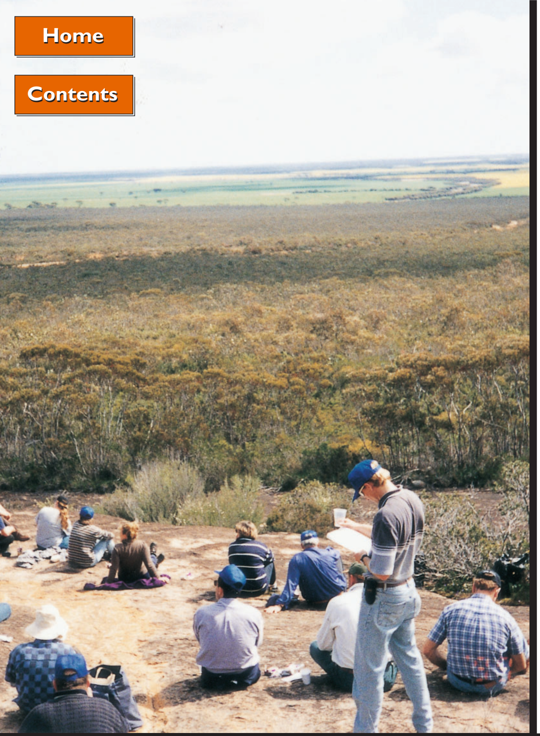


Natural Heritage Trust

Helping Communities Helping Australia

A Commonwealth Government Initiative

AUSTRALIANS AND NATURAL RESOURCE MANAGEMENT 2002

National Land & Water Resources Audit

A program of the Natural Heritage Trust

NATIONAL LAND AND WATER RESOURCES AUDIT

Providing nationwide assessments

The National Land and Water Resources Audit (Audit) is facilitating improved natural resource management decision making by:

Providing a clear understanding of the status of, and changes in, the nation's land, vegetation and water resources and implications for their sustainable use.

Providing an interpretation of the costs and benefits (economic, environmental and social) of land and water resource change and any remedial actions.

Developing a national information system of compatible and readily accessible land and water data.

Producing national land and water (surface and groundwater) **assessments** as integrated components of the Audit.

Ensuring integration with, and **collaboration** between, other relevant initiatives.

Providing a framework for monitoring Australia's land and water resources in an ongoing and structured way.

In partnership with Commonwealth, and State and Territory agencies, and through its theme activities—Water Availability, Dryland Salinity, Vegetation, Rangelands Monitoring, Agricultural Productivity and Sustainability, Australians and Natural Resource Management, Catchment, River and Estuary Condition and Information Management—the Audit has prepared:

Assessments of the status of and, where possible, recent changes in Australia's land, vegetation and water resources to assist decision makers achieve ecological sustainability. These assessments set a baseline or benchmark for monitoring change.

Integrated reports on the economic, environmental and social dimensions of land and water resource management, including recommendations for management action.

Australian Natural Resources Atlas to provide internet-based access to integrated national, State and regional data and information on key natural resource issues. It is underpinned by the **Australian Natural Resources Data Library**.

Guidelines and protocols for assessing and monitoring the condition and management of Australia's land, vegetation and water resources to meet the information needs of decision makers at regional to Australia wide scales.

This report presents the key findings for the Audit's 'Capacity of and opportunities for natural resource managers to implement change' theme as:

> ***Australians and Natural Resource Management 2002:*** *Social and economic dimensions of natural resource management based on natural resource accounting and a social profile of rural Australia.*

Home

Contents

AUSTRALIANS AND NATURAL RESOURCE MANAGEMENT 2002

National Land & Water Resources Audit
A program of the Natural Heritage Trust

Home

Contents

Published by:

National Land and Water Resources Audit
c/- Land & Water Australia
On behalf of the Commonwealth of Australia

GPO Box 2182
Canberra ACT 2601

Telephone: (02) 6263 6035
Facsimile: (02) 6257 9518
Email: info@nlwra.gov.au
Home page: www.nlwra.gov.au

Disclaimer

We invite all interested people, both within and outside Government, to make use of the Audit's reports, information, its Atlas and products in whatever way meets their needs. We encourage you to discuss the Audit findings with the various partners and contributors that have prepared this information. Partners and contributors are referenced in this report.

The Commonwealth accepts no responsibility for the accuracy or completeness of any material contained in this report and recommends that users exercise their own skill and care with respect to its use.

Publication data: '**Australians and Natural Resource Management 2002.**'

ISBN: 0 642 37123 7

Editing and design: Themeda
Cover design: City Graphics
Cover photograph: John Bourke
Printing: Union Offset

March 2002

National Land & Water Resources Audit
A program of the Natural Heritage Trust

The Hon Warren Truss
Minister for Agriculture, Fisheries and Forestry
Parliament House
Canberra ACT 2600

The Hon Dr David Kemp
Minister for the Environment and Heritage
Parliament House
Canberra ACT 2600

Dear Ministers

I have pleasure in presenting to you *Australians and Natural Resource Management 2002*—a report of the National Land and Water Resources Audit (Audit).

Australians and Natural Resource Management 2002 presents the key findings of the first Australia-wide assessment of the physical condition and use of our natural resources integrated with social and economic information. It is an important step forward in the construction of natural resource accounts.

To demonstrate the value of natural resource accounts, the report includes an assessment of the economic consequences of two key types of resource degradation—dryland salinity with its predominantly public and off-farm costs, and soil acidity with major costs to soil health and production. Soil sodicity, an inherent and important limiting factor to agricultural production, is also assessed to complete the assessment and to place soil acidity and dryland salinity in context.

The report details the type and severity of downstream impacts of dryland salinity on infrastructure and water resources and the importance of public investment in mitigating these impacts through major initiatives such as the National Action Plan for Salinity and Water Quality. It illustrates the differing approaches to dealing with salinity in catchments with particular groundwater flow systems, land use patterns and land use change opportunities.

Soil acidity is a major impediment to agricultural production with up to 25% of intensive agricultural lands affected to some degree. In economic terms, soil acidity is more significant to on-farm profitability than dryland salinity. Approaches based on good science, collation of on-farm soil fertility data to track progress, extension through government and agribusiness programs, and a focus on practice can all contribute to meeting the soil acidity challenge.

This report presents a socioeconomic profile of Australians engaged in agriculture. Some insight into current and future opportunities for structural adjustment in agriculture is provided. An assessment of the willingness of the Australian community to support natural resource management initiatives suggests that the community is willing to pay $4 billion over 20 years, in addition to existing investments, to achieve enhanced natural resource outcomes. This could take the form of 50 additional species protected, 2 million hectares of bushland restored and 1500 km of river and estuary rehabilitated to a condition that supports fishing and swimming.

The Audit Advisory Council views this report as a substantial contribution to the natural resource management debate. We commend this report and the more detailed information on the Australian Natural Resources Atlas to you. Together they provide an information base for improved natural resource management, particularly within Australia's agricultural landscapes.

I am pleased to present this report to the Natural Heritage Trust Ministerial Board.

Yours sincerely

Roy Green
Chair – National Land and Water Resources Audit Advisory Council

Level 2 Unisys Building, 91 Northbourne Avenue, Turner ACT 2612
Postal Address: GPO Box 2182, Canberra ACT 2601 Phone: (02 6257 9516 Fax: (02) 6257 9518
Email:info@nlwra.gov.au Website:http://www.nlwra.gov.au

SUMMARY

Australia is a developed economy in which agriculture, as the main user in both extent and impact on our natural resources, is an important but now (at 2.7% of gross domestic product) a relatively small part of the overall economy. Agriculture continues to be an important contributor to national, State and regional economies; other sectors remain highly dependent on the farm sector. For example, approximately 60% of manufacturing turnover in the Murray–Darling Basin is derived from food processing industries. Australia's agricultural industries are also strongly export-oriented and account for 30% of merchandise export and 20% of total export trade.

Increasingly, our land and water resources are being valued for more than their productive capacity. People now value natural resources not only for cropping, grazing, forestry and fish production, but also for their aesthetic and intrinsic values, biodiversity, and ecosystem services such as sinks for greenhouse gases and water filtration. The natural resource base supports tourism, recreation, and community lifestyles.

Environmental costs have also been associated with the benefits derived from natural resource use.

- Historically, natural resource use has often not been sustainable.
- Agricultural systems have largely been adapted from European ways of farming that are not suited to Australia's climate variability.
- Extensive tree clearing was necessary to prepare land for cropping and led to changes in water balance and dryland salinity.
- Overgrazing of native pastures led to soil erosion, increased sediment and nutrient loads in rivers and deteriorated water quality.
- Many other forms of degradation have occurred as a result of commercial use of natural resources.

Other Audit reports deal in detail with the biophysical state of natural resources, degradation processes and management opportunities to maintain the natural resource base for maximum public benefit and productivity.

Over time our knowledge of degradation processes and land use practices has increased and significant improvements have been made in the way we use our land and water resources. This improvement in practice has been underpinned by better institutional arrangements and legal frameworks governing natural resource use as well as extension and support to foster improved land use practices.

But the question remains—have we done enough to ensure a sustainable future for the management and use of our natural resources and the people who depend on them? This raises specific questions:

- are we managing our natural resources responsibly and sustainably?
- if we are not managing our natural resources sustainably, why not? and
- what are the steps towards sustainable use of natural resources and how do we prevent further degradation?

This report contributes context and some answers to these questions. It is a national assessment of the economic and social dimensions of our land and water resources and the way they are managed.

The report focuses on people—those who manage and depend on our land and water resources and their capacity, motivation and opportunities to implement changes that bring about improved social, economic and environmental outcomes consistent with sustainability objectives. Social and economic profiles of Australia's farming community provide valuable contextual information relevant to natural resource management and planning at all levels. Structural adjustment trends are presented and analysed, and future adjustment pressures and trends projected.

The report focuses on the value of land resources used in agriculture, future profits foregone due to some forms of land degradation and off-farm costs of land degradation. This includes estimates of costs of damage to infrastructure and costs relating to reduced water quality. Estimates of unpriced assets such as loss of endangered species, landscape aesthetics, waterway recreation and the viability of rural communities complete this analysis.

Natural resource issues are used to examine costs and benefits of agricultural use.

- Dryland salinity, caused by rising saline water tables, has costs on-farm and substantial impacts on water resources, biodiversity and infrastructure off farm.
- Soil acidity is caused by increased acid inputs to the soil from the farm operations such as nitrogenous fertiliser use. Impacts are on-farm through reduced plant productivity and changed soil condition.
- Soil sodicity is a natural constraint to productivity with potential off-farm impacts including increased sediment loads to rivers by soil erosion.

The main challenge presented by soil acidity and sodicity is to balance the costs of soil ameliorants against benefits of agricultural production. These three issues are used to demonstrate the role of resource accounting for Australian agriculture as an input to planning and management activities. Resource accounting approaches will be invaluable when applied as part of regional natural resource management planning under initiatives such as the Natural Heritage Trust and National Action Plan for Salinity and Water Quality.

The results of the economic analysis provide the first layer of information needed for priority setting, both from the perspective of addressing different forms of degradation and resource use constraints, and targeting different geographic locations. However, the analysis does not provide a means for establishing priorities per se or determining the appropriate level of investment in natural resource management. To demonstrate how the method can be taken further and applied to current planning, data on the impacts and cost effectiveness of alternative management options were investigated by several case studies of salinity.

Estimates of costs are based on a range of assumptions and represent 'best bets'. Varying degrees of confidence in the estimates mainly depend on the completeness and precision of the biophysical and economic input data (upper and lower range estimates are reported on the Australian Natural Resources Atlas). Estimates of foregone returns have been based on the concept of 'yield gap', providing an upper bound to the level of benefit that could be generated if factors limiting yield were removed. They provide insight to the ceiling on investment for cost effective natural resource remediation and does not necessarily reflect an optimal economic solution. The complexities of modelling the optimal decision require farm level analysis and therefore such modelling was not part of this Australia-wide context setting analysis. Therefore, estimates should be read as indicative and relative rather than absolute measures.

Australians and Natural Resource Management 2002 provides insight into the social and economic dimensions of natural resource management. These insights, the collated information and the methods developed for application at regional scale are key to meeting the challenges of natural resource management and the triple bottom line.

Key findings

Defining the issues

- Australia has significant natural resource degradation problems. Although the biophysical causes of these problems are well understood, they persist because of complex interactions between physical, biological, economic and social processes.
- The extended timeframe over which the environment responds to changes (highlighted in the case of salinity and acidity) is an important consideration in natural resource management decision making.
- Sixty percent of the Australian continent is used for agriculture—cropping and grazing. Land managers have a crucial 'front line' influence on biophysical processes and resource degradation. They operate in complex communities and respond to a plethora of cultural, legal and institutional agenda. Clearly, natural resource management is just one of many priorities for agricultural land managers.

Economic returns

- Agriculture contributes about 2.7% to Australia's gross domestic product. Approximately:
  - 80% of the profits come from less than 1% of the area used;
  - 50% of the profits are derived from irrigated agriculture; and
  - 10% of farm establishments produce between 40 and 50% of gross agricultural income.
- Resource degradation, from an economic point of view, should be regarded as a 'sunk cost'—what is done is history. The focus should be on assessing priorities and taking actions that give the greatest net present value of benefits.

- A five-step assessment approach is presented in this report—providing the framework for assessing public and private net benefits.

Attitudes and resource management practice

- Australian farmers generally have a positive and pragmatic attitude towards environmental issues. Many factors determine adoption and motivation and capacity to change to sustainable natural resource management practices. Adoption is enhanced by confidence in future income stability and low debt, management skills, technical knowledge, participation in training courses, Landcare or similar membership and involvement with industry development.
- Sustainable resource management practices are more likely to be adopted if they provide economic and other advantages, are low risk and simple to manage. Few natural resource management practices have these characteristics. One of the roles of government is to determine and promote the public and private benefits of changed practice, recognising that with public benefits comes some level of obligation by the community to support private land managers.
- Rural Australia is in a period of significant structural change that might lead to some regions remaining clearly agricultural in character while others move towards amenity landscapes with less emphasis on agriculture.

Costs of resource use on agriculture

- Dryland salinity adversely affects agricultural or pastoral yields on approximately 3.3 million hectares—compared with 5.7 million hectares judged to be 'at risk'. The area where yield is affected represents 1% of agricultural land in Australia. Ninety percent of dryland salinity occurs in areas of sheep, beef and cereals production.
- Soil acidity affects approximately 5% of agricultural land—a much higher area than affected by dryland salinity. Putting both dryland salinity and soil acidity in context, sodicity affects approximately 23% of agricultural land.
- To assess the economic significance of soil health problems affecting agriculture the values of the yield gaps were calculated. Yield gaps are the difference between profits with and without soil health problems. The value of yield gaps for salinity for all agriculture is estimated at approximately $200 million for 2000, increasing to $300 million by 2020. This represents less than 3% of profits from agriculture. For the year 2000, the value of yield gaps for acidity is estimated at $1.5 billion representing 24% of profits from agriculture. Impacts from the inherent factor of soil sodicity for 2000 is $1 billion and 18% of profits from agriculture. These estimates give indications of the relative extent of problems. Based on estimates of input costs for application and resulting changes in production, it would be economical to treat about 4% of areas affected by acidity and sodicity with lime and gypsum, respectively.

Costs of resource use—off-farm impacts

- Land degradation causes significant off-farm effects including physical damage to local infrastructure through dryland salinity, costs to water users (e.g. water treatment) through decreases in water quality, reduced quality of natural ecosystems. Current damage to local infrastructure (roads and public buildings) caused by rising water tables and salinity, is estimated at about $90 million a year. This could rise by around $60 million or 70% by 2020. On the conservative assumption that average water quality decreases by 5% over the next 20 years, the present nature of increases in costs would be about $1.3 billion comprising salinity (~$500 million), turbidity (~$700 million) and sedimentation (~$80 million). This assumes a 5% discount rate.
- Resource degradation has a range of adverse consequences for the environment and rural communities. The results of a 'choice modelling' (stated preference) study indicate that the community is willing to pay a significant amount for programs that would deliver major environmental benefits. Over the next 20 years the community appears willing to pay approximately $4 billion additional to existing investment. This additional investment was nominally to ensure 50 additional species were protected, 2 million hectares of bushland was restored and 1500 km of river and estuary were rehabilitated to sufficient condition to support fishing and swimming.

Ways forward

Actions to address resource degradation problems need to be evaluated in an investment, benefit–cost framework. Four case study regions were selected for detailed evaluation of dryland salinity. Key insights from these case studies are summarised below.

- Each catchment is different. There are no simple and universally applicable solutions or recommended responses to ameliorating the cause or symptoms of dryland salinity.
- Broadscale re-afforestation of wide areas of recharge zones will mostly prove to be a poor investment from an economic and social viewpoint.
- Relying solely on farmers to implement farming practices that will ameliorate salinity and achieve socially acceptable results is expecting too much.
- A lack of profitable and technically feasible options is a major constraint on farmers' capacity to contribute to salinity management.
- Where significant public assets are at risk, solutions such as engineering works—drainage or pumping—may need to be implemented and publicly funded.

This first Australia-wide attempt at resource accounting has demonstrated the complexities of natural resource management and the need to build strong links between social, economic and biophysical assessments as part of regional planning and management activities.

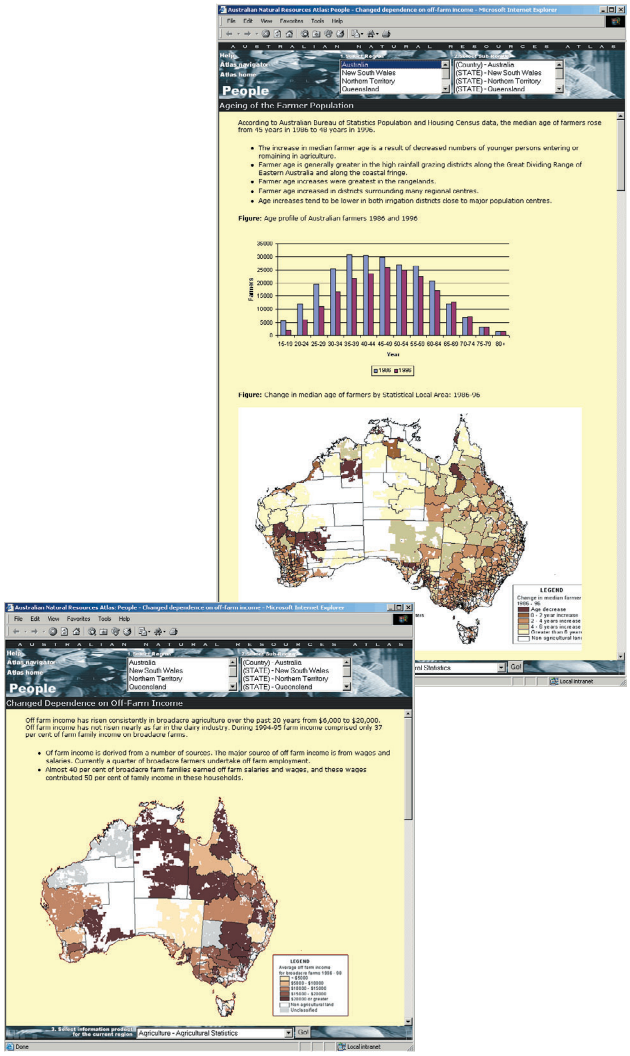
Australian Natural Resources Atlas

Access to information on natural resources provides opportunities for increased awareness and informed debate. This access has been improved through internet and database technology. The interactive web-based Australian Natural Resources Atlas (Atlas) presents Audit products at scales from local to regional to national.

The Atlas provides information to aid decision making across all aspects of natural resource management. It covers the broad topics of water, land, agriculture, people and ecosystems. The Atlas presents information by geographic region (national, State, regional) and by information topic. Users of the Atlas can prepare a map—using the 'make a map facility'—or search hundreds of reports.

The Australian Natural Resources Data Library supports the Atlas with links to Commonwealth, State and Territory data management systems.

Outputs of *Australians and Natural Resource Management 2002* have been reported in the 'People' (social profile and economic returns and cost) and 'Land' (salinity) topics of the Atlas.



www.environment.gov.au/atlas

CONTENTS

Figures

Chapter 1

Chapter 2

Chapter 3

Chapter 4

Chapter 5

Chapter 6

Chapter 7

Appendices

Tables

Chapter 1

Chapter 2

Chapter 3

Chapter 4

Chapter 7

Appendices

AUSTRALIANS AND NATURAL RESOURCE MANAGEMENT 2002

Australians and Natural Resource Management 2002 reports an Australia-wide assessment of the economic and social dimensions of our land and water resources and the way they are managed.

This report focuses on people—those who manage and depend on our natural resources, and their capacity, motivation and opportunities to implement changes to bring about improved social, economic and environmental outcomes.

Australians and Natural Resource Management 2002 has drawn on many of other Audit activities. This report should be read in conjunction with the following assessments.

Dryland salinity

Resource protection across Australia is an increasingly important policy issue. 'Resource protection' (used separately here from conservation) is concerned with the protection of natural resources as they are used to sustain our economic and social development. To address dryland salinity Australia needs to make major changes in water balance in many catchments. This will require changes in agricultural land use patterns and land management activities so that targets for protection of downstream land and water resources are met. Assessment of the extent of, and management options for, dryland salinity are presented in *Australian Dryland Salinity Assessment 2000*.

Water resource management

Major opportunities to increase economic activity with social benefits are generated by water resource development and improved water use efficiency. The status of Australia's water resources, surface and groundwater, is detailed in *Australian Water Resource Assessment 2000.*

Resource challenges faced by agriculture

Assessment of resource challenges facing agriculture and practice issues on-farm (acidification, nutrient management, soil erosion) and off-farm (sediment, nutrients transported through waterways to estuaries) are presented as part of the *Australian Agriculture Assessment 2001* report. These biophysical assessments provide much of the information for this report.

Vegetation and biodiversity

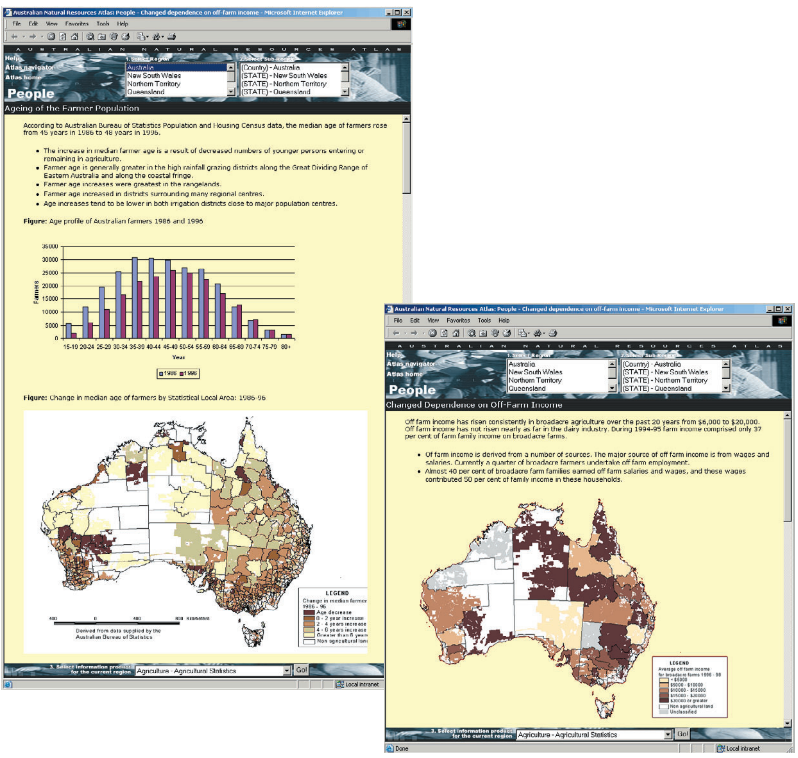
Aligning agricultural development and practice to also meet native vegetation and biodiversity management objectives is part of community demands on Australian agriculture. The Audit's *Landscape Health in Australia*, *Australian Native Vegetation Assessment 2001* and *Australian Biodiversity Assessment* (due for release in 2002) provide important baseline information on the extent, threats and condition of Australia's natural assets. This information will help government and industry to set priorities for preventive management and remedial works towards achieving ecologically sustainable development.

Catchment, river and estuary impacts

Sediment and nutrient loads reported as part of *Australian Agriculture Assessment 2001* are inputs to the assessment of the ecological impact of the changes to hydrology, habitat, sediment and nutrient regimes within rivers and estuaries. These assessments are part of the *Australian Catchment, River and Estuary Assessment 2002* report. These common property resources and their condition are good integrated indicators of the sustainability of our land use patterns and are key un-priced values that the community aspires to retain and use.

Access to data and information

Government and public alike seek improved, solutions-orientated and more accessible information on our natural resources. Access to information increases opportunities for informed debate and cost effective and efficient investment in natural resource management activities. Audit activities have improved access to natural resources information through internet and database technology. The Audit's Australian Natural Resources Atlas (www.environment.gov.au/atlas) and Data Library (http//adl.brs.gov.au/) provides access to summary data and information at national, State and regional scales as well as an access point to project documentation underpinning this summary report.



www.environment.gov.au/atlas

IN PARTNERSHIP

Australians and Natural Resource Management 2002 was prepared in partnership with:

- CSIRO Land and Water
- Agriculture, Fisheries, Forestry – Australia; Australian Bureau of Agricultural and Resource Economics; and Bureau of Rural Sciences
- Department of Land and Water Conservation, New South Wales
- Agriculture New South Wales
- Department of Lands, Planning and Environment, Northern Territory
- Department of Natural Resources and Environment, Victoria
- Department of Natural Resources and Mines, Queensland
- Department of Primary Industries, Water and Environment, Tasmania
- Primary Industries and Resources South Australia
- Agriculture Western Australia
- Dairy Research and Development Corporation and Australian Dairy Farmers Federation

A list of contributing projects is provided in the *Acknowledgments* section at the end of this report.

1

OUR LAND AND WATER RESOURCES

Setting the scene

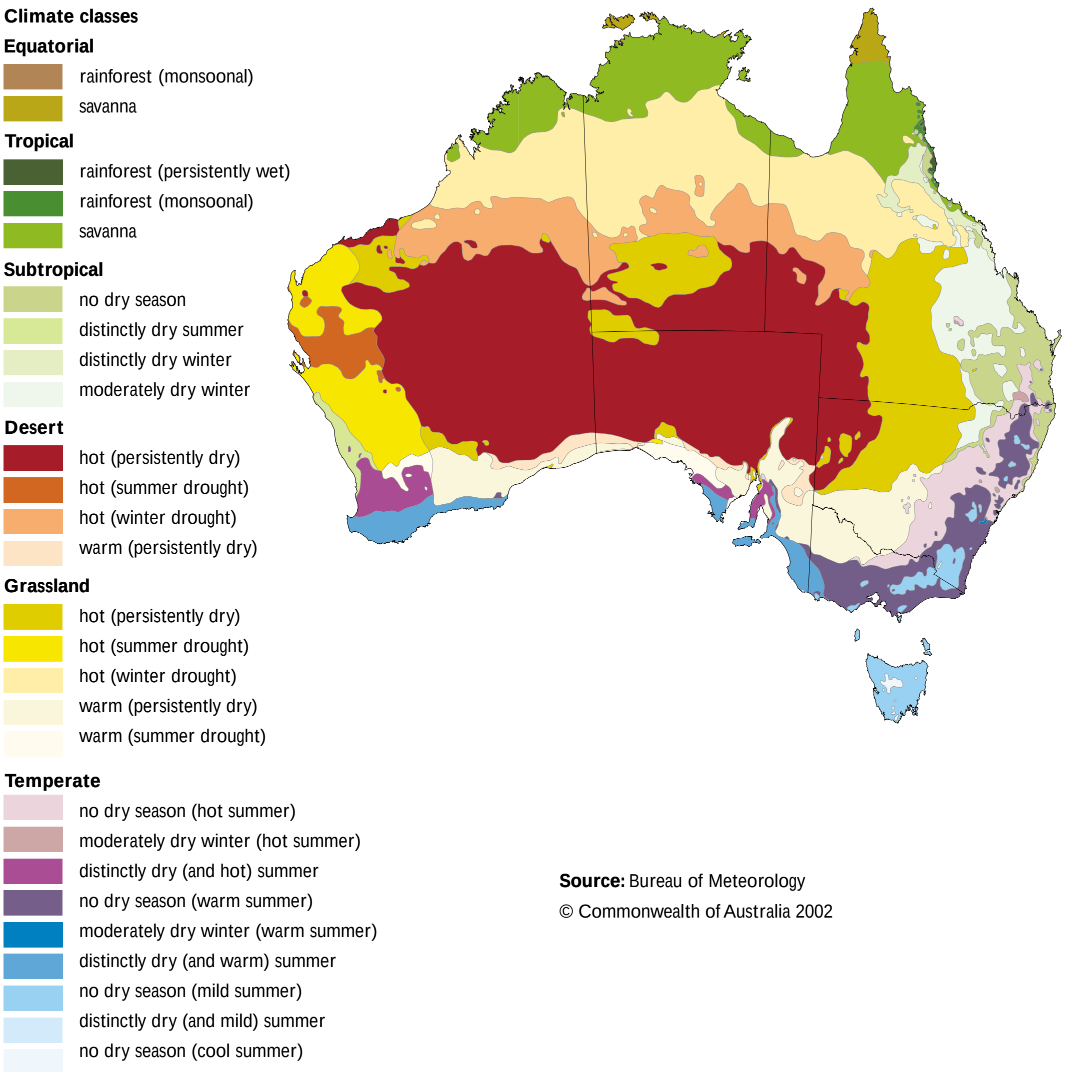
Key points

- Approximately 60% or 454 million hectares of Australia is agricultural land but only about 6% of this is cultivated or intensively farmed. Land under irrigation has grown to 2.3 million hectares in 1999.
- Private land makes up nearly 63% of the area of Australia. About 21% is freehold and 42% is leasehold.
- Over the past 20 years, productivity of Australian agriculture has grown at about 2.6% per annum. This has significantly offset the decline in farmers terms of trade over this period.
- Economic value added by agriculture amounts to about $17 billion and contributes about 2.7% to Australia's gross domestic product.
- After accounting for all costs, industry depreciation, all labour costs and other adjustments, total net agricultural income was $6.6 billion in 1996/97.
- Profit of full equity is used as a measure to assess the returns to the agricultural resource base and management. Spatial analysis of this measure reveals that in 1996/97, 80% of the profits from Australian agriculture came from only four million hectares or less than 1% of the area used for agriculture. Also nearly 50% of profits come from just 10 of 246 river basins in Australia.
- For the five years to 1996/97 over half of profits from agriculture were derived from irrigated agriculture which use just 2–3 million hectares.
- Over the past 40 years agriculture has gown in absolute terms but with the more rapid expansion of other sectors of the economy—particularly services, mining and manufacturing—agriculture's contribution to economic growth, exports and employment has declined significantly. Agriculture now accounts for approximately 3% of Australia's gross domestic product, 4.2% of total employment and 19.6% of total exports. In 1950 agriculture accounted for 25% of Australia's gross domestic product and 85% of total exports.

LAND USE AND CLIMATE

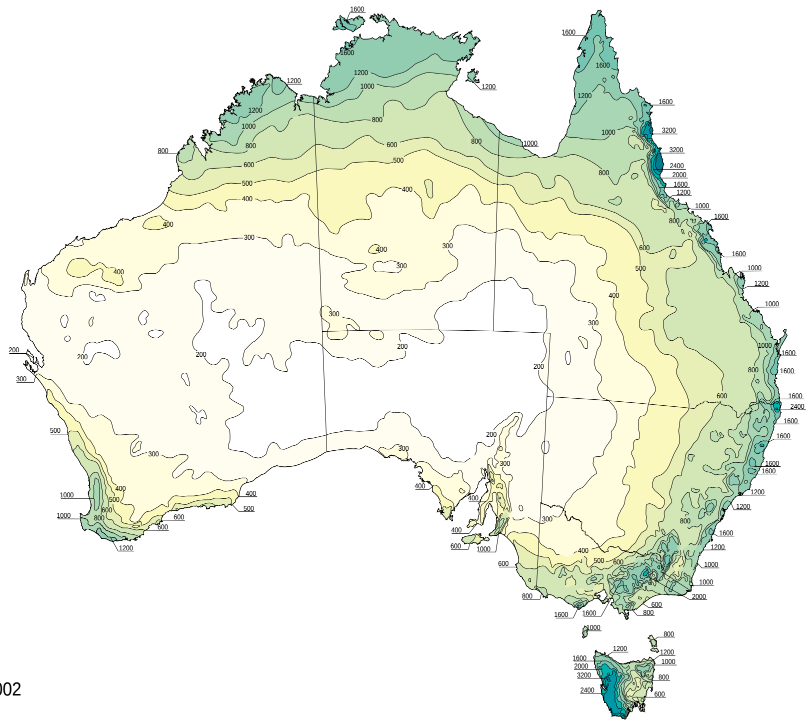
Australia has a land area of 769 million hectares. In 1996/97, the last Australian Bureau of Statistics agricultural census year, nearly 60% of Australia was classified as 'agricultural land'. Over 90 % of agricultural land is land used for extensive livestock grazing and is mainly under leasehold tenure. Australian agriculture operates within a diverse and variable climate (Figures 1.1, 1.2). Table 1.1 and Figure 1.3 show the extent and geographic locations of broad land use groups.

Figure 1.1 Australia's climate zones.



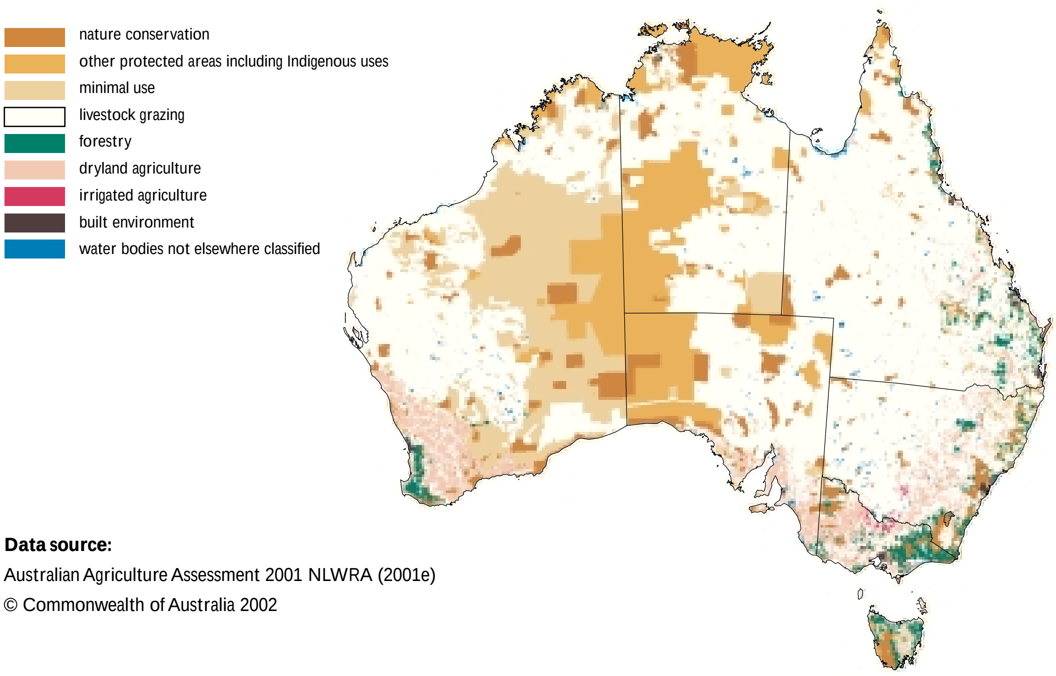
Source: Bureau of Meteorology

Figure 1.2 Mean annual rainfall for Australia.



Source: Bureau of Meteorology

Figure 1.3 Broad land use by category across Australia.



Data source:
Australian Agriculture Assessment 2001 NLWRA (2001e)

Table 1.1 Broad land use in Australia.

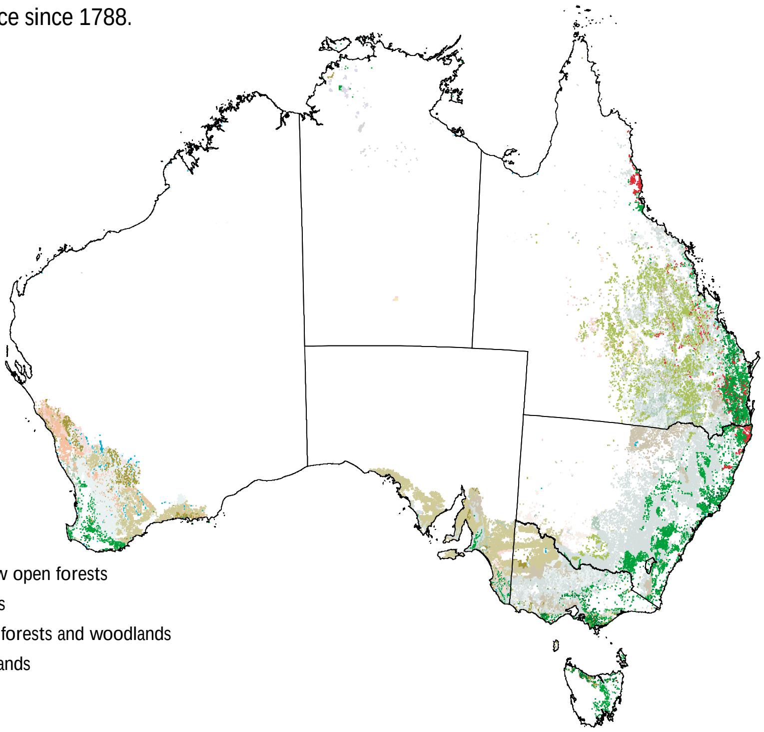
Broad land use	**Area** (million ha)	**Proportion of total** (%)
Agricultural land	472.6	61.5
• livestock grazing	430.1	56.0
• dryland agriculture	40.3	5.2
• irrigated agriculture	2.2	0.3
Forestry	15.2	2.0
Nature conservation	49.9	6.5
Other protected areas (including Indigenous uses)	102.6	13.4
Minimal use	120.8	15.7
Built environment	2.4	0.3
Water bodies not elsewhere classified	5.0	0.6
No data	0.2	–
Total	768.7	100.0

Source: National Land Use Map V2 (Stewart et al. 2001)

The area of agricultural land reached a peak of 500 million hectares in the mid-1970s but has declined since then—in 1998/99 the area of agricultural land was 453.7 million hectares. In the same year 22.5 million hectares were sown to pasture and grasses and 23.3 million hectares of land were under crops (ABS 2000). Less than 6% of Australia is under cultivation or intensive grazing.

Our use of land has significantly changed the landscape since European settlement. These changes have occurred mostly in the eastern, south-eastern and south-western parts of the continent. Most of the land clearing occurred prior to 1980 (Figure 1.4). Whereas in the 1950s, 1960s and early 1970s tax concessions were given to farmers who cleared land, now there are legislative restrictions and management controls on land clearing in all States and Territories.

Figure 1.4 Vegetation clearance since 1788.



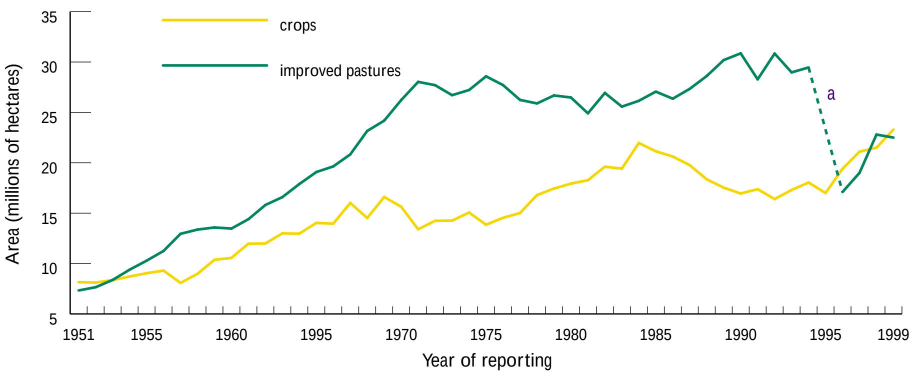
Present vegetation extent
Rainforest and vine thickets
Eucalypt tall open forests
Eucalypt open forests and low open forests
Acacia forests and woodlands
Callitris, casuarina and other forests and woodlands
Melaleuca forests and woodlands
Eucalypt woodlands
Eucalypt open woodlands
Tropical eucalypt woodlands/grasslands
Low closed forests, closed shrublands and other shrublands
Mallee woodlands and shrublands
Acacia open woodlands
Acacia shrublands
Chenopod shrubs, samphire shrubs and forblands
Heath
Tussock grasslands
Other grasslands, herblands, sedgelands and rushlands
Hummock grasslands
Mangroves, samphires, sand, rock, salt lakes, freshwater lakes

Source: Australian Native Vegetation Assessment 2001 (NLWRA 2001c)

The area under improved pasture increased rapidly during the two decades to 1970 but since then, further increases have been marginal. Over the past 20 years the area under cropping has fluctuated around a slightly upward trend (Figure 1.5).

Patterns of land use on agricultural land are shown in Figure 1.6 and are detailed in the Audit's report on land use change, diversity and sustainability of agricultural enterprises (NLWRA 2001e).

Figure 1.5 Trends in areas under improved pasture and crops.



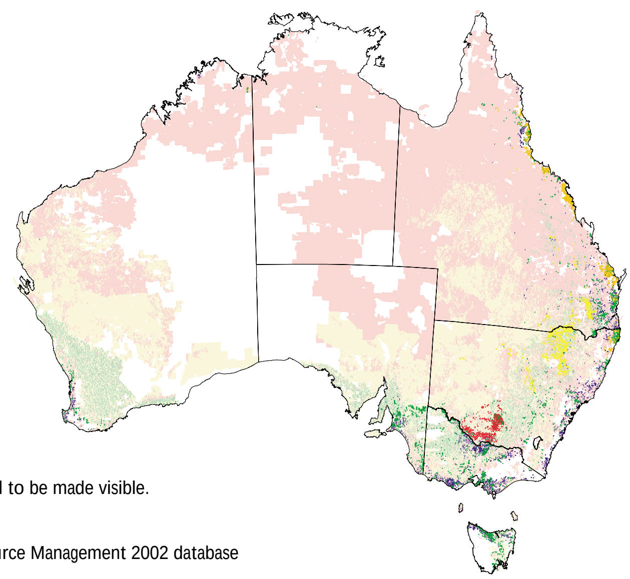
a Difference due to change in basis of data collection by ABS

Data source: Australian Bureau of Statistics Catalogue number 7117.0 (various years)

Figure 1.6 Agricultural land use in Australia.

Land uses

- beef
- sheep
- grains
- dairy
- sugar cane*
- cotton*
- horticulture and fruit trees*
- rice*



* The land use has been scale exaggerated to be made visible.

Data source: Australians and Natural Resource Management 2002 database

Home
Contents

Significant changes in commodities—largely reflecting changes in relative profitability of alternative enterprises—have occurred over the past three decades. They include:

- in the early 1970s during the boom in beef prices, beef cattle enterprises expanded rapidly in southern regions replacing cropping and sheep enterprises;
- since 1996, cropping has expanded in response to favourable grain prices relative to wool and beef, and areas under horticulture (such as wine grapes, bananas and tropical fruit) have increased;
- deregulation of acreage controls in the sugar industry has led to a significant expansion of the area under sugar cane.

The area of land irrigated in 1997 was around 2.1 million hectares, or 5% of the total area under crops or sown pastures and grasses. Details are shown in Table 1.2. The area of land irrigated increased to 2.3 million hectares in 1998 and 1999. Substantial increases in the areas of irrigated horticulture, sugar cane and rice, and especially cotton have occurred over the past 30 years. Irrigated cotton, for example, has increased from around 50 000 hectares in 1980 to 375 000 hectares in 1999.

Privately managed land, including urban land, in Australia makes up nearly 63% of the area of Australia. About 21% is freehold and 42% is crown leasehold, the latter normally being held on long-term lease or licence (AUSLIG 2001). Leasehold tenure ranges from perpetual lease to the occasional annual lease (see NLWRA 2001b for greater detail).

Table 1.2 Areas under irrigation and quantities of water used (1996/97).

Irrigation sector	NSW	NT	QLD	SA	TAS	VIC	WA	Australia	Percent of Aus total
			Areas under irrigation ('000 ha)						
Pastures	246.1	0.1	47.7	50.1	24.8	454.7	10.6	834.1	42.6
Cereal crops[a]	279.5	0.1	30.7	2.9	2.2	18.6	1.9	335.9	17.2
Vegetables	14.5	0.3	23.4	8	15.3	19.9	7.3	88.7	4.5
Sugar cane	–	–	172.3	–	–	–	0.9	173.2	8.9
Fruit	19	1.1	22.5	13.8	2.4	18.6	4.8	82.2	4.2
Grapes	15.2	0.1	0.8	30.4	0.2	20.8	2.6	70.1	3.6
Other crops	232.5	0.1	106.3	10.2	6.8	13.4	2.3	371.6	19.0
Total	**806.8**	**1.8**	**403.7**	**115.4**	**51.7**	**546**	**30.4**	**1955.8**	**100.0**
			Quantity of water used[b] (GL)						
Pastures	1 049.5	1.2	102.0	105.7	38.5	1 766.8	57.4	3 121.0	37.6
Cereal crops[a]	1 406.7	-	53.7	1.4	0.9	38.6	3.8	1 505.1	18.1
Vegetables	38.7	15.1	43.0	37.4	14.9	39.5	18.2	206.9	2.5
Sugar cane	-	-	659.5	-	-	-	6.1	665.6	7.9
Fruit	118.7	3.3	46.4	250.8	0.9	81.4	10.1	511.8	6.2
Grapes	56.0	0.3	1.9	225.2	0.8	89.7	2.8	376.8	4.5
Other crops	1 329.3	0.3	407.0	66.7	8.2	105.9	5.3	1 922.7	23.1
Total	**3 998.9**	**20.2**	**1 313.5**	**687.2**	**64.2**	**2 121.9**	**103.7**	**8 309.9**	**100.0**

a Includes rice

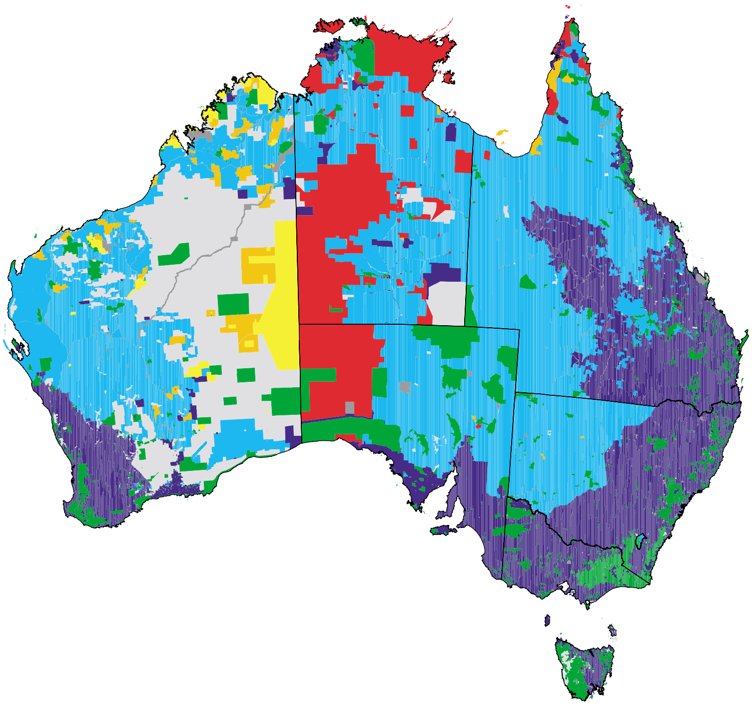
b Derived from ABS agricultural survey data

Source: Australian Bureau of Statistics (June 1999)

Home
Contents

Home
Contents

Figure 1.7 Distribution of land tenure types in Australia.



Data source: AUSLIG (1993)

Table 1.3 Land tenure in Australia.

Land tenure category*	**Area** (million ha)	**Proportion of total** (%)
Private land	**482.0**	**62.7**
• freehold	158.5	20.6
• crown leasehold	323.5	42.1
Public land	**176.8**	**23.0**
• assigned land	96.1	12.5
• nature conservation reserve	52.4	6.8
• forest reserve	14.8	1.9
• other crown land	8.1	1.1
• other	5.4	0.7
Indigenous land	**109.5**	**14.3**
• freehold	72.7	9.5
• leasehold	16.6	2.2
• reserve	20.2	2.6
Total	**769.0**	**100.0**

* Excludes State/Territory and Commonwealth waters, and seabed.

Source: AUSLIG Land Tenure database (1993)

Home
Contents

Likewise, Indigenous land may be freehold, leasehold or reserve and can be broadly defined as those areas under a range of title available for the use, benefit and residence by Aboriginal and Torres Strait Islander people. A considerable proportion of these lands are used for agricultural (mainly pastoral) purposes.

Public land includes land that is reserved or owned for public purposes or is vacant and under government administration. It includes reserves for nature conservation, forestry, water conservation, mining, defence, and vacant and other crown land (Table 1.3 and Figure 1.7).

Home

Contents

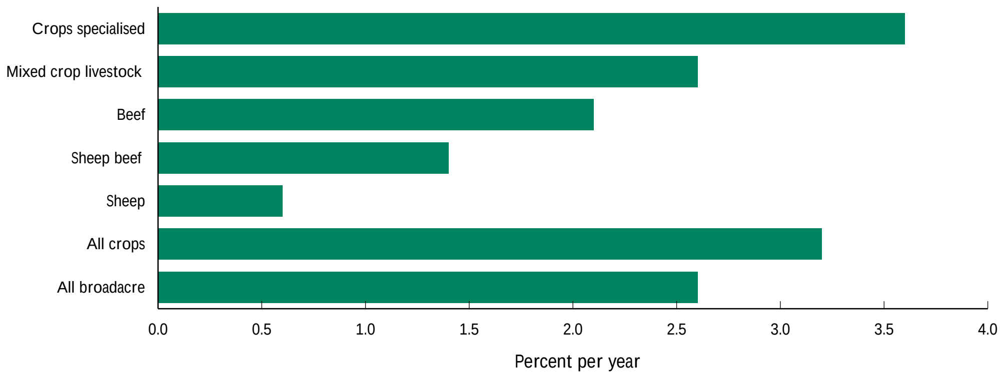
Productivity in agriculture

Broadacre agricultural industries in Australia have shown substantial increases in productivity, especially the cropping industries (Figure 1.8). Productivity gains come from increasing outputs for a given set of inputs or reducing inputs relative to outputs. Overall, total factor productivity* growth in these industries has been approximately 2.6% each year over the past 20 years.

Agricultural productivity in the decade to the mid-1980s was substantially greater than productivity growth in the rest of the Australian economy but, since then, productivity growth in the economy generally has tended to match or exceed that in agriculture (Parham 1999). Measures of productivity growth in agriculture are influenced by seasonal fluctuations and commodity prices.

Over the past 140 years the area under crops has expanded substantially, especially since 1960 (Figure 1.9). Increases in crop production over the past two decades have come primarily from increases in yield rather than in area sown (see Figure 1.10 for wheat).

Figure 1.8 Productivity growth in Australian broadacre agriculture (1977/78 to 1998/99).



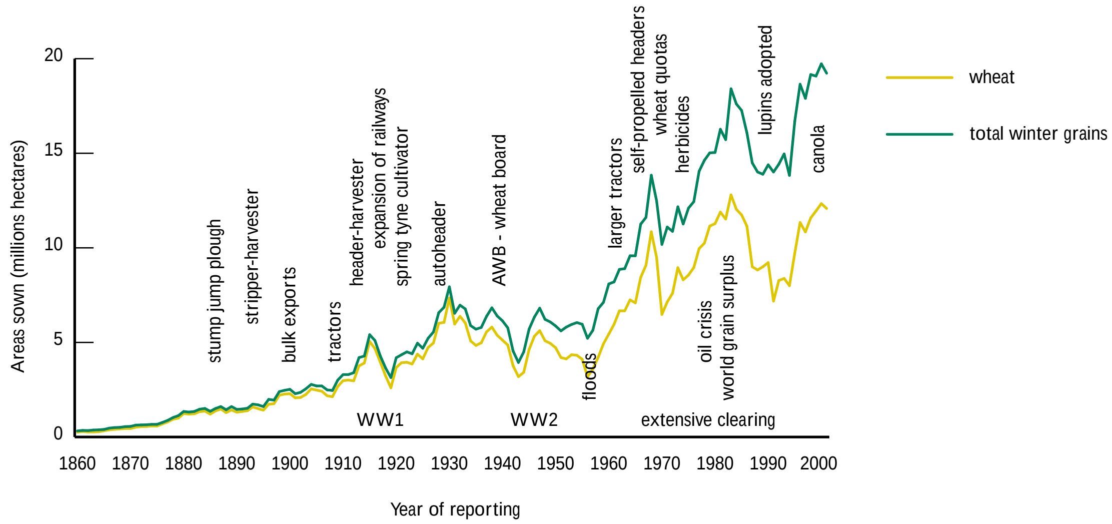
Data source: ABARE (2000)

* *Total factor productivity* for an industry or sector is a measure of total outputs to total inputs. Diverse outputs and inputs are expressed in terms of indices. In this case, so-called Tornquist indices are used. Total factor productivity for a year is derived by dividing the index of total outputs by the index of total inputs. Annual growth rates of total factor productivity are then derived by filling a logarithmic trend line, with the annual index data being regressed against a time variable.

Home

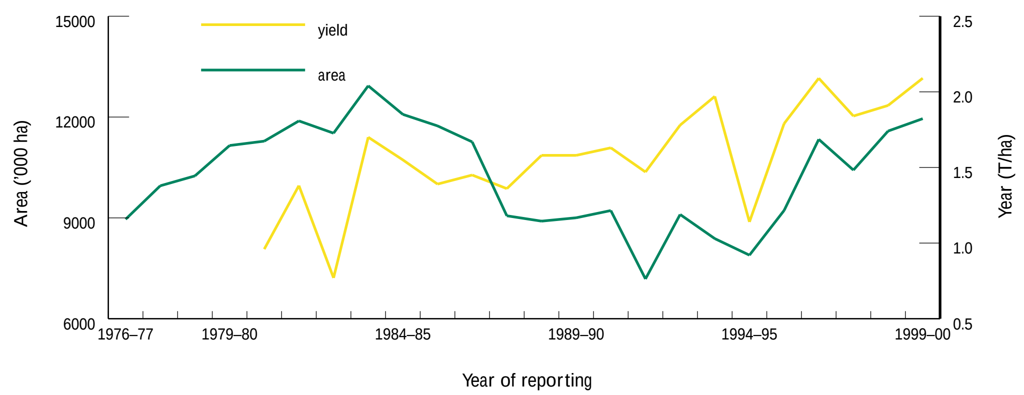
Contents

Figure 1.9 Area of winter grains in Australia since 1860.



Data source: Australian Agriculture Assessment 2001 (NLWRA 2001e)

Figure 1.10 Wheat yield and area.



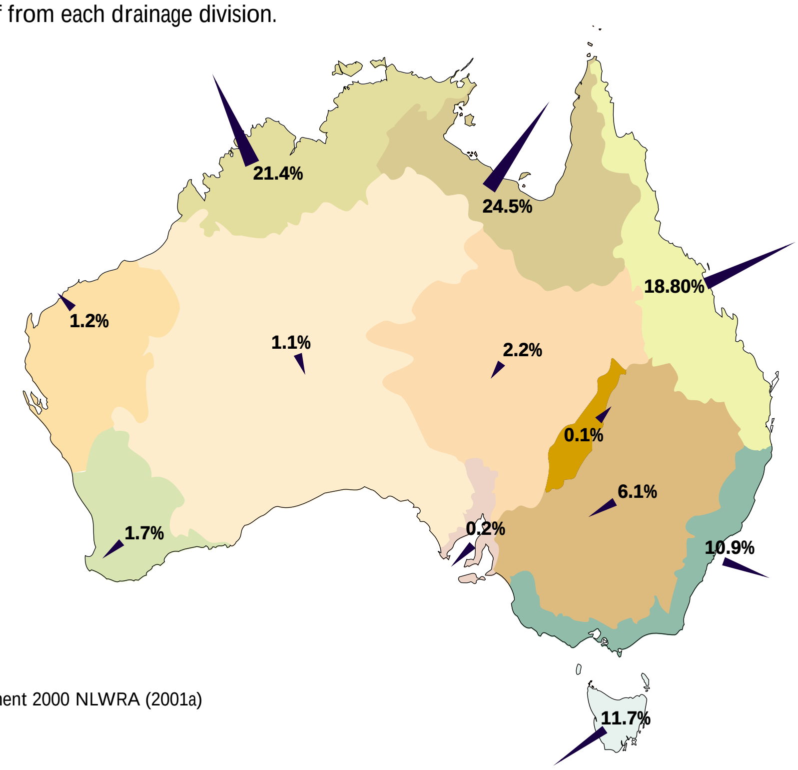
Data source: ABARE (2000)

WATER RESOURCES AND USE

Australia has less than 1% of the total available renewable fresh water resources of the world. Key features of Australia's water resource availability and use are listed.

- Only 12% of rainfall runs off to collect in rivers.
- Australia's northern drainage divisions—Timor Sea, Gulf of Carpentaria and North-East Coast—account for about 60% of divertible fresh surface water resources but the volume of water actually diverted and used in these drainage divisions is quite low (Figure 1.11).
- In contrast, the Murray–Darling drainage division accounts for only about 12% of the potentially divertible fresh surface water but nearly all of this is diverted and used (Table 1.4).
- In several drainage divisions in southern Australia, development of water resources is approaching or in some cases has exceeded sustainable extraction limits (NLWRA 2001a).
- 26% of Australia's 325 surface water management areas are either fully used or overused when compared with sustainable flow regime requirements. These account for 55% or 13 200 GL of water use in Australia.
- Australia has an estimated 25 780 GL of groundwater that could be sustainably extracted each year for livestock and domestic use and for irrigation. About 10% is currently used. However, 161 or 30% of Australia's 535 ground water management units are close to or overused compared with their estimated sustainable yield.
- Water use increased by nearly 60% in the 13 years to 1996/97 to 24 000 GL. 75% of the water used in Australia is for irrigation with an increase of 70% over the same period. Urban or industrial uses account for 20% of total water use and this has increased by 53% over this 13-year period. Water for rural domestic use accounts for only 5% of total water use.
- While data on water quality is lacking at a national scale, some 65 basins assessed for water quality were found to have major exceedances of guidelines for nutrients, salinity or turbidity (NLWRA 2001a). Major exceedances of salinity were most prominent in the Murray–Darling and the South-West Coast drainage divisions.
- Australia has a combined large dam storage capacity of 79 000 GL and an estimated 9% of total water stored is accounted for by private dams on farms.

Figure 1.11 Percent run-off from each drainage division.



Data source:

Australian Water Resources Assessment 2000 NLWRA (2001a)

Table 1.4 Summary of Australia's surface water resources.

Drainage division	Mean annual run-off[a] (GL)	Divertible fresh surface water[b] (GL)	Volume diverted[a] (GL)
Timor Sea	83 320	22 000	48
Gulf of Carpentaria	95 615	13 200	52
North-East Coast	73 411	22 900	3 185
Indian Ocean	4 609	235	12
Western Plateau	1 486	102	1
Lake Eyre	8 638	204	7
Bulloo–Bancannia	546	41	<1
Murray–Darling	23 850	12 300	12 051
South-East Coast	42 390	14 700	1 852
South-West Coast	6 785	1 390	373
South Australian Gulf	952	160	144
Tasmania	45 582	10 900	451
Australia	**387 184**	**98 100**	**18 147**

Sources:

a Australian Water Resources Assessment 2000 (NLWRA 2001a)

b Water Review '85 Department of Primary Industries and Energy (1987)

RETURNS FROM AGRICULTURE

The Australian Bureau of Statistics and Australian Bureau of Agricultural and Resource Economics report on a range of measures that track the performance of the agricultural sector.

Australian Bureau of Statistics

- Reports several measures as part of the national accounts and also measures the financial performance of farms from its Agricultural Finance Survey—of management units undertaking agricultural activity having an *estimated value of agricultural output* of $22 500 or more.
- Every five years, conducts a census of all agricultural enterprises with an economic value of agricultural output in excess of $5000.

Australian Bureau of Agricultural and Resource Economics

- Reports annually on the financial performance of broadacre and dairy farms from its annual farm survey program based on agricultural operations with a similar minimum estimated value of agricultural output.
- Occasionally reports financial estimates for some other agricultural industries.
- Presents aggregate estimates of gross value of farm production, farm costs and net value of farm production (ABARE 2000) derived from Australian Bureau of Statistics data.

Each measure of performance is designed for a specific purpose but none is available at a very fine scale. Consequently the performance measures fall short of what is required for some resource management planning and assessment purposes.

A major project commissioned by the Audit estimated the net returns to the agricultural resource base on a reasonably fine scale (1:1 000 000) for the base year 1996/97 and the average of five years ending 1996/97 (CSIRO Policy and Economic Research Unit 2001). Net returns are calculated based on the concept of *profit at full equity* (see Box 1.1). For each 1 square kilometre of agricultural land in Australia net returns were calculated and mapped based on dominant land use, the local gross value of production, and costs of production including costs of capital and managerial labour. The net return estimates presented here are average profit at full equity—effectively the profit or net return to the natural resource base and managerial skill under current farming conditions. From the available data sets it is not possible to separate the return to the natural resource base from the return to managerial skill. The estimate does not include income received from off-farm sources. As a consequence of the full equity assumption, transfers in the form of interest payments are not deducted.

A spatial representation of profit at full equity across the Australian agricultural landscape provides a useful basis on which to evaluate costs and benefits of land use. Land degradation costs and investment in remedial management can be combined with this profitability perspective to guide decisions on land use change and further investment.

Home

Contents

BOX 1.1 THE CONCEPT AND METHOD OF ESTIMATING PROFIT AT FULL EQUITY

Profit at full equity is a measure of the net returns to land and water resources used for agriculture and the managerial skill of land managers. The concept is based on the assumption that the land is fully owned (100% equity) and that all income is derived from farming. The definition of profit at full equity used in this report is similar to that used by the Australian Bureau of Agricultural and Resource Economics in its farm surveys and the Australian Bureau of Statistics, with some minor differences. Whereas the Agricultural and Resource Economics, and Australian Bureau of Statistics estimate profit at full equity for a farm unit that includes income earned by contracting and all members of the farm family. However, the measure presented here is derived with reference to a square kilometre of agricultural land classified by industry/commodity type as represented in the national land use map. Off-farm income (net revenue derived off farm from the use of farm resources, such as for carting grain or contracting to help repair a shire road) is also included in the Australian Bureau of Agricultural and Resource Economics and Australian Bureau of Statistics estimates but there is no allowance for this here. In this report, profit at full equity is defined as:

$$\underset{(\$/\text{ha/yr})}{\text{Profit at full equity}} = \underbrace{\text{price} \times \text{quantity produced}}_{\text{Revenue}} - \text{variable costs} - \text{fixed costs}$$

$$\text{Revenue} = \left[\underset{(\$/\text{t or }\$/\text{DSE})}{\text{unit price}} \times \underset{(\text{t/ha or DSE/ha})}{\text{quantity}} \times \text{turn off rate}\right] + \left[\underset{\$/\text{L or }\$/\text{kg}}{\text{price of secondary product}} \times \underset{(\text{L/DSE or kg/DSE})}{\text{yield of secondary product}} \times \text{quantity}\right]$$

$$\text{Variable costs} = \left[\underset{(\$/\text{t or }\$\text{DSE})}{\text{quantity-dependent costs}} \times \text{quantity} + \underset{(\$/\text{ha})}{\text{area-dependent costs}}\right] + \left[\underset{(\text{L/ha})}{\text{water requirement}} \times \underset{(\$/\text{L})}{\text{water price}}\right]$$

$$\text{Fixed costs} = \underset{(\$/\text{ha})}{\text{fixed operating costs}} + \underset{(\$/\text{ha})}{\text{fixed depreciation costs}} + \underset{(\$/\text{ha})}{\text{fixed labour costs}}$$

Revenue is derived from:

- information about yields for the area in question;
- derived local prices; and
- price and production data for agricultural commodities recorded by the Australian Bureau of Statistics at the statistical local area level.

Data on fixed and variable costs were derived from Agricultural and Resource Economics data at a regional level. Interest or rent payments, and depreciation on leased items were excluded in line with the full equity assumption.

Use was also made of State government gross margin information handbooks which give quantity and area-dependent variable costs of agricultural production for various enterprises. Information on land uses was derived from the Audit's land use maps representing 67 land use types. Using satellite imagery, measures of vegetation vigour referred to as the normalised difference vegetation index or 'greenness' are used to distribute production in proportion to yield variation across each statistical local area.

Net economic return is defined as:

$$\text{Net economic return} = \text{profit at full equity} - \text{net government support}$$

Information on government support to agriculture was derived from Productivity Commission report (1998). State and industry aggregate estimates were converted to a value per hectare or percentage of gross product value.

Such spatially explicit data sets relating economic returns to agricultural land uses and the natural resource base provide a critical link between land management strategies and their economic consequences. Further information on the method used in estimating profit at full equity and net economic returns to land and water resources can be found in Appendix 1 of CSIRO Policy and Economic Research Unit project report (2002).

Home

Contents

NET VALUE OF AGRICULTURAL PRODUCTION

How much profit is derived from agriculture in Australia? Table 1.5 presents estimates of the net value of agricultural production. They were derived from this Audit assessment using Australian Bureau of Statistics and the Australian Bureau of Agricultural and Resource Economics data in association with maps of land tenure and information on value of production from local sources when this information was not available from Agricultural and Resource Economics or the Australian Bureau of Statistics. For the three estimates, there are slight differences in definition and differences in derivation although the basic source for most components is Australian Bureau of Statistics agricultural surveys. Estimates of agricultural income from Australian Bureau of Statistics and the Australian Bureau of Agricultural and Resource Economics are shown for comparison (Figure 1.12). Despite differences in derivation and definition, the estimates are reasonably comparable and indicate that for 1996/97 profits from agriculture were in the order of $4.2 billion to $6.5 billion. One of the reasons for the difference is that the Audit's estimate includes all agricultural land.

Table 1.5 Comparison of data sets estimating net value of agricultural production (1996/97).

	ABS[a] ($m)	**Audit**[b] ($m)	**ABARE**[c] ($m)
Revenue	24 694	28 419	28 086
Costs	18 317	21 865	23 808
Net value of agricultural production	6 377[d]	6 555	4 279
Agricultural income[e]	5 962		
	(million ha)	(million ha)	(million ha)
Area of agricultural land	453.7	472.7	466.1

a Derived from: ABS 1998, *7507.0 Agricultural Industries, Financial Statistics, Australia, Final Issue (1996/97)*, Australian Bureau of Statistics, Canberra. These values are only for industries that are also represented in this project.

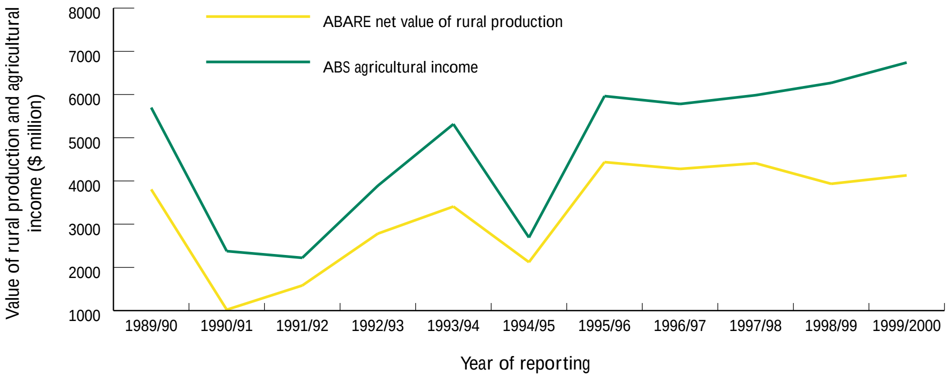
b Prepared by CSIRO, Policy and Economic Research Unit.

c Derived from ABARE 2000, *1999 Australian Commodity Statistics*, Australian Bureau of Agriculture and Resource Economics, Canberra.

d Determined by subtracting Australian Bureau of Statistics costs from Australian Bureau of Statistics revenue.

e ABS 1999, *Australian System of National Accounts 1997/98*, Cat. no. 5204.0, Canberra.

Figure 1.12 Movements in net value of rural production[a] and agricultural income[b].



a ABARE 2000, *Australian Commodity Statistics*, Canberra.

b ABS 1999, *Australian System of National Accounts 1997/98*, Cat. no. 5204.0, Canberra.

Home
Contents

SPATIAL ESTIMATES OF PROFIT AT FULL EQUITY

Over the five years to 1996/97, the net returns per hectare to the land resource in the arid or semi-arid interior where extensive grazing predominates, have been negative or very low. Only relatively small areas of Australia have high returns per hectare and these are confined largely to the irrigated southern regions and parts of southwest Queensland (Figures 1.13, 1.14).

Over the five years to 1996/97 total profit at full equity from agriculture averaged $7.5 billion, with the land use groups of dairy, cereals and cotton accounting for over 50% of profit. The depressed state of the sheep industry over this period is readily apparent (Table 1.6).

Since 1996/97 wool, sheep meat and beef prices and profits have recovered significantly (Figure 1.15). Undertaking a re-analysis of profit at full equity using the 2001 Agricultural Census once it becomes available should reflect these more recent changes in agriculture.

A very small proportion of the Australian agricultural landscape produces most of the net return to land, water, capital and management. Eighty percent of profit at full equity comes from 4 million hectares—less than 1% of the area used for agriculture. This is highlighted in Figure 1.16 which shows the location of the most profitable areas of agriculture on a per hectare basis. Similarly, 14 river basins in Australia, out of a total of 246, account for 50% of total profits from agriculture in Australia. Many of these are major irrigation regions (Table 1.7). Estimates of profit at full equity are dependent on commodity prices and will vary from year to year. More detailed estimates of profit at full equity are presented in Appendix 1.

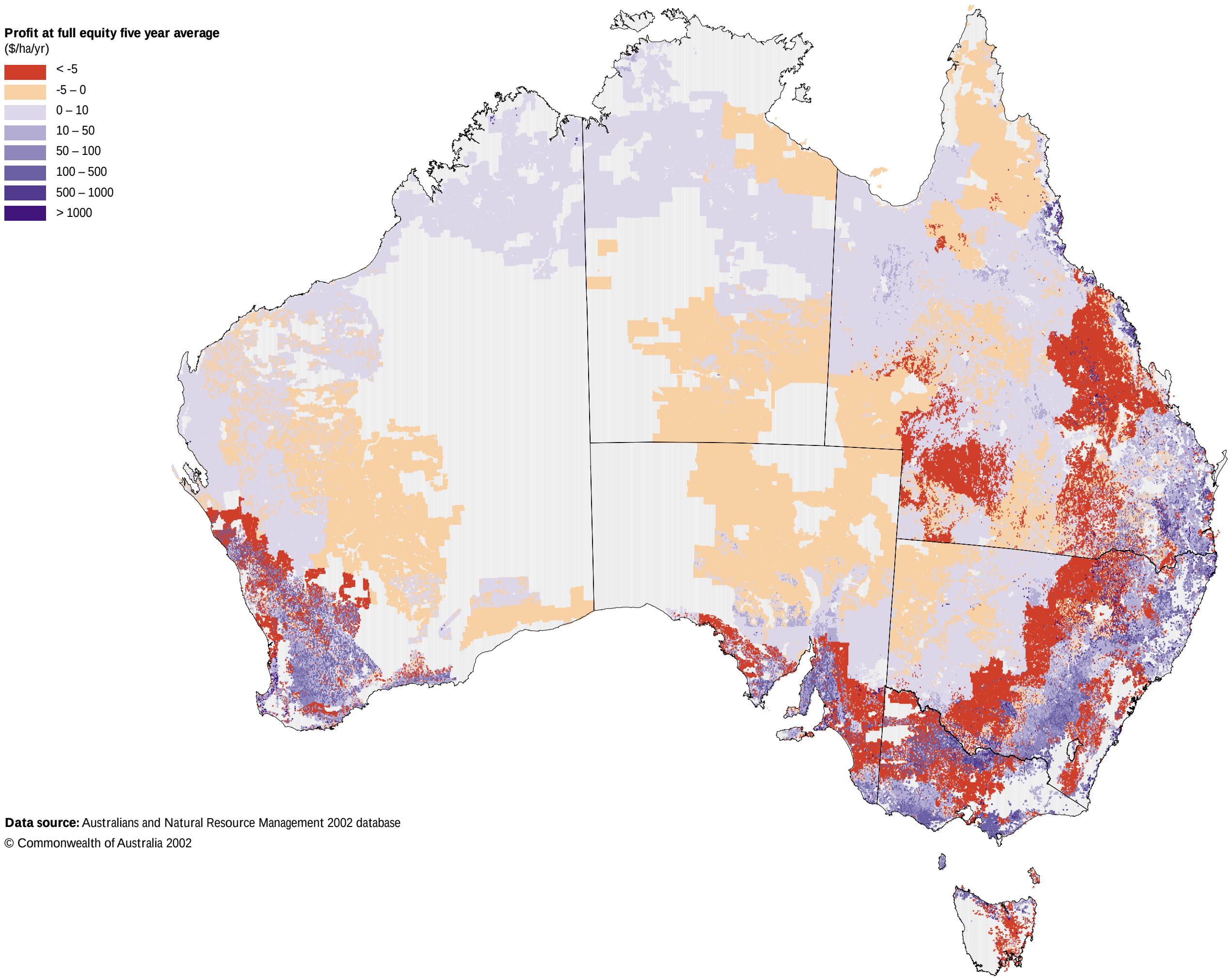
Table 1.6 Profit at full equity by dominant land use type.

Land use*	Five-year mean ($m)	1996/97 ($m)
Dairy	1 649	1 590
Cereals	1 305	1 836
Cotton	1 089	1 213
Fruit	951	889
Coarse grains	649	560
Vegetables	593	508
Beef	578	-718
Grapes	482	468
Sugar cane	264	167
Tree nuts	68	71
Oilseeds	63	93
Rice	48	52
Legumes	19	85
Peanuts	17	23
Tobacco	15	13
Hay	9	11
Sheep	-270	-306
Total	**7 530**	**6 555**

* Figures are Australia-wide including extensive and intensive agriculture;. They have not segmented industry sectors, such as intensive beef or feedlots. Profit from production from mixed farming enterprises (e.g. a wheat–sheep farm) are reported within each 'land use' class.

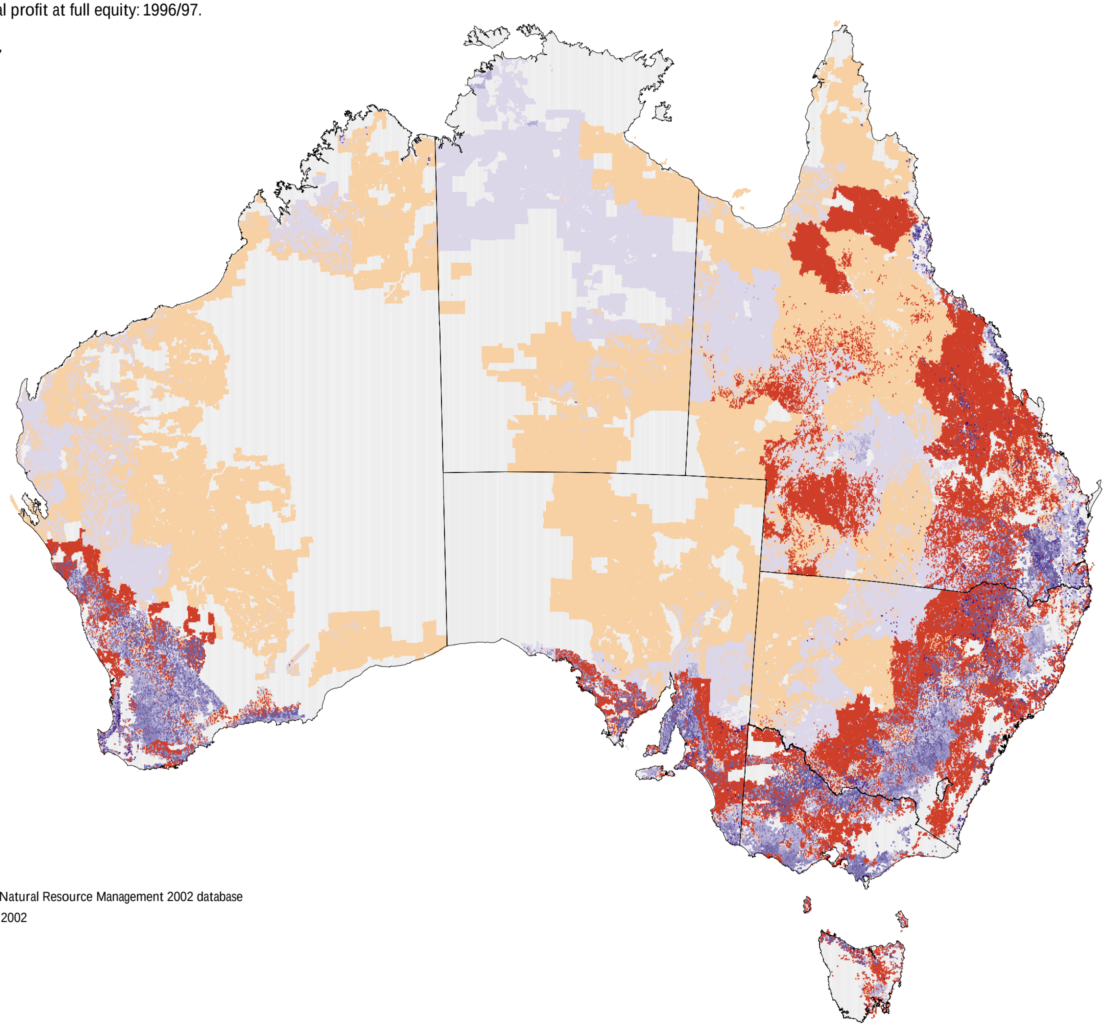
Home
Contents

Figure 1.13 Agricultural profit at full equity: five year average to 1996/97.



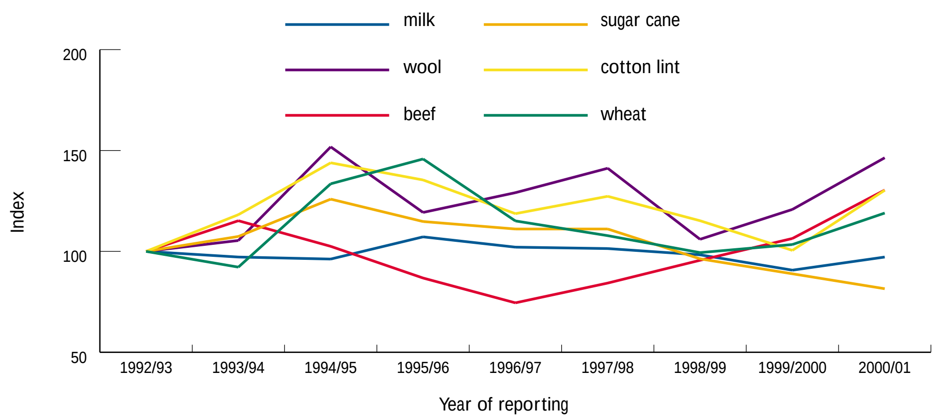
Data source: Australians and Natural Resource Management 2002 database

Figure 1.14 Agricultural profit at full equity: 1996/97.



Data source: Australians and Natural Resource Management 2002 database

Figure 1.15 Price movements for major agricultural commodities.

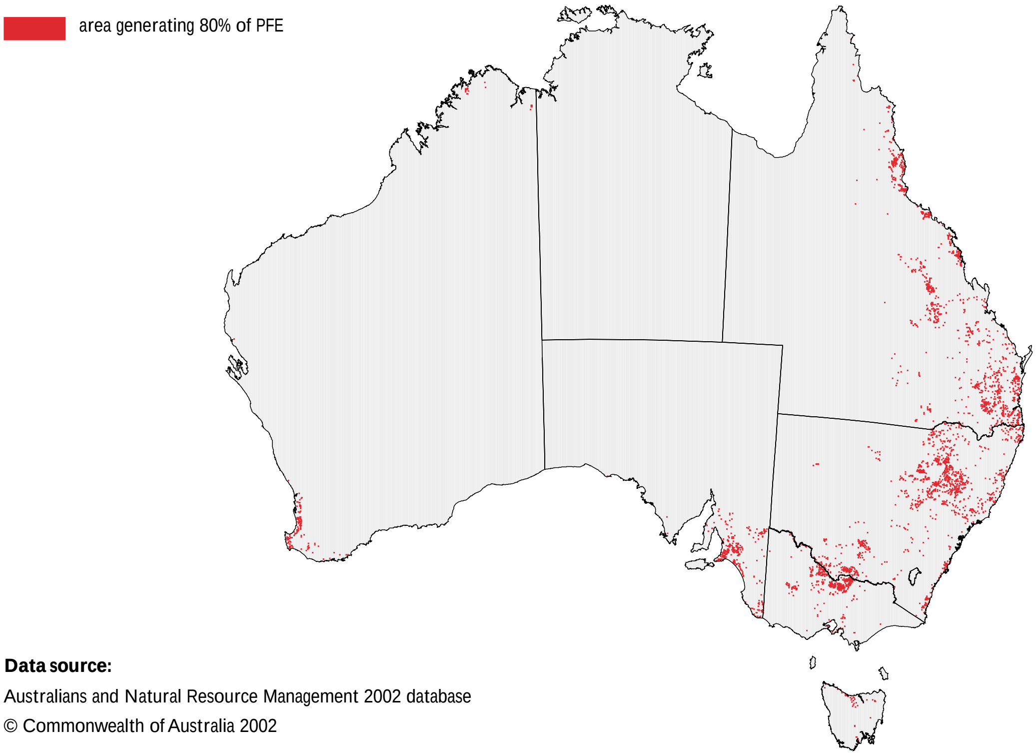


Data source: ABARE commodity statistical bulletin (2000)

Table 1.7 Contribution of river basins to total profit at full equity.

Basin	**Total profit at full equity** ($'000)	**Cumulative contribution to total for all agriculture** (%)
Condamine–Culgoa Rivers	424 572	5.6
Murrumbidgee River	418 392	5.6
Namoi River	380 857	5.1
Avon River	303 668	4.0
Lower Murray River	302 864	4.0
Mallee	283 720	3.8
Border Rivers	266 110	3.5
Gwydir River	225 494	3.0
Broken River	197 455	2.6
Fitzroy River (Qld)	196 296	2.6
Goulburn River	193 330	2.6
Brisbane River	191 824	2.5
Broughton River	168 094	2.3
Macquarie–Bogan Rivers	159 375	2.1
Subtotal	**3 712 051**	**49.3**
Rest of Australia	3 817 938	50.7
Total	**7 529 989**	**100.0**

Figure 1.16 Areas in Australia accounting for 80% of profit at full equity (1996/97).



Data source:
Australians and Natural Resource Management 2002 database

RETURNS TO WATER RESOURCES

Over 50% of the total profits generated from use of agricultural and pastoral land come from irrigation (Table 1.8). Estimates of average profit at full equity per megalitre of water used per year (Table 1.9) show the relative intensity of water use. Land uses such as vegetables and fruit have high returns per unit of water used. In contrast, a high proportion of irrigation water is used for intensive pasture grazing, particularly dairying, where the returns per megalitre of water are an order of magnitude less.

For the major irrigation industries, the costs of water as a proportion of total input costs range from about 14–16% for dairy, sugar cane and rice; 3–4% for grapes and cotton; and only 1–2% for fruit and vegetables.

