to more intensive bull-beef finishing as part of that redesign.
- ³³ www.niwa.cri.nz/pubs/no8/whatawhata [Accessed July 2004].
- ³⁴ Ingham *et al.*, 2000
- ³⁵ The Sustainable Agriculture Management Systems Network (SAMsn) was established in 2000 with the aim of gathering together information about all the programmes currently used in New Zealand. See <http://www.samsn.org.nz/> for more information.
- ³⁶ National Coalition on Integrated Pest Management, 1994
- ³⁷ Texas Pest Management Association, 2004
- ³⁸ *ibid.*
- ³⁹ Williams, 1995
- ⁴⁰ HortResearch, 2002
- ⁴¹ *ibid.*
- ⁴² See www.zespri.com and www.samsn.org.nz for more information.
- ⁴³ Insecticidal bacterium *Bacillus thuringiensis*.
- ⁴⁴ For more information see <http://www.projectgreen.co.nz/index.htm>, the New Zealand Deer Farmers' Landcare Model (Project Green case study) and the Agribusiness Group (2004).
- ⁴⁵ www.projectgreen.co.nz/srp-conditions.htm [Accessed, February 2004]
- ⁴⁶ www.projectgreen.co.nz/principles.htm [Accessed August 2004]
- ⁴⁷ www.projectgreen.co.nz/lem_conditions.htm [Accessed, February 2004]
- ⁴⁸ www.projectgreen.co.nz/srp_conditions.htm [Accessed, February 2004]
- ⁴⁹ www.projectgreen.co.nz/amp_conditions.htm [Accessed, February 2004]
- ⁵⁰ www.projectgreen.co.nz/lem_conditions.htm [Accessed, February 2004]
- ⁵¹ A catchment is the area of land drained by a river and its tributaries.
- ⁵² Murray-Darling Basin Ministerial Council, 2001
- ⁵³ Mitchell, 1990; Edgar, 2004
- ⁵⁴ Bowden, 1999
- ⁵⁵ The New Zealand Landcare Trust in conjunction with the Ministry for the Environment is running a project called *Integrated catchment management: sharing best practice nationally* which investigates catchment case studies from across the country to determine some of the good (and bad) lessons learnt from participation in community ICM projects. ICM projects featured include Kaipatiki Stream (Auckland), Whaingaroa Harbour and Whatawhata Hill Country (Waikato), Motueka River (Tasman), Styx and Orari Rivers (Canterbury) and the Taieri River (Otago). See www.landcare.org.nz/integrated_catchment_management/index.htm for more information.
- ⁵⁶ New Zealand Dairy Research Institute, 2001

- ⁵⁷ For more information contact the Fonterra Research Centre Limited or go to www.fonterraresearch.com.
- ⁵⁸ Parkes and Panelli, 2001
- ⁵⁹ Undertaken for a University of Otago PhD.
- ⁶⁰ www.taieri.net.nz
- ⁶¹ Edgar, 2002
- ⁶² Tyson, 2004
- ⁶³ Edgar, 2004
- ⁶⁴ Environment Waikato, 2002
- ⁶⁵ <http://www.taupoinfo.org.nz/>
- ⁶⁶ Environment Waikato, 2003e
- ⁶⁷ Press release by the Hon Marian Hobbs. *Budget confirms funding for Lake Taupo project*. 27 May 2004.
- ⁶⁸ McDermott Fairgray Group Limited, 2001
- ⁶⁹ Petch *et al.*, 2002
- ⁷⁰ The economic theory of income elasticity suggests that there will be a change in the quantity demanded of a product as income changes. Thus the demand for luxury good tends to increase as income increases (Saunders *et al.*, 2004).
- ⁷¹ Background report *Food market and trade risks* (Saunders *et al.*, 2004)
- ⁷² *ibid.*
- ⁷³ Background report *Food market and trade risks* (Saunders *et al.*, 2004) provides an extended discussion into the research on this issue.
- ⁷⁴ A generally accepted definition of organic rules are: no use of synthetic fertilisers, pesticides, growth regulators and livestock feed additives; and no use of genetically modified stock, no application of sludge to organic acreage and no food irradiation (Saunders *et al.*, 2004: 48).
- ⁷⁵ See background report *Food market and trade risks* (Saunders *et al.*, 2004) for more information
- ⁷⁶ MAF, 2002b
- ⁷⁷ MAF, 2002b
- ⁷⁸ Dairy InSight, 2004
- ⁷⁹ www.interfacesustainability.com/miles_mn.com
- ⁸⁰ www.interfacesustainability.com; Anderson, 1998
- ⁸¹ Prain, 2002
- ⁸² Background report *The food production revolution* (Saunders and Ross, 2004)
- ⁸³ Globe and Mail, 2002
- ⁸⁴ Erisman, 2004
- ⁸⁵ See <http://www.oecd.org/agr/env/indicators.htm> for more information.
- ⁸⁶ New Zealand Government, 2002. See Chapter 4 for more information on the GIF.
- ⁸⁷ FRST, 2004
- ⁸⁸ The research contact for this project is Caroline Pratt, Agribusiness Group, Christchurch.
- ⁸⁹ The research contact for this project is Nicola Shadbolt, Massey University, Palmerston North.
- ⁹⁰ See ViaLactia, Agritech Investments Ltd, DEEResearch and AgResearch Ltd for more information.
- ⁹¹ See www.gecommission.govt.nz and www.mfe.govt.nz/issues/organisms/law-changes/commission/index.html
- ⁹² See PCE (2000b) for more information on the sorts of concerns expressed.
- ⁹³ PCE, 2001b
- ⁹⁴ MORST, 2003
- ⁹⁵ Knight *et al.*, 2003: 6
- ⁹⁶ *ibid.*
- ⁹⁷ *ibid.*
- ⁹⁸ See Chapter 2 for a discussion of the key principles of sustainable agriculture.
- ⁹⁹ Barr and Cary, 2000
- ¹⁰⁰ Barr and Cary, 1984

