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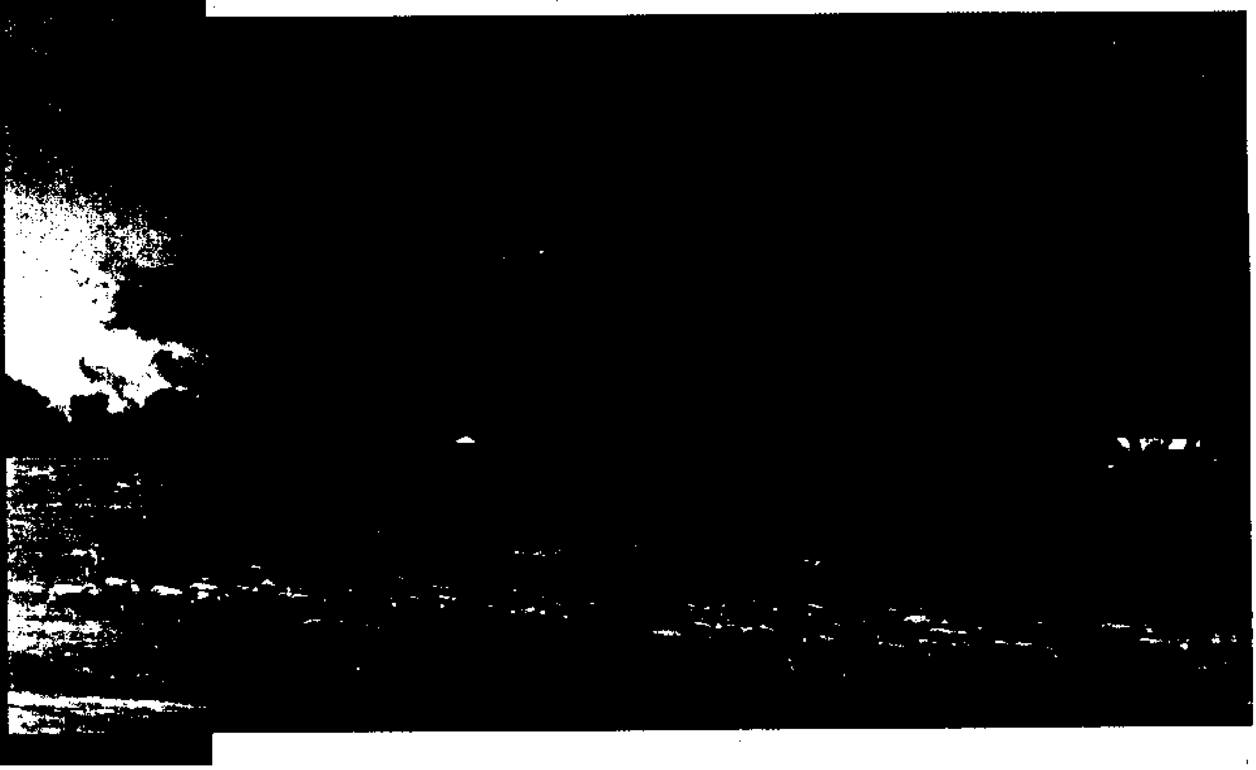
Australian Bureau of Statistics

Australian Agriculture and the Environment



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NEW ISSUE

AUSTRALIAN AGRICULTURE AND THE ENVIRONMENT

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AUSTRALIAN BUREAU OF STATISTICS

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INQUIRIES

- *for further information about statistics in this publication and the availability of related unpublished statistics*, contact Graeme Oakley on (06) 252 7369 or any ABS State Office.
- *for information about other ABS statistics and services*, please refer to the back page of this publication.

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PREFACE

The impact of agricultural activities on the environment has attracted the attention of the general public, politicians and decision-makers. It is high among international agendas with the Organisation for Economic Cooperation and Development (OECD) selecting this sector as one for further research concerning sustainability issues. Agricultural systems have special importance in the Australian economy and social life.

To obtain a better understanding of the relevant issues, a comprehensive set of statistical information is crucial. This publication presents an overall picture of Australia's agricultural activity using a presentational model that focuses on the interactions between the environment, society and the economy as it relates to agriculture. The work has a foundation based on the description of sustainability indicators for agriculture resulting from an initiative from the Standing Committee on Agriculture and Resource Management (SCARM).

The Australian Bureau of Statistics (ABS) has comprehensive data on many aspects of Australian agriculture. External sources have been used to provide as complete a picture as possible. Most of the information relating to the environment component has been sourced from non-ABS databases. In particular, the ABS acknowledges the information made available from sources such the Australian Bureau of Agricultural and Resource Economics (ABARE), the Murray–Darling Basin Commission, and many researchers in their journal articles. The framework used in this publication to organise the presentation is based on one used by Statistics Canada.

In Australia, environmental reporting is still a relatively new endeavour. Many issues and methodologies used in assessing the impact of agriculture on the environment are still under development. Suggestions and comments, particularly on future ABS publications in this field, would be greatly appreciated and should be sent to the Director, Environment Statistics and Accounts Section at the address indicated on the back page.

ABS publications draw extensively on information provided freely by individuals, businesses, governments and other organisations. Their continued cooperation is very much appreciated; without it the wide range of statistics published by the ABS would not be available for general use by governments and the community.

W. McLennan
Australian Statistician

Australian Bureau of Statistics
August 1996

LIST OF ABBREVIATIONS AND SYMBOLS

The following abbreviations and symbols used in tables represent:

n.a.	not available
n.c.	not collected
n.e.	not estimated
n.e.c.	not elsewhere classified
n.e.i.	not elsewhere included
n.f.d.	not further defined
n.p.	not available for publication, but included in totals where applicable
n.y.a.	not yet available
p	preliminary — subject to revision
. .	not applicable

INTERNATIONAL SYSTEM OF UNITS

Prefix	*Symbol*		
peta	P	10^{15}	1000000000000000.00
tera	T	10^{12}	1000000000000.00
giga	G	10^{9}	1000000000.00
mega	M	10^{6}	1000000.00
kilo	k	10^{3}	1000.00
hecto	h	10^{2}	100.00
deca	D	10^{1}	10.00
		10^{0}	1.00
deci	d	10^{-1}	0.10
centi	c	10^{-2}	0.01
milli	m	10^{-3}	0.001
micro	μ	10^{-6}	0.000 001
nano	n	10^{-9}	0.000 000 001
pico	p	10^{-12}	0.000 000 000 001

The prefixes in this table are used to simplify the standard units used in this publication. For example, rather than a table having a number of 0.000027 grams, this can be expressed as 27 milligrams or 27 mg.

CHAPTER 1

INTRODUCTION

THE NATURE AND PURPOSE OF THIS PUBLICATION

This publication was commenced soon after the SCARM 1993 report which specified a set of sustainability indicators for agriculture was released, and before the national State of Environment reporting process was properly under way.

In a general environment statistics compendium published in June 1992, *Australia's Environment: Issues and Facts* (4140.0), the ABS presented available environmental data at a broad level, in terms of the condition of various elements of the environment (land, water, atmosphere, etc.) and information about human activities that impact on the environment.

It appeared at that time that it would also be useful to compile sectoral publications, in greater depth and detail, showing the relationship between particular sectors (such as agriculture and transport) and the environment, emulating studies undertaken by some other countries and by international agencies such as the OECD. Agriculture is the human activity which perhaps interacts most widely with the natural environment through land use, dependence on ground and surface water supply, and impacts on ecosystems. The interaction is extensive and complex and thus not easily reduced to a few simple measures. Nevertheless, there has been substantial progress towards defining a set of sustainability indicators for agriculture in Australia.

While the process of monitoring a small set of indicators is a cost-effective approach to assessing general trends, it does not do away with the need to use a much more extensive database to examine issues at a more detailed level, i.e. at the scale of particular industries, regions, etc. The sum total of relevant information held by many federal and State agencies is very large indeed and cannot be represented fully in a publication of this size. The challenge is to assemble the information in public access databases (such as those maintained by the ABS, Department of Primary Industries and Energy and Department of Environment) so that it can be accessed for the purpose of more detailed analysis.

In the meantime it seems useful to publish a substantial slice across the database, that will provide some insight into the relationship between agriculture and the environment and the scale of the many activities involved indicate the range of information that is available in various forms, and signal data gaps that need to be addressed. This publication sets out to group the available data in such a way as to focus on the environmental, economic and social interactions that are relevant to a broad-ranging examination of agricultural activities from a sustainability viewpoint.

THE IMPORTANCE OF AGRICULTURE IN AUSTRALIA

The Australian economy has become increasingly diverse as it has expanded; agriculture's contribution has consequently been declining, the direct contribution (based on ABS industry classification) currently being 3% of Gross Domestic Product (GDP). It is nevertheless a vital and thriving sector and is particularly significant in export terms. Australian agriculture occupies an important place in global rural trade with wool, beef, wheat and sugar being particularly important in volume terms. Australia is also a significant source of dairy produce, fruit, cotton, rice and flowers. It is said that agricultural production in Australia is sufficient to produce the food and fibre needs of 55 million people.

Thus, agriculture contributes substantially to Australia's economic prosperity but also provides the population with the bulk of its food requirements. In 1993–94:

- the gross value of agricultural production was $23,479 million;
- gross farm product was 3.2% of GDP;
- agricultural exports amounted to $17,618 million, representing 27% of the total value of Australia's merchandise exports; and
- the agricultural sector employed over 401,900 persons (5% of the workforce).

In providing benefits to society, agriculture relies heavily on the natural resource base. It is Australia's most extensive form of land use and also the largest sectoral user of water. Approximately 470 million hectares, or 60%, of our land is classified as agricultural and over 10,000 gigalitres, representing 70% of Australia's use of stored water (including ground water), is consumed by the agricultural sector.

Agriculture also has a significant impact on the environment. In the 200 years since Europeans first settled in Australia, vast changes have been made to the natural vegetation. Tracts of the country that once supported eucalypts and wattles now support wheat and other crops, while areas that were previously grasslands in 1788 are now covered with timber and scrub (Standing Committee on Agriculture (SCA) 1991). The transformed landscape is recognised to be, in most cases, more susceptible than natural ecosystems to various kinds of land degradation including: erosion by water and wind, soil salinisation, soil acidification, and soil structure decline. This is not to overlook efforts that have been made to protect, maintain and even improve soils in many regions.

Where land degradation processes are accelerated by agricultural land use, the possibility of a deterioration in the quality of water resources is usually increased as soil and soil nutrients may find their way into river systems. Waste outputs associated with the use of manufactured fertilisers and chemicals in agriculture also have the potential to pose a threat to the natural environment, domestic stock and human health.

The economic and social importance of agriculture, coupled with the sector's dependence and impact on the environment highlight the need to recognise the linkages between each of these elements in shaping the agricultural process in Australia. This publication is an attempt to provide an integrated statistical overview of agriculture's relationship to the environment and society. It also provides a summary of the responses being made by the sector to improve the sustainability of agricultural activity.

THE CONCEPT OF SUSTAINABILITY

There has long been concern in Australia about issues such as soil erosion, water quality and the effect of farming practices on productivity. More recently, the importance of viewing human activities, such as agriculture and development in general, from the perspective of sustainability, has been gaining increasing acceptance. This development has been marked by the release of the World Conservation Strategy in 1980, and more recently, the 1987 report of the World Commission on Environment and Development (WCED), *Our Common Future*, referred to as the Brundtland Report. The Brundtland Report concluded that the 'current pattern of global economic growth was unsustainable on ecological grounds and that in the future, development would need to be pursued in an alternative manner which was sustainable' (WCED 1990). Sustainable development was viewed as 'development meeting the economic and social needs of today while conserving ecosystems for the benefit of future generations'. Increasingly, it is being recognised that economic policies need to take account of environmental impacts, including any effect on the ability of the land to generate future income. By the same token, environmentally motivated policies are unlikely to be accepted or to be successful unless they take into account the economic and social adjustments that may be required. Policies and programs aimed at achieving sustainable levels of agricultural activity therefore need to be based on environmental, economic and social considerations.

International commitment to the concept of sustainable development was confirmed at the United Nations Conference on Environment and Development (UNCED) held in Rio de Janeiro in June 1992. At the conference, all member countries were urged to adopt a national strategy for sustainable development which would build upon and harmonise the various sectoral, economic, social and environmental policies and plans they were operating. At this time, Australia was already a long way towards finalising its National Strategy for Ecological Sustainable Development (NSESD) and this was unveiled later in 1992. The theme of the strategy is 'to improve the total quality of life both now and in the future, in a way that maintains the ecological processes on which life depends' (NSESD 1992).

The Rio summit was responsible for establishing an action plan (Agenda 21) to 'address the pressing problems of today and aim at preparing the world for the challenges of the next century'. The plan incorporated a set of guiding principles, agreed to by participating nations, to provide direction to a global move towards sustainable development. As a signatory to the agreement, Australia has a commitment to its principles.

Significantly, Agenda 21 recognised the value of data as a tool to improve planning and management systems. It recommended the use of 'data and information at all stages of planning and management, making systematic and simultaneous use of social, economic, developmental, ecological and environmental data'.

ASSESSING SUSTAINABILITY IN AGRICULTURE

Sustainable agriculture has been defined as the use of farming practices and systems which maintain or enhance the economic viability of agricultural production; the natural resource base; and other ecosystems which are influenced by agricultural activities (SCARM 1993).

While the definition rightly focuses on the environmental and economic interactions involved in agriculture it does not spell out a means of assessing sustainability in quantitative terms. One approach is to monitor a key set of indicators. To make an assessment on this basis we need to be confident about the representativeness of the indicators and their predictive value. They should also be linked in some sort of analytical framework. It will not be easy to make an overall assessment in the form of even a notional 'index' of sustainability, unless there is agreement on the weighting that should be given to each indicator within the framework. This is not surprising, because similar judgements have to be made when assessing prospects for the economy, where trends in a variety of measures (e.g. production, prices, labour conditions, external balances) have to be considered together.

The assessment will be easier if consensus can be reached on target values for key environmental indicators, so that the implications of achieving them can be examined in economic and social terms.

Considering the information system as a whole, we appear to need:

- data from scientific and economic research to indicate the nature of the problems and the causal relationships involved and thus to guide the selection of indicators;
- a broad range of activity data to provide a measure of the scale of possible problems; and
- the data classified geographically and by industry, in order to identify where problems are likely to be concentrated and have greatest impact.