Table 1.8 Total profit at full equity generated from dryland and irrigated agriculture.

Land use	**Net returns**		**Area***
	1996/97 ($m)	**Average of five years to 1996/97** ($m)	(million ha)
Dryland cropping and grazing	2888	3691	469.7
Irrigation	3667	3839	2.3

* Based on a reclassification of the National Land Use Map (Stewart et al. 2001 to identify irrigation areas).

Table 1.9 Annual returns to water and intensity of water use (profit at full equity, 1996/97)[a].

Land use	**Water returns** ($/ML)	**Total water use** (GL)	**Percent of total water use** (%)	**Water use** (ML/ha)
Beef	14	1080	7.2	4
Cereals	-9	87	0.6	3
Coarse grains	116	518	3.5	3
Cotton	452	2 314	15.5	7
Dairy	94	5 902	39.5	7
Fruit	1276	665	4.4	7
Grapes	600	781	5.2	8
Hay	54	20	0.1	4
Legumes	24	33	0.2	3
Oilseeds	10	85	0.6	3
Peanuts	90	25	0.2	3
Rice	31	1 696	11.3	11
Sheep	23	13	0.1	4
Sugar cane	21	1 195	8.0	7
Tobacco	985	13	0.1	4
Tree nuts	507	140	0.9	6
Vegetables	1295	392	2.6	3
All irrigated land uses	193	14 959	100.0	7

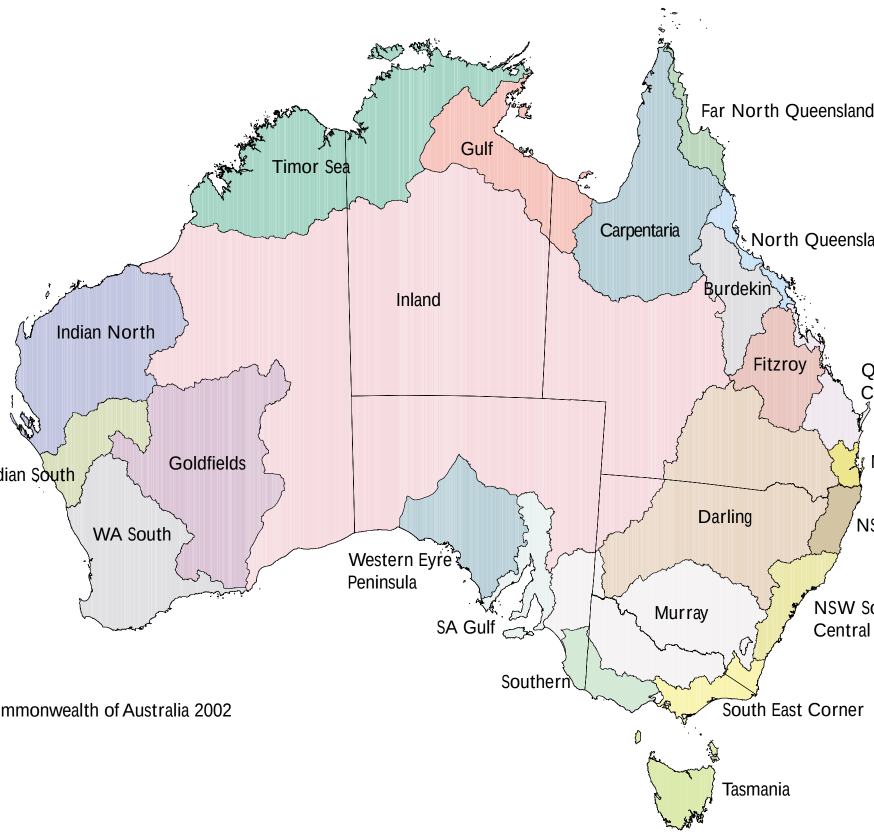
a Derived from estimates of mean water use per land use type in each region.

NET ECONOMIC RETURNS

To facilitate international debate about degrees of protection, the Organisation for Economic Cooperation and Development has developed a method for converting estimates of the costs of all forms of assistance to agricultural production into a producer subsidy equivalent. This is that amount of money which, if paid in lieu of all government programs and arrangements such as research and extension that tend to increase the value of agricultural production, would result in farmers receiving the same net income benefit. Arguably, if this estimate is deducted from profit at full equity, the result is an estimate of the *net economic return* to the resource base and management skill from agricultural production in Australia (see Box 1.1). Critics of this measure argue that the most appropriate measure is one that effectively compares Australian agriculture with the average degree of support for all agriculture across the world.

Profit at full equity is a measure of returns to land resources and management skill under control of private individuals. This results in estimate of the *net economic return* per hectare (see Box 1.1). As explained above, estimates of the net value of support to agriculture were derived from data supplied to the Organisation for Economic Cooperation and Development and also data published by the Productivity Commission. The total value of support to

Figure 1.17 Reporting regions used for the economic assessment.



agriculture, using the internationally agreed measure of support was $2.2 billion in 1996/97 or 34% of profit at full equity. It is appreciated that all Organisation for Economic Cooperation and Development countries provide some support to agriculture and that on an international scale the level of support supplied by Australia is relatively low. Moreover, under a scenario where there was global free trade in agricultural products, the nature of Australian agriculture would be quite different. The measure does not include the cost of environmental programs such as the Natural Heritage Trust and the National Action Plan for Salinity and Water Quality. Net economic returns by reporting region are presented in Table 1.10. Estimates of net economic return by river basins are also presented in Appendix 1.

Table 1.10 Net economic returns by region.

Region	Government Support in 1996/97 ($m)[1]	Support as portion of profit at full equity (%)[2]	Share of total support (%)	Net economic returns in 1996/97 ($m)[3]
Burdekin	14	-23	1	-78
Carpentaria	20	-32	1	-83
Darling	289	16	13	1 507
Far North Queensland	7	91	0	1
Fitzroy	41	53	2	36
Goldfields	4	115	0	0
Gulf	1	-44	0	-5
Indian North	2	-20	0	-10
Indian South	13	36	1	23
Inland	19	-15	1	-150
Moreton	97	34	4	189
Murray	664	34	30	1 287
NSW North	59	43	3	78
NSW South & Central	145	100	6	0
North Queensland	68	34	3	131
Queensland South & Central	87	41	4	123
SA Gulf	76	17	3	364
South East Corner	160	90	7	18
Southern	175	74	8	62
Tasmania	86	75	4	29
Timor Sea	12	21	1	47
WA South	187	21	8	723
Western Eyre Peninsula	12	35	1	23
Australian	**2 239**	**34**	**–**	**4 316**

1 This includes Commonwealth, State, Territory and local government support to agriculture. It has been determined from nominal rates of Commonwealth assistance on outputs and State government outlays calculated as a portion of farm gate value. Data on nominal rates of assistance are assembled and published by the Productivity Commission.

2 Negative percentages are given in regions where the total 1996/97 profit at full equity is also negative.

3 Net economic return is equal to profit at full equity less government support.

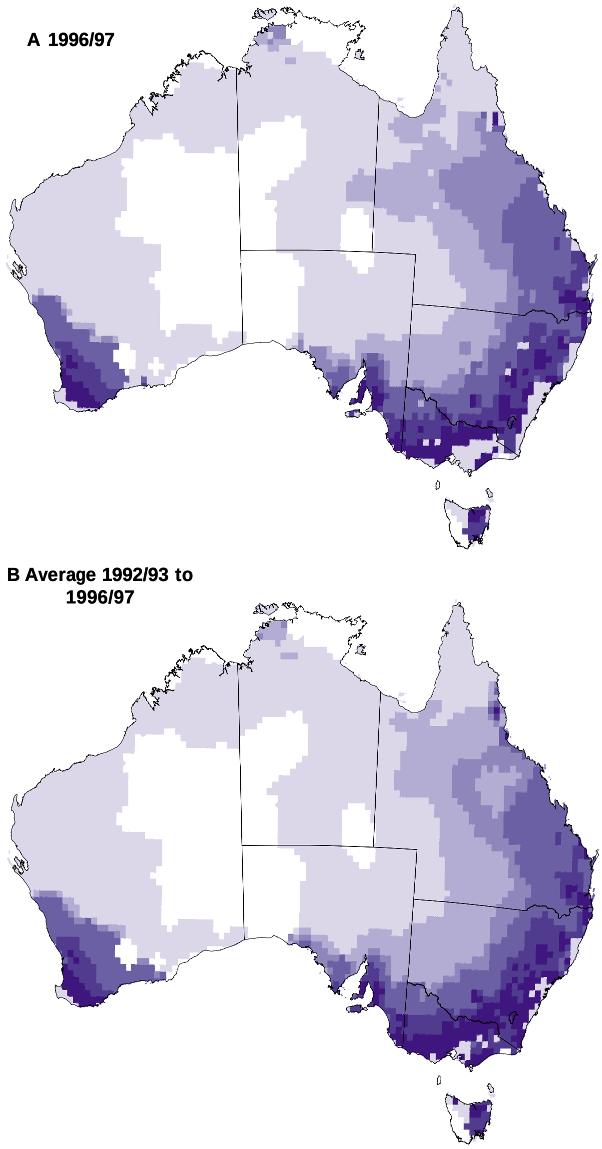
LAND VALUES

The market value of agricultural land should reflect its expected money earning capacity. In most cases this is generally so but near large cities and towns and on the coast, land values are often more a reflection of demand for non-agricultural uses and values. These include amenity and lifestyle values.

The value of land used for agriculture may also be affected by the perceived degree of degradation on that land (see Chapter 4).

Estimates of broadacre farm land values generally increase as one moves from the arid interior regions to the more settled higher rainfall regions in the eastern, southern and south-western coasts, as shown in Figure 1.18(A) (for 1996/97) and Figure 1.18(B) (five-year average 1992/93 to 1996/97).

Figure 1.18 Land values of broadacre farms—as estimated by the Australian Bureau of Agricultural and Resource Economics survey respondents.

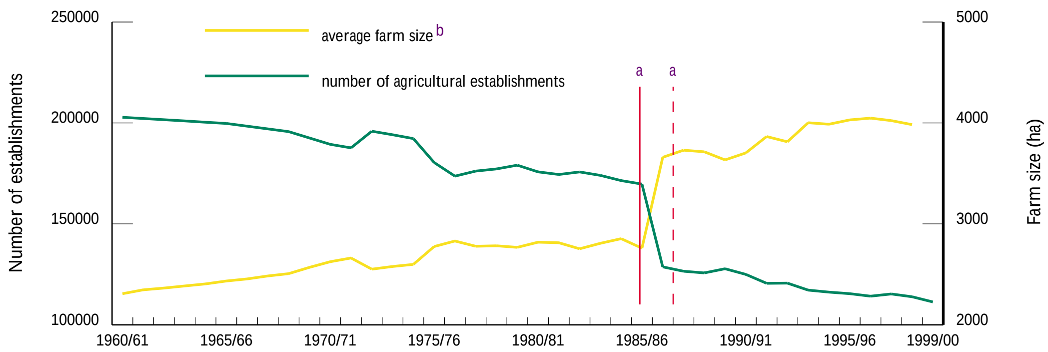


Data source: ABARE (2000)

SOME LONG-TERM TRENDS AND DRIVING FORCES

Continuous change in the structure and social characteristics of agriculture in Australia mirrors similar trends in nearly all developed countries. The net value of agricultural production in Australia has grown in absolute terms but other sectors of the economy have grown much faster. Because of increases in technological efficiencies in agricultural productivity as well as demand for labour in other sectors, there has been a movement of labour out of agriculture into other sectors of the economy. Consequently agriculture has steadily declined as a contributor to total economic growth as measured by gross domestic product (GDP) and total value of exports. The number of agricultural establishments (farming businesses) has declined but the average size of farms has increased (Figure 1.19). Farmers' terms of trade and the real net value of agricultural production have both shown strong downward trends (Figure 1.20). Farmers, however, have responded to these changing conditions by adopting more efficient technologies. Structural changes are the inevitable consequence of economic maturity as a nation moves away from a heavy reliance on the primary industry sector. In Australia's case, the economy's dependence on agriculture has declined markedly over the past thirty years (Figure 1.21).

Figure 1.19 Change in farm number and area (1960–2000).

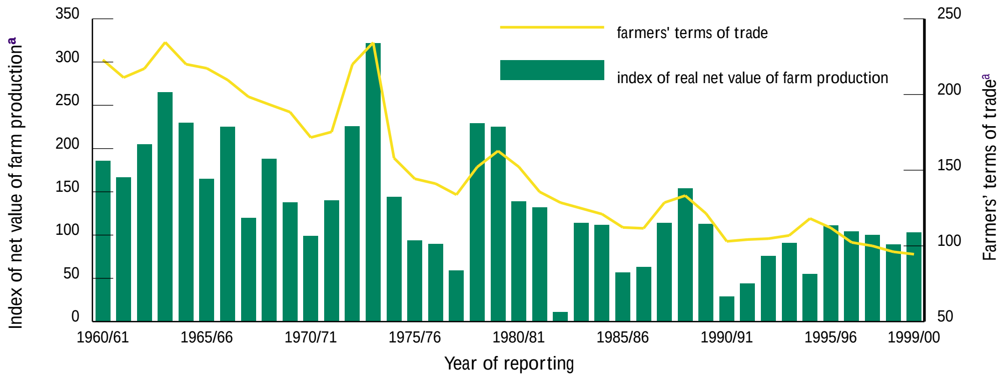


a Alteration due to change in definitions by ABS

b Derived by dividing total area of farms by the number of agricultural establishments

Data source: ABARE (2000)

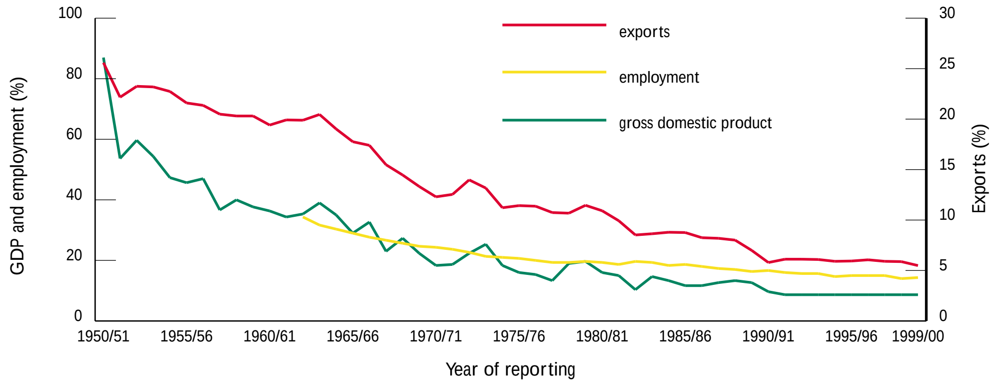
Figure 1.20 Farmers' terms of trade and the real net value of agricultural production.



a Indices with base or reference year 1997/98 = 100. Farmers' terms of trade is the ratio of the index of prices received by farmers to the index of prices paid by farmers.

Data source: ABARE **(**2000)

Figure 1.21 Contribution of agriculture to economic growth (GDP), employment and exports.



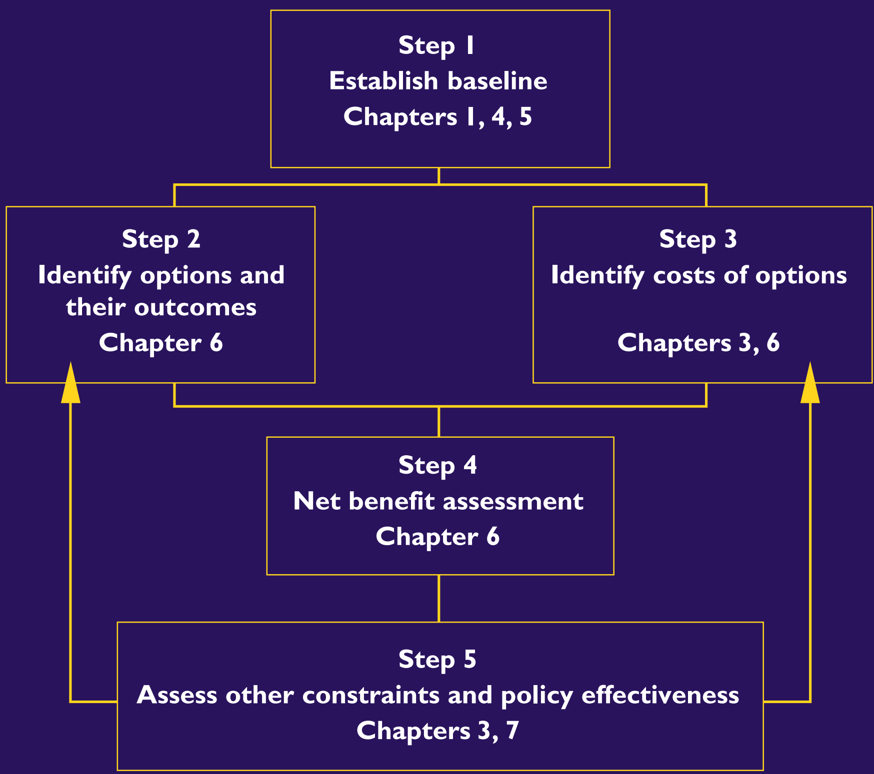
Data source: ABARE (2000)

NATURAL RESOURCE MANAGEMENT DECISIONS

An integrated approach

Key messages

- Priorities cannot be set by estimates of where costs of current natural resource management practices are highest. To set priorities the effectiveness, benefit, and cost of a solution must be known and the net benefits assessed.
- Private natural resource management goals tend to focus on sustainable production and profitability. Public goals not only include these private goals but also include reducing negative off-site effects and enhancing conservation. Understanding where private and public goals are consistent and where they conflict should be a priority for policy makers.
- Even if natural resource management goals are consistent, land owners may deliver less public good than society would choose as their choice of resource management is driven by their private objectives.
- A five-step approach to assessing the net benefits of any natural resource management option is proposed. It can be used as input into the priority setting and design phases of natural resource management decision making. It provides information to help identify the best socioeconomic option for tackling a specific resource management issue.



Awareness of Australia's natural resource management challenges

There are many goals and stakeholders in managing natural resources. Goals of private land owners include:

- maintaining sustainable profit flows from enterprises that utilise the landscape such as agriculture and tourism; and
- maintaining and improving aesthetics and landscape utility on site for the benefit of the land owner or manager.

Public goals include:

- aesthetics; and
- maintaining landscape utility that provides services such as clean water.

Driven by the precautionary principle, concerns about inter-generational equity or for ethical or other reasons, they also include protection and restoration of the environment for its own sake.

Public and private goals are not always consistent although in some areas and industries, production and conservation objectives can be delivered by the same natural resource management approach. In addition, private management decisions on site can have off-site impacts on both production and conservation in other areas. Divergence in goals and the off-site impacts present the main problems for natural resource management.

Governments, as agents of society, are increasingly concerned about perceptions of worsening resource condition. This is driven, in part, by the values that society as a whole places on the natural environment, not only due to greater recognition of the services provided by the environment, but also its intrinsic value. This is reflected in the increasing controls placed by State and Territory legislation on the use of resources on private land (e.g. restrictions on land clearing and rainfall harvesting). With society increasingly demanding the sustainable use of natural resources, private resource managers are coming under pressure to take account of the public benefits and costs and the off-site impacts of their management decisions as well as their own benefits and costs.

Deterioration in the quality of the resource base occurs for many reasons. Natural processes such as erosion are often accelerated by human disturbance, but some occur regardless of the actions of humans (e.g. soil acidity and sodicity are an inherent part of the resource base). Deterioration due to human interference can also be due to a lack of knowledge, delivering short-term needs at the cost of longer-term returns, or delivering private returns at the cost of public returns. While addressing lack of knowledge can lead to a win-win outcome, an explicit consideration of the public and private benefits and costs is required for sensible resource management where private and public interests do not align.

The scale and scope of problems with the natural resource base are described in Chapters 4 and 5, which bring together biophysical information on landscape change and economic information on the value derived from using the resource base. While economic data on future costs or profits foregone provide information about potential gains by addressing natural resource management (and some inherent) problems, it does not tell us anything about optimal management of the resource as it does not address the cost of correcting the problem. In many cases damage may not be reversible or the cost of addressing the problem may greatly outweigh the benefits—both private and public.

The cost of change in resource management practices is not just the financial cost. It includes the personal cost of making decisions, increased perceived risk and having to acquire the skills and knowledge to implement change. Where these costs are high for individual resource managers, even 'no regrets' solutions may not be implemented. Some of the characteristics of farmers that impact on these costs are discussed in Chapter 3.

The risks associated with change in resource management practices involve a complex interaction of agricultural practices and systems, inputs, outputs, prices, uncontrollable constraints (e.g. weather) and resource and social priorities. Ultimately all these issues must be incorporated into any natural resource management framework that takes into account varying response time frames.

The costs and benefits from natural resource management are not static. The social costs and benefits do not necessarily equal the sum of private costs and benefits. The public benefits of successful natural resource management depend on the values placed on social returns—recreation opportunities, ecosystem services and existence values—that are rising with the growing urban population and the change in social norms that favour a high quality natural environment. Falling commodity prices in real terms are reducing the private returns to natural resource management that aim to preserve the resource base for agricultural use. Private land owners will have little incentive to invest in natural resource management for society's well being if the private returns from the investment fall short of the costs.

The role of government in natural resource management

Where all costs and benefits of natural resource management are borne by the individual (no public costs or benefits), the landholder needs to make optimal decisions in regard to natural resource management. In these cases the government has little role in directing natural resource management as, even if managers are poorly informed about the true costs and benefit, their decisions impact only on themselves. However, it is rarely the case that poor decisions will not impact beyond the 'farm gate'. Even where off-site physical impacts such as dust storms and increased turbidity in waterways might be minimal, the socioeconomic impacts of poor longer-term profitability of the enterprises provide a role for government, industry, the community and even neighbours, in providing information and decision-making support.

Government has a more active role in preventing or mitigating externalities or off-site effects of poor management as the costs are widespread and degradation is often difficult to identify. Salinity is a clear example of actions in one area affecting many resource users downstream, albeit with a considerable time lag (e.g. the costs of salinity include reduced agricultural productivity for downstream farmers, loss of fishery resources, damage to wetlands and the environment, and higher water treatment costs). A better understanding of the services provided by the natural environment, from cleaner air and water to the services of genetic diversity, has widened the concept of externalities. The potential benefits from protecting some of the services provided by the natural environment are discussed in Chapter 5.

The challenges to achieving sustainable natural resource management stem mainly from:

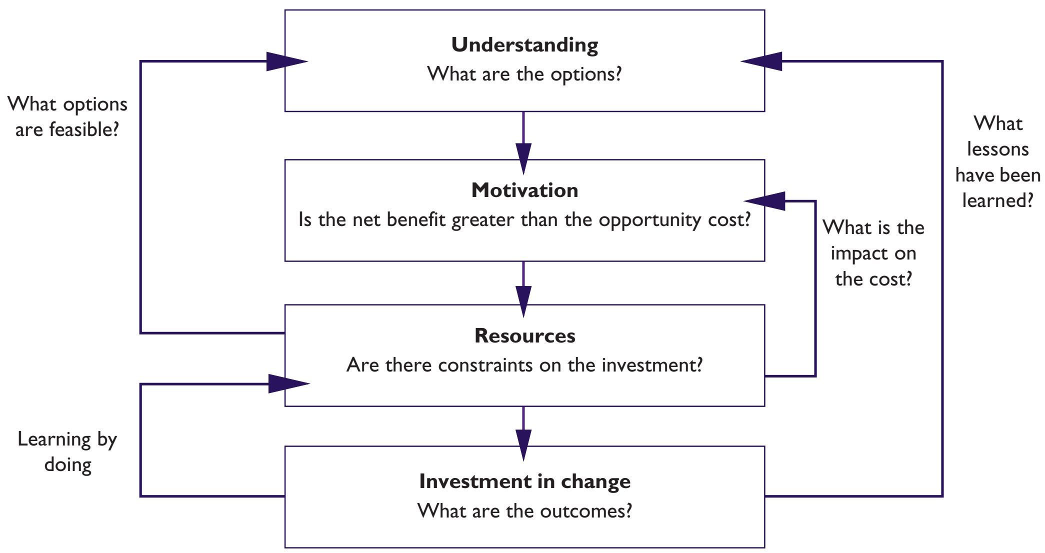
- a lack of knowledge about the causes and consequences of resource use and deterioration, and hence private decision makers not being fully informed in their choices;
- some issues being inter-generational and requiring a long term view and strategy;
- externalities or spillovers where private actions impact on the quality of the natural resources available to others; and
- differences between private and public objectives, time horizons, and the public good nature of many of the 'services' provided by the resource base. These services include existence services such as biodiversity and landscape aesthetics.

What are the challenges to greater investment in natural resource management?

This Audit theme has focused on the capacity of individuals and rural communities to change—that is to invest more and/or more wisely in resource management. Capacity to change presupposes an awareness of current or future problems and a desire for change based on assessments of benefits and costs. Yet the four challenges discussed above as being at the heart of resource management problems explain why some desire change and why others do not.

Figure 2.1 explains how an investment decision process might work with many feedback points.

Figure 2.1 A conceptual framework for decisions on natural resource management investment.



Awareness

The first challenge is understanding that there is a problem. A problem is not just perceived or defined in biophysical terms. It imposes costs (e.g. loss of agricultural productivity, loss of ecosystem services and threats to ecosystem existence). These costs depend respectively on the market prices of farm production, the costs of services to replace those of the environment, and the values placed on the existence of natural ecosystems. But even recognising costs, and hence potential benefits, is not sufficient—there must also be recognised solutions. Lack of information on not only which management practices to undertake, but also on the consequences of any management practice is perhaps the biggest challenge to investment in natural resource management.

Motivation

Challenges arise from conflicts between natural resource management for private and public returns and from competing uses of investment resources. The motivation to address a resource management problem comes from expected benefits exceeding expected costs. These benefits and costs include time and effort as well as financial returns, social impacts and changes in risk exposures. The discount rate that individuals and organisations apply impacts on their assessment of lifetime costs and benefits (e.g. farmers who are nearing the end of their working life and do not wish to leave the farm to the next generation may place a lower value on the longer-term benefit flow from such investments).

Overcoming barriers

The challenge to investment is to overcome barriers caused by lack of capacity rather than lack of understanding or motivation. Capacity is defined here to mean physical and financial resources, skills, and institutions to implement a desired policy, program or action (e.g. investments that require large up-front cash injections, face financial constraints and/or are complex may be beyond the capacity of many landowners). Chapter 3 looks at the characteristics of individual farmers to see how they interact with the characteristics of practices and the impact on adoption.

Investment can be a reorganisation of production systems, change in land use, as well as change in land management practices. The challenge for policy makers is:

- to fully understand the nature of the problems and identify the barriers to adoption;
- to assess whether the gains from change will exceed the costs; and
- if this is the case, to design policies to reduce the barriers and promote adoption.

Natural resource management is all about investment in protecting and remediating the natural resource base and about encouraging people and communities to acquire the necessary resources to do this. And like all investments, hard decisions have to be made about how much to invest relative to other investments, and what types and levels of investment yield satisfactory returns. This chapter develops a framework to address these issues. The overwhelming conclusion of the research for this work is that there are no easy answers—but the work presented here should help guide decision-making processes as well as providing critical information to inform choices.

The institutional framework for natural resource management policy

The 1992 Intergovernmental Agreement on the Environment between the Commonwealth, States and Territories and the National Strategy for Ecologically Sustainable Development provided a framework for a cooperative approach to environmental decision making, policy development and program implementation. The Council of Australian Governments and its Ministerial Councils and the working groups reporting to these bodies have the task of coordinating natural resource management policy.

The Intergovernmental Agreement on the Environment also provided for the establishment of the National Environmental Protection Council. This statutory body is able to make law and is made up of Ministers from State, Territory and Commonwealth governments. It has responsibility for making environmental protection measures.

Constitutionally the States and Territories are responsible for land and water management. Consequently in a federal system of government, collaborative and consultative arrangements have been developed, regionally and locally, to deliver focused, action-oriented programs such as the National Landcare Program and Natural Heritage Trust.

The National Strategy for Ecologically Sustainable Development commits Australian governments to ensure that land use decision-making processes and land use allocations meet the overall goal of ecologically sustainable development and are based on a consideration of all land values, uses and flow-on effects. Under the National Strategy for Ecologically Sustainable Development, governments are working to:

- clarify and publicise policies and legislation for land access (including the conservation and heritage estate);
- promote multiple and sequential land and marine area use, while recognising that there are areas of exceptional environmental or cultural value that are not compatible with economic development;
- develop cooperative and consultative arrangements between jurisdictions; and
- continue efforts to improve understanding of Australia's natural resource base and work towards land use planning and decision making processes which take these values into account.

In recent years the Commonwealth and the States have developed a number of strategies and plans designed to move Australia forward in relation to nationally important issues and to redress specific problems that are limiting to the productive capacity of agriculture or posing risks to the environment.

Within the framework of the National Strategy for Ecologically Sustainable Development a number of strategies and plans provide a focus for particular resource issues, including the National Greenhouse Strategy, National Strategy for the Conservation of Australia's Biological Diversity, the National Forest Policy Statement, the National Weeds Strategy, the National Strategy for Agricultural and Veterinary Chemicals, the National Principles and Guidelines for Rangeland Management.

SCARM 1999

Initiatives also include the revised National Overview for the Decade of Landcare Plan (the main strategic plan for the National Landcare Program), the National Water Quality Management Strategy and the Council of Australian Governments Water Reform Framework.

Additional strategies and plans are being developed between the three levels of Australian governments and regional and community interest groups. These include the National Action Plan for Salinity and Water Quality, a Salinity Management Strategy for the Murray–Darling Basin and a rehabilitation strategy for the Great Artesian Basin groundwater resource. The Audit has provided benchmark information for these and other initiatives.

The complex nature of the causes of lack of sustainability within Australia and the range of participants require a mix of instruments to provide effective solutions. Therefore Australian governments are undertaking a range of measures to address sustainability issues. These measures include:

- developing partnerships across State, Territory and local governments and community groups that coordinate policies and activities to more effectively address resource degradation concerns that are nationally significant. Examples include agreements such as Regional Forestry Agreements for the management of specific types of forests and strategic management plans developed for specific regions. Initiatives such as the Natural Heritage Trust and the National Action Plan for Salinity and Water Quality are funding a wide range of activities to address high priority natural resource degradation issues;
- supporting research and enhanced access to information by landholders and community groups, such as the National Land and Water Resources Audit (information) and National Dryland Salinity Program (research);
- introducing regulatory approaches, such as restrictions on land clearing and capping water allocations in the Murray–Darling Basin;
- creating market-based mechanisms to encourage sustainable and economically viable natural resource management such as water pricing;
- conducting comprehensive environmental impact assessments by Commonwealth and State/Territory agencies of proposals (e.g. for mining developments in environmentally significant areas) that ensure that possible impacts on biodiversity, water resources and fragile ecosystems are taken into account;
- seeking, in accordance with the Council of Australian Governments (COAG) Water Reform Framework, to ensure the provision of environmental water allocations necessary to maintain biodiversity and ecosystem services; and
- supporting traditional owners in sustainable land use methods in national parks (Agenda 21—Australia).

Australia-wide legislation also provides tools for facilitating and implementing a sustainable approach to natural resource management. The *Environmental Protection and Biodiversity Conservation Act 1999* (Cwlth) has six objectives.

- To provide for the protection of the environment, especially those aspects of national environmental significance.
- To promote ecologically sustainable development through the conservation and ecologically sustainable use of natural resources.
- To promote the conservation of biodiversity.
- To promote a cooperative approach to the protection and management of the environment involving governments, the community, landholders and Indigenous people.
- To recognise the role of Indigenous people in the conservation and ecologically sustainable use of Australia's biodiversity.
- To promote the use of Indigenous people's knowledge of biodiversity with the involvement of and in cooperation with the owners of that knowledge.

This Act also includes mandatory reporting requirements on environmentally sustainable development for Australian government agencies, including the extent to which environmentally sustainable development principles are applied in decision making.

Returns to natural resource management and how they might be assessed

The natural resource base:

- prioritises direct inputs into industries which deliver income and employment benefits;
- delivers supporting services for industries and households (e.g. clean air and water); and
- provides opportunities for recreation and enjoyment.

By its very existence it infers benefits. These benefits are enhanced by management to protect and restore the natural resource. Some of these benefits are discussed below to provide a perspective on how they might be assessed.

- Agriculture uses about 60% of the land base and approximately 80% of the water used in Australia. It contributes about 3% to gross domestic product. Management that protects the inherent productivity of the resource base (e.g. maintaining soil nutrients and structure and providing high quality water for irrigation and stock) delivers higher yields and/or lower input costs than would otherwise be the case. The net value of the resource base to agriculture is estimated to be between $6 and $7 billion (Chapter 1). Chapter 4 provides a baseline estimate of the potential benefit if a specific set of resource problems—inherent, induced and off-farm—were corrected.

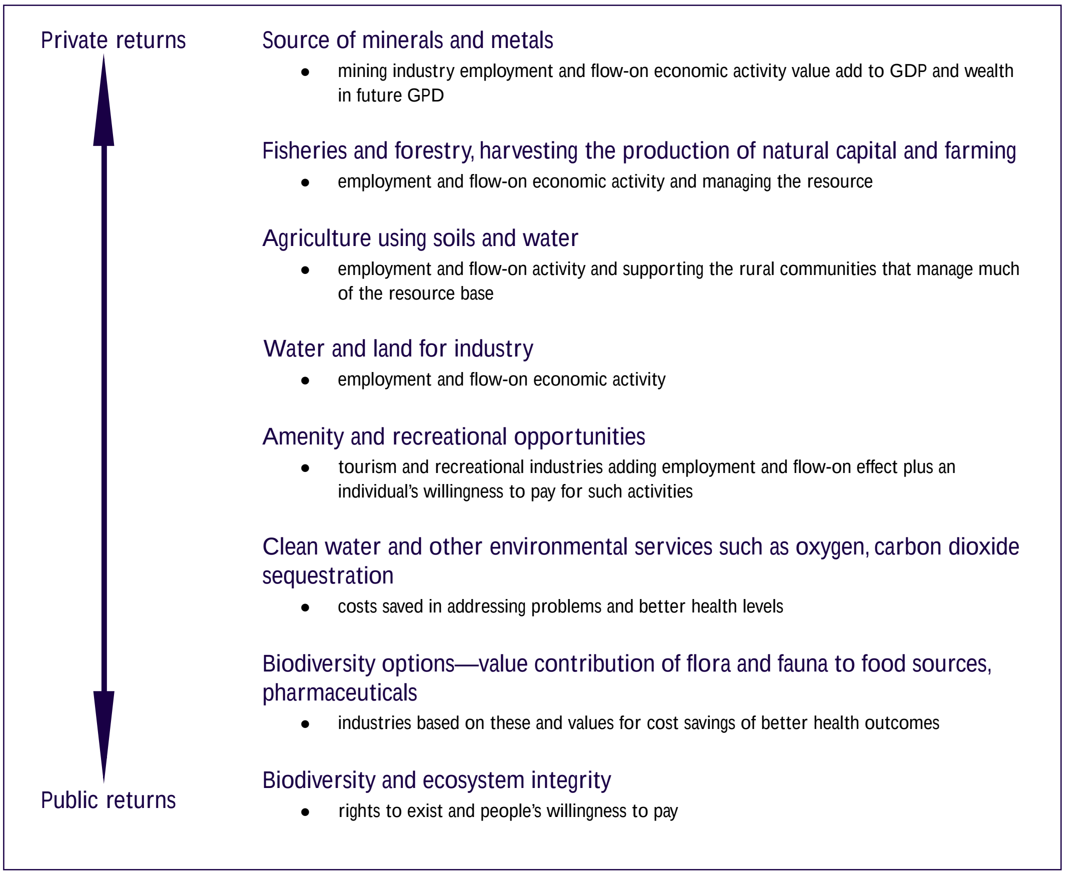
- Fisheries and forestry rely mainly on harvesting native stocks although aquaculture and timber from plantations are increasing. These industries currently contribute around 0.2% of gross domestic product. Although increasingly these products are farmed, sustainable harvesting of naturally occurring stocks has been a major resource management issue for some time. Despite management policies, most native forests and fisheries resources have been declining, partly from:
  - conscious decisions such as land clearing for agriculture;
  - failure to control extraction rates; and
  - lack of knowledge of the size and vulnerability of the resource to natural and human-induced changes.

  Socially optimal rates of harvest tend to be below economically optimal rates as society places greater value on existence and has a lower discount rate (i.e. a lower rate of trading off future consumption for consumption now). Estimates of sustainable harvest rates also vary depending on uncertainty about stocks and replacement rates.
- The landscape and ecosystems play a major role in supporting tourism both directly, through the provision of natural attractions, and indirectly, through the provision of viable country towns with cultural heritage. Visitors to Australia are attracted by pristine beaches, coral reefs and 'wilderness', as well as ecotourism. Yet the benefit to the tourism industry of good resource management is rarely considered as it is hard to establish how many tourists would visit and what their rate of spending would be with and without good resource management.
- Viable, prosperous country communities are a valued asset. Estimates of these values, based on a 'choice modelling' study, are given in Chapter 5.
- Recreation, from bushwalking to swimming, fishing and sailing, benefits from good resource management as little of this activity is conducted in the market economy. Establishing the value of management is difficult. Some of the non-market use value of the environment was captured in the choice modelling estimates of environmental values in Chapter 5. Other approaches to estimating these values are travel cost methods and contingent valuation surveys.
- The values of the services provided by ecosystems, including clean water and air, are starting to be recognised, but are not easy to establish. One approach is to look at the cost of fixing the problems caused by less than clean air and water—used to assess the cost of poor water quality for urban infrastructure in Chapter 5. Another approach is to estimate the value of the service as the price of preventing problems by using alternative technology—used where there is a preventive mechanism such as water treatment systems for urban water.
- Preserving the natural environment for inter-generational equity, for the option to use later and for precautionary principles forms an additional set of benefits from natural resource management. These values can only be revealed indirectly as there is no market to establish a 'price' and they are essentially public goods—they are available to all and not excludable. The value placed by the public on these benefits can be estimated through revealed-preference techniques such as choice modelling,

contingent valuation and hedonic pricing methods. The choice modelling technique is used in Chapter 5 to estimate values for native species protection.

The benefits referred to in Figure 2.2 are gross benefits. Against these must be set the costs of maintaining or enhancing our natural resources—implementing resource management—which include direct costs of putting the practice in place and indirect costs in terms of foregone benefits if use of resources is restricted as a result of the practice. Benefits derived also depend on the success of resource management in achieving restoration and protection outcomes. There is still much to learn about effective management options.

Figure 2.2 Examples of benefits from natural capital.



Who has responsibility for resource management?

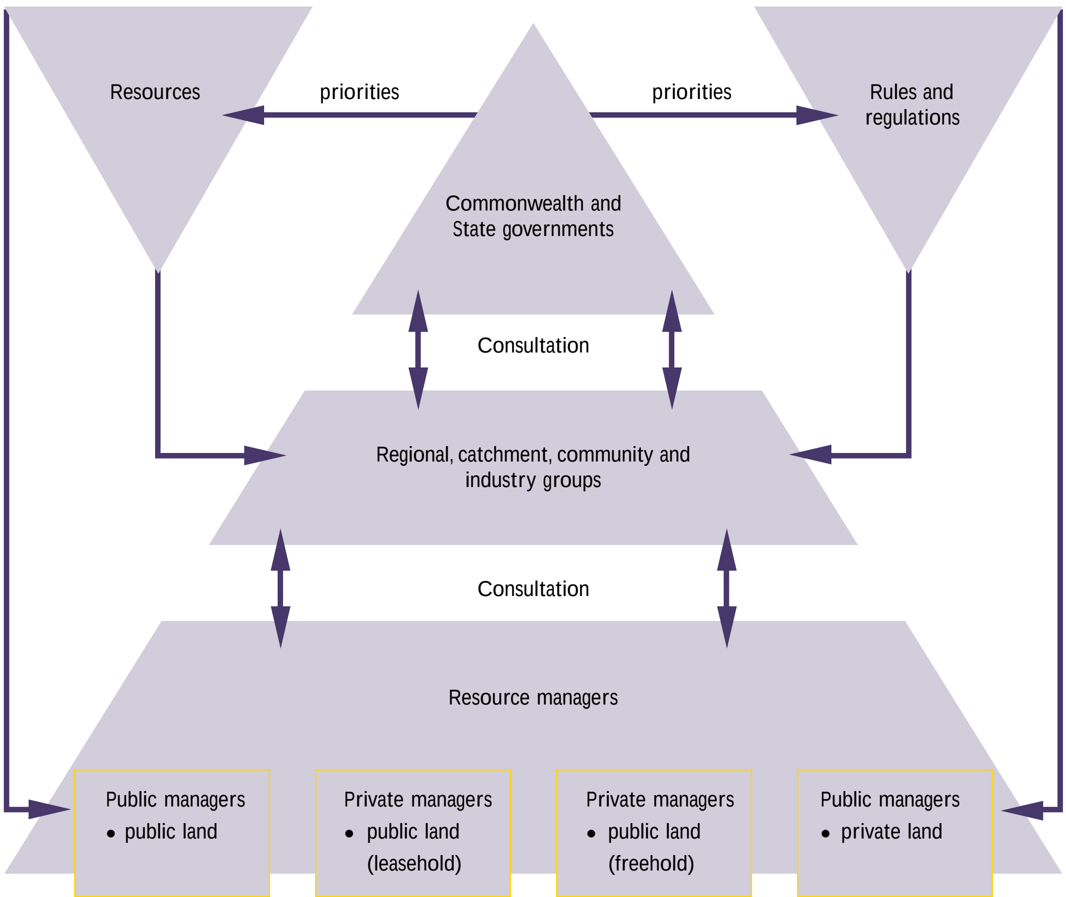
Resource managers fall into a hierarchy:

- managers who undertake investment on their own or on others' behalf.
- groups who provide guidance or set rules at an industry, catchment or regional level,
- managers at State and national levels providing guidance, setting rules and allocating resources to the middle level (Figure 2.3).

Constitutionally, the States and Territories are responsible for land and water management. Consequently in a federal system of government, collaborative and consultative arrangements have been developed through programs such as the National Landcare Program, Natural Heritage Trust and National Action Plan for Salinity and Water Quality.

Figure 2.2 illustrates some of the sources of benefits which accrue from our natural resources.

Figure 2.3 Decision making and doing.



What are the problems facing policy makers?

Policy makers need to know—what to do, how to do it and how to fund it. Given limited resources policy makers must establish priorities. They need to determine:

- size and location of the problem and economic, environmental and social costs if it is not addressed—this will depend on the number of people impacted, the economic importance of the activity affected, the nature of environmental damage and the vulnerability of the group to a shock and, hence, the social costs;
- timing and type of actions imperative for addressing the problem—will the situation deteriorate quickly if not addressed? and
- who is, or should be, addressing the problem—is there a role for government due to market failure, lack of information or divergence between private and social goals and objectives?

These three issues seek to establish a baseline showing what will happen under an operating environment of 'business as usual'. However, where baseline trends suggest priority the most important piece of information for the policy maker is whether there is a feasible alternative outcome. In particular the:

- availability of solutions and benefits that will flow from successful implementation; and
- cost of successfully implementing options, relative to the benefits.

Figure 2.4 sets out the four phases in natural resource management decision making and some of the key issues facing the policy maker.

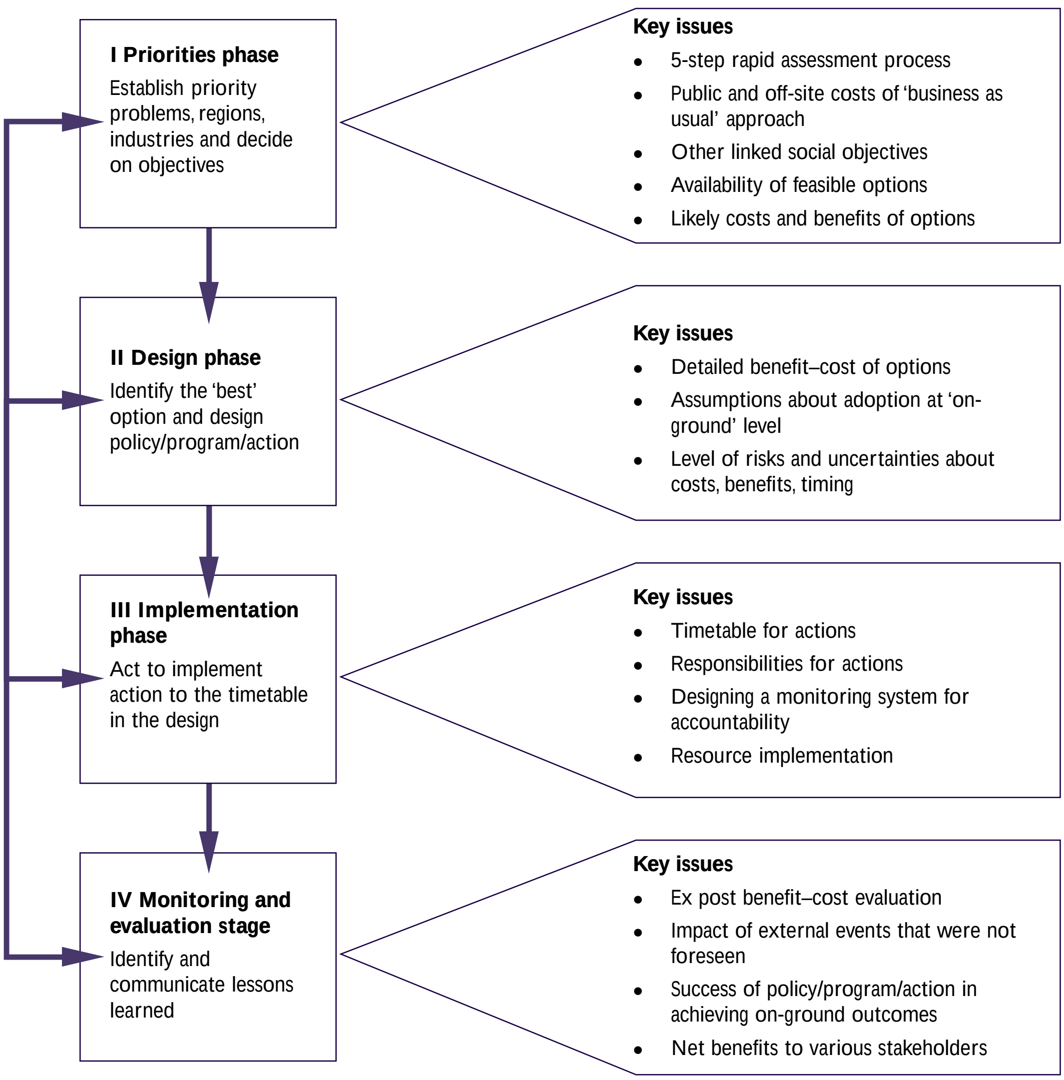
Business as usual

Business as usual is a continuation of current policies, on-farm and off-farm management practices, similar levels of adoption and adaptation, access to knowledge and information; current trends in markets or environmental variability assumed consistent with current agricultural productivity trends.

A RAPID ASSESSMENT FRAMEWORK

A rapid assessment framework, that combines environmental, social and economic aspects of natural resource assessment into the natural resource management decision-making process (Figure 2.4), was established. The five step rapid assessment framework described in this section primarily supports the Priorities Phase (Phase I) in the decision making process.

Figure 2.4 Phases in natural resource management decision making.



Home

Contents

Steps to assessment

The five basic steps to assessing priorities for action (Phase I in Figure 2.4) are applicable at the level of the policy maker, catchment committee, community group and individual land manager. They aim to set out a process for estimating the total *net* benefit of undertaking any policy or practice. Those with the highest net benefits should take priority. Measurement of costs and benefits in dollar terms is a convenience as it allows for easy comparison across space and time. While environmental and social impacts are difficult to quantify, failure to do so may lead to their being left out of the assessment. Hence even if dollar assessments are not made, comparable quantification of the physical outcomes is advised. These can then be included in decision rules (e.g. establishing minimum acceptable change levels as one criterion).

- *Step 1-establish a baseline* —what will happen if nothing is done beyond current measures to address deterioration in the resource base?
- *Step 2-identify potential solutions (options) and their expected outcome*—what are the benefits that flow from an action? These outcomes need to be described in terms of their economic, environmental and social impacts. An estimate of the uncertainty over these outcomes is also required. The potential benefit estimate should reflect expected adoption and/or effectiveness rates and not assume 100% adoption or effectiveness.
- *Step 3-identify the direct and indirect costs of the potential solutions or options*—what are the financial costs, the costs of foregone production (less any reduction in input costs) and the unintended environmental costs (if any) and social costs of the change?
- *Step 4-net benefit assessment* —net benefits are realised when the discounted benefits that were estimated in identification of potential solutions (Step 2) relative to the baseline costs (Step 1) are greater than the discounted direct and indirect costs of the potential solutions estimated in Step 3. Key issues are:

    the appropriate discount rate to use will vary between private and public decisions;

    private net returns where benefits flow on to others; and

    for the public decision maker, the comparison of the return on the natural resource management investment relative to other investments.
- *Step 5-assessment of other constraints and policy effectiveness*—are there other constraints to the investment in resource management? How effective are the policy tools available at overcoming these constraints? These assessments need to feed back into Step 2—the likelihood of achieving the desired outcomes, and into Step 3—the cost of the option. The reason this step comes last is that there need to be at least two rounds from Steps 2 to 5. The first round establishes priorities—which requires an assessment of feasibility, the second round pays more attention to design, market cost and effectiveness estimates. Figure 2.5 summarises the framework with regard to public and private costs and benefits.

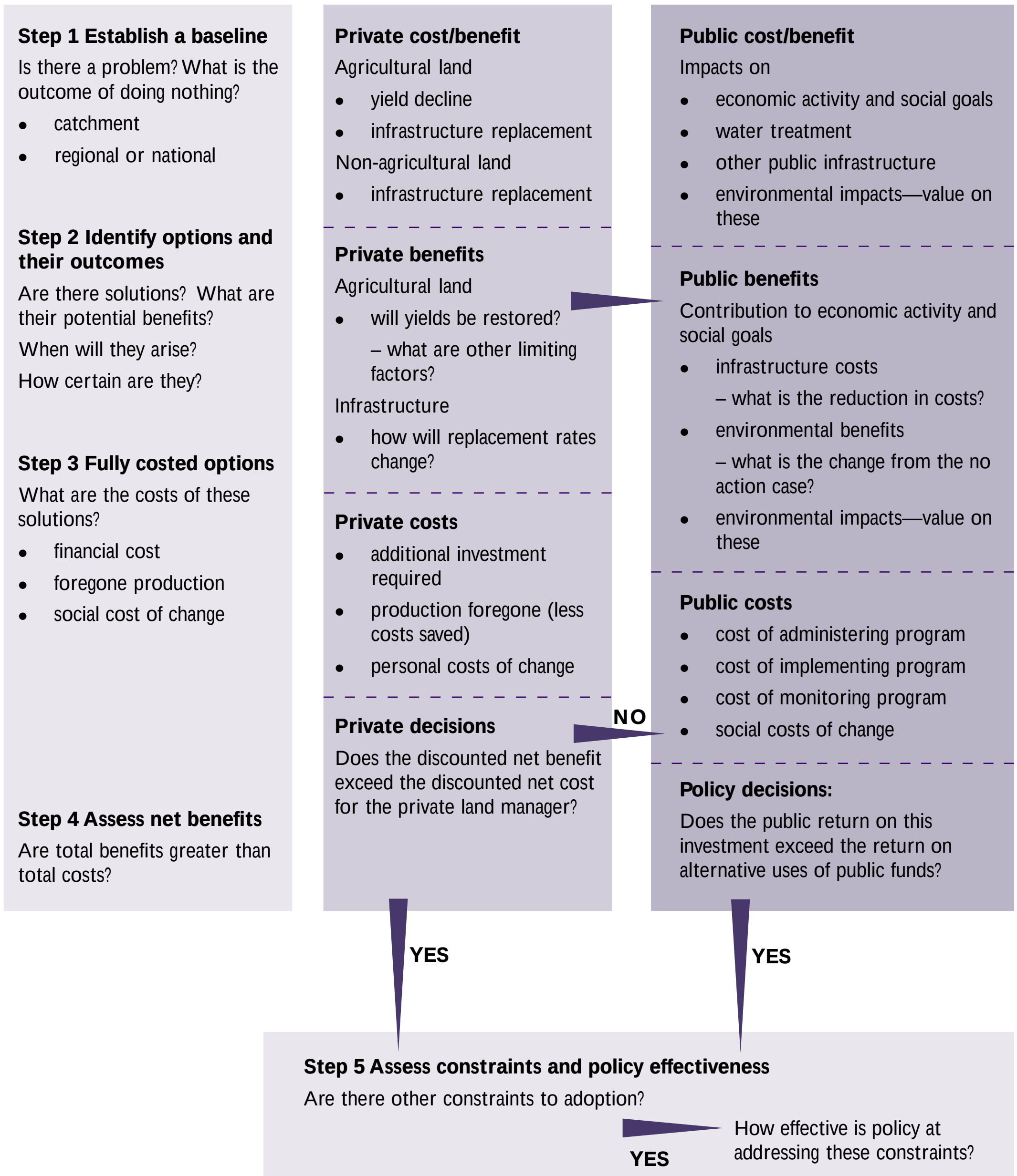
Discount rates

In this report, an appropriate discount rate for public long-term investments is assumed to be 2–5%. This is an acceptable rate of time preference for evaluating potentially large benefits and costs that accrue across multiple generations. Where private investments are referred to, the discount rate chosen is 10% reflecting a more realistic opportunity cost for private investor funds over a shorter time period.

Home

Contents

Figure 2.5 Framework for options assessment by policy makers in a catchment.



A rapid assessment process

Undertaking a full benefit–cost analysis of options to address resource management problems is expensive. The Audit's four salinity case studies (Chapter 6) took several years to do, with much of the time taken up in characterising the biophysical outcomes of the various options. Clearly such a detailed level of analysis should only be undertaken in areas identified as priority areas. Yet the broad scale data available will only provide the first layer of information needed for priority setting. We need an assessment of the costs and likely benefits of options on a case by case basis.

While the Audit work does not claim to do this beyond a few case studies, the projects undertaken provide some guidance on how to proceed. A rapid assessment process is one approach.

The options canvassed in the four salinity case studies were planting trees, switching from annual to perennial pasture, planting deep-rooted perennials such as lucerne and 'living with the salt'. These case studies showed that local information was critical for assessment—and this is as true with a rapid assessment as with a detailed assessment process. This is because a critical piece of information in at least one of the case studies was only available at the local level—lucerne did not grow in the local soil type in the area, eliminating the option that looked viable on a salinity impact and economic return basis. Rapid assessment must be done at the relevant scale for the problem and the proposed solution.

An example of a set of guidelines for a rapid assessment process is given in Table 2.1. As a general guide a large number of answers in the first column would imply that there is more benefit to addressing these potential problems than if most answers were in the last column. There is considerable interaction between the answers and a simple evaluation of them can provide a guide on the most fruitful way to proceed.

Such guidelines require further development and must be tailored for different situations. Development of guides and ground-truthing using existing detailed case studies is suggested as a follow-up activity to support regional planning such as that under way as part of the National Action Plan for Salinity and Water Quality.

Widening the scope of benefit–cost assessment to include environmental and social costs and benefits

Many texts outline how to undertake a benefit–cost assessment (e.g. CIE 1997). The methods for applying discount rates, estimating net present values and calculating internal rates of return are straightforward. So too, are methods for estimating the sensitivity of the return estimates to variations in key parameters. What is difficult is the clear identification of option costs (including unintended costs), changes resulting from them and an estimation of the often complex impact of these changes. Here, the changes from an option are relative to what would have happened without the option and excluding the impact of any other sources of change. Much progress has been achieved in ensuring that the feedback effects of changes in demand and supply on prices, and quantities of goods and services produced and consumed, are taken into account in estimating benefits and costs.

The focus of most assessments has largely been on the economic impacts. Social impacts are usually included only to the extent that the change in consumer and producer welfare is separately identified. Non-market environmental impacts are rarely included. The framework for estimating benefits and costs allows for incorporation of environmental and social benefits and costs wherever a sensible value can be estimated. This is a significant challenge for social assessment—in terms of method and available data.

Table 2.1 Guidelines for a rapid assessment.

Question	Low	Medium	High
Biophysical change anticipated			
What is the area impacted or likely to be impacted by deterioration in the resource base?	< 1000 ha	1 m < > 1000 ha	> 1 million ha
What is the time profile of the biophysical change anticipated?	>25 years	10 < > 25 years	< 10 years
Current resource use values			
What is the land use(s)? And their gross margin per hectare?	< $500	$5000 < > $500	> $5000
How much water is used per hectare?	< 0.5 ML	0.5 ML < > 3 ML	> 3 ML
What is the gross value of production per ML of water?	< $50	$500 < > $50	> $500
Anticipated impact on land use			
What proportion of current land use will be able to continue?	> 90%	90% < > 50%	< 50%
What is the anticipated reduction in gross margin due to declining yields/increased inputs on continued current use?	< 2%	20% < > 2%	> 20%
What is the gross margin of the next best alternative land use given the problem?	> $5000	$500 < > $5000	< $500
Off-site effects			
What is the estimated cost of repairs/additional depreciation on public infrastructure affected in the local area?	< $50 000	$1m < > $50 000	> $1m
What is the change in salt and sediment loads in major downstream river flows?	< 1%	5% < > 1%	> 5% increase
Are there wetlands or other sensitive areas impacted?	No	Yes—minor	Yes—extensive
Costs and effectiveness of options			
Are the current problems reversible?	< 10%	50% < > 10%	> 50%
What is the cost of achieving this per hectare?	< $10	$100 < > $10	> $100
What is the time profile for these outcomes?	> 25 years	10 < > 25 years	< 10 years
Is further deterioration preventable?	< 40%	90% < > 40%	> 90%
What is the cost of achieving this per hectare?	> $100	$100 < > $10	< $10
What is the time profile for these outcomes?	> 25 years	10 < > 25 years	< 10 years

Home
Contents

How does the work in the Audit's assessment support this process?

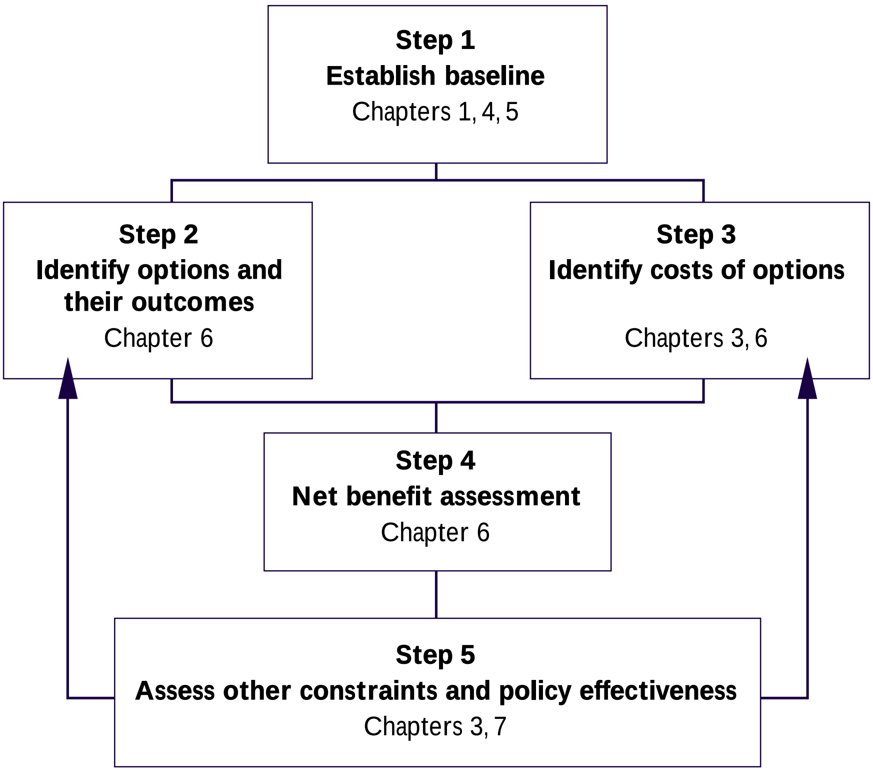
The Audit work has the greatest applicability to Phase I of the natural resource management decision making process (Figure 2.4) It provides input to establishing priorities for public expenditure on natural resource management.

- Chapters 4 and 5 help establish a baseline trend in 'costs' of decline in resource condition for agriculture and infrastructure—Step 1 in Phase I. The information can also be used to establish gross benefits of reversing trends—Step 2 in Phase I.
- The section in Chapter 5 on impacts of land and water degradation on environmental values can be used to establish the potential benefits from natural resource management options —Step 2 in Phase I, but also Phase II.
- Chapter 3 provides information on the problems, costs and issues of implementing options and the adoption of sustainable management practices—Step 3 in Phase I. This information is also relevant to likely constraints and policy effectiveness—Step 5 in Phase I.
- The examples in Chapter 6 demonstrate use of benefit–cost analysis to assess options—Phases I and II.

Chapter 7 draws on regional case studies to inform Step 5 in Phase I.

Figure 2.6 summarises the five-step approach of Phase I.

Figure 2.6 Summary of the five-step process for assessing priorities in natural resource management.



Home
Contents

How can the Audit information be used to develop priorities?

The Audit has provided considerable information on the biophysical status and trends of the natural resource base. This information cannot be turned into policy priorities per se, but forms a starting point. Policy priority areas are those where economic, environmental and social net benefits of changing landscapes are high and there is insufficient motivation for and/or capacity among private land managers to address the problem. These are usually problems with substantial public spillovers.

This report is of considerable value in creating a baseline—where we are now and where we are heading under a 'business as usual' scenario (Phase I in Figure 2.4). The benefits of addressing problems in agriculture accrue largely to farmers and will largely be undertaken by farmers. A baseline can also be developed that provides a ceiling on the potential public benefits from farmers' and other land managers' actions.

Some information presented in the report is relevant to the other three phases in Figure 2.4 but detailed benefit–cost assessments are mostly applicable to particular regions, catchments or even smaller areas. This requires detailed information at those levels.

AUSTRALIAN FARMERS

Relating to natural resource management

3

Key points

- Approximately 10% of farm establishments produce 40 to 50% of gross agricultural income and manage 60% of agricultural and pastoral land. Encouraging changes in the management practices on this small number of large farms is likely to provide the greatest impact in land management for natural resource protection.
- Australian farmers generally have a positive but pragmatic attitude towards environmental issues. There are significant regional variations in attitude have occurred. Little change has occurred in the level of farmers' environmental concern over the past decade.
- Environmental attitudes generally show a limited relationship with changed management practices. Recognition of a resource degradation problem is usually a necessary but rarely a sufficient condition for adopting sustainable practices. Other factors such as financial risk and management skills influence farmers' capacity to change.
- The inherent characteristics of natural resource management practices largely determine the rate of their adoption by producers. Sustainable practices that provide economic and other advantages have lower risk, they are simpler to manage and will generally be adopted more rapidly. Few natural resource management practices have all these characteristics.
- Low farm incomes and high debt are likely to discourage adoption of sustainable practices. Confidence in the stability of future farm incomes is likely to be associated with a greater capacity and willingness to invest in natural resource management.
- Landholders who consider they do not have the technical knowledge and skills to adequately address land and water degradation on their properties are less likely to adopt resource management practices. More frequent landholder participation in training courses is commonly associated with adoption of resource management practices. Investment in skills acquisition should remain a key tool in promoting improved natural resource management.
- Farmers do not all learn about sustainable practices in the same manner. Styles of farmer learning vary from reliance on a few key informants to the use of a wide range of personal and indirect sources. No delivery system will be appropriate for all farmers. Dissemination of local knowledge will remain a key feature of any successful training program.

- Approximately 37% of broadacre and dairy farms had a property representative who was a member of a community Landcare group in 1998/99, with the highest level of membership reported in the wheat/sheep and pastoral zones. 10% of farmers are actively involved in Landcare. Landcare membership is most strongly related to the adoption of practices such as tree planting that place only limited demands upon financial capacity and management skill.
- Rural Australia is in the middle of a period of significant structural change. The number of large farm businesses is increasing while the number of middle sized farms has been decreasing; the recruitment of young people to agriculture has decreased; many farm families are becoming increasingly dependent on off-farm income; and the median age of the farm population has been rising. The rate of change is likely to accelerate in response to pressures such as:
  - accelerating urbanisation;
  - changing life aspirations of rural youth;
  - a decline in the cultural relevance of farming as a lifestyle identity;
  - changing female expectations of marriage and work relationships within the farm business; and
  - the impact of the looming retirement of the 'baby-boomer' population segment on the Australian labour market.

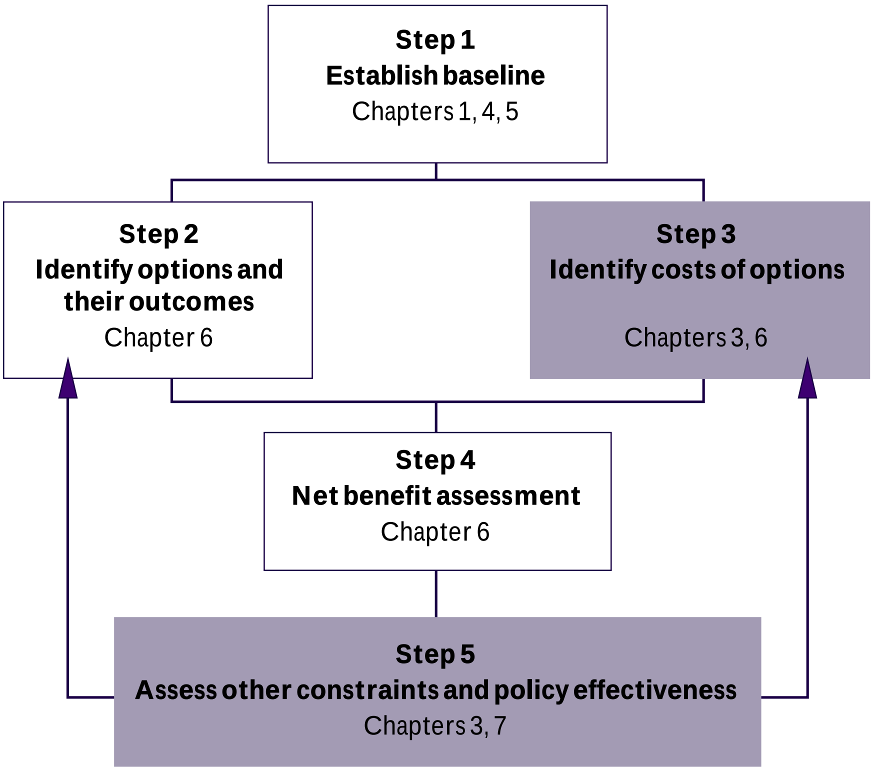
These changes will lead to some regions remaining clearly agricultural in their character and others moving towards amenity landscapes where agricultural productivity does not determine land values. They will shift the values local communities place upon their landscapes and resources. Protecting natural assets for cultural or economic reasons may override the needs of agricultural industries.

Catchment management plans and other natural resource management strategies need to take account of the ongoing changes in social and economic structures.

ASSESSMENT FRAMEWORK CONTEXT

With 60% of the Australian continent under leasehold or freehold tenure for agriculture or grazing (Chapter 1) farmers and pastoralists are responsible for much of the land management in Australia. This chapter examines the characteristics of farms and farmers that may influence natural resource management.

Estimates of the number of farm establishments vary with the definition* of a farm one uses. In 1996 there were 104 400 farm establishments that earned more than $5000 gross value of production. In the same year 196 000 persons described farming as their main occupation. There were 98 600 farm families.



* The Australian Farm Census data set has had an inconsistent structure over the period 1983–1997. Farm businesses (establishments) are included in data aggregation if the value of their production exceeds a minimum Estimated Value of Agricultural Operations. The minimum Estimated Value of Agricultural Operations required for inclusion within the census has varied inconsistently from $2500 to $22 500 measured in nominal dollars. This report is based upon a data set with an Estimated Value of Agricultural Operations cut-off of $30 000 (measured in 1996 dollar terms). The definition of a farmer is also problematic. The categorisation of a person's occupation as farmer is based upon a self-description question used in the Australian Population and Housing Census. Respondents are asked to identify their major occupation within the preceding week. The self-description of farmer is open to ambiguity. Any family with at least one member who describes his or her major occupation as farming is defined here as a farm family. For further discussion refer to Barr (2001).

Australian agriculture is characterised by a large number of small farms and a small number of large farms. In 1996 the median gross farm establishment (farm business) income was estimated at $96 400 (using 1996 dollars and farms with at least $5000 gross income). The financially smallest 50% of farm establishments (incomes lower than $96 000) produced approximately 10% of total value of agricultural production. The financially largest 10% of farm establishments (incomes greater than $400 000) produced between 40% and 50% of the gross value of Australian agricultural output. These larger farms managed over 60% of Australian agricultural land—over a third of the total land area of Australia.

For further information see Audit project reports on structural adjustment and capacity for resource managers to implement sustainable practice by Barr (2001) and Cary et al. (2001).

RESPONSES TO PRESSURES FOR CHANGE

Australian agricultural development in the last two hundred years has been generally driven by a production-focused ethos. Natural resource protection was often a reaction to unanticipated major threats to the productive resource. Australian agricultural development has consequently been described as a continuing unplanned experiment (Barr & Cary 1992). In more recent times the focus of the Australian community has shifted from a production-focused ethos towards a balance of concern for both the protection of natural values such as biodiversity and landscapes and the maintenance of food safety and quality. Agricultural landholders have not been immune from this shift in concerns—landholders generally now recognise significant land or water degradation problems. A quarter of the farms in most of the major farming regions of Australia reported one or more significant land or water degradation problems in 1998/99. There was also a widespread awareness amongst farmers of the importance of environmental impacts beyond the farm boundary (Reeve et al. 2001).

The translation of these changes in awareness of environmental impacts and attitudes to changes in land management practice has been mixed. There are some significant success stories where the methods of production have undergone major change with consequent real improvements in natural resource protection. The widespread adoption of minimum tillage and direct drilling in many parts of the cropping zone is a good example of this. However, other aspects of land management have been relatively unchanged despite clear deleterious impacts on natural resource management. The continued use of cultivated fallow and stubble burning in other parts of the cropping zone is an example of this latter situation (Karunaratne & Barr 2001a, 2001b).

Recognition of a resource degradation problem is a necessary, but rarely sufficient, condition for the adoption of sustainable natural resource management practices. Whether farmers change their land management in response to this recognition depends on many interrelated factors including:

- characteristics of the natural resource management practices;
- farmers' beliefs about the environment and practices to protect the environment;
- financial capacity of farm businesses to invest in natural resource protection;
- management skills and knowledge of land managers;
- support for environmentally friendly behaviour from peers and social networks;
- individual differences between landholders; and
- regulatory and legal pressures.

THE NATURE OF NATURAL RESOURCE MANAGEMENT PRACTICES

Inherent characteristics of natural resource management practices largely determine the rate of their adoption by producers. Sustainable practices that provide economic and other advantages that can be captured by the adopting landholder will generally be adopted more rapidly. In most cases such advantages will depend on prevailing commodity prices.

Landholders generally seek to reduce the risk of adopting a new practice. Sustainable practices that are observable, trialable and less complex are generally more quickly adopted than practices that are not (Table 3.1). The characteristics of a practice vary in different locations. We cannot assume that a practice with advantages in one location will yield the same advantages elsewhere.

CHARACTERISTICS OF AGRICULTURAL PRACTICES

Relative advantage

Relative advantage is normally interpreted in terms of financial advantage to the farm business or the adopter. The perceived financial advantages to the adopting landholder of environmental innovations have consistently been shown to be one of the best indicators of their subsequent adoption.

Many environmental innovations offer advantages which cannot be captured by the adopter of the technology, but are instead of benefit to others in the community. These are not considered in our assessment of relative advantage.

Geographic applicability-locality differences in relative advantage

Appropriateness and relative advantage of given practices will vary in geographic space.

Risk avoidance

The motivation behind human behaviour is more complex than a simple drive for financial profit. While considerable research demonstrates relationships between beliefs about profitability and adoption behaviour this is mediated by a great variation in attitudes towards business profit and a consideration of the risks that characterise Australian agriculture.

Complexity

Sometimes innovations that appear simple may in fact imply significant and complex changes to the farm production system. Such innovations are less likely to be adopted. Complexity increases the risk of failure and introduces increased costs in gaining knowledge.

Compatibility

Compatibility refers to the extent to which a new idea fits in with existing knowledge and existing social practice. If a new idea fits easily into an existing system it will be adopted more quickly. There are usually two 'systems' against which the compatibility of a practice will be judged—the current *system of farming* on a given property and the *social system* embracing a farming community or broader cultural beliefs and values.

Trialability

Innovations which can be trialed on a small scale prior to full implementation are more likely to be adopted. Trialing enables decisions about the utility of an innovation with minimal risk. Trialability is dependent upon observability.

Observability

Natural resource management practices whose advantages are observable are more likely to be adopted. Traditionally, new varieties or crops are often quite visible to passing observers and this visibility has been used to advantage.

3

Table 3.1 Characteristics of some agricultural practices with beneficial impacts on natural resources.

Sustainable practice	Geographic applicability	Relative advantage	Risk avoidance	Simplicity	Compatibility	Trialability	Observability
Ideal rating	**(high)**	**(high)**	**(high)**	**(high)**	**(high)**	**(high)**	**(high)**
Maintaining soil cover	high	high (temporal)	high	med–low (locality)	med	med	med–low
Establishing and monitoring groundcover targets (monitoring of pasture and vegetation condition)[a]	high	med	high	med–low	med	med	med–low
Nutrient balance accounting (soil and plant sampling)	low	low	high	low	med	low	low
Testing soil and plant tissue to determine fertiliser needs[a]	low	low	high	low	med	low	low
Testing soil regularly	med	med	high	high	med	low	low
Fertilising pastures	med	high–med (locality)	med	high	high	high	high–med
Treating agricultural lands with gypsum	med	low	med–low	high	high	med	med
Treating agricultural lands with lime	med	low	med–low	high	high	med	med
Regularly monitoring watertables[a]	med	med (locality)	high	high	low	high	med
Using deep-rooted perennial pastures[a]	high	med	med–low	med–low	med (locality)	med	low
Non-commercial tree and shrub planting[a]	med–high	low	high	high	med–high	high	high
Commercial tree and shrub planting (farm forestry)[a]	low	low (locality)	low	med	low	low	high
Preserving, enhancing areas of conservation value[a]	med	low	high	med	low	med	med–high
Retaining vegetation along drainage lines[a]	med	low	high	med	med–low	med	med–high
Protecting land from stock by fencing (exclude stock from degraded areas)[a]	low	low	high	med	med	high	high
Protecting waterways from stock by fencing[a]	low	low	med–low	high	med	high	high
Controlling animal pest or weed to control land degradation[a]	high	med	med	med	med–high	med	med
Controlling pest and disease in pastures	med	med–high (locality)	med	med	med–high	med–low	med
Using integrated pest management (reducing pesticide use)	low	med–low	med–low	low	med	med–low	med–low
Slashing and burning pastures	low	med–low	med	high	med	high–med	high

a Some measure of the level of landholder adoption of this practice available from the ABARE Australian Resource Management Supplementary survey.
Comments in brackets refer to locality or temporal constraints on expression of attribute
high = high
med = medium
low = low

Home

Contents

Table 3.1 Characteristics of some agricultural practices with beneficial impacts on natural resources (continued).

Sustainable practice	Geographic applicability	Relative advantage	Risk avoidance	Simplicity	Compatibility	Trialability	Observability
Ideal rating	**(high)**	**(high)**	**(high)**	**(high)**	**(high)**	**(high)**	**(high)**
Cropping farms							
Using reduced or zero tillage (minimum tillage)[a]	high	med	med	med	med–high	high	med
Retaining stubble or pasture in ploughing (direct drilling)[a]	med	med	med–low	med–low	med	high–med	med
Using crop or pasture legumes in rotations[a]	high	med–high	med–high	med–high	med–high	med	med–low
Using contour banks in cropland[a]	med	med–low	med–high	med–low	med–low	med–low	med–high
Strip cropping[a]	med						
Adjusting crop sequences in response to seasonal conditions	high	med–high	med	med	med–low	med–low	low
Irrigation farms							
Irrigation scheduling[a]	med	med	high	med–low	med–low	med–low	low
Laser graded layout[a]	high	med–high	high–med	med	med–low	med	high
Storing and reusing drainage water[a]	med	med–high	med	med	med	med–low	med
Automating irrigation[a]	med	med–low	med–low	low	med–low	low	high
Rangelands							
Controlling grazing pressure by excluding access to water[a]	med	med	high	med–low	med	med–low	med–high
Controlling water flow from bores[a]	high	med–low	high	high	high	high	high
Piping water supplies for stock[a]	high	med–low	med	high	high	med	high
Stocking pastoral land at recommended rates	high	med	med	med	high	med–low	med–high
Converting degraded pastoral land to less damaging use	med	low	high	med	med	med–low	med
Destocking pastoral land in low feed conditions	high	med–high	med–low	med–low	high	med–low	med
Dairy farms							
Using effluent disposal systems (collection of effluent; ponds or drainage sump)[a]	high	med–low	med	med	med	med	high
Pumping dairy shed effluent onto pasture [a]	med	med–low	high	high	med	high	high

a Some measure of the level of landholder adoption of this practice available from the ABARE Australian Resource Management Supplementary survey.

Comments in brackets refer to locality or temporal constraints on expression of attribute

high = high

med = medium

low = low

Home

Contents

Many but not all practices designed to improve natural resource management are unprofitable. Many that are profitable are less profitable than alternative practices and often more complex, harder to trial and have benefits which are difficult to observe (see Box 3.1). For many sustainable practices (such as deep-rooted perennials) the advantage to be gained by adoption is dependent on the value of the rural commodities produced as a result of using the practice. Low commodity prices for beef and wool over the past ten years have reduced the relative advantage of adopting many sustainable practices in the broadacre industries. Some practices offer advantages that are captured beyond the farm gate.

For further information see Audit project reports on capacity for resource managers to implement sustainable practice (Cary et al. 2001).

BELIEFS ABOUT THE ENVIRONMENT

Farmer concern for the environment rose dramatically in the late 1980s. The change in attitude during the 1990s has been much less. The University of New England has recently repeated a monitor survey of farmer attitudes (Reeve et al. 2001). That survey found:

- decreasing concern overall about the seriousness of land degradation, but with decreases in concern in Queensland, New South Wales and Tasmania being partly offset by increases in Victoria, South Australia and Western Australia;
- increasing concern overall about chemical residues in agricultural produce and about the environmental and health effects of agricultural chemicals, but with those who are regular users of chemicals, such as cereal or fodder crop producers, being less concerned and showing relatively little change over the period;
- increasing awareness that farm practices have impacts beyond the farm boundary and increasingly favourable views nationally towards consideration of the wider public interest in farm decision making, although the trend was reversed in Queensland;
- increasingly favourable, but slightly more polarised, views about conservation, while there is less support for conservation organisations and their activities;
- increasing acceptance that there will have to be major transformation of agricultural landscapes if farming is to be sustainable, with just over 46% of respondents agreeing with the proposition that if Australian agriculture is going to have a long term future, a lot of cleared country will have to be put back to bush and forestry plantations; and
- strong support for the view that farmers should be compensated for loss of income or autonomy of decision making due to measures taken in the public interest. However, there is also substantial, but not majority, support for the view that compensation should be a matter of degree—that is, when the loss of income is relatively small no compensation should be expected.

These findings demonstrate the existence of a positive but pragmatic attitude towards environmental issues on the part of Australian farmers. Attitudes to resource degradation do set the bounds of achievable social change. Recognition of a resource degradation problem is usually a necessary pre-condition for change but rarely a sufficient condition for the adoption of sustainable practices. Other factors, such as financial risk and management skill, intervene and influence farmers' capacity to change.

It cannot be assumed that an investment in attitude change might modify the behaviour of land managers. The expectation that changing attitudes of land managers will directly lead to changed behaviour is simplistic in many situations. This is most evident in beliefs about the value of promoting a 'stewardship ethic' as a means of changing management practices. Stewardship is the responsibility or obligation to maintain the land for future generations. Policies to change behaviour via changing the stewardship ethic are likely to achieve relatively little in the absence of other enabling conditions. In situations involving common property resources or externalities there will be a conflict between individual self-interest and the expectation that farmers will undertake activity for the common or future good for little, or negative, financial return (Cary & Webb 2001).

BOX 3.1 DRYLAND LUCERNE: A PROFITABLE BUT COMPLEX INNOVATION

The watertable under the riverine plains of northern Victoria has been rising since the introduction of European agriculture. The long-term solution for rising watertables in this region is to develop a system of farming based on productive, profitable and deep-rooted perennial crops. The most appropriate commercial plant available at present is lucerne, yet only a minority of farmers grow significant areas of lucerne.

Lucerne is relatively complex to introduce into a pastoral management system and there are considerable risks in its successful establishment. Sowing lucerne does not guarantee a successful crop. The chance of failure is greater than with many other pasture species. One way to minimise the financial risk of establishing lucerne and to make up for the time a paddock may be out of production, is to sow lucerne with a faster-growing crop such as safflower. Farmers may have to learn to grow new crops that are more compatible with lucerne.

Lucerne requires a rotational grazing management. Using the four-paddock rotation system, a farm running three flocks would need 12 or 16 paddocks. For farms previously 'set-stocked', this implies additional expensive fencing, more dams and reticulation to provide watering points in each paddock. Fencing at this intensity is likely to impede the easy management of cropping activity on mixed farms.

Lucerne pasture is more productive than normal pasture, but there are complex ramifications in the farm system as more sheep will be required to graze the extra pasture. The increased flock size requires extra capital, more work in sheep handling and an increased workload of rotational grazing. Higher sheep densities in paddocks may mean a greater need for control of intestinal parasites and increased use of veterinary chemicals or greater attention to rotational grazing systems to minimise parasite infestation. One means of maximising the benefit of lucerne is to abandon lambing in autumn in favour of spring lambing. This may mean a need to further rearrange the farm timetable. To maximise the benefits of prime lamb production, the farmer will often need to develop new marketing skills and develop relationships with export abattoirs.

These changes have to be worked in with the continuing cropping enterprise. There are good reasons to maintain a lucerne paddock for its full eight-year life after successful establishment. Consequently, the farmer may have to crop paddocks elsewhere on the farm for a longer period before putting them back into pasture. This will require improved cropping skills.

Lucerne will also introduce greater risk into cropping systems. The environmental advantage of lucerne is its ability to remove water from the soil profile to reduce recharge of the watertable. Traditional long fallow crop systems reduce risk by conserving soil moisture before a crop phase. Entering a crop phase after drying the soil moisture may increase crop production risk if the following season's rainfall is below average.

Ransom & Barr 1993, Oxley 1997

3

There is a significant body of research that demonstrates that links between environmental beliefs and environmental behaviour are tenuous. Environmental attitudes are far more weakly linked to measures of adoption of farm conservation practices than beliefs about the profitability and risk associated with those practices (Cary 1994, Gorddard 1993, Vanclay 1988, Wilkinson & Cary 1992).

A stewardship ethic alone cannot be relied upon alone as a sufficient condition to facilitate change in farming practices. Policies designed to promote a stewardship ethic may often indirectly, rather than directly, influence the adoption of improved resource management practices. Community awareness programs create effective impacts through a two-stage process where awareness generates a favourable climate for the use of other policy instruments that, more directly, influence behaviour change. Recent examples of this use of a public stewardship ethic are the implementation of a cap on the extraction of water from the Murray–Darling system and tree clearing controls in some States.