¹⁰¹ Barr and Cary, 2000

¹⁰² See www.ecan.govt.nz for more information.

¹⁰³ For example, local government.

¹⁰⁴ PCE, 2004

¹⁰⁵ Cary and Wilkinson, 1997

¹⁰⁶ An example of this would be the Otago Regional Council's booklet *Environmental considerations for dairy farming in Otago* (2001). Environment Waikato has also produced an excellent range of materials.

¹⁰⁷ Memon, 2003

¹⁰⁸ *ibid.*

¹⁰⁹ Recent prosecutions for breaches of dairy shed effluent discharge consents may indicate this is changing (see *Southland Regional Council v de Bruyn*, unreported, 27/8/2004, Smith J, DC Invercargill, CRN 4025500128, fine of \$16,000 plus costs; and *Taranaki Regional Council v Mullan*, unreported, T31/8/2004, Thompson J, DC New Plymouth, CRI 2004-043-3046, fine of \$25,000)

¹¹⁰ Barr and Cary, 2000

¹¹¹ See Chapter 2.

Chapter 7

¹ Hill, 1998

² Maurice Strong, 24 July 2002 – addressing the US Senate Environment Treaty Implementation Review.

³ The Sustainable Agriculture Management Systems Network (SAMsn) is an excellent initiative and should receive on-going support so that its information is constantly up-to-date.

⁴ FRST, 2004

⁵ A detailed analysis of the costs and benefits of establishing the Australian CRCs for Catchment Hydrology and Coastal Zone, Waterway and Estuarine Management could be a useful starting point.

⁶ Edgar, 2004

⁷ Edgar, 2004

⁸ By comparison, the federal government in Australia offers matching dollar for dollar funding support to the contributions provided by the research agencies and end users for ICM.

⁹ See Chapter 6 Section 6.1.2.

¹⁰ FRST, 2004

¹¹ Sustainability Institute, 2003: 22

¹² Sustainability Institute, 2003

¹³ PCE, 2003a

¹⁴ HortResearch, AgResearch, Crop & Food Research and Landcare Research, 2004

¹⁵ www.mfe.govt.nz/state/reporting/index.html

¹⁶ www.mfe.govt.nz/issues/susdev/programme.html

¹⁷ This investigation may not be confined to farming issues alone – see PCE (2003a) for more information.