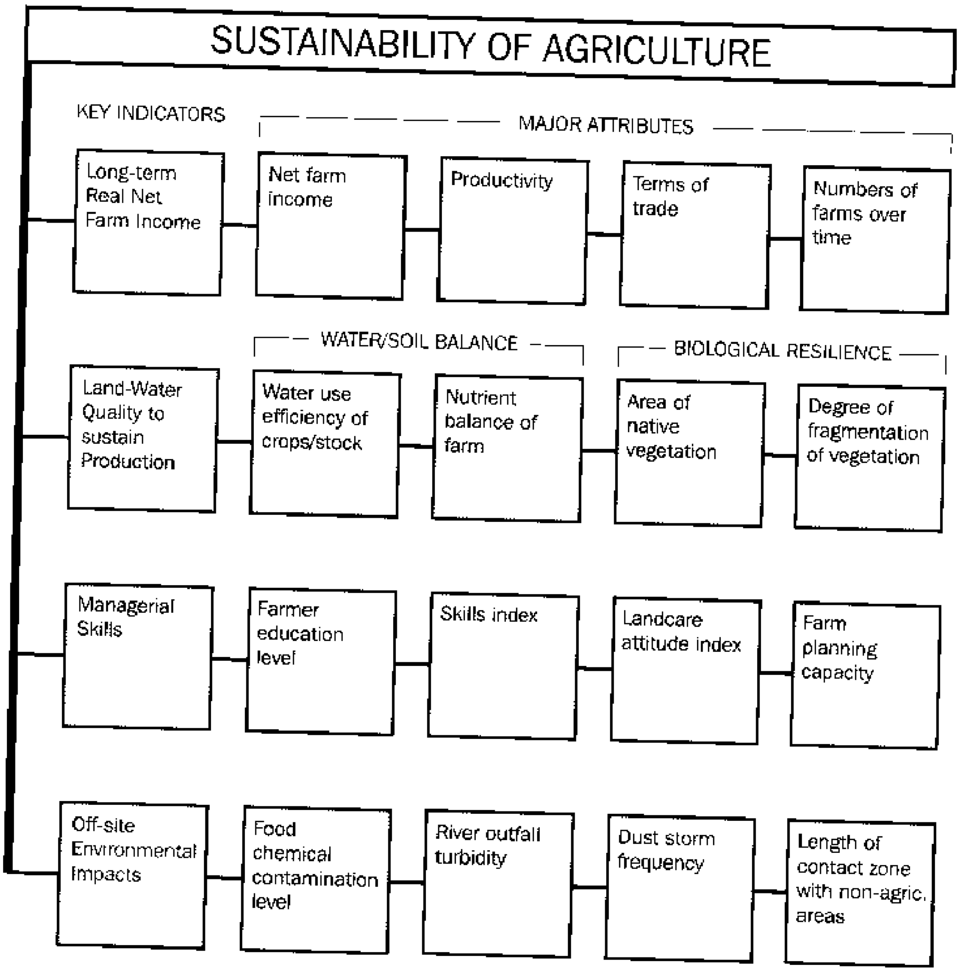
A further consideration is the question of averaging over a number of years in order to iron out the fluctuations that occur year by year in seasons and market conditions.

This publication presents a range of data in the economic, environmental and social domains, that appear relevant to an assessment of sustainability. However, it does not attempt to actually make that assessment, for the various reasons referred to above and because this is not the ABS role.

INDICATORS

The SCARM has developed a draft set of indicators which may be used in assessing the sustainability of Australian agriculture at scales ranging from the regional to national level. Table 1.1 shows the four key indicators that the working group initially selected, along with the major attributes relating to each indicator. Note that 'indicators' are defined as a composite set of measures or attributes which embody a particular aspect of agriculture, with the attributes being numerical descriptions of individual parameters.

1.1 *SCARM INDICATORS OF SUSTAINABLE AGRICULTURE*



Source: Sustainable agriculture: tracking the indicators for Australia and New Zealand, Agricultural Council of Australia and New Zealand Standing Committee on Agriculture and Resource Management

Following recent field testing, some further attributes have been proposed, for example, debt to equity ratio and off-farm income for the financial dimension; rate of appearance of pests and disease and biological index of water quality for the on-site environmental indicator;

and family stability and skills recruitment and retention for the on-farm social dimension.

The OECD has also developed indicators for the integration of environmental concerns into agricultural policies. The criteria used in selecting their indicators were 'policy relevance, analytical soundness and measurability'. Table 1.2 lists the OECD indicators as they stood in mid-1995. The list is quite lengthy and diverse and it appears that further work is being undertaken at the OECD to clarify the analytical framework which underlies the selection and to further develop the definition of each indicator.

1.2 SUMMARY OF A PROPOSED SET OF OECD AGRI-ENVIRONMENTAL INDICATORS

1	Agricultural nutrient balance (fertiliser use)
2	Pesticide use
3	Crop yields
4	Fertiliser management
5	Farm pest management (pesticide management)
6	Agricultural soil conservation management (soil management)
7	Irrigation management (water management)
8	Whole farm management
9	Agricultural soil degradation (soil quality)
10	Water pollution from agriculture (water quality)
11	Greenhouse gas emissions from agriculture
12	Acid air emissions from agriculture
13	Agricultural biodiversity
14	Natural and semi-natural habitats affected by agriculture
15	Agricultural landscape
16	Sustainable use of groundwater resources by agriculture
17	Economic, financial and social aspects of sustainable agriculture
18	Farm animal welfare
19	Agricultural net energy balance
20	Conservation of agricultural land

Source: OECD 1995.

Where possible, information relating to the SCARM indicators has been identified as such. Data limitations at the time of publication, particularly involving SCARM's environmental indicators and component attributes, and the perceived lack of relevance, and details about some of the OECD indicators, explain why not all indicators are addressed in the publication. Table 1.6 provides a summary of information related to some of the SCARM indicators. In some cases the data provided is not exactly what was specified by the working group.

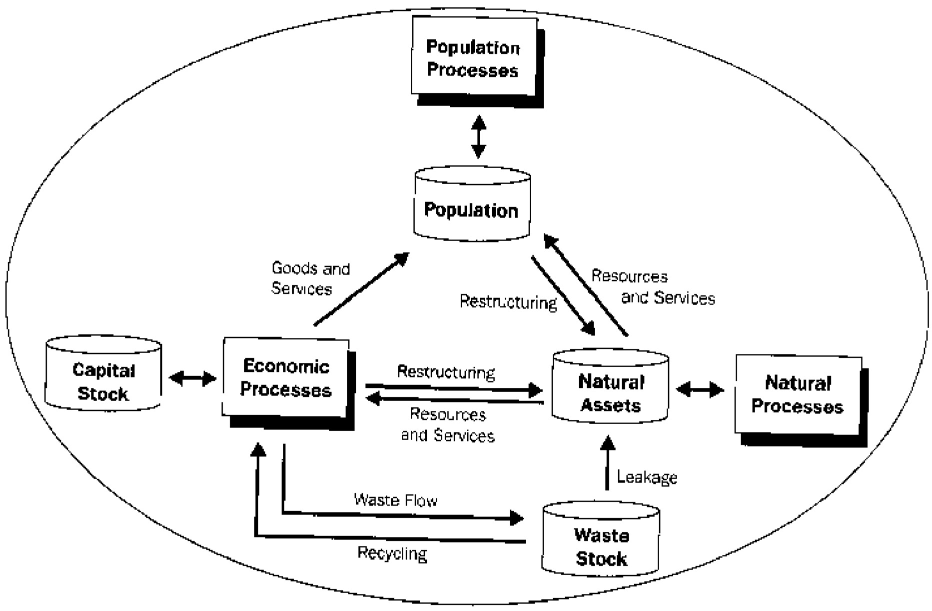
SCARM has commenced another project, the National Collaborative Project on Indicators for Sustainable Agriculture (NCPISA), to carry forward the task of indicator development that commenced with the work mentioned above. The tasks of NCPISA are to specify and negotiate for the collection of farm survey data needed to compile the agreed indicators, further develop the attributes, and to compile a 'report card' about the sustainability of agriculture in Australia. The first 'report card' is expected to be released towards the end of 1997.

PRESENTATION FRAMEWORK

In order to systematise the research and presentation of such an extensive range of data, a particular framework was adopted. This is the Population-Environment Process framework developed by Statistics Canada, which draws out the interactions between the economy, the environment and society. Diagram 1.3 contains a schematic representation of the PEP framework. The framework assisted in decisions about where to include particular data series. The model has many flows between its various components, and broadly speaking we have structured the chapters of this publication as follows:

- Chapter 2 examines the resources and services flow between natural assets and the socioeconomic processes, for example, land use, water use;
- Chapter 3 discusses the detail of the economic processes, for example, gross value of production, economic performance;
- Chapter 4 explores the interactions between the economic processes and the population, through data on supply of food, employment;
- Chapter 5 covers the waste flow between the economic processes and the waste stock and natural assets, for example, chemical residues, animal wastes;
- Chapter 6 describes the restructuring flow between economic processes and natural assets, with data about soil erosion, river turbidity; and
- Chapter 7 contains information about the responses to the impact of agricultural activity on the natural assets, by examining data on the adoption of sustainable management techniques, farm planning.

1.3 THE PEP FRAMEWORK



Source: Statistics Canada 1994.

A comprehensive coverage of this nature is a necessary starting point for assessing the sustainability of an industry and implementing policies which take into account a range of socioeconomic and environmental considerations.

DATA AVAILABILITY

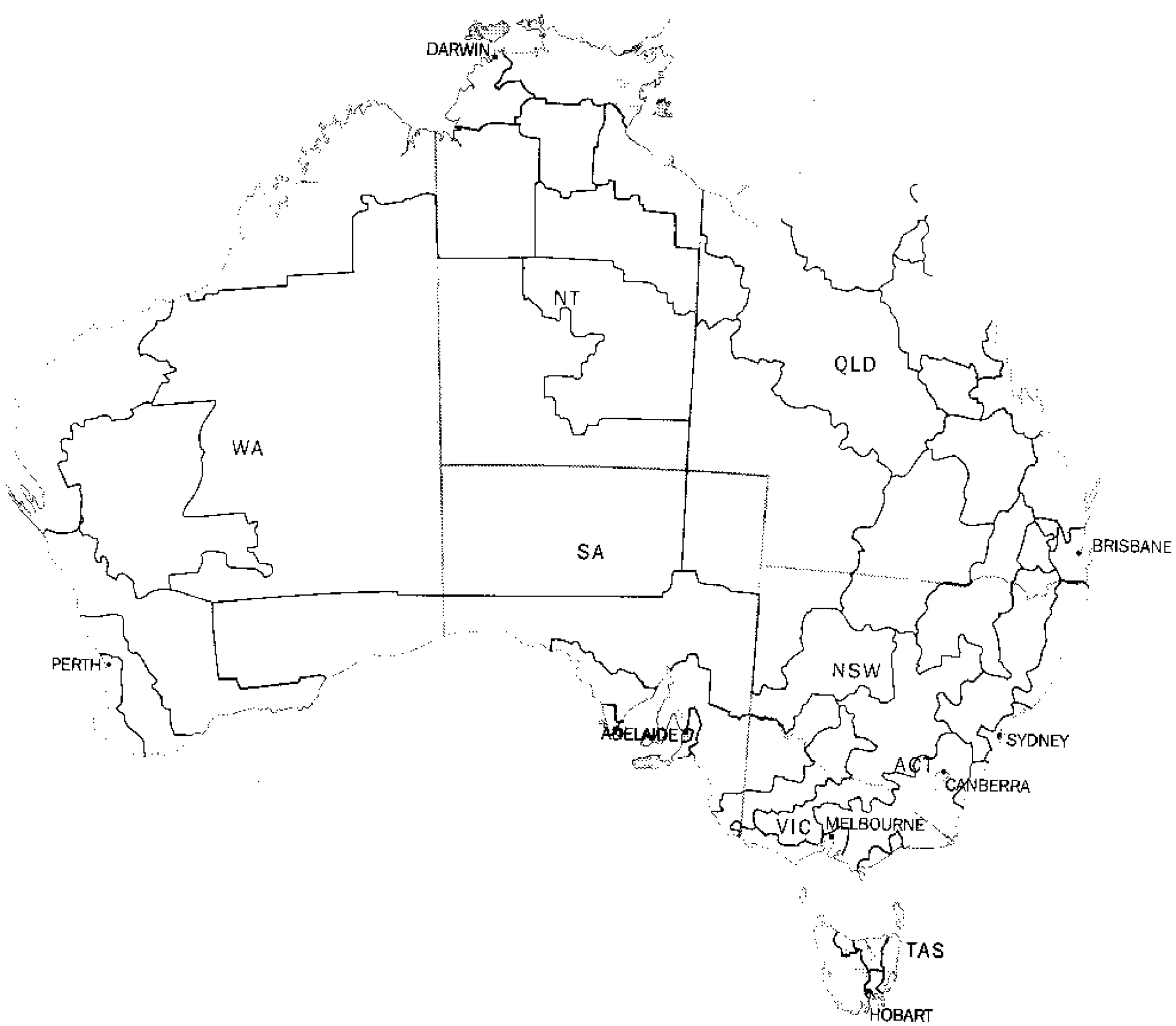
While there is considerable data available on the financial and production aspects of all economic sectors, including agriculture, datasets relating to the stock, quality and sectoral usage of natural resources at the national level are less extensive. Similarly, there is only limited information available on the extent and severity of many environmental impacts linked to agriculture and the environmental processes which can magnify these impacts. In an attempt to overcome some of these data limitations, this publication makes use of case studies.

Much of the ABS data used in this publication comes from the Agricultural Census and Agricultural Finance Survey. These two collections have not only provided comprehensive coverage of the financial and production aspects of Australian agriculture but also allowed some insight into the environmental and social dimensions involved. For example, the Agricultural Census has included questions on such issues as: the prevalence of particular land management practices, including minimum tillage, farmers' perceptions of the extent of land degradation and the usage of inputs such as fertilisers in agriculture. Similarly, the Agricultural Finance Survey has collected data on farmers' expenditure on a range of land management initiatives, their membership to Landcare groups and usage of farm management plans. In the near future the survey will also gather information relating to the education and training of Australian farmers, farm management planning and other aspects of farm practice.