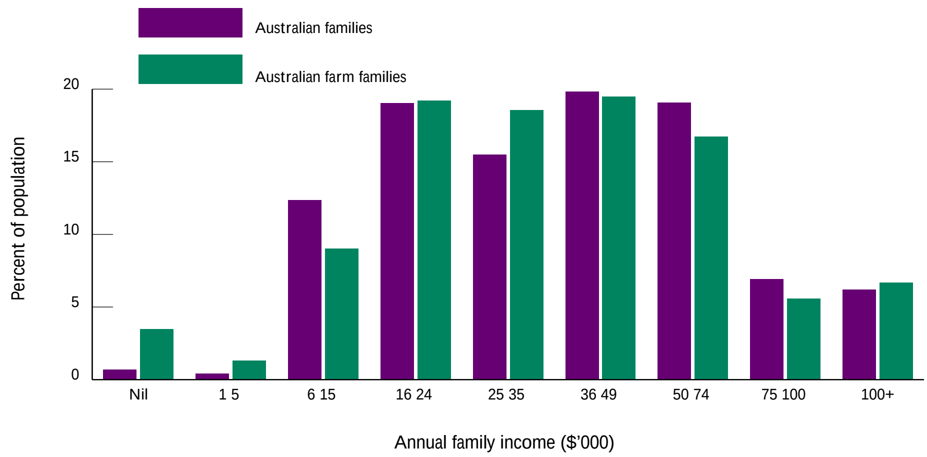
For further information see the attitudinal survey results following a Decade of Landcare (Reeve et al. 2001).

FINANCIAL CAPACITY

Over the past decade the farm sector in Australia has generated a net annual value of farm production of between $3 billion and $7 billion dollars (ABARE 2000). For farming families this surplus must fund farm family living expenses, farm investment, superannuation and natural resource protection.

The contribution of off-farm income to total farm family income has been steadily increasing for many of Australia's farm families over the past 20 years. This strategy has helped to maintain standards of living for many Australian farm families. Approximately 3.5% of farm families reported no net family income compared with less than 1% of all Australian families. Farm families are under-represented in the income category between $6000 and $15 000 and over-represented in the income category between $25 000 and $35 000 (Figure 3.1). The similarity between the income distributions of farm families and non-farm families is striking*.

Figure 3.1 Australian farm family income distribution and Australian family income distribution in 1996.



Data source: Australian Bureau of Statistics Population and Housing Census

* It must not be assumed that farm family income is similar to rural family income. In 1996 farm families comprised more than 20% of all families in only three statistical local areas (Conargo, Kent and Kulin). This apparently low figure may in part result from the definitional ambiguity of farming in census data. It is also a timely reminder of the common tendency to confuse 'rural' and 'farm' in popular debate (Gleeson 2000).

Home
Contents

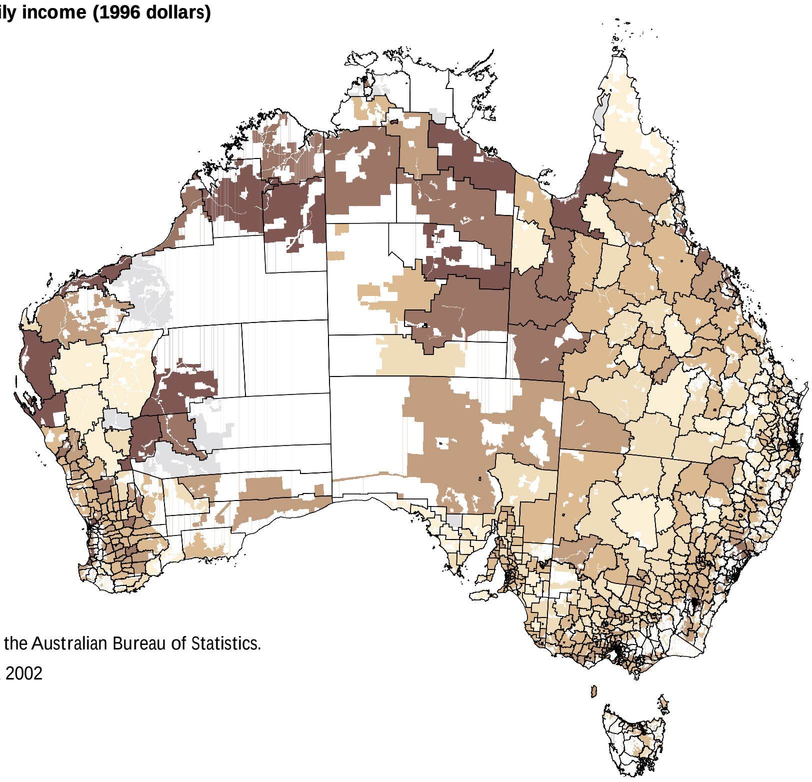
The patterns of income distributions between farm families and all Australian families are remarkable similar. Issues related to low income are common to urban and rural families. From the perspective of natural resource management policy, the distributions imply that given voluntary behaviour and financial capacity we should expect no more and no less of Australian farm families in their financial contributions to the environment than we expect of Australian families in general.

Low incomes, resulting from farm industry structural change, extended low commodity prices or extended drought conditions, will frequently be concentrated in specific localities, with potentially adverse effects on resource management. This makes it difficult to draw conclusions about the financial capacity of Australian farms based upon regional data from any one year. Areas with consistent low farm family incomes (Figure 3.2) suggest the existence of underlying structural problems in regions such as the Murchison–Gascoyne in Western Australia, the Eyre Peninsula in South Australia and parts of the semi-arid rangelands of New South Wales.

Low farm incomes and high debt are likely to discourage adoption of sustainable practices that require capital investment but do not have immediate financial returns or that increase the risk exposure of a farm business. Confidence in the stability of future incomes is associated with a greater likelihood to invest in natural resource management (see Table 3.2).

For further information (see Chapter 4) (Cary et al. 2001).

Figure 3.2 Median farm family income averaged from 1986 to 1991 and 1996 censuses using 1996 dollars, by statistical local area.



Derived from data supplied by the Australian Bureau of Statistics.

Home
Contents

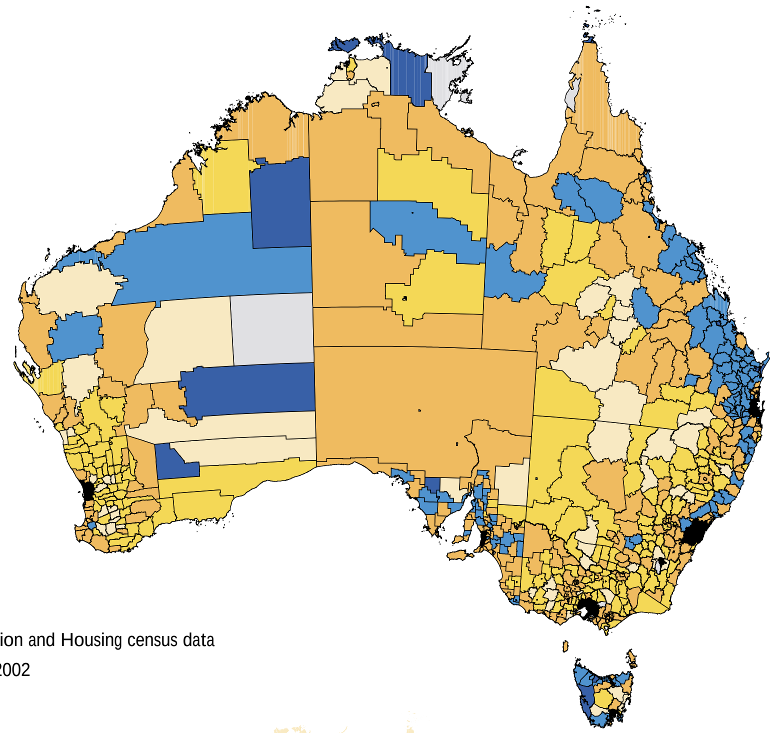
The low rates of observability and trialability of many sustainable management practices will continue to impede their adoption. Work commissioned by the Audit found that landholders who considered they did not have the technical knowledge to adequately address land and water degradation on their properties were less likely to adopt resource management practices (Cary et al. 2001).

For further details see Cary et al. 2001a.

There is a wide range of abilities and knowledge among farmers. There is also a wide range of formal education and knowledge about sustainable farm practices. There are significant regional differences in the formal education level of farmers (see Figure 3.3). According to the 1996 Population and Housing Census, 50% of farm owner-managers had completed 1–4 years of secondary school and 23% had completed 5–6 years. Educational levels are related to age, with younger farmers generally having higher educational attainment than older ones.

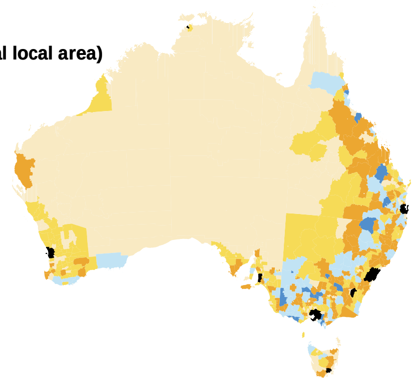
Figure 3.3 Farmers aged 14–16 years when they completed their formal schooling as a percentage of all farmers.

Percent of farmers
- > 85%
- 75 – 85%
- 65 – 75%
- 55 – 65%
- < 55%
- no data
- not analysed



Source: Based on 1996 Population and Housing census data

Farm population in 1996 (per statistical local area)
- > 900
- 500 – 900
- 300 – 500
- 150 – 300
- < 150
- not analysed



It is reasonable to assume that more complex sustainable management practices will be more easily grasped and integrated into farming systems in the future as the formal education level within the agricultural sector rises. Where adoption needs to be increased for the benefit of the wider community, the wider community may need to invest in extension support to facilitate learning and skill development.

Participation in training courses related to management and skills is an important contributor to an individual's capacity to adopt sustainable practices as well as an indicator of their interest in better resource management. More frequent landholder involvement in training courses is associated with adoption of new management practices (Kilpatrick 2000). Improved investment in farmer training and the development of more advanced learning strategies for farmers are likely to enhance the adoption of sustainable management practices.

Table 3.2 Factors which are associated with the adoption of sustainable management practices (derived from an analysis of the ABARE 1998/99 Resource Management Survey).

Farm family, farm property and business characteristics	Pastoral zone			Wheat–sheep and high		
	controlling flow bores	controlling grazing pressure by excluding access to water	monitoring of pasture and vegetation condition	deep rooted perennial pasture[1]	soil/plant tissue tests to determine fertiliser needs[1]	tree and shrub establishment[2]
Age						
Environmental concern attitude			+		+	+
Technical concern attitude			−	−		+
Financial concern attitude				+		
Financial outlook attitude	−		+	−		−
Landcare membership (1998/99)	+					+
Length of Landcare membership					+	
Recent training					+	
Farm cash income					+	
Closing equity ratio	+		−	−		
Profit at full equity			+			
Farm plan			+		+	+
Farm size				−		
Land use intensity					+	+
Participation in property management planinng in the last 3 years				+		

+ significant positive association at the 95% confidence level or higher
− significant negative association at the 95% confidence level of higher
1 broadacre farms only
2 including dairy farms

Home
Contents

Decisions about the level or extent of support by government for such learning activities should be based on the extent of public benefit.

Farmers do not all learn about sustainable practices in the same manner. Styles of farmer learning vary from reliance on a few key informants to styles that are based on extensive networks of sources and informants. No one delivery system will be appropriate for all farmers (Kilpatrick & Johns 1999). Dissemination of local knowledge will remain a key feature of any successful training program. The adoption of more complex management practices into existing farming systems often involves a higher level of risk with less certain outcomes. Learning how to master this complexity and accommodate the technical and financial uncertainty will often require locally adapted knowledge and the need for local networks or local professional sources of knowledge support.

For further information see Chapter 4 of the Audit project report on the capacity for resource managers to implement sustainable practice (Cary et al. 2001)

rainfall zones	Dairy farms		Irrigation farms		All farms			
regularly monitoring watertables[2]	collecting of dairy effluent	pumping dairy dairy shed effluent onto pasture	laser graded layout	using irrigation scheduling tools	monitoring pasture and vegetation and vegetation condition	preserving/ enhancing areas of conservation value	excluding stock from degraded areas	percentage conservation tillage
							–	–
			+			+	+	
	–							–
						–		
		–			–	–	–	
		+						
		–						
	+			+	+	+		+
–								
+			+		+			
+					+	–		–
				+				

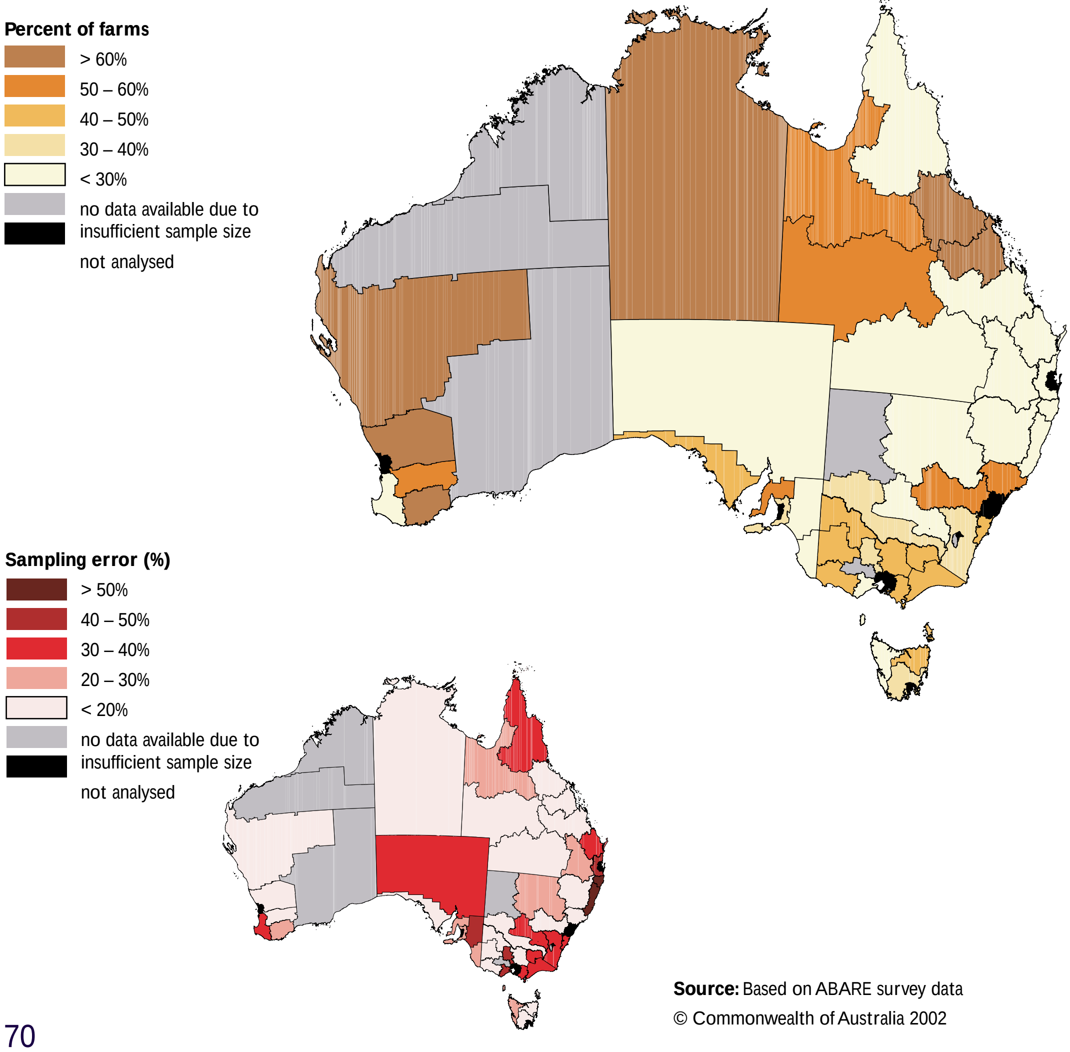
Home
Contents

LANDCARE INVOLVEMENT

Community landcare is based upon landholder groups promoting self-reliance and developing social capital and social norms that encourage the adoption of sustainable farming practices. This participatory approach has become the dominant way for implementing policies to improve natural resource management in Australia (Curtis & De Lacy 1996).

Approximately 37% of broadacre and dairy farms had a property representative who was a member of a community Landcare group in 1998/99. Ten percent of all farmers are actively involved in Landcare (Reeve et al. 2001). There are distinct geographic variations in Landcare membership (see Figure 3.4). Australian Bureau of Agricultural and Resource Economics surveys show the highest level of membership is in the wheat/sheep and pastoral zones (Mues, Chapman & Van Hilst 1998). This variation is a reflection of the history of Landcare in different regions and differing membership structures in different States/Territories.

Figure 3.4 Membership of Landcare in 1998/99.



Source: Based on ABARE survey data

Community Landcare has contributed to human and social capital building by increasing awareness, extending skills and knowledge, and developing networks that are conducive to the acceptance of sustainable farming practices. However, the causal relationship between Landcare membership, the changing of attitudes and the actual adoption of improved sustainable farming practices is not particularly strong.

An audit of farmer environmental attitudes found that the change in environmental attitudes between 1991 and 2000 is about the same among Landcare group members and those who are not members (Reeve et al. 2001). However, the findings show more favourable environmental attitudes among those who report they are actively involved in a Landcare group. It is unclear to what degree membership of Landcare groups changes attitudes or Landcare attracts active members with already strongly held attitudes.

Analysis of data from ABARE surveys shows a limited relationship between adoption of sustainable management practices and either Landcare membership or length of time as a member of Landcare. Landcare membership is most strongly related to the adoption of practices, such as tree planting, which place only limited demands upon financial capacity and management skill (see Table 3.2). In the dairy industry there was generally a higher level of financial capacity than many other agricultural industries during the 1990s. The Audit commissioned case study of this industry found a clearer relationship between Landcare membership and investment in Best Management Practices (see Chapter 7). This underlines the importance of financial capacity to mobilise the influence of the Landcare movement and the critical importance of government co-investment through programs such as the National Landcare Program, the Natural Heritage Trust, the Property Management Planning program and the National Action Plan for Salinity and Water Quality.

Change has been constrained by other major factors: limited capital, the common incidence of low farm incomes, physical constraints such as remoteness and a lack of feasible technical solutions to degradation issues that can be easily and profitably implemented on farms (Cary & Webb 2001). Excessive expectations of the capacity of the Landcare movement runs the risk of reducing the current effectiveness of the movement through member burnout (Byron, Curtis & Lockwood 2000).

For further information see Chapter 6 of the Audit project report on the capacity for resource managers to implement sustainable practice (Cary et al. 2001).

INDIVIDUAL DEMOGRAPHIC AND PSYCHOLOGICAL DIFFERENCES

Individual capacity to change is not one-dimensional. An individual's capacity to change differs according to the changes being considered and is particularly influenced by the stage reached in a person's life. It is difficult to predict whether landholders are more likely or less likely to change land management practices (Fenton, MacGregor & Cary 1999; Taylor et al. 2000). Important landholder characteristics that might be useful indicators of capacity to change to sustainable management practices are:

- participation in training;
- level of farm income;
- optimism about future farm income;
- farms with a documented farm plan;
- proportion of farms carrying out Landcare-related work;
- membership of Landcare; and
- age of landholders.

The relationship between these factors and adoption behaviour was investigated using sample data provided from the annual Australian Bureau of Agriculture and Resource Economics farm survey. This survey covers a sample of broadacre grazing, cropping and dairy farms across Australia.

Landholders' expectations of their future financial situation were one of the better predictors of the adoption of sustainable management practices. In fact, financial outlook was more often associated with practice adoption than were objectively measured indicators of financial position. Similar associations between financial perceptions and business behaviour can be observed in the wider economy. This highlights the importance of perceived reality in adoption behaviour. Adoption of major changes to a farm business is not just an intellectual task but often an emotional and social task as well (Barr & Cary 2000). Farmers who feel secure in their financial future are more likely to invest resources in adopting new resource management practices. Feeling financially secure is an outcome not just of current financial circumstances, but of future expectations and psychological disposition.

There is a long tradition of research that shows how individual personality traits and psychological resources have a significant influence on determining response to risk. Recent research in Queensland suggests farmers are more likely to have a personality style adapted to perseverance, autonomy, solitude and a capacity to cope with adversity (Shrapnel & Davie 2000). Of 14 general personality styles expected in the wider community, farmers were found to generally fall into a limited suite of five styles. These five styles have a common tendency to experience discomfort in group situations. Whilst this work is formative, it provides an indication of why membership of Landcare groups is unlikely to cover the whole of the farm population or why Landcare is not necessarily the most effective means to inform or influence land managers or why group extension is, at best, one tool for delivering training on new farming techniques.

Like most other occupations in Australia, the average age of Australian farmers has been increasing (Barr 2001). Age is an important social characteristic because it is an indicator of the structure of the changing agricultural workforce in Australia. The evidence concerning the impact of age on adoption of sustainable practices is mixed; any relationship between age and the adoption of sustainable practices is unlikely to be linear and may be confounded by other factors such as income and education. In localities with an increasingly aged farmer population and low rates of inter-generational transfer, adoption of changed management practices that require increased capital and labour commitment is likely to be lower. This scenario will become more common in the Australian farming landscape over the next decade.

For further information see Chapter 6 of the Audit project reports on the capacity for resource managers to implement sustainable practice (Cary et al. 2001).

Home
Contents

CHANGING SOCIAL LANDSCAPE OF AGRICULTURAL AUSTRALIA

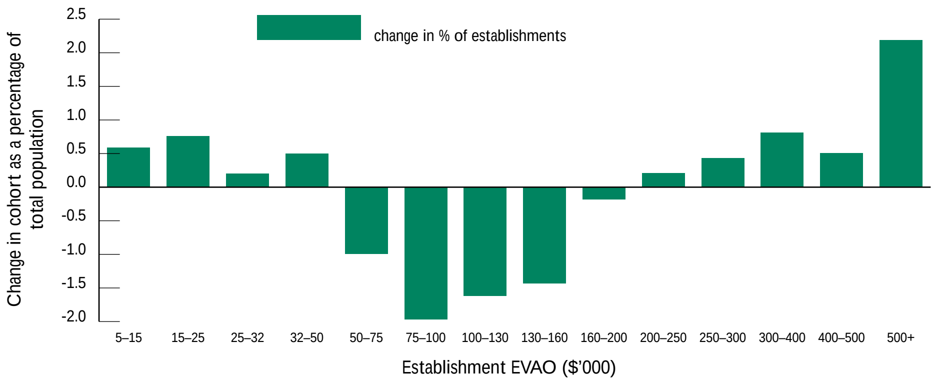
The gradual long-term movement of labour out of agriculture and declining proportional contribution of agriculture to total economic growth bring with them significant changes in the social structure of rural areas. During necessarily gradual implementation of catchment management plans, rural communities are likely to change in response to these global economic trends. These structural changes may influence the capacity to implement catchment plans or adopt changed farming practices. These changes in rural communities need to be taken into account as part of the implementation of catchment plans and natural resource management strategies.

Declining number of farms

The social and economic structure of Australian agriculture has changed significantly over the past two decades.

- There was an 18% decline in farm establishment numbers between 1986 and 1996.
- There was a 16% decline in the number of farm families and a 21% decline in the number of farmers over the same decade. Establishment decline was greatest amongst the middle sized farms, with gross farm incomes between $50 000 and $200 000 (see Figure 3.5). The rate of decline in farm numbers appears to be inversely related to remoteness (see Figure 3.6).
- The net rate of decline in farm numbers masks a much higher rate of farm exit and entry to farming.

Figure 3.5 Change in number of farm establishments by estimated value of agricultural operations (EVAO)grouping as a percentage of all farm establishments 1986 to 1996 (using constant 1996 dollars).



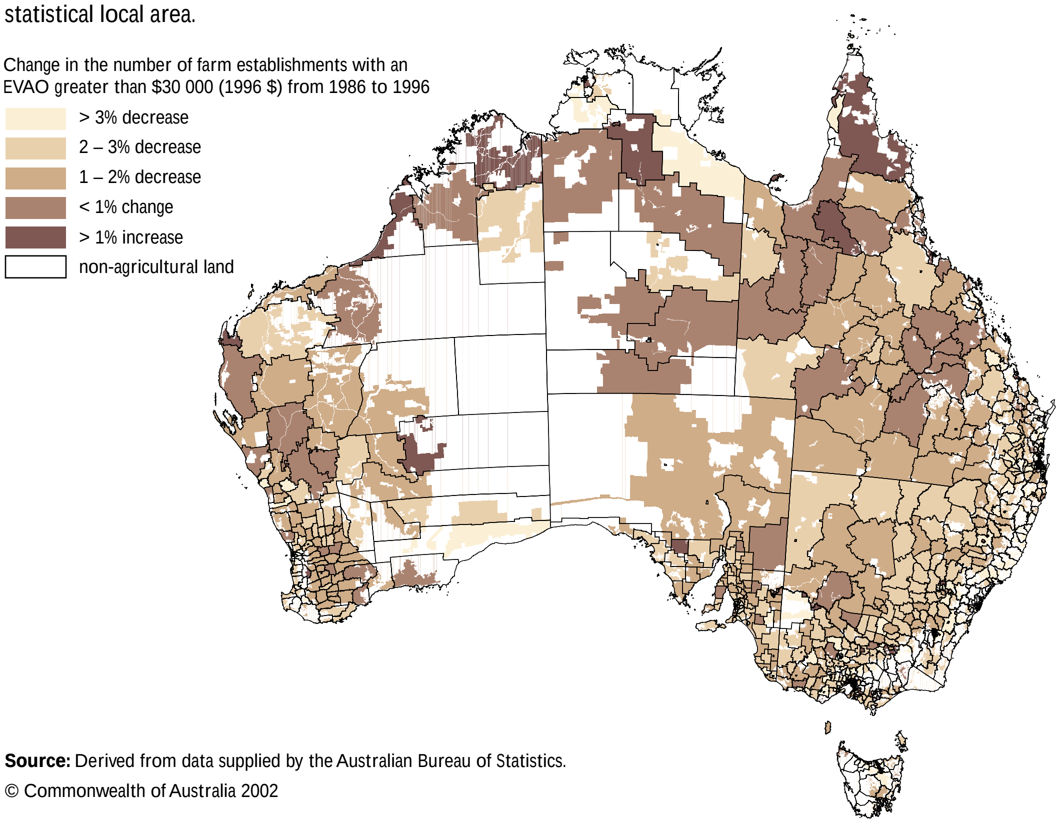
Source: ABS Australian Agricultural Census data.

Home
Contents

3

- Between 1986 and 1996 the number of Australian farmers declined at an annual rate of 2.2%. In this same period the annual rate of exit from farming was 5.7% and the rate of entry was 3.5%*.
- The number of farmers exiting agriculture was greatest during periods of higher commodity prices. Higher land values provided a greater incentive to sell farms while higher commodity prices gave neighbouring farms greater financial resources to buy. During low commodity price periods these incentives were greatly reduced.
- Entry to farming was less influenced by commodity prices. Entry was more likely to occur in more attractive locations or in irrigation areas. Entry to farming was far less likely in traditional broadacre cropping regions. This in part reflects the lower perceived amenity and the higher capital requirements for entry.

Figure 3.6 Average annual percentage change in the number of farm establishments 1986 to 1996 by statistical local area.



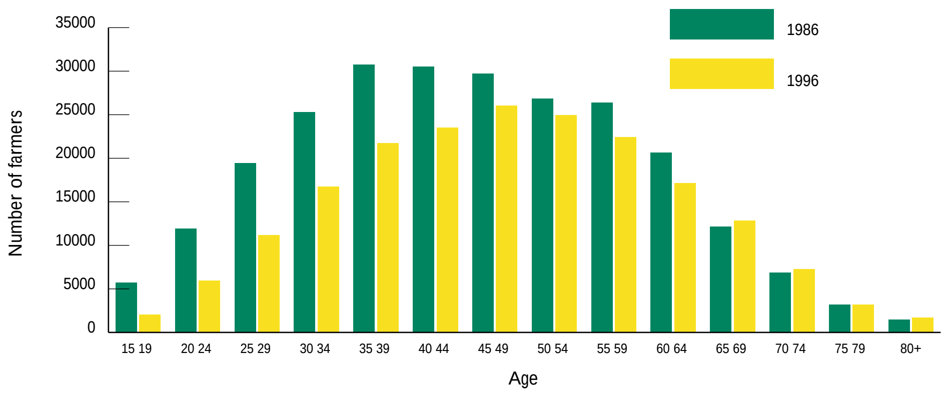
Source: Derived from data supplied by the Australian Bureau of Statistics.

* Measures of entry and exit to farming were calculated using migration and occupational data drawn from the ABS Population and Housing Census. For further details see Barr (2001).

Fewer younger people entering agriculture

Throughout this period there was an underlying trend of fewer younger people entering agriculture as a vocation (see Figure 3.7). The low recruitment of younger people to agriculture may be a reflection of major adjustment decisions (e.g. handing the farm over to younger family members) being delayed to the inter-generational transfer period (well beyond standard retirement age). Given the need for agriculture to maintain international competitiveness through farm consolidation, the declining entry of younger persons to agriculture is not necessarily bad news, particularly as most entries to farming have historically been through the purchase of small farms.

Figure 3.7 Number of people with farming as their main occupation by age group 1986 and 1996.



Data source: ABS Australian Population and Housing Census

Home

Contents

3

Increased dependence on off-farm income

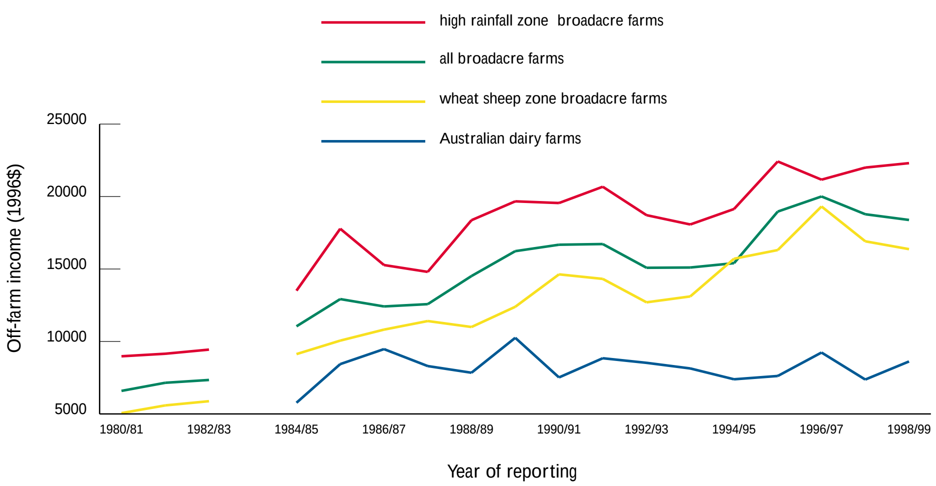
During the last two decades a significant increase in the dependence of many farm families on off-farm income, particularly those operating smaller farms, has occurred (Figure 3.8). This may in part explain why, despite periods of low commodity prices and adverse seasonal conditions, average farm family incomes were remarkably similar to Australian family incomes (Figure 3.1). During 1986 to 1996 areas with significant numbers of low income farm families were not necessarily those with the smallest farms. More often these areas had small to medium sized farms with less access to off-farm employment.

The increasing reliance of farm families upon the income of a spouse working off the farm should be viewed within the context of two major demographic trends across the developed world:

- the shift towards the two income family as the middle class norm that has taken place over the past generation within Australian society; and
- the trend towards part-time farming in other developed countries.

In both North America and Europe farm households are more dependent on off-farm employment than Australian farm households. The United States Department of Agriculture estimates that 90% of farm family income is derived from off-farm sources (Economic Research Service 1996, Korb 1999). This estimate is not strictly comparable with Australian data as the United States Department of Agriculture definition of a farm includes smaller farms than are included in definitions used by the Australian Bureau of Statistics or Australian Bureau of Agricultural and Resource Economics. In Canada, farm families have become increasingly dependent on the off-farm earnings of farm women (Olfert, Taylor & Stabler 1998).

Figure 3.8 Off-farm income earned on Australian broadacre and Australian dairy farms 1980 to 1998 (constant 1996 dollar terms).



Data source: Australian Bureau of Agricultural and Resource Economics Farm Surveys.

Home

Contents

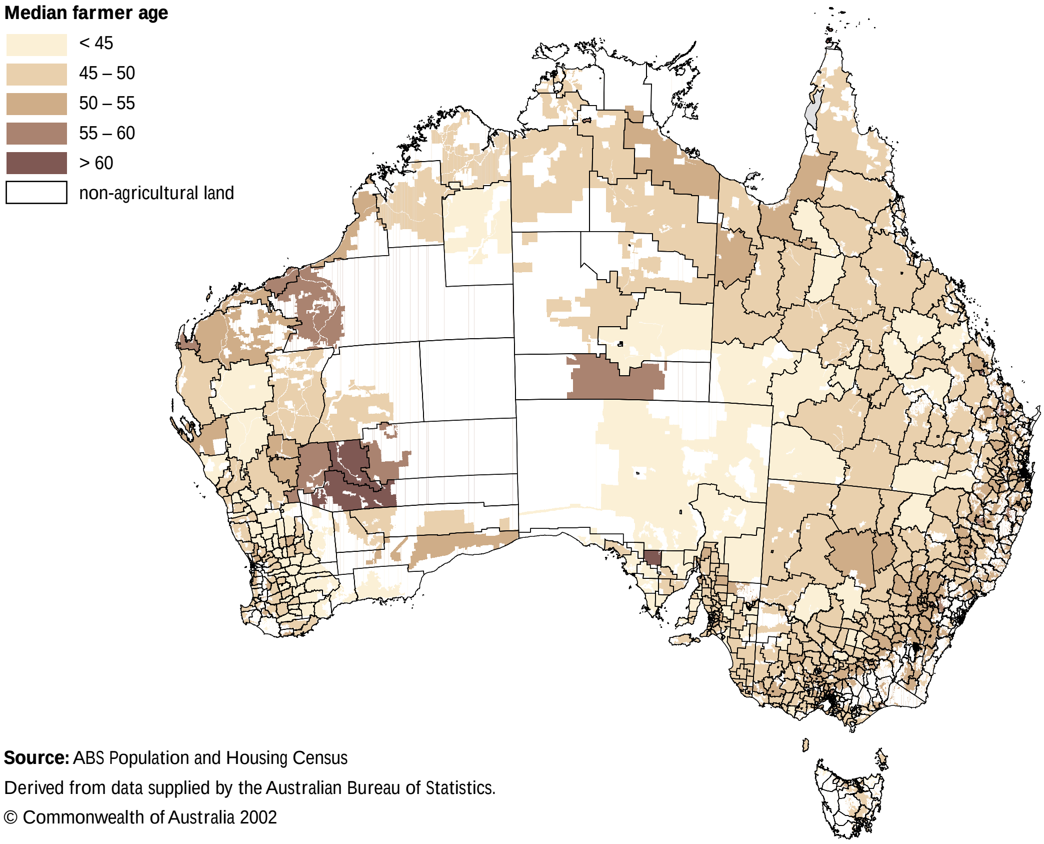
Home

Contents

Ageing of the farm population

The average age of Australian farmers rose by three years between 1986 and 1996. Farmer age is generally higher along the Great Dividing Range and in coastal areas (see Figure 3.9). Increasing farmer age in part reflects broader trends in the Australian workforce with the progression of the baby-boomer generation toward retirement. It is also an outcome of a lower recruitment of younger people to agriculture, a greater movement towards off-farm income dependence among younger farm-based families and a deferral of decisions to exit farming in the face of low commodity prices and limited demand for farm land. The farmer attitude survey in 2000 shows that passing the family farm on to family members is declining (Reeve et al. 2001). While 61% of respondents indicated that their farm had been owned by parents or parents-in-law in the past, only 29% believed that their farm would be run by their children in the future. These findings all point to a period of rapid structural change in agriculture in the coming years.

Figure 3.9 Median age of farmers by statistical local area (1996).



Source: ABS Population and Housing Census
Derived from data supplied by the Australian Bureau of Statistics.

Home

Contents

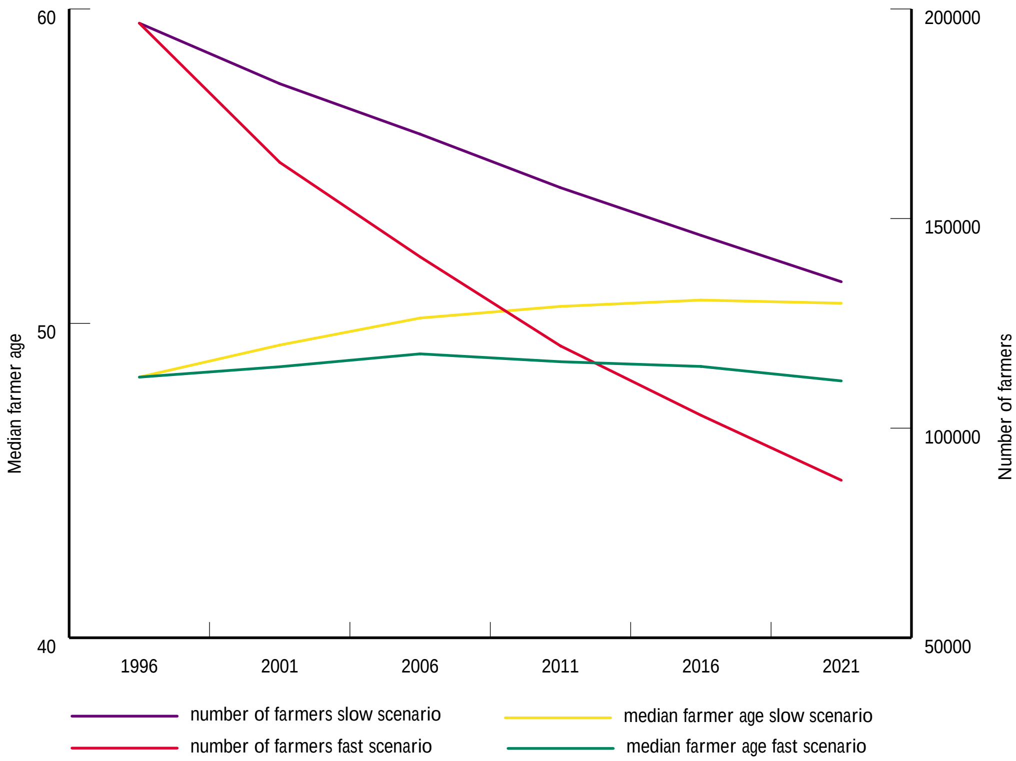
Continuing decline in the size of Australia's farm population

Demographic modelling of future structural change in Australian agriculture has produced two scenarios:

- a 30% decline in farmer numbers to 2020 and a further increase in median farmer age, peaking in 2011—based on the behaviour of farmers during the period 1991–96 with poor prices for broadacre farm commodities; and
- a 55% decline in farmer numbers with little increase in current median age—a faster adjustment scenario based on behaviour during the period 1986–91 in which commodity prices were generally higher (Figure 3.10).

3

Figure 3.10 Projected Australian farmer numbers and farmer age 1996 to 2021 using slow and fast adjustment scenarios.



Source: Derived using ABS Population and Housing Census data. See Barr (2001) for methodology

Diverging landscape changes

These projections present a picture of a rapidly changing agricultural community. Other factors which were not able to be modelled suggest the rate of change may be even greater than assumed in these scenarios. Some of these additional factors include:

- accelerating urbanisation of the Australian population, leading to increasing amenity competition for land use in less remote locations;
- increased urbanisation of the life aspirations of rural youth, leading to increased rates of youth migration to urban areas (Gabriel 2000);
- a decline in the cultural relevance of farming as a lifestyle identity, potentially slowing the rate of entry to farming (Bryant 1999);
- changing female expectations of marriage and career, complicating the establishment of farm family businesses in more remote locations (Barr 1999, Weston 1999); and
- ageing and retirement of the 'baby-boomer' population segment, reducing market labour supply and providing increasingly attractive alternative employment opportunities beyond farming for rural youth (Access Economics 2001).

In the next decade some contemporary agricultural landscapes will remain clearly agricultural in their character, while in others the land values will not be determined by agricultural productivity. In these landscapes the path of existing farm businesses to seek increased competitiveness through land purchase will be blocked by high land values. Equal, if not greater, challenges face amenity landscape managers in their responsibility for achieving sustainable resource use; capacity and knowledge remain issues.

Planners need to be aware that some landscapes are on a pathway out of traditional agriculture. Catchment management will be less likely to mean sustainable agriculture in these areas than sustainable landscape management. Structural changes in the social landscape may offer opportunities for landscape change that are complementary to current trends of structural change. Catchment planners also need to be aware of the continuing social and economic changes in the structure of their catchments.

Monitoring changing social landscapes

Some changes to national data collections would greatly increase our capacity to monitor structural change within farm communities. Improvements include:

- broadening the scope of the Australian Agricultural Census to encompass a regular suite of questions on environmental and social issues;
- developing methods that provide tables based upon links between data from the Australian Agricultural Census and the Population and Housing Census to provide greater confidence in Population Census data based upon self-definition of the farmer; and
- developing sample longitudinal data sets for the Australian Agricultural Census to provide an enhanced capacity to understand the dynamics of structural change within Australian agriculture.

For further information see the Audit project report on structural adjustment of Australian agriculture (Barr 2001).

SOIL RESOURCES

Productivity

Key points

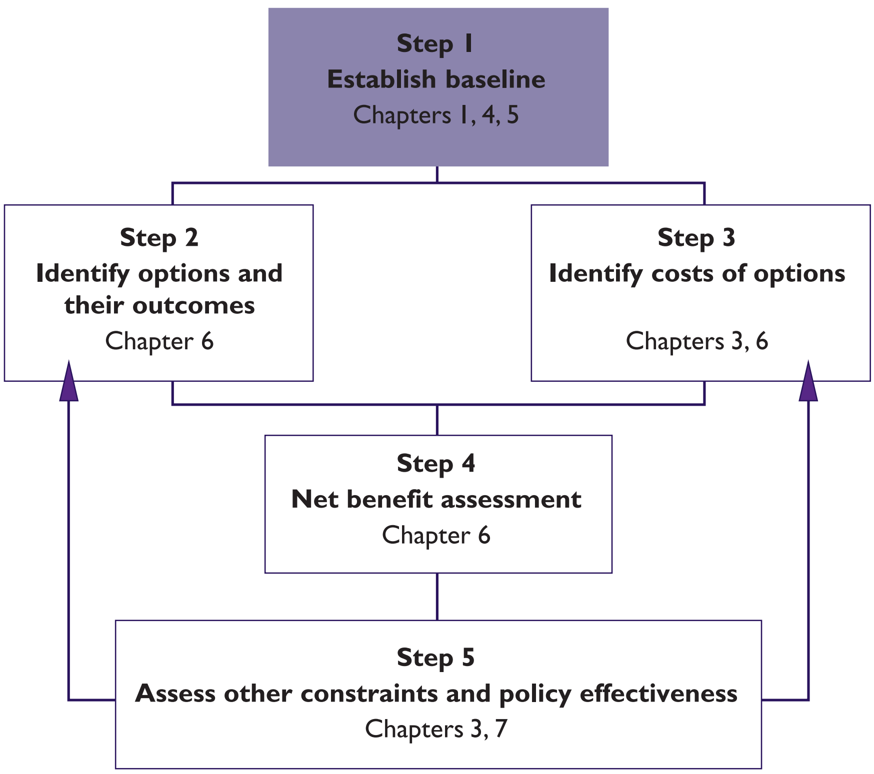
- Areas in Australia adversely affected by sodicity and acidity are much more extensive than the areas adversely affected by salinity. Sodicity and acidity affect 23% and 4.5% of agricultural land respectively. Sodicity is largely naturally occurring and can be corrected by gypsum the condition. Induced acidification can also be treated by change in practice (e.g. fertiliser regime), and corrected by application of lime.
- Land uses in sheep, beef and cereals account for 90% of the incidence of dryland salinity. But relative to total areas of each land use, the cropping industries appear most affected, with 3–6% of land area affected.
- The concept of yield gap value has been used to gauge the economic significance of soil health problems. Yield gap is the difference between value of yield on land assuming no health problems and the value of yield on that land with soil health problems. It can be viewed as the value of net income forgone because yields are not at biophysical potential, or the maximum yield benefits which could be expected if soil health was improved.
- Salinity is having a relatively small impact on total profits from Australian agriculture. The value of the yield gap for salinity over all agricultural land in Australia is estimated at $187 million a year and this is projected to rise to $288 million a year by 2020.
- Looking to the future the greatest increases in impacts from salinity are likely to be experienced by New South Wales and Victoria, although at present, the greatest overall impact is in Western Australia.
- Over the 20 years to 2020, the sum of annual increases in yield losses due to salinity is estimated to be $712 million in present value terms. This represents a decrease in the net present value of profits of 1.5%.
- A benefit–cost analysis of treating soil acidity and sodicity problems with lime and gypsum indicates that these treatments would be profitable only on about 4% of agricultural land. The results indicate that the benefits to farmers would be substantial if this area was treated—in perpetuity, in aggregate, over $11 billion in the net present value of increased profit at full equity. Such treatment represents private investment by farmers and the results raise the question of why there is not greater private investment in lime and gypsum applications to acidic and sodic soils.
- Farmers, generally, are aware of the extent of land degradation and a high proportion perceive significant land degradation problems on their land. This represents a major shift in perceptions compared with a decade ago.
- Farmer perceptions of land values suggest that land markets are capturing the impact of land degradation in Australia.

4

ASSESSMENT FRAMEWORK CONTEXT

People have radically changed the way they think about and value our land and water resources. Whereas previously attitudes and policies towards land use were focused mainly on the productivity of land, soil and water resources used in agriculture, now society is turning to landscapes for a much wider range of services (e.g. increasing concerns are being voiced about the effects of land and soil degradation on water quality, landscape amenity values, biodiversity, the environment and other attributes). These, so called, 'off-site' impacts or externalities are considered in the next chapter. This chapter provides an agricultural productivity perspective of soil degradation issues and opportunities to improve agricultural productivity.

Three particular types of poor soil condition—dryland salinity, sodicity and acidity are important. Emphasis is given here to identifying the extent of the problems from an economic perspective or establishing a baseline—Step 1 in the five-step process for assessing priorities in natural resource management (see Figure 2.6 in Chapter 2). Benefit–cost analyses of options to alleviate soil acidity and sodicity are also presented (Steps 2, 3 and 4). Case studies on dryland salinity are detailed in Chapter 6. Survey results of landholder perceptions of land degradation and impacts on land values are also given.



Home
Contents

LAND DEGRADATION—WHAT IS IT?

'Land degradation' has several interpretations. At one extreme, some people believe that where land is not in its natural, pre-European settlement state, it is degraded. Redclift (1987) states that *...sustainability is not endangered by ecologically unwise agriculture practices, it is endangered by all agriculture.* Cameron (1991) argues that the closer all land is to its natural state, the more sustainable the ecosystem is likely to be.

Vast areas of Australia have been cleared for agriculture (Figure 1.4 in Chapter 1) and this has contributed greatly to Australia's development. Clearing of native vegetation for agriculture has changed the character of the landscape but all agricultural land is far from being 'degraded', and not all agricultural activities are unsustainable. Some apparently 'degraded' land is the result of natural conditions or processes. To a large extent, soil sodicity, and to a lesser extent, soil acidity, fall in this category as inherent constraints on agricultural development.

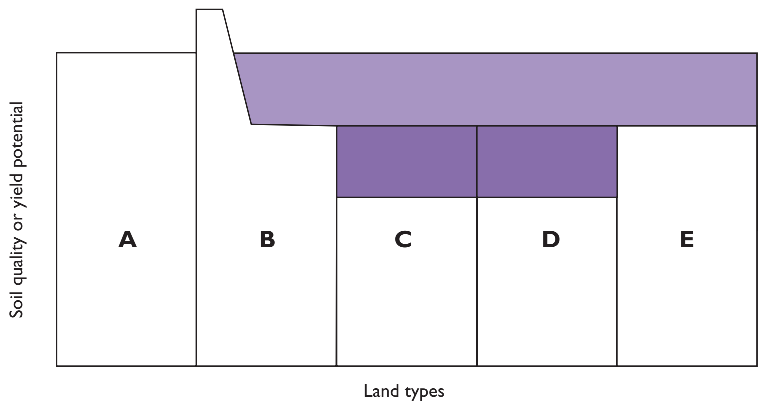
Assessing the extent of land degradaton

How can we assess the extent of land degradation in Australia and how can we fix it?

The extreme position is to argue that all land other than A and possibly E in Figure 4.1 is, to some extent, degraded. The lightly shaded area in Figure 4.1 should not be regarded as 'land degradation' from an agricultural perspective unless agricultural practices are having significant off-site adverse effects such as nutrient run off into streams—considered in Chapter 5.

A more realistic approach is that society should be aiming to prevent land represented by B from deteriorating in quality, to prevent C and, where possible, D land from degrading any further and where technically feasible and economically profitable, restore C and D land towards maximum potential yield. This dark shaded area does provide an indication of the magnitude of the problem and the maximum effort required to restore agricultural land to its maximum potential yield. But technical and economic considerations will mean that this shaded area will never be eliminated. Consideration of the

Figure 4.1 The concept of land degradation.



Area A: land in its natural state, not affected by agriculture or other industries.

Area B: agricultural land that most would regard as being in good condition. In part, this land may experience loss of soil carbon or soil quality compared with land in its natural state but, overall, it is producing to its maximum capability and there are no significant 'off-site' effects. Some of this land may have soil quality that is even better than comparable land in its natural state (e.g. significant areas in southern Australia have been made substantially more productive for agriculture through application of fertiliser and trace elements as well as other technological advances, Figure 4.2).

Area C: land that is degraded to varying degrees, where agricultural production is not at maximum potential yield and there are varying degrees of 'off-site' adverse effects. In this case, the primary reason for the degradation is inappropriate agricultural practices or other human-related activities.

Area D: represents agricultural land that is also of poor quality, not because of human activity, but mainly from natural causes. Sodic and some acidic soils fall in this category. However, the potential exists for management practices to greatly improve the productive capacity of some types of this land (e.g. in the case of sodic and acidic soils, by the application of gypsum and/or lime). Such land treated in this way can be represented by area E.

Home
Contents

dark shaded area and how it may expand in the future under a 'business as usual' scenario establishes a baseline (Step 1) but it will not be profitable to restore all degraded land to its maximum potential. Degraded land is a 'sunk cost' (meaning that costs have occurred in the past and are unrecoverable) and this land should be regenerated only to the point where it is profitable to do so, taking into account both net benefits from an agricultural viewpoint and also all other benefits and costs.

Costs associated with degradation

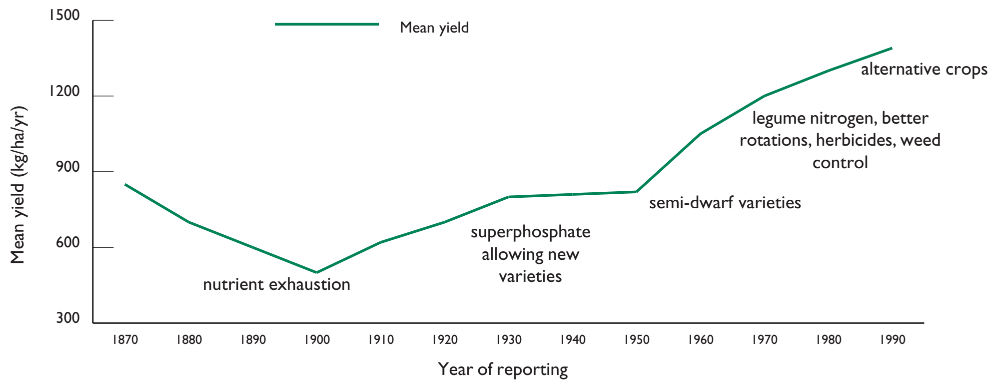
Frequently, the term 'costs of land degradation' is used. The 'on-site' or on-farm costs of land degradation can be represented by the value of the dark shaded area in Figure 4.1 This can be split into human-induced costs (value of shaded area above C) and costs due to natural causes or inherent soil characteristics (shaded area above D). To the total on-farm costs of land degradation must be added all 'off-site' or downstream costs which are considered in Chapter 5. Rather than focusing on 'on-farm' costs of degradation a better interpretation of the value of the dark shaded area in Figure 4.1 is the maximum potential yield gain from taking positive remedial measures to improve land productivity and the sustainability of their use in agriculture. As outlined in Chapter 2, this requires an investment or benefit–cost approach to decisions on land management (Steps 2, 3 and 4 in Figure 2.6).

Many types and causes of land degradation

Land degradation (Figure 4.3) can be caused by water, wind, soil type/topography and biological agents (Figure 4.3). There are strong interactions among these (e.g. rising groundwater tables can result in waterlogging where the soils and/or groundwater is saline; dryland salinity can occur leading to further loss of vegetation and potentially gully, sheet or rill erosion).

The primary causes and processes of land degradation are generally well known and summarised (Reeves, Breckwoldt & Chartres 1998) but a challenge for the future is to better understand the secondary causes (Figure 4.3). This report is a positive step in this direction.

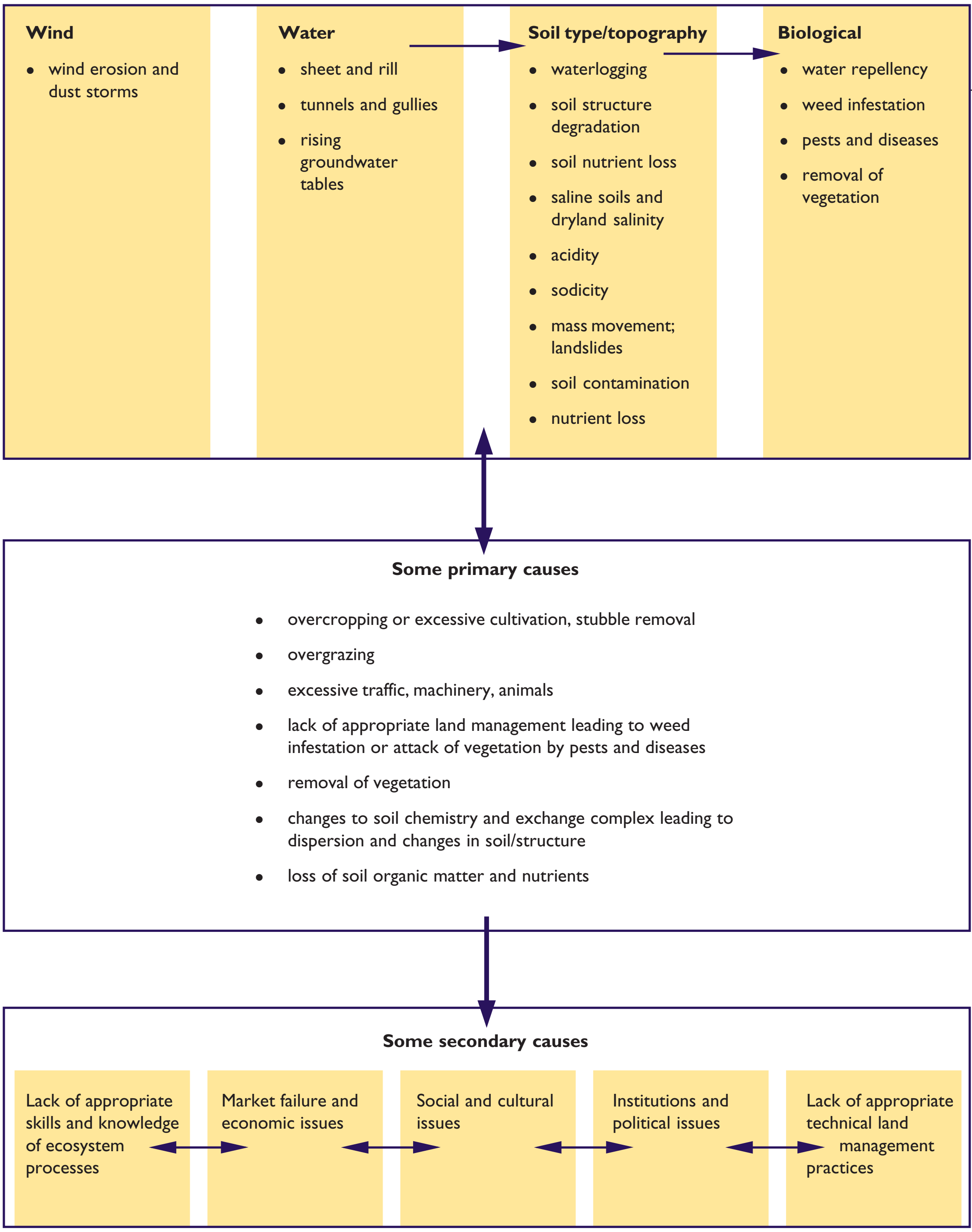
Figure 4.2 Wheat yields between 1870 and 1990.



Data source: Hamblin & Kyneur 1993

4

Figure 4.3 Some types and causes of land degradation.



DRYLAND SALINITY, SODICITY AND ACIDITY

Areas of agricultural land where significant crop/pasture yield loss is likely to occur because of dryland salinity, soil sodicity and acidity were identified (Figure 4.4, Box 4.1).

- Saline soils affect relatively small areas. However, where soils are affected by salinity the reductions in yield are generally much greater than for sodicity or acidity. The current extent of salinity represents only about 1% of agricultural land (Table 4.1) but the yield losses are large where it occurs. Agricultural land includes vast areas of tropical, arid or semi-arid grazing where salinity or acidity are generally not significant issues.
- Inherent soil sodicity is the most widespread limiting factor on potential productivity with nearly a quarter of agricultural land affected (Figure 4.4).
- Soil acidity is a less significant constraint with 4.5% of agricultural land affected. However, acid soils cause appreciable yield loss mainly in the coastal areas of north Queensland and in Victoria and southern New South Wales.

BOX 4.1 ESTIMATING THE YIELD GAP

Areas of agricultural land where significant crop/pasture yield loss may occur because of production-limiting soil conditions were identified. Yield loss was defined as all those areas with at least 5% yield loss due to acidity or sodicity compared with maximum potential yields or where yield loss is actually occurring in the case of salinity. Perhaps a better way to interpret this is as areas where there is the potential to raise yields by 5% or more by alleviating the problems of sodicity or acidity. For simplicity, the term 'relative yield' is used. Land with a relative yield of say 85% for sodicity, means that because of sodicity, actual (current) yields on that land are only 85% of what they could be if sodicity problems were alleviated. Thus:

$$\text{Relative yield} = \frac{\text{actual yield}}{\text{potential yield}}$$

The absolute difference between potential and actual yields is referred to in this report as the 'yield gap'.

Yield gap—a relative measure

The estimate of yield gap provides an upper bound to the level of benefit that could be generated if production limitations were removed. It therefore provides insight to the ceiling on investment for cost effective natural resources remediation. It is recognised that the 'yield gap' does not necessarily reflect an economically optimal solution. The complexities of modelling the optimal decision require farm level analysis and therefore were not part of this Australia-wide context setting analysis. Estimates in this chapter should be considered as indicative and relative rather than absolute.

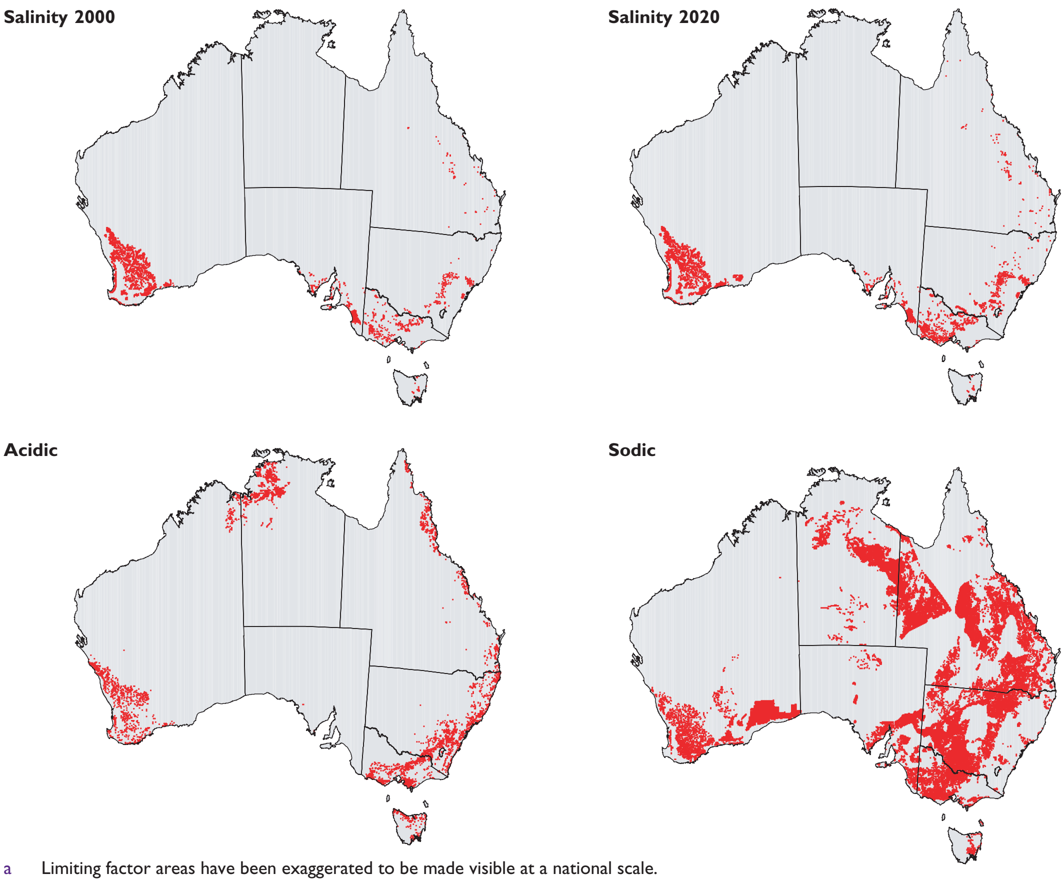
Details of how relative yields for these three types of land degradation were estimated are given in Appendix B. For salinity, the extent of area affected is that where yields are adversely affected by dryland salinity. Estimates of the projected extent of dryland salinity in 2020 also demonstrate the long lag times between cause and impact for dryland salinity.

Home
Contents

Two different aspects of dryland salinity are presented (Table 4.2 in Box 4.2)—area at risk and modelled estimates of the dryland salinity extent. The risk assessment defines the 'catchment of concern', that is, areas within which dryland salinity is known or expected to occur. The risk area also includes areas surrounding the severely impacted land that can contribute to, or be subject to secondary effects from dryland salinity. The risk-based approach was adopted, as data does not exist to define the actual extent of salinity. The modelling of dryland salinity extent used the delineated risk area and allocated within these areas land where agricultural production is reduced or lost.

The risk assessment for spatially explicit economic modelling would result in an overestimate of future costs and potential benefits (about 40%). A 'best-bet' modelling of dryland salinity extent was therefore used. In addition when *Dryland Salinity Assessment 2000* (NLWRA 2001b)was prepared, Queensland was unable to provide an estimate for the year 2000 and it was necessary to develop an estimate for Queensland for 2000 and then to convert all estimates of 'risk' into an estimate of the land area where dryland salinity reduces agricultural yield and income for the economic analysis.

Figure 4.4 Location of factors that limit agricultural production[a].



a Limiting factor areas have been exaggerated to be made visible at a national scale.

Home
Contents

Home

Contents

Table 4.1 Areas where soil conditions constrain yield[a], by State and Territory.

	Saline soils				Acidic soils		Sodic soils	
	2000		2020		2000		2000	
	Area ('000 ha)	Proportion of agricultural land (%)	Area ('000 ha)	Proportion of agricultural land (%)	Area ('000 ha)	Proportion of agricultural land (%)	Area ('000 ha)	Proportion of agricultural land (%)
Australian Capital Territory[b]	0	0.0	0	0.2	4	13.3	1	3.7
New South Wales	89	0.1	286	0.4	4 095	6.3	24 731	38.0
Northern Territory[b]	0	0.0	0	0.0	2 973	4.2	11 533	16.2
Queensland	62	0.0	145	0.1	6 192	4.2	42 191	28.7
South Australia	472	0.8	670	1.2	20	0.0	7 635	13.6
Tasmania	26	1.4	35	1.9	677	36.9	504	27.5
Victoria	287	2.0	689	4.9	2 754	19.5	8 008	56.6
Western Australia	2 169	1.8	2 602	2.2	4 602	3.9	14 615	12.5
Australia	**3 106**	**0.7**	**4 426**	**0.9**	**21 317**	**4.5**	**109 219**	**23.1**

a Table shows the area and proportion of total agricultural land affected by salinity, sodicity or acidity in each State. For salinity the areas shown are those where yields are adversely affected. Affected areas are where yields are judged to be 95% or less of potential yield. Upper and lower range estimates are reported on the Australian Natural Resources Atlas.

b The Northern Territory and Australian Capital Territory were considered to have very minor salinity problems and were not included in the NLWRA salinity hazard areas (NLWRA 2001b).

A measure of the area where salinity reduces agricultural productivity was required for the economic analysis for 2000 and 2020. (Box 4.2). The difference between the modelled dryland salinity extent and risk assessment of agricultural land is between 40% and 50% (Table 4.2 in Box 4.2).

4

Home

Contents

BOX 4.2 SUMMARY OF DRYLAND SALINITY EXTENT MODELLING METHOD

Table 4.2 contains an estimate of the modelled extent of salinity for each State and Territory. This is a measure of the area where salinity actually reduces agricultural productivity. The effect of salinity on productivity can be either slight, moderate, severe or extreme.

The extent estimates were prepared in consultation with State/Territory representatives, by developing a range of algorithms to convert each 'at risk' estimate into an estimate of 'extent'. As definitions of 'at risk' vary from State to State, different algorithms were needed for each State. In the case of South Australia, the 'at risk' estimate was derived by mapping areas where the impact of salinity was moderate, severe or extreme. Areas where there is a risk but no visible effect on yield were not included in the 'at risk' assessments. All moderate, severe or extreme areas were assumed to be surrounded by buffer zones where yields gradually increased to full potential to produce an estimate of extent that is consistent with those developed for other States and Territories. As a result, the South Australian spatial estimate of the 'extent' of salinity is larger than the estimate of area 'at risk' shown in Table 4.2. In consultation with State/Territory representatives, the Queensland estimate of area 'at risk' was produced by shrinking the 2050 area and linking this with point information available from a 1992 survey of areas where salinity was known to exist.

Table 4.2 Comparisons of estimates of the modelled extent of dryland salinity and agricultural areas* 'at risk'.

	Extent of dryland salinity		Area 'at risk' of dryland salinity	
	2000	2020	2000	2020
	('000 ha)		('000 ha)	
New South Wales	89	286	181	580
Queensland	62	145	na	na
South Australia	472	670	326	421
Tasmania	26	35	53	70
Victoria	287	689	665	1 306
Western Australia	2 169	2 602	3 553	4 182
Australia	3 106	4 426	4 778	6 559
Proportion of agricultural land (%)	**0.7**	**0.9**	**1.0**	**1.4**

* The Northern Territory and Australian Capital Territory are not included, as the dryland salinity problem is considered very minor in these areas.

Data sources: *Australian Dryland Salinity Assessment 2000* (NLWRA 2001b), CSIRO Policy and Economic Research Unit 2002.

Home
Contents

Areas affected by salinity, acidity and sodicity

For each of the various uses of land, Table 4.3 presents estimates of the area of land affected by sodicity, acidity and salinity. For selected land use types Figure 4.5 shows the proportion of each land use that is adversely affected by salinity.

It is estimated that about half of all land affected by salinity is used for sheep grazing (Table 4.3, Figure 4.5). Four percent of cereal cropping land is estimated to be affected and this accounts for about 22% of all land affected by salinity. Some industries are less affected by salinity because of their geographic location (e.g. cotton and sugar). In each case, some increases in the areas affected by salinity are projected for 2020 and the overall areal extent of agricultural land affected by salinity is projected to increase by over 40% over the next 20 years.

4

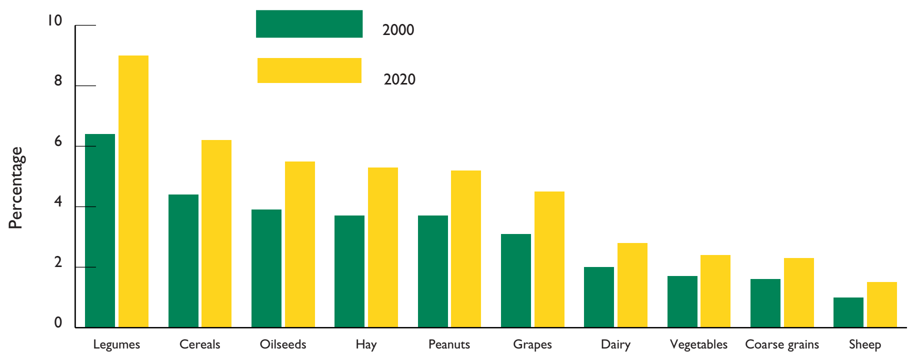
Table 4.3 Areas where soil conditions constrain yield, by land use grouping.

Land use	**Area ('000)**				**Proportion of agricultural land (%)**			
	Salinity 2000	Salinity 2020	Acidity	Sodicity	Salinity 2000	Salinity 2020	Acidity	Sodicity
Agroforestry	1	1	7	1	4.5	6.4	32.8	6.6
Beef	570	812	13 796	53 327	0.2	0.3	4.8	18.5
Cereals	703	1 002	2 980	1 898	4.1	5.9	17.6	11.2
Coarse grains	21	30	13	222	1.5	2.2	1.0	16.4
Cotton	1	2	0	89	0.3	0.5	0.0	22.0
Dairy	65	92	1 309	1 442	1.9	2.6	37.3	41.2
Fruit	1	1	51	37	0.6	0.8	44.4	32.1
Grapes	3	4	21	43	3.0	4.2	21.5	43.3
Hay	4	5	11	19	3.5	5.0	10.8	19.0
Legumes	134	190	490	148	6.0	8.6	22.0	6.6
Oilseeds	23	33	230	73	3.7	5.2	36.8	11.8
Other	0	0	5	4	1.0	1.4	16.3	13.5
Peanuts	1	2	3	9	3.5	4.9	9.1	24.7
Rice	1	1	0	10	0.5	0.6	0.0	6.5
Sheep	1 574	2 242	2 123	51 793	1.0	1.4	1.3	32.8
Sugar cane	3	4	162	46	0.6	0.8	33.1	9.4
Tobacco	0	0	3	0	0.0	0.0	83.7	12.9
Tree nuts	0	0	13	3	0.4	0.6	55.7	13.4
Vegetables	3	4	99	53	1.6	2.3	59.3	32.0
All land uses	**3 106**	**4 426**	**21 317**	**109 219**	**0.7**	**0.9**	**4.5**	**23.1**

Upper and lower range estimates are reported on the Australian Natural Resources Atlas.

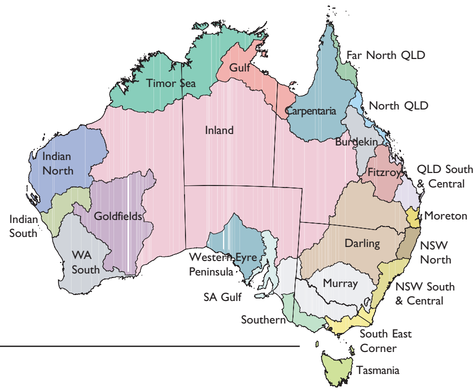
Home
Contents

Figure 4.5 Proportion of specific land uses currently affected by dryland salinity.



Home

Contents



It is apparent that while salinity affects significant areas of the Southern, New South Wales and Central and Western Australian southern regions, many regions are affected to a much greater extent by acidity and sodicity (Table 4.4).

Table 4.4 Area of land where soil attributes constrain agricultural yields, by regions.

Reporting region	Area ('000 ha)				Proportion of agricultural land (%)			
	Salinity	Salinity 2020	Aciditiy	Sodicity	Salinity	Salinity 2020	Aciditiy	Sodicity
Burdekin	13	33	56	3 644	0.1	0.3	0.5	30.3
Carpentaria	5	14	3 896	2 595	0.0	0.0	11.1	7.4
Darling	39	99	511	21 723	0.1	0.2	0.9	38.7
Far North Queensland	0	1	996	123	0.0	0.0	38.8	4.8
Fitzroy	24	51	130	4 965	0.2	0.5	1.2	44.2
Goldfields	0	113	2	1 934	0.0	0.5	0.0	8.1
Gulf	0	0	4	2 346	0.0	0.0	0.0	14.6
Indian North	0	0	0	0	0.0	0.0	0.0	0.0
Indian South	76	76	1 080	145	0.7	0.7	10.2	1.4
Inland	0	0	1	37 464	0.0	0.0	0.0	25.9
Moreton	1	2	215	262	0.1	0.1	16.2	19.8
Murray	272	559	2 543	15 567	0.8	1.7	7.5	46.2
NSW North	1	1	630	172	0.0	0.1	31.6	8.6
NSW South & Central	25	57	1 379	309	0.8	1.8	43.4	9.7
North Queensland	1	4	497	510	0.0	0.2	25.3	25.9
Queensland South & Central	6	15	350	1 501	0.2	0.4	8.8	38.0
SA Gulf	92	92	12	1 569	1.3	1.3	0.2	22.8
South East Corner	9	15	1 050	704	0.4	0.6	45.8	30.7
Southern	368	791	797	4 021	6.1	13.0	13.1	66.1
Tasmania	26	35	677	504	1.4	1.9	36.9	27.5
Timor Sea	0	0	3 464	1 624	0.0	0.0	11.2	5.3
WA South	2 094	2 413	3 024	6 713	9.5	11.0	13.8	30.5
Western Eyre Peninsula	54	54	5	825	0.4	0.4	0.0	6.3
Australia	**3 106**	**4 426**	**21 317**	**109 219**	**0.7**	**0.9**	**4.5**	**23.1**

Home

Contents

THE VALUE OF YIELD GAPS

The extent of areas affected by salinity, sodicity and acidity presents only half the story, since estimates give equal weight to a hectare of land in either the rangelands or the intensive and most productive agricultural regions. The other half of the story is provided by taking into account different potential profit levels which can be earned on different types of land and under different land use regimes. It is far more significant if salinity, for example, adversely affects our most productive and valuable agricultural land than if equivalent areas of marginal land are affected to the same extent.

Conversely, in considering investments to address soil health problems, the level of increased profits that can be earned from alleviation provides an upper bound on the gross benefits from the investment. Of course, in a benefit–cost framework, the costs of investment in remedial actions also need to be carefully considered, as do the off-site or non-agricultural costs and benefits (see Chapter 5). Correction of dryland salinity in a region will not only improve yields, but will also have significant other benefits for biodiversity, water quality and other factors. Only the on-farm productivity aspects are considered in this chapter. The concept of change in *profit at full equity* (see Box 1.1 in Chapter 1) is used to value the yield gap (see p. 89) resulting from soil attributes which keep yields at less than their potential. Solely from an agricultural perspective, the change in profit at full equity or value of the yield gap is equal to the maximum benefits or increase in profits which can be expected from alleviation of these soil attribute problems—without any consideration of the costs of remedial actions (see Chapter 6).

Taking 2000 as the base year, the total value of agricultural net income forgone (value of yield gap) due to dryland salinity is estimated at about $187 million a year (Table 4.5). This represents just under 3% of the total net return from agriculture. Prima facie, it appears that sodicity and acidity are much greater problems limiting agricultural returns from a national perspective than dryland salinity. This does not necessarily mean that greater public resources should be devoted to options for addressing sodicity or acidity since the cost estimates do not indicate:

- the ease with which impacts can be prevented;
- whether the costs are primarily public or private; or
- the trajectory of yield losses into the future.

Table 4.5 Value of the yield gap measured as change in profit at full equity for salinity, sodicity and acidity (1996/97), by State and Territory.

	Value of yield gap ($m)				Proportion of total profit at full equity (%)			
	Salinity	Sodicity	Acidity	Combined impact[a]	Salinity	Sodicity	Acidity	Combined impact[a]
Australian Capital Territory	0.0	0.0	0.2	0.2	0.0	7.6	28.5	29.9
New South Wales	6.3	280.3	378.7	624.1	0.3	13.8	18.6	30.7
Northern Territory	0.0	3.0	58.2	61.1	0.0	6.0	117.0	122.8
Queensland	10.2	180.3	232.5	392.9	0.8	13.8	17.7	30.0
South Australia	39.1	126.4	2.9	162.0	4.1	13.4	0.3	17.2
Tasmania	1.9	12.3	214.8	220.3	1.7	10.8	187.6	192.4
Victoria	18.5	342.5	471.1	757.4	1.6	30.1	41.4	66.6
Western Australia	111.0	89.7	226.1	341.6	11.5	9.3	23.4	35.4
Australia	187.0	1 034.6	1 584.5	2559.5	2.9	15.8	24.2	39.0

a As salinity, sodicity and acidity constraints often coincide the aggregate affect is significantly less than the sum of each constraint. This estimate is based on the most limiting factor. Upper and lower range estimates are reported on the Australian Natural Resources Atlas.

4

Sodicity can be treated by applying gypsum, but costs, and hence concern, are generally private and borne by the land owner. Benefits and costs of gypsum application are considered later.

Soil acidity has similar characteristics. Some soils are naturally acid. Use of legumes and repeated applications of fertilisers such as nitrogen-based fertilisers have, over a long period, induced or accelerated acidification. The impacts are largely on site and the condition can be treated by the application of agricultural lime.

In some severe cases, sodicity or acidity that retard plant growth can lead to more severe forms of soil erosion, (e.g. gully, sheet or rill erosion), that in turn can contribute to off-site effects such as water turbidity or water with high acidity. Such severe cases may warrant attention by community, industry and government on the grounds that externalities can be significant.

Salinity has a much greater capacity to cause off-site effects and is characterised by irreversible impacts if allowed to progress too far (both on- and off-farm). Hence there is potentially a greater role for community and government in addressing salinity. A response to this is seen in the November 2000 commitment by Commonwealth, State and Territory governments to the National Action Plan for Salinity and Water Quality.

For dryland salinity, land uses where the values of yield gaps are greatest are cereals, dairy and sheep (Table 4.6). Together these land uses account for over 70% of the total value of yield gaps for dryland salinity at a national level.

Table 4.6 Modelled value of yield gap ($m/year) measured as profit at full equity (PFE) for salinity, sodicity and acidity, by land use (2000).

	Annual value of yield gap ($m)				Proportion of total PFE (%)			
	Salinity	Sodicity	Acidity	Combined impact	Salinity	Sodicity	Acidity	Combined impact
Beef	15.8	138.0	95.0	220.5	2.2	19.2	13.2	30.7
Cereals	70.6	168.0	156.7	337.9	3.8	9.1	8.5	18.4
Coarse grains	2.9	28.9	5.4	34.0	0.5	5.2	1.0	6.1
Cotton	2.1	75.8	1.8	77.8	0.2	6.3	0.1	6.4
Dairy	24.0	224.4	255.0	451.5	1.5	14.1	16.0	28.4
Fruit	3.2	93.2	515.7	594.8	0.4	10.5	58.0	66.9
Grapes	6.0	53.8	117.9	167.4	1.3	11.5	25.2	35.7
Hay	1.8	1.9	2.1	5.5	17.0	17.9	19.6	51.0
Legumes	9.6	13.1	12.7	28.1	11.2	15.4	14.9	32.9
Oilseeds	2.4	8.4	22.5	28.8	2.6	9.0	24.2	31.0
Peanuts	0.9	1.6	0.9	2.9	3.8	7.2	3.8	13.1
Rice	0.1	1.8	0.2	2.0	0.1	3.5	0.4	3.9
Sheep	38.9	168.6	50.5	223.2	12.7	55.2	16.5	73.0
Sugar cane	0.6	8.2	27.8	32.1	0.3	4.9	16.7	19.3
Tobacco	0.0	0.1	17.8	17.8	0.0	0.6	139.1	139.1
Tree nuts	0.1	3.9	12.2	15.8	0.1	5.5	17.2	22.2
Vegetables	8.1	44.8	290.5	319.5	1.6	8.8	57.2	62.9
Total	**187.0**	**1 034.6**	**1 584.5**	**2 559.5**	**2.9**	**15.8**	**24.2**	**39.0**

4

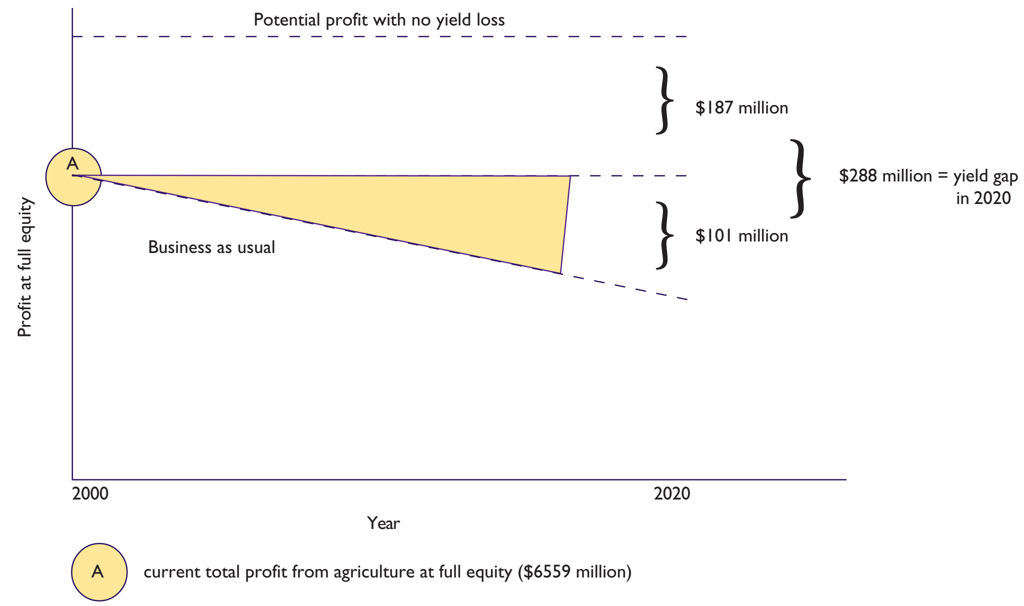
Value of yield gap for salinity in 2020

Problems of salinity are likely to intensify and expand given the long lag time between change in the catchment water balance and salinity impacts (*Australian Dryland Salinity Assessment 2000*, NLWRA 2001b). From a national perspective, the annual value of the yield gap for salinity in 2020 in real terms is estimated at $288 million for 2020, an increase of $101 million on the estimated current value of yield gap (Table 4.7; Figure 4.6). This again represents about 3% of the estimated total net returns from agriculture by 2020.

Table 4.7 Summary of salinity values of yield gap in 2000 and expected increases to 2020.

	Value of yield gap ($m)		Increase in value of yield gap ($m)
	2000	2020	2020
New South Wales	6.3	29.3	23.0
Queensland	10.2	18.2	8.0
South Australia	39.1	55.1	16.0
Tasmania	1.9	2.4	0.5
Victoria	18.5	55.5	37.0
Western Australia	111.0	127.0	16.0
Australia	**187.0**	**287.5**	**100.5**

Figure 4.6 Interpretation of the current and future yield gap values for dryland salinity.



The greatest proportional increases in value of yield gap for the dryland salinity are estimated to occur in New South Wales and Victoria. This reflects the regional and long-lag-time groundwater flow systems dominating New South Wales and Victoria. Western Australia has the highest yield gap in 2020 (as it does in 2000) and this points to the need for targeted investment within Western Australia.