¹⁸ PCE, 2004

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Appendix 1: People interviewed for this report

Southland

Peter McLeish	Farmer
Gay Stringer & others	Rural Women NZ
Ian Brown	ORC
Nick Round-Turner	Crops for Southland Inc
Bruce Halligan	Southland District Council
Alan Henry	Alliance Group Limited
Grant Cuff	Alliance Group Limited
Wayne Hutchinson	Venture Southland
Lynne Johnston	Telford Rural Polytechnic
Malcolm Little	Southland Building Society
Tom May	Mayfield Elk Farm
Kathy & Lloyd McCallum	Farmers
Councillors and staff	Environment Southland
Dr Ross Monaghan	AgResearch
Gay Munro & others	Waituna Landcare
Ken Murray	Department of Conservation
Nelson Pyper	Pyper's Produce
Maurice Rodway & others	Fish and Game
Philip Ryan	Southern Wide Real Estate
Michael Skerritt	Te Ao Marama
Andrew & Heather Tripp	Farmers
Fiona Young & others	Federated Farmers
Yvonne & Steve Dennis	Farmers

Canterbury

Carole Donaldson & others	Lake Ellesmere Community Group
Dermott O'Sullivan	Aoraki Water Trust
Cheryl Macauley	Cheryl Macauley Limited
Andy Macfarlane	Macfarlane Rural Business Ltd
Bob Engelbrecht	Engelbrecht, Evans & Co
Ian Morten	Farmer
James Halford	Farmer
Bruce Tweedy	Fruit grower

Professor Keith Cameron	Lincoln University
Dr Hong Di	Lincoln University
Dr Tim Jenkins	Lincoln University
Dr Steve Wratten	Lincoln University
Professor Alison Stewart & others	Lincoln University
Richard Christie	Ravensdown Fertiliser
Pita Alexander	Farm accountant
Murray Doak	Ministry of Agriculture and Forestry
Grant McFadden	Ministry of Agriculture and Forestry
Stuart Ford	The Agribusiness Group
Jon Manhire	The Agribusiness Group
Kevin Geddes	Grains Council Federated Farmers
Henry Schat and others	Federated Farmers
Alison Undorf-Lay	Federated Farmers
Councillors and staff	Environment Canterbury
Don Kennedy	Rabobank Group
Doug Archbold & others	Ballance Farm Environment Awards
Brian Meadows	Wrightson Real Estate
Hugh Morrison	Wrightson Real Estate
Ross Millichamp & others	Fish and Game
David O'Connell	Te Runanga o Ngai Tahu
Bob Penter	Te Runanga o Ngai Tahu
Nick Pyke	Foundation for Arable Research
Nick Poole	Foundation for Arable Research
Dr Marion Savill & others	ESR
Mayor Stan Scorringe	MacKenzie District Council
Paul Tocker & team	Crop and Food Research
Eric & Maxine Watson	Rangitata Holdings Ltd
Will Nixon	Dairy farmer
Phil McKendry	Barhill Chertsey Irrigation Ltd
John Young	Rangitata Diversion Race Management Ltd
Canterbury Water Rights Trust	
Doug Marsh	Central Plains Trust

Hawke's Bay

Andrew Russell	Federated Farmers
John Russell	Farmer
Moray Grant	Farmer
Marei Apatu & others	Te Taiwhenua o Heretaunga
Jonathan Bell	Rabobank Group
Ralph Pedersen	Rabobank Group
Councillors and staff	Hawke's Bay Regional Council
David Brownrigg	Brownrigg Agriculture
Jonathan Brownrigg	Brownrigg Agriculture
Mike Butcher	NZ Pipfruit
Ru Collin	NZ Fruitgrowers Federation
Clive Durand	Turners and Growers ENZA
Jonathan Wiltshire	Orchardcrisp
Brent Morris	Investment New Zealand
Mayor Tim Gilberston	Central Hawke's Bay District Council
Ken Fox	General Manager, Central Hawke's Bay District Council
Rebecca Gore	Food Hawke's Bay
Alan Kale	Heinz Watties Ltd
Richard Keller	Williams & Kettle
Scott Lawson	Lawson's Organic Farms
Max Lyver	Wrightson Real Estate
Iain Maxwell	Fish and Game
Mal McLennan	Stirling Vines
Rachel Monk	Ministry of Agriculture and Forestry
Duane Redward	Ministry of Agriculture and Forestry
Karen & Michael Palleson	Dairy farmers
Hugh Ritchie	Arable farmer
Peter Robertson	Brookfields Vineyards
Dr Jim Walker	Hort Research
David Manktelow	Hort Research
Sarah Gurnsey	Hort Research