AGRO-ECOLOGICAL REGIONS AND REGIONAL ANALYSIS

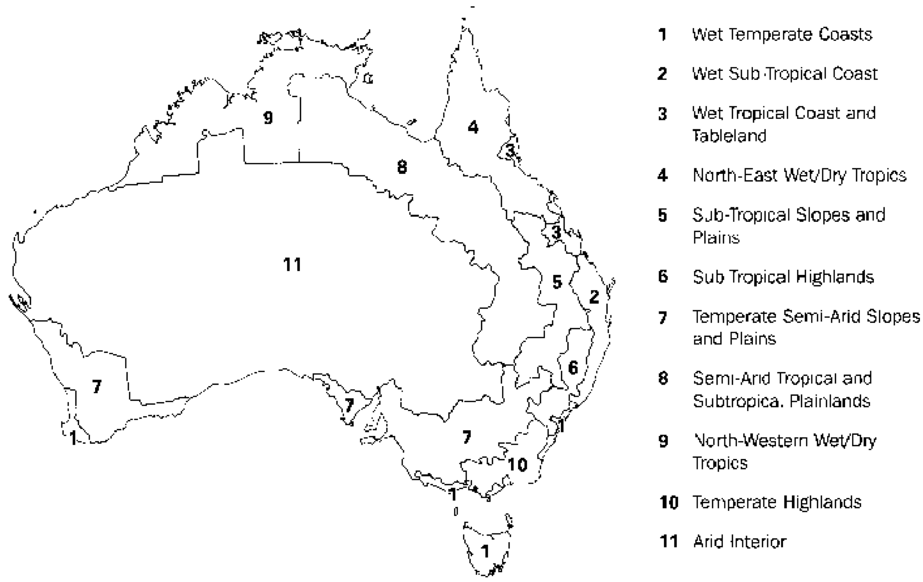
In 1991 the Standing Committee on Agriculture Working Group developed an agro-ecological regionalisation of Australia as a framework to address sustainable agriculture issues. Forty-six agro-ecological regions were identified by aggregating Statistical Local Areas (SLAs) into groupings of common agricultural practice within relatively homogenous regions of climate and geography (see map 1.4). A simplified version of this regionalisation was then developed for the Federal Government's Ecologically Sustainable Development Strategy. This divides Australia into eleven larger agro-ecological regions (see map 1.5).

1.4 *AGRO-ECOLOGICAL REGIONS OF AUSTRALIA*



Source: Standing Committee on Agriculture 1991.

1.5 *SIMPLIFIED VERSION OF AUSTRALIA'S AGRO-ECOLOGICAL REGIONS*



Source: Standing Committee on Agriculture 1991.

For national datasets that are available at the SLA level, (for example, cattle and sheep stocking rates, fertiliser use, gross value of production) it has been possible to map and analyse the data at the regional level. Where this has occurred, the agro-ecological regionalisation dividing Australia into forty-six regions has been preferred because it offers a greater level of detail than the simplified agro-ecological regionalisation.

A disadvantage of the agro-ecological regions is that they are built up from administrative boundaries (SLAs). Although they have been aggregated to take geography into account, it would clearly be better if there was the option to analyse interactions between agriculture and the environment for areas such as drainage basins or catchments. Spatial referencing of cadastral, statistical and environmental information will offer this opportunity in the near future. The ABS is aware of the benefits of spatial referencing, and is currently investigating options which may facilitate coding of data from the Agricultural Census in this way in the future.

1.6 SUMMARY OF AGRICULTURAL INDICATORS

Indicator and description	Time period, unit	Value
On-site financial		
Number of farms	1970–71, '000	249.5
	1980–81, '000	189.8
	1993–94, '000	150.4
Index of terms of trade (base: 1987–88 = 100)	1970–71	135
	1980–81	120
	1993–94	84
Net farm income		
Real estimate of cash operating surplus (base = 1989–90)	1986–87, $m	4 536
	1990–91, $m	3 274
	1993–94, $m	4 024
Real net value of farm production index (1987–88 =100)	1970–71	116
	1980–81	139
	1993–94p	78
On-site managerial skills		
Education level		
Proportion of farm workers with		
No qualifications	1991, %	80.4
Diploma, Bachelor or higher degree, vocational	1991, %	19.6
Proportion of all workers with		
No qualifications	1991, %	58.6
Diploma, Bachelor or higher degree, vocational	1991, %	41.4
Landcare attitude index		
Farm businesses involved with Landcare Australia	1992–93, %	13.5
Farms with the operator who is a Landcare member	1992–93, %	28.0
Farm planning		
Farm businesses with a plan of some kind	1992–93, %	30.6
Farm businesses with a documented farm plan	1992–93, %	16.1
Showing land classes	1992–93, %	10.5
Off-site environmental		
Food chemical contamination		
Percentage of samples above maximum residue limit	1991, %	0.8
Percentage of samples above maximum residue limit	1992, %	0.9
Dust storm frequency		
Dust storm days at 28 stations	1950	50
	1960 (in drought)	58
	1970 (just after drought)	94
	1980	2

Source: Based on information contained in various sections of this publication.

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CHAPTER 2

AGRICULTURE AND THE USE OF ENVIRONMENT RESOURCES

INTRODUCTION

This chapter deals with the way in which agricultural activity and production in Australia has evolved in response to the characteristics of the physical environment. The first section examines the environmental setting which underpins Australian agriculture and the way in which technological advances have helped overcome some of the limitations that Australia's environment would otherwise impose on agricultural activity. The subsequent sections look at the extent and pattern of agricultural land use and other resource usage and aspects of agricultural activity. The final section discusses agricultural production.

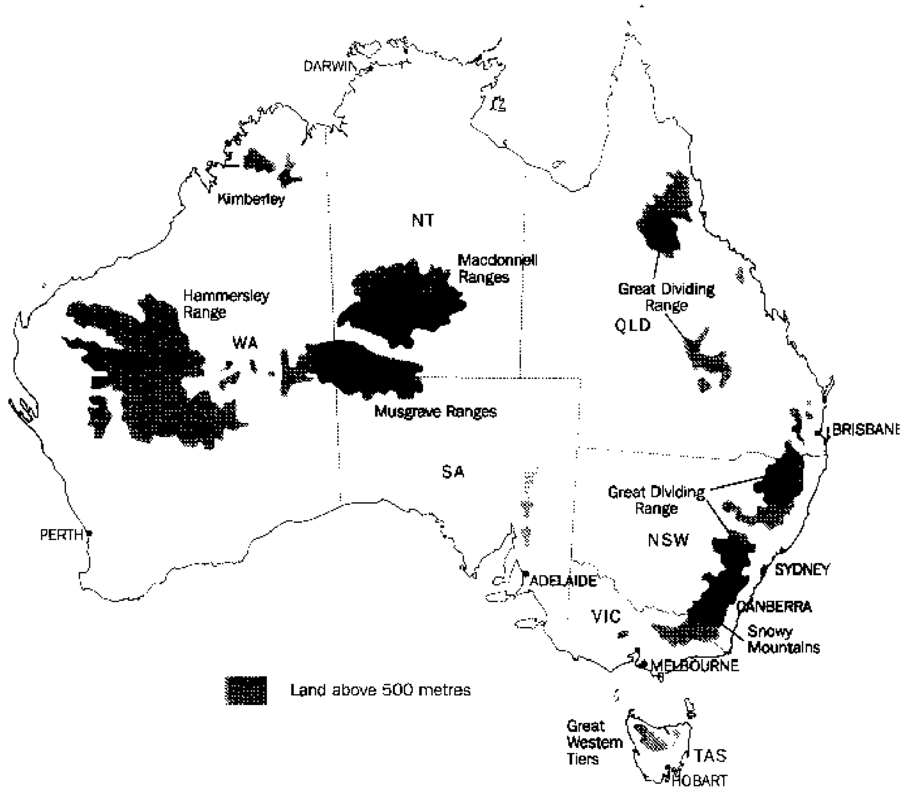
THE ENVIRONMENTAL SETTING OF AUSTRALIAN AGRICULTURE

Although economic factors are important in determining agricultural activity, the physical environment has an underlying influence on Australia's pattern of agricultural land use. Topography, climate, soils and vegetation are all vital determinants of agricultural land use.

Topography

Australia is a relatively flat continent, with mean elevation just exceeding 200 metres. The dominant feature of the continent is the Great Dividing Range which spans the length of the eastern seaboard. The Great Dividing Range varies in elevation from 1,000 metres to 2,300 metres and its distance from the coast is generally less than 120 kilometres. To the west of the Great Dividing Range, undulating slopes progressively give way to open plains which are interspersed by a few ranges exceeding 500 metres in height (see map 2.1).

2.1 *TOPOGRAPHY*

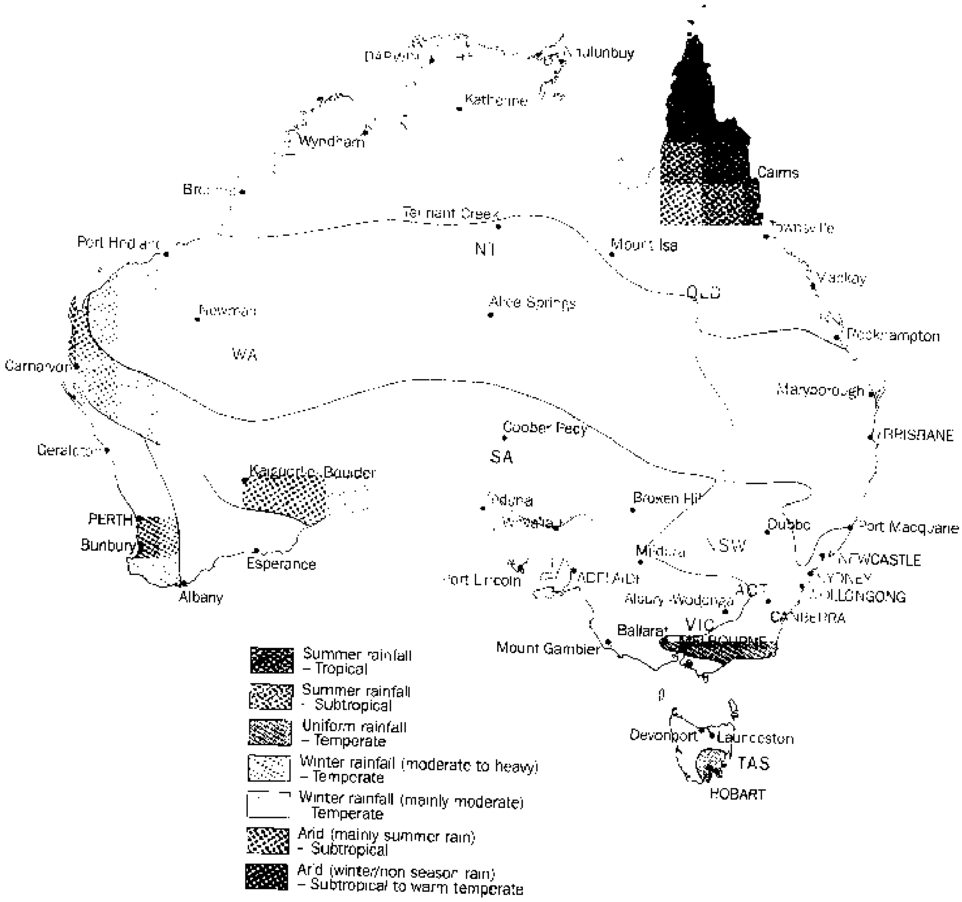


Source: Australian Academy of Science 1994.

This topographic setting influences Australia's distribution of water resources and the method by which water is discharged. 'Just one-third of Australia's surface water resources drain directly to the ocean, mainly on the coastal side of the Great Dividing Range, inland via the Murray–Darling Basin or at points along the northern or Tasmanian coastlines' (NFF 1989). Along the east coast and, in particular in the Murray–Darling Basin, it has been possible to develop these water resources, allowing a diversity of agricultural activities to emerge. In arid areas, where surface drainage can be totally absent, only limited grazing occurs on the more favourable sites.

Climate Australia has been divided into seven climatic zones based on rainfall patterns and mean January and July temperatures. Map 2.2 details these climatic zones and their main characteristics.

2.2 *CLIMATIC ZONES OF AUSTRALIA*



Source: Australian Bureau of Statistics 1994.

With the possible exception of Antarctica, Australia is the world's driest continent. Almost '80% of the land mass has a median rainfall of less than 600 millimetres and half has a median rainfall of less than 300 millimetres' (Yearbook Australia, 1994 (1301.0) p. 14). Above average rainfall only occurs within a narrow belt extending along the northern, eastern, south-eastern and south western coasts of the continent and throughout Tasmania. Map 2.4 shows the distribution of the median annual rainfall of Australia.

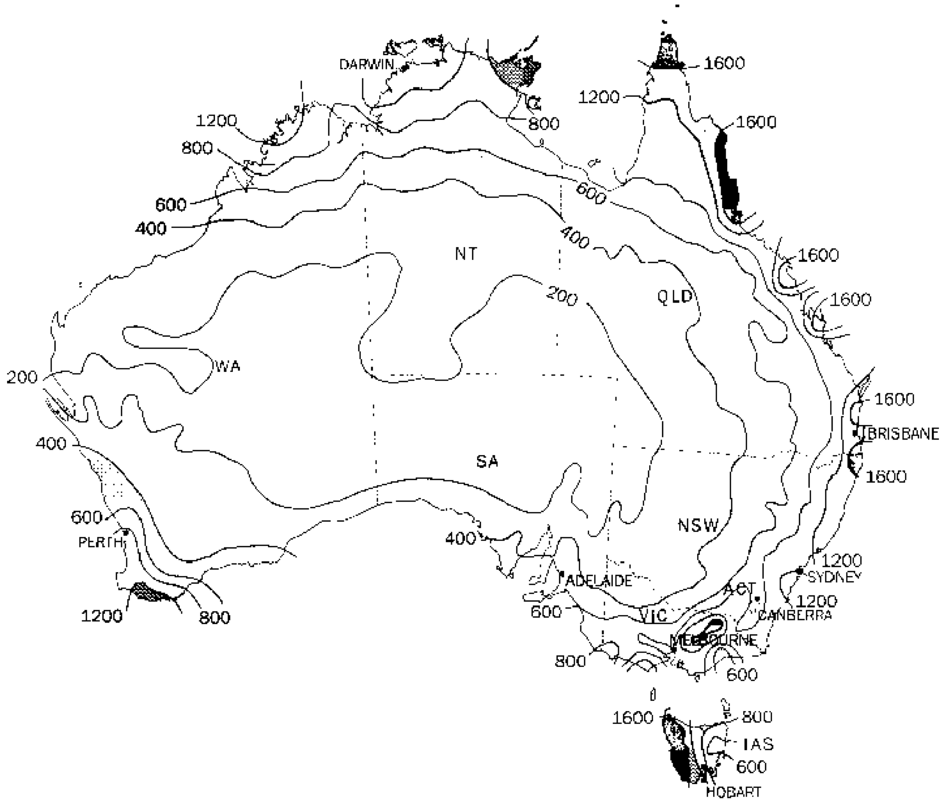
2.3 DISTRIBUTION OF MEDIAN ANNUAL RAINFALL

	State/Territory							
	NSW	Vic.	Qld	SA	WA	Tas.	NT	Aust.
Median annual rainfall (mm)	%	%	%	%	%	%	%	**%**
<200	8.0		10.2	74.2	43.5	—	15.5	**29.6**
200–300	20.3	6.3	13.0	13.5	29.6	—	35.6	**22.9**
300–400	19.0	19.2	12.3	6.8	10.5	—	9.0	**11.2**
400–500	12.4	11.8	13.5	3.2	4.3	—	6.6	**7.6**
500–600	11.3	14.1	11.6	1.8	3.1	12.2	5.8	**6.6**
600–800	15.1	24.5	20.5	0.5	4.6	18.2	11.6	**10.7**
800–1 200	11.3	17.7	12.6	—	3.7	25.0	9.6	**7.7**
>1 200	2.6	6.4	6.3	..	0.7	44.6	6.3	**3.7**

Source: Australian Bureau of Statistics 1994.