The present value of the stream of annual yield gaps to 2020 (the shaded area in Figure 4.6) is estimated at $712 million at a social discount rate (see p. 46 for definition of discount rate) of 3% or $558 million at a 5% discount rate (Table 4.8). In relative terms, dryland salinity is predicted to reduce the present value of agricultural profits over the next 20 years by 1.5% (assuming a 5% discount rate). Thus, direct impacts on agricultural exports and agricultural profits are likely to be relatively small.

Table 4.9 shows the discounted sum of increases in annual yield gap values for dryland salinity over 20 years to 2020—disaggregated by land use type (again, the shaded area in Figure 4.6). For each land use type the estimates are also expressed in terms of percent losses in agricultural profit at full equity over the next 20 years. When salinity costs are viewed in this context, the losses if no action is taken range from 6% for the sheep industry to 0.1% for cotton.

Comparisons with other studies

A recent study of the Australia-wide costs associated with saline, sodic and acidic soils was undertaken by the Cooperative Research Centre for Soil and Land Management (1999). This study estimated the value of extra production from amelioration of soil acidity and sodicity (that is the value of yield gap) at $933 million per year and $23 million per year respectively. Hayes (1999) estimated the losses from human-induced dryland salinity (equivalent to value of yield gap) at $130 million per year. Also a recent report by the Virtual Consulting Group and Griffin NRM for the Australian Conservation Foundation and National Farmers Federation (Madden et al. 2000) estimated that the annual cost of degradation in rural landscapes is at least $2 billion a year. Given that these previous studies did not have access to the Audit's fine-scale land use maps and fine-scale soil attribute data, these estimates are not inconsistent with those reported in this study. However, it is emphasised that impact costs on agriculture reported are equivalent to the value of yield gaps only. They do not give any indication of likely returns after remedial action is undertaken.

4

Home
Contents

Table 4.8 Impact on agricultural profits resulting from increased severity and extent of dryland salinity from 2000 to 2020.

	Net present value of income losses in profit at full equity 2000–2020 ($m) 3% DR[a]	5% DR[a]	Decrease in PFE by 2020 (%)
New South Wales	156.5	123	1.1
Victoria	266.0	208	3.3
Queensland	53.6	42	0.6
South Australia	116.6	91	1.7
Western Australia	115.3	90	1.7
Tasmania	3.6	3	0.4
Australia	**711.9**	**558**	**1.5**

a DR = social discount rate

Table 4.9 Impact on agricultural profits resulting from increased severity and extent of dryland salinity from 2000 to 2020, by land use groupings.

	Net present value of income losses in profit at full equity 2000–2020 ($m) 3% DR[a]	5% DR[a]	Decrease in PFE by 2020 (%)
Beef	101	79	2.0
Cereals	153	120	1.2
Coarse grains	22	17	0.6
Cotton	8	7	0.1
Dairy	184	144	1.6
Fruit	20	16	0.3
Grapes	26	20	0.8
Hay	1	1	1.7
Legumes	12	10	2.0
Oilseeds	10	8	1.5
Peanuts	4	3	2.6
Rice	6	5	1.7
Sheep	132	104	6.1
Sugar cane	9	7	0.8
Tobacco	0	0	0.0
Tree nuts	0	0	0.0
Vegetables	22	17	0.6
All land uses	**712**	**558**	**1.5**

a DR = social discount rate

Home
Contents

BENEFITS AND COSTS OF TREATING SODIC AND ACIDIC SOILS

Sodic and acidic soils can be treated by applying gypsum and lime respectively and application generally represents private investment. This raises the question of whether such treatments are profitable and, if so, why more has not been done to treat these soil conditions. Benefit–cost analyses of these treatments were undertaken (brief underlying assumptions are given in Box 4.3).

In areas affected only by sodicity or acidity application of gypsum for sodicity or lime for acidity was assumed to correct the condition immediately and permanently provided maintenance applications were continued in perpetuity every three years for sodicity and every year for acidity. Under these treatments, relative yields were restored to 100% and yield gaps were eliminated. A limiting factor approach was taken where areas were subject to multiple soil health conditions, (e.g. where salinity was the most limiting factor, any treatment with lime or gypsum was assumed to have no impact on yields).

Results indicate that while acidity and sodicity affect 28% of agricultural land, additional soil treatment by farmers is only financially worthwhile on about 4% of this land (Table 4.10). However, within this area, soil treatment by lime and/or gypsum has the potential to provide large financial net benefits to farmers. Assuming treatments run in perpetuity and that they eliminate yield gaps, gives a net present value of over $16 billion at a 10% private discount rate and $11 billion at a 15% discount rate. This represents a substantial return on investment and begs the question of why farmers whose properties are adversely affected by sodicity or acidity do not undertake soil treatment. Information on the adoption and type of management strategies implemented to deal with acidity and sodicity is largely anecdotal. The research outcomes of the former National Soil Acidification Program (Land & Water Australia) and Cooperative Research Centre for Soil and Land Management are key inputs into further regional investigations.

Table 4.10 Net present value of soil treatment options for sodicity and acidity[a].

Soil treatment options		Do nothing	Apply gypsum only	Apply lime only	Apply lime and gypsum	Total
10% discount rate						
Area affected	million ha	218.5	3.2	5.4	0.8	227.9
Proportion of total area	%	95.9	1.4	2.4	0.3	100.0
Net present value of net benefits	$m	0.0	3 490	8 554	4 421	16 465
15% discount rate						
Area affected	million ha	219.2	2.9	5.1	0.7	227.9
Proportion of total area	%	96.2	1.3	2.2	0.3	100.0
Net present value of net benefits	$m	0.0	2 290	5 605	2 887	10 783

a Areas affected were calculated on the basis of those areas for which relative yield is less than 100% due to sodicity and/or acidity. Thus the area estimates exceed those reported in Table 4.1, which were estimated on the basis of yield reductions of 5% or more.

BOX 4.3 ASSUMPTIONS UNDERLYING BENEFIT–COST ANALYSIS FOR TREATMENT OF SODICITY AND ACIDITY

Sodicity

Sodic soils have a tendency to chemically disperse especially when cultivated and/or impacted by rain or surface run off. Dispersed clays may form crusts on the surface or be translocated down through the soil profile, plugging pore spaces, restricting drainage and causing surface waterlogging, crusting and very poor seed emergence or plant growth. Application of gypsum can change the chemistry and structure of the soil and remedy the situation.

Gypsum is often applied to sodic soils at rates around 2.5 tonnes/ha/year. In the benefit–cost model it was assumed that this would be sufficient to restore crop/pasture yields to full yield.

Highly dispersive sodic soils are prone to soil erosion

Acidity

Remediation of acidic soils involves the application of lime to raise soil pH_{ca} to 5.5. At this level, most crops and pastures have negligible yield loss from acidity. A challenge in the analysis was to estimate the amount of lime required to bring all acidic agricultural soils (those with pH less than 5.5) up to the benchmark pH of 5.5. This was determined by:

$$\text{Lime required} = \begin{matrix}\text{number of pH units to}\\ \text{bring soil pH up to 5.5}\end{matrix} \times \begin{matrix}\text{number of units of lime required}\\ \text{to raise soil pH by 1 unit}\end{matrix}$$

The required lime application was assumed to bring acid soils up to full potential capacity in the absence of any other limiting factors. To prevent re-acidification it was assumed that each treated hectare would have a maintenance application of 250 kg/ha/year of lime every year in perpetuity. Spatial information on lime requirements was obtained from the Australian Soil Resources Information System.

Costs

Costs of purchasing, transporting and spreading lime were based on information from the commercial market and varied by location.

LANDHOLDER PERCEPTIONS OF LAND DEGRADATION AND EFFECTS ON LAND VALUES

As part of the Australian Bureau of Agriculture and Resource Economics farm survey program, a survey of the extent of land degradation as perceived by those farmers interviewed was carried out in 1999 for Australia's broadacre and dairy farms (Kemp & Connell 2001).

An expectation is that the market value of agricultural land will generally reflect the stream of financial returns that can be earned from that land, discounted to present value. If a farm is degraded then its future productive capacity is diminished and one would expect the market value of that farm to be somewhat lower than would otherwise be the case. This hypothesis was tested by Australian Bureau of Agriculture and Resource Economics using farm survey data and farmers' estimates of the land values of their farms. Of course, land values are also affected by many other issues such as proximity to large towns, amenity, type and topography of land, degree of development. These factors were taken into account in the analysis as far as possible. In addition, the increasing incidence of landholders reporting degradation on their farms may indicate that their knowledge and recognition of degradation is improving rather than that the actual incidence or severity of degradation is getting worse.

Results indicated that of nearly 410 million hectares of broadacre and dairy farm land, just over 100 million hectares were estimated to be affected to varying degrees by some form of significant land degradation. Approximately 36% of farmers reported at least one form of significant land degradation on their farm. These farmers estimated that on average approximately 21% of their total farm area was affected to some extent (Table 4.11).

Table 4.11 Incidence and extent of significant land degradation (1998/99).

	Pastoral zone[a]	Wheat–sheep zone[a]	High rainfall zone[a]	All zones
Population (no.)	4228	44776	36570	85574
Sample (no.)	210	667	593	1470
Proportion of farms with significant degradation problem (%)[b]	34(22)	38(7)	33(9)	36(6)
• acid soils	–	11(17)	10(24)	10(15)
• water erosion	10(37)	9(17)	12(20)	11(13)
• wind erosion	4(41)	2(25)	2(35)	2(19)
• dryland salinity	–	11(16)	5(26)	8(13)
• irrigation salinity	–	4(22)	–	2(21)
• sodicity	–	4(24)	2(35)	3(20)
• loss of soil structure	–	7(17)	3(25)	5(14)
• waterlogging	–	9(17)	5(26)	7(14)
• weeds	25(27)	15(14)	16(16)	16(10)
Proportion of farms with a significant degradation problem (%)	34(22)	38(7)	33(9)	36(6)
Area affected by land degradation (ha/farm)[c]	10 029(34)	464(12)	206(16)	812(20)
Proportion of total farm area (%)[c]	19(37)	27(13)	23(15)	21(23)

a For a description of the location of the three zones see ABARE (2000) *Australian Farm Surveys.*

b There may be more than one form of land degradation on a farm. Estimates may include human induced as well as natural degradation.

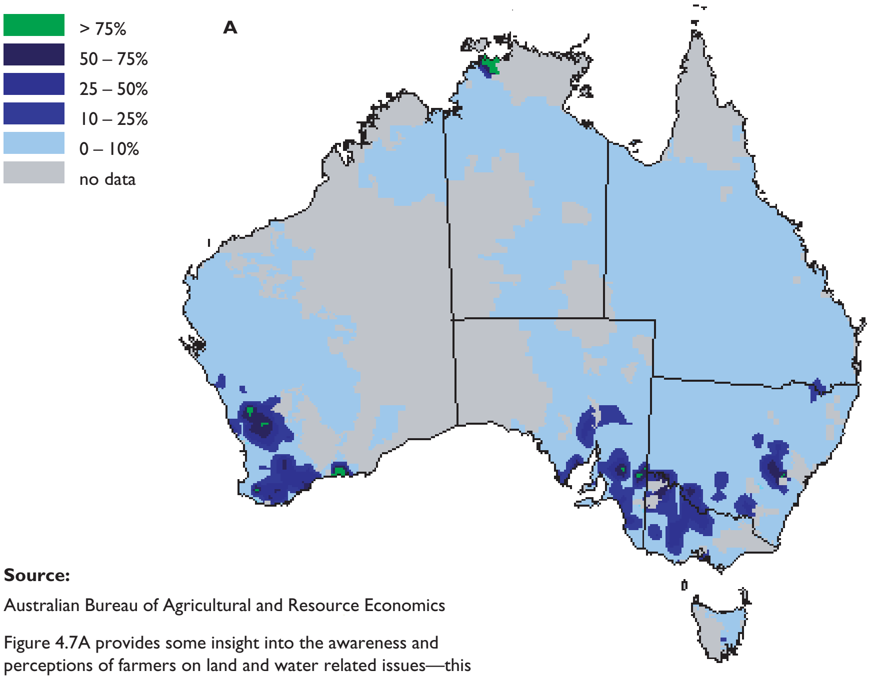
c Average figures for farms with land degradation.

Figures in parentheses are relative standard errors, expressed as percentages of the estimates.

Source: Kemp & Connell (2001)

The region most significantly affected appears to be the wheat–sheep zone of Western Australia where an estimated 46% of farmers reported degradation problems on their farms (Figures 4.7 to 4.10).

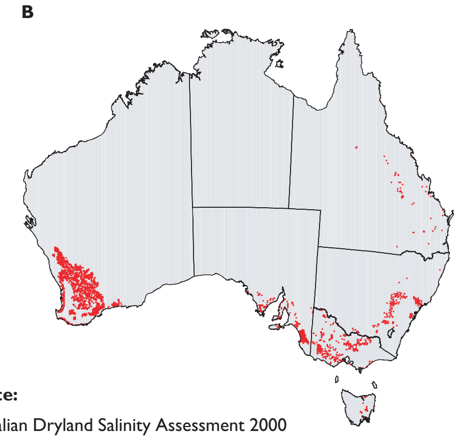
Figure 4.7 Proportion of farms with salinity problems, 1998/99 showing (A) farmer perceptions and (B) salinity yield loss extent (2000).



Source:

Australian Bureau of Agricultural and Resource Economics

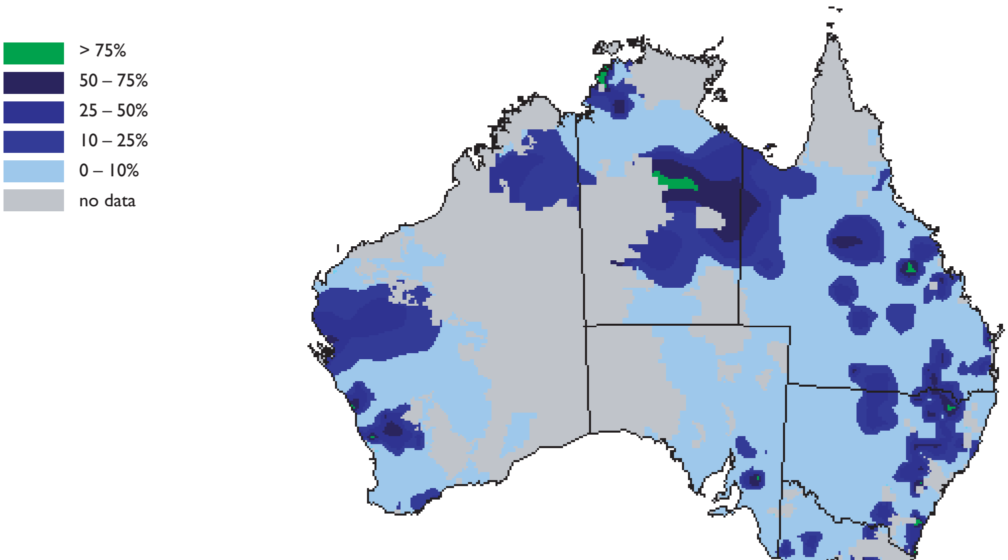
Figure 4.7A provides some insight into the awareness and perceptions of farmers on land and water related issues—this map **should not** be interpreted as representing the actual geographic distribution or severity of the issue.



Source:

Australian Dryland Salinity Assessment 2000

Figure 4.8 Proportion of farms with perceived water erosion (1998/99).



Source:

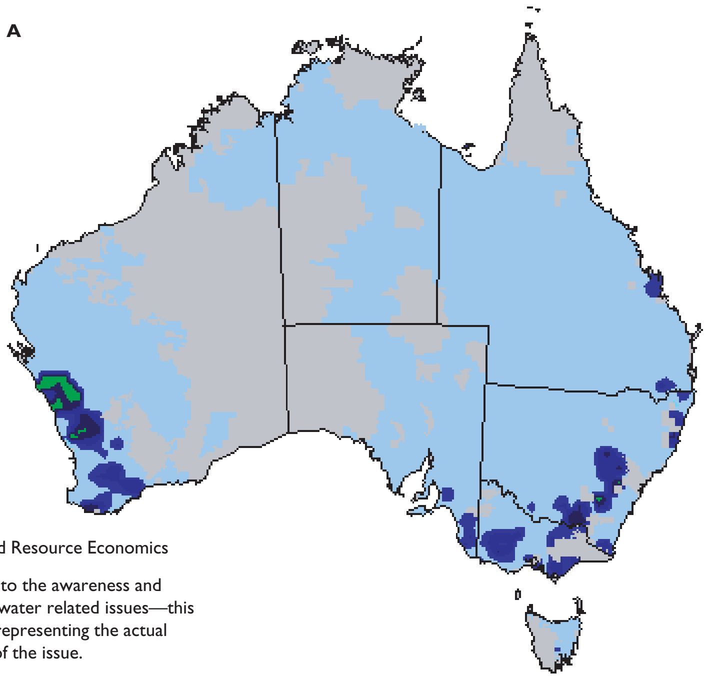
Australian Bureau of Agricultural and Resource Economics

Figure 4.8 provides some insight into the awareness and perceptions of farmers on land and water related issues—this map **should not** be interpreted as representing the actual geographic distribution or severity of the issue.

Figure 4.9 Proportion of farms with soil acidity problems, 1998/99 showing (A) farmer perceptions and (B) acidity yield loss (at least 5%) areas.

> 75%
50 – 75%
25 – 50%
10 – 25%
0 – 10%
no data

A

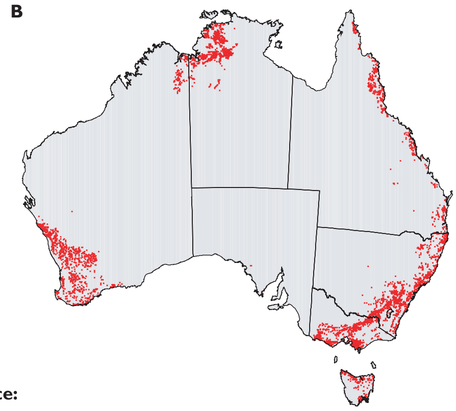


Source:

Australian Bureau of Agricultural and Resource Economics

Figure 4.9A provides some insight into the awareness and perceptions of farmers on land and water related issues—this map **should not** be interpreted as representing the actual geographic distribution or severity of the issue.

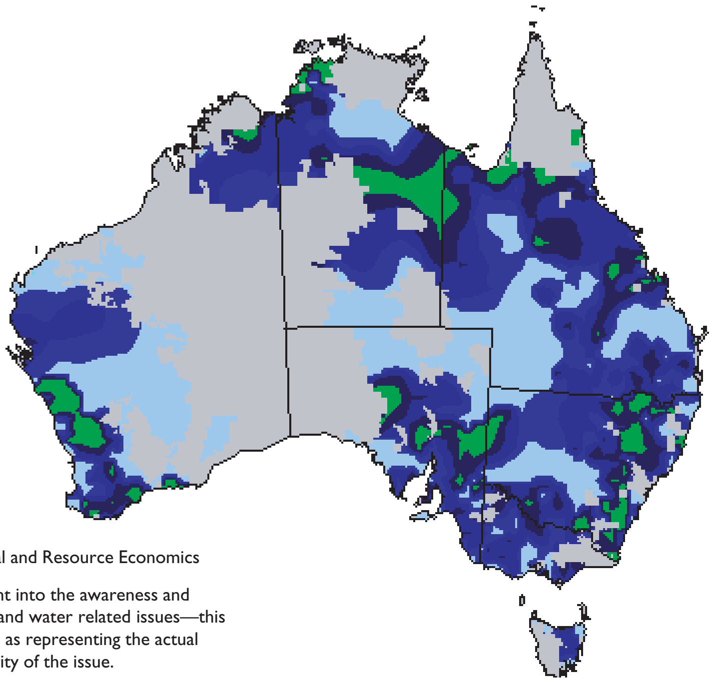
B



Source:

Australian Agriculture Assessment 2001

Figure 4.10 Proportion of farms indicating at least one significant degradation problem.



Source:

Australian Bureau of Agricultural and Resource Economics

Figure 4.10 provides some insight into the awareness and perceptions of farmers on land and water related issues—this map **should not** be interpreted as representing the actual geographic distribution or severity of the issue.

Impact on farm capital values

The difference between capital values of farms with land degradation and the capital value of these same farms if they were valued at the capital value of farms without degradation was estimated to be $14 billion. This translates to an equivalent amenity or annual difference of around $994 million a year and represents the value of the consequences of past land degradation on future farm profits. The figures include all forms of land degradation. It is stressed that these estimates do not reflect in any way the returns on investment from measures which would be taken to ameliorate land degradation. They do give some idea of the maximum potential benefits that would be associated with measures to eliminate all degradation and the costs of such measures or the probability of their success if adoption is ignored.

BEYOND THE PADDOCK

5

Key points

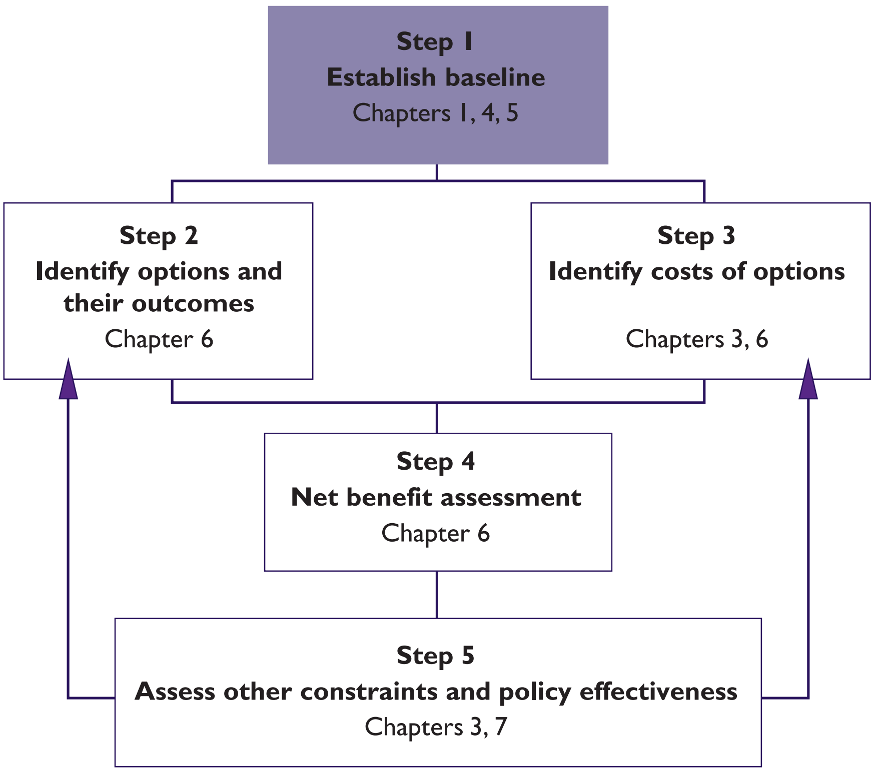
- Land degradation causes significant 'off-site' impacts. Salinity and rising water tables cause damage to local infrastructure while salinity, turbidity and other forms of degradation reduce water quality and impose significant costs on downstream water users. Land degradation also causes damage to the environment and biodiversity.
- Future 'off-site' damage costs are difficult to estimate and at this stage only indicative estimates on a national scale can be given. A 'best bet' estimate is that damage to local infrastructure is at present around $89 million per year in Australia and that this could rise by around $62 million or 70% over the next 20 years. This includes damage to general urban infrastructure, roads, railways and bridges.
- On the conservative assumption of an 'across the board' 5% increase in levels of salinity, turbidity and sedimentation in rivers across Australia and assuming a 5% discount rate, the net present value of the increases in damage up to 2020 are estimated to be $511 million for salinity, $715 million for turbidity and $78 million for erosion/sedimentation.
- Downstream impacts of salinity on urban, industrial and commercial water users are estimated to be much higher than previously thought. The increase in estimated salinity and water hardness costs for the River Murray is 200% higher and now estimated to be in the vicinity of $150 000 per EC unit rather than $50 000.
- Significant impacts on the environment (e.g. the deterioration of wetland ecosystems due to salinity) will continue to be among the key off-site impacts of land and water degradation. Estimation of the current and future size of this cost has not been possible in this analysis. However, it is important to improve our capacity to value off-site impacts on the natural resource base—particularly given the increasing value being placed on the environment and environmental services by the Australian community.
- At a national scale, 'off-site' and 'downstream' damages caused by salinity are probably more important than yield losses on farm.
- The choice modelling study of non-market social and environmental impacts represents a major step forward in developing an insight into how the community values these impacts. The results indicate that people are willing to pay significant amounts for implementation of policies that deliver environmental and social improvements over and above what is expected to be achieved with existing rehabilitation programs. This applies particularly to policies that affect land degradation in local regions.
- Guidelines for benefit transfer will assist in future applications of this approach.
- Upper and lower range estimates are reported on the Australian Natural Resources Atlas at www.environment.gov.au/atlas.

ASSESSMENT FRAMEWORK CONTEXT

Degradation of our natural resources has implications not just for agricultural (considered in Chapter 4) but for many other industries, local governments, infrastructure assets, environmental assets and individuals (Figure 5.1). This chapter examines the economic implications of selected forms of land degradation for assets and activities other than agriculture within a region or catchment where degradation is occurring as well as remote 'off-site' impacts that are distant from the immediate area of degradation and generally associated with decreased water quality. The results of a study aimed at estimating non-market values associated with environmental changes resulting from degradation and changes to rural communities are also reported.

- Figure 5.1 puts into perspective the range of 'off-site' and other non-agricultural impacts of land degradation and the contribution that this chapter makes to furthering our knowledge on these issues.

The information in this chapter will be useful for further establishing baselines (Step 1 in Figure 2.6) relevant to more detailed benefit–cost analyses of options to address the problems. The off-site costs of selected forms of land degradation should be considered in conjunction with the economic implications for agriculture estimated in Chapter 4.



Due to the lack of reliable information on the physical impacts of degradation on non-agricultural assets, only a subset of the costs that occur beyond the paddock were estimated (salinity and water quality—see shaded areas in Figure 5.1). Some of the off-site costs imposed by degradation were estimated in terms of current impacts (e.g. salinity, damage to roads and infrastructure) while other costs, such as those imposed by waterway turbidity and sedimentation, were estimated in terms of future costs of incremental increases in degradation.

The approach taken for turbidity and sedimentation was to answer the question, 'what would be the cost implications of these types of degradation *increasing* by a certain amount over a certain time period in the future?' Limited data meant that it was not possible to assess the present costs imposed by turbidity and sedimentation. Cost estimates relate only to future *increases* in water quality or degradation. If trends in some form of degradation are judged to have stabilised, then there will be no costs imposed on water users that are *additional* to those currently being incurred.

There are limitations to this approach:

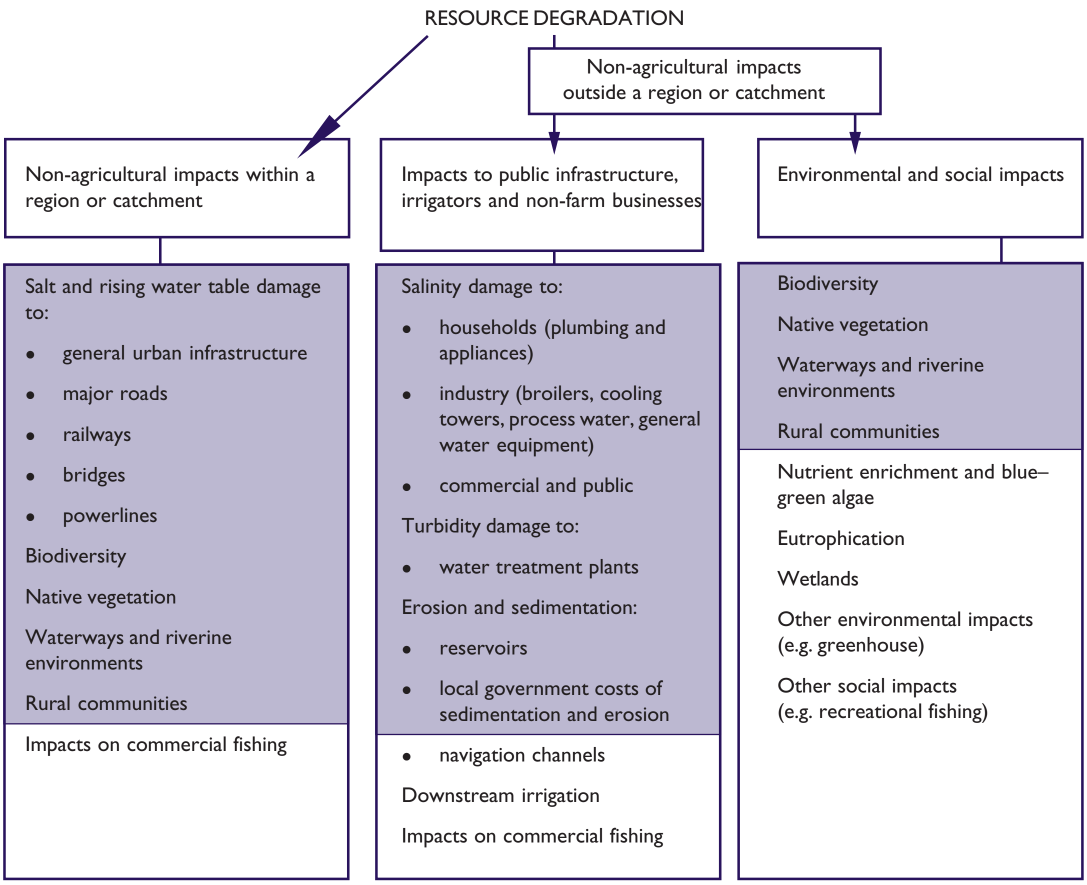
- to the extent that water quality can be improved, ignoring current costs will underestimate the potential benefits to be gained from addressing the source of degradation; and
- costs may rise without any further declines in water quality—for example, if there are no future increases in salinity levels in rivers the total costs of current high salinity levels to water users will increase if the number of water users in the region increases.

This report provides a basis for assessing the severity of the issues and gives an indication of the maximum gross benefits that could be expected from investments to prevent any further drop in water quality. But alternative options for controlling water quality, or the level of investments required and benefit–cost assessments of alternative investment options, are not considered.

5

Home
Contents

Figure 5.1 Some forms of 'off-site' impacts of resource degradation*.



Note: coloured sections represent issues addressed.

* For the purposes of this report, costs that occur beyond the paddock are classified as being either 'within catchment' costs or off-site impacts that occur outside the catchment, remote from the source of degradation. These off-site impacts are further broken down into damages that are imposed on:

- irrigators, public assets and non-farm business
- social and environmental values

Home
Contents

LOCAL INFRASTRUCTURE COSTS OF SALINITY AND HIGH WATER TABLES

Although rising groundwater tables and salinity frequently occur together, their impacts on infrastructure are different. Rising groundwater reduces the structural integrity of soils beneath infrastructure creating unstable foundations. Salt is a corrosive agent. In most cases, the increased maintenance costs associated with each process are additive.

Estimates were made of the annual costs of damage caused by rising salt and high water tables to infrastructure such as general urban assets (houses, public buildings, light poles etc.), roads and railway lines, underground drainage, airports, sports fields, parks and gardens and other such public and private assets. These estimates were linked to data on population density as no national data sets for the location of assets could be identified. Estimates for roads and rail were based on unit cost functions and applied to the length of road or rail adversely affected. Projections to 2020 were based on the projections of the increase in extent of dryland salinity and water tables within 2 m of the surface. Given the uncertainties involved in estimations of this kind, a 'best bet' scenario is presented in this report (Table 5.1). A range of estimates (low, best bet and high), the methods of estimation, assumptions made and unit cost functions are set out in full in CSIRO Policy and Economic Research Unit (2002). In preparing estimates for 2020, a 'business as usual' assumption was adopted. This broad assumption recognises the long lag time before salinity control activities improve water quality. Thus, the estimate may be at the upper end of estimates based on the commitment and activities now under way through the National Action Plan Salinity and Water Quality that, among other things, aims to reduce expected increases in salinity.

Results show substantial increases in costs of damage to infrastructure in New South Wales and Victoria, in contrast to Western Australia where damage costs are already substantial but, in relative terms, unlikely to rise by much more. Further spread of salinity in Western Australia is unlikely to coincide with major regional towns and hence infrastructure.

Most of the current costs of damage to infrastructure caused by dryland salinity and projected increases in costs are related to general urban infrastructure (Table 5.2).

It is estimated that the net present value of increases in infrastructure costs associated with salinity and rising water tables is $341 million, assuming a 5% discount rate (Table 5.3). Victoria and New South Wales are the most affected States.

Over half the total cost increments in the effects of salinity and watertables on infrastructure are estimated to occur in the Murray and Southern regions (Table 5.4).

Table 5.1 Best bet* estimates of annual salinity costs from local infrastructure damage.

	2000 ($m)	2020 ($m)	Increase+ ($m)	(%)
New South Wales	14.0	37.9	23.9	171
Queensland	2.2	5.5	3.3	151
South Australia	6.7	10.9	4.2	63
Tasmania	1.9	2.5	0.6	31
Victoria	12.2	38.5	26.3	215
Western Australia	51.8	55.1	3.3	6
Total	**88.8**	**150.3**	**61.5**	**69**

* upper and lower range estimates are reported on the Australian Natural Resources Atlas

\+ increase = difference in cost estimates between 2000 and 2020

Table 5.2 Best bet* estimates of annual salinity costs to Australia from local infrastructure damage, by type of infrastructure.

	2000 ($m)	2020 ($m)	Increase ($m)	(%)
General urban	60.3	109.0	48.7	81
Major roads	14.7	23.1	8.4	57
Rail	13.5	17.8	2.9	16
Bridges	0.3	0.4	–	–
Total	**88.8**	**150.3**	**61.5**	**69**

* upper and lower range estimates are reported on the Australian Natural Resources Atlas

Table 5.3 Net present value (NPV) of local infrastructure costs per State (5% DR[a]).

	2000–2020 increase (%)	**Change in annual costs** ($m)	**NPV of increase in costs** ($m)
New South Wales	171	23.9	133
Queensland	151	3.3	18
South Australia	63	4.2	23
Tasmania	31	0.6	3
Victoria	215	26.3	146
Western Australia	6	3.3	18
Total	**69**	**61.5**	**341**

a DR = social discount rate

Table 5.4 Best bet* estimates of annual infrastructure costs for 2000 and 2020 by region: dryland salinity at 5% DR[a].

Region	**2000** ($'000)	**2020** ($'000)	**Present value of increase in costs** ($'000)
Burdekin	72	160	488
Carpentaria	1	6	26
Darling	1 546	4 965	18 967
Far North Queensland	88	395	1 704
Fitzroy	488	835	1 925
Goldfields	0	46	254
Gulf	0	0	0
Indian North	0	0	0
Indian South	645	645	0
Inland	0	0	0
Moreton	497	1 155	3 653
Murray	12 268	31 681	107 694
NSW North	44	102	317
NSW South & Central	9 500	21 715	67 763
North Queensland	182	768	3 253
Queensland South & Central	631	1 615	5 460
SA Gulf	2 638	2 639	5
South East Corner	429	2 788	13 086
Southern	5 922	23 133	95 480
Tasmania	1 911	2 506	3 304
Timor Sea	0	0	0
WA South	51 134	54 378	17 996
Western Eyre Peninsula	779	779	0
Total	**88 774**	**150 310**	**341 375**

* upper and lower range estimates are reported on the Australian Natural Resources Atlas

a DR = social discount rate

INCREASES IN IMPACT COSTS OF DECLINING WATER QUALITY ON DOWNSTREAM NON-AGRICULTURAL INDUSTRIES AND HOUSEHOLDS

Water quality trends

The Audit's database on water quality trends shows that although the condition of surface water resources in Australia over the past ten years has largely stabilised, water quality is poor in some rivers.

Some insights into water quality trends in river salinity can be drawn from data prepared for the *Murray-Darling Basin Salinity Audit* (MDBC 1999). Under the Murray–Darling Basin audit, estimates are provided of river salinity at 1998 and 2020 for 33 river valleys. Of these river valleys, 15 are predicted to have an increase of over 20%; 21 river valleys are predicted to have an increase of over 10%. The median percentage increase in river salinity for all the river valleys is 19%. Assuming these estimates are representative of national trends (for areas affected by salinity) then the 5% and 10% scenarios presented in this report provide a conservative estimate. These scenarios provide a view of relative magnitude of costs and how these are partitioned between the various water quality issues and assets at risk. They assume that land use activities in catchments have precipitated change in the water balance, and that flow regimes also drive water quality in terms of turbidity, sedimentation and nutrient water quality.

The Audit's water quality database includes measurements for salinity, acidity, total phosphorous, total nitrogen, turbidity, faecal coliforms and frequency of blue–green algae occurrences.

Dryland salinity and most water quality issues are controlled by catchment hydrology. A river basin (catchment) breakdown of profits and costs is presented in Appendix A.

The *Murray-Darling Basin Salinity Audit* (MDBC 1999) also suggests some increases in salinity levels in inland rivers in the basin.

> *The average salinity of the lower River Murray (monitored at Morgan) will exceed the 800 EC threshold for desirable drinking water quality in the next 50-100 years.*
>
> MDBC 1999

Between 1993 and 1999, the average salinity level measured at Morgan was 570 EC* and was less than 800 EC for 92% of the time.

As part of the Audit's work on assessing the economic impacts of deteriorating resource condition, a study was undertaken to estimate national downstream incremental damage costs incurred by non-agricultural industries and households, arising from water quality degradation at the level of individual river basins. That is, taking the year 2000 as a base, the *increases* in costs caused downstream by further deterioration in water quality over the next 20 years were estimated using standardised *marginal cost functions* (Box 5.2) and applying these to expected changes in resource condition in some river basins. The river basins selected were those where water quality is expected to further deteriorate or is judged to be 'at risk' of further water quality deterioration (see Box 5.1 for river salinity).

There is a lack of reliable estimates of future water quality trends in river basins. Because the cost estimates relate to unit or incremental decreases in water quality, the estimates can be used to gain an appreciation of the total additional costs for any river basin where the *increases* in specific water quality attributes are assessed.

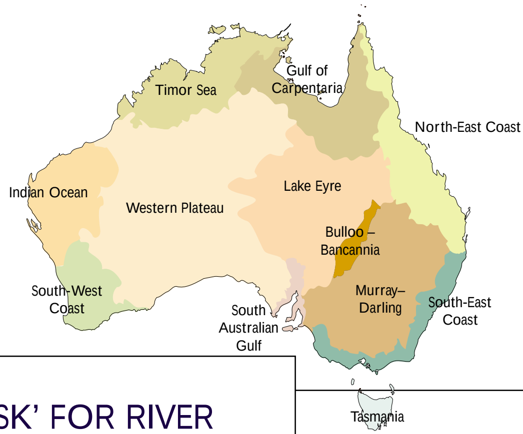
To illustrate how the estimates might be used at a national level, an assumption is made that water quality attribute readings across all river basins (Box 5.1) will increase by 5% and 10% over the period to 2020. In reality water quality will probably get better in some river basins while it will deteriorate in others but reliable projections are not available. A 5% increase in water quality attribute readings is probably conservative, given the results from the *Murray-Darling Basin Salinity Audit* (MDBC 1999).

Water quality attributes analysed were salinity, turbidity and erosion/sedimentation. Data limitations at a national level prevented analysis of other attributes such as rising acidity and nutrient levels which are associated with eutrophication and algal blooms. The estimates do not include the effects of poor water quality on commercial fishing, irrigators and tourism.

The Audit's database on estimates summarised in this report is constructed so that results following a variety of assumptions can be readily tested. Discount rate, time frame and unit cost estimates can all be varied and data extracted for any river basin in Australia.

* EC—electrical conductivity—is a measure used to express salt content. 'EC unit' is electrical conductivity expressed in microsiemens per metre.

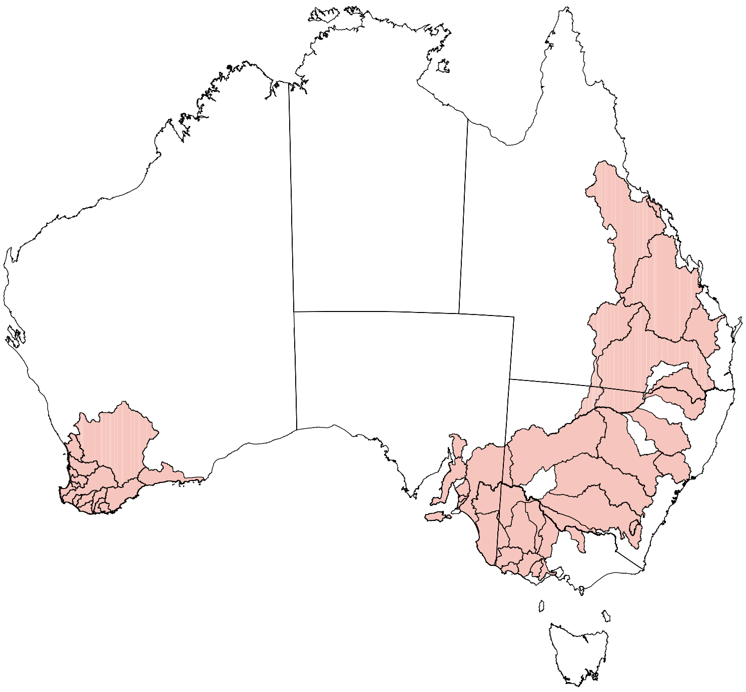
Home
Contents



BOX 5.1 DRAINAGE BASINS IDENTIFIED AS 'AT RISK' FOR RIVER SALINISATION

A range of methods for deriving national figures on downstream infrastructure costs of degradation were evaluated. The most reliable data were considered to be those derived from applying the cost functions to a selection of drainage basins identified as 'at risk'. They include:

- a number of Queensland basins in Division I, the North East Coast Division, that were identified in the Australian Dryland Salinity Assessment 2000 (NLWRA 2001b) as likely to be affected by increasing dryland salinity;
- a number of basins in the South East Coast Division, where salinity is already a significant issue, including the Hunter Basin in New South Wales, the Latrobe Valley in Victoria, the Victorian coastal basins west of the Otways, and the Millicent Basin in south east of South Australia;
- all basins in the Murray–Darling Basin Division, that had evidence of increasing trend in the publication by Williamson et al. *Salt Trends: Historical trend in salt concentration and saltload of streamflow in the Murray-Darling Basin* (MDBC Dryland Technical Report No 1, 1997);
- all basins in the South Australian Gulf Division; and
- all basins in the south west of Western Australia Division.



Source: CSIRO Policy and Economic Research Unit (2002)

Home
Contents

BOX 5.2 ESTIMATION OF UNIT IMPACT COSTS

The unit cost functions used and their method of derivation are technical and readers are referred to the detailed reports (CSIRO Policy and Economic Research Unit 2002). Unit cost functions are estimated for salinity, turbidity, erosion and sedimentation.

Unit salinity costs

Incremental cost estimates were derived using a methodology essentially developed by Gutteridge, Haskins and Davey (and used for two previous studies of downstream costs in the Murray–Darling Basin). Review of this previous work and the collection of additional data for the Audit:

- revealed that the economic assessments had used straight line discounting methods rather than standard amortisation techniques used for cost estimation by economists;
- suggested that household plumbing costs are higher, industrial water treatment practices are different to those previously assumed and that water use is higher; and
- identified some assumptions that no longer appear to hold.

Modification of the method to account for these issues substantially changes the previous estimate used for policy development and program selection in the Murray Darling Basin and elsewhere. The result is a 200% increase in the estimated impact cost per EC unit from $50 000 to $150 000.

As the differences between these estimates are so large and because some of the information used is not underpinned by experimental data, the team responsible for this study recommended that there be a systematic review of:

- the methodological options; and
- the quality of the data used to make these estimates; and
- if appropriate, a research program needs to be implemented to collect the necessary data to enable these estimates to be refined.

Turbidity costs

The function for estimation of turbidity costs takes into account the size of water treatment plants, the level of treatment already undertaken, set water treatment standards and the cost of upgrading water treatment plants to the level needed to reduce turbidity to the standard set for the plant in question.

Erosion and sedimentation costs

The function for estimation of erosion and sedimentation costs takes into account impacts on roads, railways, river navigation and the operational life of reservoirs. Data on fine sediment loads to rivers and streams comes from *Australian Agriculture Assessment 2001* (NLWRA 2001e).

Source: CSIRO Policy and Economic Research Unit (2002), Appendices D to H.

5

Home
Contents

Impacts of increases in water salinity

Table 5.5 presents a State and national summary of downstream water degradation costs due to salinity for basins where salinity in rivers is 'at risk' of increasing. These are total cost *increase* estimates discounted to net present value over the 20 years—from 2000 to 2020—based on a discount rate of 5%. Estimates are shown for two scenarios—5% and 10% increases in water salinity in river basins.

South Australia accounts for over half of all downstream costs due to salinity and on the conservative assumption of a 5% decrease in water quality across river basins over the next 20 years, total cost amounts to $511 million.

Turbidity

Turbidity is a potential cause of significant cost to water users. The estimates presented in Table 5.6 are the *increases* in costs of treating water supplies where turbidity levels due to land degradation are assumed to increase by a specified amount. Estimates are based on:

- establishment of a 'baseline case' for each river basin based on the assumption that current median turbidity levels and current levels of water treatment will continue over the next 20 years; and
- assumptions about the degree to which turbidity levels will increase. The percentage increases in turbidity are applied to standard unit or marginal cost functions to give estimates of the *increase* above the baseline case in costs of water treatment.

Home
Contents

Table 5.5 Net present value of downstream costs of the *increase* in salinity in rivers and streams over 20 years to 2020[a, b, c].

	Increase in water salinity 5% ($m)	10% ($m)
New South Wales	68	137
Queensland	13	26
South Australia	292	584
Victoria	20	39
Western Australia	118	235
Total	**511**	**1 021**

a Expressed in 1996/97 dollars.
b Present values were determined using a social discount rate of 5%.
c Data for Tasmania, Australian Capital Territory and Northern Territory are unavailable.

Table 5.6 Increases in the net present value of treatment costs associated with various increases in turbidity levels over 20 years[a, b].

	Increase in turbidity 5% ($m)	10% ($m)
Australian Capital Territory	8	9
New South Wales	161	193
Queensland	278	307
South Australia	119	137
Victoria	122	137
Western Australia	27	31
Total	**715**	**814**

a Expressed in 1996/97 dollars.
b Present values were determined using a social discount rate of 5%.
c Data for Tasmania and Northern Territory are unavailable.

Where actual treatment practices in some basins were not recorded a standard treatment procedure was assumed. This included chlorination, pH remediation, sedimentation, sand filtration and coagulation–precipitation. The capital costs for additional treatment would generally be associated with higher grade filtration and coagulation–precipitation processes and higher capital expenditure on sludge processing. Increased operating costs would be associated with higher expenditures on treatment chemicals (Table 5.7).

It is apparent that the largest single component of additional costs is the expenses associated with upgrading existing treatment plants (Table 5.7).

Estimates presented in Table 5.7 could have large error bounds. They are based on model results and while giving broadly plausible estimates they have not been comprehensively verified against actual experiences of water treatment plant operators dealing with increasing turbidity.

The last row in Table 5.7 presents the results for only those river basins which, according to the Audit's database, have historically shown an increasing trend in turbidity. For the relatively small number of these it is assumed that future turbidity will increase by 5%. On this assumption the total increase in treatment costs is clearly very much less than assuming turbidity will increase by 5% for all river basins.

Erosion and sedimentation

Removal of or reduction in vegetative cover can increase run-off which can lead to river flooding following heavy rain. Material deposited on roads and highways often needs to be removed by main roads departments, local governments or rail operators. Sediment in rivers can reduce reservoir capacity or cause navigation restrictions. Estimates of clean-up costs were obtained by surveying appropriate organisations (e.g. the survey of local governments suggested expenditures per resident due to erosion and sedimentation problems of around $7 per person per year on average; surveys of road and rail operators indicated that clean-up costs of sediment deposits are about 1.5 times those of local governments).

Additional costs associated with further increases in erosion and sedimentation were estimated using the survey results to estimate marginal cost functions (Tables 5.8, 5.9). Results indicate that future additional erosion and sedimentation costs are likely to be highest in Queensland, probably reflecting the greater incidence of heavy rainfall downpours. All three components—clean up of roads and rail tracks, reservoir silting and channel cleaning—incur significant costs.

Table 5.7 Present value of cost increases for a 5% increase in turbidity over 20 years (2000 to 2020)[a, b].

	ACT	NSW	Qld	SA ($m)	Vic	WA	Total[c]
Existing water treatment plant upgrades	7	130	248	101	106	22	614
Upgrades for increases in turbidity	1	11	11	3	11	4	41
Operating cost impacts	0	21	19	15	4	1	60
Total turbidity cost	8	161	278	119	122	27	715
Turbidity cost in river basins showing an increasing trend in turbidity levels	0	40	0	64	4	0	108

a Expressed in 1996/97 dollars.

b Present values were determined using a social discount rate of 5%.

c Data for Tasmania and Northern Territory are unavailable.

Table 5.8 Net present value of downstream costs of an *increase* in sedimentation from erosion over 20 years[a].

	Increase in sedimentation 5% ($m)	10% ($m)
Australian Capital Territory	0	1
New South Wales	22	34
Queensland	52	84
South Australia	1	1
Victoria	3	4
Western Australia	0	0
Total	**78**	**123**

a Expressed in 1996/97 dollars.

Present values were determined using a social discount rate of 5%.

Data for Tasmania and Northern Territory are unavailable.

5

Table 5.9 Net present value of cost increases for a 5% increase in erosion and sedimentation over 20 years (2000 to 2020)[a, b].

	ACT	NSW	Qld	SA ($m)	Vic	WA	Total[c]
Reservoirs	0	7	19	0	1	0	28
Local government, road and rail	0	11	21	0	1	0	33
Channels	–	4	13	0	0	–	18
Total erosion and sedimentation	**0**	**22**	**52**	**1**	**3**	**0**	**78**

a Expressed in 1996/97 dollars.

b Present values were determined using a social discount rate of 5%.

c Data for Tasmania and Northern Territory are unavailable.

Summary of downstream water degradation costs

Past rates of increase in water degradation are not necessarily a good indication of future increases. If the past trends in water quality degradation (as suggested in the Audit's database) are assumed to continue into the future, then it appears that relatively few catchments will experience a deterioration in water quality. But, of course, current costs associated with poor quality water, where it applies, would continue. If, on the other hand, the results of the recent Murray–Darling Basin salinity audit are more indicative of future national deteriorating water quality trends, then the costs of treatment and damage escalate dramatically. Not enough information is available at present to make projections of future water quality trends with confidence. Given the trends established for increases in areas affected by dryland salinity, a reasonable 'best bet' would be that national water quality trends could decrease by at least 5% over the next 20 years.

Modelling results indicate that for any given level of increase in water quality parameters the downstream costs associated with salinity and turbidity are expected to be much greater than the increased costs associated with increased erosion and sedimentation (Table 5.10). At high levels of increase in water quality parameters salinity imposes greater costs than turbidity but the reverse is the case at low increases in water quality parameters.

Limitations of this analysis include the exclusions of costs of deteriorating water quality on sensitive environmental ecosystems, such as wetlands and estuaries (e.g. in the Fitzroy River Basin in Queensland there is an issue with the deterioration of water quality flowing into the coastal marine environment adjacent to the Great Barrier Reef—see Chapter 7).

Table 5.10 Net present value of over 20 years of increased costs for Australia associated with assumed increases in water quality attributes[a].

Type of degradation	Assumed increase in measurements of degradation[a, b] 5% ($m)	10% ($m)
Salinity	511	1 021
Turbidity	715	814
Erosion/sedimentation	78	123
Total of parameters	**1 304**	**1 958**

a Assumes a 5% discount rate
b Expressed in 1996/97 dollars

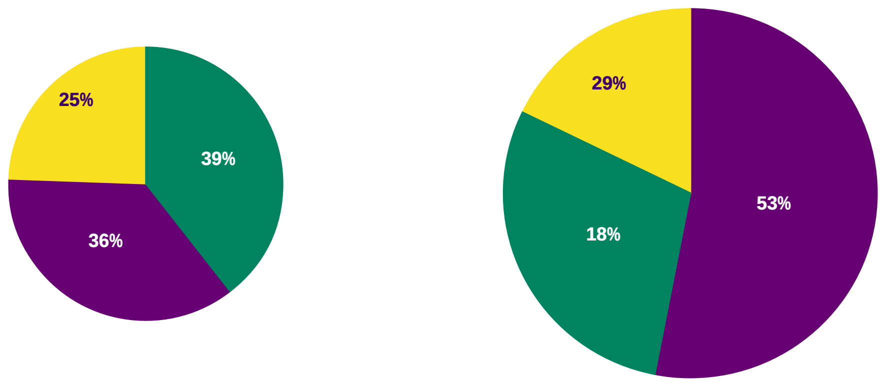
Home
Contents

SUMMING UP THE COSTS OF SALINITY

Future increases in the occurrence of dryland salinity will result in increasing costs borne not only by landholders but also by many other people. Will the cost increases be mainly incurred by agricultural industries or by other industries and communities? While a comprehensive analysis of all off-site costs was beyond the scope of the Audit, an attempt to show the relative size of future costs imposed by salinity on agriculture, local infrastructure and downstream infrastructure over the next 20 years was made (Figure 5.2).

Using the conservative but reasonable assumption of a 5% increase in water salinity 'across the board', it is likely that about two-thirds of the total increase in damage costs will be off farm. This proportion would be much higher if environmental damage was included as an off-farm cost. Furthermore, if water salinity levels were to increase by 20%, as the Murray–Darling Basin salinity audit suggests, then the proportion of increased costs borne by off-farm users would be approximately 80%.

Figure 5.2 Comparison of national salinity cost increases over the period 2000 to 2020. Net present values of increases at 5% discount rate.



5% INCREASE IN WATER SALINITY ($M)

Yield loss on farms	558
Local infrastructure costs	341
Downstream infrastructure costs	511
Total	**1 410**

10% INCREASE IN WATER SALINITY ($M)

Yield loss on farms	558
Local infrastructure costs	341
Downstream infrastructure costs	1 021
Total	**1 920**

Home
Contents

A choice modelling approach was adopted for valuation of the non-market environmental and social values that could be impacted by land and water degradation. Estimates are based on the community's willingness to pay to protect key environmental and social attributes from degradation. Choice modelling is a 'stated preference' method by which a sample of people are asked to make choices among different twenty-year outcomes associated with alternative resource management options (Box 5.3).

Choice modelling provides a way to estimate the total value of resource use change and allows this total value to be disassembled into unit values for individual attributes, known as 'implicit prices'. These implicit prices are useful for benefit transfer, where the unit values are taken from the original study and 'reassembled' to estimate the total value of resource use change at a different location. Valuation is not restricted to the set of scenarios presented in the questionnaire. Rather the costs or benefits associated with a whole range of resource use changes away from the 'business as usual' scenario can be calculated using the estimated choice model.

BOX 5.3 CHOICE MODELLING

In a choice modelling application, respondents are presented with a series of questions, each containing a set of options known as a choice set. Typically, five to eight choice sets are included in a questionnaire. In each choice set, respondents are asked to choose their preferred option from a range of alternatives. The options can be viewed as separate management policies whose outcomes are described through standard attributes. The options are differentiated from one another by the levels assigned to the attributes. An experimental design is used to ensure that the range of options presented to respondents in the choice sets is adequate.

Each choice set includes a 'business as usual' option that describes the outcomes associated with a 'no change' policy. It serves as a base against which respondents' willingness to make trade-offs in securing change can be measured. The other options are deviations from the no change policy. Choices made by respondents enable the estimation of the relationship between their choices, the levels of attributes describing choice outcomes and socioeconomic characteristics of the respondents. This model allows an estimation of the extent to which individuals are prepared to trade off one attribute against another. Provided one of the attributes is measured in dollar terms (e.g. a tax, levy or entry fee), it is possible to estimate the amount of money people are prepared to pay for improving a non-monetary attribute by one unit. This value is known as the implicit price of the attribute.

Attribute selection

Attributes for the questionnaire were selected in consultation with focus groups made up of people from a wide range of socioeconomic backgrounds. In total, seven focus group meetings were held in city and regional centres in different parts of Australia. This consultation revealed that people have five main environmental and social concerns related to land and water degradation:

- native species and ecosystem functioning;
- landscape aesthetics;
- outdoor recreation opportunities;
- productivity of the land and quality of drinking water; and
- viability of country communities.

These concerns were consistent across most of the focus groups, with differing degrees of emphasis depending on geographical location. A clear result from the initial scoping phase was that people possess both use and non-use values. Landscape aesthetics, recreation and productivity all represent use values because people benefit from interacting directly with the environment. By contrast, non-use values are reflected by the concerns expressed for native species and the viability of rural townships. Here, benefits are derived simply from the knowledge that these attributes are being maintained in a healthy state.

Based on this information, four attributes were selected for the questionnaire: *species protection*, *landscape aesthetics*, *waterway health*, and *social impact* (Table 5.11). Production-related effects of land and water degradation were omitted from the questionnaire because the purpose of the study was to estimate non-market values. The *social impact* attribute was included to 'force' respondents to consider the social dimensions of conservation policies, some of which may lead to a reduction in the viability of country communities.

Table 5.11 Attributes selected for the choice modelling application.

Attribute	Unit of measurement
Species protection	The number of native species protected from extinction
Landscape aesthetics	The area of farmland repaired or bushland protected (ha)
Waterway health	The length of waterways restored for fishing and swimming (km)
Social impact	The net loss of people from country towns each year

5

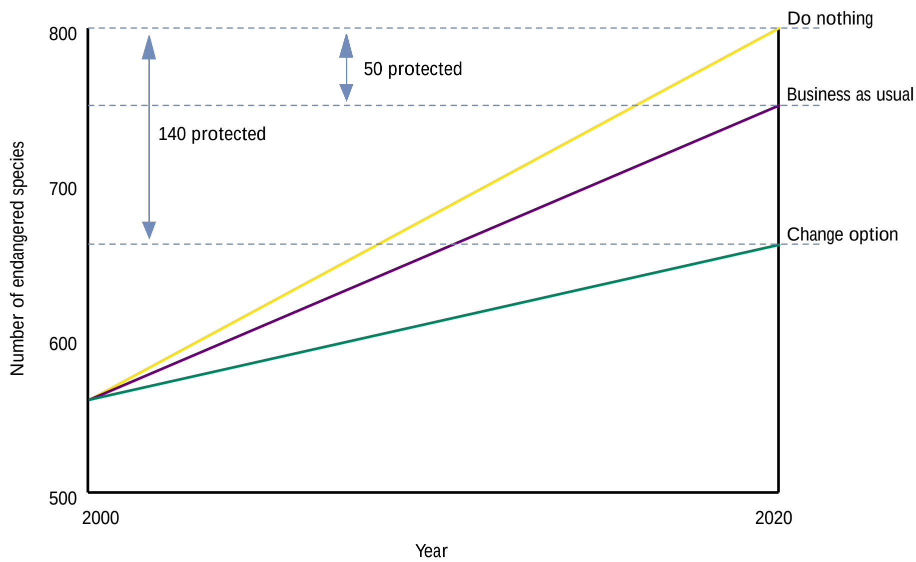
Survey application

The choice task was introduced to respondents by explaining that public money is currently being spent on a wide range of environmental projects and that this level of action would result in a specific set of outcomes in 2020 (the 'business as usual' scenario). Respondents were told that additional investment would be required to secure an improvement above this baseline, with each set of improvements presented as a 'change scenario'. Attribute levels associated with the change scenarios and 'business as usual' option were expressed relative to a benchmark, namely a 'do nothing' scenario. Under this scenario it is assumed that even the current level of remedial work is not undertaken (Figure 5.3).

An environmental levy on households was proposed as a way to fund the change scenarios. The questionnaire introduced the concept of a household levy to be paid each year for the next 20 years. A specific level of payment was associated with each choice option, being zero for the business as usual scenario and $20 to $200 for the 'change' scenarios (Figure 5.4).

It was recognised that people living in different regions may have different values for different contexts of land and water degradation, thereby limiting the extent to which value estimates can be 'transferred' from one region to the next. To understand these differences, separate choice modelling applications were carried out in Brisbane, Perth, Albany, Rockhampton and nationally, for cases of degradation involving the Fitzroy Basin Region (Queensland), the Great Southern Region (Western Australia) and the whole nation. Regional questionnaires were identical in every respect to the national version with the exception that the attribute levels were varied to reflect the conditions in each region.

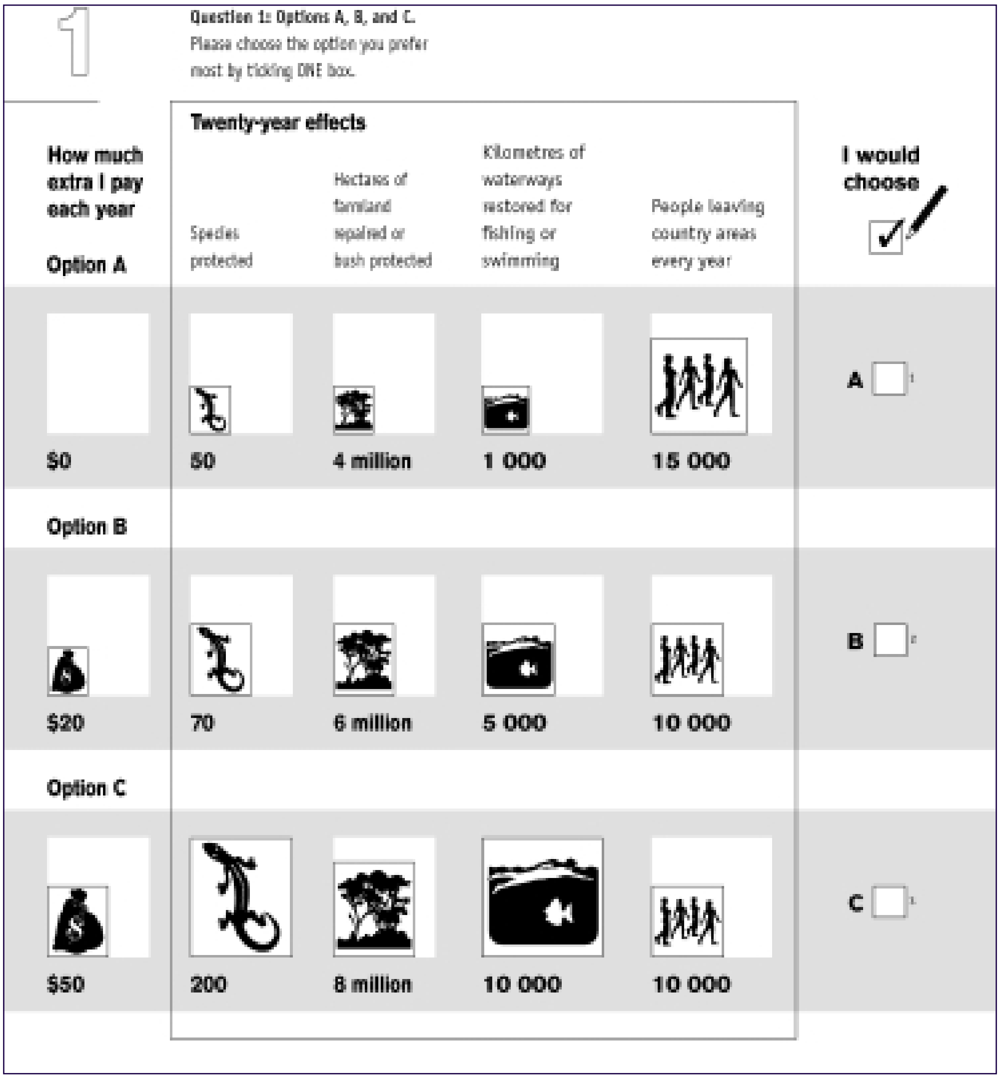
Figure 5.3 Example scenarios developed for the choice modelling questionnaire.



The questionnaires were administered as a mail-out mail-back survey. A random sample of households was drawn from 'Australia on Disk', a telephone directory database of the Australian population. The total sample was 10 800 households, with a main national sample including 3200 households and smaller samples for each case-study region (Table 5.12).

The overall response rate to the survey was 16%, which equated to 1569 completed questionnaires. This response rate is net of the questionnaires that were undeliverable due to outdated address details, which accounted for approximately 10% of mail-outs. The majority of respondents (89%) answered all five choice sets, and most of these people (80%) chose a levy option in at least one of the choice sets.

Figure 5.4 Example choice set used in choice questionnaire.



Key results

Results of the national questionnaire demonstrate that respondent households value improvements to each of the environmental attributes and perceive rural depopulation as a cost. Averaged attribute implicit prices were estimated:

- 68 cents per household each year for every additional species protected;
- 7 cents per household each year for every additional 10 000 ha of bushland protected or farmland restored;
- 8 cents per household each year for every additional 10 km of waterway restored for fishing or swimming; and
- minus 9 cents per household each year for every 10 persons leaving country communities.

The choice model also allows estimation of aggregate values for an array of potential policy options. The values represent the community's willingness to pay for improvements that are additional to the outcomes that are expected to be achieved with existing investment in environmental programs. For example, a 20-year national program involving the protection of an additional 50 species; improvement of the aesthetics of 2 million hectares of bushland and farmland; the restoration of 1500 km of waterway for swimming and fishing; and the loss of an additional 5000 people per year from rural areas, produces an estimated aggregate welfare benefit of $2.7 to $5.4 billion in present value terms, or a best-bet estimate of $3.9 billion. However, if the same environmental improvements could be achieved while reversing the decline in rural communities by 10 000 people per year, the best-bet estimate increases to $5.8 billion. These estimates assume a 5% discount rate and the extrapolation of survey results to 45% of the national population (which assumes that 35% of non-respondents hold equivalent values to respondents—an assumption backed up by a follow-up survey of non-respondents).

Table 5.12 Sample sizes of the choice modelling survey.

	Questionnaire version		
Population sample	**National**	**Great Southern**	**Fitzroy Basin**
National	3 200	–	–
Albany	1 200	1 200	–
Rockhampton	1 200	–	1 200
Perth	–	1 400	–
Brisbane	–	–	1 400

Validity of results

Critics of non-market valuation are generally sceptical about the reliability and validity of value estimates generated by stated preference surveys. This is because of the hypothetical nature of questions presented to respondents and the potential biases associated with this approach. In this study every effort was made to minimise these biases by adhering to 'state of the art' survey procedures and protocols. Importantly, the value estimates are within the realm of 'believability' when viewed in the context of people's income constraints. For instance, the estimate of $3.9 billion for improvements outlined in the scenario above is based on the finding that respondent households are willing to pay $92 per year for 20 years. This estimate is 'believable' given the many other demands on disposable income. Further discussion about the validity of results is provided in van Bueren and Bennett (2000).

Benefit transfer procedure

Implicit prices for attributes are useful for making a 'first pass' assessment of the size of non-market values associated with land and water degradation. The estimates are suitable for establishing, in monetary terms, the impacts of policies that affect major regions or the nation as a whole and that can be described using one or more of the generic attributes. The estimates can be used as an input to the five-step framework (Steps 3 and 4) outlined in Chapter 2 for assessing the net benefits of alternative policies and management options.

There are a number of steps involved in transferring value estimates from this study to evaluate policy options. A critical step is to calibrate the value estimates to ensure that they are appropriate for the policy context and the particular population affected by the change. In this study, the results from surveying different populations about their values for the two case study regions indicate that implicit price estimates are sensitive to population type and geographic context. Unit values for policies that involve regional changes were found to be significantly larger than the unit values estimated for changes in the national context (Table 5.13). The scaling factors provide a way to calibrate the national implicit prices for transfer to a regional context. A range is given for each scaling factor, reflecting the variability in results across the two case study regions (Box 5.4).

Table 5.13 Scaling factors for calibrating national value estimates to a regional context.

Attribute	National implicit prices $	Scaling factors
Species protection	0.68	x 2
Landscape aesthetics	0.07	x 20–25
Waterway health	0.08	x 20–25
Social impact	-0.09	x6–26

5

BOX 5.4 EXAMPLE APPLICATION OF NON-MARKET VALUATION

To illustrate how the results can be applied to evaluate the welfare impacts of a management policy, consider the case of a proposal to redress land and water degradation in a region in New South Wales. Under the proposal, 20 000 ha of rural land will be rehabilitated, 160 km of waterways will be restored, three additional species will be protected and 50 additional people will leave the region each year because the proposal involves lower farming intensities.

As a regional project, the implicit prices to be used in the valuation exercise will be scaled from the national estimates. Using the scaling factors in Table 5.13, the best estimate implicit prices are:

Species protection	=	0.68	x	2	=	$1.36 per species
Landscape aesthetics	=	0.07	x	20	=	$1.40 per 10 000 ha
Waterways health	=	0.08	x	20	=	$1.60 per 10 km
Social impact	=	-0.09	x	6	=	-$0.54 per 10 persons leaving rural areas per year

Given the changes in attribute levels specified, the best estimate of household willingness to pay for the policy is:

(1.36 x 3) + (1.40 x 2) + (1.60 x 16) + (-0.54 x 5) = $29.78 per household for 20 years

This value is then aggregated to the relevant household population that is expected to be affected by the policy. Suppose the relevant ‘extent of market’ includes metropolitan Sydney and proximate areas of rural New South Wales, which numbers 1.6 million households. Further, assume that 45% of these households hold values equivalent to those estimated for the respondent sample. The aggregate value estimate is then:

$29.78 x 0.45 x 1 600 000 = $21 441 600 per annum for 20 years

Where it becomes clear that the magnitude of the value estimated using this process of attribute value aggregation is critical in the assessment of a policy, a more detailed analysis may be required. That analysis in the first instance may involve a refinement of the scaling factors used, which would involve an assessment of whether the situation is closer to the Fitzroy Basin or the Great Southern case studies. Further, analysis may also involve the use of a complete choice model rather than the aggregation of attribute values (see van Bueren & Bennett 2000 for details).

REGIONAL ECONOMIC ASSESSMENT

Dryland salinity – a case study

Key points

- There are no simple and universally applicable solutions or recommended responses to dryland salinity.
- Broadscale reafforestation of recharge zones will mostly prove to be a poor investment from an economic and social perspective.
- Expectations of farm-based change leading to salinity control need to be tempered.
- A lack of profitable and technically feasible options is a major constraint on farmers' capacity to contribute to salinity control.
- Where significant public assets are at risk, other solutions such as engineering works—drainage or pumping—may need to be implemented and publicly funded.

6

Home

Contents

Home

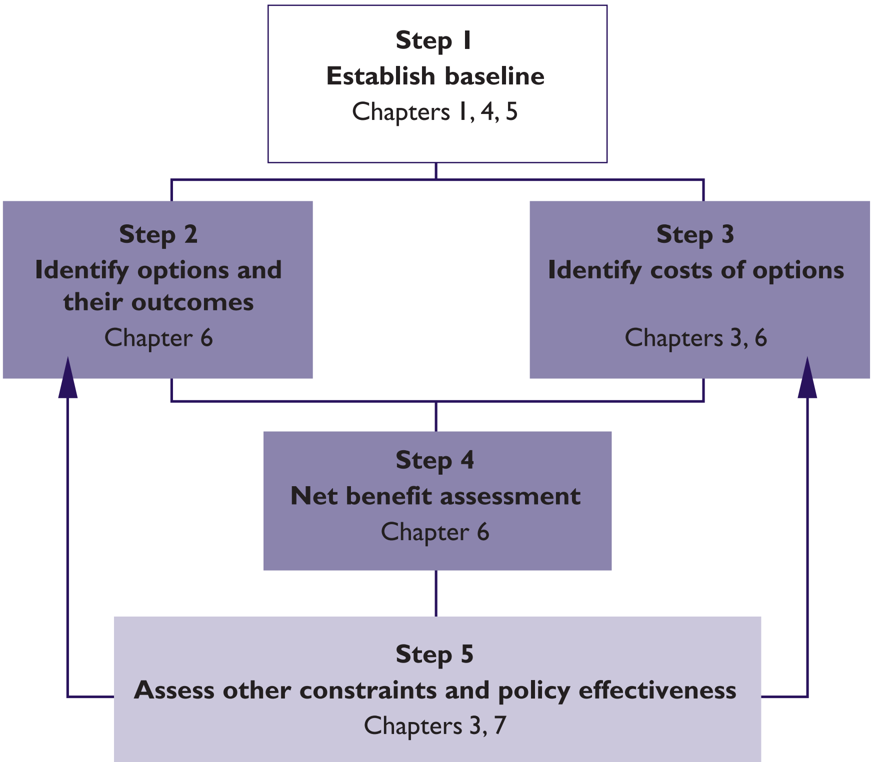
Contents

ASSESSMENT FRAMEWORK CONTEXT

As part of the Audit's report *Australian Dryland Salinity Assessment 2000* (NLWRA 2001b) four representative case study regions were chosen for detailed economic analysis of the opportunities for managing dryland salinity (Figure 6.1). They were:

- the Wanilla catchment on Eyre Peninsula in South Australia;
- Lake Warden near Esperance in Western Australia;
- Kamarooka in north central Victoria; and
- Upper Billabong near Holbrook in southern New South Wales.

The information in this chapter brings the rapid assessment framework together (Steps 2, 3 and 4 in Figure 2.6 of Chapter 2) and presents, by way of an example, benefit–cost analyses of options to address dryland salinity.

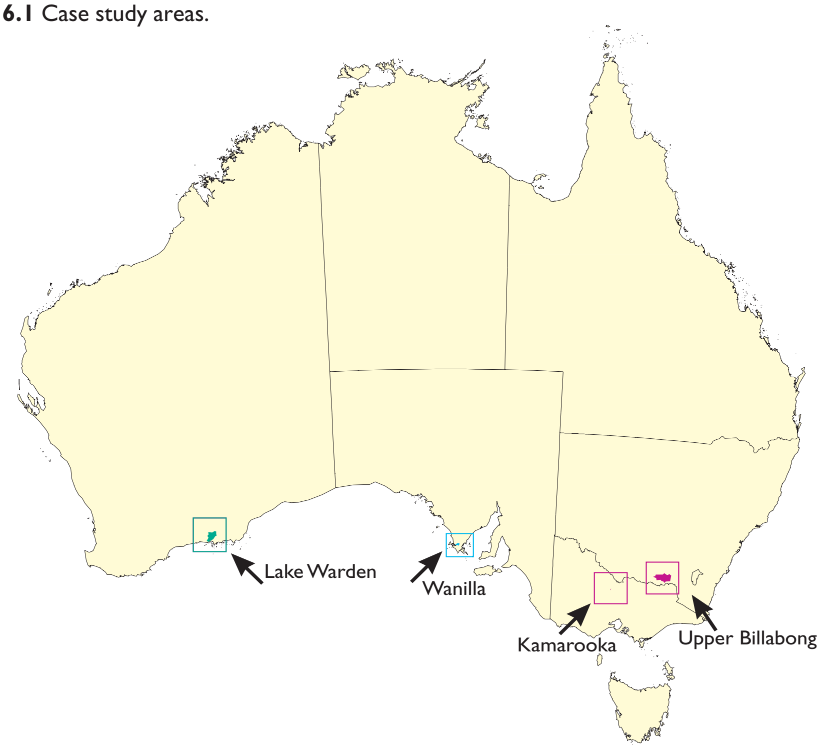


In each of the four catchment case study areas, the Bureau of Rural Sciences and CSIRO undertook detailed assessments of the groundwater systems and how they would respond to different management regimes—in particular, management regimes that would decrease groundwater recharge. This work has greatly increased our understanding of groundwater movement and how this influences the extent of dryland salinity and opportunities for mitigating measures. Groundwater flow systems were classified (Box 6.1) into three broad types:

- local;
- intermediate; and
- regional.

Changes to the landscape over the past 200 years have greatly increased the rate of recharge of surface water to groundwater systems and all three types of groundwater flow systems are slowly but surely filling up, causing the spread of dryland salinity. A result of the Audit is a greater appreciation of the slow response times of these groundwater systems. Changes to recharge in even local systems may show no apparent changes in groundwater levels in the lower parts of the catchment for periods of up to between 30 and 50 years. This period may extend to 200 years or more in the case of large regional groundwater systems. Growing trees or deep-rooted perennials on individual farms may in some cases cause a 'dent' in the groundwater profile which may result in some, very localised, beneficial response—more likely to occur in local groundwater flow systems.

Figure 6.1 Case study areas.



Source: *Australian Dryland Salinity Assessment 2000*, NLWRA (2001b).

Home
Contents

For each of the four catchment case study regions the options to reduce recharge in the upper catchments by 50%, 75% and 90% over the next 50 years were estimated. Comprehensive fieldwork in each region was undertaken to assist in key parameter estimation, assessing both the practicalities of alternative options and the capabilities of land managers to change (Read Sturgess and Associates 2001).

Social and structural adjustment trends were considered in the context of capacities of communities and land managers to change land use in a way that would contribute to salinity control (Tables 6.1, 6.2).

Table 6.1 Summary of results from case studies—qualitative.

	Kamarooka	Lake Warden	Upper Billabong	Wanilla
Substantial environmental benefits	no	yes	no	no
Substantial impacts for agriculture and rural infrastructure	yes	yes	no	yes
Substantial impacts for urban infrastructure	no	no	no	no
Substantial impacts for water users	no	no	yes	no
Availability of effective option(s) for salinity control	yes	yes	yes	no
Implementation of substantial salinity control is occurring	yes	yes	no	no

Home
Contents

Table 6.2 Summary of results from case studies—quantitative.

	Kamarooka	Lake Warden	Upper Billabong	Wanilla
Catchment area (ha)	10 000	171 000	300 000	17 000
Mean farm size (ha)	800	1 300	850	700
Present extent of severely salinised catchment (%)	7	8	0.1	8
Projected extent (2050) of severely salinised catchment without control (%)	7	> 45	1.1	15
Present impact of salinity ($/yr)	50 000	1 400 000	40 000	300 000
Projected impacts from salinity over next 50 years without control (NPV) ($)	900 000	probably > 200 000 000	3 700 000	8 400 000
Agricultural share of impacts (%)	85	43	80	95
Environmental share of impacts (%)	not significant	42	not significant	not significant
Roads, rural, urban share of impacts (%)	2	15	6	5
Water users share of impacts (%)	10	nil	14	nil
Net economic benefit over next 50 years from implementing 50% reduction in recharge (NPV $ million)	0.6	44	na	na
Net economic benefit over next 50 years from implementing 75% reduction in recharge (NPV $ million)	na	-65	na	na
Net economic benefit over next 50 years from implementing 90% reduction in recharge (NPV $ million)	-0.4	-251	na	-27

BOX 6.1 GROUNDWATER, THE KEY TO UNDERSTANDING DRYLAND SALINITY

The process of salinisation is now well known, but differs across Australia according to different groundwater flow systems. The removal of deep-rooted trees or other vegetation in the elevated recharge areas of a catchment increases the rate of recharge into the groundwater. Consequently, the groundwater level rises in the catchment and in the lower areas comes close to or reaches the surface. During this process, salts in the soil are mobilised and rise to the surface causing salinity. Across large areas of Australia these groundwater aquifers are slowly but surely filling up, causing the spread of dryland salinity. Only recently has the length of time taken for ground water to flow through the subsurface rock or sediment substrate been appreciated. This depends on the nature of the groundwater flow system. A classification system that categorises groundwater flow systems into local, intermediate and regional was developed as part of *Australian Dryland Salinity Assessment 2000* (see NLWRA 2001b, p. 48 for details). Each is further classified into four subcategories based on underlying geological structures.

Local groundwater flow systems are fully contained within small catchments; the area contributing to groundwater discharge is readily identifiable; and the number of landholders who must adopt alternative management practices if salinity is to be controlled is relatively small. Local systems afford some opportunities for dryland salinity mitigation through the application of land management practices.

Intermediate groundwater flow systems operate within much larger catchments than local systems and afford much greater challenges for farm-based catchment management programs aimed at dryland salinity mitigation. Engineering options such as pumping and drainage, and 'living with salt' options are important in dryland salinity management in these systems.

Regional groundwater flow systems are the most difficult of all to manage using farm management. They occur on a scale that is so large as to make farm-based catchment management options impractical and dryland salinity mitigation under these circumstances will involve selective engineering measures to protect high value assets and infrastructure, together with adopting 'living with salt' strategies.

6

Wanilla catchment—South Australia

The Wanilla catchment is a small basin of about 17 000 ha. The groundwater flow system is local to intermediate in deeply weathered rock. Groundwater discharge occurs at the break of slope and valley floors. There are 25 farms in the catchment and the average farm area is around 700 ha. It is estimated that farm numbers in the catchment declined by about 50% in the decade to 1996. Eighty-six percent of the catchment is cleared, with the remainder mainly being remnant vegetation. Broadacre cropping and sheep are the main farming enterprises.

Approximately 8% of the catchment is severely salinised. This land is located mainly adjacent to natural drainage lines. On the basis of a water balance model developed for the catchment, estimates are that under a 'business as usual' scenario, the extent of dryland salinity will increase to 15% by 2020 and to nearly 17% of the catchment over the next 50 years (Figure 6.2; Tables 6.1, 6.2).

The total net profit (gross margin) from agriculture in the catchment is estimated at $2.3 million per year. This would be increased by 12% or $300 000 if no salinity was present. Thus, $300 000 represents the current value of yield loss. Based on current prices, the value of yield loss is estimated to increase to $620 000 a year by 2050. This also represents the maximum agricultural or 'on-site' benefit from salinity control. Over the next 50 years, assuming a 5% social discount rate, the net present value of the maximum potential benefits of eliminating salinity would be $8.4 million in additional net farm income. In the Wanilla catchment the downstream or off-site effects are thought to be small (e.g.. eliminating salinity is estimated to save only $.04 million in road maintenance costs). Water quality is not a critical issue for the catchment.

A 50% reduction in recharge in the catchment would mean that the extent of salinity would increase to about 13% of the area of the catchment over the next 50 years compared with nearly 17% under a 'business as usual' scenario and 8% at present. The 50% reduction in recharge could be achieved by replacing all current farmland with trees in the upper catchment and replacing all annual pastures with lucerne in the lower catchment areas. This would amount to abandoning all agricultural production in the upper catchment regions (40% of the catchment). Furthermore, soil types mean that lucerne is unlikely to be a suitable enterprise for most farms in Wanilla.

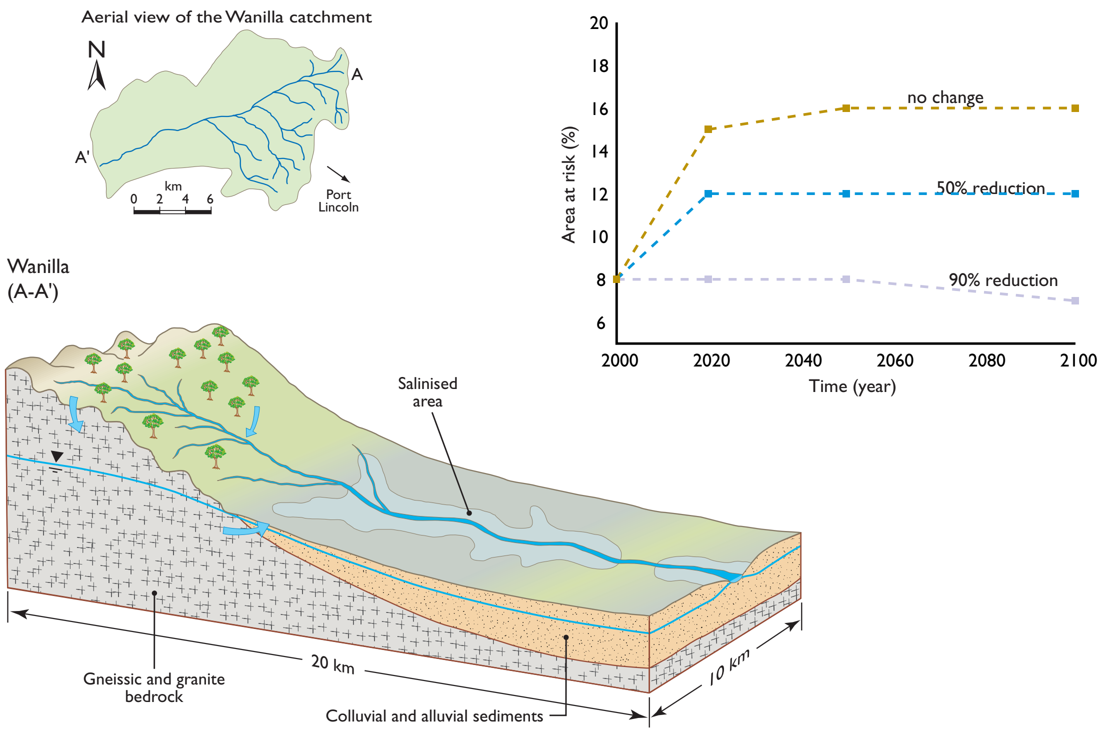
Even using optimistic assumptions regarding lucerne yields and returns for firewood from woodlots and assuming a 5% discount rate, it is estimated that achieving a 50% reduction in recharge would result in a net loss in net present value of $13 million in farm profits compared with a 'business as usual' scenario. Under more pessimistic yield assumptions for woodlots and lucerne, this loss increases to $40 million.