Waikato

Peter Buckley	Dairy farmer
Jim Cotman	Farm advisor
David Findlay	Dairy farmer
Jan Findlay	Dairy farmer
Allan Geck	Farmer
John Kneebone	
Peter Levin	Farmer
Vivienne Lockwood-Geck	Farmer
Rob Pringle	P ³ Pringle Phoenix Partnership
Mandy and Innes Semmens	Dairy farmers
Gordon & Celia Stephenson	Farmers
Richard Prew	Fruit grower
Ineke & Kees Zegwaard	Fruit growers
Gary Guerts	Vegetable grower
John Carter	Deer farmer
Steve Allen	Tatua Cooperative Dairy Company Ltd
Dacey & Kevin Balle	Balle Brothers Fresh Produce Ltd
Andrew Barber	Franklin Sustainability Project
Glenys Pellow	Franklin Sustainability Project
Karen & Matthew Bartleet	Farmers
John Caradus	Dexcel
Mark Blackwell	Dexcel
Bruce Thorrold	Dexcel
Gwyneth Verkerk	Dexcel
Carin Burke	Landcare Research
Daniel Rutledge	Landcare Research
Louis Schipper	Landcare Research
Graham Sparling	Landcare Research
Bob Lee	Landcare Research
Jake Overton	Landcare Research
Phillipa Crequer	Ballance Farm Environment Awards
Jim Ecclestone	Wrightson Real Estate
Fiona Edwards	Whaingaroa Community Restoration Project
Fred Lichtwark	Whaingaroa Community Restoration Project

John Fisher & others	Federated Farmers
Gerry & Greg Glover	Dairy farmers
Professor David Hamilton	University of Waikato
Roy Harlow	Integrated Systems Engineers
Norman Hill	Waikato Raupatu Trustees
Julian Williams	Waikato Raupatu Trustees
Tim Manakau	Waikato Raupatu Trustees
Phil Journeaux	Ministry of Agriculture and Forestry
Irene Parminter	Ministry of Agriculture and Forestry
Craig McBeth	ASB Bank
Soren Moller	Intelact Nutrition, veterinarian
Peter Nation	ANZ Bank
Dr Keith Steele	AgResearch
Warren Parker	AgResearch
Brian Peacocke	Pastoral Realty
Councillors and staff	Environment Waikato
Dr Rick Pridmore	NWA
Bob Wilcox	NWA
Peter Te Moananui	Hauraki Maori Trust Board
Lakes & Waterways Action Group	Lake Taupo
Doug Emmett	Fish and Game
Anne McLeod and team	Taupo District Council
Gerry Kessels	QEII National Trust
Wellington	
Tom Lambie	President, Federated Farmers
Cath Petrie	Federated Farmers
Neil Barton	Federated Farmers
Bryce Johnston	Fish and Game
Jeff McDougall	Agriculture New Zealand
Peter Kerr	Agriculture New Zealand
Clifford King and others	Agricultural Investments
Dr John Bright	Lincoln Environmental
Policy team	Ministry of Agriculture and Forestry
Peter Silcock	VegFed and NZ Fruitgrowers Federation
Ken Robertson	VegFed

Barry Carbon & team

Grethen Robertson

Jim Barnett

Shane Lodge

Peter Bodeker

Auckland

Rod Oram

Professor Garth Cooper

Michael Dosser

Kieran Elborough

Zac Hanley

Dick Hubbard

Philip Manson

Henry van der Heyden

Philip Turner

Earl Rattray

Jim Watson

Ministry for the Environment

Taieri Trust

Fonterra Cooperative Group

Fonterra Cooperative Group

Dairy Insight

Journalist

School of Biological Sciences Auckland University

Turners & Growers

Vialactia Biosciences

Vialactia Biosciences

Hubbard Foods

New Zealand Winegrowers

Chairman, Fonterra Cooperative Group

Fonterra Cooperative Group

Fonterra Cooperative Group

Genesis Research and Development Corporation

Appendix 2: Sustainable agriculture indicators

I. Agriculture in the broad economic, social and environmental context	1. Contextual information and indicators	Agricultural GDP		
		Agricultural output		
		Farm employment	• Number of jobs per farmed hectare and per farm	
		Farmer age/gender distribution		
		Farmer education (see No 5)		
		Number of farms		
		Agricultural support		
		Land use	<ul style="list-style-type: none"> • Stock of agricultural land • Change in agricultural land • Agricultural land use 	
		2. Farm financial resources	Farm income	
			Agri-environmental expenditure (public, private, research)	<ul style="list-style-type: none"> • Public and private agri-environmental expenditure • Expenditure on agri-environmental research
	3. Local community	Proportion of farm inputs and environmental services bought from local businesses (within 15km radius for the UK)		
		Number of local businesses supported through adoption of more sustainable agriculture		
	4. Partnerships and learning	Number of stakeholder consultations and discussion forums		
		Investment in and support for group-based activities		
	5. Local innovations	Rate of innovation and adaptation of technologies (no. experiments per farm)		
		Investment in training and learning		