As map 2.4 indicates, rainfall seasonality varies markedly across Australia from the 'summer dominated rainfall regions of tropical northern Australia to the predominantly winter rainfall regions of temperate southern Australia' (Ockwell 1990). The wet northern summer is suited to beef cattle grazing inland and the growing of sugar and tropical fruits on the coast. The drier summer conditions of southern Australia favour wheat and other dryland cereal farming, sheep grazing and dairy cattle (in the higher rainfall areas) as well as beef cattle.

2.4 MEDIAN ANNUAL RAINFALL (mm)



Source: AUSLIG 1992.

Within Australia there also exists a high degree of rainfall variability from year to year, which is most pronounced in the arid and semi-arid regions. Rainfall variability often results in lengthy periods without rain (dry spells) and droughts. Since the 1860s there have been nine major droughts in Australia, the most severe in terms of extent and effect on agriculture, occurring between 1895–1903, 1958–68 and 1982–83.

The seasonality and variability of rainfall in Australia requires that water be stored to ensure there are adequate supplies all year round for activities requiring a continuous supply. Table 2.5 lists the major dams and reservoirs which have been built in Australia to provide water, for among other things, agriculture through irrigation. Irrigation has opened up areas of Australia to agricultural activities which would otherwise not be practical. For example, irrigation has allowed cotton to be grown in areas of northern New South Wales and fruit, vegetables and rice to be produced in other parts of the Murray–Darling Basin.

2.5 MAJOR DAMS AND RESERVOIRS USED FOR IRRIGATION PURPOSES

Name and year of completion	*Location*	*Gross capacity* gigalitres	*Height of wall* metres
New South Wales			
Eucumbene (1958)	Eucumbene River	4 798	116
Hume (1936, 1961)	Murray River, near Albury	3 038	51
Menindee Lakes (1960)	Darling River, near Menindee	1 794	18
Burrendong (1967)	Macquarie River, near Wellington	1 678	76
Blowering (1968)	Tumut River	1 628	112
Copeton (1976)	Gwydir River	1 364	113
Wyangala (1936, 1971)	Lachlan River	1 220	85
Burrinjuck (1927, 1956)	Murrumbidgee River	1 026	79
Talbingo (1971)	Tumut River	921	162
Glenbawn Dam (1958, 1987)	Hunter River, near Scone	870	100
Jindabyne (1967)	Snowy River	688	72
Lake Victoria (1928)	Murray River, near Wentworth	680	—
Keepit (1960)	Namoi River, near Tamworth	423	55
Split Rock (1966)	Manilla River, Namoi Valley	370	64
Windamere (1984)	Cudgegong River, near Mudgee	368	69
Glennies Creek (1983)	Hunter Valley, near Singleton	284	65
Tantangara (1960)	Murrumbidgee River	254	45
Lake Brewster (1952)	Lachlan River, near Hillston	150	—
Victoria			
Dartmouth (1979)	Mitta Mitta River	4 000	180
Eildon (1927, 1955)	Upper Goulburn River	3 390	79
Thomson (1984)	Thomson River, near Moe	1 175	164
Waranga (1910)	Near Rushworth (swamp)	411	12
Mokoan (1971)	Winton swamp, near Benalla	365	10
Eppalock (1964)	Campaspe River	312	45
Glenmaggie (1927, 1958)	Macalister River	190	37
Cairn Curran (1958)	Loddon River, near Maryborough	148	44
Yarrawonga (1939)	Murray River	117	22
Toolondo (1952, 1960)	Natural depression, near Horsham	107	—

... *continued*

2.5 MAJOR DAMS AND RESERVOIRS USED FOR IRRIGATION PURPOSES — *continued*

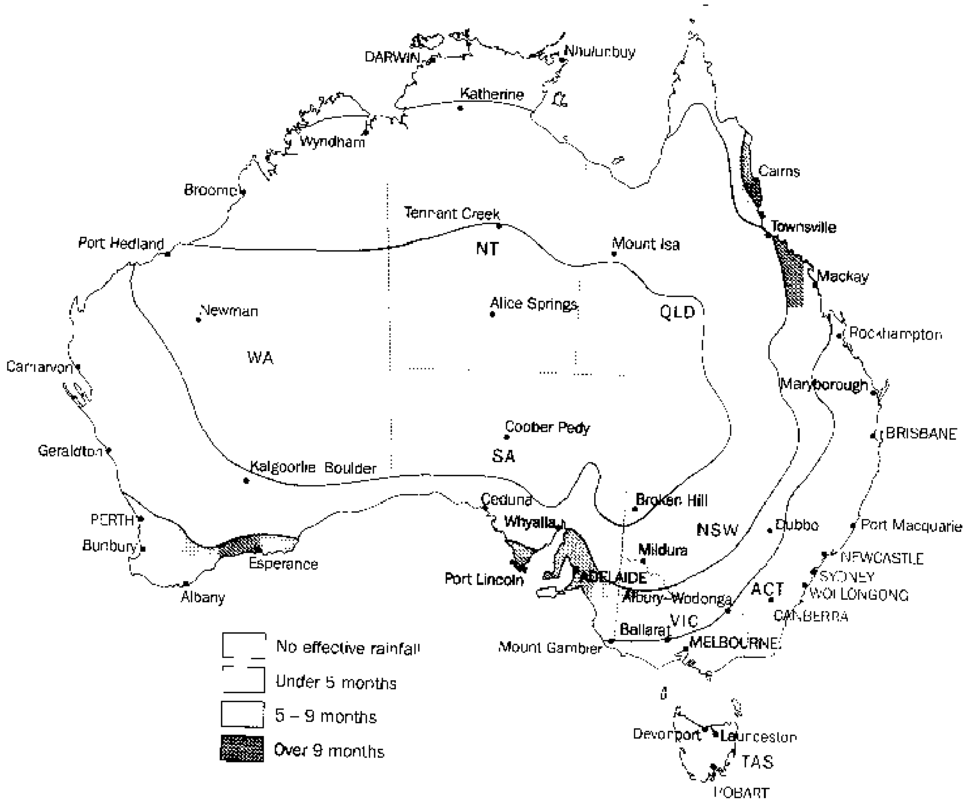
Name and year of completion	*Location*	*Gross capacity* gigalitres	*Height of wall* metres
Queensland			
Burdekin (1986)	Burdekin River, near Townsville	1 860	55
Fairbairn (1972)	Nogoa River, near Emerald	1 440	49
Fred Haigh (1975)	Kolan River, near Gin Gin	586	52
Tinaroo Falls (1958)	Barron River, near Mareeba	407	47
Glenlyon (1976)	Pike Creek, near Stanthorpe	261	62
Boondooma (1983)	Boyne River, near Gladstone	212	64
Wuruma (1968)	Nogo River, near Eidsvold	194	46
Eungella (1969)	Broken River, near Eungella	131	49
Callide Dam (II) (1986)	Callide Creek, near Bileola	127	35
Leslie Dam (II) (1985)	Sandy Creek, near Warwick	108	34
Beardmore (1972)	Balonne River, near St George	101	17
Western Australia			
Lake Argyle (Ord) (1971)	Ord River, near Kununurra	5 797	99
Wellington (1933, 1944, 1960)	Collie River	185	37

Source: Australian Bureau of Statistics 1992.

Another element of Australia's climate is hot summers and mild winters. In January, average maximum temperatures exceed 35°C over a vast area of the interior and 24°C in most other areas. In July, average minimum temperatures only fall below 5°C in areas which are south of the tropics and away from the coast. The generally warm to hot temperatures are accompanied by an abundance of sunlight. This combination of climatic variables leads to rates of evaporation which are high relative to other continents.

Due to generally 'low rainfall, high temperatures, high potential evaporation and the poor water holding capacity of many Australian soils, effective rainfall (that is the number of months where rainfall exceeds evaporation) for crop and pasture production in Australia is lower than for other continents' (Ockwell 1990). Graph 2.6 shows the distribution of effective rainfall across Australia. Those areas which have been cleared for crop and pasture production tend to coincide with the five to nine month zone of effective rainfall. In areas of effective rainfall exceeding nine months it is generally only higher value crops or tropical crops and fruits which are grown, while in areas with effective rainfall of less than five months, cropping is usually restricted to areas that are irrigated.

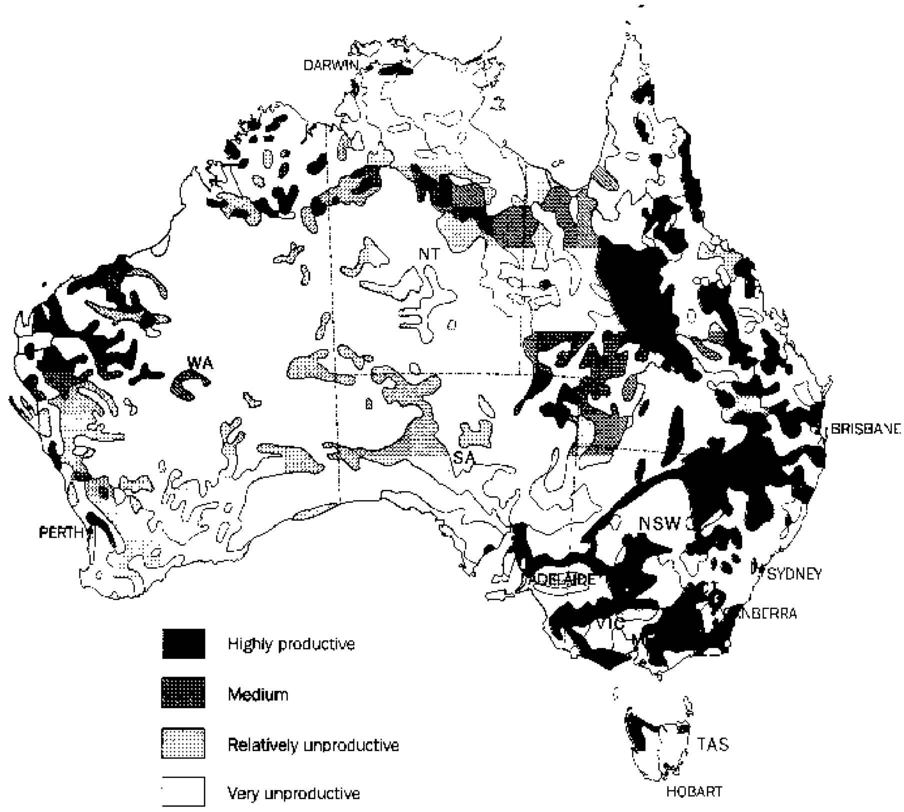
2.6 *EFFECTIVE RAINFALL REGIONS*



Source: Ockwell 1990.

Soils Australia has very few naturally good soils for agriculture (map 2.7). Most are infertile and shallow with deficiencies in phosphorous and/or nitrogen. To offset these deficiencies to some extent, superphosphate and nitrogenous fertilisers are widely used, particularly on pasture and cereal crops. Fragile soil structure and a susceptibility to waterlogging are other common features of Australian soils while large areas are naturally affected by salt and/or acidity. These soil characteristics may restrict particular agricultural activities or rule out agricultural activity altogether.

2.7 PRODUCTIVITY OF SOILS

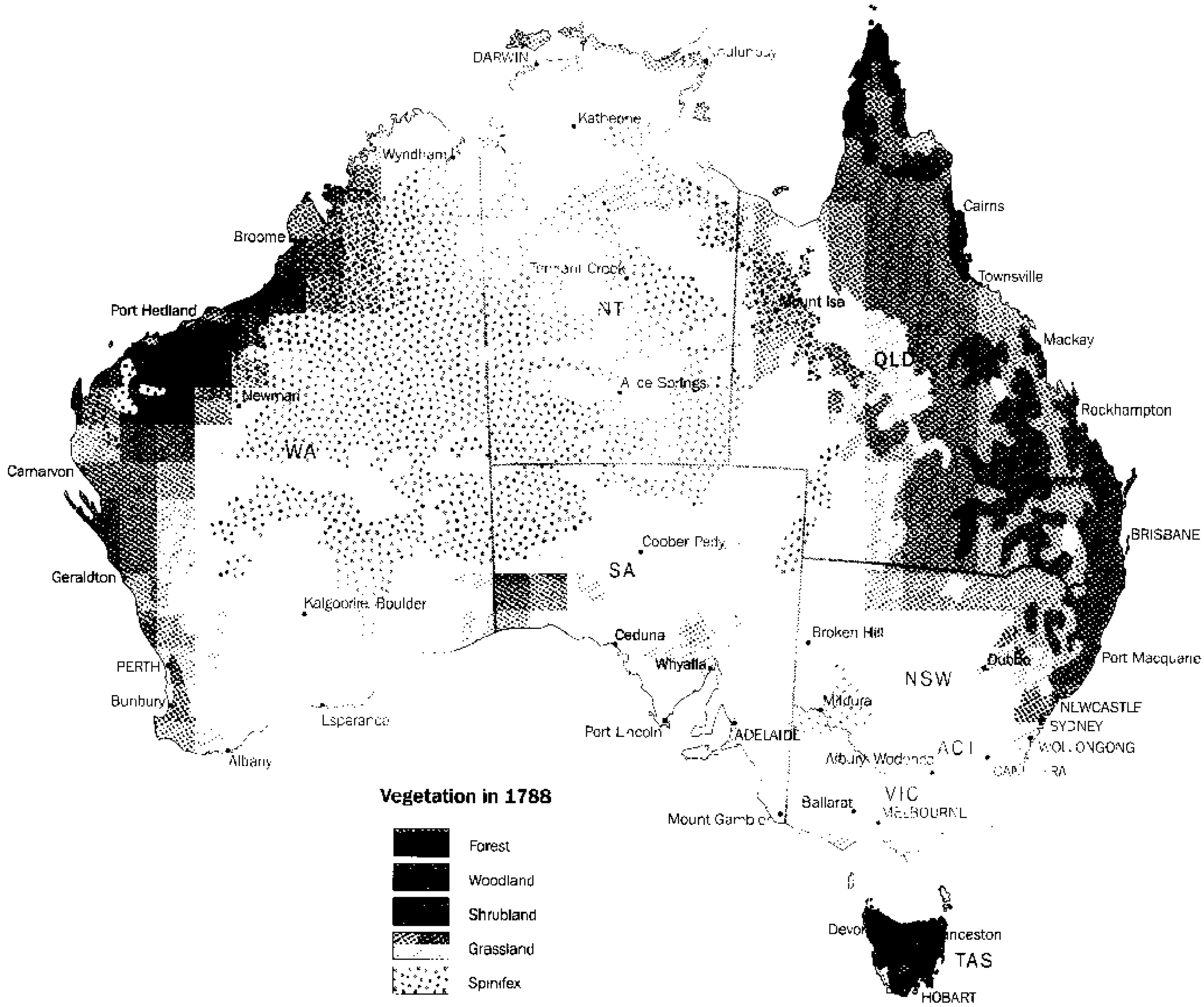


Source: Australian Academy of Science 1994.