Farmers in this catchment do not have high farm incomes and would, in general, have substantial difficulty in funding significant changes in land use to control salinity (Barr 2001). The lucerne planting option is untested and unlikely to be adopted given the soil conditions. Catchment-wide tree planting would substantially lower farm incomes compared with a 'business as usual' scenario. Overall, catchment-scale changes to vegetation cover to control salinity are clearly not within the capacity of existing landholders.

Conclusions

- Any catchment-wide treatment involving extensive tree planting in the upper catchment would virtually eliminate agricultural production in those areas and result in substantial net losses compared with a 'business as usual' scenario.
- On the basis of current technology there are no cost-effective measures that could be implemented in the catchment to control dryland salinity.
- Landholders will have to 'live with salt' and this is likely to increase in extent and reduce their incomes by a maximum of 18%. Land is only one input to production and landowners will undoubtedly adapt to increased salinity in a variety of ways including changes in enterprises and other investments—indeed as they have adapted to a wide variety of influences including climate variability and the declining terms of trade in the past.
- From the public viewpoint, there are few compelling reasons to invest public funding in landscape change in Wanilla. There are no significant off-site impacts as the saline water in the river flows into the sea, with minimal if any external effects on downstream biodiversity. Salinity is projected to spread on already cleared agricultural land.

Figure 6.2 Wanilla catchment and recharge modelling results.



Kamarooka catchment—Victoria

This catchment has an area of 10 000 ha and is situated on the northern slopes of the Great Divide in north central Victoria, just north of Bendigo. Discharge occurs mainly on farmland along the 'break of slope'. The catchment is situated on a local groundwater flow system in deeply weathered rock (Figure 6.3). This means that there are likely to be some opportunities to address salinity within a reasonable time scale. Indeed, the catchment has been the focus of intensive extension projects and research as well as grants to landholders, with the result that a substantial amount of salinity control on farms is practised. Farmers have been encouraged to grow lucerne for salinity control and, at present, about 20% of pastures contain lucerne in most seasons. Average farm size in the catchment is about 800 ha and the area has 13 farms. On average, around 30% of farm area is cropped each year. Farming is based on traditional sheep–wheat and grazing enterprises. Farm incomes in this region are relatively low and it is likely that they are supplemented in most cases by off-farm income (Figure 6.3; Table 6.1, 6.2).

Dryland salinity affects about 7% of this catchment and appears to have stabilised even without further management of the problem (i.e. the water balance in the groundwater system appears to have reached equilibrium). The estimated value of the yield gap due to salinity is only $50 000 per year through minor losses in agricultural yield. Over the next 50 years this would give a net present value of losses of $900 000. It is estimated that about 87% of the impacts of salinity are related to loss of agricultural incomes. There is only a small impact on water quality and rural infrastructure—11% and 2% respectively. The catchment is extensively cleared so that there are virtually no losses of native vegetation or biodiversity directly due to salinity.

A 50% reduction in recharge in the upper parts of the catchment would result in a 50% reduction in the area of land affected by dryland salinity over the next 20 years: and a further reduction to 2% of the catchment within 100 years. A 50% reduction in recharge could be achieved by replacing all annual pastures with lucerne in the pasture phase of crop rotations. Benefit–cost analysis of this option indicates that if adopted by farmers, their net farm incomes would increase by about 40% relative to the 'business as usual' scenario. That is, it would be highly profitable for farmers to adopt this option of including lucerne in crop rotations. Overall, the net economic benefit from this option would be a net present value of $0.6 million.

Approximately 20% of pastures in the catchment are lucerne although a common view among landholders was that radical changes to farming systems would be required to incorporate lucerne and many indicated that they would not be expanding their lucerne production even though they recognised the benefits of lucerne for salinity control. Farmers placed high value on flexibility in farming systems so that they can respond to commodity prices. The establishment of lucerne reduced that flexibility.

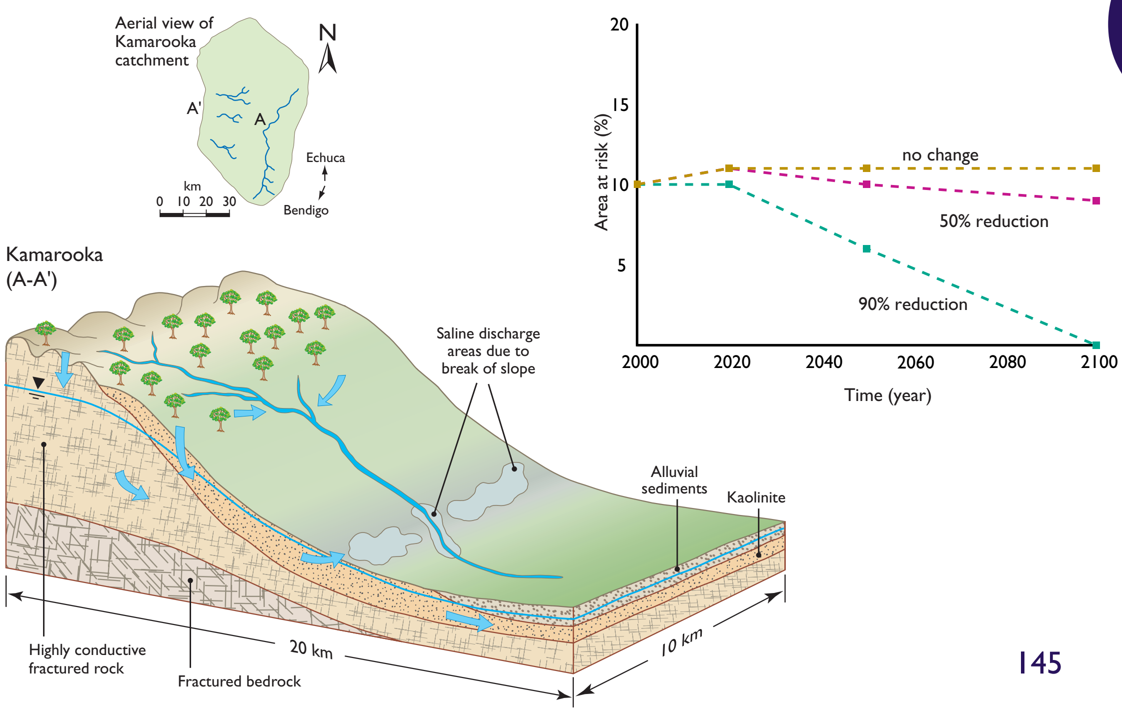
Lucerne has been promoted as a farming enterprise for many years and the area sown to lucerne was steadily increasing up until 1991, at which time the area of lucerne was about 7.6% of farmland. But over the next five years to 1996 little increase occurred—those actively taking up lucerne growing were matched by previous lucerne farmers returning to traditional cropping rotations. During this period some farmers were responding to buoyant cereal prices and growing more cereals while others were introducing lucerne into rotations. With better returns to livestock prices, mainly since 1996, some further steady increases in areas under lucerne have occurred. Past activities show that farmers are responding to market forces and will change farming enterprises according to commodity prices and relative profitability regardless of salinity impacts.

A 70% reduction in the area of land affected by dryland salinity could be achieved within 20 years, and complete elimination within 100 years by reducing recharge by 90% in those parts of the catchment above the break of slope. This would require tree plantings on 80% of the recharge areas in the catchment. Benefit–cost analysis of this option revealed that it would result in a 30% drop in net farm income amounting to a loss in net present value of profits from farming of $0.4 million over 50 years.

Conclusions

- Salinity is not a major issue in the catchment and appears to have stabilised with current land use practices.
- Significant reductions in salinity could be achieved by the widespread adoption of including lucerne in crop rotations. Lucerne grows well in the area.
- While some farmers have adopted this practice others consider it to be too radical a change to their current farming systems, and have indicated that they are unlikely to adopt this practice. Including lucerne reduces flexibility in farming systems and the ability to profit from changing commodity prices.
- The eventual complete elimination of salinity in the catchment by extensive tree planting over 80% of the recharge area would not be cost-effective.
- Only minor 'off-site' effects of salinity occur in this catchment.

Figure 6.3 Kamarooka catchment and recharge modelling results.



6

Upper Billabong Creek catchment—New South Wales

This catchment is located near Holbrook in southern New South Wales in the Murray–Darling Basin. It was originally chosen as a case study area because it was located upstream of a gauging station that was showing rapidly increasing water salinity levels. It is also in a high rainfall area providing some opportunity for introducing plantation softwood forestry as a way to reduce recharge and controlling salinity. The groundwater flow systems are local and intermediate in variably weathered fractured rocks connected to a regional flow system in alluvial aquifers. The catchment has an area of around 300 000 ha with average farm size being around 850 ha. There are about 350 farms in the catchment.

Tree clearing started about 150 years ago with most clearing occurring prior to 1900. Dryland salinity is only a very minor problem, affecting less than 1% or 140 ha of the catchment. Even without any measures to control salinity, the extent of dryland salinity is expected to expand to only about 1% of the catchment area over the next 50 years (Figure 6.4; Tables 6.1, 6.2).

Impacts of salinity are not great enough to warrant implementation of any specific salinity control measures. This catchment is significant in that the small amount of existing salinity does have a small impact on water quality in the catchment. It is estimated that 78% of the projected impact costs of salinity, albeit small impacts, arise through the adverse impacts on water quality. This, taken in isolation, is of no real consequence. But there are a large number of catchments similar to this one, in the Murray–Darling Basin. Collectively each small impact on water quality adds up to rising salinity in our major rivers.

The present in-stream salt load from the catchment is estimated to be 310 tonnes of salt each year. This is estimated to increase the salinity content of water downstream at Morgan by 0.085 EC at a cost to downstream water users of about $13 000 per annum, based on marginal cost functions (see Chapter 5).

Yield losses from dryland salinity are valued at about $22 500 per year and impacts on roads are estimated at $2000 a year. These are quite small costs relative to agricultural incomes earned in the catchment.

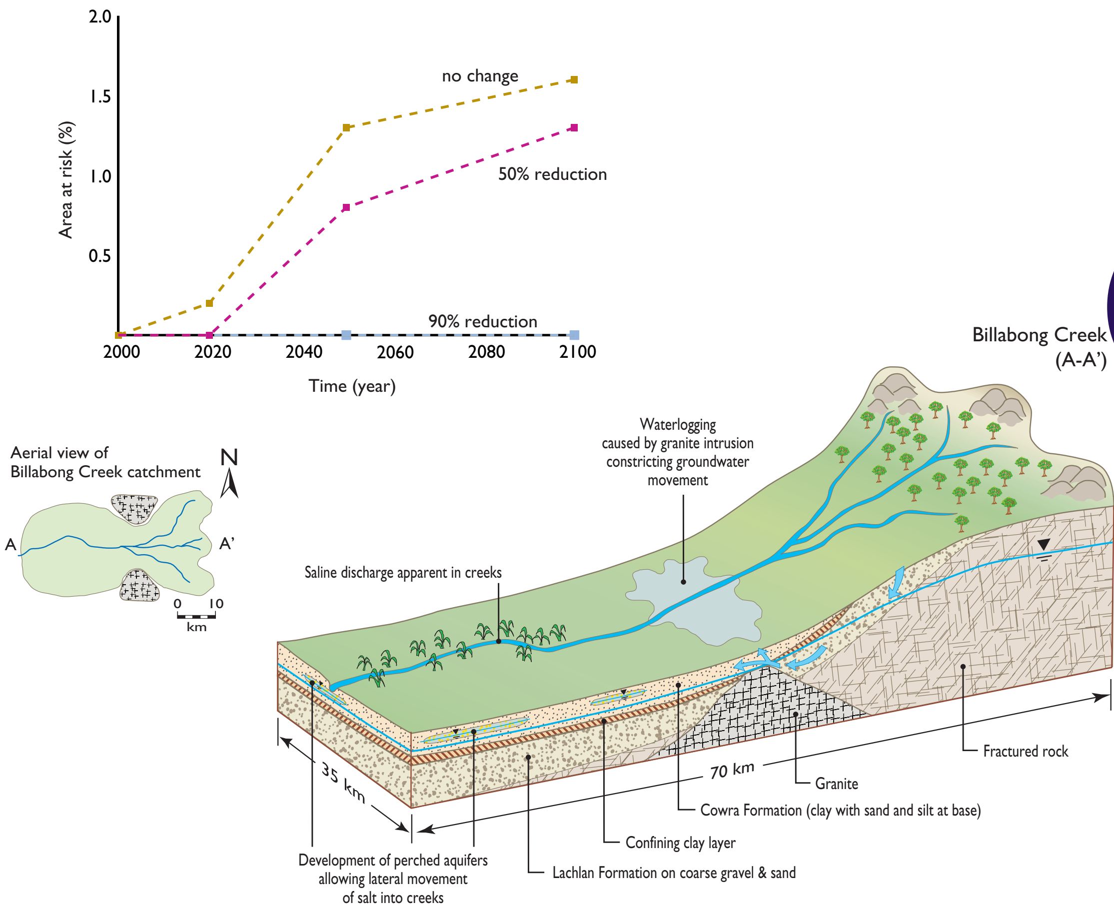
Rainfall varies significantly across the catchment and economic analysis of tree planting indicates that most landholders would face reductions in income if this measure was adopted. But some landholders with higher rainfall in the upper catchment could achieve increases in income over the longer term with tree planting. Given that benefits from tree planting or other measures would primarily eliminate salinisation for only about 1% of the catchment area, there is no great incentive for landholders in the catchment to adopt radical and extensive land use changes. However, in the high rainfall regions, tree planting may be considered for its own sake, as a commercial crop.

Home
Contents

Conclusions

- Detailed study of this type of catchment can avoid the costly implementation of ‘works on the ground’, tree planting schemes or other control measures which are unprofitable, in the mistaken belief that a serious salinity problem exists.
- From a community and economic perspective it would not be logical to take large areas of land out of agricultural production and plant with trees just to protect 1% of the catchment.
- Solutions to the level of in-stream salinity leaving this catchment will not be found by persuading farmers to take up unprofitable salinity control measures.

Figure 6.4 Upper Billabong catchment and recharge modelling results.



6

Home
Contents

Lake Warden—Western Australia

This catchment is near Esperance in Western Australia and mainly has a regional groundwater flow system in alluvial sediments with low to moderate ability to move groundwater. Some of the local groundwater flow systems are located on top of the regional systems, and, in some cases, the two systems appear to be connected. The key feature of this catchment is that salinity is expanding quite rapidly (Figure 6.5; Tables 6.1, 6.2).

Lake Warden catchment has about 130 farms with an average farm size of 1300 ha. Farms are, therefore, larger than average Australian farms. A small number of quite large farms account for most of the agricultural land area and agricultural production. The predominantly mallee scrub was cleared in the 1960s and 1970s and secondary salinity has developed relatively quickly as a result, reflecting the influence of the local groundwater flow systems. About 8% is salinised—2% on agricultural land and 6% around wetlands and other low-lying water bodies. Approximately 7.5% or 12 500 ha of cleared agricultural land in the catchment is affected by dryland salinity.

Under a ‘business as usual’ scenario, the part of the catchment that is both agricultural and severely salinised will rise to 27% by 2020 and 45% by 2050. If current land use is maintained, watertables will reach the surface in most of the lower parts of the catchment within 40 years. This is one catchment where salinity is expanding quite rapidly and farmers are aware of and concerned about this prospect.

The catchment is significant because it contains a series of diverse and internationally recognised lakes and wetlands that come under the Ramsar Convention. The Western Australia Government has already given high priority to the rehabilitation and protection of these wetlands that are at risk from increasing salinisation. Lake Warden has been declared a Biodiversity Recovery Catchment under Western Australia’s State Salinity Action Plan.

It is estimated that the net value of lost agricultural production as a result of dryland salinity across all farms in the catchment is about $0.7 million a year or about $20 000 per affected farm. Taking account of other ‘off-site’ effects, the total impact costs of salinity are estimated at approximately $1.4 million a year. Total impact costs are made up of:

- costs to agriculture in lost production (value of yield gap)—43%
- costs to rural infrastructure—15%
- estimated environmental damage costs—42%.

Under a ‘business as usual’ scenario it is estimated that, given the projected substantial increases in areas of land affected by dryland salinity, the net present value of yield losses over the next 50 years would amount to $110 million at a 5% social discount rate. Only relatively minor additional impacts on roads and railways were estimated. Major environmental damage, especially to the wetlands, would occur.

Benefit–cost analyses were undertaken for three scenarios—50%, 75% and 90% reductions in recharge.

A 50% reduction in recharge could be achieved by replacing all annual pastures with kikuyu and replacing 50% of cropped land with perennial kikuyu grass pastures. This option would delay the spread of salinity so that by 2050, 33%

rather than 45% of the catchment would be affected by salinity. It is estimated that this change in land use would slightly improve farm incomes relative to the 'business as usual' scenario. Adverse environmental impacts on the wetlands would remain high and engineering options may need to be considered.

A 75% reduction in recharge could be achieved by replacing all annual pastures with kikuyu, two-thirds of crop lands with trees and the remaining one-third of crop land with a rotation based on phased farming with lucerne. By 2050 this would mean that only 7% of the catchment would be affected by salinity. This change would be very radical and would lower farm incomes by 25%; equal to a net present value loss of $65 million. There would be large environmental benefits compared with a 'business as usual' scenario, and the saving on road and rail damage would be $10 million net present value.

A 90% reduction in recharge could be achieved by replacing all annual pastures and 90% of cropped land with trees. This option would lead to stabilisation of the area of salinisation on present agricultural lands at 4% to 5% of the catchment by 2020. Farm incomes would be almost eliminated representing a net present value loss of about $250 million. This option would result in substantial environmental benefits from protection of the wetlands but they would need to be in excess of $250 million to be economic. Social disruptions to communities also need to be considered.

Figure 6.5 Lake Warden catchment and recharge modelling results.

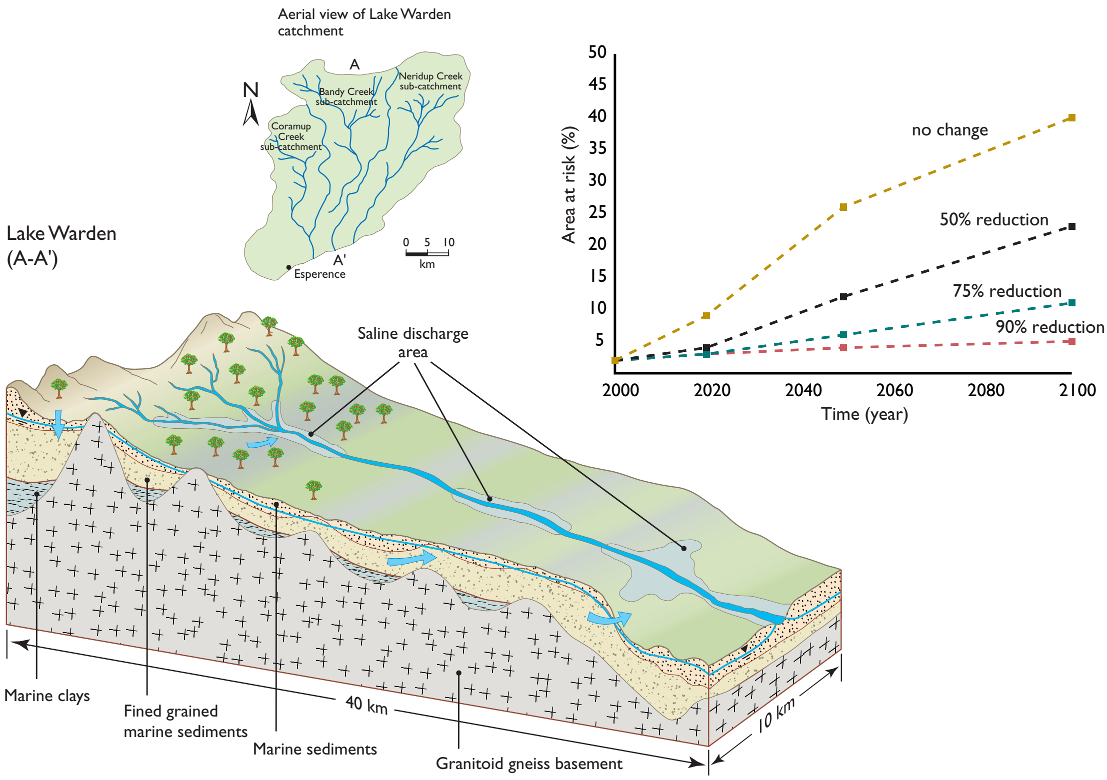


Table 6.3 Benefits and costs of various reductions in recharge to 2050 for Lake Warden catchment.

Options	Reduction in recharge		
	50% Replace all annual pastures and 50% of crop land with kikuyu	**75%** All pastures replaced with kikuyu, two thirds with trees and the remaining crop land phase farming with lucerne	**90%** All annual pastures and 90% of crop land replaced with trees
Change in farmers incomes (NVP) compared with business as usual	Marginally profitable	Loss of $65 million over 50 years	Incomes almost eliminated—net loss of $250 million
Extent of catchment affected by salinity by 2050	33%	7%	4%
Environmental effects compared with business as usual	Few benefits but buys time	Substantial reduction of adverse effects on wetlands	Net present value of benefits from saving species of $40 million to $100 million—major benefits to wetlands

Assessment of the consequences of these catchment-wide options indicate significant trade-offs between losses of income from farming and environmental gains. Landholders in the catchment are individually pursuing some control measures on their farms especially those on local ground water flow systems. These include planting kikuyu and in some cases oil mallee.

Significant structural adjustment has already occurred in the catchment, driven largely by declining terms of trade and other macro-economic changes. Over the next few decades, farmers in the catchment will experience significant additional adjustment pressures through rising groundwater levels.

Conclusions

- A 50% reduction in recharge is within the capacity of the farming community, through more extensive use of kikuyu grass, a deep rooted perennial.
- This option will only 'buy time'—a substantial salinity problem will still remain, and this option will make little difference to the growing adverse effects of salinity on the wetlands.
- Some drainage, pumping or other engineering options may be the only option to protect the wetlands. This is beyond the capacity of the farming community to adopt alone.

LESSONS FROM THE FOUR CASE STUDIES ON DRYLAND SALINITY

Results from the case studies highlight important information on managing dryland salinity. They enable a clearer understanding that managing dryland salinity is much wider than landholders just adopting recommended sustainable farming practices. The extent of externalities involved means that the management of dryland salinity requires a whole of community approach with each sector, including the farming sector, having an important role to play in finding and implementing solutions.

Key messages

There are no simple and universally applicable solutions or recommended responses.

Each of the four case studies represents a unique situation and no doubt many other catchments have different and special circumstances. The results highlight the dangers of imposing common strategies to address dryland salinity across all catchments or even transferring what may work in one catchment to others without very careful consideration of the unique characteristics of each catchment.

Circumstances in each catchment must be thoroughly examined and options to control salinity carefully investigated before any costly control measures are implemented.

Broadscale reafforestation of recharge zones will mostly prove to be a poor investment from an economic and social perspective.

Results of economic modelling of alternative control actions for the case studies clearly indicate that broadscale tree planting in the upper catchments would substantially reduce land holder incomes and lead to major social disruption of communities—a case of the cure being worse than the disease. Most salinised catchments across Australia are not well suited to commercial tree growing because of insufficient rainfall. Vast areas of the upper catchments need to be planted to make any significant difference and the beneficial effects of tree planting on salinity in the lower part of catchments are unlikely to be apparent for many years—in several cases, well beyond the lifetime of current landholders.

Furthermore, large-scale tree planting in the upper part of catchments may reduce surface run-off and may worsen salinity in rivers and streams in the short to medium term. Farm-based control measures are unlikely to be effective on intermediate or regional groundwater flow systems and these make up over 50% of projected area 'at risk' from salinity (Table 6.4).

Exceptions occur where only a relatively small portion of the catchment requires revegetation and/or where substantial off-site benefits would be achieved.

Table 6.4 Projected area of land in Australia 'at risk' from salinity in 2050, by groundwater system.

Groundwater system	Area at risk from salinity 2050 (million ha)	Proportion of total area of salinity risk (%)
Local	7.8	43
Intermediate	5.3	29
Regional	5.1	28
Total	**18.2**	**100**

6

Expectations of farm-based change leading to salinity control need to be tempered.

Relying solely on farmers to implement farming practices that will control salinity and achieve socially acceptable results may be expecting too much. Modelling work in the four case studies indicates that the level of adoption of salinity control measures such as planting deep-rooted perennials or trees needs to be very high to have any effect on salinity.

Not all farmers will adopt even profitable practices and very few will adopt unprofitable practices. Adoption rates of farming practices that are beneficial for salinity control have been shown to be low where:

- practices are unprofitable—a lack of motivation;
- practices are untested and their effectiveness in controlling salinity is in doubt;
- farmers lack the capacity to adopt new regimes either through lack of knowledge or lack of financial capacity;
- practices are profitable but farmers lack motivation because the scale of change required is incompatible with existing farming systems or their flexibility and profit-making capacity are reduced; and
- farmers do not see salinity as a significant problem for them or their catchment.

A lack of profitable and technically feasible options is a major constraint on farmers' capacity to contribute to salinity control.

Most Australian farmland is unsuitable for the commercial production of trees. A few exceptions occur in Western Australia and the higher rainfall areas. Deep-rooted perennial pastures are an option in some catchments but adoption is limited because they significantly reduce flexibility in overall farming systems.

Without new farming systems that offer both reduced leakage and improved profitability and flexibility, the scope for major changes in farming systems sufficient to make a significant difference to lowering watertables is limited.

This provides some incentives for researchers to find better options. In catchments like Kamarooka, it appears that improved farming practices may have halted the spread of salinity but in other cases, a lack of profitable options will mean that farmers may have to learn to 'live with salt' and concentrate on productivity improvements elsewhere. Living with salt may mean better use of salt-tolerant species.

Where significant public assets are at risk, other solutions such as engineering works—drainage or pumping—may need to be implemented and publicly funded.

Some large-scale strategies are profitable (Thomas & Williamson 2001) but detailed analyses of particular situations should be carried out before public funds are committed. The analyses of benefits should include the restoration or prevention of damage to natural assets of particular value, biodiversity and other non-tangible attributes.

BUILDING REGIONAL CAPACITY FOR CHANGE

Lessons from case studies

Benefits of group action

Most of Australia's land resources are ultimately controlled and managed by individual farmers or land managers. Their actions have a major bearing on the state of the natural resources on their properties as well as those off farm such as the health of rivers and streams, wetlands, estuaries, biodiversity, native vegetation and other natural resources. If improvements are to be made to the state of our natural resources, changes will need to be made, at the individual farm level, to the way resources are managed.

A key element of change by individual land managers is recognition of the nature and extent of the problems, knowledge and understanding of the underlying causes and an acceptance that there are practical options which if adopted will address the problems. Land managers acting individually with different time frames and levels of understanding of key regional problems are much less effective than regional communities addressing key issues in a coordinated manner though regional strategic planning and management processes. The case studies have demonstrated the benefits of forming partnerships and coordinated approaches through regional strategic planning processes and in the case of the dairy industry, how commodity-based approaches can be part of the delivery of improved natural resources management.

Setting realistic goals

Regional strategic planning and management processes need to set realistic goals that are achievable yet challenge the resources and processes of the region. Objectives and targets need to be specific and easily understood (e.g. setting specific targets for reductions in nutrients or sediment levels in rivers may be useful for scientists or experts but could be better translated into practical measures that landowners can understand such as length of riparian areas revegetated or proportion of farmers adopting effective means of limiting run-off into streams).

Central to any regional planning and management that addresses key natural resource degradation issues are information on the extent, condition, trend and nature of natural resources; an understanding of the causes of any impacts; and information on the effectiveness, benefits and costs of options to address the degradation.

Regional planning processes must have accurate, scientifically based information to report progress and changes as management activities take effect. The planning process should include efforts to get all stakeholders to fully understand the regional natural resource issues and their consequences. This is akin to getting wide understanding of the problem definition and 'baseline' for the future or what will happen under a 'business as usual' scenario (see Chapter 2, Figure 2.5). The datasets and information compiled by the Audit can be highly informative. They need to be 'translated' to provide regional perspectives and to be supplemented with regional studies.

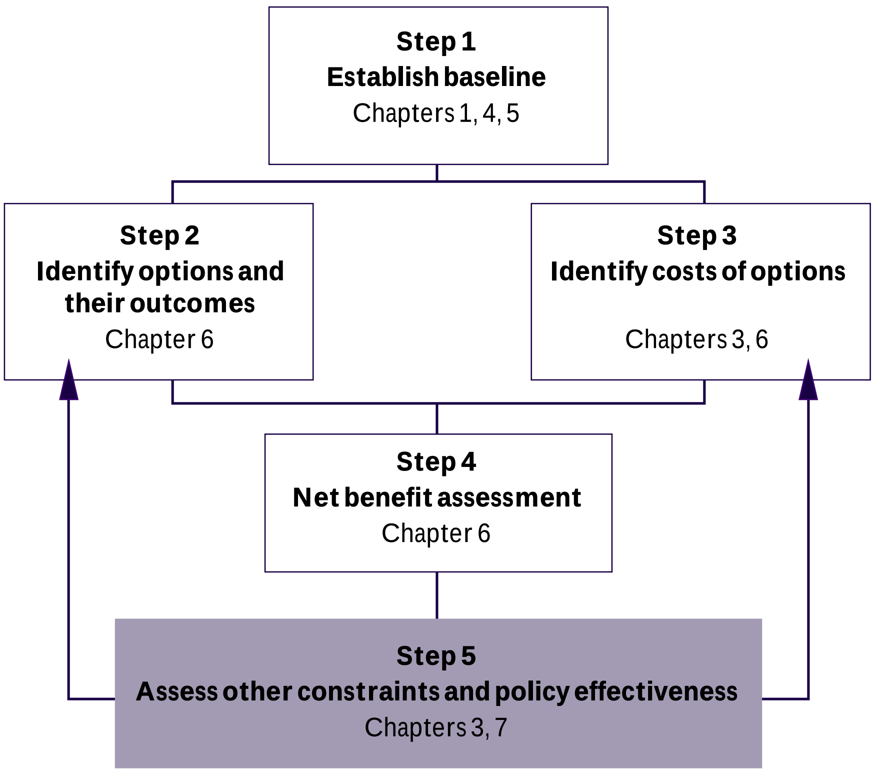
Gains beyond 'no regrets' options

The severity of many regional natural resource degradation issues will often require measures that go well beyond the adoption of relatively simple and inexpensive 'best management practices'. Such 'no regrets' options can be useful and should in most cases be implemented at an early stage as a demonstration of actions being taken and to boost community confidence. But such actions will not always be sufficient to address the extent of problems being faced. At a certain point, trade-offs will need to be made in a community context. Trade-offs may be at several levels. On individual farms, beyond the adoption of best management practices, farmers may need to make trade-offs between pursuing particular beneficial environmental outcomes, and striving for greater profitability. At a community level, trade-offs may be needed between spending community funds on certain engineering options to address environmental problems, for example, and spending those funds on other community projects. Such trade-offs need careful assessment as to their economic and social consequences and should be evaluated in a benefit–cost framework as outlined under Steps 2, 3 and 4 in Figure 2.5 of Chapter 2. Frequently, these trade-offs require hard decisions.

ASSESSMENT FRAMEWORK CONTEXT

In many cases, damage to natural resources has occurred out of ignorance of degradation processes and a failure to adequately assess change in degradation, plan for the amelioration or prevention of the degradation, implement plans and monitor changing resource conditions. Such changes in the physical condition of natural resources are often taking place very gradually, over extended periods until an 'over the cliff' state is reached where damage becomes readily apparent and serious.

Australia-wide data sets collated by the Audit provide a wealth of information that can be accessed by regional planners in developing strategies and action plans to manage natural resources sustainability while providing for regional, economic and social development.



7

The case studies described in this chapter illustrate how regions and, in one case, a regionally focused but national industry—the dairy industry—can develop strategic and action plans for sustainable development based on regional and Audit information.

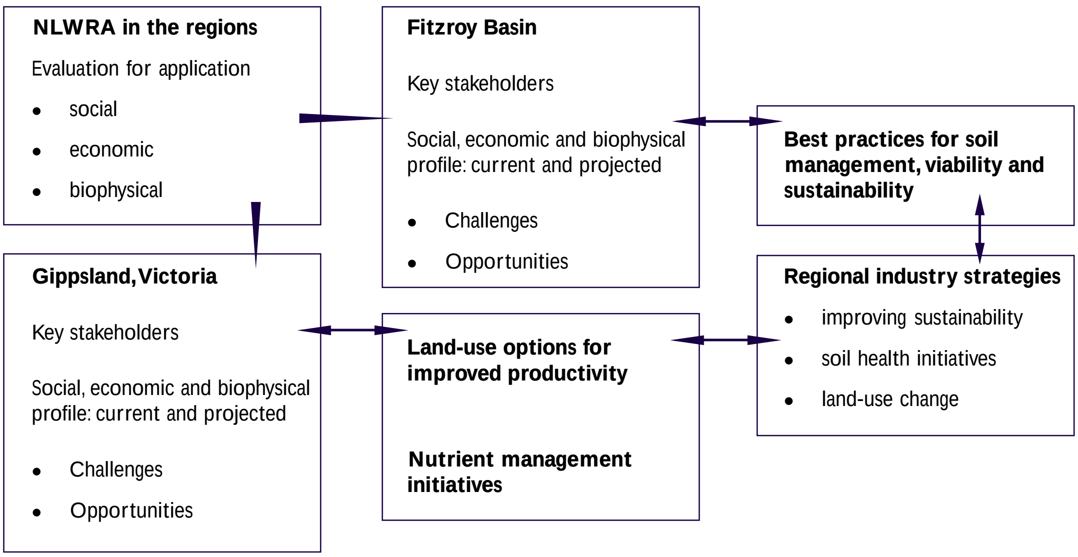
- Case Study 1 focuses on Gippsland in Victoria where a particular problem is nutrient run off into the Gippsland Lakes.
- Case Study 2 is the Fitzroy Basin in Central Queensland. Here the key issue is the reduction in the amount of sediment and nutrients exported off farm and impacting on rivers and estuaries and near-shore coastal waters of the Great Barrier Reef.
- Case Study 3 focuses on the dairy industry, which faces a range of environmental issues, of varying importance in differing regions. The dairy industry through the Australian Dairy Farmers Federation is taking a proactive industry-led approach to natural resource management, gaining understanding of the key issues and developing strategies and action plans to deliver continuous improvement in on-farm practice.

Case Studies 1 and 2 were known and referred to as the *Signposts* project.

INFORMATION SUPPORTING REGIONAL PLANNING AND DEVELOPMENT

The Audit's *Signposts for Australian Agriculture* project together with its earlier 'Implementation' project were designed to integrate Audit data with regional information as the basis for identifying regional profiles and problems, strategic opportunities and devising regional action plans (Figure 7.1).

Figure 7.1 The Audit's *Signposts* project.



7

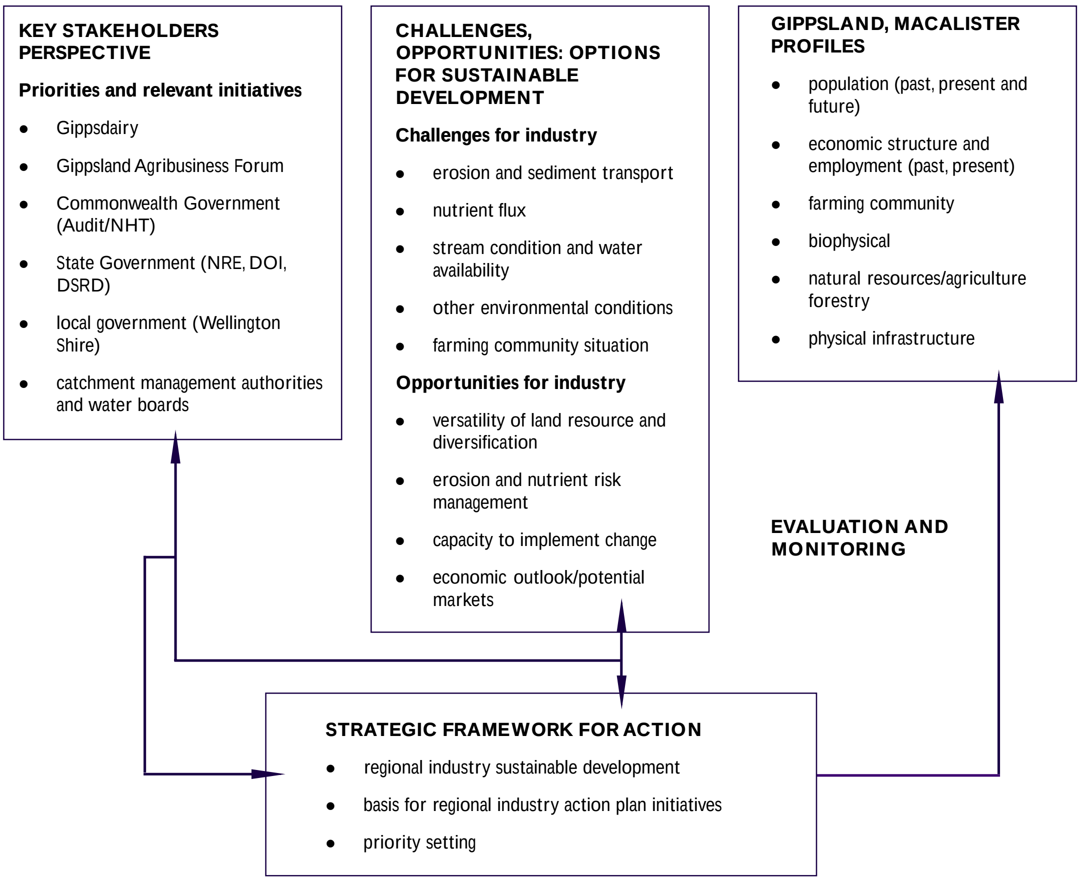
'GIPPSLAND MODEL' CASE STUDY

The Gippsland region of Victoria (Figure 7.3) faces a number of environmental problems including deteriorating water quality (turbidity, nutrients, salinity, colour and bacterial contamination) and degrading aquatic and terrestrial ecosystems. A particular community concern is the high concentrations of nutrients in rivers and streams that run off into the Gippsland Lakes. In 1988 and 1999, severe problems of algal bloom developed in these lake systems with subsequent environmental and tourism implications.

The Gippsland community generally considers the regional dairy industry, rightly or wrongly, to be a major contributor to the deteriorating water quality. High levels of phosphorus and nitrogen in waterways are thought by the community to result from high fertiliser use and effluent run-off on dairy farms. The dairy industry is also a major employer in the region.

Between 1998 and 2000, the Audit, in partnership with the Victorian Department of Natural Resources and Environment, developed a regional implementation project of the West Gippsland Catchment Management Authority region.

Figure 7.2 The Gippsland model.



Initial work included preparation of a regional profile and collation of key environmental indicators for monitoring the condition of natural resources. It resulted in several partnerships formed between Commonwealth, State and local governments; and industry organisations. The resulting strategic planning approach has become known as the 'Gippsland model'.

The Gippsland model uses a range of data sets and information from different sources to develop regional understanding of biophysical, social and economic conditions (Figure 7.2). Assessment and interpretation is done by experts.

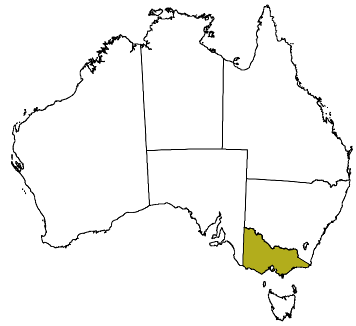
Challenges

- To correctly identify the sources of the high nutrient loads in the Gippsland Lakes. The Audit's report *Australian Agriculture Assessment 2001* (NLWRA 2001e) identifies the relative contributions of nutrients from a range of sources (see Appendix 1). Certainly the dairy industry is likely to be a contributor with the total diffuse sources estimated at contributing 60% of the phosphorus from East Gippsland, 53% from the Thomson River and 47% from South Gippsland. Phosphorus attached to fine sediments from riverbank erosion is also a major contributor to the remaining portion.
- To determine the fate of nutrients once within the Gippsland Lakes and what are the particular limnological conditions that result in a high propensity for algal blooms. CSIRO is studying the Gippsland system in detail to determine the key processes driving algal blooms in the area.
- To move towards best practice for all land uses, controlling enrichments at source. This particular project has concentrated on the dairy industry and reflects this industry's willingness to move towards improved practice and performance.

Following the pressure – state – response model (ANZECC 1998) a set of 26 environmental indicators was developed to form a baseline for Gippsland's regional natural resources and for monitoring and evaluation. The indicators were grouped into five issues:

- inland waters;
- land, vegetation and biodiversity;
- estuaries;
- atmosphere; and
- regional economic and social issues.

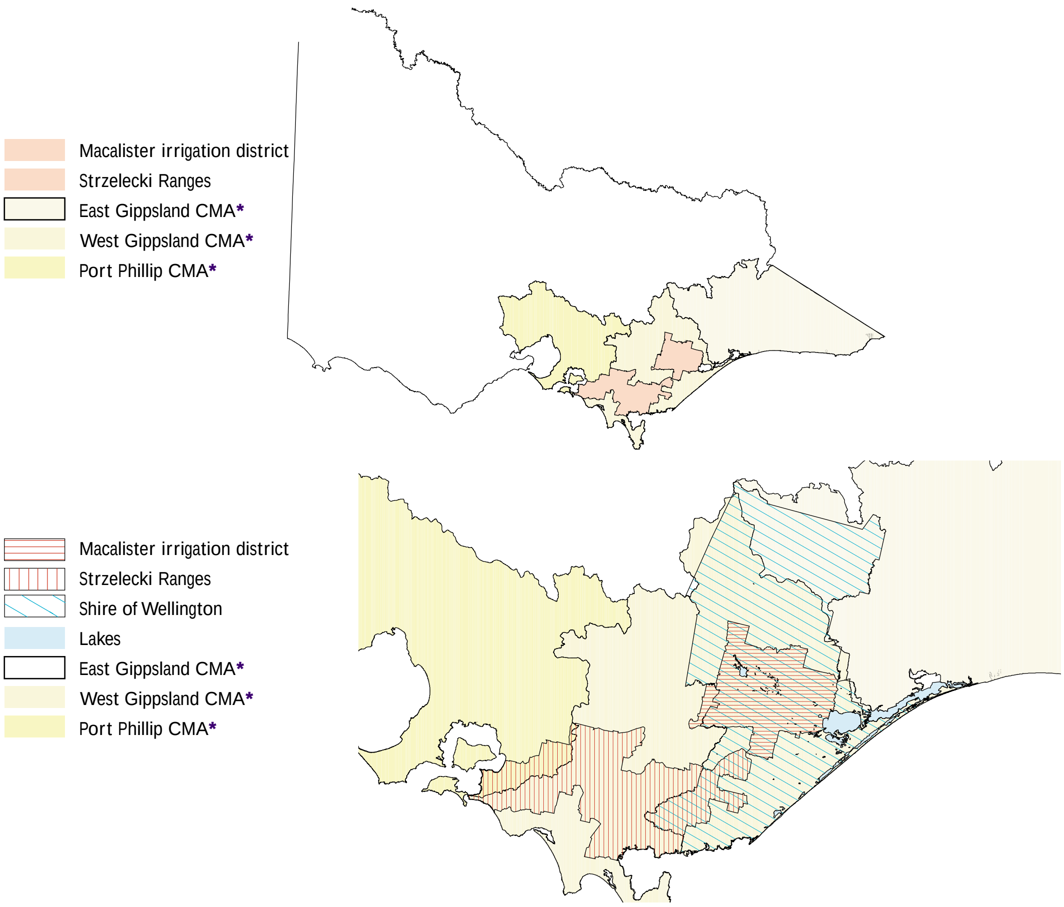
7



Shire of Wellington, Gippsland: a profile of the region and its challenges

The West Gippsland catchment management region covers an area of just over 2 million hectares and is situated in the south east of Victoria (Figure 7.3). It is divided into three river basins—the Latrobe, Thomson and South Gippsland. The region has a population of about 172 000 people and it is the most densely settled rural area in Victoria. Half the area is public land, most of which is forested. The other half is primarily private farm holdings with dairying the most important enterprise. Over 50% of the agricultural income of the region is derived from milk sales, with livestock and livestock products accounting for 85% of agricultural income. Horticultural enterprises account for about 9% of agricultural income.

Figure 7.3 Location of Gippsland study area (Victoria).



Source: Department of Natural Resources and Environment (2001)

* CMA = catchment management authority

Wellington Shire forms about half the area of the West Gippsland region and contains most of the Macalister Irrigation District that represents the powerhouse of the dairying industry in the region.

- Average taxable income of $27 295 is below that of Gippsland ($28 463), Victoria ($32 730) and Australia ($32 902).
- 76.6% of the residents in the Shire of Wellington are taxpayers compared to 78.3% in Gippsland, 84.6% in Victoria and 84.2% in Australia (Table 7.1).
- Unemployment in the Shire of Wellington is highly variable over time. Workforce participation rates have worsened but remain above 50%.
- Age of farmers has increased over time to approximately 46–53 years across the Shire of Wellington (Table 7.2).
- Milk production for the whole of East and West Gippsland was valued at $414.5 million in 1998/99 (ABS Ag Survey), with $108.5 million worth of production from the Shire of Wellington. In the Shire of Wellington this accounted for more than half of all agricultural production ($193 million).
- Consolidation of the dairy industry is ongoing, although the Shire of Wellington now has an increased proportion of the number of farms when compared with the rest of Gippsland (Table 7.3).
- Management practices are mainly geared to intensive pasture production for dairy and beef cattle grazing. This means substantial

Table 7.1 Employment in the Shire of Wellington.

	1986	1991	1996
Total employed persons	16 010	9 624	15 546
Total unemployed persons	1 343	1 355	1 883
Labour force	17 353	10 979	17 429
Participation rate (%)	56.9	54.5	52.7
Unemployment rate (%)	7.7	12.3	10.8

Source: CData96, ABS (1998)

Table 7.2 Median age of farmers by statistical local area in the Shire of Wellington.

Statistical local area	1986 Median age (years)	1991	1996
Alberton	45	47	49
Avon	45	47	49
Maffra	46	45	46
Rosedale	44	45	46
Sale	57	61	53

Home

Contents

use of fertilisers on pastures to boost pasture yields and livestock productivity. As a result of the introduction of various technologies in pasture and herd management practices, milk yield per cow has more than doubled in the past 25 years. Only about 5% of the land in the Shire is irrigated—mainly the Macalister Irrigation District.

- Costs of milk production vary greatly. In Gippsland the variable cost per litre of milk is 15.1 cents placing the region on par with most other regions in Victoria. The Macalister Irrigation District is a high input irrigation area within the region and returns the lowest margins on investment per hectare and per cow in the region. Profitability (gross margin) for the irrigation district is $412 per cow and $775 per hectare as compared with regional measures of $412–$518 per cow and $775–$936 per hectare.

Table 7.3 Number of dairy farms in the Shire of Wellington 1996 and 1999.

	1996	1999	Change (%)
Wellington	701	680	-3
Gippsland (GippsDairy Licences)	2 709	2 603	-4
Share of Gippsland (%)	25	26	+4

Source: Victorian Dairy Industry Association 1999

Resource condition

An estimated 60% of West Gippsland's waterways are considered to be in a poor to very poor environmental condition. High nutrient levels occur in the lower reaches of several rivers that flow into Lake Wellington and the other Gippsland Lakes.

High turbidity levels as well as nutrients are recorded frequently in the lower reaches on the Macalister and Thomson rivers. The Thomson has been dammed to contribute to Melbourne's water supply and this has resulted in severely reduced flows downstream and into the lakes.

A 'nutrient reduction plan' that aims to reduce nutrient levels by 40% within five years has been developed locally. Implementation is being overseen by the Wellington Salinity Group formed by the West Gippsland Catchment Management Authority.

Community capacity building in Gippsland

Following the Audit's implementation project in West Gippsland, further work focused on capacity building, forming alliances of key stakeholder groups and strategic planning for the subset region of the Shire of Wellington and particularly the Macalister Irrigation District (Figure 7.4).

The goal is to conserve and enhance the state of natural resources while improving the economic prosperity of the region, particularly the farming community. As a result one of the objectives was to reduce nutrient concentration in rivers and improve water quality while enhancing productivity and economic prosperity of farmers in the region.

Home

Contents

Home
Contents

Through access to Audit data outputs and the exchange of local information, strategic planning of natural resources has been facilitated in the Gippsland region. In several cases formal memoranda of understanding have been signed between groups. Each of the organisations will take the priorities agreed to and develop action plans according to their role in regional and local natural resource management.

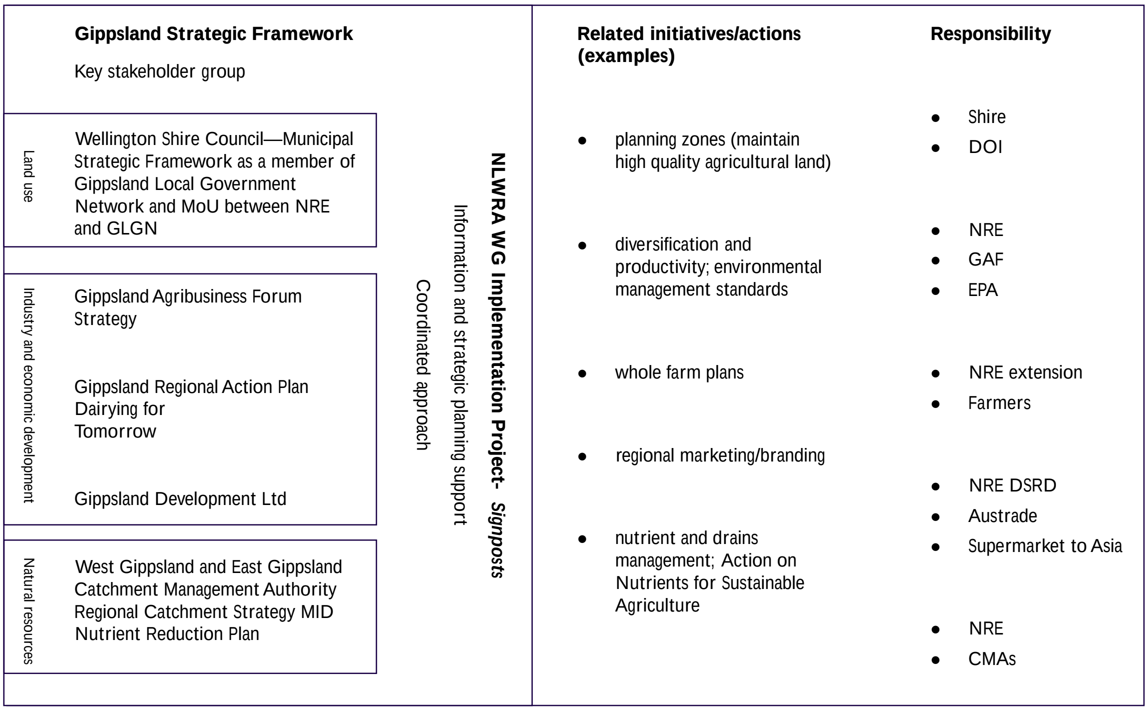
Under the regional strategic framework, the steering group is setting priorities for initiatives that are most urgently required to achieve key objectives.

A recent priority-setting process with a round table group of specialists in agriculture and natural resources management suggest that the following sets of initiatives were most relevant for sustainable development in Gippsland.

- Soil conservation measures
- Education initiatives
- Water use and irrigation efficiencies
- Regional benchmarks (environmental accreditation, etc.)
- Effluent management

Some initiatives are already occurring in Gippsland (Figure 7.4). The priority list will help to provide a better focus for targeted and coordinated regional investment in the dairy industry.

Figure 7.4 The coordination of strategy and investment in Gippsland.



Home
Contents

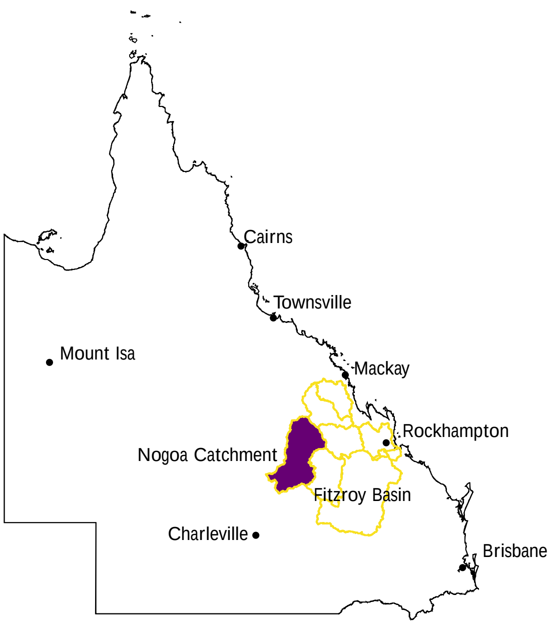
FITZROY RIVER BASIN CASE STUDY

The region and the challenges it faces

The Fitzroy River Basin in central Queensland covers about 14.3 million hectares. It is the largest river basin draining to the east coast of Australia and drains to the southern end of the Great Barrier Reef. It has a subtropical semi-arid climate with high rainfall variability. Frequent heavy downpours, often after dry periods, provide particular challenges to land mangers to maintain sufficient ground cover to prevent soil erosion leading to sedimentation in rivers and transport of sediment and nutrients to the Great Barrier Reef lagoon.

- Most of the Basin is devoted to cattle grazing (82% of land) with other land uses including irrigated cotton and dryland cropping (7%), forests and parks (9%) and mining (1%).
- Over the past few decades there have been significant land use changes. Extensive clearing of brigalow scrub has provided large tracts of new land for grazing and cropping but the loss of native vegetation cover has made the land vulnerable to soil erosion. New dams in the basin have expanded the areas under irrigation and have trapped some of the bedload of sediment that would otherwise be transported downstream.
- The Fitzroy region including the Fitzroy Basin and Central Highlands (Figure 7.5) has a population of about 185 000 people. In 1996 there were an estimated 1980 beef producers, 216 grain growers, 101 cotton farmers and 512 mixed beef/grains farmers. For 1998/99 the gross value of rural production was $836 million with 60% being accounted for by returns from beef cattle grazing.

Figure 7.5 Location of Fitzroy Basin study area (Queensland).



- Surface soil erosion is a major problem in the basin (Table 7.4) and is caused by a combination of overgrazing and cropping activities with the summer-dominant rainfall often occurring in intense, sometimes cyclonic events. An estimated 2–4 million tonnes of suspended sediment leaves the basin annually and enters the marine environment of the Great Barrier Reef Marine Park. Erosion from cropped land is higher than from pastures, but regional land use is dominated by grazing. River sediment loads in the Fitzroy Basin are predicted to have increased by 15 times the natural rate that prevailed prior to European settlement. Hillslope erosion is a particular problem. An estimated 3100 tonnes of nitrogen and 1300 tonnes of phosphorus per year are transported in the basin's waterways to the marine environment.
- The sediment export from the Fitzroy to the Great Barrier Reef lagoon is estimated at 21 times natural loads with phosphorus 6.9 times estimates of natural loads and nitrogen 3.3 times.

Table 7.4 Soil erosion in the Fitzroy Basin.

Attribute	Fitzroy Basin	Fitzroy as a proportion of national total (%)
Area (mha)	14.3	8.5
Stream length ('000 km)	15.5	8.5
Sediment sources		
• bank erosion (Mt/yr)	2.0	6.0
• gully erosion (Mt/yr)	4.0	9.0
• hillslope erosion (Mt/yr)	10.0	20.0
Total (Mt/yr)	**16.0**	**12.5**
Sediment delivered to marine environment (Mt/yr)	2–4	12.0
Stream length with degraded riparian vegetation ('000 km)	7.8	6.5
• percent of total stream length (%)	50.0	

Source: Australian Agriculture Assessment 2001 (NLWRA 2001e)

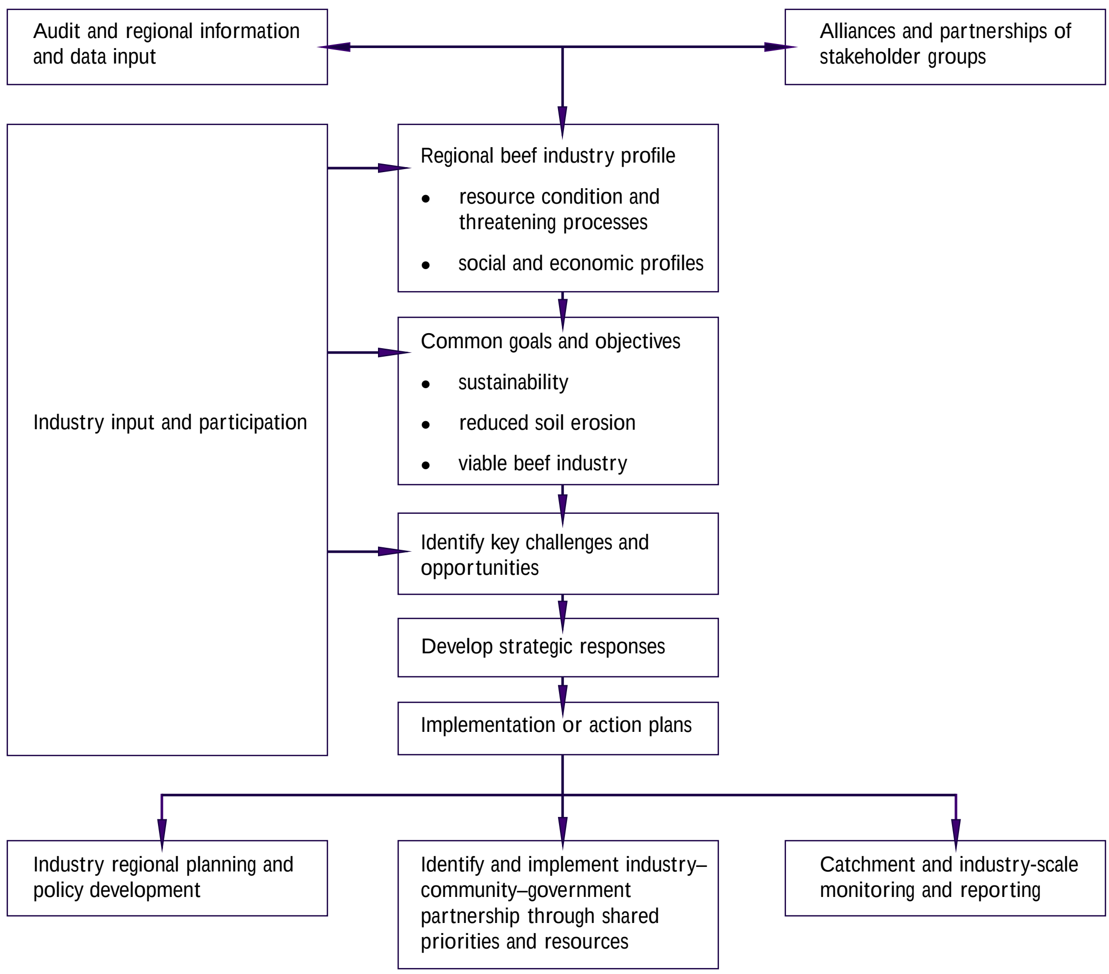
7

Implementing the Fitzroy project

Stakeholders were identified and informal partnership groups formed (Figure 7.6). These included CSIRO, Central Queensland University and Queensland government agency representatives on the *Signposts* team, Agforce Central Queensland, the Central Highlands Regional Resource Use Planning Project pastoral and grains group and the Integrated Catchment Management Committee of the Fitzroy Basin Association. Each group had a slightly different perspective and set of goals, but substantial areas of overlap enabled the groups to work together towards common goals of sustainability, reducing soil erosion and increasing the viability of beef producers in the region.

Substantial amounts of regional biophysical, social and economic information were supplemented with Audit data sourced from national data sets.

Figure 7.6 Developing strategic directions for the Fitzroy region.



Data were collected and summarised into a regional beef industry profile that documented resource condition, and social and economic information on beef producers. This provided the contextual information for a workshop to identify key industry challenges and opportunities and to develop strategic responses. Out of this process four key 'briefing papers' or industry strategic response papers were prepared which will form the blueprint for implementation plans. The briefing papers reproduced in Appendix C cover:

- human capital development: pastoral industry
- marketing sustainability
- environmental compatibility; and.
- soil erosion risk in the Fitzroy Basin.

Implementation will be driven by each group using the strategic plans to augment existing plans. Strategic plans will include works, extension activities, monitoring and reporting on progress. Further partnerships are likely to be formed to implement plans under major programs such as the National Action Plan for Salinity and Water Quality.

Key findings* on capacity for change and management practices

- The bulk of central Queensland beef operations have property values of between $800 000 and $2 million with an estimated equity of about 80% (Reeve pers. comm. 2000). In the late 1990s there were considerable adjustment pressures with net returns generally low or negative. On average, a herd size of 1000 head appears to be the minimum for financial viability. Two thirds of beef producers have herd sizes less than this. With the recent increases in beef prices, adjustment pressures may have eased slightly.
- The average beef producer in the Basin had 23–25 years of farming experience, was third generation in farming and was 50 years of age.
- Between 1996 and 1999, approximately 20% to 25% of beef producers had undertaken post-secondary school education and around half of the region's beef producers had been involved in Landcare or catchment field days with slightly more having participated in short courses. A third of beef producers participated in some form of property management planning, 'Future Profit' or 'Grass Check', or other similar activities.
- Beef producers, in general, place most importance on 'other producers' and 'field days' for sources of information on land management.

* Based largely on 1999 regional survey by Rolfe and Donaghy (2000).

- Beef producers reported high levels of adoption of sustainable management practices—over 80% of producers for some practices. But this may, in part, be due to a broader interpretation by producers of what a particular sustainable practice, such as drought management planning or pasture monitoring, actually entailed. It may also reflect a belief that best practices are widely in use and therefore efforts to move towards an industry code of practice or greater adoption of sustainable practices are not warranted. This perception, however, appears inconsistent with the levels of soil erosion occurring and the low levels of recorded profits from beef production. The levels and pattern of soil erosion in the Fitzroy Basin suggest that practices aimed at reducing soil movement off-property are not as widely used as perceived by industry members.
- Management practices that focus on reduced stocking rates but increased quality of production, especially under quality assurance programs, are generally more profitable. Also, producers who participate in land management or productivity-focused training and who access a broad range of sources of management information are more likely to use best practice management.

Industry strategic responses

- Agreement by industry on sustainable carrying capacities for different land types as part of industry guidelines.
- Promotion of pasture management practices that achieve healthy pastures and adequate ground cover especially on 'texture contrast' soils that are highly susceptible to erosion. Promotion to be based on local case studies or demonstrations and peer-based learning.
- Promotion of awareness of the net benefits of management practices that reduce risks of soil erosion and associated water quality problems. Exploration and promotion of market-driven incentives for 'clean and green' production.
- Identification of opportunities for funding works that control soil erosion, especially for hillslope erosion and gully erosion in key areas; works would include combined landholder riparian fencing programs, devolved grants for off-river water supply and rehabilitation of filter systems such as wetlands and riparian vegetation.
- Promotion by peak industry bodies to encourage participation in management relevant training while supporting existing business, Landcare and social networks as important information networks.
- Improvement of existing training programs to better meet the needs and learning styles of producers.
- Creation of regional partnerships or alliances between regional groups to enhance regional capacity building.
- Industry adoption of key human capacity and resource condition indicators to monitor progress towards objectives of sustainable and viable management.

Home
Contents

DAIRY INDUSTRY—CASE STUDY OF PLANNING FOR IMPROVED NATURAL RESOURCES MANAGEMENT

The dairy industry is Australia's largest processed food export industry generating employment for over 60 000 people and export income of over $2 billion per year. The industry has undergone significant structural change, with the number of dairy farms having halved to under 15 000 in the past 20 years. Recent deregulation is likely to continue that structural change.

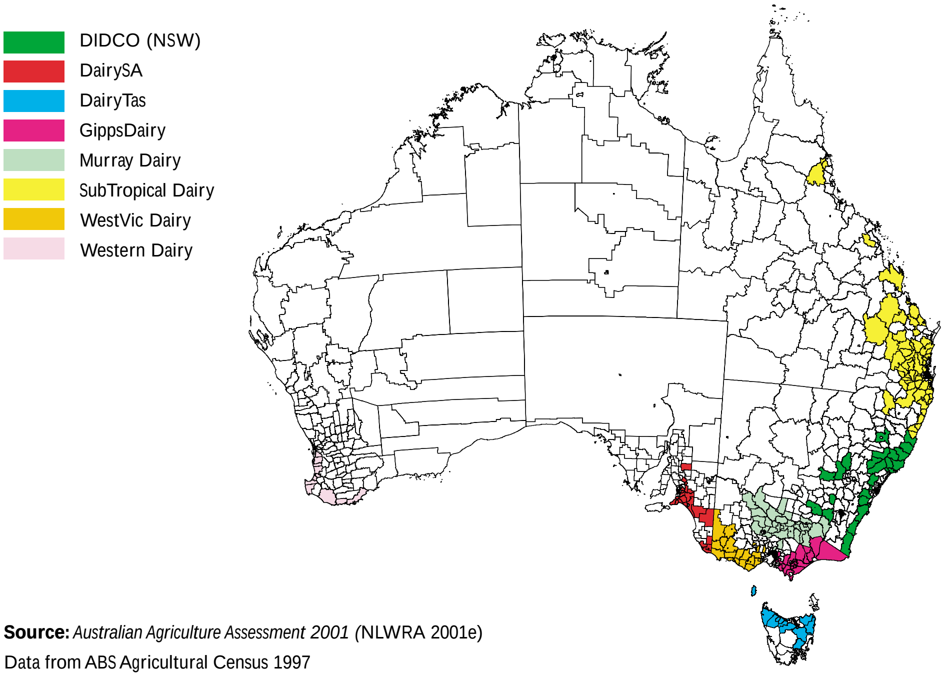
Methods of production have intensified, with increased use of inputs particularly fertiliser on pastures and increased use of irrigated pastures. Intensified dairying activities may have negative impacts on water quality in adjacent rivers through elevated nutrient levels. In some regions, increased irrigation is adding to salinity problems. At the same time, external environmental issues such as water salinity are adversely impacting on irrigated dairying enterprises.

In recognising environmental and sustainability issues on the one hand, and dairy enterprise profitability and viability issues on the other, the dairy industry formed a partnership with the Audit to undertake an initiative called Sustaining Our Natural Resources — Dairying for Tomorrow. The project's aims were to:

- assess the sustainability and best practice management issues in Australia's eight major dairying regions;
- survey current practices, production methods and opportunities and attitudes among dairy farmers; and
- develop programs to promote adoption of best practice sustainable management.

Regional profiles for the eight major dairying regions (Figure 7.7) were prepared, using Audit and other data. A national telephone survey of

Figure 7.7 Major dairying regions in Australia in 1996/97.



Source: *Australian Agriculture Assessment 2001* (NLWRA 2001e)
Data from ABS Agricultural Census 1997

Home
Contents

1800 dairy farmers was also conducted. The survey covered personal and financial information relating to capacity and motivation to change as well property management issues relating to water and land use efficiencies, nutrient and effluent management, soil conservation, biodiversity and waterway management.

Each region, on the basis of the information collected, has prepared a regional action plan to promote continual improvement within the industry. These have been used to develop the National Strategic Natural Resource Management Plan for the dairy industry providing a coordinated and visionary framework for action at national and regional levels.

Plans and strategies being developed are designed to ensure that:

- natural resources used in dairy production will be used sustainably, efficiently and productively with minimal off-site impact;
- research needs are identified;
- the industry will be in a sound position to feed information into and influence relevant policy and regulation; and
- the information will contribute to the Audit's assessment of the health of Australia's natural resources, providing an example of industry leadership to address natural resource management issues.

Nutrient pollution

Nutrient pollution of waterways, associated mainly with diffuse as well as point source movement of soil, phosphorus and nitrogen is an environmental challenge common to all dairying regions and an issue for many agricultural industries. The severity of pollution is greater in the more closely settled dryland and irrigated districts. In these districts dairying is part of a mosaic of intensive agriculture. The combined result of this intensity of all land uses means that many rivers and streams are now classed as significantly degraded, with eutrophication and algal blooms occurring. Pollution of aquifers is also a problem in some intensive agriculture regions such as the south-east region of South Australia.

The dairy industry recognises that it is a contributor to water pollution through excessive nutrient movement in flood irrigation and other run-off from dairy farms and is seeking to improve practices and minimise the risk of water pollution. Sources of nutrients on dairy farms, as with any intensive livestock enterprise, include effluent, high rates of fertiliser use and soil erosion. Diffuse movement of nutrients from paddocks may be significant particularly in steep, high rainfall areas. High bacterial and faecal coliform counts indicative of pollution by warm blooded animals have occurred in South Australian waterways where dairy exists with other rural industries and urban and industrial land uses.

Water salinity and soil health

Surface water salinity and irrigation-induced soil salinity is mainly confined to intensive flood irrigation agriculture and, along with a range of other rural land uses, includes farms in the Western Dairy, Dairy SA, Murray Dairy and GippsDairy regions. Groundwater salinity is a growing problem in the South East district of South Australia, again covering an area of varied rural uses.

The impacts of upper catchment change in water balance have led to dryland salinity in many intensive agriculture areas and are most threatening in the dairy industry in Western Dairy, the South East district of Dairy SA and GippsDairy.

In most of the irrigated and high rainfall dairy districts, especially those with medium to heavy textured soils, water logging and deteriorating soil structure are common problems. These can be exacerbated by excessive irrigation, poor drainage, salinity, high stocking rates or grazing of wet pastures (pugging). Soil acidification, while predominantly an issue for broadscale agriculture, occurs in several dairy regions. Acidity can be exacerbated by excessive nitrogen fertiliser applications, pasture legumes and poor stock management.

Environmental problems and best practice management

The industry overall has a good ‘report card’ with respect to investment in sustainable management practices (Table 7. 5).

Some key issues for public policy need to be addressed—particularly in terms of partitioning public and private benefit and costs. Approximately half the number of dairy farmers surveyed believes that the adoption of environmentally friendly farming practices will not necessarily reduce farm profitability (Table 7.6). Older dairy farmers are inclined to believe that there is a trade-off between increased profitability and adoption of environmentally friendly practices. Those with little training or without a written farm plan are also inclined to this view.

Regional profiles show that a high proportion of farmers are using sustainable practices. So why do environmental problems persist and for that matter, what proportion of the problem is confined to the dairy versus other industries?

7

Issues

- A key element of capacity to change is awareness of the full extent of environmental challenges, detailed knowledge and understanding of the issues and a conviction that certain management practices will satisfactorily address the problems. Many environmental problems are insidious and develop over long periods of time so that changes are hard to notice. This underscores the need for accurate and convincing scientific data on the extent of environmental problems at a regional and local level.
- 'Best practice', even if fully implemented on farms, cannot be guaranteed to produce outcomes that are acceptable in regards to both profit and the environment and may not be good enough to meet some of the environmental objectives of the community.
- Best practice might not meet the challenges of Australia's variable climate. Major flood and storm events are often periods of failure for practice in all industries—be it urban sewage treatment or agriculture.

These issues have been recognised by the dairy industry and are being factored into the planning processes.

Modern dairying requires increased efficiency of production and this requires increased stocking rates fuelled by supplementary feeds and establishment of highly productive pasture through use of fertilisers and irrigation. But these intensive systems require sound management to ensure that the inputs are fully used and do not 'leak' into the adjacent environment. A comprehensive list of best management principles has been devised and their adoption is part of the regional action plans (Appendix 4).

Table 7.5 Use of sustainable management practices by Australian dairy farmers.

Management practice	**Proportion of dairy farmers using the practice** (%)
Reuse of effluent for irrigating and fertilising pastures	81
Regular soil testing to match fertiliser application to soil and plant needs	80
Effluent management system	80
Flood irrigators who reuse tail water	80
Flood irrigators using laser grading	95
Farmers who recognise soil erosion problem who are dealing with it	99
Farmers addressing soil crusting or compaction problem	91
Farmers with salinity problems who are controlling or ameliorating it	98
Farmers involved in property revegetation	56
Farmers with waterways who have fenced off all or part	57

Source: Pomfret (2000)

Table 7.6 Dairy survey results—responses to statement: 'Adoption of environmentally friendly farming practices will reduce profitability'.

	Disagree	Neither	Agree
Dairy region			
West Victoria	52	15	33
Gippsland	54	19	27
Murray	46	17	37
DIDCO	49	15	37
Sub Tropical	43	17	40
Tasmania	48	18	34
West Australia	47	21	32
South Australia	49	17	34
Australia	49	17	34
Age of operator			
Less than 35 years	54	18	28
36–50 years	51	18	31
51–65 years	45	16	39
66+ years	44	16	41
Member of Landcare/environmental group			
Yes	52	14	34
No	47	18	35
Written farm plan			
Yes	55	16	29
No	46	17	37
Training activities			
None	42	19	40
1–2	44	19	38
3–4	55	13	32
5+	52	18	30

Source: Pomfret (2000)

7

Some characteristics of dairy farms and farmers and capacity to change

Farm characteristics

The 'average' dairy farm, from the telephone survey, was 186 ha with a herd size of 191 milking cows. The median herd size was 156 milking cows. About 29% of farms milked more than 200 cows. Stocking rates varied from between 1 and 2 cows per hectare to three or more cows per hectare on 11% of intensively stocked farms.

Some 70% of farmers indicated that their entire property was valued at less than $1 million. Over 7% of farms were valued at $2 million or more. There was much regional variability so the 'average' farm value is at most indicative (e.g. 40% of farms in Western Australia were valued above $2 million).

Forty-one percent of farmers indicated they earned less than $10 000, where net income is defined as 'returns after payment of all farm costs including wages you may pay yourself'. Only 15% indicated that they earned more than $50 000. On the other hand, farm debt tends to be high in comparison with the ability of farmers to service debts from farm income. Two-thirds of all dairy farmers had farm debts of $100 000 or more and 43% had debts in excess of $250 000. Overall, this could indicate limited capacity on the part of most dairy farmers to finance sizeable investments on environmental projects. Another view is that dairy farmers recognise the value of intensifying their development and are borrowing with a view to the high profitability that will follow from development. Certainly, many of the larger farmers would appear to be also those with high levels of investment in environmental management activities.

Farm operator characteristics

The average age of a dairy farmer in Australia was reported to be 49 years and, on average, they had 29 years of farming experience. These statistics were broadly uniform across all dairying regions.

Involvement in groups or programs such as Landcare appears to be associated with more environmentally beneficial management practices. On average:

- 31% of farmers belong to Landcare;
- 40% attend discussion groups;
- 30% have and use a written farm plan; and
- 86% have attended some form of training in the last five years (e.g. courses on quality assurance, farm chemicals and pasture management).

Age of farmer or years of experience appear to have little influence on whether a farmer belongs to Landcare, but there is a positive association between having a farm plan and belonging to a Landcare group (Table 7.7).

Table 7.7 Association between farmers having a farm plan and belonging to Landcare.

	Member (%)	Non-member (%)	Total (%)
Farmers with a farm plan	37	26	30
Farmers without a farm plan	63	74	70
Total	**100**	**100**	**100**

Home
Contents

The adoption of several 'best management' practices was found to be stronger among farmers who were members of a Landcare or environmental group. The strongest correlations were found to exist between farming practices and where farmers had a written farm plan (Table 7.8). Existence of a farm plan was also generally associated with larger farms with more intensive production methods and younger farmers (Table 7.9). Most farm plans are focused on productivity and farm management with environmental management part of 'doing business'.

Money and finance was by far the most common constraint limiting adoption of environmental practices and farm productivity (Table 7.10), reflecting public rather than private benefits of these practices.

Table 7.8 Characteristics of farmers by existence of farm plans (average).

	Farm plan	No farm plan
Age of farmer (yrs)	47	50
Years of experience (yrs)	26	30
Milking area (ha)	135	117
Herd size (number)	224	176
Stocking rate (cows/ha)	2.0	1.8
Production rate (L/cow)	4800	4500

Source: Pomfret (2000)

This dairy industry case study demonstrates how a major rural industry through continuous improvement in practice will address the natural resource management challenges it faces. Several other leading industries are also recognising the importance of a proactive and industry-led approach and are following the example set by the Australian Dairy Farmers Federation in developing their *Natural Resources Management Strategy*.

Table 7.9 Farming practices by existence of farm plans (% with issue undertaking activity).

Practice	Farm plan	No farm plan
Soil acidity		
Plant deep-rooted pastures	59	47
Dryland salinity		
Regional group revegetation strategy	36	15
Fencing areas	56	36
Rising water tables		
Revegetation	69	45
Salinity survey	51	30
Soil erosion		
Fencing	73	59
Conservation tillage	79	65
Wet soils and pugging		
Loafing pads	54	38
Soil testing		
Soil test nutrient levels every year	42	25
Soil test to determine fertiliser requirements	88	76
Soil crusting		
Conservation tillage	82	69
Apply gypsum	48	31

Source: Pomfret (2000)

Home
Contents

Table 7.10 Constraints faced by farmers in improving environmental management and farm productivity.

Constraints facing farmers	Improving environmental management (% of farmers)	Constraints facing farmers	Improving productivity (% of farmers)
Money/finance	47	Money/finances	44
Time	13	Low return/milk prices	16
Low returns/milk prices	9	Availability of water	14
Availability of water	5	Size of farm	12
Size of farm	4	Time	8
Climate	4	Climate	6
Government	3	Labour/manpower	5
Labour/manpower	2	Deregulation	3
Better irrigation practices	2	Farmer's age	3
Topography/terrain	2	Government	2
Lack of energy/desire	1	Pasture quality	2
Deregulation	1	Topography/terrain	2
Weeds	1	Lack of energy/desire	1
Farmer's age	1	Market uncertainty	1
		Herd management	1

Source: Pomfret (2000)

WAYS FORWARD

Key points

Actions to address resource degradation problems need to be evaluated in an investment, benefit–cost framework. Four case study regions were selected for detailed evaluation of dryland salinity. Key insights from these case studies are summarised below.

- Each catchment is different. There are no simple and universally applicable solutions or recommended responses to ameliorating the cause or symptoms of dryland salinity.
- Broadscale re-afforestation of wide areas of recharge zones will mostly prove to be a poor investment from an economic and social viewpoint.
- Relying solely on farmers to implement farming practices that will ameliorate salinity and achieve socially acceptable results is expecting too much.
- A lack of profitable and technically feasible options is a major constraint on farmers' capacity to contribute to salinity management.
- Where significant public assets are at risk, solutions such as engineering works—drainage or pumping—may need to be implemented and publicly funded.

This first Australia-wide attempt at resource accounting has demonstrated the complexities of natural resource management and the need to build strong links between social, economic and biophysical assessments as part of regional planning and management activities.

INTRODUCTION

Over the past few decades, there have been major changes in attitudes to the use and appreciation of natural resources. From a predominant focus in the early post-war period on how natural resources could be exploited to earn export income and contribute to our economic development, there is now greater awareness of and value placed on the many other attributes of our natural resources. Concurrently, whereas agriculture was then the mainstay of the Australian economy, it is now a relatively minor component.

Use of our natural resources has come at a price. This and other Audit reports have documented the extent of land degradation and its implications. But land degradation is a 'sunk' cost—what is done is history. What should be done in the future? In addressing this question, we need to consider the following questions:

- Are we now managing our natural resources responsibly and sustainably?
- If we are not managing sustainably, why not?
- How can we change, and what capacity do we have to change to a management regime that is sustainable?
- What are the nature, size and significance of the problems?
- Are there technically feasible and economically and socially acceptable options that can be implemented?
- To what extent should we be investing in protective management to prevent further degradation?
- Do we have enough knowledge to make the right investment decisions or is more investment in knowledge generation and distribution needed?
- Is the resource degradation a public or private issue?
- Is investment in research and innovation needed to develop viable options?
- To what extent should we be investing to repair damage already done?

Nature and size of land degradation

The Audit's *Australian Dryland Salinity Assessment 2000* (NLWRA 2001b) estimates the areas 'at risk' or with a high potential to develop dryland salinity through high water tables at around 5.7 million hectares; of this area about 4.6 million hectares is agricultural land. This 'at risk' area is projected to expand to 6.4 million hectares of agricultural land by 2020 under a 'business as usual' scenario.

But areas 'at risk' do not necessarily imply total impact on agricultural yields. Estimations using the modelled extent of dryland salinity suggest that yields may be reduced by 5% or more—approximately 3.3 million hectares. This represents 0.7% of agricultural land. Under a 'business as usual' scenario (excluding any effects of recent policy initiatives) this is projected to expand to 4.7 million hectares which is still only 1% of all agricultural land by 2020. It is also concluded that relatively small areas of most high value forms of land use are likely to be adversely affected by salinity over the next 20 years.

The processes driving salinity—groundwater movement and soil salt mobilisation—are very slow moving so that even if recharge is slowed, it will take many years for the effects to become apparent in discharge areas (*Australian Dryland Salinity Assessment 2000* [NLWRA 2001b]).

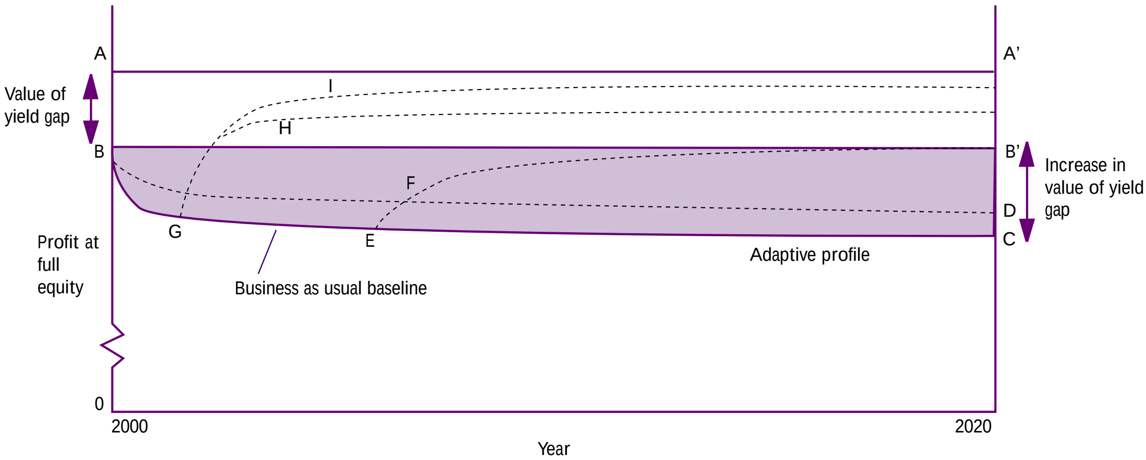
Soil acidity affects much larger areas of agricultural land than dryland salinity. It is estimated that losses from acidity are at least 5% of potential yields and occur over 21.3 million hectares—representing 4.5% of agricultural land. This soil health problem is generally naturally occurring but exacerbated by agricultural practices (e.g. repeat applications of nitrogen-based fertilisers and the use of the legumes in the pasture rotation). In severe cases it can lead to other forms of land degradation such as soil erosion and turbidity or sedimentation in streams and rivers—driven primarily by the reduced level of ground cover at critical times in the year. Future trends in acidity could not be projected because of lack of technical data. Depending on the benefits and costs of treatment, soil acidity can be addressed by changing fertiliser regimes and/or applying lime.

