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
E. coli	*Escherichia coli*. 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	Integrated Pest Management. This focuses on a careful consideration of all available pest control techniques and the subsequent integration of appropriate measures that: • 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 Krausse *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 *bio*logical organisms and their *geo*logical (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 NOx, 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 N_2O emitted into the atmosphere has the same contribution to the greenhouse effect as about 310 kilograms of CO_2 (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 + nitrate; 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] Klena, 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&sectionid=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	NIWA
Bob Wilcox	NIWA
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	Ministry for the Environment
Grethen Robertson	Taieri Trust
Jim Barnett	Fonterra Cooperative Group
Shane Lodge	Fonterra Cooperative Group
Peter Bodeker	Dairy Insight

Auckland

Rod Oram	Journalist
Professor Garth Cooper	School of Biological Sciences Auckland University
Michael Dosser	Turners & Growers
Kieran Elborough	Vialactia Biosciences
Zac Hanley	Vialactia Biosciences
Dick Hubbard	Hubbard Foods
Philip Manson	New Zealand Winegrowers
Henry van der Heyden	Chairman, Fonterra Cooperative Group
Philip Turner	Fonterra Cooperative Group
Earl Rattray	Fonterra Cooperative Group
Jim Watson	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	• Stock of agricultural land • Change in agricultural land • Agricultural land use
	2. Farm financial resources	Farm income	
		Agri-environmental expenditure (public, private, research)	• 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	• Environmental whole farm management plans • Organic farming
		Nutrient management	• Nutrient management plans • Soil tests
		Pest management	• Use of non-chemical pest control methods • Use of integrated pest management
		Soil and land management	• Soil cover • Land management practices
		Irrigation and water management	• Irrigation technology
III. Use of farm inputs and natural resources	1. Nutrient use	Nutrient balance	• 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	• Total active ingredient used per hectare and per tonne of net output
		Pesticide risk	• Proportion of products used that are narrow spectrum and wild-life safe
	3. Water use	Water use intensity	• Irrigation water used per hectare and per tonne of net output
		Water use efficiency	• 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	Risk of soil erosion by water Risk of soil erosion by wind	• Amount of soil eroded per hectare and per tonne of output
		Organic matter content of soil (percent) Mineralisable nitrogen pH soil test	
	2. Water quality	Water quality risk indicator	
		Water quality state indicator	• 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	Proportion of wastes recycled (plastic bags, polythene)	
		Amount of livestock waste incorporated on-farm	
		Liquid wastes	• Stock density • Nutrient loadings • Quantity of major discharges to water (BOD) • Stock effluent equivalent of total nitrogen
	4. Land conservation	Water retaining capacity Off-farm sediment flow (soil retaining capacity)	

5. Greenhouse gases	Gross agricultural greenhouse gas emissions	• Emissions of methane, nitrous oxide and carbon dioxide per hectare and per tonne of net output
6. Biodiversity	Genetic diversity	
	Species diversity	• 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
	Ecosystem diversity (see Wildlife habitats)	
7. Wildlife Habitats	Intensively farmed agricultural habitats	
	Semi-natural agricultural habitats	
	Uncultivated natural habitats	
	Habitat matrix	
8. Landscape	Structure of landscapes	• 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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