Vegetation

The natural distribution of vegetation over the Australian land mass is principally regulated by the amount and seasonality of rainfall, temperature and soil fertility. The coastal regions, where a long growing season exists, are 'characterised by tropical rainforest in the north and cool temperate rainforest in Tasmania, or by tall open forests dominated by a wide range of eucalyptus species' (Ockwell 1990). On the slopes inland of the coastal zone, the growing season tends to be slightly shorter and dry sclerophyll forest or woodland is dominant. As rainfall diminishes these forests give way to open native grass lands. Map 2.8 shows the distribution of vegetation in Australia prior to European settlement.

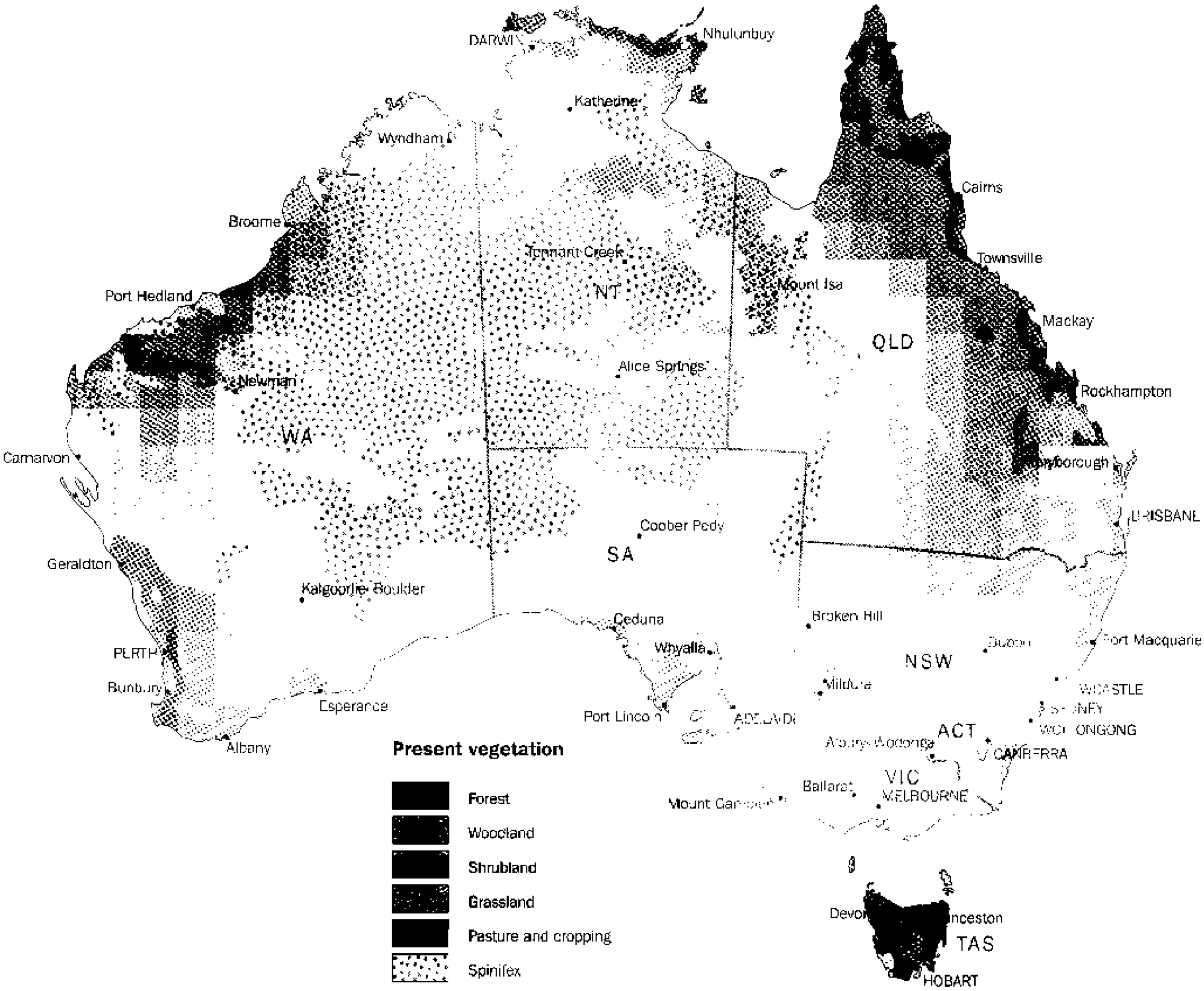
2.8 *AUSTRALIA'S VEGETATION IN THE 1780s*



Source: Australian Bureau of Statistics 1992.

Since European settlement the vegetation of Australia has been altered significantly. In particular, large areas of Australia's forest and woodland vegetation systems have been cleared, predominantly for agricultural activity. The areas which have been altered most are those which have been opened up to cultivation or intensive grazing. Other areas, particularly in the semi-arid regions, where extensive grazing of native grasses occurs also show signs of adaptation. Map 2.9 shows the present distribution of vegetation in Australia.

2.9 *AUSTRALIA'S VEGETATION IN THE 1980s*



Source: Australian Bureau of Statistics 1992.

RESOURCE USE BY AGRICULTURE

Agricultural land use

In spite of Australia's harsh environmental setting, agriculture constitutes the most extensive form of land use in Australia. At 31 March 1994, the estimated total area of agricultural establishments in Australia was 469 million hectares, representing 61% of the total land area. At this time, the principal regions not used for agriculture were western Central Australia and those Aboriginal land reserves principally located in the Northern Territory.

Although agriculture utilises a large proportion of Australia's land mass, historically the total area of agricultural establishments has been greater than is presently the case. Table 2.10 shows that the total area of agricultural establishments steadily increased during the 1960s and early 1970s to a peak of 501 million hectares in 1975–76. The gradual decline since seems to reflect a removal of some areas from agriculture due to economic circumstances and/or environmental problems as well as other competing land uses such as urban development.

2.10 TOTAL AREA OF AGRICULTURAL ESTABLISHMENTS

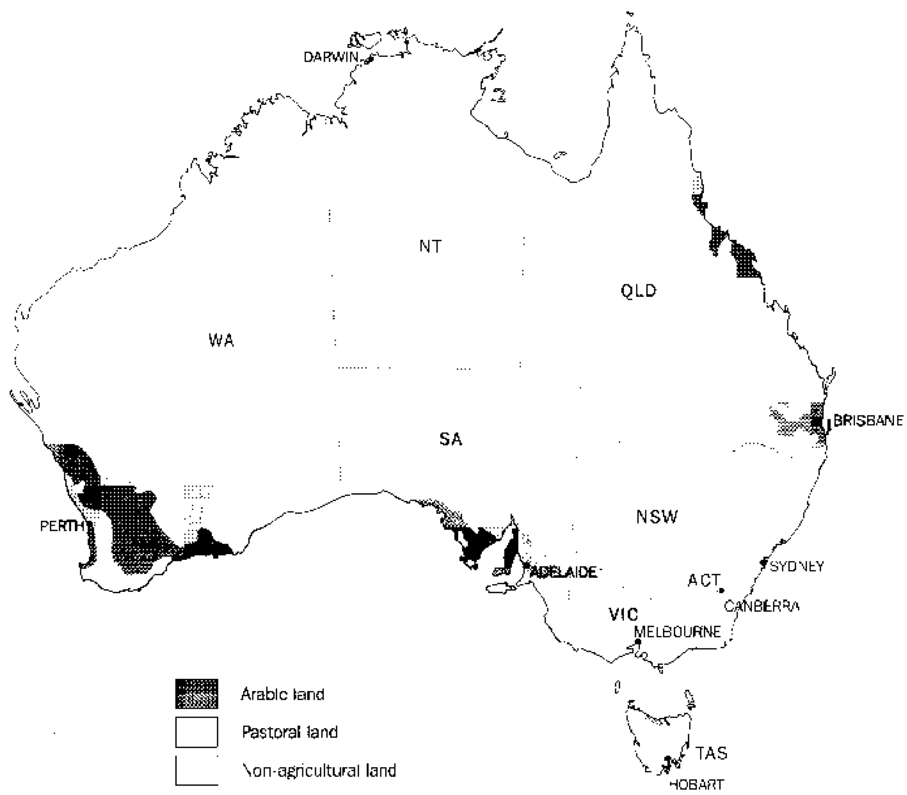
	NSW	*Vic.*	*Qld*	*SA*	*WA*	*Tas.*	*NT*	*ACT*	***Aust.***
Year	million ha	million ha	million ha	million ha	million ha	million ha	million ha	million ha	**million ha**
1960–61	69.9	15.4	151.4	63.3	100.3	2.6	65.2	0.2	**468.3**
1965–66	69.3	15.3	154.0	64.5	109.3	2.6	71.2	0.1	**486.4**
1970–71	69.3	15.8	154.8	65.8	114.6	2.6	74.9	0.1	**497.7**
1975–76	68.8	15.1	155.6	63.6	116.3	2.5	78.8	0.1	**500.7**
1980–81	65.2	14.7	157.5	62.4	115.8	2.2	79.6	0.1	**495.4**
1985–86[1]	63.3	14.2	158.1	60.7	113.8	2.1	72.9	0.1	**485.2**
1990–91	60.7	12.7	150.8	57.0	110.9	1.9	68.8	0.1	**462.8**
1991–92	60.4	12.4	150.0	56.9	115.7	1.8	68.7	0.1	**466.0**
1992–93	59.4	12.3	149.5	56.6	110.6	1.8	69.9	0.1	**460.1**
1993–94[2]	61.2	13.0	152.6	57.3	114.4	2.0	68.6	0.1	**469.1**

1 The ABS uses estimated value of agricultural output (EVAO) as a measure to determine those agricultural establishments within the scope of the Agricultural Census. In 1985–86 the EVAO cutoff was set at $22 500 reducing the number of agricultural establishments in the scope of the Agricultural Census. This would have had a small resultant effect on the total area of agricultural establishments.
2 EVAO cutoff lowered to $5 000.

Source: Australian Bureau of Statistics n.d. (a) and (b).

As map 2.11 indicates, livestock grazing activity is the largest land-user in Australian agriculture. This grazing activity has led to the replacement of large areas of native vegetation with introduced pastures and grasses in the higher rainfall and irrigation areas. In the semi-arid and arid zones livestock graze on native grasses.

2.11 *AGRICULTURAL LAND USE IN AUSTRALIA*



[1] *Large areas of land classified as pastoral in arid and/or rugged areas are not always used for pastoral purposes. Other pastoral land in specific regions of Australia is often used for grazing and cropping at different times during a given year.*

Source: Australian Bureau of Statistics 1992.

Sheep and cattle account for most grazing activity in Australia. Their numbers and stocking rates provide a good indicator of the dimension and regional importance of pastoral land use Australia-wide. At 31 March 1994, sheep numbers in Australia were just over 132 million while the estimated number of cattle was 25.8 million (with 23.1 million beef cattle and 2.7 million dairy cattle). Sheep numbers were at their lowest levels for many decades, reflecting below average sheep and wool prices. In contrast, cattle numbers have remained relatively stable since the early 1980s, after having peaked at 33.4 million in 1975–76.

During 1994, most sheep were found on New South Wales (46.5 million), Western Australian (32 million) and Victorian (23.4 million) properties. Map 2.14 shows sheep stocking rates by agro-ecological region.

2.12 SHEEP NUMBERS

Year	*NSW* '000	*Vic.* '000	*Qld* '000	*SA* '000	*WA* '000	*Tas.* '000	**Aust.**[1] **'000**
1960–61	—	—	—	—	—	—	**146 550**
1965–66	—	—	—	—	—	—	**154 420**
1970–71	70 605	33 761	14 774	19 166	34 709	4 517	**177 792**
1975–76	54 983	26 410	13 908	17 621	34 476	4 136	**151 652**
1980–81	46 000	25 487	10 620	17 056	30 764	4 380	**134 407**
1985–86	58 001	26 892	14 311	17 938	33 213	5 083	**155 561**
1990–91	59 763	27 494	17 440	17 153	36 465	4 804	**163 238**
1991–92	53 612	24 782	15 273	16 072	34 060	4 295	**148 203**
1992–93	48 112	23 552	13 407	15 702	32 962	4 264	**138 100**
1993–94	46 531	23 439	11 547	14 679	31 952	4 324	**132 569**

[1] Australia total incorporates the Australian Capital Territory and the Northern Territory.

Source: Australian Bureau of Statistics n.d. (a) and (c).

The majority of beef cattle (68%) were concentrated in Queensland (9.7 million) and New South Wales (6.1 million) while dairy cattle were predominantly found in the southern States, particularly Victoria (1.6 million). Map 2.15 shows cattle stocking rates for Australia on a regional basis and highlights the high stocking rates of many coastal districts where dairy farming dominates.