Some of the many other forms of land degradation have been assessed in other Audit reports. *Australian Agriculture Assessment 2001* (NLWRA 2001e) highlights:

- the five-fold increase of nutrients in the landscape over natural levels—giving potential for leakage into rivers and at least doubling productivity of landscapes from their natural state; and
- significant erosion and sediment movement—700 million tonnes of soil erodes on agricultural hillslopes each year and 107 million tonnes of soil is deposited into rivers from hillslopes, gullies and river banks, including 20 000 tonnes of bound phosphorus.

A survey (Kemp & Connell 2001) of farmer perceptions of the extent of land degradation on Australia's broadacre and dairy farms in 1999 showed that of the nearly 410 million hectares of broadacre and dairy farmland in Australia, almost 101 million hectares were estimated to be affected, to varying degrees, by some form of significant land degradation. An estimated 36% of farmers reported at least one form of significant land degradation affecting their farm, with degradation on these farms affecting approximately 21% of their total farm area.

BOX 8.1 INTERPRETING BASELINE DATA: RECAPPING ON CONCEPTS



Baseline

The base year is 2000.

- OB represents the current profit at full equity from agriculture. Conceptually, this profit would increase by AB (the value of the yield gap) if there was no degradation.

Abstracting from trends in commodity prices or changes in productivity

- AA' represents the maximum profits based on relative yields of 100%. Such a line is conceptual only and would be impossible or impractical to achieve.
- BB' represents a profile of profits equal to current profits and no further land degradation from that which now occurs. But given the momentum of processes causing degradation, especially dryland salinity, the 'business as usual' profile represents a declining profit profile as land degradation continues to get worse (curve BC).

Year 2020

- The value of the yield gap has increased to A'C
- The increase in value of the yield gap by 2020 is represented by B'C.
- Estimates for AB, OB, A'C and B'C as well as the net present value of the shaded area have been presented in this report.

'Business as usual'

- The BC profile represents a worse case (business as usual) baseline scenario and assumes that there is no response by governments or producers to a worsening situation.
- In reality, even in the absence of government intervention, producers are likely to adopt or react so that a baseline such as BD could be considered. There is little or no reliable data to establish such a baseline.

Yield gaps

Data on the value of yield gaps should be interpreted with caution. The best interpretation is the maximum additional profits which could be earned if land degradation was ameliorated. If the costs of proposed government programs to address degradation exceed this they should not proceed unless the costs in excess of the value of the yield gap can be justified in terms of off-farm benefits.

Any actions to ameliorate land degradation or prevent further degradation need to be considered in an investment benefit–cost assessment context. Investment should only be contemplated if the present value of the stream of benefits from all sources, including agriculture and off farm, exceed the costs of remedial measures. Some profiles of agricultural benefits are also shown in the diagram.

- For dryland salinity expert opinion suggests that in most cases the best we can hope for is to hold the line (BB') at current levels of salinity by a range of measures (Salinity Task Force 2001). Even then, given the long lag times, a salinity benefit profile may look like BEFB'. This implies some worsening in the short term if deep-rooted perennial plantings in recharge zones are contemplated.
- For treatments of sodic or acidic soils, benefit profiles more like BGH or BGI could be expected, where response times are more rapid and chances of amelioration are better in some cases.

The same concepts as in the diagram apply to all off-site effects. Here, benefits in terms of restored water quality, biodiversity and other attributes can be measured on the vertical axis and the value of the yield gap becomes the 'benefit gap'. Again, it will not be possible—or desirable from a community net benefits perspective—to completely ameliorate all effects of degradation.

Earlier estimates of the extent of other forms of land degradation by area (summarised in Reeves et al. 1998) include:

- soil structure decline—25.6 million hectares; and
- wind erosion—2.8 million hectares.

Lack of geo-referenced time series data on the condition of soil resources and management practices has prevented assessment of *trends* in resource condition. Consideration needs to be given to more investment in assessment and monitoring of landscape condition on the basis that the information gained has value beyond its costs of collection.

Economic significance

The extent of land degradation is generally a poor indication of its significance. One hectare of degraded land in marginal country has less significance from a national viewpoint than one hectare in a prime agricultural area or an area of high ecological, aesthetic or recreational value.

In this report an attempt has been made at a national level to provide baseline data on the economic significance of land degradation by looking at implications for agriculture and also off-site or downstream costs of degradation. From an agricultural perspective three particular forms of soil health problems have been investigated—salinity, acidity and sodicity.

National baseline data for dryland salinity

The effects of dryland salinity on national agricultural profits are relatively small although some areas are obviously more affected than others.

It is estimated that the value of the yield gap for dryland salinity (see Box 8.1) is around $187 million a year. This is equivalent to less than 3% of profits from agriculture. This annual loss is estimated to increase to $287 million by 2020, an increase of $100 million.

The net present value of the increase in value of the yield gap between 2000 and 2020 is estimated at about $560 million at a 5% social discount rate. This represents about 1.5% loss in agricultural profits over that period.

These estimates need to be weighed against potential productivity gains in agricultural production from all sources of around 2–3% a year, based on past trends (ABARE 2000).

Western Australia is the State at present most severely affected by dryland salinity but New South Wales and Victoria are likely to show the greatest absolute and relative increases in the value of yield gap over the next 20 years.

Increases in salinity are likely to have a much greater impact on future profits from sheep enterprises than other forms of land use, especially high value enterprises such as horticulture, because sheep farming is the predominant form of agricultural land use in areas where salinity is forecast to spread.

Looking at off-farm implications of dryland salinity, the best-bet estimate of current damage to infrastructures is around $89 million a year, trending to $150 million a year by 2020. The net present value of the future increases in infrastructure costs over 20 years is estimated at $341 million, with most of the increase due to worsening salinity in New South Wales and Victoria.

We do not have consistent trend data on water quality in our inland waterways. On the reasonable, and perhaps, conservative assumption of an ‘across the board’ 5% increase in water salinity, the increase in infrastructure costs (e.g. pipes, water equipment, water processing plant) is estimated to have a net present value of $561 million over 20 years to 2020 assuming a 5% social discount rate. In the Murray–Darling Basin, the median percentage increase in river salinity to 2020 for all river valleys has been forecast at 19% (MBDC 1999).

A 5% increase in water salinity will increase costs from worsening water quality by around $1.46 billion. Two-thirds of this is accounted for by off-farm costs. Even if water salinity on average was to increase by only 1%, nearly half the damage costs of increased salinity from current levels would be off farm. Other off-farm costs such as damage to irrigated agriculture, wetlands, environmental ecosystems, or other industries such as tourism or fishing have not been included.

Taking all factors into account a general conclusion is that the costs of worsening salinity will impact on dryland agriculture to some extent but more particularly on a wide range of off-farm assets and other activities downstream. This means that we need public investment if we are to change on-farm practices. Government response to the public benefit aspects of dryland salinity is being shaped and implemented through the National Action Plan for Salinity and Water Quality.

The case studies summarised in Chapter 6 give further insights into the great variability in the nature and extent of salinity problems between catchments.

- In Wanilla dryland salinity affects 8% of the catchment but this will expand to 15% by 2020. Agricultural incomes will be adversely affected as a result, with relatively few off-farm implications.
- In Upper Billabong Creek dryland salinity affects less than 1% of the area of the catchment with 78% of the impact costs accounted for by adverse water quality effects.
- In Lake Warden 8% of agricultural land is affected by salinity but this is projected to increase to 27% by 2020, having a severe impact on agriculture. In addition, rising salinity levels in streams will seriously impact on adjacent Ramsar-listed wetlands.

Baseline data for other forms of land degradation

At a national level, the value of the yield gaps in 2000 for acidity and sodicity are estimated at $1.6 billion and $1.0 billion respectively and are very much larger than for salinity. While this indicates, prima facie, that these problems are worth investigating, the estimates do not indicate the net benefits from treating these soil conditions. They are mostly naturally occurring and in only about 4% of the areas affected would it be economically justifiable to treat the soil with lime or gypsum respectively.

Downstream water quality is also affected by turbidity and sedimentation/erosion. While costs of water treatment or damage due to these attributes were not estimated, the report does contain estimates of the magnitude of future costs over the next 20 years for several different increases in sedimentation and turbidity levels. If water quality were to deteriorate 'across the board' by 5% on average over the next 20 years, the net present value of additional impact costs associated with turbidity and erosion/ sedimentation are estimated at $786 million and $86 million respectively. These estimates add weight to potential benefits from investing in monitoring and evaluation processes to better establish trends in water quality. The argument is further strengthened when we consider water quality impacts on ecosystem services (biota) that have not been costed here and therefore need to be added to the above costs.

Insights to environmental and social values

Results of a choice modelling study that estimated the Australian community's willingness to pay for improvements across a range of environmental attributes including landscape aesthetics, recreation and native species protection indicate that the community is willing to pay approximately $4 billion in present value terms over the next 20 years for a comprehensive package of environmental improvements over and above what is forecast to be achieved with current spending on resource management. The estimate is based on a program that delivers:

- protection of an additional 50 endangered species (that is a stemming of the loss of species);
- improvement to landscape aesthetics from the restoration of an additional 2 million hectares of remnant vegetation and farmland; and
- improvement in recreation opportunities through restoration and protection of an additional 1500 km of waterway for swimming and fishing.

This estimate allows for some potential social costs, as respondents to the choice modelling survey were asked to consider the impacts that a large conservation program might have on farming communities. The package of environmental improvements outlined above was assumed to be accompanied by the loss of an additional 5000 people each year from rural areas.

The results of the choice modelling survey provide an indicative measure of the magnitude of environmental and social impacts associated with land and water degradation. They can be used to estimate economic impacts for a range of different resource use changes, provided the implications of these changes are specified in terms of the three attributes—waterway recreation, aesthetics and species protection.

Constraints, policy design and institutional change

Where it is clear that a change in resource management will yield strong economic, environmental and/or social returns to the community, a fifth and final step in the assessment process (Chapter 2) involves a careful analysis of the constraints that may stand in the way of implementing change. These constraints include:

- lack of human capacity to change (e.g. skills base, motivation, social norms);
- financial constraints and risk;
- information deficiencies;
- high transaction costs;
- lack of arrangements to correct for market failure;
- lack of adequate conflict resolution processes;
- outdated policies, laws and regulations that impede change; and
- complex and inefficient institutional arrangements.

No attempt has been made in this report to analyse in detail the diverse range of impediments to change. However, it provides an insight into some of the social issues in rural areas that drive or retard adjustment (Chapter 3). While Australian farmers generally have a positive attitude towards environmental issues, factors such as farm debt and managerial skills mediate their capacity to change. A clear message is that new farming systems or practices must be commercially competitive with existing enterprises if they are to be widely adopted and the changes involved must be relatively straightforward. Even if changes are relatively profitable, on-farm adoption is hampered if the adjustments are complex, risky or are not adequately supported with good information.

The very nature of resource degradation means that trends in resource quality are gradual and not easily observable. Landholders may not even be aware of the need for change, especially if the impacts of deteriorating natural resources are being masked by productivity improvements achieved through ongoing technological advances such as new crop varieties.

Assessment of social issues has shown that rural Australia continues to experience significant structural change: the number of farm businesses is shrinking, farm sizes are increasing and the median age of the farming population is increasing. These trends suggest that in the 10 to 20 years there is likely to be a period of rapid adjustment during which a large proportion of farm businesses will be transferred to a younger, more highly educated generation. This could represent an opportunity for increasing adoption of complex sustainable farming practices or land use change.

In addition to socioeconomic factors, an array of institutional factors impede change. These include the rules established by society, which influence or govern the behaviour of people, firms, governments and markets. In some circumstances market failure is the primary cause of sustainability problems. It occurs where ill-defined property rights give rise to a situation where private actions are undertaken without explicit account being taken of the costs imposed on other landholders downstream or in the wider community.

Market failure and socioeconomic constraints mean that we cannot rely solely on a stewardship ethic as a sufficient condition to facilitate changes in farming practices of sufficient magnitude to address the land degradation problems we face as a nation. Rather, community awareness and education programs should be viewed as a necessary precursor to applying policy instruments and institutional reforms to encourage behavioural change.

We still need to research and develop new ways of overcoming constraints to change. However, significant progress has been made over the past decade towards recognising and alleviating institutional impediments. Some of these developments include:

- national policy initiatives that coordinate the activities of State, Territory, local governments and community groups to more effectively address resource degradation concerns that are nationally significant (e.g. Regional Forestry Agreements for managing specific types of forests and programs such as National Action Plan for Salinity and Water Quality to address specific degradation concerns that are of high priority);
- national programs that enhance the flow of natural resources research and information available to landholders (e.g. National Landcare Program and the National Dryland Salinity Program);
- introduction of regulatory approaches (e.g. restrictions on land clearing);
- capping of water diversions in the Murray–Darling Basin;
- reforms initiated by the Council of Australian Governments that ensure the provision of environmental water allocations necessary to maintain biodiversity and ecosystem services;
- creation of market-based mechanisms as a flexible way of meeting environmental targets (e.g. tradeable water entitlements, native vegetation offsets);
- actions for environmental services accompanied by new investment vehicles (e.g. NSW Environmental Services Investment Fund);
- the promotion of environmental accreditation schemes and management systems (e.g. ISO 14000); and
- changes to environmental taxation laws to promote conservation on private land.

Data from the Audit provide resource managers and government with an improved information base on which to design natural resource policies. Setting of environmental targets and application of market instruments will require ongoing refinement of existing data to enhance our knowledge of the spatial distribution of degradation and the relationships between 'on-ground' remedial actions and subsequent environmental impacts.

LOOKING TO THE FUTURE

The Audit analyses provide a 'first pass' assessment of the economic significance of different forms of degradation and identify regions that are most likely to be impacted by declining resource health. Linking physical data to social and economic information (drawn from a wide range of data sources including Australian Bureau of Agricultural and Resource Economics, Australian Bureau Statistics, CSIRO, Murray-Darling Basin Commission, Environment Australia, State and Territory agencies) allows an objective assessment of potential solutions and the likely costs and benefits of changes in resource use. This phase of the assessment process constitutes the first four steps of the rapid assessment framework described in Chapter 2.

The five-step rapid assessment (Chapter 2) provides a useful approach to policy decision making in this area.

Baseline information including the value of the yield gap for agriculture and damage costs off farm provides indications of the extent, nature and magnitude of the problems but does not give any indications of the benefits that can actually be achieved or the costs of alternative remedial actions. The case studies on dryland salinity have demonstrated the significant variation between catchments in what can technically and economically be achieved. In many cases, especially on regional groundwater flow systems, regions will have to learn to 'live with salt' as remedial measures to reduce salinity across the whole region could not be justified from a technical, economic or social view point. In such cases, engineering solutions may be justified to protect high value public assets. In other cases, the strategic planting of deep-rooted perennials and consequent changes in land use may have some beneficial effects on a local scale in the longer term. Detailed information on a catchment basis is required before appropriate policy decisions can be made. This includes information on the relative public and private benefits from any remedial actions. In this context, benefits need to include any on-farm benefits as well as all off-farm benefits including environmental benefits. Estimates presented in Chapter 5—including estimates of community willingness to pay for environmental improvements and suggestions for 'benefit transfer'—are a starting point.

Education and changes in attitudes of land managers are an important element in addressing land degradation issues. Attitudes of land managers towards land degradation and the environment have not changed much over the past ten years (Chapter 3) but farmers are generally aware of the extent of land degradation on their farms (Chapter 4). What is less clear is the extent to which they are aware of remedial measures. Farmers generally take a very pragmatic approach to these issues and have a greater chance of adopting those land management practices that are beneficial for the environment where such practices are profitable, their impacts are certain and the practices do not unduly disrupt farming systems. Governments and research institutions have a role in researching better options to address dryland salinity and other land degradation issues. Such options will generally need to be 'tailor made' to particular situations or catchments, as demonstrated by the case studies on dryland salinity.

Land managers will be more effective in addressing land degradation and environmental issues where they are part of regional, industry or catchment plans and strategies or part of community efforts to address these issues (Chapter 7 case studies). Regional issues and problems being faced are often beyond the capacity of individuals to remedy, particularly where significant public assets are at stake. Governments need to act in partnership with local communities and industry to strategically research the issues and options, and plan and implement coordinated action.

Such approaches require sound technical, economic and social data and should take an investment approach to remedial actions.

Technical information on the nature of the problems, their causes and alternative options is vitally important. As the regional case studies show, relying only on land owner opinions on the extent to which they are managing sustainably is likely to lead to underestimation of the actual extent of problems and overestimation of the extent to which landowners are addressing them.

The Audit has made a valuable contribution to collating and assessing information on the state and management of our natural resources. Good baseline information has been laid down but continuous efforts will be needed to implement appropriate follow-up evaluations and monitoring to establish trends that can be used to evaluate future progress on addressing the problems we now face.

Coordinating and formalising data collection, and analysis and reporting of environmental statistics (Box 8.3) could provide the framework and processes required to support the fundamental information needs of a range of government natural resources programs (e.g. Natural Heritage Trust, State of the Environment Reporting, Indicators of Agricultural Sustainability, Headline Sustainability Indicators, National Action Plan for Salinity and Water Quality).

BOX 8.2 IMPROVING AUSTRALIA'S ENVIRONMENTAL REPORTING CAPACITY

Integrating the triple bottom line

At the time the Audit was established there was a general recognition that the systems for collecting and integrating environmental information were in need of enhancement and coordination. Additionally the methods for integrated analysis for the 'triple bottom line' were very poorly defined. The Audit was the first step in redressing these problems, drawing together a wide range of data and expertise. Ongoing structures are needed to ensure assessments of Australia's land and water resources across aspects of the biophysical, social and economic environment can be made regularly, easily and efficiently.

Standards and coordination

Requirements and components of a natural resource information system for Australia are discussed in the *Australian Natural Resource Information 2002* report (NLWRA 2002). One element of this system is the standardisation and coordination of environmental statistics and their integration with other data. Many agencies collect environmental information using a variety of techniques and reporting formats and, while there are many similarities between techniques and formats, there are often differences that can make comparisons difficult. Linking environmental data to economic and social data is still an emerging area and problematic in many cases. The Commonwealth, in partnership with State/Territory agencies, needs to take the lead in improving standardisation and comparability as well as analysis methods.

A potential mechanism

To coordinate and enhance statistical data collection, analysis and dissemination, the Australian Bureau of Statistics has established a number of National Statistical Centres on specific themes (e.g. crime and justice, education and training, Aboriginal and Torres Strait Islander). These centres work through collaborative arrangements between the Australian Bureau of Statistics and Commonwealth, State/ Territory, industry and community stakeholders. The Australian Bureau of Statistics is considering establishing a similar centre for the environment—the National Centre for Environmental Statistics.

Building on existing initiatives for priority issues

If established, the National Centre for Environmental Statistics would aim to complement and enhance the existing environmental statistical activity (e.g. surveys of households, businesses and farms) through an active partnership with the key environment and land management agencies of the Commonwealth, States and Territories as well as other interested organisations. National centres draw on the expertise and experience of other agencies and individuals and set up a management board, which would guide the centre's work to then coordinate analysis and develop priority information products that link biophysical, social and economic data sets.

MEETING AUDIT OBJECTIVES

Australians and Natural Resource Management 2002 reports on the economic and social dimensions of natural resource management. The report serves as both context and an input towards improving our understanding of the triple bottom-line in natural resource management.

Audit objective 1. Providing a clear understanding of the status of, and changes in, the nation's land, vegetation and water resources and implications for their sustainable use by:

- assessing the **economic consequences of change in water and land quality** based on biophysical baselines and trends in Australia's water and land condition.

Audit objective 2. Providing an interpretation of the costs and benefits (economic, environmental and social) of land and water resource use change and any remedial actions by:

- developing methods to **spatially compare economic returns** on production with costs of production, including the costs caused by land degradation;
- estimating **returns to investment in natural resource use as profit at full equity** for Australian agriculture;
- assessing the type and severity of **downstream impacts of dryland salinity on infrastructure and water resources;**
- evaluating the **on-farm production benefits** that would accrue by ameliorating soil acidity and dryland salinity and as a comparison to these two degrading processes, ameliorating soil sodicity, an inherent constraint to production; and
- testing a stated-preference or choices method for calculating **non-market benefits.**

Audit objective 3. Developing a national information system of compatible and readily accessible resource data by:

- compiling Australia-wide data on **social and economic attributes** that characterise rural Australia and provide context for natural resource management activities;
- collating information on **agricultural output, fixed and variable costs of production** used to calculate profit at full equity and provide a benchmark for continued analysis and assessment of trends.
- ensuring this information and underlying **data sets are readily available** with all data compiled in standardised databases and made accessible through the Australian Natural Resources Data Library and presented as information on the Australian Natural Resources Atlas.

8

Audit objective 5. Ensuring integration with, and collaboration between, other relevant initiatives by:

- working in partnership with Australia's leading research, agricultural industry and resource management agencies to deliver value-added outputs from the Audit's work plan;
- assessing the economic feasibility of remedial actions for dryland salinity control at a catchment scale to serve as a key input to priority setting as part of the National Action Plan on Salinity and Water Quality; and
- demonstrating how scientifically based biophysical, economic and social information can be used in priority setting and regional planning under the Natural Heritage Trust across issues such as productivity, water quality, soil acidity, soil erosion and dryland salinity.

Audit objective 6. Providing a framework for monitoring Australia's land and water resources in an ongoing and structured way by:

- demonstrating the application of resource accounting; and
- demonstrating the roles of agribusiness and commodity groups—especially tracking and fostering adoption of sustainable practice.

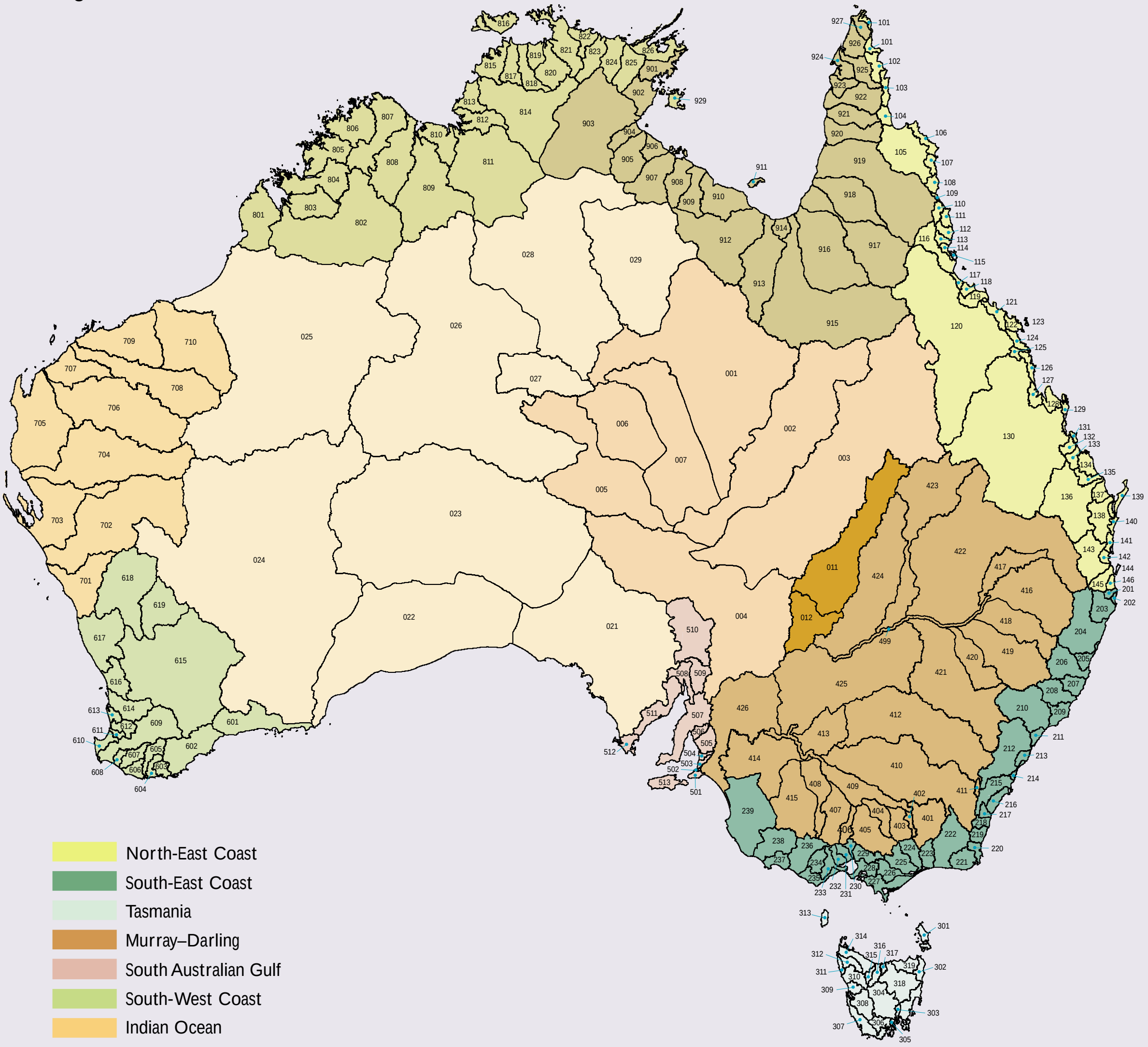
Home
Contents

APPENDIX 1 ECONOMIC DATA BY RIVER BASIN

Key economic parameters

Economic data were compiled on returns to the natural resource base, opportunities associated with soil treatment, and off-site infrastructure damage costs. The following table presents this data by river basin for each State and Territory (Figure A1).

Figure A1 Australian river basins.



- North-East Coast
- South-East Coast
- Tasmania
- Murray–Darling
- South Australian Gulf
- South-West Coast
- Indian Ocean
- Timor Sea
- Gulf of Carpentaria
- Lake Eyre
- Bulloo–Bancannia
- Western Plateau

Source:

National Land and Water Resources Audit 2001.

Data used are assumed to be correct as received from the data suppliers.

Home
Contents

Context

Basin name	basin name
Basin number	unique basin identifier
State	State name
Total area	hectares
Non-agricultural area	hectares
Agricultural area	hectares
Irrigated agricultural area in 1996/97	hectares
Dryland agricultural area in 1996/97	hectares

Revenue, costs, profits and economic returns

1996/97 gross revenue	$'000 per year (1996/97 dollars)
1996/97 variable costs	$'000 per year (1996/97 dollars)
1996/97 fixed costs	$'000 per year (1996/97 dollars)
1996/97 profit at full equity	$'000 per year (1996/97 dollars)
1996/97 government support	$'000 per year (1996/97 dollars)
1996/97 economic returns	$'000 per year (1996/97 dollars)
5 yr (1992/93 – 1996/97) gross revenue	$'000 per year (1996/97 dollars)
5 yr (1992/93 – 1996/97) total costs	$'000 per year (1996/97 dollars)
5 yr (1992/93 – 1996/97) profit at full equity	$'000 per year (1996/97 dollars)
Irrigated agriculture 5 yr profit at full equity	$'000 per year (1996/97 dollars)
Dryland agriculture 5 yr profit at full equity	$'000 per year (1996/97 dollars)
Minimum area of basin needed to produce 80% of profit at full equity within basin[1]	hectares
Ranking of basin in order of contribution to national profit at full equity (#)	rank

Soil constraints and opportunities

Area where lime application, on its own, is the most profitable soil treatment option[2]	hectares
Area where gypsum application, on its own, is the most profitable soil treatment option[2]	hectares
Area where combined lime/gypsum application is the most profitable soil treatment option[2]	hectares
Area where dryland salinity caused yield loss in 2000	hectares
Area where dryland salinity is expected to cause yield loss in 2020	hectares
Maximum gross benefit[3] from ameliorating acidic soils	$'000 per year (1996/97 dollars)
Maximum gross benefit[3] from ameliorating sodic soils	$'000 per year (1996/97 dollars)

1 Not calculated for negative profit at full equity basins. In cases where basins are cut by State or Territory borders, the values can be summed to obtain an estimate for the whole basin.

2 Net present values (NPV) determined from a benefit cost analysis of soil treatments run in perpetuity using a private landholder discount rate of 10%. This was modelled using a 1 km grid. For each 1 km by 1 km grid cell four soil treatments are possible: do nothing; apply lime; apply gypsum; or apply lime and gypsum together.

3 The gross benefit is the increase in profit at full equity attainable if the soil constraint were removed without cost. It provides an approximate investment ceiling for addressing a soil constraint.

Soil constraints and opportunities (continued)	
Maximum gross benefit[3] from ameliorating saline soils	$'000 per year (1996/97 dollars)
Limiting factor[4] gross benefit	$'000 per year (1996/97 dollars)
Impact cost[5] of dryland salinity to agriculture from 2000 to 2020	$'000 per year (1996/97 dollars)
Present value[6] of dryland salinity impact cost to agriculture from 2000 to 2020	$'000 (1996/97 dollars)
Net present value of lime application in areas where lime application is profitable[7]	$'000 (1996/97 dollars)
Net present value of gypsum application in areas where gypsum application is profitable[7]	$'000 (1996/97 dollars)
Net present value of lime and gypsum application in areas where combined lime/gypsum application is profitable[7]	$'000 (1996/97 dollars)
Local infrastructure cost impacts	
Local infrastructure cost of salinity and water table rise 2000	$'000 per year (1996/97 dollars)
Local infrastructure cost of salinity and water table rise 2020	$'000 per year (1996/97 dollars)
Present value[5] of local infrastructure costs from salinity and rising water tables from 2000 to 2020	$'000 (1996/97 dollars)
Present value of downstream infrastructure cost impacts[8]	
• 1% increase in salt loads	$'000 (1996/97 dollars)
• 5% increase in salt loads	$'000 (1996/97 dollars)
• 10% increase in salt loads	$'000 (1996/97 dollars)
• 1% increase in turbidity	$'000 (1996/97 dollars)
• 5% increase in turbidity	$'000 (1996/97 dollars)
• 10% increase in turbidity	$'000 (1996/97 dollars)
• 1% increase in sediment loads	$'000 (1996/97 dollars)
• 5% increase in sediment loads	$'000 (1996/97 dollars)
• 10% increase in sediment loads	$'000 (1996/97 dollars)

3 The gross benefit is the increase in profit at full equity attainable if the soil constraint were removed without cost. It provides an approximate investment ceiling for addressing a soil constraint.

4 For each grid cell, the limiting factor gross benefit is determined from the minimum relative yield of sodicity, acidity and salinity. As such it is not equal to the sum of gross benefits associated with each soil constraint. It is the total gross benefit attainable if all soil constraints were treated without cost. It is an approximation of an investment ceiling on combined treatment of sodic, acidic and saline soils.

5 Impact cost is the expected decline in profit at full equity due to increasing extent and severity of dryland salinity over time.

6 Determined using a discount rate of 5%.

7 Net present values determined from a benefit cost analysis of soil treatments run in perpetuity using a private landholder discount rate of 10%. This was modelled using a 1 km grid. For each 1 km by 1 km grid cell four soil treatments are possible: do nothing; apply lime; apply gypsum; or apply lime and gypsum together. The net present value is summed only for areas where the given soil treatment option performs better than all other soil treatment options.

8 Present values of downstream costs are determined from assumed national increases in river/stream salinity, turbidity and sediment loads. A 5% discount rate is used over a period of 20 years, 2000 to 2020.

Basin number	410	3	4	11
Basin name	Murrumbidgee River	Cooper Creek	Lake Frome	Bulloo River
State name	ACT	NSW	NSW	NSW
CONTEXT				
Total area (ha)	235 985	67 797	1 943 931	2 047 591
Non-agricultural area (ha)	203 337	67 365	169 406	219 399
Agricultural area (ha)	32 648	432	1 774 525	1 828 192
Irrigated agricultural area in 1996/97 (ha)				
Dryland agricultural area in 1996/97 (ha)	32 648	432	1 774 525	1 828 192
PROFIT				
1996/97 gross revenue ($'000)	4 460	2	7 266	6 641
1996/97 variable costs ($'000)	720	0	987	1 084
1996/97 fixed costs ($'000)	3 136	2	8 586	8 481
1996/97 profit at full equity ($'000)	604	-1	-2 307	-2 924
1996/97 government support ($'000)	280	0	279	260
1996/97 economic returns ($'000)	324	-1	-2 586	-3 184
5 yr (1992/93 – 1996/97) gross revenue ($'000)	6 014	2	8 172	8 002
5 yr (1992/93 – 1996/97) total costs ($'000)	3 870	2	9 567	9 555
5 yr (1992/93 – 1996/97) profit at full equity ($'000)	2 143	-1	-1 395	-1 552
Irrigated agriculture 5 yr profit at full equity ($'000)				
Dryland agriculture 5 yr profit at full equity ($'000)	2 143	-1	-1 395	-1 552
Minimum area of basin needed to produce 80% of profit at full equity within basin (ha)	1 216			
Ranking of basin in order of contribution to national 1996/97 profit at full equity (#)	160	177	234	239
AGRICULTURAL COSTS				
Area where NPV of lime application is positive (ha)	302			
Area where NPV of gypsum application is positive (ha)				
Area where NPV of lime and gypsum application is positive (ha)				
Area where dryland salinity caused yield loss in 2000 (ha)				
Area where dryland salinity may cause yield loss in 2020 (ha)	65			
Gross benefit from ameliorating acidic soils ($'000)	172			0
Gross benefit from ameliorating sodic soils ($'000)	46	0	67	83
Gross benefit from ameliorating saline soils ($'000)				
Limiting factor gross benefit ($'000)	181	0	67	83
Impact cost of dryland salinity to agriculture from 2000 to 2020 ($'000)				
Present value of dryland salinity impact cost to agriculture from 2000 to 2020 ($'000)				
Net present value of lime application ($'000)	245			
Net present value of gypsum application ($'000)				
Net present value of lime and gypsum application ($'000)				
OFF-SITE COSTS				
Local infrastructure cost of salinity and water table rise 2000 ($'000/yr)	0			
Local infrastructure cost of salinity and water table rise 2020 ($'000/yr)	10			
Present value of increase in local infrastructure costs from salinity and rising water tables from 2000 to 2020 ($'000)	54			
Downstream costs				
1% increase in salt loads ($'000)				
5% increase in salt loads ($'000)				
10% increase in salt loads ($'000)				
1% increase in turbidity ($'000)	6 782			
5% increase in turbidity ($'000)	7 590			
10% increase in turbidity ($'000)	8 564			
1% increase in sediment loads ($'000)	256			
5% increase in sediment loads ($'000)	411			
10% increase in sediment loads ($'000)	606			

Where basins run over State or Territory boundaries, values are only provided for the portion of the indicated State or Territory. The total

12 Lake Bancannia NSW	201 Tweed River NSW	202 Brunswick River NSW	203 Richmond River NSW	204 Clarence River NSW	205 Bellinger River NSW	206 Macleay River NSW	207 Hastings River NSW	208 Manning River NSW
2 328 905	107 784	51 552	702 470	2 227 981	346 954	1 139 094	452 239	817 645
182 007	48 883	17 041	310 165	1 429 927	238 562	537 827	332 728	499 937
2 146 898	58 900	34 511	392 304	798 053	108 392	601 267	119 511	317 708
	1 847	4 341	16 761	4 947	5 748	742	2 424	4 616
2 146 898	57 054	30 170	375 543	793 106	102 644	600 525	117 086	313 092
8 414	59 922	51 567	233 183	168 729	71 453	96 437	63 103	108 243
1 228	35 676	23 156	88 877	60 475	32 099	18 201	19 119	33 327
10 213	16 751	16 800	86 651	79 646	27 824	58 631	25 067	49 823
-3 026	7 496	11 610	57 656	28 607	11 530	19 605	18 917	25 094
326	4 052	2 997	20 260	14 777	9 341	7 576	12 468	20 481
-3 352	3 444	8 614	37 395	13 830	2 189	12 029	6 449	4 613
9 776	66 769	54 459	267 642	225 694	73 303	122 559	64 309	116 759
11 431	55 342	41 223	185 422	146 785	59 341	76 545	43 976	82 619
-1 655	11 427	13 235	82 219	78 909	13 962	46 014	20 333	34 141
	563	7 954	29 443	6 594	3 216	403	2 453	4 378
-1 655	10 864	5 281	52 776	72 315	10 746	45 611	17 880	29 763
	8 803	4 450	37 677	34 072	8 305	144 882	20 324	32 326
240	106	91	27	52	92	64	65	56
	19 781	11 833	60 368	37 541	21 708	19 007	29 372	51 439
			109	216			105	
	217		9 093	11 544	2 768	318	2 845	5 564
	14	14	265	210	28			91
	32	32	607	480	64			209
0	5 577	25 249	22 140	10 208	11 029	3 284	5 938	5 700
156	12	0	1 031	2 818	332	1 082	343	620
	1	18	15	5	2			2
156	5 577	25 250	22 328	11 063	11 029	3 665	6 032	5 738
	3	27	38	8	8			4
	18	151	212	46	44			21
	48 707	248 314	182 050	49 304	81 726	11 548	47 657	31 221
			6	55			704	
	346		8 658	11 761	20 163	97	1 242	3 196
	1	1	7	20	15			2
	3	3	16	46	33			5
	8	10	50	144	105			16
	193	4	49	197	5	80	58	50
	414	19	118	524	26	395	283	244
	681	37	205	917	52	773	556	478
	34		0	32		97	3	4
	169		0	159		278	13	19
	339		0	318		504	25	37

value for a river basin can be obtained by summing the component State and Territory river basin parts.

Home

Contents

	Basin number	209	210	211	212
	Basin name	Karuah River	Hunter River	Macquarie-Tuggerah Lakes	Hawkesbury River
	State name	NSW	NSW	NSW	NSW
CONTEXT	**Total area (ha)**	437 984	2 143 286	157 793	2 196 447
	Non-agricultural area (ha)	297 823	801 991	120 447	1 383 488
	Agricultural area (ha)	140 161	1 341 295	37 346	812 959
	Irrigated agricultural area in 1996/97 (ha)	942	34 731	310	11 893
	Dryland agricultural area in 1996/97 (ha)	139 218	1 306 564	37 035	801 066
PROFIT	**1996/97 gross revenue ($'000)**	32 228	331 752	10 689	204 410
	1996/97 variable costs ($'000)	10 344	107 470	3 353	68 902
	1996/97 fixed costs ($'000)	17 708	176 347	5 463	117 775
	1996/97 profit at full equity ($'000)	4 176	47 935	1 873	17 732
	1996/97 government support ($'000)	6 015	48 122	1 629	31 449
	1996/97 economic returns ($'000)	-1 839	-187	244	-13 716
	5 yr (1992/93 – 1996/97) gross revenue ($'000)	34 887	363 890	5 380	177 887
	5 yr (1992/93 – 1996/97) total costs ($'000)	27 802	280 473	4 596	155 179
	5 yr (1992/93 – 1996/97) profit at full equity ($'000)	7 086	83 416	784	22 708
	Irrigated agriculture 5 yr profit at full equity ($'000)	718	36 684	1 833	24 801
	Dryland agriculture 5 yr profit at full equity ($'000)	6 367	46 732	-1 049	-2 093
	Minimum area of basin needed to produce 80% of profit at full equity within basin (ha)	5 431	30 148		1 030
	Ranking of basin in order of contribution to national 1996/97 profit at full equity (#)	124	33	139	70
AGRICULTURAL COSTS	**Area where NPV of lime application is positive (ha)**	14 838	71 488	2 069	71 689
	Area where NPV of gypsum application is positive (ha)	104	12 517		
	Area where NPV of lime and gypsum application is positive (ha)	2 089	21 371	3 417	24 060
	Area where dryland salinity caused yield loss in 2000 (ha)		20 473		4 264
	Area where dryland salinity may cause yield loss in 2020 (ha)		46 796		9 786
	Gross benefit from ameliorating acidic soils ($'000)	1 886	43 055	3 616	35 164
	Gross benefit from ameliorating sodic soils ($'000)	361	6 791	446	2 693
	Gross benefit from ameliorating saline soils ($'000)		1 572		450
	Limiting factor gross benefit ($'000)	1 990	45 260	3 637	35 450
	Impact cost of dryland salinity to agriculture from 2000 to 2020 ($'000)		3 123		908
	Present value of dryland salinity impact cost to agriculture from 2000 to 2020 ($'000)		17 325		5 035
	Net present value of lime application ($'000)	10 077	92 590	2 109	220 781
	Net present value of gypsum application ($'000)	157	4 094		
	Net present value of lime and gypsum application ($'000)	1 803	292 206	31 695	78 195
OFF-SITE COSTS	**Local infrastructure cost of salinity and water table rise 2000 ($'000/yr)**		5 498		3 941
	Local infrastructure cost of salinity and water table rise 2020 ($'000/yr)		12 566		9 009
	Present value of increase in local infrastructure costs from salinity and rising water tables from 2000 to 2020 ($'000)		39 211		28 114
	Downstream costs				
	1% increase in salt loads ($'000)				
	5% increase in salt loads ($'000)				
	10% increase in salt loads ($'000)				
	1% increase in turbidity ($'000)	26	173	3 794	686
	5% increase in turbidity ($'000)	129	850	4 224	3 367
	10% increase in turbidity ($'000)	258	1 661	4 746	6 583
	1% increase in sediment loads ($'000)		1 252	5	2 207
	5% increase in sediment loads ($'000)		3 940	26	7 303
	10% increase in sediment loads ($'000)		7 301	53	13 673

Where basins run over State or Territory boundaries, values are only provided for the portion of the indicated State or Territory. The total

Home

Contents

Home
Contents

213 Sydney Coast- Georges River NSW	214 Wollongong Coast NSW	215 Shoalhaven River NSW	216 Clyde River- Jervis Bay NSW	217 Moruya River NSW	218 Tuross River NSW	219 Bega River NSW	220 Towamba River NSW	221 East Gippsland NSW
173 502	79 239	720 531	322 023	148 250	216 077	283 809	215 505	114 844
149 924	49 209	414 638	293 175	129 494	182 956	183 669	196 238	111 693
23 577	30 029	305 893	28 848	18 756	33 121	100 139	19 267	3 151
613	305	1 522	808		997	7 447	692	99
22 964	29 724	304 371	28 040	18 756	32 124	92 692	18 576	3 053
7 755	26 180	69 713	24 016	7 904	15 323	84 036	9 394	1 203
2 756	8 553	19 210	6 980	2 326	4 480	23 883	2 695	322
4 046	10 258	40 558	8 150	3 159	5 947	26 575	3 445	451
953	7 369	9 946	8 885	2 418	4 897	33 577	3 253	429
1 445	5 652	11 532	5 080	1 542	2 662	17 629	1 839	226
-491	1 717	-1 586	3 805	877	2 235	15 947	1 415	203
5 513	21 757	74 542	23 334	7 694	15 698	84 915	10 191	1 383
4 675	16 184	59 536	15 054	5 407	10 368	50 339	6 140	774
838	5 573	15 006	8 280	2 287	5 330	34 576	4 051	610
1 359	357	1 582	760		1 723	9 959	768	135
-521	5 217	13 424	7 520	2 287	3 607	24 616	3 283	474
511	9 969	10 059	9 595	2 905	3 894	30 607	3 261	321
152	107	97	101	135	121	48	127	164
3 585	16 690	24 980	7 657	3 706	6 185	40 316	4 347	197
924		2 940	5 060	100	300		98	296
56				42	14	14		
128				96	32	32		
3 421	3 422	8 234	2 387	550	2 745	5 413	618	105
43	0	861	774	11	29		10	41
0				4	5			
3 421	3 422	8 277	2 478	550	2 746	5 413	618	107
0				11	10			
2				59	54			
32 032	28 119	57 571	11 673	4 001	24 612	44 072	4 294	375
671		3 498	7 802	78	114		79	308
56				3	2	1		
129				6	4	1		
403				19	14	4		
	8	15	40	4	22	19	19	6
	39	73	197	19	109	95	93	28
	79	144	385	37	215	186	182	56
	12	1	1		0	17	0	
	29	2	4		2	18	1	
	51	4	8		4	20	2	

value for a river basin can be obtained by summing the component State and Territory river basin parts.

Home
Contents

Basin number	222	401	409	410
Basin name	Snowy River	Upper Murray River	Murray-Riverina	Murrumbidgee River
State name	NSW	NSW	NSW	NSW
CONTEXT				
Total area (ha)	893 897	521 020	1 504 147	7 926 983
Non-agricultural area (ha)	407 938	309 908	122 267	1 082 666
Agricultural area (ha)	485 959	211 112	1 381 880	6 844 317
Irrigated agricultural area in 1996/97 (ha)	199	601	214 593	313 318
Dryland agricultural area in 1996/97 (ha)	485 760	210 511	1 167 287	6 530 998
PROFIT				
1996/97 gross revenue ($'000)	41 438	41 999	506 700	1 605 301
1996/97 variable costs ($'000)	8 217	11 471	226 110	666 390
1996/97 fixed costs ($'000)	50 341	17 440	162 753	571 492
1996/97 profit at full equity ($'000)	-17 120	13 089	117 837	367 419
1996/97 government support ($'000)	1 729	3 043	61 512	85 967
1996/97 economic returns ($'000)	-18 848	10 045	56 326	281 452
5 yr (1992/93 – 1996/97) gross revenue ($'000)	50 209	52 568	504 964	1 647 881
5 yr (1992/93 – 1996/97) total costs ($'000)	58 578	29 149	385 297	1 231 632
5 yr (1992/93 – 1996/97) profit at full equity ($'000)	-8 369	23 420	119 667	416 248
Irrigated agriculture 5 yr profit at full equity ($'000)	552	1 801	113 506	298 680
Dryland agriculture 5 yr profit at full equity ($'000)	-8 921	21 618	6 161	117 568
Minimum area of basin needed to produce 80% of profit at full equity within basin (ha)		61 233	82 226	254 947
Ranking of basin in order of contribution to national 1996/97 profit at full equity (#)	255	87	19	3
AGRICULTURAL COSTS				
Area where NPV of lime application is positive (ha)	498	11 621	4 406	176 601
Area where NPV of gypsum application is positive (ha)		1 500	213 278	201 374
Area where NPV of lime and gypsum application is positive (ha)		1 400	1 804	17 925
Area where dryland salinity caused yield loss in 2000 (ha)	21	224	3 760	15 010
Area where dryland salinity may cause yield loss in 2020 (ha)	48	1 439	30 927	78 061
Gross benefit from ameliorating acidic soils ($'000)	1 135	7 096	1 031	79 024
Gross benefit from ameliorating sodic soils ($'000)	666	861	42 987	55 443
Gross benefit from ameliorating saline soils ($'000)	1	8	729	880
Limiting factor gross benefit ($'000)	1 621	7 363	43 389	126 889
Impact cost of dryland salinity to agriculture from 2000 to 2020 ($'000)	1	62	5 994	5 853
Present value of dryland salinity impact cost to agriculture from 2000 to 2020 ($'000)	5	343	33 255	32 469
Net present value of lime application ($'000)	4 170	44 261	1 363	457 202
Net present value of gypsum application ($'000)		40	266 613	175 573
Net present value of lime and gypsum application ($'000)		1 609	4 739	149 079
OFF-SITE COSTS				
Local infrastructure cost of salinity and water table rise 2000 ($'000/yr)	1	6	301	2 153
Local infrastructure cost of salinity and water table rise 2020 ($'000/yr)	1	150	2 250	7 339
Present value of increase in local infrastructure costs from salinity and rising water tables from 2000 to 2020 ($'000)	4	802	10 811	28 773
Downstream costs				
1% increase in salt loads ($'000)			8 915	
5% increase in salt loads ($'000)			44 575	
10% increase in salt loads ($'000)			89 151	
1% increase in turbidity ($'000)	208	65	51 034	22 291
5% increase in turbidity ($'000)	332	152	58 227	23 568
10% increase in turbidity ($'000)	484	259	67 154	25 113
1% increase in sediment loads ($'000)	2	31	549	3 240
5% increase in sediment loads ($'000)	12	34	630	3 511
10% increase in sediment loads ($'000)	23	36	732	3 848

Where basins run over State or Territory boundaries, values are only provided for the portion of the indicated State or Territory. The total

411 Lake George NSW	412 Lachlan River NSW	413 Benanee NSW	416 Border Rivers NSW	417 Moonie River NSW	418 Gwydir River NSW	419 Namoi River NSW	420 Castlereagh River NSW	421 Macquarie-Bogan Rivers NSW
94 055	9 089 181	2 136 359	2 450 100	41 956	2 659 640	4 199 623	1 742 367	7 480 182
29 723	777 150	394 224	539 560		427 917	752 710	164 165	485 631
64 332	8 312 031	1 742 135	1 910 541	41 956	2 231 724	3 446 913	1 578 201	6 994 551
	84 474	5 827	55 793	647	80 142	99 170	528	62 800
64 332	8 227 557	1 736 308	1 854 747	41 309	2 151 581	3 347 743	1 577 673	6 931 751
5 157	997 172	93 625	650 407	4 077	900 608	1 000 539	243 943	1 074 145
1 086	369 390	23 673	288 433	2 177	402 139	410 005	77 914	421 159
6 323	499 471	23 432	168 593	2 713	202 579	267 089	114 776	462 359
-2 252	128 311	46 521	193 381	-813	295 890	323 444	51 253	190 628
210	50 348	5 070	23 989	160	31 100	43 139	13 587	50 574
-2 462	77 963	41 451	169 392	-972	264 790	280 305	37 666	140 054
6 275	999 220	97 671	571 833	3 894	796 916	1 049 351	266 349	1 025 416
7 393	862 868	47 230	432 829	4 839	571 422	668 494	191 539	866 041
-1 117	136 351	50 441	139 004	-945	225 494	380 857	74 810	159 375
	61 654	40 679	96 771	453	177 002	190 587	707	134 569
-1 117	74 697	9 763	42 233	-1 398	48 492	190 270	74 103	24 806
	259 492	3 886	129 050	3 849	71 882	151 391	97 558	38 105
232	17	34	7	209	6	4	30	9
808	118 064		34 571		18 077	15 089	210	42 253
	108 900	4 396	59 799	108	180 057	171 736	52 192	36 611
	7 672		323		107	1 058		7 698
86	16 154	51	511			1 672	1 358	24 534
261	41 492	194	5 672			4 328	5 610	59 126
190	30 134		9 547	2	3 910	3 171	492	42 796
165	30 952	5 150	20 653	120	31 748	29 599	7 833	19 234
3	1 046	56	2			132	64	1 331
226	55 087	5 150	29 630	122	35 121	31 484	8 217	58 887
6	2 322	186	102			320	185	2 925
32	12 881	1 035	565			1 777	1 024	16 226
113	102 435		72 299		21 991	2 488	6	136 579
	41 080	35 271	90 429	173	163 807	142 580	8 217	32 096
	66 526		101		24	191		220 976
2	653	100	1			133	40	1 147
79	1 791	181	47			308	337	3 715
428	6 311	446	252			971	1 653	14 244
	1 379					613		1 966
	6 894					3 065		9 831
	13 787					6 130		19 661
	14 232		5 367		3 742	6 645	3 678	10 084
	14 916		7 169		4 892	7 776	3 922	10 823
	15 754		9 415		6 326	9 181	4 220	11 723
	19		9		8	2 029	4	3 410
	96		47		39	2 138	22	3 638
	193		95		79	2 275	43	3 922

value for a river basin can be obtained by summing the component State and Territory river basin parts.

	Basin number	422	423	424	425
	Basin name	Condamine-Culgoa Rivers	Warrego River	Paroo River	Darling River
	State name	NSW	NSW	NSW	NSW
CONTEXT	**Total area (ha)**	2 604 164	1 127 023	4 052 256	11 283 322
	Non-agricultural area (ha)	88 363	29 070	292 621	676 032
	Agricultural area (ha)	2 515 802	1 097 954	3 759 635	10 607 290
	Irrigated agricultural area in 1996/97 (ha)	2 043	2 458	10 054	9 063
	Dryland agricultural area in 1996/97 (ha)	2 513 758	1 095 496	3 749 582	10 598 227
PROFIT	**1996/97 gross revenue ($'000)**	80 798	29 199	51 350	121 831
	1996/97 variable costs ($'000)	34 810	11 399	19 253	40 216
	1996/97 fixed costs ($'000)	69 108	6 003	19 024	71 037
	1996/97 profit at full equity ($'000)	-23 120	11 798	13 073	10 578
	1996/97 government support ($'000)	3 467	851	1 601	5 110
	1996/97 economic returns ($'000)	-26 587	10 947	11 472	5 467
	5 yr (1992/93 – 1996/97) gross revenue ($'000)	78 561	34 345	53 372	144 819
	5 yr (1992/93 – 1996/97) total costs ($'000)	103 480	18 607	37 709	112 653
	5 yr (1992/93 – 1996/97) profit at full equity ($'000)	-24 919	15 739	15 663	32 166
	Irrigated agriculture 5 yr profit at full equity ($'000)	2 279	13 711	11 419	29 451
	Dryland agriculture 5 yr profit at full equity ($'000)	-27 198	2 028	4 243	2 715
	Minimum area of basin needed to produce 80% of profit at full equity within basin (ha)	47 010	400	1 443	614
	Ranking of basin in order of contribution to national 1996/97 profit at full equity (#)	257	90	88	94
AGRICULTURAL COSTS	**Area where NPV of lime application is positive (ha)**	107			1 277
	Area where NPV of gypsum application is positive (ha)	860	320	5 712	3 854
	Area where NPV of lime and gypsum application is positive (ha)		2 031		320
	Area where dryland salinity caused yield loss in 2000 (ha)				10
	Area where dryland salinity may cause yield loss in 2020 (ha)				50
	Gross benefit from ameliorating acidic soils ($'000)	72	154	5	186
	Gross benefit from ameliorating sodic soils ($'000)	4 172	917	4 086	6 980
	Gross benefit from ameliorating saline soils ($'000)				0
	Limiting factor gross benefit ($'000)	4 193	926	4 090	7 143
	Impact cost of dryland salinity to agriculture from 2000 to 2020 ($'000)				0
	Present value of dryland salinity impact cost to agriculture from 2000 to 2020 ($'000)				0
	Net present value of lime application ($'000)	21			129
	Net present value of gypsum application ($'000)	1 162	1 007	30 703	25 956
	Net present value of lime and gypsum application ($'000)		4 730		567
OFF-SITE COSTS	**Local infrastructure cost of salinity and water table rise 2000 ($'000/yr)**				0
	Local infrastructure cost of salinity and water table rise 2020 ($'000/yr)				18
	Present value of increase in local infrastructure costs from salinity and rising water tables from 2000 to 2020 ($'000)				99
	Downstream costs				
	1% increase in salt loads ($'000)	31			775
	5% increase in salt loads ($'000)	153			3 875
	10% increase in salt loads ($'000)	307			7 750
	1% increase in turbidity ($'000)	2 800	4	4	10 643
	5% increase in turbidity ($'000)	5 833	19	19	12 606
	10% increase in turbidity ($'000)	9 622	37	37	15 049
	1% increase in sediment loads ($'000)	0			68
	5% increase in sediment loads ($'000)	2			98
	10% increase in sediment loads ($'000)	4			135

Where basins run over State or Territory boundaries, values are only provided for the portion of the indicated State or Territory. The total

Home
Contents

426	1	5	6	7	26	27	28	29
Lower Murray River	Georgina River	Finke River	Todd River	Hay River	Mackay	Burt	Wiso	Barkly
NSW	NT	NT	NT	NT	NT	NT	NT	NT
895 080	9 967 809	4 374 942	5 963 150	6 266 412	21 556 782	3 879 707	22 931 960	12 400 363
89 175	1 042 949	983 453	1 749 470	3 443 338	16 064 767	1 332 179	13 286 078	2 966 063
805 905	8 924 860	3 391 489	4 213 680	2 823 074	5 492 016	2 547 528	9 645 882	9 434 300
							118	
805 905	8 924 860	3 391 489	4 213 680	2 823 074	5 492 016	2 547 528	9 645 764	9 434 300
4 889	15 770	3 205	5 133	3 760	7 833	2 753	25 907	31 574
1 677	7 027	2 406	3 098	2 106	4 147	1 840	8 750	8 838
4 278	6 899	2 622	3 257	2 182	4 245	1 969	7 766	7 292
-1 065	1 845	-1 823	-1 222	-529	-559	-1 056	9 391	15 444
205	710	144	231	169	352	124	1 145	1 421
-1 270	1 135	-1 967	-1 453	-698	-912	-1 180	8 246	14 023
6 345	14 968	3 235	4 771	3 765	8 001	3 007	24 526	27 610
5 949	13 793	5 018	6 303	4 275	8 378	3 822	16 298	15 651
396	1 175	-1 784	-1 532	-510	-376	-815	8 229	11 960
							571	
396	1 175	-1 784	-1 532	-510	-376	-815	7 658	11 960
4 699	23 865						2 508 477	5 379 087
214	141	225	218	198	203	213	99	77
2								
22								
					1		1	
159	474	15	4	4	48	16	189	1 545
159	474	15	4	4	48	16	190	1 545
0								
0								
0								
0								
0								

value for a river basin can be obtained by summing the component State and Territory river basin parts.

Home
Contents

Home

Contents

Basin number	809	810	811	812
Basin name	Ord River	Keep River	Victoria River	Fitzmaurice River
State name	NT	NT	NT	NT
CONTEXT				
Total area (ha)	1 125 896	594 223	7 812 695	1 036 549
Non-agricultural area (ha)	4 142	138 766	1 860 921	629 400
Agricultural area (ha)	1 121 754	455 457	5 951 774	407 148
Irrigated agricultural area in 1996/97 (ha)				
Dryland agricultural area in 1996/97 (ha)	1 121 754	455 457	5 951 774	407 148
PROFIT				
1996/97 gross revenue ($'000)	3 798	1 832	20 251	1 599
1996/97 variable costs ($'000)	1 055	553	5 608	404
1996/97 fixed costs ($'000)	867	355	4 601	315
1996/97 profit at full equity ($'000)	1 875	924	10 043	880
1996/97 government support ($'000)	171	82	911	72
1996/97 economic returns ($'000)	1 704	842	9 131	809
5 yr (1992/93 – 1996/97) gross revenue ($'000)	3 740	1 806	19 940	1 575
5 yr (1992/93 – 1996/97) total costs ($'000)	1 903	899	10 104	710
5 yr (1992/93 – 1996/97) profit at full equity ($'000)	1 837	906	9 837	865
Irrigated agriculture 5 yr profit at full equity ($'000)				
Dryland agriculture 5 yr profit at full equity ($'000)	1 837	906	9 837	865
Minimum area of basin needed to produce 80% of profit at full equity within basin (ha)	683	142 347	4 286 031	289 401
Ranking of basin in order of contribution to national 1996/97 profit at full equity (#)	138	155	96	156
AGRICULTURAL COSTS				
Area where NPV of lime application is positive (ha)		119		
Area where NPV of gypsum application is positive (ha)				
Area where NPV of lime and gypsum application is positive (ha)				
Area where dryland salinity caused yield loss in 2000 (ha)				
Area where dryland salinity may cause yield loss in 2020 (ha)				
Gross benefit from ameliorating acidic soils ($'000)	57	93	336	104
Gross benefit from ameliorating sodic soils ($'000)	27	13	328	2
Gross benefit from ameliorating saline soils ($'000)				
Limiting factor gross benefit ($'000)	77	98	635	106
Impact cost of dryland salinity to agriculture from 2000 to 2020 ($'000)				
Present value of dryland salinity impact cost to agriculture from 2000 to 2020 ($'000)				
Net present value of lime application ($'000)		383		
Net present value of gypsum application ($'000)				
Net present value of lime and gypsum application ($'000)				
OFF-SITE COSTS				
Local infrastructure cost of salinity and water table rise 2000 ($'000/yr)				
Local infrastructure cost of salinity and water table rise 2020 ($'000/yr)				
Present value of increase in local infrastructure costs from salinity and rising water tables from 2000 to 2020 ($'000)				
Downstream costs				
1% increase in salt loads ($'000)				
5% increase in salt loads ($'000)				
10% increase in salt loads ($'000)				
1% increase in turbidity ($'000)				
5% increase in turbidity ($'000)				
10% increase in turbidity ($'000)				
1% increase in sediment loads ($'000)				
5% increase in sediment loads ($'000)				
10% increase in sediment loads ($'000)				

Where basins run over State or Territory boundaries, values are only provided for the portion of the indicated State or Territory. The total

Home

Contents

	813 Moyle River NT	814 Daly River NT	815 Finniss River NT	817 Adelaide River NT	818 Mary River NT	819 Wildman River NT	820 South Alligator River NT	821 East Alligator River NT	903 Roper River NT
	708 989	5 320 643	950 147	746 769	807 347	480 864	1 192 143	1 587 130	7 962 037
	708 750	1 953 347	600 838	283 526	337 893	388 610	1 188 903	1 583 164	3 012 277
	239	3 367 296	349 309	463 243	469 454	92 254	3 240	3 966	4 949 760
			601	120					
	239	3 367 296	348 708	463 123	469 454	92 254	3 240	3 966	4 949 760
	1	12 633	10 137	1 859	1 834	446	16	19	11 156
	0	3 284	2 124	463	465	99	4	4	4 125
	0	2 603	1 570	358	363	71	3	3	3 826
	1	6 746	6 444	1 038	1 007	276	10	11	3 205
	0	568	383	84	83	20	1	1	502
	1	6 178	6 061	954	924	255	10	10	2 703
	1	12 455	5 806	1 918	2 000	404	15	17	9 612
	0	5 823	3 626	820	836	165	6	7	7 769
	1	6 632	2 180	1 099	1 164	239	9	10	1 843
			-174						
	1	6 632	2 354	1 099	1 164	239	9	10	1 843
	239	2 288 722	92 288	306 708	325 993	70 155	2 520	2 764	1 680 562
	176	108	110	150	151	166	174	173	128
			601						
	0	607	56 404	283	229	83	1	2	1
		110	27	23	19	3	0	0	63
	0	684	56 413	283	230	83	1	2	64
			555 664						

value for a river basin can be obtained by summing the component State and Territory river basin parts.

Section	Basin number	904	905	906	907
	Basin name	Towns River	Limmen Bight River	Rosie River	Mcarthur River
	State name	NT	NT	NT	NT
CONTEXT	**Total area (ha)**	543 712	1 593 358	504 535	2 002 612
	Non-agricultural area (ha)	191 746	205 238	95 297	246 028
	Agricultural area (ha)	351 967	1 388 120	409 238	1 756 584
	Irrigated agricultural area in 1996/97 (ha)				
	Dryland agricultural area in 1996/97 (ha)	351 967	1 388 120	409 238	1 756 584
PROFIT	**1996/97 gross revenue ($'000)**	126	733	151	1 535
	1996/97 variable costs ($'000)	230	930	268	1 234
	1996/97 fixed costs ($'000)	272	1 073	316	1 357
	1996/97 profit at full equity ($'000)	-376	-1 270	-433	-1 056
	1996/97 government support ($'000)	6	33	7	69
	1996/97 economic returns ($'000)	-381	-1 303	-440	-1 125
	5 yr (1992/93 – 1996/97) gross revenue ($'000)	173	844	206	1 568
	5 yr (1992/93 – 1996/97) total costs ($'000)	506	2 010	588	2 588
	5 yr (1992/93 – 1996/97) profit at full equity ($'000)	-333	-1 167	-383	-1 020
	Irrigated agriculture 5 yr profit at full equity ($'000)				
	Dryland agriculture 5 yr profit at full equity ($'000)	-333	-1 167	-383	-1 020
	Minimum area of basin needed to produce 80% of profit at full equity within basin (ha)				
	Ranking of basin in order of contribution to national 1996/97 profit at full equity (#)	194	219	195	212
AGRICULTURAL COSTS	**Area where NPV of lime application is positive (ha)**				
	Area where NPV of gypsum application is positive (ha)				
	Area where NPV of lime and gypsum application is positive (ha)				
	Area where dryland salinity caused yield loss in 2000 (ha)				
	Area where dryland salinity may cause yield loss in 2020 (ha)				
	Gross benefit from ameliorating acidic soils ($'000)				
	Gross benefit from ameliorating sodic soils ($'000)		1		4
	Gross benefit from ameliorating saline soils ($'000)				
	Limiting factor gross benefit ($'000)		1		4
	Impact cost of dryland salinity to agriculture from 2000 to 2020 ($'000)				
	Present value of dryland salinity impact cost to agriculture from 2000 to 2020 ($'000)				
	Net present value of lime application ($'000)				
	Net present value of gypsum application ($'000)				
	Net present value of lime and gypsum application ($'000)				
OFF-SITE COSTS	**Local infrastructure cost of salinity and water table rise 2000 ($'000/yr)**				
	Local infrastructure cost of salinity and water table rise 2020 ($'000/yr)				
	Present value of increase in local infrastructure costs from salinity and rising water tables from 2000 to 2020 ($'000)				
	Downstream costs				
	1% increase in salt loads ($'000)				
	5% increase in salt loads ($'000)				
	10% increase in salt loads ($'000)				
	1% increase in turbidity ($'000)				
	5% increase in turbidity ($'000)				
	10% increase in turbidity ($'000)				
	1% increase in sediment loads ($'000)				
	5% increase in sediment loads ($'000)				
	10% increase in sediment loads ($'000)				

Where basins run over State or Territory boundaries, values are only provided for the portion of the indicated State or Territory. The total

908 Robinson River NT	909 Calvert River NT	910 Settlement Creek NT	912 Nicholson River NT	1 Georgina River QLD	2 Diamantina River QLD	3 Cooper Creek QLD	4 Lake Frome QLD	11 Bulloo River QLD
1 136 765	1 004 329	549 355	1 575 426	14 423 009	11 912 660	24 384 108	15 239	5 507 137
83 751	149 673	17 300	946 343	890 037	1 087 105	1 169 250	108	361 168
1 053 013	854 657	532 055	629 083	13 532 972	10 825 555	23 214 858	15 131	5 145 970
						113		
1 053 013	854 657	532 055	629 083	13 532 972	10 825 555	23 214 745	15 131	5 145 970
439	445	225	2 429	54 828	38 945	149 928	60	23 002
694	572	351	620	11 345	8 044	20 710	13	3 846
814	661	411	486	44 056	56 855	165 786	43	28 182
-1 069	-787	-537	1 323	-574	-25 954	-36 569	4	-9 027
20	20	10	109	2 448	1 643	6 359	3	974
-1 089	-807	-547	1 214	-3 022	-27 597	-42 928	1	-10 001
568	549	307	2 084	71 524	53 023	190 655	63	23 527
1 518	1 240	769	1 066	55 653	65 265	186 591	55	31 926
-950	-692	-462	1 019	15 871	-12 242	4 064	8	-8 399
-950	-692	-462	1 019	15 871	-12 242	4 064	8	-8 399
				36 187				
215	208	200	146	204	258	260	175	250
					15	11		
					15	11		
						1		0
2	2	2	79	1 825	1 194	7 017		334
						0		
2	2	2	79	1 825	1 194	7 018		334
					0	0		
					0	0		

value for a river basin can be obtained by summing the component State and Territory river basin parts.

	Basin number	101	102	103	104
	Basin name	Jacky Jacky Creek	Olive-Pascoe Rivers	Lockhart River	Stewart River
	State name	QLD	QLD	QLD	QLD
CONTEXT	Total area (ha)	294 900	419 402	286 716	269 669
	Non-agricultural area (ha)	150 659	175 985	258 446	104 782
	Agricultural area (ha)	144 242	243 416	28 270	164 887
	Irrigated agricultural area in 1996/97 (ha)				
	Dryland agricultural area in 1996/97 (ha)	144 242	243 416	28 270	164 887
PROFIT	1996/97 gross revenue ($'000)	189	3 252	1 965	5 814
	1996/97 variable costs ($'000)	116	1 200	687	2 064
	1996/97 fixed costs ($'000)	410	1 485	607	2 002
	1996/97 profit at full equity ($'000)	-337	567	671	1 748
	1996/97 government support ($'000)	8	654	425	1 242
	1996/97 economic returns ($'000)	-346	-87	246	507
	5 yr (1992/93 – 1996/97) gross revenue ($'000)	454	3 728	2 009	6 075
	5 yr (1992/93 – 1996/97) total costs ($'000)	524	2 682	1 294	4 064
	5 yr (1992/93 – 1996/97) profit at full equity ($'000)	-70	1 046	716	2 012
	Irrigated agriculture 5 yr profit at full equity ($'000)				
	Dryland agriculture 5 yr profit at full equity ($'000)	-70	1 046	716	2 012
	Minimum area of basin needed to produce 80% of profit at full equity within basin (ha)		963	1 079	2 869
	Ranking of basin in order of contribution to national 1996/97 profit at full equity (#)	191	161	159	142
AGRICULTURAL COSTS	Area where NPV of lime application is positive (ha)		2 165	1 438	3 825
	Area where NPV of gypsum application is positive (ha)				
	Area where NPV of lime and gypsum application is positive (ha)				358
	Area where dryland salinity caused yield loss in 2000 (ha)				
	Area where dryland salinity may cause yield loss in 2020 (ha)				
	Gross benefit from ameliorating acidic soils ($'000)	13	2 696	1 716	324
	Gross benefit from ameliorating sodic soils ($'000)				21
	Gross benefit from ameliorating saline soils ($'000)				
	Limiting factor gross benefit ($'000)	13	2 696	1 716	324
	Impact cost of dryland salinity to agriculture from 2000 to 2020 ($'000)				
	Present value of dryland salinity impact cost to agriculture from 2000 to 2020 ($'000)				
	Net present value of lime application ($'000)		26 053	16 674	1 512
	Net present value of gypsum application ($'000)				
	Net present value of lime and gypsum application ($'000)				661
OFF-SITE COSTS	Local infrastructure cost of salinity and water table rise 2000 ($'000/yr)				
	Local infrastructure cost of salinity and water table rise 2020 ($'000/yr)				
	Present value of increase in local infrastructure costs from salinity and rising water tables from 2000 to 2020 ($'000)				
	Downstream costs				
	1% increase in salt loads ($'000)				
	5% increase in salt loads ($'000)				
	10% increase in salt loads ($'000)				
	1% increase in turbidity ($'000)				
	5% increase in turbidity ($'000)				
	10% increase in turbidity ($'000)				
	1% increase in sediment loads ($'000)				
	5% increase in sediment loads ($'000)				
	10% increase in sediment loads ($'000)				

Where basins run over State or Territory boundaries, values are only provided for the portion of the indicated State or Territory. The total

	105 Normanby River QLD	106 Jeannie River QLD	107 Endeavour River QLD	108 Daintree River QLD	109 Mossman River QLD	110 Barron River QLD	111 Mulgrave-Russell Rivers QLD	112 Johnstone River QLD	11 Tully River QLD
	2 430 992	394 622	207 532	191 157	53 740	214 679	200 235	232 238	164 442
	733 783	236 891	113 740	168 558	38 975	113 264	157 031	139 299	125 045
	1 697 209	157 731	93 791	22 599	14 765	101 414	43 204	92 938	39 397
						2 708	1 295	4 934	821
	1 697 209	157 731	93 791	22 599	14 765	98 706	41 910	88 004	38 576
	6 429	7 866	5 548	12 042	5 891	40 384	70 484	171 714	27 209
	3 203	2 766	1 942	7 926	3 686	13 724	45 556	101 744	17 943
	5 800	2 542	1 746	2 033	1 068	8 437	11 006	32 716	5 071
	-2 574	2 559	1 860	2 082	1 136	18 224	13 922	37 253	4 195
	782	1 692	1 195	634	388	5 494	4 618	15 158	1 260
	-3 356	867	664	1 449	748	12 730	9 304	22 096	2 936
	9 574	8 122	5 712	13 629	6 687	41 454	80 191	192 734	31 955
	8 997	5 305	3 687	10 124	4 827	21 914	59 482	140 451	23 654
	576	2 817	2 025	3 505	1 860	19 539	20 710	52 283	8 301
						7 187	-35	3 472	1 399
	576	2 817	2 025	3 505	1 860	12 353	20 744	48 811	6 902
		4 046	2 970	4 023	2 008	10 944	20 833	32 556	3 518
	236	133	140	137	149	69	84	45	123
	1 422	2 974	1 543	8 049	2 363	11 531	33 072	79 073	8 559
						236			
			1 306			354		117	
	145				177	703		35	
	437			27	380	2 125	65	631	39
	246	722	3 633	1 604	181	3 543	6 187	38 331	18 718
	15		108	1	0	311	4	33	12
	0				7	174		10	
	250	722	3 633	1 604	182	3 746	6 188	38 332	18 718
	0			6	33	242	19	197	7
	1			32	181	1 344	108	1 092	37
	807	6 393	4 375	12 889	941	26 098	53 132	352 398	181 439
						982			
			30 296			1 544		2 637	
	0				88	175		3	
	0			7	388	575	2	68	0
	0			38	1 666	2 217	12	359	2
			19	283	654	5 399	420		1 087
			92	417	881	5 907	696		1 328
			181	583	1 163	6 527	1 030		1 625
			1	1	1	148	68		5
			3	6	7	454	339		14
			7	11	14	836	678		25

value for a river basin can be obtained by summing the component State and Territory river basin parts.

Home

Contents

	Basin number	114	116	117	118
	Basin name	Murray River (QLD)	Herbert River	Black River	Ross River
	State name	QLD	QLD	QLD	QLD
CONTEXT	**Total area (ha)**	121 406	984 798	114 361	139 396
	Non-agricultural area (ha)	89 309	378 231	58 832	60 931
	Agricultural area (ha)	32 098	606 567	55 529	78 466
	Irrigated agricultural area in 1996/97 (ha)	586	2 924	1 864	349
	Dryland agricultural area in 1996/97 (ha)	31 512	603 643	53 665	78 117
PROFIT	**1996/97 gross revenue ($'000)**	12 160	191 967	12 766	5 156
	1996/97 variable costs ($'000)	8 654	109 922	6 572	2 598
	1996/97 fixed costs ($'000)	2 783	35 531	3 349	2 220
	1996/97 profit at full equity ($'000)	723	46 513	2 844	339
	1996/97 government support ($'000)	495	17 780	693	693
	1996/97 economic returns ($'000)	228	28 734	2 152	-354
	5 yr (1992/93 – 1996/97) gross revenue ($'000)	14 911	193 292	14 841	4 430
	5 yr (1992/93 – 1996/97) total costs ($'000)	11 726	137 396	10 161	3 864
	5 yr (1992/93 – 1996/97) profit at full equity ($'000)	3 185	55 896	4 681	566
	Irrigated agriculture 5 yr profit at full equity ($'000)	-198	1 502	3 270	247
	Dryland agriculture 5 yr profit at full equity ($'000)	3 383	54 394	1 411	319
	Minimum area of basin needed to produce 80% of profit at full equity within basin (ha)		65 407	1 514	465
	Ranking of basin in order of contribution to national 1996/97 profit at full equity (#)	158	36	131	165
AGRICULTURAL COSTS	**Area where NPV of lime application is positive (ha)**	2 578	51 289	5 243	
	Area where NPV of gypsum application is positive (ha)			233	1 978
	Area where NPV of lime and gypsum application is positive (ha)	117	3 864	349	
	Area where dryland salinity caused yield loss in 2000 (ha)		10		3
	Area where dryland salinity may cause yield loss in 2020 (ha)	82	208		3
	Gross benefit from ameliorating acidic soils ($'000)	1 734	10 669	619	31
	Gross benefit from ameliorating sodic soils ($'000)	62	1 248	359	287
	Gross benefit from ameliorating saline soils ($'000)		0		
	Limiting factor gross benefit ($'000)	1 735	10 769	868	295
	Impact cost of dryland salinity to agriculture from 2000 to 2020 ($'000)	6	54		
	Present value of dryland salinity impact cost to agriculture from 2000 to 2020 ($'000)	34	299		
	Net present value of lime application ($'000)	14 298	70 657	3 107	
	Net present value of gypsum application ($'000)			350	1 085
	Net present value of lime and gypsum application ($'000)	894	3 650	1 677	
OFF-SITE COSTS	**Local infrastructure cost of salinity and water table rise 2000 ($'000/yr)**		0		0
	Local infrastructure cost of salinity and water table rise 2020 ($'000/yr)	2	47		0
	Present value of increase in local infrastructure costs from salinity and rising water tables from 2000 to 2020 ($'000)	12	257		
	Downstream costs				
	1% increase in salt loads ($'000)				
	5% increase in salt loads ($'000)				
	10% increase in salt loads ($'000)				
	1% increase in turbidity ($'000)		2 109	41	20 268
	5% increase in turbidity ($'000)		2 583	202	21 654
	10% increase in turbidity ($'000)		3 171	395	23 358
	1% increase in sediment loads ($'000)		11	3	964
	5% increase in sediment loads ($'000)		54	14	3 451
	10% increase in sediment loads ($'000)		108	29	6 560

Where basins run over State or Territory boundaries, values are only provided for the portion of the indicated State or Territory. The total

Home

Contents

119 Haughton River QLD	120 Burdekin River QLD	121 Don River QLD	122 Proserpine River QLD	123 Whitsunday Island QLD	124 O'Connell River QLD	125 Pioneer River QLD	126 Plane Creek QLD	127 Styx River QLD
435 940	13 012 363	357 181	258 497	27 508	238 764	157 129	256 001	307 479
135 706	992 250	56 640	124 854	26 241	118 086	97 691	105 586	67 499
300 234	12 020 113	300 541	133 643	1 267	120 679	59 438	150 414	239 980
30 771	15 632	3 475	9 246	230	7 601	14 375	25 731	114
269 463	12 004 481	297 066	124 397	1 037	113 078	45 063	124 683	239 866
117 326	252 008	51 340	51 106	268	80 534	83 503	156 275	10 025
82 354	121 483	15 980	34 855	106	52 611	56 695	107 264	4 686
18 103	194 002	14 563	8 116	59	11 704	13 341	22 603	7 980
16 869	-63 476	20 797	8 135	103	16 219	13 468	26 408	-2 642
6 044	14 400	2 933	2 741	55	4 448	5 873	8 766	496
10 825	-77 876	17 864	5 394	48	11 771	7 594	17 642	-3 138
142 041	338 027	56 095	52 226	361	82 956	88 302	160 820	12 612
105 701	316 494	30 438	39 801	173	60 497	68 888	123 757	12 664
36 340	21 533	25 657	12 425	188	22 459	19 415	37 062	-52
29 250	37 177	26 927	3 854	181	3 061	5 883	10 919	
7 090	-15 644	-1 270	8 570	7	19 398	13 531	26 143	-52
20 903		1 853	14 444		26 954	23 116	46 054	
73	261	61	102	170	74	86	54	237
1 626	3 478	232	7 164		23 958	26 680	44 415	114
18 575	4 380	2 086	2 542		577	115	5 049	1 938
3 020	932	347	11 209		2 769	1 265	21 233	114
1	12 877				134		8	
575	32 703	37	8		690		207	
623	1 615	1 269	1 728		2 863	2 418	8 022	102
1 976	6 647	2 923	1 543		638	488	3 072	1 145
	745				3		2	
2 201	8 514	3 314	2 690		3 114	2 468	9 002	1 200
116	615	192	1		75		42	
646	3 411	1 064	7		415		234	
293	5 828	740	2 222		17 413	13 011	26 682	20
5 876	17 243	15 906	815		42	4	3 577	1 780
4 418	801	3 683	10 792		863	636	25 638	192
0	72				3		0	
26	160	18	0		30		5	
145	488	99	0		149		24	
207	17 822		2 631		107	2 868	1 052	
395	19 595		3 074		200	3 233	1 413	
630	21 789		3 608		315	3 677	1 863	
248	12 391	1	216		2	130	6	
250	13 014	5	1 081		10	648	32	
253	13 794	10	2 162		20	1 295	65	

value for a river basin can be obtained by summing the component State and Territory river basin parts.

	Basin number	128	129	130	131
	Basin name	Shoalwater Creek	Water Park Creek	Fitzroy River (QLD)	Curtis Island
	State name	QLD	QLD	QLD	QLD
CONTEXT	Total area (ha)	387 548	187 851	14 266 397	57 532
	Non-agricultural area (ha)	215 167	158 145	3 025 844	46 341
	Agricultural area (ha)	172 380	29 706	11 240 553	11 190
	Irrigated agricultural area in 1996/97 (ha)	455	227	31 690	
	Dryland agricultural area in 1996/97 (ha)	171 925	29 479	11 208 863	11 190
PROFIT	1996/97 gross revenue ($'000)	8 282	6 372	732 939	118
	1996/97 variable costs ($'000)	3 418	2 578	268 496	133
	1996/97 fixed costs ($'000)	6 047	2 855	386 624	350
	1996/97 profit at full equity ($'000)	-1 183	939	77 820	-365
	1996/97 government support ($'000)	816	576	41 385	5
	1996/97 economic returns ($'000)	-2 000	364	36 434	-371
	5 yr (1992/93 – 1996/97) gross revenue ($'000)	10 005	6 760	848 853	441
	5 yr (1992/93 – 1996/97) total costs ($'000)	9 462	5 377	652 556	488
	5 yr (1992/93 – 1996/97) profit at full equity ($'000)	543	1 383	196 296	-47
	Irrigated agriculture 5 yr profit at full equity ($'000)	119	1 057	84 967	
	Dryland agriculture 5 yr profit at full equity ($'000)	424	325	111 330	-47
	Minimum area of basin needed to produce 80% of profit at full equity within basin (ha)		227	13 970	
	Ranking of basin in order of contribution to national 1996/97 profit at full equity (#)	216	154	25	193
AGRICULTURAL COSTS	Area where NPV of lime application is positive (ha)	683	340	8 189	
	Area where NPV of gypsum application is positive (ha)		113	75 323	
	Area where NPV of lime and gypsum application is positive (ha)	1 365	1 247	3 971	
	Area where dryland salinity caused yield loss in 2000 (ha)		23	23 928	
	Area where dryland salinity may cause yield loss in 2020 (ha)		28	51 065	
	Gross benefit from ameliorating acidic soils ($'000)	224	261	2 889	3
	Gross benefit from ameliorating sodic soils ($'000)	603	238	26 149	6
	Gross benefit from ameliorating saline soils ($'000)			4 514	
	Limiting factor gross benefit ($'000)	725	398	31 486	6
	Impact cost of dryland salinity to agriculture from 2000 to 2020 ($'000)		0	2 559	
	Present value of dryland salinity impact cost to agriculture from 2000 to 2020 ($'000)		0	14 194	
	Net present value of lime application ($'000)	259	1 369	7 252	
	Net present value of gypsum application ($'000)		59	34 002	
	Net present value of lime and gypsum application ($'000)	1 523	1 468	5 860	
OFF-SITE COSTS	Local infrastructure cost of salinity and water table rise 2000 ($'000/yr)		1	488	
	Local infrastructure cost of salinity and water table rise 2020 ($'000/yr)		1	835	
	Present value of increase in local infrastructure costs from salinity and rising water tables from 2000 to 2020 ($'000)		0	1 925	
	Downstream costs				
	1% increase in salt loads ($'000)				
	5% increase in salt loads ($'000)				
	10% increase in salt loads ($'000)				
	1% increase in turbidity ($'000)		66	49 442	
	5% increase in turbidity ($'000)		322	55 313	
	10% increase in turbidity ($'000)		631	62 609	
	1% increase in sediment loads ($'000)		19	4 451	
	5% increase in sediment loads ($'000)		93	11 833	
	10% increase in sediment loads ($'000)		187	21 061	

Where basins run over State or Territory boundaries, values are only provided for the portion of the indicated State or Territory. The total

132	133	134	135	136	137	138	140	141
Calliope River	Boyne River	Baffle Creek	Kolan River	Burnett River	Burrum River	Mary River (QLD)	Noosa River	Maroochy River
QLD	QLD	QLD	QLD	QLD	QLD	QLD	QLD	QLD
220 600	250 953	413 336	290 992	3 331 833	335 595	941 977	195 917	160 439
89 542	172 779	211 875	133 716	1 113 309	222 579	518 641	169 011	92 963
131 058	78 174	201 460	157 276	2 218 525	113 015	423 336	26 906	67 476
		1 459	17 245	34 710	23 578	14 631	1 549	5 731
131 058	78 174	200 001	140 031	2 183 815	89 437	408 705	25 357	61 745
8 545	6 460	33 752	63 585	328 833	96 972	195 322	21 063	107 126
2 773	1 240	13 822	43 839	138 410	61 758	74 697	8 525	47 547
4 942	2 599	12 135	14 054	112 503	19 461	50 990	5 919	30 929
831	2 621	7 794	5 691	77 920	15 753	69 635	6 619	28 650
1 001	396	2 653	3 525	33 573	5 310	27 476	2 302	6 309
-170	2 225	5 141	2 166	44 347	10 444	42 159	4 317	22 341
11 848	7 803	37 505	73 451	368 616	104 279	197 796	22 842	111 034
7 194	3 828	26 151	59 327	250 218	79 986	122 453	14 348	78 429
4 654	3 975	11 354	14 124	118 399	24 293	75 343	8 494	32 605
		2 461	6 479	34 476	18 929	15 986	3 968	22 102
4 654	3 975	8 894	7 645	83 923	5 364	59 357	4 526	10 503
1 016	6 649	8 084	4 369	62 007	2 348	52 097	5 312	7 499
157	132	103	113	24	76	26	109	51
		1 459	2 577	9 912	4 025	61 963	7 200	22 278
1 355	5 183	2 026	784	41 754	558	667		
1 466	225	5 053	1 232	6 659	335	9 637	665	2 097
725		9	578	2 326	1 810	652	3	
1 751	18	109	1 288	6 875	4 443	773	3	
109	76	988	1 104	4 276	2 757	16 247	2 156	17 596
605	461	1 261	769	8 362	232	1 342	85	460
4		0	198	1 155	1 209	9		
608	466	1 662	1 786	11 628	3 561	16 773	2 157	17 615
4	2	1	204	657	777	17		
21	13	7	1 131	3 646	4 312	95		
		1 117	4 318	11 225	14 350	126 667	15 917	100 301
523	192	1 313	179	20 072	25	165		
882	88	5 408	3 848	16 250	781	11 647	3 257	68 151
5		0	73	280	230	42	0	
19	5	1	153	812	555	66	0	
75	25	4	444	2 953	1 803	131		
				1 852				
				9 260				
				18 521				
		65	368	15 564	2 556	18 607		3 528
		249	582	16 559	2 926	19 745		3 932
		479	849	17 773	3 375	21 121		4 428
1	224	0	173	1 388	40	328	0	42
5	565	0	177	2 216	135	1 537	1	177
10	990	0	181	3 252	253	3 047	1	346

value for a river basin can be obtained by summing the component State and Territory river basin parts.