II. Farm management and the environment	1. Farm management	Whole farm management	<ul style="list-style-type: none"> • Environmental whole farm management plans • Organic farming
		Nutrient management	<ul style="list-style-type: none"> • Nutrient management plans • Soil tests
		Pest management	<ul style="list-style-type: none"> • Use of non-chemical pest control methods • Use of integrated pest management
		Soil and land management	<ul style="list-style-type: none"> • Soil cover • Land management practices
		Irrigation and water management	<ul style="list-style-type: none"> • Irrigation technology
III. Use of farm inputs and natural resources	1. Nutrient use	Nutrient balance	<ul style="list-style-type: none"> • Total N, P and K used per hectare and per tonne of output • Proportion of N used on farms that has been fixed from the atmosphere
		Nutrient efficiency	
	2. Pesticide use and risks	Pesticide use	<ul style="list-style-type: none"> • Total active ingredient used per hectare and per tonne of net output
		Pesticide risk	<ul style="list-style-type: none"> • Proportion of products used that are narrow spectrum and wild-life safe
	3. Water use	Water use intensity	<ul style="list-style-type: none"> • Irrigation water used per hectare and per tonne of net output
		Water use efficiency	<ul style="list-style-type: none"> • Water use technical efficiency • Water use economic efficiency
		Water stress	
	4. Energy use	Direct and indirect energy used (machinery, electricity, embodied in fertilisers and pesticides) per hectare and per tonne of net output	
		Product miles or kilometres per tonne of net output	

IV. Environmental impacts of agriculture	1. Soil quality	<p>Risk of soil erosion by water</p> <p>Risk of soil erosion by wind</p> <p>Organic matter content of soil (percent)</p> <p>Mineralisable nitrogen</p> <p>pH soil test</p>	<ul style="list-style-type: none"> • Amount of soil eroded per hectare and per tonne of output
	2. Water quality	<p>Water quality risk indicator</p> <p>Water quality state indicator</p>	<ul style="list-style-type: none"> • Pesticide leakage to ground and surface water • Leakage of nutrients to ground and surface water/ groundwater nitrate • River, lake, recreational and drinking water quality • Cultural health index for streams • Occurrence of native fish • Stream macroinvertebrates • Riparian condition • Wetland condition and extent
	3. Wastes	<p>Proportion of wastes recycled (plastic bags, polythene)</p> <p>Amount of livestock waste incorporated on-farm</p> <p>Liquid wastes</p>	<ul style="list-style-type: none"> • Stock density • Nutrient loadings • Quantity of major discharges to water (BOD) • Stock effluent equivalent of total nitrogen
	4. Land conservation	<p>Water retaining capacity</p> <p>Off-farm sediment flow (soil retaining capacity)</p>	

5. Greenhouse gases	Gross agricultural greenhouse gas emissions	<ul style="list-style-type: none"> • Emissions of methane, nitrous oxide and carbon dioxide per hectare and per tonne of net output
6. Biodiversity	Genetic diversity	
	Species diversity	<ul style="list-style-type: none"> • Indigenous species • Introduced species (pests and weeds) • Number of species and populations of birds per hectare of farmland • Insect diversity in non-crop habitats • Population size of key predators
7. Wildlife Habitats	Ecosystem diversity (see Wildlife habitats)	
	Intensively farmed agricultural habitats	
	Semi-natural agricultural habitats	
	Uncultivated natural habitats	
	Habitat matrix	
8. Landscape	Structure of landscapes	<ul style="list-style-type: none"> • Environmental features and land use pattern • Man-made objects (cultural features)
	Landscape management	
	Landscape costs and benefits	

Source: Adapted from Pretty, 1998; OECD, 2001c; Ministry for the Environment.

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