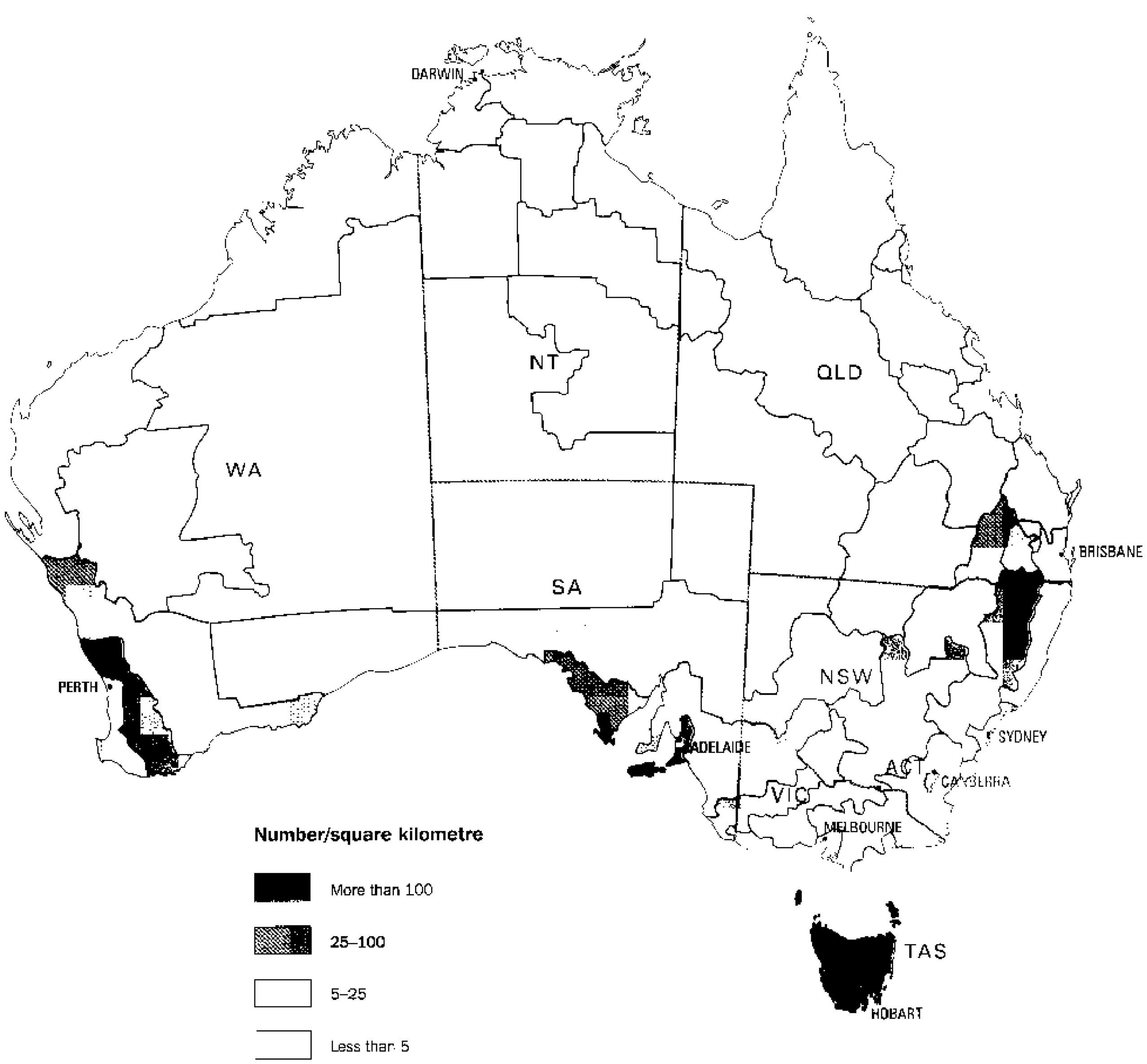
2.13 CATTLE NUMBERS

Year	*NSW* '000	*Vic.* '000	*Qld* '000	*SA* '000	*WA* '000	*Tas.* '000	*NT* '000	**Aust.**[1] **'000**
1960–61	—	—	—	—	—	—	—	**17 330**
1965–66	—	—	—	—	—	—	—	**17 940**
1970–71	6 494	5 061	7 944	1 196	1 781	733	1 145	**24 373**
1975–76	9 138	5 868	11 347	1 891	2 654	909	1 603	**33 434**
1980–81	5 459	4 313	9 925	1 091	2 034	658	1 675	**25 168**
1985–86	5 409	3 720	9 662	914	1 690	570	1 458	**23 436**
1990–91	5 653	3 631	9 856	990	1 584	584	1 353	**23 662**
1991–92	5 697	3 574	10 005	1 016	1 649	593	1 334	**23 880**
1992–93	5 783	3 689	9 873	1 104	1 648	605	1 347	**24 062**
1993–94	6 491	4 189	9 942	1 202	1 806	679	1 435	**25 758**

[1] Australia total incorporates the Australian Capital Territory.

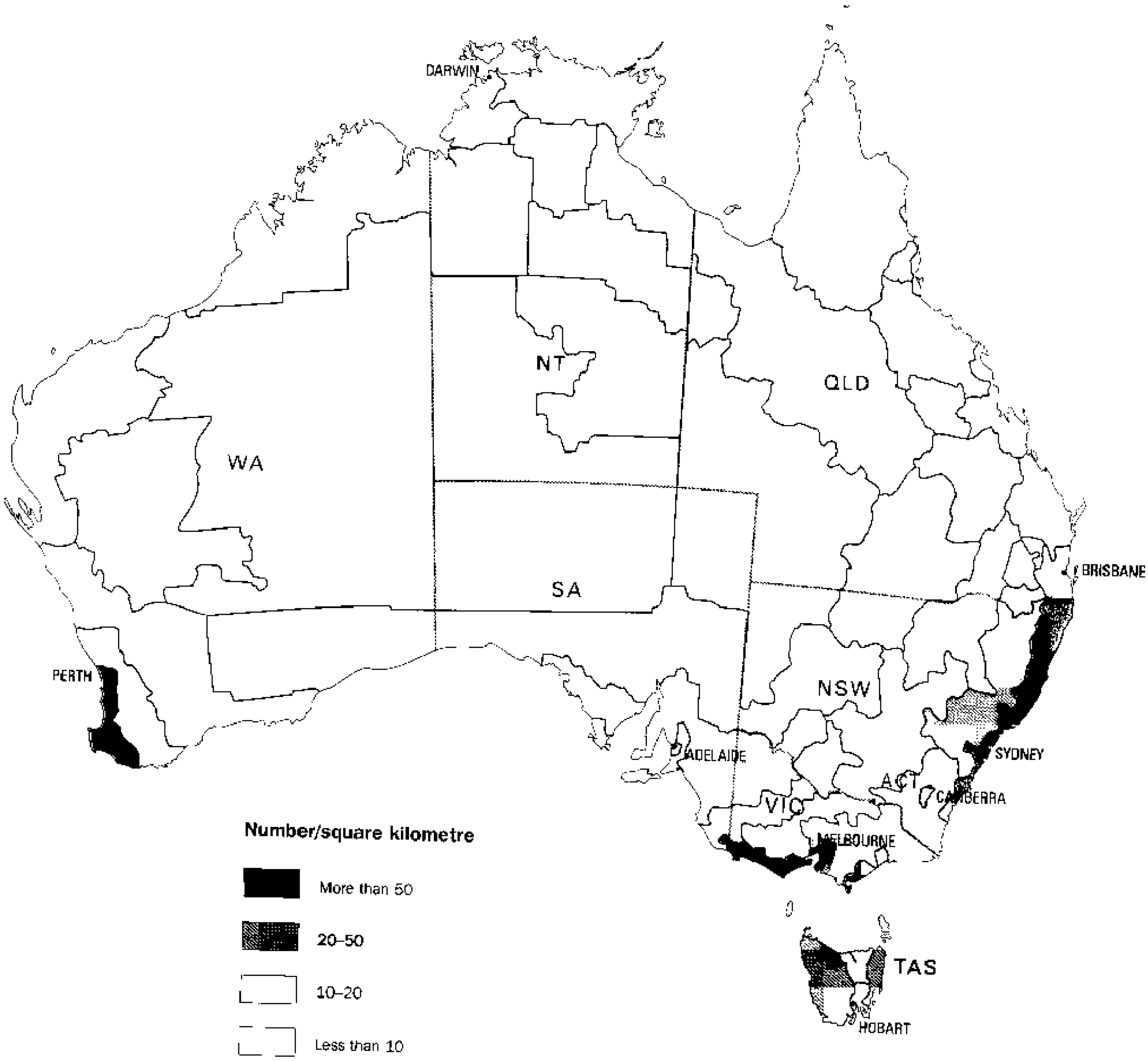
Source: Australian Bureau of Statistics n.d. (a) and (c).

2.14 *SHEEP STOCKING RATES FOR AUSTRALIA*



Source: Map prepared by Australian Bureau of Statistics based on Agriculture Census data.

2.15 *CATTLE STOCKING RATES FOR AUSTRALIA*



Source: Map prepared by Australian Bureau of Statistics based on Agriculture Census data.

Table 2.16 shows livestock numbers by State for various domesticated animals other than sheep or cattle.

2.16 NUMBERS OF DOMESTICATED ANIMALS OTHER THAN SHEEP OR CATTLE, 31 MARCH 1994

Livestock	NSW '000	Vic. '000	Qld '000	SA '000	WA '000	Tas. '000	NT '000	ACT '000	**Aust. '000**
Pigs	834	460	682	440	312	46	3	—	**2 775**
Goats	117	31	32	18	24	8	1	—	**232**
Deer	44	35	18	17	14	21	n.c.	n.c.	**149**
Poultry									
Chickens									
For egg production	4 708	3 056	2 410	840	1 194	266	112	201	**12 788**
For meat production	20 891	12 307	7 915	4 559	4 375	n.p.	105	n.c.	**50 153**
Total chickens	*25 599*	*15 364*	*10 325*	*5 399*	*5 569*	*266*	*218*	*201*	***62 941***
Ducks	255	189	—	1	2	—	n.c.	n.c.	**447**
Turkeys	702	106	1	n.p.	29	n.p.	n.c.	n.c.	**838**

Source: Australian Bureau of Statistics n.d. (a) and (c).

In many regions of Australia introduced crops and pastures have replaced the native vegetation. At 31 March 1994, almost 4% (18 million hectares) of Australia's agricultural land was cropped while another 6% (29.5 million hectares) was sown to pasture or grasses. This continues a trend which has seen roughly 10% of Australia's agricultural land cultivated each year since the early 1980s. Up until this time, the area of land cropped or sown to pasture or grasses had been expanding rapidly. This expansion was facilitated by factors including 'technological progress, increased use of fertilisers and reduction of rabbit populations by myxomatosis' (Hamblin & Kyneur 1993).

2.17 AREA OF LAND CROPPED AND SOWN TO PASTURE OR GRASSES

	Crops		Pastures and grasses		
	Area (million hectares)	*Proportion of total farm area* (%)	*Area* (million hectares)	*Proportion of total farm area* (%)	*Total area of farms* (million hectares)
1960–61	11.0	2.3	14.4	3.1	468.3
1965–66	13.3	2.7	19.6	4.0	486.4
1970–71	13.4	2.7	28.0	5.6	497.9
1975–76	14.5	2.9	27.7	5.5	500.7
1980–81	18.3	3.7	24.9	5.0	495.4
1985–86	20.9	4.3	27.5	5.7	485.2
1990–91	17.4	3.8	28.3	6.1	462.8
1991–92	16.4	3.5	30.8	6.6	466.0
1992–93	17.3	3.8	29.0	6.3	460.1
1993–94	18.0	3.8	29.5	6.3	469.1

Source: Australian Bureau of Statistics n.d. (a) and (e).

Wheat is Australia's largest crop. In 1993–94 wheat for grain accounted for almost half of all land area cropped (8.4 million hectares). It is grown in all States but primarily on the mainland in a narrow crescent known as the wheatbelt (map 2.19). Barley and oats also make up significant component of the total land area cropped while the area planted to grain sorghum, sugar cane and cotton is extensive in New South Wales and Queensland.

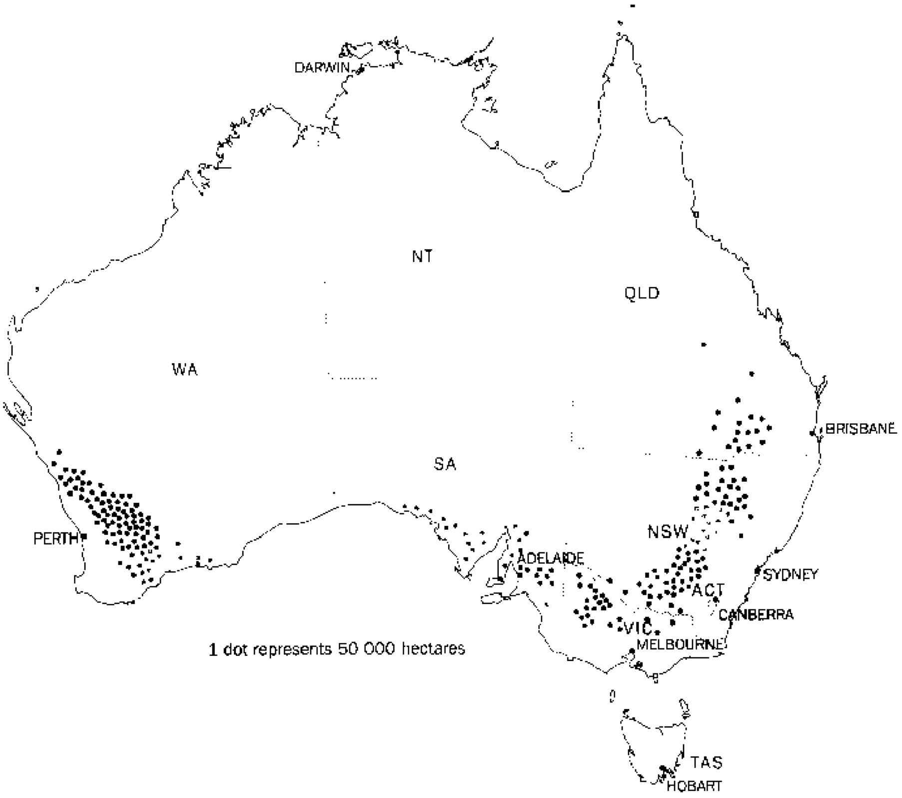
2.18 AREA OF CROPS AND PASTURES, YEAR ENDING 31 MARCH 1994

	NSW	Vic.	Qld	SA	WA	Tas.	NT	Aust.[1]
	'000 ha	'000 ha	'000 ha	'000 ha	'000 ha	'000 ha	'000 ha	'000 ha
Cereals for grain								
Barley	623	639	232	1 115	799	15	n.c.	3 424
Grain sorghum	99	—	399	n.c.	—	n.c.	1	499
Maize	14	—	28	n.c.	2	n.c.	—	44
Oats	369	186	16	101	268	7	n.c.	947
Rice	125	n.c.	n.c.	n.c.	n.c.	n.c.	—	125
Rye	n.c.	13	n.c.	15	2	n.c.	n.c.	30
Triticale	43	32	4	30	19	2	n.c.	129
Wheat	1 978	780	556	1 216	3 852	2	n.c.	8 383
Total	*3 256*	*1 652*	*1 273*	*2 478*	*4 944*	*25*	*1*	*13 629*
Legumes for grain								
Lupins	96	55	—	70	929	1	n.c.	1 150
Field peas	27	200	—	138	34	1	n.c.	400
Other	48	166	46	53	7	—	—	320
Total	*171*	*421*	*46*	*261*	*970*	*2*	*–*	*1 870*
Crops for hay								
Oats	62	46	n.c.	47	78	n.c.	n.c.	233
Wheat	17	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	17
Other	8	15	12	22	12	2	n.c.	71
Total	*87*	*61*	*12*	*69*	*90*	*2*	*–*	*321*
Crops for green feed/silage								
Forage sorghum	28	—	142	n.c.	1	n.c.	—	172
Oats	n.c.	n.c.	179	24	29	n.c.	n.c.	231
Total	*200*	*34*	*384*	*38*	*35*	*15*	*1*	*707*
Oilseeds								
Linseed	2	3	—	2	1	n.c.	n.c.	8
Canola	101	29	—	11	36	–	n.c.	177
Safflower	14	29	1	10	n.c.	n.c.	n.c.	54
Soybean	22	2	17	n.c.	n.c.	n.c.	n.c.	41
Sunflower	39	2	70	1	n.c.	n.c.	n.c.	113
Total	*177*	*66*	*88*	*24*	*37*	*—*	*n.c.*	*392*
Vegetables for human consumption								
Potatoes	7	12	5	7	3	7	–	40
Other	15	18	28	5	7	12	—	85
Total	*21*	*30*	*33*	*12*	*10*	*19*	*—*	*125*
Fruit								
Orchard fruit	34	23	25	19	6	3	1	111
Tropical fruit	4	—	13	—	1	—	—	17
Grapes	14	21	1	27	3	—	—	67
Total	*52*	*44*	*39*	*46*	*10*	*3*	*1*	*195*
Other crops								
Sugar cane	27	n.c.	404	n.c.	n.c.	n.c.	n.c.	431
Cotton	210	n.c.	84	n.c.	n.c.	n.c.	n.c.	293
Peanuts	1	n.c.	21	n.c.	—	n.c.	n.c.	22
Tobacco	—	1	1	n.c.	n.c.	n.c.	n.c.	3
Total area of crops	**4 209**	**2 317**	**2 394**	**2 940**	**6 100**	**78**	**5**	**18 043**

[1] Australia total incorporates the Australian Capital Territory.