Basin number	142	143	144	145
Basin name	Pine River	Brisbane River	Stradbroke Island	Logan-Albert Rivers
State name	QLD	QLD	QLD	QLD
CONTEXT				
Total area (ha)	148 496	1 357 934	49 526	414 221
Non-agricultural area (ha)	83 063	508 151	40 881	129 171
Agricultural area (ha)	65 432	849 783	8 645	285 050
Irrigated agricultural area in 1996/97 (ha)	1 427	36 890		7 955
Dryland agricultural area in 1996/97 (ha)	64 006	812 893	8 645	277 095
PROFIT				
1996/97 gross revenue ($'000)	51 606	454 147	252	107 186
1996/97 variable costs ($'000)	19 986	151 118	103	35 855
1996/97 fixed costs ($'000)	17 753	120 315	264	26 592
1996/97 profit at full equity ($'000)	13 867	182 714	-115	44 739
1996/97 government support ($'000)	8 570	55 521	11	19 007
1996/97 economic returns ($'000)	5 296	127 192	-126	25 732
5 yr (1992/93 – 1996/97) gross revenue ($'000)	47 682	455 287	251	95 241
5 yr (1992/93 – 1996/97) total costs ($'000)	34 794	263 463	366	54 915
5 yr (1992/93 – 1996/97) profit at full equity ($'000)	12 888	191 824	-114	40 326
Irrigated agriculture 5 yr profit at full equity ($'000)	1 712	107 379		8 001
Dryland agriculture 5 yr profit at full equity ($'000)	11 176	84 445	-114	32 325
Minimum area of basin needed to produce 80% of profit at full equity within basin (ha)	14 165	97 553		38 211
Ranking of basin in order of contribution to national 1996/97 profit at full equity (#)	85	10	185	39
AGRICULTURAL COSTS				
Area where NPV of lime application is positive (ha)	15 596	48 303		19 922
Area where NPV of gypsum application is positive (ha)		24 728		2 503
Area where NPV of lime and gypsum application is positive (ha)	8 452	40 000		16 905
Area where dryland salinity caused yield loss in 2000 (ha)		1 397		67
Area where dryland salinity may cause yield loss in 2020 (ha)	46	1 676		96
Gross benefit from ameliorating acidic soils ($'000)	1 884	24 851	6	3 354
Gross benefit from ameliorating sodic soils ($'000)	1 235	13 451	3	1 715
Gross benefit from ameliorating saline soils ($'000)		490		9
Limiting factor gross benefit ($'000)	2 454	32 166	8	3 962
Impact cost of dryland salinity to agriculture from 2000 to 2020 ($'000)	0	7		1
Present value of dryland salinity impact cost to agriculture from 2000 to 2020 ($'000)	2	41		3
Net present value of lime application ($'000)	8 141	81 377		7 989
Net present value of gypsum application ($'000)		15 215		534
Net present value of lime and gypsum application ($'000)	8 702	154 228		13 181
OFF-SITE COSTS				
Local infrastructure cost of salinity and water table rise 2000 ($'000/yr)		398		99
Local infrastructure cost of salinity and water table rise 2020 ($'000/yr)	20	408		100
Present value of increase in local infrastructure costs from salinity and rising water tables from 2000 to 2020 ($'000)	114	58		5
Downstream costs				
1% increase in salt loads ($'000)				
5% increase in salt loads ($'000)				
10% increase in salt loads ($'000)				
1% increase in turbidity ($'000)	15 531	66 063		7 408
5% increase in turbidity ($'000)	16 504	69 228		8 021
10% increase in turbidity ($'000)	17 689	73 109		8 770
1% increase in sediment loads ($'000)	182	3 725		168
5% increase in sediment loads ($'000)	704	12 434		813
10% increase in sediment loads ($'000)	1 355	23 321		1 619

Where basins run over State or Territory boundaries, values are only provided for the portion of the indicated State or Territory. The total

Home
Contents

146 South Coast QLD	416 Border Rivers QLD	417 Moonie River QLD	422 Condamine-Culgoa Rivers QLD	423 Warrego River QLD	424 Paroo River QLD	910 Settlement Creek QLD	911 Mornington Island QLD	912 Nicholson River QLD
135 140	2 353 680	1 391 410	13 654 203	5 167 030	3 340 946	1 181 569	123 148	3 588 300
85 210	728 375	272 928	2 107 936	690 885	207 146	87 876	18 054	645 008
49 930	1 625 305	1 118 482	11 546 267	4 476 145	3 133 799	1 093 693	105 094	2 943 292
218	27 574	2 176	72 637					
49 712	1 597 730	1 116 306	11 473 630	4 476 145	3 133 799	1 093 693	105 094	2 943 292
41 518	412 854	110 910	1 364 339	46 385	21 046	4 452	27	9 285
15 885	135 179	29 893	431 311	6 391	2 344	1 373	68	2 754
9 817	99 314	37 411	420 569	40 542	22 969	3 194	297	8 362
15 817	178 361	43 606	512 458	-548	-4 267	-115	-338	-1 831
7 630	18 725	4 891	88 411	2 553	849	256	1	418
8 187	159 635	38 715	424 047	-3 101	-5 115	-370	-340	-2 249
23 202	355 317	84 459	1 284 197	53 616	19 430	10 873	69	18 147
14 954	228 211	65 848	834 707	46 701	25 256	4 558	365	11 136
8 248	127 106	18 611	449 491	6 915	-5 826	6 315	-296	7 011
70	89 207	5 738	211 656					
8 178	37 899	12 873	237 835	6 915	-5 826	6 315	-296	7 011
17 324	109 783	102 610	215 754	1 630	1 203			
75	11	42	1	202	243	184	192	226
19 169	866		24 729					
	64 980	37 352	365 735	111		118		
2 072	4 551		4 804					
	360	105	10 812					
123	1 728	772	21 900					
1 909	15 097	34	4 793	52	4			
225	18 638	7 028	61 481	1 418	37	107		278
	18	8	1 661					
1 951	30 775	7 037	64 415	1 464	41	107		278
0	79	80	1 547					
1	438	446	8 580					
13 143	1 573		9 988					
	47 135	9 212	206 061	102		52		
1 013	139 700		3 621					
	4	0	221					
627	34	2	505					
3 477	163	8	1 577					
			742					
			3 709					
			7 417					
8 463	2 741		8 936					
9 190	3 129		10 686					
10 069	3 609		12 864					
62	641		1 278					
275	668		1 297					
541	703		1 321					

value for a river basin can be obtained by summing the component State and Territory river basin parts.

Home
Contents

Section	Basin number	913	914	915	916
	Basin name	Leichhardt River	Morning Inlet	Flinders River	Norman River
	State name	QLD	QLD	QLD	QLD
CONTEXT	**Total area (ha)**	3 329 033	361 289	10 970 824	5 002 747
	Non-agricultural area (ha)	184 295	75 930	481 586	171 779
	Agricultural area (ha)	3 144 737	285 359	10 489 238	4 830 968
	Irrigated agricultural area in 1996/97 (ha)				
	Dryland agricultural area in 1996/97 (ha)	3 144 737	285 359	10 489 238	4 830 968
PROFIT	**1996/97 gross revenue ($'000)**	17 452	807	68 056	15 151
	1996/97 variable costs ($'000)	3 342	291	14 320	4 854
	1996/97 fixed costs ($'000)	8 977	811	67 790	31 254
	1996/97 profit at full equity ($'000)	5 132	-295	-14 054	-20 957
	1996/97 government support ($'000)	812	36	3 049	682
	1996/97 economic returns ($'000)	4 320	-331	-17 103	-21 639
	5 yr (1992/93 – 1996/97) gross revenue ($'000)	27 243	2 106	125 044	35 216
	5 yr (1992/93 – 1996/97) total costs ($'000)	12 346	1 103	82 894	36 083
	5 yr (1992/93 – 1996/97) profit at full equity ($'000)	14 896	1 003	42 150	-867
	Irrigated agriculture 5 yr profit at full equity ($'000)				
	Dryland agriculture 5 yr profit at full equity ($'000)	14 896	1 003	42 150	-867
	Minimum area of basin needed to produce 80% of profit at full equity within basin (ha)	531 995			
	Ranking of basin in order of contribution to national 1996/97 profit at full equity (#)	119	189	254	256
AGRICULTURAL COSTS	**Area where NPV of lime application is positive (ha)**				
	Area where NPV of gypsum application is positive (ha)			231	
	Area where NPV of lime and gypsum application is positive (ha)				
	Area where dryland salinity caused yield loss in 2000 (ha)			4 975	
	Area where dryland salinity may cause yield loss in 2020 (ha)			10 889	24
	Gross benefit from ameliorating acidic soils ($'000)			1	
	Gross benefit from ameliorating sodic soils ($'000)	232	18	1 846	61
	Gross benefit from ameliorating saline soils ($'000)			10	
	Limiting factor gross benefit ($'000)	232	18	1 852	61
	Impact cost of dryland salinity to agriculture from 2000 to 2020 ($'000)			29	0
	Present value of dryland salinity impact cost to agriculture from 2000 to 2020 ($'000)			159	0
	Net present value of lime application ($'000)				
	Net present value of gypsum application ($'000)			70	
	Net present value of lime and gypsum application ($'000)				
OFF-SITE COSTS	**Local infrastructure cost of salinity and water table rise 2000 ($'000/yr)**			1	
	Local infrastructure cost of salinity and water table rise 2020 ($'000/yr)			2	0
	Present value of increase in local infrastructure costs from salinity and rising water tables from 2000 to 2020 ($'000)			7	0
	Downstream costs				
	1% increase in salt loads ($'000)				
	5% increase in salt loads ($'000)				
	10% increase in salt loads ($'000)				
	1% increase in turbidity ($'000)				
	5% increase in turbidity ($'000)				
	10% increase in turbidity ($'000)				
	1% increase in sediment loads ($'000)				
	5% increase in sediment loads ($'000)				
	10% increase in sediment loads ($'000)				

Where basins run over State or Territory boundaries, values are only provided for the portion of the indicated State or Territory. The total

917 Gilbert River QLD	918 Staaten River QLD	919 Mitchell River (QLD) QLD	920 Coleman River QLD	921 Holroyd River QLD	922 Archer River QLD	923 Watson River QLD	924 Embley River QLD	925 Wenlock River QLD
4 630 188	2 583 804	7 153 857	1 291 731	1 020 877	1 383 880	469 581	469 077	746 488
398 117	516 743	591 743	458 169	199 947	779 860	242 500	243 293	160 322
4 232 071	2 067 061	6 562 114	833 562	820 929	604 021	227 082	225 784	586 166
		9 797	119					
4 232 071	2 067 061	6 552 317	833 443	820 929	604 021	227 082	225 784	586 166
22 619	6 406	104 726	1 146	1 166	4 126	277	412	740
5 908	2 117	55 127	820	712	1 644	180	290	468
29 759	11 316	54 917	2 381	2 352	2 638	645	651	1 665
-13 048	-7 026	-5 318	-2 055	-1 898	-156	-548	-530	-1 393
1 455	288	12 773	43	56	775	12	18	33
-14 502	-7 314	-18 092	-2 098	-1 954	-931	-560	-548	-1 426
47 364	15 480	130 370	2 351	2 587	5 168	667	802	1 781
35 577	13 419	108 081	3 189	3 054	4 274	822	939	2 126
11 787	2 062	22 289	-838	-467	893	-155	-136	-345
		24 371	-15					
11 787	2 062	-2 082	-823	-467	893	-155	-136	-345
253	247	245	230	228	186	201	199	220
		8 975						
		354						
		1 534						
	8	114						199
12	509	2 544	128					199
1	8	22 192	3	0	0			0
102	28	514	3	2	1			
	0	0						0
102	35	22 442	6	2	1			0
0	0	10						
0	2	57						
		202 867						
		463						
		4 739						
	0	0						0
0	0	3	0					0
0	0	18	0					
3		1						
14		6						
28		12						

value for a river basin can be obtained by summing the component State and Territory river basin parts.

	Basin number	926	927	928	1
	Basin name	Ducie River	Jardine River	Torres Strait Islands	Georgina River
	State name	QLD	QLD	QLD	SA
CONTEXT	**Total area (ha)**	680 650	329 503	56 924	395 311
	Non-agricultural area (ha)	471 545	326 720	35 140	159 528
	Agricultural area (ha)	209 106	2 783	21 784	235 783
	Irrigated agricultural area in 1996/97 (ha)				
	Dryland agricultural area in 1996/97 (ha)	209 106	2 783	21 784	235 783
PROFIT	**1996/97 gross revenue ($'000)**	265	0	3	117
	1996/97 variable costs ($'000)	167	2	14	156
	1996/97 fixed costs ($'000)	594	8	62	697
	1996/97 profit at full equity ($'000)	-496	-9	-73	-735
	1996/97 government support ($'000)	12	0	0	5
	1996/97 economic returns ($'000)	-508	-9	-73	-741
	5 yr (1992/93 – 1996/97) gross revenue ($'000)	637	1	6	212
	5 yr (1992/93 – 1996/97) total costs ($'000)	759	10	76	854
	5 yr (1992/93 – 1996/97) profit at full equity ($'000)	-121	-9	-70	-642
	Irrigated agriculture 5 yr profit at full equity ($'000)				
	Dryland agriculture 5 yr profit at full equity ($'000)	-121	-9	-70	-642
	Minimum area of basin needed to produce 80% of profit at full equity within basin (ha)				630
	Ranking of basin in order of contribution to national 1996/97 profit at full equity (#)	196	178	180	207
AGRICULTURAL COSTS	**Area where NPV of lime application is positive (ha)**				
	Area where NPV of gypsum application is positive (ha)				
	Area where NPV of lime and gypsum application is positive (ha)				
	Area where dryland salinity caused yield loss in 2000 (ha)				
	Area where dryland salinity may cause yield loss in 2020 (ha)				
	Gross benefit from ameliorating acidic soils ($'000)	0			
	Gross benefit from ameliorating sodic soils ($'000)				4
	Gross benefit from ameliorating saline soils ($'000)				
	Limiting factor gross benefit ($'000)	0			4
	Impact cost of dryland salinity to agriculture from 2000 to 2020 ($'000)				
	Present value of dryland salinity impact cost to agriculture from 2000 to 2020 ($'000)				
	Net present value of lime application ($'000)				
	Net present value of gypsum application ($'000)				
	Net present value of lime and gypsum application ($'000)				
OFF-SITE COSTS	**Local infrastructure cost of salinity and water table rise 2000 ($'000/yr)**				
	Local infrastructure cost of salinity and water table rise 2020 ($'000/yr)				
	Present value of increase in local infrastructure costs from salinity and rising water tables from 2000 to 2020 ($'000)				
	Downstream costs				
	1% increase in salt loads ($'000)				
	5% increase in salt loads ($'000)				
	10% increase in salt loads ($'000)				
	1% increase in turbidity ($'000)				
	5% increase in turbidity ($'000)				
	10% increase in turbidity ($'000)				
	1% increase in sediment loads ($'000)				
	5% increase in sediment loads ($'000)				
	10% increase in sediment loads ($'000)				

Where basins run over State or Territory boundaries, values are only provided for the portion of the indicated State or Territory. The total

	2 Diamantina River SA	3 Cooper Creek SA	4 Lake Frome SA	5 Finke River SA	7 Hay River SA	21 Gairdner SA	22 Nullarbor SA	23 Warburton SA	238 Glenelg River SA
	3 832 821	5 302 824	18 210 776	5 634 078	3 429 687	19 788 422	5 334 235	18 086 360	16 197
	572 973	2 327 317	2 684 710	1 319 969	3 259 543	6 662 884	5 023 487	16 611 614	11 517
	3 259 848	2 975 507	15 526 066	4 314 109	170 144	13 125 538	310 747	1 474 746	4 679
						103			391
	3 259 848	2 975 507	15 526 066	4 314 109	170 144	13 125 435	310 747	1 474 746	4 289
	1 795	2 018	37 101	3 335	91	266 613		1 413	3 043
	2 175	2 018	15 589	2 961	113	113 761		1 017	1 139
	9 630	8 790	52 641	12 744	503	117 075		4 244	960
	-10 010	-8 789	-31 129	-12 370	-525	35 777		-3 848	944
	81	91	1 638	150	4	12 366		63	335
	-10 091	-8 880	-32 767	-12 520	-529	23 410		-3 911	609
	3 234	3 637	49 690	6 009	163	266 762		2 518	3 004
	11 818	10 822	68 384	15 729	617	230 590		5 271	2 100
	-8 584	-7 185	-18 695	-9 720	-453	36 172		-2 753	904
						445			492
	-8 584	-7 185	-18 695	-9 720	-453	35 727		-2 753	413
						130 946			1 856
	251	249	259	252	197	47		242	153
						613			
			311			41 248			
			42			53 840			
			42			53 840			
			1			178			
	20	10	1 052	15	0	7 945		4	1
			7			1 755			
	20	10	1 057	15	0	9 365		4	1
						106			
			58			16 038			
			0			779			
			0			779			
						0			
		5 514							
		13 491							
		23 459							
		5							
		25							
		51							

value for a river basin can be obtained by summing the component State and Territory river basin parts.

Section	Basin number	239	414	426	501
	Basin name	Millicent Coast	Mallee	Lower Murray River	Fleurieu Peninsula
	State name	SA	SA	SA	SA
CONTEXT	**Total area (ha)**	2 696 181	1 996 221	4 933 879	98 707
	Non-agricultural area (ha)	493 799	114 894	1 101 378	16 093
	Agricultural area (ha)	2 202 382	1 881 326	3 832 501	82 614
	Irrigated agricultural area in 1996/97 (ha)	55 848	21 001	42 190	1 409
	Dryland agricultural area in 1996/97 (ha)	2 146 534	1 860 325	3 790 311	81 204
PROFIT	**1996/97 gross revenue ($'000)**	504 501	482 903	755 596	47 424
	1996/97 variable costs ($'000)	116 058	160 703	217 775	12 329
	1996/97 fixed costs ($'000)	304 076	170 152	241 451	14 638
	1996/97 profit at full equity ($'000)	84 367	152 048	296 370	20 456
	1996/97 government support ($'000)	38 029	31 933	70 950	8 742
	1996/97 economic returns ($'000)	46 338	120 115	225 420	11 714
	5 yr (1992/93 – 1996/97) gross revenue ($'000)	503 284	489 986	761 942	49 292
	5 yr (1992/93 – 1996/97) total costs ($'000)	421 067	331 234	459 474	26 988
	5 yr (1992/93 – 1996/97) profit at full equity ($'000)	82 217	158 752	302 467	22 304
	Irrigated agriculture 5 yr profit at full equity ($'000)	61 021	178 523	252 917	2 380
	Dryland agriculture 5 yr profit at full equity ($'000)	21 196	-19 771	49 550	19 924
	Minimum area of basin needed to produce 80% of profit at full equity within basin (ha)	48 914	14 103	22 346	19 829
	Ranking of basin in order of contribution to national 1996/97 profit at full equity (#)	23	14	5	63
AGRICULTURAL COSTS	**Area where NPV of lime application is positive (ha)**	98		1 620	
	Area where NPV of gypsum application is positive (ha)	65 159	56 154	92 189	1 208
	Area where NPV of lime and gypsum application is positive (ha)	3 435			
	Area where dryland salinity caused yield loss in 2000 (ha)	275 804	6 409	43 773	88
	Area where dryland salinity may cause yield loss in 2020 (ha)	447 883	9 362	66 632	88
	Gross benefit from ameliorating acidic soils ($'000)	702	0	234	0
	Gross benefit from ameliorating sodic soils ($'000)	22 453	23 778	42 168	171
	Gross benefit from ameliorating saline soils ($'000)	20 985	861	4 910	6
	Limiting factor gross benefit ($'000)	40 841	24 535	46 317	178
	Impact cost of dryland salinity to agriculture from 2000 to 2020 ($'000)	12 970	131	3 370	
	Present value of dryland salinity impact cost to agriculture from 2000 to 2020 ($'000)	71 953	728	18 697	
	Net present value of lime application ($'000)	13		1 325	
	Net present value of gypsum application ($'000)	62 889	178 517	353 120	511
	Net present value of lime and gypsum application ($'000)	9 925			
OFF-SITE COSTS	**Local infrastructure cost of salinity and water table rise 2000 ($'000/yr)**	1 723	124	1 413	2
	Local infrastructure cost of salinity and water table rise 2020 ($'000/yr)	3 829	475	3 129	2
	Present value of increase in local infrastructure costs from salinity and rising water tables from 2000 to 2020 ($'000)	11 686	1 947	9 520	
	Downstream costs				
	1% increase in salt loads ($'000)	4 648	202	22 737	
	5% increase in salt loads ($'000)	23 241	1 010	113 683	
	10% increase in salt loads ($'000)	46 483	2 021	227 367	
	1% increase in turbidity ($'000)			60 723	2 351
	5% increase in turbidity ($'000)			63 990	3 018
	10% increase in turbidity ($'000)			68 007	3 849
	1% increase in sediment loads ($'000)	1	0	10	1
	5% increase in sediment loads ($'000)	4	1	51	4
	10% increase in sediment loads ($'000)	7	1	103	7

Where basins run over State or Territory boundaries, values are only provided for the portion of the indicated State or Territory. The total

502 Myponga River SA	503 Onkaparinga River SA	504 Torrens River SA	505 Gawler River SA	506 Wakefield River SA	507 Broughton River SA	508 Mambray Coast SA	509 Willochra Creek SA	510 Lake Torrens SA
15 122	92 245	113 402	457 650	192 269	1 639 875	593 875	662 156	2 623 980
806	23 775	63 780	33 456	3 070	112 525	83 273	13 324	664 472
14 316	68 470	49 622	424 194	189 199	1 527 350	510 602	648 831	1 959 507
504	10 715	2 738	9 063	1 025	1 540			
13 812	57 755	46 884	415 132	188 174	1 525 810	510 602	648 831	1 959 507
12 242	143 728	53 535	202 365	68 148	423 269	10 723	31 562	4 346
3 031	54 509	25 351	51 771	20 301	121 493	2 982	11 187	1 262
3 589	42 871	13 738	61 377	17 060	111 075	6 566	14 841	3 289
5 623	46 348	14 446	89 217	30 787	190 700	1 174	5 533	-205
2 087	12 593	4 844	13 469	3 848	21 941	484	1 669	173
3 535	33 755	9 601	75 748	26 938	168 759	691	3 864	-377
12 820	143 345	51 961	189 641	63 198	399 479	11 727	34 492	9 535
6 626	96 656	38 127	112 460	37 057	231 385	9 588	26 112	4 761
6 194	46 688	13 834	77 181	26 141	168 094	2 139	8 379	4 774
1 852	38 031	11 913	32 817	4 233	6 510			
4 342	8 657	1 921	44 364	21 908	161 584	2 139	8 379	4 774
4 033	8 995	1 623	112 181	79 198	518 851	6 209	47 920	
114	37	81	22	50	8	148	116	187
	203	405	509		1 213	104		
605	8 686	508	41 276	11 364	13 751	104	936	
	303	203						
		0	308	1 407	52 069	187		
		0	307	1 407	52 074	187		
	177	372	682	30	170	1	1	1
90	3 342	472	8 325	2 166	7 690	343	1 026	106
			49	263	7 659	4		
90	3 494	829	9 023	2 314	15 130	345	1 027	106
					1			
					4			
	1 498	3 529	6 732		73	4		
689	29 564	1 639	48 458	5 765	12 128	61	430	
	1 324	2 799						
		0	19	33	1 334	9		
		0	19	33	1 334	9		
			0	0	1			
1 287	13 361	9 159	5 475		1 396		103	
6 436	66 807	45 797	27 376		6 978		515	
12 872	133 613	91 593	54 752		13 956		1 030	
4 524	21 917	9 307						
4 985	23 349	10 014						
5 548	25 109	10 873						
9	42	36	18		30		0	
37	180	141	88		47		2	
73	354	273	174		69		3	

value for a river basin can be obtained by summing the component State and Territory river basin parts.

Home

Contents

	Basin number	511	512	513	301
	Basin name	Spencer Gulf	Eyre Peninsula	Kangaroo Island	Flinders-Cape Barren Islands
	State name	SA	SA	SA	TAS
CONTEXT	**Total area (ha)**	1 089 517	320 531	443 245	200 379
	Non-agricultural area (ha)	151 194	123 988	182 872	125 510
	Agricultural area (ha)	938 323	196 543	260 372	74 869
	Irrigated agricultural area in 1996/97 (ha)				
	Dryland agricultural area in 1996/97 (ha)	938 323	196 543	260 372	74 869
PROFIT	**1996/97 gross revenue ($'000)**	72 052	22 062	40 353	9 452
	1996/97 variable costs ($'000)	26 311	6 415	5 294	1 226
	1996/97 fixed costs ($'000)	22 332	7 906	30 113	11 003
	1996/97 profit at full equity ($'000)	23 408	7 742	4 947	-2 778
	1996/97 government support ($'000)	3 315	1 006	1 734	388
	1996/97 economic returns ($'000)	20 093	6 736	3 213	-3 166
	5 yr (1992/93 – 1996/97) gross revenue ($'000)	65 162	24 072	40 631	10 646
	5 yr (1992/93 – 1996/97) total costs ($'000)	48 266	14 354	35 748	12 238
	5 yr (1992/93 – 1996/97) profit at full equity ($'000)	16 896	9 719	4 884	-1 592
	Irrigated agriculture 5 yr profit at full equity ($'000)				
	Dryland agriculture 5 yr profit at full equity ($'000)	16 896	9 719	4 884	-1 592
	Minimum area of basin needed to produce 80% of profit at full equity within basin (ha)	109 605	29 756	42 434	
	Ranking of basin in order of contribution to national 1996/97 profit at full equity (#)	59	104	120	238
AGRICULTURAL COSTS	**Area where NPV of lime application is positive (ha)**		7 330	902	
	Area where NPV of gypsum application is positive (ha)	23 647	713	201	
	Area where NPV of lime and gypsum application is positive (ha)	102	305		
	Area where dryland salinity caused yield loss in 2000 (ha)	12 151	17 441	8 644	
	Area where dryland salinity may cause yield loss in 2020 (ha)	12 151	17 441	8 702	
	Gross benefit from ameliorating acidic soils ($'000)	39	320	36	
	Gross benefit from ameliorating sodic soils ($'000)	3 838	525	847	389
	Gross benefit from ameliorating saline soils ($'000)	1 213	761	623	
	Limiting factor gross benefit ($'000)	4 571	1 340	1 352	389
	Impact cost of dryland salinity to agriculture from 2000 to 2020 ($'000)			1	
	Present value of dryland salinity impact cost to agriculture from 2000 to 2020 ($'000)			8	
	Net present value of lime application ($'000)		1 203	102	
	Net present value of gypsum application ($'000)	8 470	107	119	
	Net present value of lime and gypsum application ($'000)	4	11		
OFF-SITE COSTS	**Local infrastructure cost of salinity and water table rise 2000 ($'000/yr)**	674	413	154	
	Local infrastructure cost of salinity and water table rise 2020 ($'000/yr)	674	413	155	
	Present value of increase in local infrastructure costs from salinity and rising water tables from 2000 to 2020 ($'000)	1	0	3	
	Downstream costs				
	1% increase in salt loads ($'000)				
	5% increase in salt loads ($'000)				
	10% increase in salt loads ($'000)				
	1% increase in turbidity ($'000)			59	
	5% increase in turbidity ($'000)			294	
	10% increase in turbidity ($'000)			588	
	1% increase in sediment loads ($'000)				
	5% increase in sediment loads ($'000)				
	10% increase in sediment loads ($'000)				

Where basins run over State or Territory boundaries, values are only provided for the portion of the indicated State or Territory. The total

Home

Contents

302 East Coast TAS	303 Coal River TAS	304 Derwent River TAS	305 Kingston Coast TAS	306 Huon River TAS	307 South-West Coast TAS	309 King-Henty Rivers TAS	310 Pieman River TAS	311 Sandy Cape Coast TAS
697 848	68 172	983 016	76 400	301 024	549 831	178 706	415 925	87 537
498 712	22 239	660 715	47 481	256 063	542 447	177 511	410 922	86 140
199 136	45 933	322 302	28 919	44 960	7 384	1 195	5 003	1 397
1 752	1 092	9 405	272	3 350	720	92		
197 384	44 841	312 897	28 647	41 611	6 663	1 103	5 003	1 397
37 155	11 897	49 887	2 987	113 473	14 328	170	507	591
9 873	2 941	10 932	990	80 718	10 285	20	79	167
29 152	7 403	43 652	5 208	18 054	2 521	244	1 009	372
-1 870	1 552	-4 698	-3 211	14 701	1 523	-94	-581	52
2 742	663	3 627	392	6 641	824	8	22	101
-4 612	890	-8 324	-3 603	8 059	699	-101	-603	-49
37 607	11 915	51 828	2 889	115 553	14 385	247	771	695
38 946	10 301	54 526	5 901	99 393	12 805	264	1 093	539
-1 339	1 614	-2 697	-3 012	16 160	1 580	-17	-322	156
956	2 947	5 255		14 560	2 435			
-2 295	-1 333	-7 952	-3 012	1 600	-855	-17	-322	156
	364			2 173	271			186
227	143	244	241	79	144	182	205	171
10 393	1 092	7 588	815	2 986	2 160	1 011	1 574	1 211
549	273	912						
2 030	455	1 459		2 715				
2 005		6 021						
2 633		7 907						
1 678	1 244	2 334	200	76 013	3 380	66	279	204
1 796	628	1 723	48	1 092				
52		484						
2 787	1 446	3 563	202	76 013	3 380	66	279	204
14		129						
78		714						
3 592	4 653	8 095	325	180 296	32 741	409	469	1 615
663	134	426						
2 852	5 984	2 496		573 714				
1 176		341						
1 543		448						
2 034		590						

value for a river basin can be obtained by summing the component State and Territory river basin parts.

Home
Contents

		312	313	314	315
	Basin number	312	313	314	315
	Basin name	Arthur River	King Island	Smithton-Burnie Coast	Forth River
	State name	TAS	TAS	TAS	TAS
CONTEXT	**Total area (ha)**	249 796	109 158	466 010	113 707
CONTEXT	**Non-agricultural area (ha)**	239 822	22 901	243 842	88 816
CONTEXT	**Agricultural area (ha)**	9 974	86 257	222 168	24 891
CONTEXT	**Irrigated agricultural area in 1996/97 (ha)**	466	95	15 215	1 859
CONTEXT	**Dryland agricultural area in 1996/97 (ha)**	9 507	86 162	206 954	23 032
PROFIT	**1996/97 gross revenue ($'000)**	4 569	25 225	214 867	16 742
PROFIT	**1996/97 variable costs ($'000)**	1 603	4 308	76 046	5 125
PROFIT	**1996/97 fixed costs ($'000)**	2 829	19 431	88 162	7 267
PROFIT	**1996/97 profit at full equity ($'000)**	137	1 486	50 659	4 350
PROFIT	**1996/97 government support ($'000)**	647	2 483	31 569	1 463
PROFIT	**1996/97 economic returns ($'000)**	-511	-997	19 090	2 886
PROFIT	**5 yr (1992/93 – 1996/97) gross revenue ($'000)**	4 719	31 139	218 271	18 879
PROFIT	**5 yr (1992/93 – 1996/97) total costs ($'000)**	4 039	23 759	156 703	12 415
PROFIT	**5 yr (1992/93 – 1996/97) profit at full equity ($'000)**	680	7 380	61 568	6 464
PROFIT	**Irrigated agriculture 5 yr profit at full equity ($'000)**	77		35 040	6 492
PROFIT	**Dryland agriculture 5 yr profit at full equity ($'000)**	603	7 380	26 528	-28
PROFIT	**Minimum area of basin needed to produce 80% of profit at full equity within basin (ha)**	280	4 179	45 742	466
PROFIT	**Ranking of basin in order of contribution to national 1996/97 profit at full equity (#)**	169	145	31	122
AGRICULTURAL COSTS	**Area where NPV of lime application is positive (ha)**	6 720		134 742	4 090
AGRICULTURAL COSTS	**Area where NPV of gypsum application is positive (ha)**				
AGRICULTURAL COSTS	**Area where NPV of lime and gypsum application is positive (ha)**				
AGRICULTURAL COSTS	**Area where dryland salinity caused yield loss in 2000 (ha)**				
AGRICULTURAL COSTS	**Area where dryland salinity may cause yield loss in 2020 (ha)**				
AGRICULTURAL COSTS	**Gross benefit from ameliorating acidic soils ($'000)**	1 066		55 764	7 441
AGRICULTURAL COSTS	**Gross benefit from ameliorating sodic soils ($'000)**				
AGRICULTURAL COSTS	**Gross benefit from ameliorating saline soils ($'000)**				
AGRICULTURAL COSTS	**Limiting factor gross benefit ($'000)**	1 066		55 764	7 441
AGRICULTURAL COSTS	**Impact cost of dryland salinity to agriculture from 2000 to 2020 ($'000)**				
AGRICULTURAL COSTS	**Present value of dryland salinity impact cost to agriculture from 2000 to 2020 ($'000)**				
AGRICULTURAL COSTS	**Net present value of lime application ($'000)**	7 616		514 908	69 942
AGRICULTURAL COSTS	**Net present value of gypsum application ($'000)**				
AGRICULTURAL COSTS	**Net present value of lime and gypsum application ($'000)**				
OFF-SITE COSTS	**Local infrastructure cost of salinity and water table rise 2000 ($'000/yr)**				
OFF-SITE COSTS	**Local infrastructure cost of salinity and water table rise 2020 ($'000/yr)**				
OFF-SITE COSTS	**Present value of increase in local infrastructure costs from salinity and rising water tables from 2000 to 2020 ($'000)**				
OFF-SITE COSTS	**Downstream costs**				
OFF-SITE COSTS	**1% increase in salt loads ($'000)**				
OFF-SITE COSTS	**5% increase in salt loads ($'000)**				
OFF-SITE COSTS	**10% increase in salt loads ($'000)**				
OFF-SITE COSTS	**1% increase in turbidity ($'000)**				
OFF-SITE COSTS	**5% increase in turbidity ($'000)**				
OFF-SITE COSTS	**10% increase in turbidity ($'000)**				
OFF-SITE COSTS	**1% increase in sediment loads ($'000)**				
OFF-SITE COSTS	**5% increase in sediment loads ($'000)**				
OFF-SITE COSTS	**10% increase in sediment loads ($'000)**				

Where basins run over State or Territory boundaries, values are only provided for the portion of the indicated State or Territory. The total

Home
Contents

316 Mersey River TAS	317 Rubicon River TAS	318 Tamar River TAS	319 Piper-Ringarooma Rivers TAS	221 East Gippsland VIC	222 Snowy River VIC	223 Tambo River VIC	224 Mitchell River (VIC) VIC	225 Thomson River VIC
197 001	67 438	1 133 001	355 940	450 483	684 519	420 117	487 699	657 902
127 148	37 592	611 692	217 059	443 022	601 341	330 811	414 266	470 703
69 853	29 846	521 309	138 882	7 461	83 178	89 306	73 433	187 200
11 709	4 465	12 289	7 922	687	981	782	2 542	25 148
58 144	25 381	509 020	130 960	6 774	82 197	88 523	70 892	162 051
106 386	49 316	131 749	68 631	4 565	24 666	21 648	29 453	118 465
45 276	14 282	43 470	22 058	1 958	9 204	5 932	9 127	47 198
36 636	16 607	87 791	36 676	2 129	15 546	13 293	14 473	50 509
24 474	18 427	488	9 897	478	-84	2 423	5 854	20 758
11 262	3 725	10 124	9 005	737	3 639	1 907	2 366	21 373
13 212	14 702	-9 636	892	-259	-3 723	516	3 488	-615
115 274	57 203	158 128	74 496	5 178	31 578	21 025	30 621	128 758
81 994	30 925	132 640	58 730	4 094	25 079	19 033	23 408	97 619
33 280	26 278	25 488	15 766	1 084	6 500	1 991	7 213	31 139
28 577	25 577	20 149	9 504	463	1 451	1 049	5 637	14 916
4 703	701	5 339	6 262	621	5 048	942	1 576	16 223
7 998	2 328		5 873	760		11 584	2 151	78 260
58	67	162	98	163	181	134	112	62
30 263	6 601	33 040	18 357	2 258	7 643	2 351	2 840	2 344
		186				1 075	390	20 666
836	1 208	7 680	6 716	196	3 718	489	1 956	40 854
		16 437	1 930				126	2 754
		21 587	2 534				159	3 247
28 080	13 887	14 233	8 962	987	1 971	925	3 965	2 929
177	1 158	3 550	1 751	30	528	359	1 078	9 015
		1 287	69				7	257
28 081	14 125	16 228	9 287	992	2 201	1 102	4 589	10 059
		350	18				2	16
		1 942	98				13	87
262 220	108 749	64 207	26 151	8 561	10 581	566	20 774	6 354
		10				133	360	12 599
6 880	29 149	47 298	46 336	96	2 500	4 503	16 389	36 957
		349	44				2	45
		458	58				2	54
		604	76				2	48
				18	27	36	46	789
				90	132	175	228	2 129
				178	259	344	447	3 737
				0	0	0	1	78
				1	2	2	5	249
				3	4	4	10	463

value for a river basin can be obtained by summing the component State and Territory river basin parts.

Section	Basin number	226	227	228	229
	Basin name	Latrobe River	South Gippsland	Bunyip River	Yarra River
	State name	VIC	VIC	VIC	VIC
CONTEXT	Total area (ha)	467 132	679 783	407 605	410 577
	Non-agricultural area (ha)	236 445	230 919	134 721	263 160
	Agricultural area (ha)	230 687	448 864	272 884	147 416
	Irrigated agricultural area in 1996/97 (ha)	11 869	8 627	10 306	5 673
	Dryland agricultural area in 1996/97 (ha)	218 818	440 237	262 578	141 743
PROFIT	1996/97 gross revenue ($'000)	154 606	276 308	249 090	80 033
	1996/97 variable costs ($'000)	63 258	105 808	106 570	36 157
	1996/97 fixed costs ($'000)	70 218	124 523	89 180	34 975
	1996/97 profit at full equity ($'000)	21 131	45 977	53 340	8 900
	1996/97 government support ($'000)	25 144	46 027	28 034	6 234
	1996/97 economic returns ($'000)	-4 014	-51	25 305	2 666
	5 yr (1992/93 – 1996/97) gross revenue ($'000)	157 550	303 868	267 180	85 819
	5 yr (1992/93 – 1996/97) total costs ($'000)	125 384	230 606	188 647	69 484
	5 yr (1992/93 – 1996/97) profit at full equity ($'000)	32 166	73 262	78 533	16 334
	Irrigated agriculture 5 yr profit at full equity ($'000)	11 354	7 569	60 827	24 458
	Dryland agriculture 5 yr profit at full equity ($'000)	20 812	65 694	17 707	-8 123
	Minimum area of basin needed to produce 80% of profit at full equity within basin (ha)	44 605	267 164	4 856	586
	Ranking of basin in order of contribution to national 1996/97 profit at full equity (#)	60	38	29	100
AGRICULTURAL COSTS	Area where NPV of lime application is positive (ha)	81 888	140 363	82 571	9 492
	Area where NPV of gypsum application is positive (ha)	9 146	9 410		687
	Area where NPV of lime and gypsum application is positive (ha)	29 862	75 653	35 802	4 404
	Area where dryland salinity caused yield loss in 2000 (ha)	768	3 598		435
	Area where dryland salinity may cause yield loss in 2020 (ha)	906	4 845		731
	Gross benefit from ameliorating acidic soils ($'000)	23 614	25 005	125 440	115 348
	Gross benefit from ameliorating sodic soils ($'000)	5 128	9 385	4 644	1 849
	Gross benefit from ameliorating saline soils ($'000)	32	498		12
	Limiting factor gross benefit ($'000)	26 537	28 027	125 496	115 678
	Impact cost of dryland salinity to agriculture from 2000 to 2020 ($'000)	6	117		7
	Present value of dryland salinity impact cost to agriculture from 2000 to 2020 ($'000)	35	650		38
	Net present value of lime application ($'000)	166 324	90 627	863 086	245 143
	Net present value of gypsum application ($'000)	4 848	4 066		201
	Net present value of lime and gypsum application ($'000)	30 498	56 720	332 950	892 307
OFF-SITE COSTS	Local infrastructure cost of salinity and water table rise 2000 ($'000/yr)	8	156		134
	Local infrastructure cost of salinity and water table rise 2020 ($'000/yr)	10	245		242
	Present value of increase in local infrastructure costs from salinity and rising water tables from 2000 to 2020 ($'000)	12	492		597
	Downstream costs				
	1% increase in salt loads ($'000)				
	5% increase in salt loads ($'000)				
	10% increase in salt loads ($'000)				
	1% increase in turbidity ($'000)	23 710	3 656	6 565	44 322
	5% increase in turbidity ($'000)	25 138	4 061	7 256	46 718
	10% increase in turbidity ($'000)	26 860	4 554	8 108	49 602
	1% increase in sediment loads ($'000)	38	5	2	171
	5% increase in sediment loads ($'000)	160	23	9	531
	10% increase in sediment loads ($'000)	313	46	18	982

Where basins run over State or Territory boundaries, values are only provided for the portion of the indicated State or Territory. The total

230	231	232	233	234	235	236	237	238
Maribyrnong River	Werribee River	Moorabool River	Barwon River	Lake Corangamite	Otway Coast	Hopkins River	Portland Coast	Glenelg River
VIC	VIC	VIC	VIC	VIC	VIC	VIC	VIC	VIC
144 735	197 135	223 272	381 527	407 996	388 764	1 009 399	396 773	1 196 142
36 395	72 040	47 191	64 458	65 865	179 336	50 584	68 681	342 003
108 340	125 094	176 081	317 069	342 132	209 428	958 815	328 092	854 139
295	4 104	1 760	3 213	3 698	3 193	3 217	3 894	2 446
108 045	120 990	174 322	313 856	338 434	206 235	955 598	324 198	851 693
11 954	50 486	40 672	95 854	128 323	163 753	304 501	129 010	169 215
3 721	19 862	13 020	34 377	47 201	70 424	100 998	41 623	36 993
13 817	25 451	26 336	55 540	66 458	75 911	161 045	62 700	104 892
-5 585	5 173	1 316	5 937	14 664	17 418	42 458	24 686	27 329
769	3 380	2 720	10 616	18 260	32 459	36 581	17 429	9 150
-6 353	1 793	-1 404	-4 678	-3 596	-15 041	5 876	7 257	18 179
13 257	57 941	44 391	100 109	137 155	176 993	324 186	136 200	176 695
17 613	45 673	39 382	89 032	113 654	145 898	262 081	104 366	141 571
-4 356	12 269	5 009	11 077	23 500	31 095	62 105	31 834	35 124
1 046	16 186	5 258	3 047	2 088	1 288	1 779	2 284	1 525
-5 402	-3 917	-249	8 031	21 412	29 806	60 326	29 551	33 599
	684	293	2 630	100 601	130 001	275 025	138 771	338 725
246	118	147	111	80	71	43	57	53
393	881	2 444	13 682	12 800	115 070	12 149	91 676	45 792
882	7 237	10 049	6 706	33 402	5 244	65 968	10 609	12 422
393	3 910	3 418	18 358	40 884	13 877	80 763	56 259	2 447
901	438	1 129	8 400	11 145	2 202	19 527	1 247	42 602
4 838	8 389	10 871	34 889	52 878	14 589	77 389	19 361	113 84
509	6 933	12 818	4 516	6 554	13 145	15 011	37 499	9 477
785	6 454	4 236	6 399	11 244	2 119	24 350	7 883	7 674
35	12	43	722	1 015	333	1 529	199	2 473
939	10 018	15 705	8 437	13 971	14 186	31 391	39 616	16 349
143	1 011	373	2 116	3 392	2 412	7 847	2 004	3 613
795	5 611	2 069	11 738	18 817	13 383	43 531	11 118	20 044
278	3 992	1 524	8 934	16 011	77 582	45 988	91 639	37 911
374	14 128	4 538	1 302	7 288	994	15 415	2 434	2 278
1 802	67 227	127 603	15 732	28 742	5 842	43 223	189 774	8 890
80	51	295	1 512	567	418	647	54	587
2 228	3 452	1 446	4 391	2 605	1 272	3 630	689	1 712
11 914	18 871	6 384	15 974	11 306	4 737	16 550	3 527	6 238
				1 244		273	880	618
				6 221		1 366	4 402	3 088
				12 441		2 731	8 803	6 176
2 518	1 831	84	3 468		3 070	1 092	38	49
2 846	2 133	415	4 063		3 486	1 336	189	240
3 247	2 500	812	4 781		3 990	1 637	370	471
3	85	23	40	1	4	0	0	1
17	226	58	88	5	20	1	2	5
35	402	100	149	10	41	2	4	10

value for a river basin can be obtained by summing the component State and Territory river basin parts.

	Basin number	239	401	402	403
	Basin name	Millicent Coast	Upper Murray River	Kiewa River	Ovens River
	State name	VIC	VIC	VIC	VIC
CONTEXT	Total area (ha)	741 698	1 014 397	190 748	797 588
	Non-agricultural area (ha)	177 700	764 235	109 051	434 102
	Agricultural area (ha)	563 998	250 162	81 696	363 486
	Irrigated agricultural area in 1996/97 (ha)	3 059	1 898	1 494	8 851
	Dryland agricultural area in 1996/97 (ha)	560 939	248 264	80 203	354 636
PROFIT	1996/97 gross revenue ($'000)	104 692	76 473	37 861	101 116
	1996/97 variable costs ($'000)	25 219	23 158	15 665	31 509
	1996/97 fixed costs ($'000)	66 981	42 320	18 778	59 509
	1996/97 profit at full equity ($'000)	12 492	10 995	3 419	10 098
	1996/97 government support ($'000)	5 643	9 604	6 183	10 765
	1996/97 economic returns ($'000)	6 849	1 390	-2 765	-667
	5 yr (1992/93 – 1996/97) gross revenue ($'000)	98 499	79 611	40 289	107 169
	5 yr (1992/93 – 1996/97) total costs ($'000)	92 297	65 316	34 080	90 995
	5 yr (1992/93 – 1996/97) profit at full equity ($'000)	6 202	14 295	6 209	16 175
	Irrigated agriculture 5 yr profit at full equity ($'000)	2 405	1 074	837	10 104
	Dryland agriculture 5 yr profit at full equity ($'000)	3 797	13 221	5 372	6 070
	Minimum area of basin needed to produce 80% of profit at full equity within basin (ha)	12 526	72 559	16 240	5 370
	Ranking of basin in order of contribution to national 1996/97 profit at full equity (#)	89	93	126	95
AGRICULTURAL COSTS	Area where NPV of lime application is positive (ha)		32 677	10 056	21 254
	Area where NPV of gypsum application is positive (ha)	12 692	2 000	498	3 499
	Area where NPV of lime and gypsum application is positive (ha)	98	9 379	9 357	1 095
	Area where dryland salinity caused yield loss in 2000 (ha)	5 819	41	4 219	10 685
	Area where dryland salinity may cause yield loss in 2020 (ha)	11 189	58	6 408	17 820
	Gross benefit from ameliorating acidic soils ($'000)	45	5 789	4 229	12 981
	Gross benefit from ameliorating sodic soils ($'000)	6 966	2 435	1 144	1 432
	Gross benefit from ameliorating saline soils ($'000)	236	2	533	731
	Limiting factor gross benefit ($'000)	7 035	6 599	4 533	14 090
	Impact cost of dryland salinity to agriculture from 2000 to 2020 ($'000)	205	1	280	611
	Present value of dryland salinity impact cost to agriculture from 2000 to 2020 ($'000)	1 138	8	1 555	3 388
	Net present value of lime application ($'000)		12 876	4 247	65 642
	Net present value of gypsum application ($'000)	5 569	71	103	1 773
	Net present value of lime and gypsum application ($'000)	266	8 077	20 642	37 298
OFF-SITE COSTS	Local infrastructure cost of salinity and water table rise 2000 ($'000/yr)	69	3	331	531
	Local infrastructure cost of salinity and water table rise 2020 ($'000/yr)	107	4	818	1 221
	Present value of increase in local infrastructure costs from salinity and rising water tables from 2000 to 2020 ($'000)	209	5	2 703	3 832
	Downstream costs				
	1% increase in salt loads ($'000)				
	5% increase in salt loads ($'000)				
	10% increase in salt loads ($'000)				
	1% increase in turbidity ($'000)		23	21	59
	5% increase in turbidity ($'000)		114	107	289
	10% increase in turbidity ($'000)		225	211	566
	1% increase in sediment loads ($'000)		121	0	21
	5% increase in sediment loads ($'000)		123	2	40
	10% increase in sediment loads ($'000)		127	4	64

Where basins run over State or Territory boundaries, values are only provided for the portion of the indicated State or Territory. The total

404	405	406	407	408	414	415	22	24
Broken River	Goulburn River	Campaspe River	Loddon River	Avoca River	Mallee	Wimmera-Avon Rivers	Nullarbor	Salt Lake
VIC	VIC	VIC	VIC	VIC	VIC	VIC	WA	WA
709 505	1 685 502	405 815	1 564 051	1 420 274	2 151 842	3 036 540	13 739 410	49 483 520
133 877	619 278	55 020	244 384	125 682	1 364 500	513 320	7 844 743	25 620 848
575 628	1 066 224	350 796	1 319 667	1 294 592	787 342	2 523 220	5 894 668	23 862 672
108 314	118 564	32 269	211 907	46 287	18 238	4 874		
467 313	947 659	318 526	1 107 760	1 248 305	769 104	2 518 346	5 894 668	23 862 672
507 172	605 172	144 409	555 554	367 283	327 028	561 131	3 682	79 380
187 667	243 692	58 693	211 521	111 947	92 332	149 378	2 327	29 280
152 373	217 730	71 435	249 157	149 566	110 547	253 707	3 508	46 995
167 132	143 750	14 280	94 876	105 770	124 150	158 046	-2 152	3 106
68 279	74 565	22 549	79 803	34 008	19 120	29 911	141	3 584
98 854	69 186	-8 269	15 072	71 762	105 030	128 134	-2 293	-478
536 316	653 007	153 674	584 394	359 699	328 246	512 667	4 714	76 988
338 861	459 677	129 945	459 441	260 206	203 278	401 381	5 830	76 085
197 455	193 330	23 729	124 953	99 493	124 968	111 286	-1 116	903
177 623	181 638	24 968	121 647	65 391	138 065	10 380		
19 832	11 693	-1 239	3 307	34 102	-13 097	100 906	-1 116	903
52 723	25 420	12 566	99 041	148 440	5 902	429 224		13 087
12	15	82	21	20	18	13	231	130
6 839	10 166	1 873	2 658	3 250		14 899		
173 810	175 175	66 173	312 771	59 741	18 133	78 565		
3 581	4 755	1 680	3 153			1 876		
15 865	36 168	16 120	22 074	4 455	23 038	53 667		
52 337	81 559	24 201	38 481	9 327	25 850	74 688		113 323
5 062	15 098	4 386	9 899	643	5	6 310		20
46 205	49 449	13 464	58 041	22 229	11 823	26 161	259	3 046
1 189	1 459	1 277	2 555	171	626	2 536		
48 870	59 749	16 852	67 012	22 584	12 177	32 650	259	3 047
5 054	4 069	560	1 708	313	370	1 320		644
28 039	22 573	3 106	9 475	1 734	2 054	7 323		3 574
10 194	56 657	718	4 875	539		31 482		
315 993	329 789	81 621	344 107	118 908	87 004	10 424		
52 093	38 497	32 225	88 840			13 649		
479	2 485	1 142	428	74	246	1 797		
2 287	5 191	2 267	723	259	308	3 198		46
10 033	15 012	6 240	1 636	1 025	345	7 773		254
			670	240				
			3 350	1 201				
			6 701	2 401				
3 703	9 896	3 972	165		116	78		
4 245	10 650	4 441	347		580	381		
4 916	11 565	5 010	569		1 160	745		
37	174	333	347	0				
43	275	363	352	0				
51	402	401	357	1				

value for a river basin can be obtained by summing the component State and Territory river basin parts.

	Basin number	25	26	601	602
	Basin name	Sandy Desert	Mackay	Esperance Coast	Albany Coast
	State name	WA	WA	WA	WA
CONTEXT	**Total area (ha)**	40 434 012	18 304 138	2 015 064	1 961 437
	Non-agricultural area (ha)	37 490 882	15 542 221	761 167	624 496
	Agricultural area (ha)	2 943 130	2 761 918	1 253 896	1 336 941
	Irrigated agricultural area in 1996/97 (ha)				508
	Dryland agricultural area in 1996/97 (ha)	2 943 130	2 761 918	1 253 896	1 336 432
PROFIT	**1996/97 gross revenue ($'000)**	2 842	3 128	175 397	206 975
	1996/97 variable costs ($'000)	2 149	2 185	52 314	60 706
	1996/97 fixed costs ($'000)	2 218	2 135	76 566	97 609
	1996/97 profit at full equity ($'000)	-1 526	-1 192	46 518	48 660
	1996/97 government support ($'000)	127	141	8 070	11 408
	1996/97 economic returns ($'000)	-1 652	-1 333	38 448	37 252
	5 yr (1992/93 – 1996/97) gross revenue ($'000)	5 836	7 694	164 471	213 375
	5 yr (1992/93 – 1996/97) total costs ($'000)	4 350	4 378	128 788	159 689
	5 yr (1992/93 – 1996/97) profit at full equity ($'000)	1 486	3 316	35 683	53 686
	Irrigated agriculture 5 yr profit at full equity ($'000)				1 065
	Dryland agriculture 5 yr profit at full equity ($'000)	1 486	3 316	35 683	52 621
	Minimum area of basin needed to produce 80% of profit at full equity within basin (ha)			295 828	214 599
	Ranking of basin in order of contribution to national 1996/97 profit at full equity (#)	222	217	35	32
AGRICULTURAL COSTS	**Area where NPV of lime application is positive (ha)**			82 974	116 437
	Area where NPV of gypsum application is positive (ha)			514	
	Area where NPV of lime and gypsum application is positive (ha)				4 059
	Area where dryland salinity caused yield loss in 2000 (ha)			94 935	247 345
	Area where dryland salinity may cause yield loss in 2020 (ha)			201 736	277 867
	Gross benefit from ameliorating acidic soils ($'000)		0	3 955	16 821
	Gross benefit from ameliorating sodic soils ($'000)		21	7 187	8 415
	Gross benefit from ameliorating saline soils ($'000)			3 469	8 555
	Limiting factor gross benefit ($'000)		21	11 229	26 755
	Impact cost of dryland salinity to agriculture from 2000 to 2020 ($'000)			5 749	1 075
	Present value of dryland salinity impact cost to agriculture from 2000 to 2020 ($'000)			31 891	5 965
	Net present value of lime application ($'000)			7 926	102 579
	Net present value of gypsum application ($'000)			163	
	Net present value of lime and gypsum application ($'000)				8 481
OFF-SITE COSTS	**Local infrastructure cost of salinity and water table rise 2000 ($'000/yr)**			392	1 711
	Local infrastructure cost of salinity and water table rise 2020 ($'000/yr)			947	1 887
	Present value of increase in local infrastructure costs from salinity and rising water tables from 2000 to 2020 ($'000)			3 079	974
	Downstream costs				
	1% increase in salt loads ($'000)				304
	5% increase in salt loads ($'000)				1 518
	10% increase in salt loads ($'000)				3 037
	1% increase in turbidity ($'000)			7	
	5% increase in turbidity ($'000)			35	
	10% increase in turbidity ($'000)			70	
	1% increase in sediment loads ($'000)			0	0
	5% increase in sediment loads ($'000)			0	2
	10% increase in sediment loads ($'000)			0	4

Where basins run over State or Territory boundaries, values are only provided for the portion of the indicated State or Territory. The total

603 Denmark River WA	604 Kent River WA	605 Frankland River WA	606 Shannon River WA	607 Warren River WA	608 Donnelly River WA	609 Blackwood River WA	610 Busselton Coast WA	611 Preston River WA
262 295	249 780	464 596	330 053	440 923	172 862	2 257 563	308 386	113 957
90 747	113 623	84 892	294 455	277 122	145 264	427 977	119 456	54 806
171 548	136 157	379 704	35 598	163 801	27 597	1 829 586	188 930	59 151
609	101	305	611	2 145	716	2 150	2 468	2 371
170 940	136 055	379 399	34 987	161 656	26 882	1 827 435	186 462	56 780
33 991	23 224	60 591	19 715	64 966	16 839	371 515	116 748	38 785
8 734	5 534	13 928	6 798	19 937	6 764	111 110	32 634	13 522
19 673	13 926	31 365	5 316	19 862	4 591	128 494	28 666	7 908
5 584	3 764	15 298	7 601	25 168	5 484	131 912	55 448	17 355
1 827	1 507	2 688	1 812	5 147	1 379	21 861	18 417	4 233
3 757	2 257	12 610	5 789	20 021	4 105	110 051	37 030	13 122
34 505	22 555	60 981	19 353	64 435	16 414	375 970	111 022	38 694
28 714	19 612	45 667	12 136	40 512	11 539	240 908	61 353	21 457
5 791	2 943	15 315	7 217	23 923	4 875	135 062	49 669	17 237
732	108	806	3 689	9 999	2 623	7 812	4 219	9 279
5 059	2 836	14 509	3 527	13 924	2 253	127 250	45 450	7 958
22 767	10 380	87 914	5 386	52 564	6 948	734 734	38 351	6 084
115	125	78	105	55	117	16	28	72
28 837	26 134	60 829	17 071	27 560	7 152	238 331	41 900	2 060
						104		
508		102	1 526	715		205	206	2 989
8 744	7 100	7 143	28 968	15 656	7 035	181 998	30 451	4 326
8 744	7 100	7 143	28 968	15 656	7 035	228 238	30 451	4 326
5 909	2 852	3 431	27 464	5 042	1 232	24 980	11 524	5 871
694	536	2 558	217	1 656	4	12 125	713	1 063
412	244	604	1 448	1 366	253	10 845	7 570	998
6 198	3 361	5 544	28 004	6 244	1 469	38 305	16 360	6 792
						2 132		
						11 828		
41 240	22 185	19 290	252 898	29 366	10 241	145 025	59 078	33 777
						56		
5 214		75	8 548	7 322		8 332	19 580	19 545
409	243	277	370	63	9	3 900	2 595	2 980
409	243	277	370	63	9	4 469	2 595	2 980
0	0		0	0	0	3 154	0	0
106		98		390	44	1 017	28	722
530		490		1 948	219	5 084	141	3 610
1 061		981		3 897	437	10 167	282	7 220
14			10	22	15		13	54
70			47	110	75		65	267
138			94	216	148		128	522
0		0	0	0	0	0	0	1
0		0	0	0	0	1	0	5
0		0	0	0	0	2	1	10

value for a river basin can be obtained by summing the component State and Territory river basin parts.

Section	Basin number	612	613	614	615
	Basin name	Collie River	Harvey River	Murray River (WA)	Avon River
	State name	WA	WA	WA	WA
CONTEXT	**Total area (ha)**	373 212	203 221	994 736	11 771 386
	Non-agricultural area (ha)	246 963	90 628	376 472	3 618 754
	Agricultural area (ha)	126 249	112 594	618 264	8 152 633
	Irrigated agricultural area in 1996/97 (ha)	3 205	6 634	1 253	
	Dryland agricultural area in 1996/97 (ha)	123 044	105 959	617 011	8 152 633
PROFIT	**1996/97 gross revenue ($'000)**	57 116	65 361	121 343	1 171 465
	1996/97 variable costs ($'000)	12 001	14 592	29 697	421 204
	1996/97 fixed costs ($'000)	12 803	13 937	47 537	376 328
	1996/97 profit at full equity ($'000)	32 313	36 832	44 108	373 933
	1996/97 government support ($'000)	9 583	11 081	9 371	55 851
	1996/97 economic returns ($'000)	22 730	25 751	34 737	318 081
	5 yr (1992/93 – 1996/97) gross revenue ($'000)	53 873	61 982	126 268	1 098 839
	5 yr (1992/93 – 1996/97) total costs ($'000)	24 874	28 533	77 377	795 171
	5 yr (1992/93 – 1996/97) profit at full equity ($'000)	28 999	33 449	48 891	303 668
	Irrigated agriculture 5 yr profit at full equity ($'000)	5 968	16 215	10 234	
	Dryland agriculture 5 yr profit at full equity ($'000)	23 031	17 234	38 657	303 668
	Minimum area of basin needed to produce 80% of profit at full equity within basin (ha)	25 523	18 766	165 039	2 289 735
	Ranking of basin in order of contribution to national 1996/97 profit at full equity (#)	49	46	41	2
AGRICULTURAL COSTS	**Area where NPV of lime application is positive (ha)**	21 477	22 909	95 771	869 658
	Area where NPV of gypsum application is positive (ha)	517	207	209	106
	Area where NPV of lime and gypsum application is positive (ha)	826	726	417	735
	Area where dryland salinity caused yield loss in 2000 (ha)	12 290	24 821	46 577	922 763
	Area where dryland salinity may cause yield loss in 2020 (ha)	12 292	24 821	46 609	1 037 539
	Gross benefit from ameliorating acidic soils ($'000)	3 248	7 902	10 773	39 186
	Gross benefit from ameliorating sodic soils ($'000)	1 420	1 534	4 169	35 482
	Gross benefit from ameliorating saline soils ($'000)	3 090	3 992	5 444	41 916
	Limiting factor gross benefit ($'000)	5 627	9 315	14 893	86 521
	Impact cost of dryland salinity to agriculture from 2000 to 2020 ($'000)	1		4	5 793
	Present value of dryland salinity impact cost to agriculture from 2000 to 2020 ($'000)	3		23	32 137
	Net present value of lime application ($'000)	18 095	47 715	61 125	120 056
	Net present value of gypsum application ($'000)	394	98	41	92
	Net present value of lime and gypsum application ($'000)	945	1 435	192	299
OFF-SITE COSTS	**Local infrastructure cost of salinity and water table rise 2000 ($'000/yr)**	1 984	3 138	6 375	11 697
	Local infrastructure cost of salinity and water table rise 2020 ($'000/yr)	1 984	3 138	6 375	13 053
	Present value of increase in local infrastructure costs from salinity and rising water tables from 2000 to 2020 ($'000)	0	0	0	7 521
	Downstream costs				
	1% increase in salt loads ($'000)	857	4 834		1 106
	5% increase in salt loads ($'000)	4 287	24 169		5 528
	10% increase in salt loads ($'000)	8 575	48 339		11 056
	1% increase in turbidity ($'000)	69	17 554	4 339	
	5% increase in turbidity ($'000)	339	18 607	5 206	
	10% increase in turbidity ($'000)	662	19 888	6 249	
	1% increase in sediment loads ($'000)	62	17	13	0
	5% increase in sediment loads ($'000)	68	51	56	1
	10% increase in sediment loads ($'000)	75	95	109	1

Where basins run over State or Territory boundaries, values are only provided for the portion of the indicated State or Territory. The total

	616	617	618	619	701	702	703	704	705
	Swan Coast	Moore-Hill Rivers	Yarra Yarra Lakes	Ninghan	Greenough River	Murchison River	Wooramel River	Gascoyne River	Lyndon-Minilya Rivers
	WA	WA	WA	WA	WA	WA	WA	WA	WA
	823 321	2 452 084	4 218 330	2 058 241	2 505 024	9 125 164	4 189 453	7 583 294	5 272 644
	432 629	516 853	306 641	910 452	188 432	862 416	537 032	396 274	565 443
	390 692	1 935 231	3 911 689	1 147 789	2 316 591	8 262 748	3 652 421	7 187 020	4 707 201
	4 204	1 374						112	225
	386 488	1 933 857	3 911 689	1 147 789	2 316 591	8 262 748	3 652 421	7 186 908	4 706 976
	72 560	233 907	119 703	27 636	219 139	42 561	6 470	8 396	10 744
	27 317	76 290	48 366	10 292	88 843	18 334	2 449	4 821	3 880
	45 269	118 534	52 924	15 146	85 560	32 772	6 358	5 174	3 703
	-25	39 082	18 414	2 197	44 735	-8 545	-2 337	-1 600	3 161
	4 265	11 174	5 598	1 252	11 001	1 952	259	318	446
	-4 291	27 909	12 816	945	33 734	-10 498	-2 596	-1 917	2 716
	69 783	231 050	122 609	26 194	225 569	46 055	7 895	10 705	13 579
	71 729	194 951	101 424	25 409	174 964	51 200	8 806	9 906	7 527
	-1 945	36 099	21 184	785	50 605	-5 146	-911	800	6 052
	12 322	9 253						788	968
	-14 267	26 846	21 184	785	50 605	-5 146	-911	11	5 083
		158 849	113 456	11 838	282 250				1 191 463
	179	44	68	136	40	248	235	223	129
	31 152	346 544	115 311	25 358	602 935	66 500			
	526								
	28 292	186 786	181 766	56 634	75 673				
	28 292	207 290	181 766	56 634	75 673				
	8 432	15 920	4 039	857	21 526	1 661	0	0	
	797	3 923	1 728	426	1 670				
	4 098	7 832	4 880	1 209	2 745				
	10 264	22 209	8 224	1 935	23 864	1 661	0	0	
		892							
		4 948							
	40 907	83 808	11 266	2 186	153 944	9 123			
	10 314								
	9 703	3 234	1 778	277	645				
	9 703	3 822	1 778	277	645				
	3	3 263	0	0					
	14 037								
	70 187								
	140 373								
	1 195	6							
	2 109	27							
	3 205	54							
	32	0			0				
	78	0			0				
	136	0			0				

value for a river basin can be obtained by summing the component State and Territory river basin parts.

	Basin number	706	707	708	709
	Basin name	Ashburton River	Onslow Coast	Fortescue River	Port Hedland Coast
	State name	WA	WA	WA	WA
CONTEXT	Total area (ha)	7 567 167	1 782 510	4 977 698	3 539 323
	Non-agricultural area (ha)	2 583 070	600 183	1 884 580	1 590 057
	Agricultural area (ha)	4 984 098	1 182 328	3 093 119	1 949 266
	Irrigated agricultural area in 1996/97 (ha)				
	Dryland agricultural area in 1996/97 (ha)	4 984 098	1 182 328	3 093 119	1 949 266
PROFIT	1996/97 gross revenue ($'000)	4 065	1 009	2 966	1 862
	1996/97 variable costs ($'000)	2 647	772	2 252	1 276
	1996/97 fixed costs ($'000)	3 330	866	2 348	1 418
	1996/97 profit at full equity ($'000)	-1 912	-628	-1 634	-832
	1996/97 government support ($'000)	165	43	132	79
	1996/97 economic returns ($'000)	-2 077	-672	-1 765	-911
	5 yr (1992/93 – 1996/97) gross revenue ($'000)	6 701	1 879	5 241	4 517
	5 yr (1992/93 – 1996/97) total costs ($'000)	5 957	1 628	4 527	2 700
	5 yr (1992/93 – 1996/97) profit at full equity ($'000)	744	251	715	1 817
	Irrigated agriculture 5 yr profit at full equity ($'000)				
	Dryland agriculture 5 yr profit at full equity ($'000)	744	251	715	1 817
	Minimum area of basin needed to produce 80% of profit at full equity within basin (ha)				
	Ranking of basin in order of contribution to national 1996/97 profit at full equity (#)	229	206	224	210
AGRICULTURAL COSTS	Area where NPV of lime application is positive (ha)				
	Area where NPV of gypsum application is positive (ha)				
	Area where NPV of lime and gypsum application is positive (ha)				
	Area where dryland salinity caused yield loss in 2000 (ha)				
	Area where dryland salinity may cause yield loss in 2020 (ha)				
	Gross benefit from ameliorating acidic soils ($'000)				
	Gross benefit from ameliorating sodic soils ($'000)				
	Gross benefit from ameliorating saline soils ($'000)				
	Limiting factor gross benefit ($'000)				
	Impact cost of dryland salinity to agriculture from 2000 to 2020 ($'000)				
	Present value of dryland salinity impact cost to agriculture from 2000 to 2020 ($'000)				
	Net present value of lime application ($'000)				
	Net present value of gypsum application ($'000)				
	Net present value of lime and gypsum application ($'000)				
OFF-SITE COSTS	Local infrastructure cost of salinity and water table rise 2000 ($'000/yr)				
	Local infrastructure cost of salinity and water table rise 2020 ($'000/yr)				
	Present value of increase in local infrastructure costs from salinity and rising water tables from 2000 to 2020 ($'000)				
	Downstream costs				
	1% increase in salt loads ($'000)				
	5% increase in salt loads ($'000)				
	10% increase in salt loads ($'000)				
	1% increase in turbidity ($'000)				
	5% increase in turbidity ($'000)				
	10% increase in turbidity ($'000)				
	1% increase in sediment loads ($'000)				
	5% increase in sediment loads ($'000)				
	10% increase in sediment loads ($'000)				

Where basins run over State or Territory boundaries, values are only provided for the portion of the indicated State or Territory. The total

710	801	802	803	804	805	806	807	808
De Grey River	Cape Leveque Coast	Fitzroy River (WA)	Lennard River	Isdell River	Prince Regent River	King Edward River	Drysdale River	Pentecost River
WA	WA	WA	WA	WA	WA	WA	WA	WA
5 673 293	2 296 610	9 384 478	1 475 646	2 001 596	1 540 100	1 762 443	2 598 361	2 914 577
1 361 789	933 969	1 301 894	276 553	1 279 425	1 424 638	945 362	1 583 853	1 212 963
4 311 504	1 362 641	8 082 585	1 199 093	722 171	115 462	817 081	1 014 507	1 701 614
4 311 504	1 362 641	8 082 585	1 199 093	722 171	115 462	817 081	1 014 507	1 701 614
4 412	1 878	11 614	2 141	1 359	222	29 328	1 334	1 806
3 322	1 128	6 765	1 067	653	105	9 332	830	1 328
3 348	1 053	6 248	927	558	89	5 955	784	1 315
-2 259	-304	-1 399	148	148	28	14 041	-281	-837
198	84	523	96	61	10	6 245	60	81
-2 457	-388	-1 921	51	87	18	7 796	-341	-918
7 834	3 846	25 692	4 447	2 823	488	30 103	3 546	4 784
6 547	2 163	13 030	1 977	1 201	194	15 326	1 658	2 700
1 287	1 683	12 663	2 470	1 623	294	14 778	1 888	2 084
1 287	1 683	12 663	2 470	1 623	294	14 778	1 888	2 084
			320 481	317 421	46 045	16 440		
233	190	221	167	168	172	83	188	211
		0						0
		0						
		0						0

value for a river basin can be obtained by summing the component State and Territory river basin parts.

Home
Contents

	Basin number	809	810
	Basin name	Ord River	Keep River
	State name	WA	WA
CONTEXT	Total area (ha)	4 423 256	590 925
	Non-agricultural area (ha)	1 645 605	177 215
	Agricultural area (ha)	2 777 651	413 710
	Irrigated agricultural area in 1996/97 (ha)	5 575	
	Dryland agricultural area in 1996/97 (ha)	2 772 076	413 710
PROFIT	1996/97 gross revenue ($'000)	40 361	549
	1996/97 variable costs ($'000)	12 796	339
	1996/97 fixed costs ($'000)	8 984	320
	1996/97 profit at full equity ($'000)	18 580	-110
	1996/97 government support ($'000)	2 811	25
	1996/97 economic returns ($'000)	15 769	-135
	5 yr (1992/93 – 1996/97) gross revenue ($'000)	47 204	1 461
	5 yr (1992/93 – 1996/97) total costs ($'000)	21 477	677
	5 yr (1992/93 – 1996/97) profit at full equity ($'000)	25 727	784
	Irrigated agriculture 5 yr profit at full equity ($'000)	21 153	
	Dryland agriculture 5 yr profit at full equity ($'000)	4 574	784
	Minimum area of basin needed to produce 80% of profit at full equity within basin (ha)	1 690	129 300
	Ranking of basin in order of contribution to national 1996/97 profit at full equity (#)	66	183
AGRICULTURAL COSTS	Area where NPV of lime application is positive (ha)	2 017	
	Area where NPV of gypsum application is positive (ha)		
	Area where NPV of lime and gypsum application is positive (ha)	119	
	Area where dryland salinity caused yield loss in 2000 (ha)		
	Area where dryland salinity may cause yield loss in 2020 (ha)		
	Gross benefit from ameliorating acidic soils ($'000)	3 449	24
	Gross benefit from ameliorating sodic soils ($'000)	67	0
	Gross benefit from ameliorating saline soils ($'000)		
	Limiting factor gross benefit ($'000)	3 455	24
	Impact cost of dryland salinity to agriculture from 2000 to 2020 ($'000)		
	Present value of dryland salinity impact cost to agriculture from 2000 to 2020 ($'000)		
	Net present value of lime application ($'000)	20 070	
	Net present value of gypsum application ($'000)		
	Net present value of lime and gypsum application ($'000)	5 105	
OFF-SITE COSTS	Local infrastructure cost of salinity and water table rise 2000 ($'000/yr)		
	Local infrastructure cost of salinity and water table rise 2020 ($'000/yr)		
	Present value of increase in local infrastructure costs from salinity and rising water tables from 2000 to 2020 ($'000)		
	Downstream costs		
	1% increase in salt loads ($'000)		
	5% increase in salt loads ($'000)		
	10% increase in salt loads ($'000)		
	1% increase in turbidity ($'000)		
	5% increase in turbidity ($'000)		
	10% increase in turbidity ($'000)		
	1% increase in sediment loads ($'000)		
	5% increase in sediment loads ($'000)		
	10% increase in sediment loads ($'000)		

Where basins run over State or Territory boundaries, values are only provided for the portion of the indicated State or Territory. The total value for a river basin can be obtained by summing the component State and Territory river basin parts.

Home
Contents

Home
Contents

APPENDIX 2 ESTIMATION OF RELATIVE YIELDS

Measures of impact cost and gross benefit depend on an assessment of relative yield. Relative yield is measured as a percentage and equals the actual yield, as currently recorded, divided by the potential yield that would occur if soil constraint(s) were not present (e.g. a crop yielding 2 t/ha with a relative yield of 50% due to constraints associated with salinity, acidity and/or sodicity, would have a full potential yield of double its current amount of 2 t/ha [2/0.5 = 4]). Relative yield is expressed as:

$$\text{Relative yield} = \frac{\text{Actual yield}}{\text{Potential yield}}$$

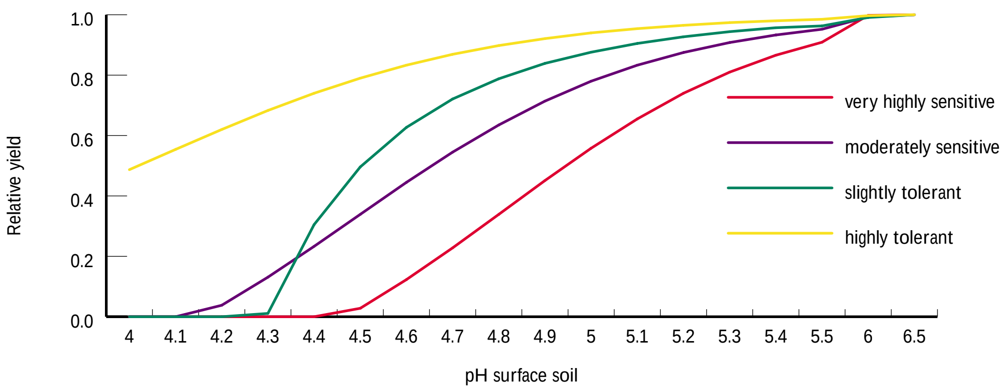
Relative yield for acidity

Relative yield from acidity was derived using a model developed by Agriculture NSW under Theme 5 of the Audit. The Policy and Economic Research Unit of CSIRO Land and Water, using data sets obtained from the Audit, ran the model. Original documentation describing the functioning of this model is provided in Dolling et al. (2001). The model's main inputs are:

- aluminium and manganese solubility class
- soil pH at 0–10 cm, 10–20 cm and 20–30 cm
- tolerance class (1 to 6) of the plant dominating the land use.

Using these it can determine relative yield (an example is shown in Figure A2). All data for the acid yield model were assembled on a 250 m grid covering the intensively used agricultural land areas of Australia. The aluminium and manganese solubility maps were obtained at this scale from the Australian Soil Resources Information System (developed by CSIRO). Surfaces of pH at the three depths were also obtained from Australian Soil Resources Information System. Each land use in the land use map was classified into one of six acid tolerance classes. The surface of relative yield from acidity, resampled to a 1 km grid to match the land use map, is shown in Figure A3.

Figure A2 Example of output from the acidity relative yield model for four plant tolerance classes within a given Al/Mn solubility class.



Data source: Dolling et al. 2001

Home
Contents

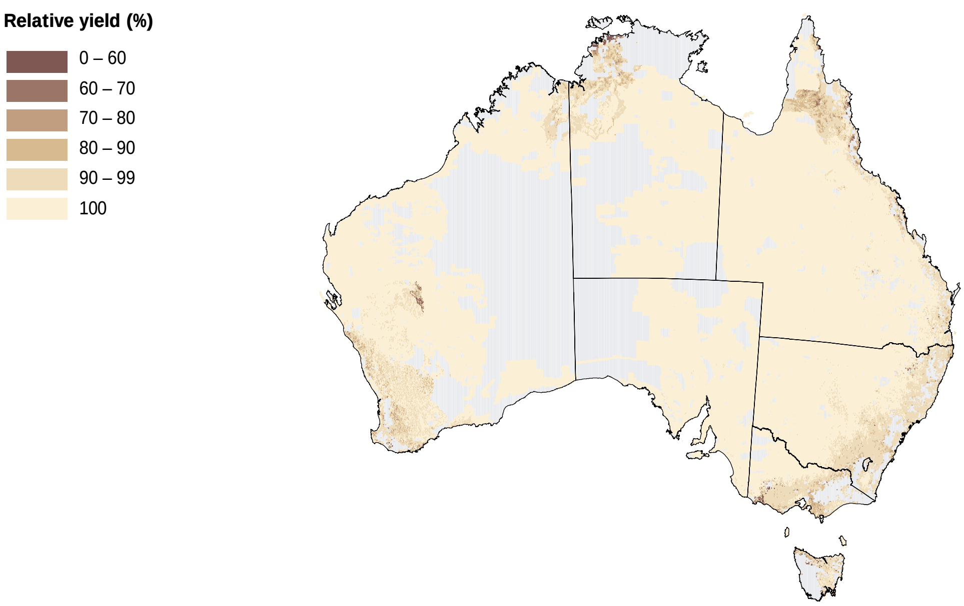
Relative yield for salinity

The relative yield for salinity was determined using data produced under Theme 2 of the Audit. Primary sources of data were maps delineating regions of high risk or hazard of dryland salinity hazard in 2000 and 2020 prepared by State and Territory agencies. It was necessary to reinterpret the maps in terms of yield impacts. This procedure was complicated by the use of slightly different methods for mapping salinity in the States and Territories.

The basic approach involved determining the extent of each specific area subject to five classes of yield loss. Maps of relative yield for salinity in 2000 and 2020 are shown in Figures A4 and A5.

The striking feature of the salinity relative yield maps is the highly pinpointed locations of yield loss. Areas of severe yield loss are barely visible at a national scale. There is also little discernible visual difference between the maps for 2000 and 2020.

Figure A3 Relative yield from acidity (%).

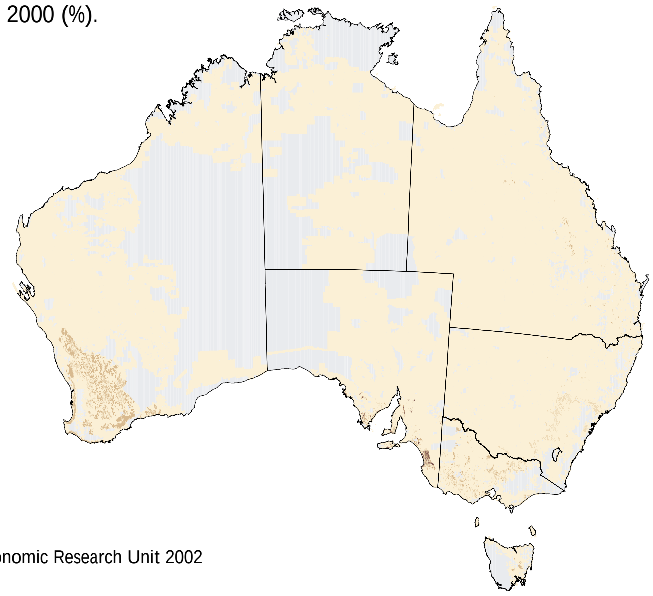


Data source: CSIRO Land & Water, Policy and Economic Research Unit 2002

Figure A4 Relative yield from salinity in 2000 (%).