Source: Australian Bureau of Statistics n.d. (a) and (e).

2.19 *WHEAT GROWING REGIONS OF AUSTRALIA*



Source: AUSLIG 1992.

Agricultural water use

Most crops require a minimum amount of annual rainfall to grow successfully without irrigation. In regions where rainfall is not sufficient, irrigation has opened up cropping activity. An estimated 2.5 million hectares of agricultural land was irrigated during 1993–94. Although this is less than 1% of the total area of land used for agriculture, it represented about 5% of the land area under crops or pasture. Most irrigated land is located within the confines of the Murray–Darling Basin which covers parts of New South Wales, Victoria, Queensland and South Australia. Table 2.20 shows the area of crops and pastures irrigated in each State.

2.20 AREA OF IRRIGATED CROPS AND PASTURE, 1994

Method	*NSW* '000 ha	*Vic.* '000 ha	*Qld* '000 ha	*SA* '000 ha	*WA* '000 ha	*Tas.* '000 ha	*NT* '000 ha	*ACT* '000 ha	*Aust.* '000 ha
Pastures	635	556	70	53	14	33	1	—	1 362
Cereals	284	23	45	7	1	2	1	—	364
Vegetables	17	20	27	9	6	16	—	—	96
All fruits	33	35	25	40	7	3	1	—	144
All other crops	176	13	73	4	3	6	—	—	275
Sugar cane	n.c.	n.c.	168	n.c.	n.c.	n.c.	n.c.	n.c.	168
Total	**1 145**	**646**	**409**	**112**	**32**	**61**	**3**	**—**	**2 408**

Source: Australian Bureau of Statistics n.d. (a).

Given the dryness of the Australian continent, water is recognised as a scarce and valuable resource. The agricultural sector is the largest user of water in Australia, with most required for irrigation purposes. Irrigated agriculture accounted for an estimated 10,200 gigalitres of water in 1989, representing 70% of annual water consumption in Australia (Industry Commission 1992). Half of this water is used on pastures. The remaining irrigation water is used for crops and horticulture. A further 1,340 gigalitres of water is consumed in rural areas for a range of purposes other than irrigation or industrial use. On-farm domestic and stock use are among these purposes.

Water used for irrigation comes from a variety of sources. Table 2.21 shows area irrigated by various sources for the 1993–94 season.

2.21 AREA IRRIGATED BY SOURCE OF WATER, 1993–94

	NSW '000 ha	*Vic.* '000 ha	*Qld* '000 ha	*SA* '000 ha	*WA* '000 ha	*Tas.* '000 ha	***Aust.* '000 ha**
Surface water from State irrigation schemes	460	500	97	22	15	3	**1 097**
Other surface water							
Direct from regulated streams	458	30	35	12	1	18	**554**
From farm dams	41	60	39	10	9	33	**191**
Underground water supply							
Within State schemes	67	32	97	47	5	2	**250**
Other	30	21	66	19	2	3	**140**
Town or country reticulated water supply	1	3	—	2	1	—	**7**

Source: Australian Bureau of Statistics n.d. (a).

Fertiliser use

Most Australian soils are deficient in phosphorus. Because of this and the significant but less widespread deficiency of sulphur in many soils, superphosphate is the one common fertiliser used. Table 2.22 shows the most recent data on general fertiliser use in Australia and map 2.24 shows the distribution of fertiliser use on an agro-ecological region basis. The application rates are low by world standards and table 2.23 shows average annual fertiliser use for selected countries.

WATER USE IN THE MURRAY–DARLING BASIN

The Murray–Darling Basin covers most of inland south-eastern Australia and the value of the agricultural produce exceeds $10 thousand million. It is estimated that $3 thousand million of this is derived from irrigation. However, the significance is even greater given the number of jobs and export earnings based on the food processing industry which depends heavily on irrigation to provide the agricultural commodities it needs.

Between 1988–89 and 1992–93 the average total diversion from the Basin was 10,680 gigalitre/year. Of this amount, over 95% was diverted for irrigation.

The current and increasing consumption of water in the Basin is having a significant impact on river health and the environment. Rivers have been altered by significant changes in the annual flow, the distribution of flow through the year and the length of low flow periods.

These changes to flow volume and flow pattern have resulted in:

- an increase in the salinity of the River Murray at Morgan of 10.5 electrical conductivity since 1988;
- a reduction in the frequency of flooding of the floodplain wetlands. for example, the Macquarie wetlands has declined by 50%;
- river conditions which are more suitable for the growth of blue-green algae; and
- a significant decline in native fish populations.

In undertaking the detailed audit of the Basin, the Murray–Darling Basin Commission collected water use data for all rivers. The following table shows the average diversion between 1988–89 and 1992–93.

AUDIT OF SURFACE WATER USE IN THE MURRAY–DARLING BASIN

River system	*Diversion for irrigation gl*	*Domestic, industrial, stock and town use gl*	*Total water diversion gl*
New South Wales			
Border rivers	221	1	222
Gwydir	299	1	300
Namoi	244	4	248
Macquarie/Castlereagh/Bogan	465	6	471
Upper Darling	188	1	189
Lower Darling	128	85	213
Murrumbidgee	2 424	19	2 443
Murray	2 024	29	2 053
Total	5 993	146	6 139
Victoria			
Upper Murray/Ovens/Kiewa	1 531	36	1 567
Lower Murray	264	20	284
Goulburn/Broken/Loddon	1 656	54	1 710
Campaspe	79	22	101
Total	3 530	132	3 662

... continued

AUDIT OF SURFACE WATER USE IN THE MURRAY–DARLING BASIN — continued

River system	Diversion for irrigation gl	Domestic, industrial, stock and town use gl	Total water diversion gl
South Australia			
Private pumped diversion	235	4	239
Government pumped diversion	129	100	229
Reclaimed swamps	106	—	106
Total	470	104	574
Queensland			
Border rivers	72	2	74
Macintyre Brook	10	—	10
Condamine/Balonne	157	5	162
Total	239	7	246
Australian Capital Territory	—	63	63
Total for Basin	**10 232**	**452**	**10 684**

Source: Murray–Darling Basin Commission 1995.

2.22 FERTILISER USE, 1993–94

State/Territory	Area fertilised '000 ha	Quantity applied '000 tonnes	Application rate tonnes/ha
New South Wales	4 508	646	0.14
Victoria	3 761	642	0.17
Queensland	1 032	407	0.39
South Australia	3 282	327	0.10
Western Australia	7 557	866	0.11
Tasmania	379	110	0.29
Northern Territory	8	2	0.20
Australian Capital Territory	4	1	0.21
Australia	**20 529**	**3 000**	**0.15**

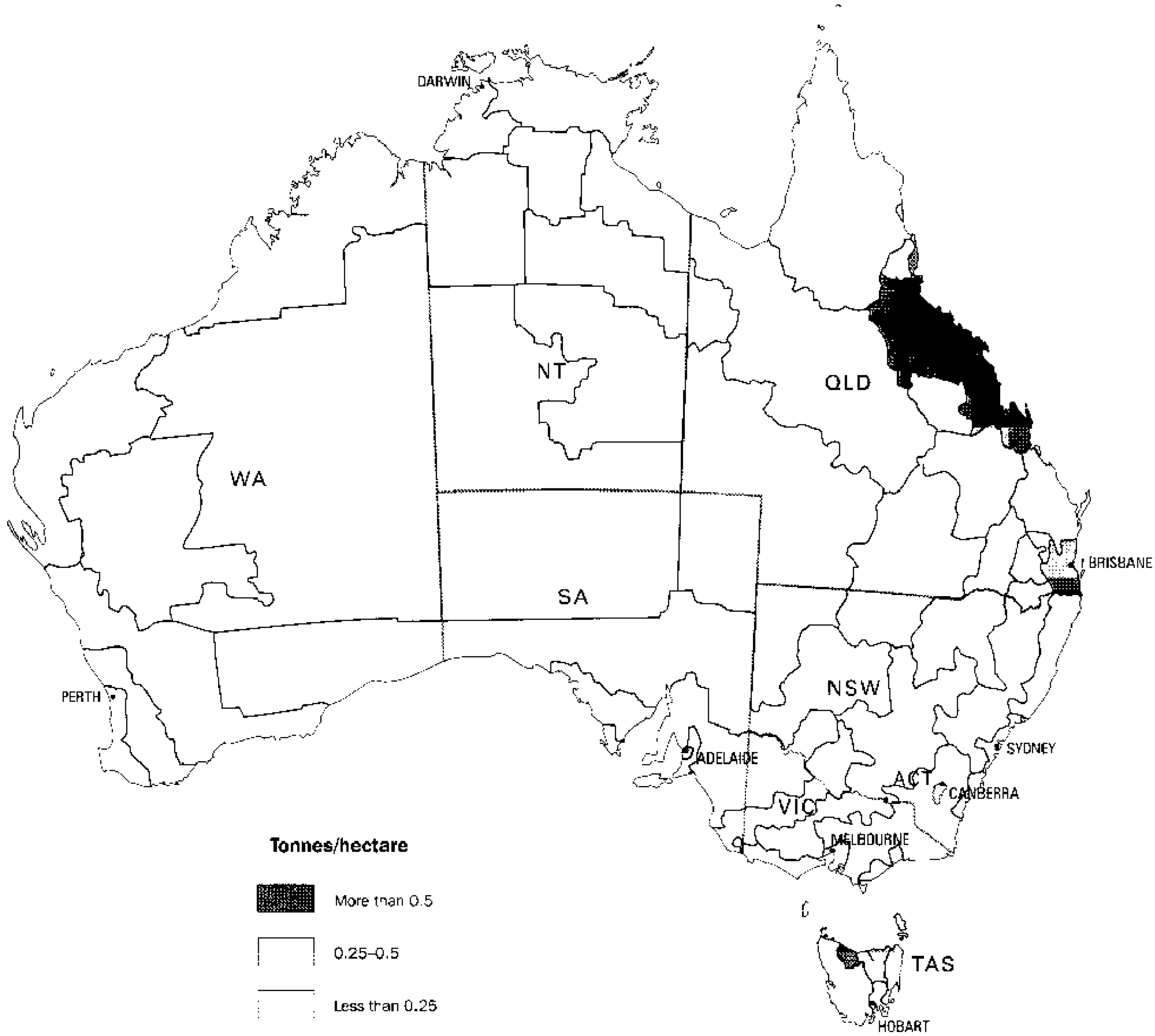
Source: Australian Bureau of Statistics n.d. (a).

2.23 AVERAGE ANNUAL FERTILISER USE, SELECTED COUNTRIES

Country	1975 77 kg/ha	1977-79 kg/ha	1985–87 kg/ha	1987 89 kg/ha
Australia	22	23	26	26
New Zealand	1 250	1 110	740	670
Canada	33	38	49	47
United States	102	105	93	95
Argentina	2	3	4	5
Brazil	1	42	49	46
India	22	29	52	62
Thailand	14	13	26	33
France	266	292	301	312
Italy	127	177	178	172
Spain	72	77	92	101
Sweden	176	182	138	134
United Kingdom	275	313	364	359
South Africa	61	70	61	58

Source: WRI 1990 and 1992.

2.24 *FERTILISER USE BY AGRO-ECOLOGICAL REGION, 1993 94*



Source: Map prepared by Australian Bureau of Statistics based on Agriculture Census data.

Phosphorus fertilisers, particularly single superphosphates, account for approximately 60% of fertiliser usage in Australia. Of the 2.3 million tonnes of superphosphate fertiliser which was applied to agricultural land in 1989–90, more than half was used on pastures in areas with moderate to good rainfall. Large quantities were also applied to cereal crops (see Chapter 5 for more information and tables).

Chemical use

Agricultural ecosystems tend to attract a variety of pests. One reason for this susceptibility is that crops are often grown in monoculture or in rotation with crops of a similar genetic makeup. Chemicals are widely used to control such pests. For the year ending March 1992, 14.9 million hectares of land were treated with herbicides. Insecticides were used to treat 3.1 million hectares of land and fungicides were used to treat about 800,000 hectares of land.

2.25 CHEMICAL USE, 1991–92

	Herbicides area	*Quantity*	*Insecticides area*	*Fungicides quantity*	*Area*	*Quantity*
	'000 ha	tonnes	'000 ha	tonnes	'000 ha	tonnes
NSW	3 346	274	976	194	212	270
Vic.	2 116	219	484	96	132	343
Qld	1 108	270	346	227	103	462
SA	2 872	180	528	40	144	349
WA	5 353	1 422	759	109	196	131
Tas.	66	14	23	23	25	59
NT	18	—	—	—	—	—
ACT	1	—	—	—	—	—
Aust.	**14 880**	**2 380**	**3 117**	**690**	**813**	**1 618**

Source: Australian Bureau of Statistics unpublished data.

Energy use

'Producing the foodstuff, meat or crop, requires more energy than the foodstuff contains so the process is a net energy consumer' (Australian Academy of Science 1994). In addition to sunlight, modern agriculture relies on energy derived from a selection of fossil fuels. Of the estimated 62.3 petajoules of energy consumed by the agriculture sector in 1993–94, most was automotive diesel oil (ADO) used primarily for farm machinery such as tractors and harvesters (table 2.26). Electricity was the next most significant energy source. Table 2.27 compares energy use in agriculture with other industries.

2.26 ENERGY CONSUMPTION BY INDUSTRY AND FUEL TYPE

	Fuel type (petajoules)						
Year	*LPG*	*Power kerosene*	*Heating oil*	*ADO*	*Natural gas*	*Elec-tricity*	*Total consumption*
1975–76	0.2	1.7	0.9	33.2	—	3.9	**40.0**
1979–80	0.3	0.7	0.4	40.7	—	5.0	**47.1**
1983–84	0.3	0.4	0.2	48.7	—	6.0	**55.6**
1987–88	0.4	0.1	0.1	47.2	—	7.4	**55.1**
1991–92	0.5	—	0.1	49.1	0.1	8.7	**58.4**
1992–93	0.5	—	0.1	50.8	0.1	8.0	**60.3**
1993–94	0.6	—	0.1	52.4	0.1	9.1	**62.3**

Source: ABARE 1995.