Relative yield (%)

- 0 – 60
- 60 – 70
- 70 – 80
- 80 – 90
- 90 – 99
- 100

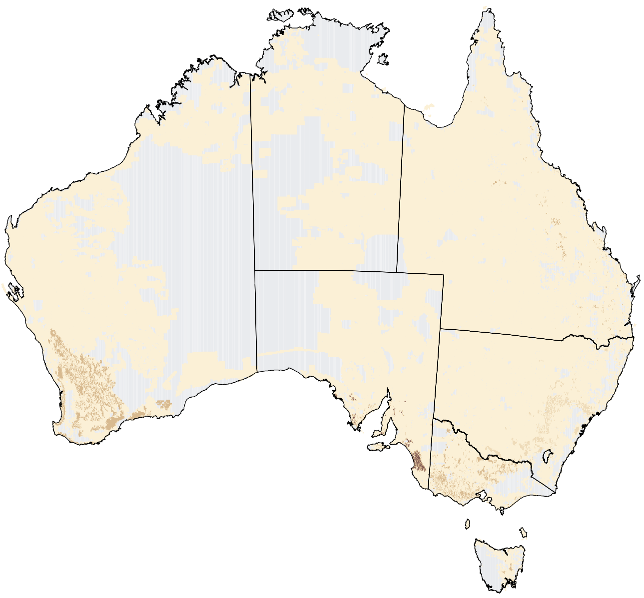


Data source: CSIRO Land & Water, Policy and Economic Research Unit 2002

Figure A5 Relative yield from salinity in 2020 (%).

Relative yield (%)

- 0 – 60
- 60 – 70
- 70 – 80
- 80 – 90
- 90 – 99
- 100



Data source: CSIRO Land & Water, Policy and Economic Research Unit 2002

Home
Contents

Relative yield for sodicity

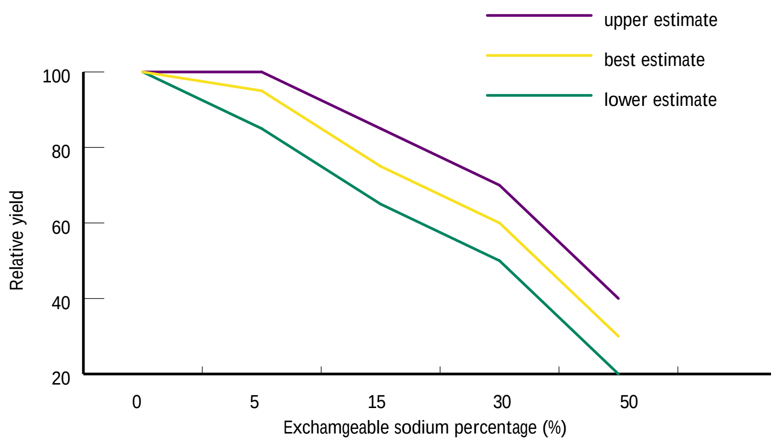
Relative yield for sodicity was modelled using a series of functions that related exchangeable sodium percentage in the soil surface to relative yield for 30 different crop/pasture types. An example of a sodicity relative yield function, used for tree crops, is provided in Figure A6. Full details of all the sodicity relative yield functions are contained in CSIRO Policy and Economic Research Unit (2001), Appendix C.

A gridded surface of exchangeable sodium percentage was derived from soil test data compiled under Theme 5 of the Audit and used in mapping regions of sodic soils. A surface of exchangeable sodium percentage was constructed from the soil test point data using a triangular irregular network, a method for constructing surfaces in a geographic information system. The extent of the triangular irregular network was limited by sodic soil specific areas. Combined with the land use map and 30 relative yield functions these data enabled the generation of relative yield from sodicity, an example of which is shown in Figure A7.

Limiting factor relative yield

The limiting factor relative yield is equal to the minimum relative yield associated with salinity, acidity and sodicity. It determines the full opportunity (i.e. maximum value of the yield gaps) for increasing yield. Where yield loss occurs as a consequence of multiple soil constraints the recovery of that yield requires addressing each soil constraint (e.g. an area subject to a relative yield of 50% due to salinity and 70% due to acidity requires the treatment of salinity up until the 70% relative yield mark, before any benefits of liming—commonly used to treat acid soils—can be attained). A map of the limiting factor relative yield is shown in Figure A8.

Figure A6 An example of a sodicity relative yield function (the central line represents the best estimate and the outer lines represent high/low estimates).



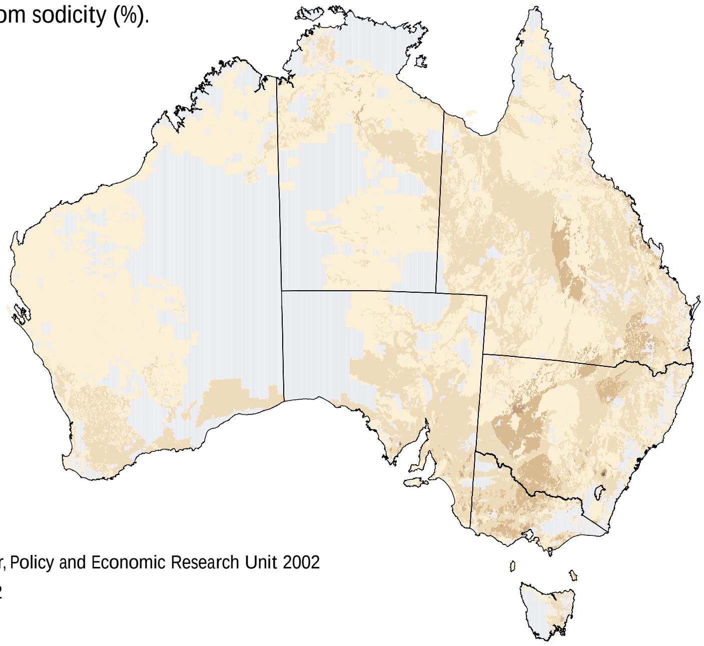
Data source: CSIRO Land & Water, Policy and Economic Research Unit 2002

Home
Contents

Home

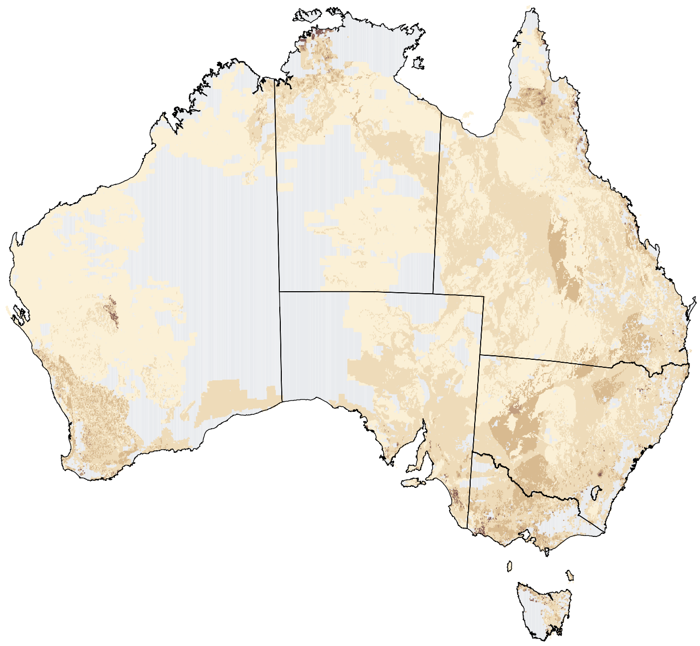
Contents

Figure A7 Relative yield from sodicity (%).



Data source: CSIRO Land & Water, Policy and Economic Research Unit 2002

Figure A8 Relative yield of the limiting factor of salinity, acidity and sodicity (%).



Data source: CSIRO Land & Water, Policy and Economic Research Unit 2002

Home

Contents

CQ Beef Industry Strategic Options: AGFORCE Briefing Paper 1, Human capital development

What is human capital?

Human capital in the beef industry is the abilities and skills of individual producers and the industry itself as a whole. It includes the practical and business skills, as well as the leadership, values, problem solving and organising abilities of beef producers and the regional industry. Developing human capital can also be thought of as 'capacity building'.

Training and education is linked to human capital and can be used as a measuring stick or indicator of human capital within the industry. Involvement in these activities can build on existing skills and experiences of land managers, building the producer's and the industry's capacity to meet challenges as they arise. This was supported by the Fitzroy Land and Water Audit project[1] that found CQ beef and beef-grains producers who participate in management-relevant training and education activities are more likely to use more sustainable grazing practices.

The three main areas where the grazing industry could target training and personal development in order to meet its vision of a viable and sustainable industry in CQ are:

- Natural resource management, better practice and sustainable land use options
- Business and marketing
- Personal development including conflict management, professional development, managing family relationships and stress management.

Current state and past trends

The information in this section is from discussed fully in the *Beef Industry Profile*[2] Participation of CQ graziers and other industry producers in farm management-relevant training activities between 1996 and 1999 is shown in the table below.

The table shows:

- around half of the CQ region's beef and beef/grains producers have taken part in Landcare/catchment field days or similar between 1996 and 1999; slightly more have participated in short courses relating to production or land management; and
- around one in every three CQ beef and beef/grains producers have participated in some form of property management planning, Futureprofit, Grasscheck type of activity between 1996 and 1999.

Other issues include:

- recent reports suggest that within FarmBis programs despite strong levels of participation in training relating to QA, business training, successional planning and WHandS there has been a low take-up rate in marketing and personal/professional development training;
- formal education levels in CQ rural industries, as of October 1999—roughly one in five beef producers and one in four beef/grains producers have undertaken post-secondary school education through avenues such as agricultural college, TAFE or university studies;

1 Taylor, B., Lockie, S., Dale, A., Bischof, R., Lawrence, G., Fenton, M. and Coakes, S. (2000) *Capacity of farmers and other land managers to implement change: Technical Report - Theme 6 Fitzroy Implementation Project* , National Land and Water Resources Audit.

2 Viability and Sustainable Resource use for the CQ Pastoral Industry: Industry profile and Strategic Options, Working paper. (2001), National Land and Water Resources Audit, Signposts for Australian Agriculture – Fitzroy

- in seeking useful property management information, beef producers in CQ in general place more importance on 'other producers' and 'field days' as valuable sources of land management information than other possible sources—this could been seen in the example of adoption of pasture monitoring in the region where those producers who use pasture monitoring as part of their management generally were located in clusters as a group of neighbouring properties, and those producers who stated they intended to adopt pasture monitoring were also generally located next to the groups of current users; and
- beef/grains producers also place importance on these sources but also rated 'technical journals and extension notes', 'accountants' and the 'internet' equally highly as a valuable information source.

Pressures influencing change

Factors—both positive and negative—influencing involvement in skill-based or professional development include:

- remoteness and a perceived or real lack of time, resources or need to do so;
- over the period 2001 to 2002, due to prices, producers may be in a better position financially to afford training opportunities;
- QRAA spending on training and skills enhancement programs in 1998/99 at $1.87 million is high compared to the mid 1990s (e.g. $0.2 million in 1994/95), it is substantially lower than in 1997/98 when expenditure was $4.4 million[3];
- land management networks such as Landcare providing activities such as field days;
- Industry moves to 'clean and green' marketing has generated a market for related training and accreditation and will continue to do so.

Type of training or education activity	Beef producers (%)	Mixed farmers (beef and grains) (%)	Grain growers (%)	Cotton growers (%)
Property management planning, future profit, QA, Grass check, Top crop etc.	34.4	38.1	61.5	26.9
Landcare, saltwatch, waterwatch catchment or similar field days or workshops	44.2	50.0	57.7	53.8
Rural leadership, self development courses, etc.	17.8	16.7	15.4	34.6
University, TAFE or distance education	18.1	23.8	30.8	15.4
Short courses such as chemical accreditation, chainsaw safety etc.	57.6	60.7	86.4	84.6

Note: number of producers surveyed: beef – 276, grains – 26, cotton – 26, mixed – 85

Source: National Land and Water Resources Audit, Theme 6, Fitzroy Audit

3 Rolfe, J. and Donaghy, P. (2000) Welfare Benefits: the changing face of the Queensland Beef Industry, Paper presented at 44th Annual Conference of the Australian Agricultural Resource Economics Society, Sydney.

- increasing signs of strain on some parts of the grazing natural resource base (e.g. soil health, pasture condition) are encouraging graziers to look for solutions that can be accessed through formal or informal training opportunities;
- a desire to be better prepared for difficult times (such as this decade's earlier drought);
- changes in the way extension agencies are delivering information; and
- recent trends amongst organisations (including government agencies) to see training as a part of capacity building in the rural sector.

Future scenarios

- Given the current community, industry and government driven agendas (both regionally and nationally) for supporting human capital development and improving the capacity of the rural sector, it is likely that a redirection of existing resources or the creation of new resources targeted at proving opportunities for industries and individuals to skill-up will continue.
- In the central and southern shires of the region there are trends of consolidation of smallholder operations into larger operations with the rate of exit from primary production (including grazing) exceeding the rate of entry[5]. These changes in ownership can result in changes in management practice use with less producers managing larger areas. There will still be a large section of the regional industry operating in the form of smaller family farms supported by income from other sources than beef production or breeding.

Industry strategies for developing human capital—actions, opportunities, information and partners

1. Improve opportunities for producers to participate in training or personal development activities

- Identify what motivates industry members to seek training
- Identify appropriate incentives for training such as industry sponsorship
- Provide meaningful and attractive industry-based scholarships or traineeships
- Use the media for exploring/improving rural industry perceptions of training
- Encourage adult learning and post-school education options
- Encourage participation in property management planning and rural leadership training type activities
- Target producers entering the industry to raise awareness of the industries direction, communication and information networks and relevant training options.

2. Improve existing training programs to be relevant to producers needs and learning styles

- Continue to provide relevant information and industry support for emerging land and business management practices
- Use industry 'champions'—promote producers within the Agforce network that have undertaken a range of sustainable land use option/changes/landscape planning

4 Fitzroy Basin Association Inc. (2001) *Central Queensland Strategy for Sustainability*. Fitzroy Basin Association, Inc, Rockhampton.

5 Barr, N. (2000) *Theme 6: Project 3.4 Interim Report, June 2000*, Department of Natural Resources and Environment Victoria, National Land and Water Resources Audit, unpublished draft report.

Home
Contents

- Ensure that training developers recognise that beef production and producers have specific learning styles and needs
- Research into what people on the farm value in terms of their lifestyle, business and environment to identify training and information needs
- e.g. of tertiary training opportunities becoming available include CQU's Graduate certificate in Beef Management
- See CQ Regional Industry Focus Group Report [6]

3. Industry make a strong collective statement to the extension community to deliver support for informal learning opportunities:

- A strong statement from the grazing industry putting forward key training needs would help direct its own policy and government programs relating to developing the human capital in the industry and the rural community more generally
- Ensure the training or extension providers offer 'one-to-one' and group-based learning opportunities, relating concepts and ideas to practical examples on pastoralists' properties and support pastoralists to access and manage information easily
- Address issues of extension credibility by securing experienced extension staff in the region
- See CQ extension survey report [7]

4. Build partnerships and identify allies in CQ who support human capital development/ capacity building in the industry

- Build stronger partnerships with Landcare, Catchment and other community groups
- Use existing networks with regional and catchment planning bodies (e.g. FBA and CHRRUPP RCC) to promote industry training opportunities and pool resources
- Both the Central Highlands Regional Resource Use Planning Project and the Fitzroy Basin Association[4] have identified 'capacity building' as regional priorities

5. Use skill-based training events and networks to promote and encourage participation in professional and personal development

- In promoting activities recognise and plan for specialist beef producers accessing different information sources/ communication networks than beef/grains producers
- Look to expand how the industry defines 'drought proofing' of properties to include financial preparedness and family/ relationship well-being
- See Industry Profile[2] section on Information Use and Access

6 Taylor, Lockie, Lawrence and Dale (1999) 'Regional Industry Focus Group Summary Report – Central Highlands and Dawson Catchment' as Appendix B In Taylor, B., Lockie, S., Dale, A., Bischof, R., Lawrence, G., Fenton, M. and Coakes, S. (2000) *Capacity of farmers and other land managers to implement change: Technical Report - Theme 6 Fitzroy Implementation Project* , National Land and Water Resources Audit.

7 Taylor, Lockie, Lawrence and Dale (2000) 'Regional Extension Survey Report: Changing Practices, Changing Landscapes' as Appendix C In, Taylor, B., Lockie, S., Dale, A., Bischof, R., Lawrence, G., Fenton, M. and Coakes, S. (2000) *Capacity of farmers and other land managers to implement change: Technical Report - Theme 6 Fitzroy Implementation Project* , National Land and Water Resources Audit.

Home
Contents

6. Seek recognition of, and training for, indigenous workers in the industry

- Initiatives such as the Agforce/emerald college training program
- Better publicity of this program to show the level of cooperation between the grazing industry and Indigenous Australians

7. The regional industry monitor its own progress by keeping track of producer participation rates in relevant training activities

- Explore possible Agforce-driven regular member survey of training needs, participation in formal and informal training and related activities on a regional basis and practice use
- Use indicators of 'participation in management-relevant training' used in the Industry Profile[2]
- Explore options for using DPI or CQU resources to undertake regular surveys to update this information
- Use the 2001 ABS Census information to build on information in industry profile

2 Viability and Sustainable Resource use for the CQ Pastoral Industry: Industry profile and Strategic Options, Working paper. (2001), National Land and Water Resources Audit, Signposts for Australian Agriculture – Fitzroy

CQ Beef Industry Strategic Options: AGFORCE Briefing Paper 2, Marketing 'Sustainability' and Sustaining Markets

Why market industry 'sustainability'?

The Australian beef industry, including producers in the CQ region, is becoming increasingly aware of the domestic and export market opportunities for a 'clean and green' product. In a climate of increasing community and consumer awareness and demand for produce from 'environmentally friendly' and 'safe' production systems, promoting beef as a 'sustainable' agricultural product has many market advantages.

There is also a growing recognition in the industry of needing to 'walk the talk' of 'clean and green' production systems and many producers are investigating and initiating various levels of accreditation that provide them with a market-recognised standard in order to maintain and expand their market opportunities. Along with marketing 'sustainability' there are several other approaches being explored by industry to maintain and improve its marketing outcomes.

Current state and past trends

How 'clean' is the industry?

- *Cattlecare:* Some 348 properties in Central Queensland are currently accredited under the Cattlecare system. These properties represent approximately 18% of beef producers in the region[1]. There are currently 1693 Cattlecare accredited properties Queensland wide. Cattlecare has also been developed in accordance with the internationally recognised ISO 9002 standard.

  The key issues addressed under the Cattlecare QA system include:

  - minimal risk of chemical contamination through the safe, responsible use of chemicals;
  - minimised bruising and hide damage; and
  - more effective management and herd improvement through better record keeping.

- As a condition of European Union accreditation a number of properties in CQ at are using the National Livestock Identification Scheme (NLIS). Current, Meat and Livestock Australia figures indicate there 562 livestock producers using the NLIS in the State of Queensland, of which 478 are fully EU accredited[2].

1 Barwell (2001) pers. comm., AUSMEAT.

2 Beasly, R. (2001) pers. comm. Meat and Livestock Australia, National Livestock Identification Scheme, Field Officer.

How 'green' is the regional industry?

Beef production in CQ has the underlying capacity to be a comparatively low impact industry in terms of chemical use, soil loss and impacts on the regions waterways. Recent research on industry practice use (see *Beef Industry Profile*[3]) have shown that there is high levels of awareness about maintaining pasture and soil health and over one-third of graziers in the region involved in PMP, GrassCheck and similar activities. There are some potentially concerning issues however with an apparent lack of awareness of the need to minimise stock access to and damage of streambank vegetation which act as important soil and nutrient filters for grazing properties (refer to *Environmental Compatibility: Briefing paper #3* for more comprehensive overview). At a national or broader industry scale there are a number of environmental or land management standards or accreditation initiatives emerging on the industry scene (refer to *APPENDIX – Current initiatives in marketing sustainability in the pastoral industry)*.

Alternative marketing approaches

- Alliance marketing groups. There have been moves in the industry towards strategic marketing alliance groups or structures. There has been a growing trend for smaller marketing groups to merge, looking to create more sustainable, larger commercial operations. Meat and Livestock Australia's BeefNet program has looked to support this trend. Nationally, there are currently around 30 BeefNet alliances operating on a commercial basis. These groups focus on a wide range of markets including branded products into various domestic and international markets, live export, organic and supply management for feedlots. A recent MLA survey of active alliance groups showed:
    - average annual throughput per group was 4000 head, and, average group membership was 53 producers;
    - on average, 45 percent of members are now Quality Assured;
    - the average proportion of annual turnover sold through the alliance was 30 pc; and
    - additional financial benefit from marketing through alliance was estimated at $20 /head.

An example of a recent merger of two alliance groups is that between CapBeef and Bluegum Beef groups in central/southern Queensland[4].

Pressures influencing change

- Globally and locally the market is looking for high quality, safe, economically and environmentally efficiently produced livestock products
- Currently landholders receive signals from society, in the form of prices and income, to produce more beef. In recent decades there has been a large shift in community values associated with 'environmental' issues linked to production which in turn act as signals to industry to modify production systems to changing demands
- Current and medium term beef price outlooks suggest there may be financial 'breathing space' or opportunities for

3 Viability and Sustainable Resource use for the CQ Pastoral Industry: Industry profile and Strategic Options, Working paper. (2001), National Land and Water Resources Audit, Signposts for Australian Agriculture – Fitzroy

4 Meat and Livestock Australia, *North Australia Program News*, Summer, 2000.

producers and the industry as a whole to invest in or explore various marketing approaches including marketing industry 'sustainability'

Future scenarios

- A scenario for the industry over the next twenty years will probably see: improved management of extensive grazing systems associated with reduced intensity of grazing; reduction in grazing activities in some areas, most noticeably in intensive grazing systems, largely in response to pressures on the resource base; growth of a variety of intensive/industrial systems of varying scales and levels of sophistication[5].
- Cost of food should increasingly reflect the cost of production proving industry with price based opportunities to build on existing environmental management and marketing components of their operations.

Industry strategies for marketing sustainability—actions, opportunities, information and partners

1. Industry and individual producers develop clear targets of what type of product/s they are wanting to market

- Rethinking and towards quality rather than quantity

2. Industry work towards demonstrating to community and markets that their production systems are sustainable

- Discuss the benefits and costs of standards or accreditation options such as: 'Green Badging', environmental codes of practice; landcare standards; ISO 9000, ISO 1400; Cattlecare and NLIS
- Industry and community support and promote those producers who are currently operating under sustainable/accredited production systems or seeking accreditation
- Funding available through sources such as the FarmBis program for Cattlecare

3. Promote the uniqueness and qualities of local/regional product

- CQ/Regional badging which identifies a distinctive local 'clean and green' product
- Investigate the role of Alliance groups and forming alliances with other regions and industries for value adding to regional product

4. Educating consumers and spreading the message

- Educational materials at point of sale which explain the accreditation and badging meanings
- Raise awareness of the cost of food production and the need for 'green' food production costs to be reflected in pricing
- Industry assumes responsibility for market development and research
- Promote activities and achievements though catchment group, Landcare and other community based networks

5 Vercoe, J. In Meat and Livestock Australia, *North Australia Program News*, Summer, 2000.

Home
Contents

5. Building partnerships to support and exploit 'clean and green' marketing opportunities

- Push for R,D&E funding to be directed into programs that support industry intentions/meet needs for a 'sustainable product' and continue to meet the ongoing information needs of beef enterprises generally

Current initiatives in marketing sustainability in the pastoral industry

Landcare standards concept

Proposal to establish industry standards include best practice management of soils, water, vegetation and biodiversity delivered at landscape level local/regional or catchment level incentive packages, form of accreditation and 'Green Badge' for product

Benefits

1. financial rewards to primary producers through direct incentives and through creating market advantage
2. establish a 'clean green' image, enhancing export capacity
3. improved environmental management will be both the public perception and on-ground reality.

Contacts

Jock Douglas, Roma, Phone 07 46268100
Source: NAP News Summer 2000

Industry codes of practice

Greater emphasis on development of sustainable management systems Adoption of pasture and land condition monitoring Accurate information on the financial advantages of sustainable management practices

Benefits

1. Retain and open access to sensitive markets (e.g. EU)
2. Retain opportunities for the appropriate development of land, with in the framework of accepted codes of practice, and land administration requirements
3. Less onerous compliance requirements in relation to government regulation
4. Social recognition of industry responsibility for environmental health guidelines for decision-making on sustainable and viable management

Contacts

North Australia Beef Research Council (NABRC) with CRC for Tropical Savannas The project is expected to start in July 2001 Source: NAP News Summer 2000 For more Information contact John Childs, Tropical Savannah CRC Phone 08 8946 6834

Home
Contents

Environmental Management Systems (ISO 14000)

A pilot study is under way to explore the potential of ISO 14000 Quality Assurance standards as an Environmental Management System for the Australian Beef Industry. Objectives of project include having at least 10 beef properties achieving ISO 14000 certification by June 2002 and to document and evaluate the benefits and difficulties of implementing the standard for the industry.

Benefits

1. Assist in maintaining market access through product differentiation and consumer education
2. Address statutory requirements for a 'duty of care' in managing grazing land
3. Traceability of individual products and their impacts on the environment
4. Adopt a responsible proactive approach to management that builds credibility for the industry

Contacts

Steering Committee contacts: Shane Walsh, NAPIC member, Phone: 07 4613 4890. Funded through NAP and Sustainable Grazing Systems Program.

CQ Beef Industry Strategic Options: AGFORCE Briefing Paper 3

Environmental compatibility

A healthy, productive and economically viable grazing industry in CQ is only achievable in the long run if the natural resources that are essential to the industry (soils, pastures and water) are also healthy. By moving towards grazing production systems that are more compatible with the landscape, the risks and costs of pasture and soil degradation can be greatly reduced.

This briefing paper gives a snapshot of the condition or state of the natural resource base that the grazing industry relies on and the use of positive land management practices in recent years that help maintain the grazing resource base. It also outlines some strategic options and actions for building on industry strengths and addressing some challenges facing the industry.

Current state

This section presents a general overview on the condition of the grazing natural resources of the whole region (Fitzroy Basin) and also some detailed information on the Nogoa catchment, Central Highlands as a case study. Grazing as a land use occupies 82% of the Fitzroy Basin land area and a similar area in the Nogoa catchment with a further 1% under pasture–cropping rotation in 1997.

Condition of the soil resource base and risks to grazing

- A 1992 assessment[1] of the condition of In the Central Highlands Grassy Eucalypt woodlands with wiregrass (*Aristida* spp.) and bluegrass (*Bothriochloa* spp.) native pastures concluded that of the total A/B area, about one-third is in good condition, one-third is fair and one-third is in poor pasture condition.
- A long term DPI grazing study[2] located on AB pastures in the Nogoa catchment has shown that continual heavy grazing causes a two-fold increase in soil movement above that occurring under moderate grazing pressures. The increase in soil loss and landscape instability at high grazing pressure is disproportionately large and there is no improvement in the value of animal product.
- Other risks on grazing lands include overgrazing on black spear grass country, herbaceous weeds and nutrient tie-up on open downs/Qld bluegrass country, brigalow pastures at risk from regrowth and regeneration, weed invasion and nutrient tie-up due to soil fertility decline. Some brigalow pastures at risk from salinisation due to tree clearing on duplex soils with saline subsoils and nutrient depletion on sown pastures[1].

1 *The pasture lands of northern Australian: Their condition, productivity and sustainability.* Tothill, J.C. and Gillies, C. (1992) Tropical Grassland Society of Australia, Occasional Publication No. 5. Meat Research Corporation, Brisbane.

2 *Sustainable Production From Eucalypt Woodlands (A/B Project)* Jones, P. (1999) in Long, Donaghy and Grimes (eds.) (1999) 2020 Vision – Extension into the new millennium, 2nd Central Queensland Extension Forum, 18th-20th of May, 1999, DPI, Qld.

Current grazing practices in the region and soil management

A 1999 survey of 276 Central Queensland Beef producers and 85 CQ Beef/grains producers along with industry based focus groups from the Fitzroy Land and Water Audit project[3] showed:

- CQ beef producers are aware of and value maintaining pasture condition and soil health as part of a viable and sustainable enterprise. Focus groups in the Dawson and Central Highlands included as key grazing practices 'conservative stocking rates', 'monitor pasture condition to check carrying capacity', 'maintain native pastures' and 'spelling paddocks or rotational grazing'.
- Two-thirds of producers indicated they currently practice 'pasture monitoring or in-field checking' or use some form of 'strategic spelling, cell grazing or time control grazing'.
- One-quarter of beef producers have begun pasture monitoring during the 1990s. This reported adoption over the last decade reflects the more 'formal' types of pasture monitoring (e.g. GRASS Check). A further 6% of graziers indicated they intended to start pasture monitoring during 1999–2002. Industry extension officers also stated that 'pasture monitoring' was a 'growing practice' that has been accessible to producers for the last 5–10 years.
- Over one-third of beef (34%) and beef–grains (38%) producers surveyed in CQ took part in activities such as property management planning, FutureProfit, GRASSCheck between 1996 and 1999, contributing to the increase in use of practices such as pasture monitoring in the region in the 1990s.

Condition of rivers and waterways on grazing and cropping lands

Stream bank stability[4]

- Most of the stream banks surveyed (65% of the Dawson and 68% of the Comet/ Nogoa/Mackenzie catchments) were rated 'stable' and 'very stable' with just under 10% of sites rated as 'unstable' and 'very unstable'
- Although mostly stable, the northern and southern areas of the Nogoa catchment have local areas of unstable banks. The central Nogoa (including Borilla, Medway and Callistemon Creeks), was rated as having all of its banks in 'moderate' to 'very stable' condition, however, it has the greatest potential for future stream bank degradation with 49% of these rated as moderate.
- The presence of stock (87% of sites in Dawson and 71% in Comet/Nogoa/ Mackenzie) was the main factor identified as affecting bank stability as was the clearing of vegetation at 65% of sites in the Dawson and 36% of sites in the Comet/ Nogoa/Mackenzie.

3 *Capacity of farmers and other land managers to implement change:Technical Report - Theme 6 Fitzroy Implementation Project* , (2000) National Land and Water Resources Audit, Taylor, B., Lockie, S., Dale, A., Bischof, R., Lawrence, G., Fenton, M. and Coakes, S.

4 *State of the Rivers. Dawson River and Major Tributaries DPI 1995 and State of the Rivers. The Comet, Nogoa, and Mackenzie Rivers and Major Tributaries DNR*, 2000.

Home

Contents

Stream bank and riparian vegetation[4]

- Only 17% of riparian vegetation in the Dawson catchment and 50% of the riparian vegetation in the Comet/Nogoa/ Mackenzie catchments were rated as moderate to very good condition (the low rating in the Dawson is partly due to the timing of the surveys which followed a very dry period in 1994)
- In the Nogoa catchment, the southern section of the Nogoa River and its tributaries, including the Claude River, had the lowest rating of riparian vegetation with 64% of stream banks surveyed rated as poor or very poor.

Grazing practices and water quality

The 1999 Fitzroy Audit survey and industry focus groups [3] showed:

- compared to soil management practices, graziers were less aware of, or considered managing the impacts of grazing on adjacent waterways and streambank vegetation comparatively less important to long term viability and sustainability of their enterprises;
- extension staff surveyed considered that fencing watercourses and using off-stream watering points would become key practices for sustainable grazing—these practices they said have only emerged on the industry scene in the last 10 years and had only limited use at present; and
- although more broad than riparian vegetation, some two-thirds of the 276 beef producers surveyed in the region indicated they have retained or fenced stands of native vegetation, generally done so from their time of entry into the industry. The remaining third of beef producers surveyed however indicated they did not intend to do so in the foreseeable future.

Pressures influencing change

Factors, both positive and negative, influencing change to sustainable grazing systems include:

- growing awareness in the industry of production/market benefits of improving and documenting land management and business practices;
- national agri-political support and interest in developing or promoting industry codes of practice (e.g. NFF, QFF);
- locally generated research on the long term effects of overgrazing on pasture health and enterprise viability;
- producers seeking tools for managing resource issues as part of their enterprise through property management planning and similar activities;

3 *Capacity of farmers and other land managers to implement change: Technical Report - Theme 6 Fitzroy Implementation Project* , (2000) National Land and Water Resources Audit, Taylor, B., Lockie, S., Dale, A., Bischof, R., Lawrence, G., Fenton, M. and Coakes, S.

4 *State of the Rivers. Dawson River and Major Tributaries DPI 1995 and State of the Rivers. The Comet, Nogoa, and Mackenzie Rivers and Major Tributaries DNR,* 2000.

- community/market demand for beef produced through clean and green systems of production;
- positive industry involvement with catchment groups and other land management networks and planning processes in CQ;
- the need for industry to have a sound policy and practice base to respond to and negotiate with government on changing policy or legislative environments; and
- pressures from family (previous generation) to maintain the land when it may not be viable or sustainable.

Industry strategies for environmental compatibility—actions, opportunities, information and partners

1. Industry look to identify and agree on sustainable carrying capacities for the different types of country/ pasture communities in the CQ region

- Discuss and identify preferred carrying capacities on a branch by branch basis—bring together at the regional level into an industry discussion paper
- Recognise earning potential of different land types—linked to individual grazier's values
- Draw on local research/technical knowledge
- Enlist the help of Agforce policy office with the development of the position paper
- The Desert Uplands Build-Up has identified and agreed on acceptable carrying capacity for land—use as an example
- Seek support and feedback from outside groups
- Opportunity to promote the industry taking a positive step towards regional guidelines

2. Promote key soil and pasture management practices that underpin maintaining a healthy grazing resource base such as formal types of pasture monitoring (e.g. GRASSCheck)

- Graziers rely heavily on management information sourced from other graziers—encourage graziers to talk more about their experiences with pasture monitoring programs and related practices

3. Improve the awareness of financial and other costs and benefits of taking-up and using management practices that reduce the risks to soil and water health

- Draw from (and document) first-hand accounts of graziers who are currently using these management practices—costs/ benefits
- Enlist the help of economists to cost out practice adoption and explore cost sharing arrangements
- The regional industry put forward a statement on the current barriers to, and requirements for, adopting more sustainable management practices.
- Draw on the Fitzroy Land and Water Audit's Focus Group work in the Central Highlands and Dawson Valley which asked graziers and grain growers what they thought were the main barriers to adoption—see CQ Rural Industry Focus Group Report[3]

3 *Capacity of farmers and other land managers to implement change: Technical Report - Theme 6 Fitzroy Implementation Project*, (2000) National Land and Water Resources Audit, Taylor, B., Lockie, S., Dale, A., Bischof, R., Lawrence, G., Fenton, M. and Coakes, S.

4. Work towards industry guidelines or codes of practice

- Review of existing options and proposals for industry codes of practice/accreditation and their costs and benefits
- Review other industry approaches to identify pitfalls and successes
- At a regional industry level build on knowledge of practice use and adoption through monitoring and reporting
- At farm level encourage resource monitoring as part of property and business planning
- Draw on information sources from DPI[5] and CSIRO[6] on sustainable grazing systems in CQ
- See '*Marketing Sustainability*' *Briefing Paper 2* – Appendix 3)'
- Build on/expand on information on practice in *Beef Industry Profile Section 4*

5. Explore more widely the options for better riparian vegetation management and improved stock watering, such as off- stream watering points.

- Develop an industry/regional position on the role of tax-based incentives or other financial incentives
- Tap into existing community/catchment-based projects in the region offering support and financial assistance to producers to undertake riparian fencing and off-stream watering points through devolved grant schemes (e.g. FBA. DCCA, Lower Fitzroy)

6. Explore market-driven incentives for promoting clean and green production

- See *Marketing Sustainability* Briefing Paper 2 – Appendix 3

5 DPI, (2000) *Managing grazing in the semi-arid woodlands: a graziers guide*

6 Balancing Conservation and Production: understanding and using landscape thresholds in property planning, (2000). Grazed Landscapes Management Group, CSIRO Tropical Agriculture.

CQ Beef Industry Strategic Options: AGFORCE Briefing Paper 4, Soil Erosion Risk in the Fitzroy Basin

For a number of years regional resource managers, including rural industry, have become increasingly aware of the need to manage soil erosion to ensure the long-term sustainability of the natural resource base, and therefore their enterprise, and to improve or maintain the health of the region's ecosystems.

This briefing paper complements *Briefing Paper 3: Environmental Compatibility*, by providing, for discussion, information on the current status land use[1] and soil erosion in the region. For the Nogoa Catchment and the Fitzroy Basin, mapping from the national water borne erosion assessment[2] conducted as part of the Audit, has been built into the current *Fitzroy Audit* project. **It should be noted that the erosion mapping presented in this briefing paper has not been ground-truthed** and it is intended that this information will be cross checked with the region's industries, extension and technical staff in coming months. Relevant catchment health information is also presented below.

Land use, catchment health and erosion—sources and management

Land use

Digital land use data sets for the Fitzroy Basin were prepared at 1:100 000 scale, and for the Dawson Valley and Emerald irrigation areas at 1:25 000 scale. Based on the catchment's major basins, 10 land use maps were prepared at 1:250 000 scale. In addition a land use map was prepared for each of the regions 16 local authorities.

In the final phase of the Audit work in the Fitzroy, Land Use, Land Systems, Land Types and a Digital Terrain Model of the Nogoa Catchment in the Fitzroy Basin have been studied and presented as a series of maps. This information will be used to refine spatial outputs for the Nogoa from the national water borne erosion modelling which will be available to run scenarios for future management options. The maps and erosion risk assessments will be used in future regional planning to relate land use and management practices to erosion risk and ecosystem health.

1 Calvert, M., Simpson, J., and Adsett, K., 2000, *Land Use Mapping of the Fitzroy Catchment,* Department of Natural Resources, Rockhampton, AUSTRALIA.

2 NLWRA Audit 2001, *Australian Agriculture Assessment 2001*, a theme report of the National Land and Water Resources Audit, Canberra.

Catchment health

A geographic information system (GIS) was developed to assemble and assess historical regional data on river water quality, which is defined to a large extent by accelerated erosion. Key findings were:

- An estimated 2–4 million tonnes of suspended sediment leaves the basin annually into the marine environment. Erosion from cropped land is higher than from pastures, but regional land use is dominated by grazing.
- Annually, an estimated 3100 tonnes of nitrogen and 1300 tonnes of phosphorus are exported in the basin's waterways, with 60% of the phosphorus being transported with sediments. Nitrogen levels in waterways appear highest in irrigation areas, but are mostly below draft ANZECC 1999 guidelines for lowland rivers. High natural levels of heavy metals (zinc, copper and cadmium) also exist in some creeks.
- Riparian vegetation cover was poor in the Central Highlands and four major river catchments. The degradation was associated with both livestock access to these important areas of landscape and to weed invasion (parthenium and prickly acacia.)
- Healthy macro-invertebrate populations were found in 60% of monitored water sites whereas the other 40% of sites were mainly associated with intensive forms of land use or with heavy grazing of riparian vegetation. Water from stream reaches was in a healthier condition than water in dams or weirs.
- Stream barriers have reduced fish movement in rivers and estuaries
- Waterway contamination by pesticides was generally localised and seasonal, but some monitored sites were above ANZECC guidelines.
- Blue green algae are found in standing waters around dams and weirs and at periods of low stream flow.
- Salinity has been recognised in some areas, associated with land clearing and over use of ground water.

Soil erosion sources

The following is based upon results of the CSIRO National Water Borne Erosion Assessment[2] modelling project for the Audit.

The Fitzroy Basin in the national context

The Fitzroy Basin is approximately 14 million hectares in area and constitutes 8.5% of the national assessment area (referred to after here as 'national') for the National Land and Water Resources Audit. Nationally 40% of sediment is delivered to streams from hillslope erosion, 34% from gully erosion and 26% from streambank erosion. In the Fitzroy Basin, hillslope erosion (involving sheetwash and rill erosion) processes dominate over gully and river-bank erosion (62%, 24%, 12% respectively). The table below presents this national context for water-borne erosion for the Fitzroy.

The Fitzroy Basin contributes 20% of all sediment delivered from hillslopes to streams nationally. Of the 21 million tonnes of fine sediment to reach the coast nationally, 12% (2.6 million tonnes) come from the Fitzroy Basin,

2 NLWRA Audit 2001, *Australian Agriculture Assessment 2001*, a theme report of the National Land and Water Resources Audit, Canberra.

3 Jones, M-A. (2000). *Technical Report 3 -Theme7-Catchment Health-Fitzroy Implementation Project, Queensland.* Queensland Dept. of Natural Resources

and the area specific sediment yield of 0.18 t/ha/yr for this basin is slightly higher than the national average. Fine sediment loads in the Fitzroy Basin are predicted to have increased by 15 times the natural rate since European settlement which is well below the national average of 100 times the natural rate.

Gully erosion contributes 0.28 t/ha/yr to streams, just above the national average of 0.26 t/ha/yr. There are significant areas of low to moderate gully density with 62% of the basin having a gully density of 0.1 to 1 km per km^2, compared with the national figure of 37%. There is a small area of very high gully density (3 – 3.5 km per km^2) in the Nogoa Catchment (see over). Overall though, gully erosion is not considered a great concern for the Fitzroy Basin as < 1% of the basin falls into the category of high gully density.

Around 15% of sediment in the Fitzroy Basin is derived from streambank erosion, a natural process which is accelerated in areas of degraded riparian and streambank vegetation and poor stability. The Fitzroy Basin contains 15 500 km of streams of which around 50% have degraded riparian vegetation, which is just below the national average. All of the coarse sediment eroded through gully and river bank erosion remains deposited in the downstream tributaries. This leads to 13% of the river network with in-stream sediment deposition greater than 30 cm, which is considered to be

Attribute	National	Fitzroy Basin	Fitzroy as percent of national
Area (million ha)	167	14	8.5%
Stream length (km)	181 500	15 500	8.5%
Sediment sources			
bank erosion (million t/yr)	33	2	6.0%
gully erosion (million t/yr)	44	4	9.0%
hillslope erosion (million t/yr)	50	10	20.0%
total (million t/yr)	127	16	12.5%
Sediment delivery to coast			
Mt/yr t/ha/yr	21 0.13	2.6 0.18	12%
In-stream sedimentation > 30 cm			
stream length (km)	30 000	2 000	6.5%
percentage of total (%)	16.5	12	
Degraded riparian vegetation			
stream length (km)	118 600	7 800	6.5%
percentage of total (%)	65	50	

The erosion assessment was undertaken for the river basins containing intensive agriculture.

poor in terms of river health. This is lower than the national average of 16.5% in poor condition.

Nogoa Catchment

The area of the Nogoa Catchment represents about 20% of the Fitzroy Basin and the Nogoa River contributes a similar proportion (21%) of the sediment to rivers of the Fitzroy system. For sediment delivered to streams in the Fitzroy Basin, hillslope, gully and streambank erosion processes contribute 62%, 24% and 12% respectively. Corresponding figures for the Nogoa Catchment are 50%, 43% and 7%. For the Nogoa, streambank erosion processes are less important while the catchment has some areas of very high gully density with gully erosion more of an issue than for the Fitzroy as a whole.

Considering sediment delivery to the coast from the Fitzroy Basin, the Nogoa contributes only about 5% of the estimated 2.6 million tonnes annual load. This is not surprising considering that the Nogoa is remote from the coast.

Where to from here?

Extensive ground-truthing of the above soil erosion information is still required by seeking the opinions and knowledge of regional agricultural industries, NRM groups, agency technical and research staff and the extension community. This will assist in assessing the accuracy and application of this technique to the region. A number of key observations can be made and key management steps recommended based on this initial assessment:

- areas for strategic investment in soil erosion control in the Fitzroy Basin appear initially to be:
  - for *hillslope erosion* control target the north east of the Issac-Conners catchment, north east of the Mckenzie and the north west of the Fitzroy catchment, the Callide Valley and central Nogoa catchment;
  - for *gully erosion* control target the middle and upper areas of Theresa and Kettle Creeks in the Nogoa Catchment to reduce the coarse sediments being deposited locally in stream channels which reduces the health of the local waterway by changing habitat;
- regionally, streambank erosion is not a major issue in contributing sediment to waterways, however State of the Rivers reports for the Dawson and Central Highlands catchments indicates riparian areas are under significant pressure, which in turn reduces their role in buffering hillslope runoff which is a significant contributor of sediment to waterways in the region;
- land use within the Fitzroy Basin is dominated by grazing (82%) with a much lower proportion of land (~ 7%) used for cropping. While higher loads of fine sediment may arise from cropped lands per unit area, erosion management needs to focus on maintaining surface cover on land used both for cropping and grazing
- use producer networks in key erosion areas to support the implementation of sound property management plans involving riparian zone management and pasture monitoring (to maintain surface ground cover to at least 60% on grazing land).

Further information

Adsett, K., Simpson, J. and Hoddy, L., 2001, *Land Uses of the Nogoa River Catchment*, Department of Natural Resources, Rockhampton.

Adsett, K., Simpson, J. and Hoddy, L., 2001, *Land Systems of the Nogoa River Catchment*, Department of Natural Resources, Rockhampton.

Irvine, S., 2001, *Land Types of the Nogoa River Catchment*, Department of Natural Resources, Rockhampton.

Adsett, K., Hewavisenthi A. C., 2001, *A Digital Terrain Model of the Nogoa River Catchment*, Department of Natural Resources, Rockhampton.

APPENDIX 4 'BEST PRACTICE' MANAGEMENT PRINCIPLES FOR THE DAIRY INDUSTRY

Best management principles	Actions
Water management	
Schedule irrigations to apply the amount of water required, when and where it is required	• Understand the water storage (holding) capacity of soil in the root zone of plants (know how much water to apply and know how much water you apply) • Match the application rate (or the discharge and duration for flood irrigation) to the rate at which water is absorbed (know how long to irrigate for) • Understand when to schedule irrigation by measuring soil moisture or analysing weather (e.g. comparing evaporation and rainfall) and/or plant requirements (know how often to irrigate) • Apply water evenly with an irrigation system designed to match soil types and use well maintained irrigation equipment • For flood irrigation, laser level bays and adopt an automated system
Minimise water losses or wastage	• Incorporate weather forecasts into irrigation decisions • Establish surface drains to collect run-off and/or subsurface drains to prevent excess infiltration • Establish and manage a drainage water re-use system (especially for flood irrigation)
Review all on-farm water use	• Compare estimated annual crop water requirements with the total water applied • Review total on-farm water use (e.g. shed and yards [recycle cooling water, yard wash down], stock and domestic consumption, drainage/effluent, and irrigation) • Review the security and best use of water rights—water allocation policies permitting • Concentrate inputs (such as water) on the most productive areas of the property • Monitor the quality of irrigation and drainage water

Best management principles	Actions
Land management	
Recognise soil condition problems and their potential	• Monitor soil nutrients, pH, salinity and groundwater level • Be familiar with any regional or catchment management strategies
Understand and apply preventive and remediation measures	
Acidity	• Test and record surface soil (0–10 cm) pH at least every three years (more frequently if intensively irrigated and fertilised) • Ensure subsurface (10–60 cm) acidity does not increase • Apply fine lime when soils become too acidic • Consider sowing deep-rooted pastures with legumes to 'mop-up' excess nitrogen • Return manure and feed refusals to the paddock • Minimise nitrogen leaching (e.g. small, repeated nitrogen applications, not over-irrigating, keeping healthy pastures that use the available nitrogen, and rotating night paddocks)
Dryland salinity	• Concentrate production on the lowest salinity soils • Do not fallow during wet seasons • Fence off and vegetate recharge and discharge areas • Plant salt-tolerant pastures • Establish deep-rooted pastures or revegetate with suitable species • Install surface and/or subsurface drains or groundwater bores and manage drainage waters • Use and manage groundwater in conjunction with surface water
Irrigation induced salinity	• Maximise irrigation efficiency to avoid over-irrigation (particularly with saline water) • Ensure sufficient irrigation water infiltrates the soil to prevent salt accumulation by capillary action • Carefully manage the use of saline effluent • Plant salt tolerant pastures • Install surface and/or subsurface drains or groundwater bores and manage drainage waters • Use, monitor and manage groundwater in conjunction with surface water

Best management principles	Actions
Land management (continued)	
Erosion	• Adopt conservation tillage methods (oversowing, minimum or zero tillage, and cultivate across slopes) • Avoid cultivating during high rainfall seasons • Reduce run-off and its velocity (e.g. maintain groundcover such as permanent pastures and/or construct contour banks or diversion structures) • Fence off and revegetate degraded areas • Fence off and manage stock access to water frontages • Farm land according to its capability • Design and locate laneways to avoid run-off-induced erosion
Acid sulfate soils	• Avoid drying out (oxidation) of acid sulfate layers (e.g. use laser levelling instead of drainage and avoid new drainage or excavation) • Adopt shallow cultivation to avoid acid sulfate layers unless wet • After cleaning drains, water lime into spoil, and hold water back for 5–7 days
Soil structure	• Adopt conservation tillage methods • Apply gypsum to sodic soils • Increase the organic matter content of soils through pastures and/or manures • Avoid compacting soils by not overgrazing or cultivating when wet and by keeping traffic to designated laneways • Deep rip or aerate compacted soils
Wet soil pugging	• Adopt special grazing measures when wet (e.g. selective grazing, on–off grazing, loafing pads or lower stock numbers) • Establish multiple entry/exit points for stock • Adopt suitable surface drainage practices (e.g. spoon drains, 'hump and hollow' or plough affected areas in lanes) • Install and manage subsurface drainage where appropriate • Fence off extremely vulnerable areas • Select locally suited pasture species and manage their recovery from grazing to maintain adequate cover

Best management principles	Actions
Nutrients from fertilisers	
Balance fertiliser applications with plant/feed/production requirements	• Test the nutrient levels of soils (at the same location) every 1–2 years and adjust fertiliser applications accordingly • Prepare nutrient budgets (at the paddock or farm level) to monitor nutrient losses through milk, crops and stock and nutrient gains through legume pastures, fertilisers, feeds and manure • Apply phosphorus around the beginning of pasture growth periods • Apply nitrogen in small quantities, to meet pasture needs, periodically during the growing season
Minimise the loss of nutrients	• Reduce phosphorus loss by controlling soil erosion in cultivated lands • Reduce nitrogen loss by minimising: - leaching (e.g. small nitrogen applications matching the needs of actively growing pastures, not over-irrigating, keeping healthy pastures that use the available nitrogen and rotating night paddocks); and - nitrogen volatilisation through the adequate availability of moisture when applying urea or ammonium. • Avoid applying fertiliser before heavy rainfalls on sloping ground or within 20 m of streams • If flood irrigating: - do not over-water and minimise run-off - do not irrigate for at least four days after applying phosphorus fertiliser - ensure there is no run-off for two irrigations after fertilising - do not fertilise the bottom 20 m of bays - re-use irrigation run-off - apply nitrogen soon after an irrigation - laser level to reduce run-off and nutrient losses

Best management principles	Actions
Nutrients from fertilisers (continued)	
Reduce the concentration of effluent on impervious surfaces	• Design dairies and manage herds so cows spend only a short holding period in yards • Use water-efficient cleaning systems • Minimise effluent loss and run-off from laneways and feedpads • Locate dairies to minimise the time cows defecate on roadways
Reclaim effluent	• Collect effluent where possible (e.g. from the shed and yards, feed pads, calving pads, laneways, roadsides, silage and wet food storages • Treat collected effluent (e.g. in a pond system) • Accommodate wet weather, herd size and soil types in pond design or effluent management practices
Recycle effluent	• Spread effluent over sufficient area to avoid concentrating nutrients and water
Prevent the off-farm movement of effluent and wastes	• Fence off and manage access by stock to waterways • Use vegetated 'filter strips' (that include ground cover) adjacent to streams, particularly in very high rainfall areas, to reduce the physical transport of manure to streams and only 'crash graze' these areas • Manage storm water (including that from roadsides) to reduce the prospect of manure being discharged to streams
Manage existing natural areas	• Fence remnant vegetation to manage its use and regeneration • Control rabbits and hares, and eradicate weeds • Fence waterways to manage access and grazing • Manage remnant wetlands to maintain natural wetting and drying cycles, retain natural snags, and eradicate introduced fish

Best management principles	Actions
Nutrients from fertilisers (continued)	
Revegetate landscapes	• Use windbreaks or shade plantings to link waterways and patches of remnant native vegetation or as part of a district, catchment or roadside program • Use a range of local native species (and local provenances if possible) • Establish groundcover and understorey plants as well as trees • Adopt direct seeding techniques or other locally proven revegetation methods • Design plantings to minimise potential local pest and weed control problems
Manage wildlife	• Maintain tree hollows and other natural habitat • Provide nesting boxes in revegetation plantations • Control cats, foxes and other vermin • Monitor, evaluate and manage wildlife populations and their impacts

Home
Contents

APPENDIX 5 BENEFIT TRANSFER GUIDELINES

Overview

The attribute implicit prices estimated in this non-market valuation study are useful for making a 'first pass' assessment of the size of non-market values associated with policies that have particular environmental and social impacts. The estimates are suitable for establishing the impacts of management decisions that affect major regions or the nation as a whole, and that can be described using one or more of the generic attributes. That is, the estimates can be used wherever impacts can be described in terms of changes in:

- the number of species protected;
- the hectares of farmland repaired or bush protected;
- the kilometres of river restored for recreation; and
- the size of rural population.

The estimates are inappropriate for assessing impacts at the individual catchment level, or for valuing resource use changes that have very narrow and specific outcomes. They are not suitable for determining the impact of policies that affect environmental assets that are considered to be national or regional 'icons', such as the protection of koalas.

The guidelines (see Section 8.2 in van Beuren & Bennett 2000) demonstrate how the implicit price estimates can be used to evaluate the non-market impacts of different policies. In circumstances where a more detailed and accurate assessment is warranted, the choice models estimated for the national study and regional case study regions can be used to evaluate the welfare impacts (compensating surplus) of alternative scenarios.

Implicit price transfer

Step 1. Defining the policy context

The first step is to determine whether the management policy is targeted at a particular region or whether it involves Australia-wide projects.

- If resource-use policies involve changes at a national level, then the set of attribute values estimated using the national sample of households is appropriate.
- For policies that are targeted at either of the two case study regions, it is recommended that the implicit prices estimated for these regions be used (see Appendix B in project report for a complete tabulation of implicit price estimates).
- For regional assessments that do not correspond to one of the case study regions, it will be necessary to use the national estimates and calibrate the implicit prices so that the values are appropriate for the region under investigation. A set of scaling factors for performing this calibration is given in Table A1. A range of scaling factors is given for each attribute to allow for a margin of variability between different regions and populations.

Table A1 Scaling factors for calibrating national value estimates to a regional context.

Attribute	National implicit prices ($)	Scaling factors
Species protection	0.68	x 2
Landscape aesthetics	0.07	x 20-25
Waterway health	0.08	x 20-25
Social impact	-0.09	x 6-26

Home
Contents

Step 2. Defining the attribute changes

This step involves determining which attributes are impacted by the policy under investigation, and identifying the expected change in the attribute levels over a given time period relative to a 'business as usual' policy.

Step 3. Aggregating the attribute values

Each attribute change caused by a particular policy (defined in Step 2) is multiplied by its scaled implicit price (defined in Step 1). These attribute values are then summed to yield an approximation of the average annual per household benefit to be derived from the implementation of the proposed policy.

Step 4. Defining the target population

If the policy under investigation involves resource use changes at a national level, then the appropriate population for aggregating implicit prices is the population of Australian households. The impacts of changes implemented in particular regions should be restricted to the rural and city populations adjacent to the region in question. Extrapolation of values to other populations is speculative and not recommended.

Step 5. Aggregation

It is recommended that the annual household values be aggregated to 45% of the target population. If the analysis calls for an estimate of the full impact of a resource use change over a number of years, the annual values will need to be consolidated to a lump sum present value. A discount rate of 3 to 5% is recommended.

A regional policy assessment example

Consider the case of a proposal to redress land and water degradation in a region located in New South Wales. Under the proposal, 20 000 hectares of rural land will be rehabilitated, and 160 km of waterways will be restored. Analysis of the policy proposal by scientists indicates that the policy will ensure that three additional species will be protected. It is also predicted that 50 additional people will leave the region each year because of the lower farming intensities the proposal involves.

As a regional project, the implicit prices to be used in the valuation exercise will be scaled from the national estimates. Using the lower bound scaling factors in Table 5.13, the best estimate implicit prices are:

Species protection = 0.68 * 2 = $1.36 per species

Landscape aesthetics = 0.07 * 20 = $1.40 per 10 000 ha

Waterway health = 0.08 * 20 = $1.60 per 10 km

Social impact = -0.09 * 6 = -$0.54 per 10 persons leaving each year

Given the changes in attribute levels specified, the best estimate of the community's annual willingness to pay for the scenario is:

Willingness to pay
= (1.36 * 3) + (1.40 * 2) + (1.60 * 16) + (-0.54 * 5)
= $29.78 per household

This estimate is the amount, on average, that a *household* is willing to pay *each year* for twenty years to see the project proposed implemented. To estimate an aggregate value it is necessary to multiply the household value by an estimate of the size of the relevant population. This process includes making an adjustment to the survey estimates, via an aggregation factor, to allow for non-respondents in the sample. Assumptions used in this example are:

- the relevant population includes metropolitan Sydney and proximate areas of rural New South Wales, which amounts to four million persons;
- the number of people per household is 2.5;
- the aggregation factor is 45%.

Based on these assumptions, the best estimate of annual value would be:

Best estimate of annual value
= $29.78 * (4 000 000/2.5) * 0.45
= $21 441 600 per annum for 20 years.

Choice model transfer

When the changes in attribute levels are relatively large, a more accurate estimate of changes in welfare can be obtained using the full choice model. This welfare measure is known as 'compensating surplus' and represents the total value of a change in the levels of multiple attributes away from the business as usual scenario. Use of the full choice model incorporates the impacts of the attributes, as well as the factors influencing choice that have not been defined in the choice sets.

If a comprehensive assessment of welfare impacts is sought for changes in resource use at a regional level, it is recommended that one of the case study models should be employed for benefit transfer. Tests show that both of the regional models—estimated with data from the corresponding regional population (i.e. Albany or Rockhampton)—produce the same welfare estimates for a standard change scenario. However, the Great Southern model yields estimates with a smaller error variability. Furthermore, all attributes in this model are statistically significant, while the insignificance of *species protection* in the Fitzroy model is problematic. For these reasons, the Great Southern model is the preferred model for benefit transfer.

The following checklist provides a guide to the procedure that should be followed when transferring the Great Southern model to a different region:

- Determine whether the set of attributes employed in this study adequately describes the issues in the target region and the policy outcomes that are under investigation.
- Ensure that the ranges for the attribute levels in the target region are within the ranges used in the Great Southern questionnaire. Extrapolation outside these ranges will introduce transfer error.

- Specify levels for the attributes that are appropriate for the region and the scenarios of interest. A business as usual scenario should be established as a benchmark against which to compare alternative management strategies.
- Identify the target population for transfer. Ensure that the target population has attitudes and characteristics that are fundamentally similar to those used in the case study. It is recommended that the target population reside within the same State as the region under investigation. That is, the Great Southern model can be transferred to regions in other States, but the value estimates should only be aggregated to that State's own population. Extrapolation of benefits to other States is speculative. An exception may be the situation where the target region straddles the border of two adjoining States.
- Determine the mean socioeconomic characteristics of the target population. Two important characteristics include household annual income (before tax) and age. Substitute these mean values into the Great Southern model. The estimated parameters for this model are defined in Table 5.11.
- Refer to Chapter 6 of the project report (van Bueren & Bennett 2000) for technical details on how to calculate estimates of welfare change for a specific scenario relative to the status quo (see Box 6.1 in project report). For the Great Southern model, the error variability associated with these estimates is plus 85% and minus 64% of the mean value.
- Aggregate the resultant household welfare estimates to 45% of the target household population. The target population should be restricted to the rural and city populations adjacent to the region in question. Extrapolation of values to other populations is speculative and not recommended.
- If the analysis calls for an estimate of the full impact of a resource use change over a number of years, the annual values will need to be consolidated to a lump sum present value. A discount rate of 3% and 5% is recommended.

GLOSSARY OF TERMS AND CONVERSIONS

Amortisation

Conversion of a lump sum to an annual value at a given discount rate.

Control cost

Costs incurred by government, individuals, industries, or infrastructure providers to control or improve the condition of the natural resource.

Damage cost

Costs incurred by industries, infrastructure providers or households, as a result of the degradation of natural resources. These costs are divided into:

- recurrent damage costs in the form of loss of income from impaired economic activity, additional repair or maintenance expenditure, reduced service life of capital items; and
- non-recurrent investment costs on such items as additional water treatment plants or provision of replacement reservoir capacity.

Discount rate (DR)

The rate of time preference for real income expressed as a percentage. The discount rate can be thought of as the rate at which we devalue economic costs or benefits that occur in the future. In this report results of analyses are generally reported at three discount rates: 6%, 5% and 3%.

EC units

Electrical conductivity units, mS/m, a measure of water salinity: equals approximately 1.6 times TDS. The World Health Organisation considers 800 EC the maximum desirable salinity level for drinking water. At 1500 EC many crops cannot be irrigated and 5000 EC is often considered the threshold for 'saline water'.

Fixed cost

Costs of agricultural production that do not vary as a consequence of quantity produced or area harvested. They must be met in order to allow an enterprise and cannot be adjusted in the short term. In this study, fixed costs are equal to the sum of fixed depreciation costs, fixed labour costs and fixed operating costs. Fixed costs are adjustable in the long term.

Gross benefit

The gross benefit is the additional profit at full equity attainable in a given year if yield constraints (salinity, acidity, sodicity) were costlessly removed.

Gross revenue

In general terms, the gross revenue is equal to the price multiplied by quantity of agricultural product sent to market.

Impact cost (salinity)

In this report, the impact cost of salinity is the decrease in agricultural profit at full equity as a consequence of salinity-induced yield decline from 2000 to 2020 in crops and pastures.

Marginal cost

The additional cost resulting from an extra unit of degradation.

Net economic returns

This is equal to the profit at full equity for agricultural production less any government support in the form of tax subsidies, extension advice and other forms of support.

Non-market goods and services

A non-market good or service cannot easily be priced because it is not traded in the market place. This includes goods such as biodiversity or clean air. These goods are sometimes valued using non-market valuation techniques.

Profit at full equity (PFE)

Profit at full equity is a measure of the economic returns to the natural resource base and management practice through agriculture. It is equal to gross revenue less fixed and variable costs.

Relative yield

Relative yield is expressed as a percentage and is equal to the actual yield divided by the potential yield (e.g. a crop currently yielding 2 t/ha with a potential yield of 4 t/ha would have a relative yield of 50%).

Salinity of water

Four quality classifications are used:

- fresh (TDS < 500 mg/L)
- marginal (TDS 500 to 1500 mg/L)
- brackish (TDS 1500 to 5000 mg/L)
- saline (TDS > 5000 mg/L).

Social welfare

Social welfare can be considered to be the well-being of the community as a whole. In this report the term is used with reference to results derived from a non-market valuation of environmental resources. The welfare impacts of a policy that affects those non-market values can be considered the impacts to society's overall well-being.

TDS

Total dissolved solids in a water sample, in mg/L: is approximately 0.625 EC units.

Variable costs

Variable costs are those costs that change as a function of the quantity of an agricultural commodity produced or as a function of the area farmed. They are adjustable in the short term.

REFERENCES

Chapter 1

ABARE (Australian Bureau of Agricultural and Resource Economics) 2001, *Australian Commodity Statistics*, previous issues, Canberra.

—— 2000, *1999 Australian Commodity Statistics*, ABARE, Canberra.

ABS (Australian Bureau of Statistics) 2000, Cat. no. 7117.0; 7113.0 Canberra.

—— 1999 *Australian System of National Accounts* 1997-98, Cat. no. 5204.0, Canberra.

——1998, *Agricultural Industries, Financial Statistics, Australia, Final Issue (1996/97)*, Cat. no. 7507.0.

AUSLIG (Australian Survey and Land Information Group) 2001, *Land tenure*, Australian Survey and Land Information Group, Canberra.

BRS (Bureau of Rural Sciences) 2001 *National Land Use for Australia (1996/97) - Version 2*, compiled by the Bureau of Rural Sciences, Canberra.

CSIRO Policy and Economic Research Unit 2002, *Value of returns to land and water and the costs of degradation*, a project report to the National Land and Water Resources Audit from a consortium led by the Policy and Economic Resource Unit, CSIRO Land and Water, Adelaide.

DPIE (Department of Primary Industries and Energy) 1987, *1985 Review of Australia's Water Resources and Water Use*, vol. 1 and 2, Water Resources Data Set, Australian Government Publishing Service, Canberra.

NLWRA (National Land and Water Resources Audit) 2001a, *Australian Water Resources Assessment 2000*, a theme report of the National Land and Water Resources Audit, Canberra.

—— 2001b, *Australian Dryland Salinity Assessment 2000: extent, impacts, processes, monitoring and management options*, a theme report of the National Land and Water Resources Audit, Canberra.

—— 2001c, *Australian Native Vegetation Assessment 2001*, a theme report of the National Land and Water Resources Audit, Canberra.

—— 2001d, *Australian Collaborative Rangeland Information System - Tracking changes*, a theme report of the National Land and Water Resources Audit, Canberra.

—— 2001e, *Australian Agriculture Assessment 2001*, a theme report of the National Land and Water Resources Audit, Canberra.

Parham D. 1999, *The New Economy? A new look at Australia's Productivity Performance*, Productivity Commission, Canberra.

State of the Environment Advisory Council 1996, *State of the Environment Australia 1996*, report presented to the Commonwealth Minister for the Environment, CSIRO Publishing, Collingwood, Victoria.

Chapter 2

CIE (Centre for International Economics) 1997, *Guidelines for Economic Evaluation of RandD*, report commissioned by GRDC and RIRDC, Canberra.

NLWRA (National Land and Water Resources Audit) 2001a, *Australian Water Resources Assessment 2000*, a theme report of the National Land and Water Resources Audit, Canberra.

—— 2001b, *Australian Dryland Salinity Assessment 2000: extent, impacts, processes, monitoring and management options*, a theme report of the National Land and Water Resources Audit, Canberra.

—— 2001d, *Australian Collaborative Rangeland Information System - Tracking changes*, a theme report of the National Land and Water Resources Audit, Canberra.

Chapter 3

ABARE (Australian Bureau of Agricultural Research Economics) 2000, *Productivity Growth in the Australian Grains Industry*, ABARE Research Report 2000.1, Commonwealth of Australia, Canberra.

Access Economics 2001, *Population Ageing and the Economy*, Department of Aged and Community Care, www.health.gov.au/acc/ofoa/documents/pdf/popageing.pdf.

ABS (Australian Bureau of Statistics) 2000, custom data tables derived from the 1996 Australian Population Census.

Barr N. 2001, *Structural Change in Australian Agriculture: Implications for Natural Resource Management*, National Land and Water Resources Audit, Canberra.

——1999, *Salinity control, water reform and structural adjustment: The Tragowel Plains Irrigation District*, unpublished doctoral thesis, Institute of Land and Food, University of Melbourne, http://adt1.lib.unimelb.edu.au/adt-root/public/adt-VU2000.0002/.

Barr N. & Cary J. 2000, *Influencing improved natural resource management on farms: A guide to factors influencing the adoption of sustainable natural resource management practices*, Bureau of Resource Sciences, Canberra, www.brs.gov.au/social_sciences/nat_resource_mgt.pdf

—— 1992, *Greening A Brown Land: The Australian Search for Sustainable Land Use*, Macmillan, Melbourne.

Bryant L. 1999, 'The detraditionalization of occupational identities in farming in South Australia', *Sociologia Ruralis*, vol. 39, no. 2, pp. 236–261.

Byron I., Curtis A.L. & Lockwood M. 2000, *Burnout in Landcare: A summary of findings from the Shepparton Irrigation Area*, http://www.ecopsychology.org/gatherings5/burnout.html.

Cary J. 1994, *Modelling Beliefs Related to Environmental Behaviour*, PhD, University of Melbourne.

Cary J., Barr N., Aslin H., Webb T. & Kelson S. 2001, *Human and Social Aspects of Capacity to Change Sustainable Management Practices*, National Land and Water Resources Audit, Canberra.

Cary J. & Webb T. 2001, *Community landcare, the National Landcare Program, and the landcare movement: The social dimensions of landcare*, AFFA, Canberra, www.affa.gov.au/docs/rural_science/social_science/landcare.html

Curtis A.L. & De Lacy T. 1996, 'Landcare in Australia: does it make a difference?', *Journal of Environmental Management*, vol. 46, no. 2, pp. 119–147.

Economic Research Service 1996, 'Farm Operator Household Income Compares Favourably with All US Households, But Varies by Geography and Size of Farm', *Rural Conditions and Trends*, vol. 7, no. 3, pp. 40-44, http://www.ers.usda.gov/publications/rcat/rcat73/index.htm.

Fenton M., MacGregor C. & Cary J. 1999, *Framework and Review of Capacity and Motivation for Change to Sustainable Management Practices*, BRS report to the National Land and Water Resources Audit, Canberra.

Gabriel M. 2000, *Between homes: politics of regional youth migration*, Australian Institute of Family Studies, Melbourne, www.aifs.org.au/institute/afrc7/papers.html.

Gleeson A. 2000, *Australian Values: Rural Policies*, www.synapseconsulting.com.au/symposium/paper.asp?id=40.

Gorddard B.J. 1993, 'Farmers' attitudes and intentions towards conservation cropping practices', *Proceedings of the 5th Australian Soil Conservation Conference*, Australian Soil Conservation Association, Perth, pp. 1–15.

Gordon J., Vincent D., Haberkorn G., MacGregor C., Stafford-Smith M. & Breckwoldt R. 2001, *Indicators within a decision framework: Social, economic and institutional indicators for sustainable management of the rangelands*, National Land and Water Resources Audit, Canberra.

Karunaratne K. & Barr N. 2001a, *A baseline of adoption of conservation cropping: Mallee region*, Natural Resources and Environment, Bendigo, www.nre.vic.gov.au/agvic/profiles/clpr.htm

—— 2001b, *A baseline of adoption of conservation cropping: North East region*, Natural Resources and Environment, Bendigo, www.nre.vic.gov.au/agvic/profiles/clpr.htm

Kilpatrick S. 2000, 'Education and Training: Impacts on Farm Management Practice', *Journal of Agricultural Education and Extension*, vol. 7, no. 2, pp. 105–116, www.agralin.nl/ejae/jaeev07n02p04.pdf.

Kilpatrick S. & Johns S. 1999, *Managing Farming: How Farmers Learn*, RIRDC, Canberra, 99/31, www.rirdc.gov.au/reports/HCC/UT-18A.doc

Korb P. 1999, 'Choosing to Work Off Farm', *Rural Development Perspectives*, vol. 14, no. 1, pp. 44–48.

Mues C., Chapman L., & Van Hilst R. 1998, *Survey of Landcare and land management practices: 1992-93*, ABARE, Canberra, Research Report 98.4.

Olfert R., Taylor J. & Stabler J. 1998, 'Nonfarm labour participation of farm women', *Canadian Journal of Agricultural Economics*, vol. 41, pp. 81–95.

Oxley T. 1997, *Dryland Lucerne: Establishment and Management in Northern Victoria*, 4th year project thesis, Dookie Campus, University of Melbourne.

Ransom K. & Barr N. 1993, *The adoption of dryland lucerne in North-Central Victoria*, Department of Agriculture, Bendigo.

Reeve I., Frost L., Musgrave W. & Stayner R. 2001, *Australian Farmers' Attitudes to Rural Environmental Issues: 1991-2000 - Draft Report*, Institute for Rural Futures, University of New England, Armidale, www.ruralfutures.une.edu.au/about/envimpact/lwafarmatt/lwafarmattcomment.html

Shrapnel M. & Davie J. 2000, *The Influence of Personality in Determining Farmer Responsiveness to Risk*, Gatton, School of Natural and Rural Systems Management, University of Queensland.

Taylor B., Lockie S., Dale A., Bishoff R., Lawrence G., Fenton M. & Coakes S. 2000, *Capacity of farmers and other land managers to implement change*, report to the National Land and Water Resources Audit, Canberra.

Vanclay F. 1992, 'Barriers to Adoption: A general review of the issues', *Rural Society*, vol. 2, no. 2, pp. 10–12, www.csu.edu.au/research/crsr/ruralsoc/v2n2p10.htm.

—— 1988 *Socio-Economic Characteristics of Adoption of Soil Conservation*, Griffith University.

Weston R.E. 1999, 'Finding happiness: Factors contributing to personal wellbeing', *Family Matters*, vol. 52, pp. 54-61, www.aifs.org.au/institute/pubs/fm/fm52.html.

Wilkinson R. & Cary J. 1992, *Monitoring Landcare in North Central Victoria*, School of Agriculture and Forestry, University of Melbourne.

Chapter 4

ABARE (Australian Bureau of Agricultural Research Economics) 2000, *Australian Farm Surveys*, Canberra.

Cameron J.I. & Elix J. 1991, *Recovering Ground*, Australian Conservation Foundation, Sydney.

CRCSLM (Cooperative Research Centre for Soil and Land Management) 1999, *The costs of soil acidity, sodicity and salinity for Australia: Preliminary Estimates*, Cooperative Research Centre for Soil and Land Management, Adelaide.

Hamblin A. & Kyneur G. 1993, *Trends in Wheat Yields and Soil Fertility in Australia*, Bureau of Rural Sciences, AGPS, Canberra.

Hayes G. 1997, *An assessment of the national dryland salinity research and development program*, LWRRDC Occasional Paper No. 16/97, Canberra.

Madden B., Hayes G. & Duggan K. 2000, *National Investment in Rural Landscapes: An Investment Scenario for NFF and ACF*, with the assistance of LWRRDC, The Virtual Consulting Group and Griffin NRM Pty Ltd, Albury, NSW.

NLWRA (National Land and Water Resources Audit) 2001b, *Australian Dryland Salinity Assessment 2000: extent, impacts, processes, monitoring and management options*, a theme report of the National Land and Water Resources Audit, Canberra.

Kemp A. & Connell P. 2001, *Impact of land degradation on Australian agriculture: A land values approach*, ABARE report to National Land and Water Resources Audit, Canberra.

Home

Contents

Redclift M.R. 1987, *Sustainable Development: Exploring the Contradictions*, Methuen, London.

Reeves G., Breckwoldt R. & Chartres C. 1998, *Does the answer lie in soil?*, occasional paper no. 17/97, prepared by Centre for International Economics for Land and Water Resources Research and Development Corporation, Canberra.

Chapter 5

CSIRO Policy and Economic Research Unit 2002, *Value of returns to land and water and the costs of degradation*, a project report to the National Land and Water Resources Audit from a consortium led by the Policy and Economic Resource Unit, CSIRO Land and Water, Adelaide.

Gutteridge, Haskins and Davey Pty Ltd 1999, *Murray-Darling Basin Commission Salinity Impact Study*, final report, Gutteridge, Haskins and Davey Pty Ltd., Melbourne.

MDBC (Murray-Darling Basin Commission) 1999, *The Salinity Audit of the Murray Darling Basin: A 100 year perspective*, Murray-Darling Basin Commission, Canberra.

—— 1997 *Dryland Technical Report No 1*, Murray-Darling Basin Commission, Canberra.

NLWRA (National Land and Water Resources Audit) 2001a, *Australian Water Resources Assessment 2000*, a theme report of the National Land and Water Resources Audit, Canberra.

—— 2001b, *Australian Dryland Salinity Assessment 2000: extent, impacts, processes, monitoring and management options*, a theme report of the National Land and Water Resources Audit, Canberra.

—— 2001e, *Australian Agriculture Assessment 2001*, a theme report of the National Land and Water Resources Audit, Canberra.

Thomas J.F. 2001, *Ex-situ Costs of Australian Land and Water Resources Degradation to non-Agricultural Industries, Infrastructure and Households. Total Ex-situ Damage Cost Estimates for Salinity, Turbidity and Erosion*, report provided to CSIRO Land and Water by the Resource Economics Unit, Canberra.

van Bueren M. & Bennett J. 2000, *Estimating Community Values for Land and Water Degradation Impacts*, project report for the National Land and Water Resources Audit, Canberra.

Chapter 6

Barr N. 2001, *Structural Change in Australian Agriculture: Implications for Natural Resource Management*, National Land and Water Resources Audit, Canberra.

Coram J.E. (ed.) 1998, *National Classification of Catchments for land and river salinity control*, RIRDC Publication No. 98/78, Rural Industries Research and Development Corporation, Canberra.

Coram J.E., Dyson P.R., Houlder P.A. & Evans W.R. 2000, *Australian Groundwater Flow Systems Contributing to Dryland Salinity*, report by Bureau of Rural Sciences for National Land and Water Resources Audit, Canberra.

NLWRA (National Land and Water Resources Audit) 2001b, *Australian Dryland Salinity Assessment 2000: extent, impacts, processes, monitoring and management options*, a theme report of the National Land and Water Resources Audit, Canberra.

Home

Contents

Thomas J.F. & Williamson D.R. 2001, *Potential Benefits from Rehabilitation of Salt Affected Land by a Drainage Canal Scheme in the Blackwood River Catchment, Western Australia*, an indicative economic study on behalf of Agritech Pty Ltd, Western Australia.

Chapter 7

ABS (Australian Bureau of Statistics) 2000, *Agriculture*, 1998–99, Cat. no. 7113.0, ABS, Canberra.

ANZECC (Australian and New Zealand Environment and Conservation Council) 1998, *Core Environmental Indicators for Reporting of the State of the Environment*, Canberra.

NLWRA 2001b, *Australian Dryland Salinity Assessment 2000: extent, impacts, processes, monitoring and management options*, theme report of the National Land and Water Resources Audit, Canberra.

—— 2001e, *Australian Agriculture Assessment 2001*, a theme report of the National Land and Water Resources Audit, Canberra.

Prosser I.P., Hughes A.O., Rustomji P., Young W. & Moran C.J. 2001, *Assessment of River Sediment Budgets for the National Land and Water Resources Audit*, CSIRO Land and Water Technical Report 12/01.

Rolfe J. & Donaghy P. 2000, 'Welfare Benefits: The changing face of the Queensland Beef Industry', paper presented at 44th Annual Conference of the Australian Agricultural Resource Economics Society, Sydney.

Parham D. 1999, *The New Economy? A new look at Australia's Productivity Performance*, Productivity Commission, Canberra.

Pomfret S. 2000, *Sustaining Our Natural Resources, Dairying for Tomorrow: A Survey of Natural Resource Management on Australian Dairy Farms*, project report to the Dairy R&D Corporation.

Stewart J.B., Smart R.V., Barry S.C. & Veitch S.M. 2001, *1996/97 Land Use of Australia*, final report for Project BRR5, National Land and Water Resources Audit, Canberra.

Chapter 8

ABARE (Australian Bureau of Agricultural and Resource Economics) 2000, *Productivity Growth in the Australian Grains Industry*, Australian Bureau of Agricultural and Resource Economics, Canberra.

MDBC (Murray-Darling Basin Commission) 1999, *The Salinity Audit of the Murray Darling Basin: A 100 year perspective*, Murray-Darling Basin Commission, Canberra.

NLWRA 2001b, *Australian Dryland Salinity Assessment 2000: extent, impacts, processes, monitoring and management options*, theme report of the National Land and Water Resources Audit, Canberra.

—— 2001e *Australian Agriculture Assessment 2001*, theme report of the National Land and Water Resources Audit, Canberra. S.M. 2001,*1996/97 Land Use of Australia*, final report for Project BRR5 , National Land and Water Resources Audit, Canberra.

—— 2002, *Australian Natural Resource Information 2002*, a theme report of the National Land and Water Resources Audit, Canberra.

ACKNOWLEDGMENTS

The National Land and Water Resources Audit Advisory Council would like to sincerely thank those who have contributed to the successful preparation of *Australians and Natural Resource Management 2002*.

Project acknowledgments

To the leaders of our projects—for your vision, team leadership and quality outputs:

George Reeves .... Economics Advisor and theme report
Centre for International Economics

Mike Young .... Project Director, Economics returns and costs
CSIRO Land and Water

Stefan Hajkowicz .... Economics returns and costs
CSIRO Land and Water

Adrian Kemp .... Degradation impacts on land values
Australian Bureau of Agricultural and Resource Economics

Jonathan Thomas .... Water quality impact costs
The Resource Economics Unit

Bruce Howard .... Infrastructure cost
URS Corp

Jeff Bennett .... Non-market costs
Australian National University

Martin van Bueren .... Non-market costs
Centre for International Economics

Neil Barr .... Structural adjustment
Natural Resources and Environment, Victoria

John Cary .... Social Atlas
Bureau of Rural Sciences

Mike Read .... Economics of dryland salinity
Read Sturgess and Associates

Also to the numerous local governments, industry groups, and research and development corporations who contributed data and information and case studies.

Special note of thanks

To the 'unsung heroes' of all projects—the project teams—without your dedication and commitment this work could not have been completed. Please accept our sincere thanks and gratitude.

PHOTO ACKNOWLEDGMENTS

John Bourke	front cover, page 148
Mirko Stauffacher	page 142, 144, 146
Murray-Darling Basin Commission	page 104

NATIONAL LAND AND WATER RESOURCES AUDIT

Who is the Audit responsible to?

The Minister for Agriculture, Fisheries and Forestry – Australia has overall responsibility for the Audit as a program of the Natural Heritage Trust. The Audit reports through the Minister for Agriculture, Fisheries and Forestry to the Natural Heritage Board which also includes the Minister for the Environment and Heritage.

How is the Audit managed?

An Advisory Council manages the implementation of the Audit. Dr Roy Green, with a background in research, science policy and management chairs the Advisory Council. Members of the Advisory Council and the organisations they represent in February 2002 are: Warwick Watkins (L&WA), Bernie Wonder (AFFA), Stephen Hunter (EA), John Radcliffe (CSIRO), Peter Sutherland (SCARM), Jon Womersley (SCC), Roger Wickes (SCARM) and Colin Creighton (Audit).

What is the role of the Audit Management Unit?

The Audit Management Unit's role has evolved over its five-year life. Phases of activity include:

Phase 1. Strategic planning and work plan formulation—specifying (in partnership with Commonwealth, States and Territories, industry and community) the activities and outputs of the Audit—completed in 1998/99.

Phase 2. Project management—letting contracts, negotiating partnerships and then managing all the component projects and consultancies that will deliver Audit outputs—a major component of Unit activities from 1998/99 onwards.

Phase 3. Reporting—combining outputs from projects in each theme to detail Audit findings and formulate recommendations—an increasingly important task in 2000/01 and the early part of 2001/02.

Phase 4. Integration and implementation—combining theme outputs in a final report, working towards the implementation of recommendations across government, industry and community, and the application of information products as tools to improve natural resource management—the major focus for 2001/02.

Phase 5. Developing long term arrangements for continuing Audit-type activities—developing and advocating a strategic approach for the continuation of Audit-type activities—complete in 2001/02.

The Audit Management Unit has been maintained over the Audit's period of operations as a small multidisciplinary team. This team as at February 2002 comprises Colin Creighton, Warwick McDonald, Maria Cofinas, Jim Tait, Rochelle Lawson, Sylvia Graham and Drusilla Patkin.

How are Audit activities undertaken?

As work plans were agreed by clients and approved by the Advisory Council, component projects in these work plans were contracted out. Contracting involves negotiation by the Audit to develop partnerships with key clients or a competitive tender process.

Facts and figures

• Total Audit worth, including all partnerships	in excess of $52 m
• Audit allocation from Natural Heritage Trust	$34.19 m
• % funds allocated to contracts	~ 92%
• Total number of contracts	149

Natural
Heritage
Trust

Helping Communities
Helping Australia

A Commonwealth Government Initiative

National Land & Water Resources Audit

A program of the Natural Heritage Trust

www.environment.gov.au/atlas