2.27 TOTAL ENERGY CONSUMPTION AND ITS GROWTH

	Energy consumption		*Share in energy consumption*		
	1973–74	*1993–94*	*1973–74*	*1993–94*	*Average annual growth rate*
Industry	petajoules	petajoules	%	%	%
Agriculture	39.2	62.3	1.5	1.5	2.4
Mining	60.1	195.0	2.3	4.7	6.1
Manufacturing	917.9	1 086.3	35.1	26.0	0.8
Electricity generation	510.0	1 121.3	19.5	26.9	4.0
Construction	26.2	42.9	1.0	1.0	2.6
Transport	685.1	1 078.9	26.2	25.8	2.3
Commercial	83.7	171.2	3.2	4.1	3.6
Residential	230.1	349.3	8.8	8.4	2.1
Other	62.8	67.1	2.4	1.6	0.4
Total	**2 615.2**	**4 174.2**	**100.0**	**100.0**	

Source: ABARE 1995.

AGRICULTURAL ACTIVITY

The use of environmental resources by agricultural activity in order to produce crops and livestock for food is part of the overall economic system. Chapter 3 focuses on the financial aspects of agricultural businesses. The next sections however provide some physical information about what the use of environmental resources supports in terms of the production of food and the numbers of businesses involved. For agriculture to be viable in the long term, then businesses need to be able to survive by undertaking agricultural activities.

Number of establishments (SCARM indicator)

At 31 March 1994, there were 150,389 establishments (above the estimated value of agricultural operations cutoff of $5,000) with agricultural activity operating across Australia, of which three-quarters were located in three States, New South Wales (42,817), Victoria (37,330) and Queensland (34,268). In the past there have been considerably more agricultural establishments than this. Table 2.28 indicates a general downward trend in the number of establishments with agricultural activity over a long period with about 100,000 less farms than 30 years ago. The reader should note the break in the series in 1985–86 and 1993–94.

2.28 NUMBER OF ESTABLISHMENTS WITH AGRICULTURAL ACTIVITY

	NSW	*Vic.*	*Qld*	*SA*	*WA*	*Tas.*	*Aust.*[1]	*Average size of establishment*
Year	no.	no.	no.	no.	no.	no.	no.	no.
1960–61	76 871	69 623	43 155	28 711	21 922	11 201	251 982	1 858
1965–66	76 152	69 199	43 914	28 759	22 853	10 777	252 162	1 927
1970–71	75 365	68 555	43 399	29 087	22 592	9 926	249 495	1 995
1975–76	69 450	58 496	38 577	25 143	18 871	8 214	219 227	2 284
1980–81	56 798	49 958	35 947	22 249	18 165	6 188	189 771	2 610
1981–82	53 712	48 607	35 320	21 402	17 552	5 972	182 972	2 586
1982–83	53 705	47 167	34 036	20 119	16 809	5 840	178 025	2 718

For footnotes see end of table.

... continued

2.28 NUMBER OF ESTABLISHMENTS WITH AGRICULTURAL ACTIVITY — *continued*

Year	*NSW*	*Vic.*	*Qld*	*SA*	*WA*	*Tas.*	*Aust.*[1]	*Average size of establish-ment*
	no.	no.	no.	no.	no.	no.	no.	no.
1983–84	53 011	45 984	34 167	19 479	16 750	5 664	175 412	2 774
1984–85	52 116	45 452	33 836	19 191	16 626	5 470	173 061	2 819
1985–86[2]	52 042	44 317	33 936	18 971	16 258	5 283	171 180	2 834
1986–87	37 131	33 987	25 676	15 084	13 692	3 615	129 538	3 637
1987–88	37 698	32 532	25 254	14 647	13 367	3 499	127 338	3 708
1988–89	37 431	31 841	25 483	14 505	13 359	3 592	126 551	3 688
1989–90	37 331	33 144	26 321	14 559	13 290	3 698	128 670	3 608
1990–91	36 651	32 415	25 129	14 392	13 121	3 560	125 615	3 685
1991–92	35 548	31 358	24 493	13 990	12 906	3 413	122 053	3 817
1992–93	35 285	31 251	25 131	14 077	13 128	3 518	122 770	3 747
1993–94	32 672	30 451	25 003	13 409	11 881	3 420	117 189	3 882
1993–94[3]	42 817	37 330	34 268	16 345	14 555	4 663	150 389	3 119

1 Australia total incorporates the Northern Territory and the Australian Capital Territory..

2 The ABS uses estimated value of agricultural output (EVAO) as a measure to determine those agricultural establishments within the scope of the Agricultural Census. In 1985–86 the EVAO cutoff was altered from $2 500 to $20 000 reducing the number of agricultural establishments in the scope of the Agricultural Census.

3 In 1993–94 the ABS lowered the EVAO cutoff to $5 000.

Source: Australian Bureau of Statistics n.d. (a) and (b).

Size of establishments

Until the mid-1980s, the steady decline in the number of agricultural establishments was matched to some extent by an increase in the size of agricultural establishments. Between 1960–61 and 1985–86 average farm size increased by 53% from 1,858 hectares to 2,834 hectares. Since the break in the series in 1985–86 it appears that average farm size has stabilised rather than continued to increase. The break in series at 1993–94 changes this picture in terms of level.

Despite an average increase in farm size over the years, relatively small agricultural establishments have continued to dominate the Australian farming scene. At 31 March 1994 and based on the new EVAO cutoff, about 66% of farms were less than 500 hectares in size, and most of the remaining establishments (29%) ranged in size from 500 to 5,000 hectares (table 2.29). Of the small proportion of farms larger than 5,000 hectares (5%), most were sheep or beef cattle farms or mixed sheep-beef cattle holdings.

2.29 NUMBER OF ESTABLISHMENTS WITH AGRICULTURAL ACTIVITY, 31 MARCH 1994

ANZSIC code	Description	*Size of establishment (hectares)* 0–499	500–4 999	5 000 or more	Total number of establishments
		no.	no.	no.	no.
0111	Plant nurseries	2 065	23	3	2 091
0112	Cut flower and flower seed growing	903	31	1	935
0113	Vegetable growing	4 728	291	5	5 024
0114	Grape growing	4 231	53	2	4 286
0115	Apple and pear growing	1 356	22	—	1 378
0116	Stone fruit growing	1 342	15	1	1 358
0117	Kiwi fruit growing	50	—	—	50
0119	Fruit growing n.e.c.	5 708	102	6	5 816
0121	Grain growing	4 401	8 906	617	13 924
0122	Grain-sheep/beef cattle growing	5 095	12 174	796	18 065
0123	Sheep–beef cattle farming	5 370	5 503	1 409	12 282
0124	Sheep farming	7 980	5 946	1 626	15 552
0125	Beef cattle farming	25 546	8 050	2 886	36 482
0130	Dairy cattle farming	13 534	770	15	14 319
0141	Poultry farming (meat)	718	14	—	732
0142	Poultry farming (eggs)	533	33	—	566
0151	Pig farming	1 329	252	12	1 593
0152	Horse farming	1 879	79	4	1 962
0153	Deer farming	403	53	5	461
0159	Livestock farming n.e.c.	2 004	120	10	2 134
0161	Sugar cane growing	4 921	177	11	5 109
0162	Cotton growing	275	472	56	803
0169	Crop and plant growing n.e.c.	1 203	133	3	1 339
Other industries & unclassified		3 564	473	91	4 128
Total all industries		**99 138**	**43 692**	**7 559**	**150 389**

Source: Australian Bureau of Statistics n.d. (a).

Industry of establishments

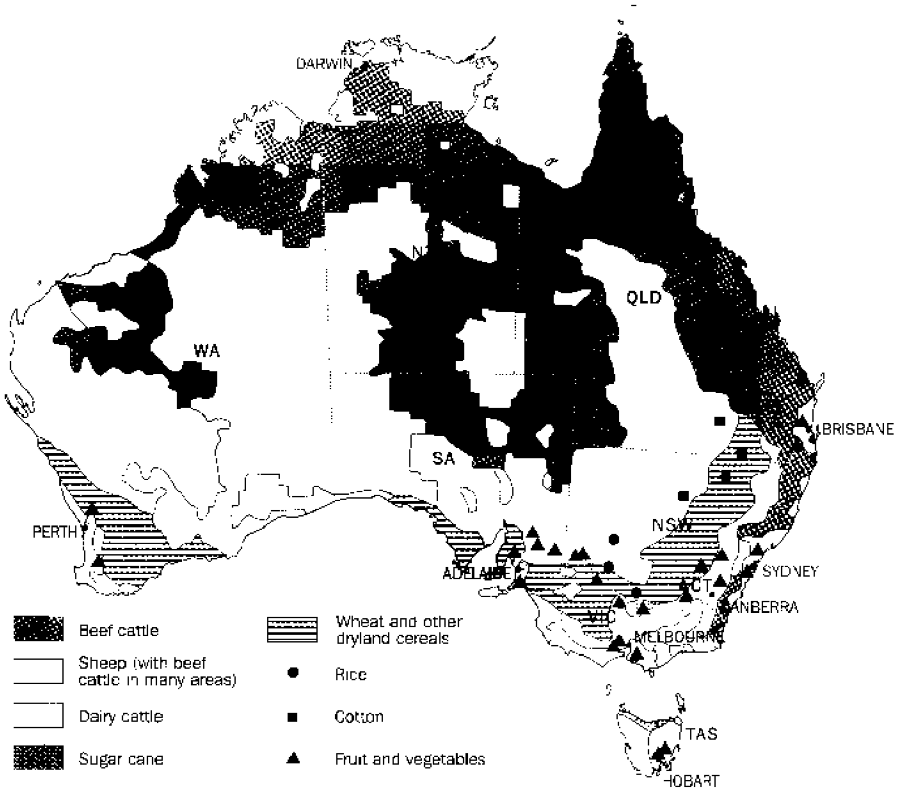
Emphasising the importance of broadacre farms to Australian agriculture, at 31 March 1994 almost 64% of all agricultural holdings were beef, sheep or grain growing establishments or establishments combining two or more of these activities (table 2.30). Broadacre farms were particularly dominant in Western Australia (77% of establishments), New South Wales (73% of establishments), Northern Territory (68% of establishments) and South Australia (65% of establishments). Map 2.31 shows in more detail the pattern of agricultural activity across Australia.

2.30 NUMBER OF ESTABLISHMENTS WITH AGRICULTURAL ACTIVITY, BY STATE, 31 MARCH 1994

ANZSIC code	Description	NSW	Vic.	Qld	SA	WA	Tas.	NT	ACT	Aust.
		no.	no.	no.	no.	no.	no.	no.	no.	no.
0111	Plant nurseries	681	291	790	123	147	39	16	4	2 091
0112	Cut flower & flower seed growing	245	185	192	111	137	60	5	—	935
0113	Vegetable	755	1 083	1 383	606	563	623	9	2	5 024
0114	Grape growing	709	1 729	92	1 468	238	47	9	2	4 286
0115	Apple and pear growing	233	466	125	158	229	164	—	3	1 378
0116	Stone fruit	446	240	115	368	172	17	—	—	1 358
0117	Kiwi fruit	26	13	3	—	8	—	—	—	50
0119	Fruit n.e.c.	1 900	396	2 271	797	360	38	53	1	5 816
0121	Grain growing	2 854	3 019	1 685	3 195	3 154	14	3	—	13 924
0122	Grain-sheep/beef cattle farming	6 669	2 689	1 887	3 253	3 479	84	4	—	18 065
0123	Sheep-beef cattle farming	5 380	3 343	1 209	1 162	625	532	—	31	12 282
0124	Sheep farming	5 617	4 773	739	1 838	1 905	653	—	27	15 552
0125	Beef cattle	10 543	8 307	13 115	1 145	1 990	1 156	207	19	36 482
0130	Dairy cattle	2 128	8 057	1 919	881	528	805	—	1	14 319
0141	Poultry (meat)	329	151	102	72	65	12	—	1	732
0142	Poultry (eggs)	151	123	129	55	84	18	5	1	566
0151	Pig farming	425	275	461	219	158	54	1	—	1 593
0152	Horse farming	638	420	535	149	158	59	1	2	1 962
0153	Deer farming	119	130	70	55	47	40	—	—	461
0159	Livestock farming n.e.c.	876	450	481	169	113	42	2	1	2 134
0161	Sugar cane	458	—	4 651	—	—	—	—	—	5 109
0162	Cotton growing	425	—	378	—	—	—	—	—	803
0169	Crop and plant growing n.e.c.	254	321	562	100	46	52	4	—	1 339
	Other industries & unclassified	956	869	1 374	421	349	154	3	2	4 128
	Total all industries	**42 817**	**37 330**	**34 268**	**16 345**	**14 555**	**4 663**	**316**	**95**	**150 389**

Source: Australian Bureau of Statistics n.d. (a).

2.31 *PATTERN OF AGRICULTURAL ACTIVITY*



Source: Australian Bureau of Statistics 1992.

AGRICULTURAL PRODUCTION

Volume of agricultural production

The level of agricultural production is intimately linked to the condition of the soil and the amount of rainfall which is received. Clearly, the better the quality of the soil and the more timely the rainfall the better agricultural production will be. However, it is recognised that careful management of the soil resource is also important to optimise production. Sufficient and balanced use of fertilisers, lime and gypsum, and the use of legumes and pasture rotations help replace soil nutrients lost during the production process. Tables 2.32, 2.33 and 2.34 provide a summary of the respective levels of production for crops, livestock products and livestock slaughterings for 1993–94.

2.32 PRODUCTION OF PRINCIPAL CROPS AND PASTURES, YEAR ENDED 31 MARCH 1994

	NSW	*Vic.*	*Qld*	*SA*	*WA*	*Tas*	*NT*	***Aust.*** [1]
	'000 tonnes	'000 tonnes	'000 tonnes	'000 tonnes	'000 tonnes	'000 tonnes	'000 tonnes	**'000 tonnes**
Cereals for grain								
Barley	1 357	1 386	261	2 242	1 381	41	n.c.	**6 668**
Grain sorghum	228	—	852	n.c.	2	n.c.	2	**1 084**
Maize	100	2	87	n.c.	15	n.c.	1	**204**
Oats	618	362	8	135	511	13	n.c.	**1 647**
Rice	1 042	n.c.	n.c.	n.c.	n.c.	n.c.	—	**1 042**
Triticale	110	71	5	49	22	6	n.c.	**263**
Wheat	5 086	2 022	555	2 121	6 689	5	n.c.	**16 479**
Legumes								
Lupins for grain	156	6082	—	82	1 181	1	n.c.	**1 480**
Field peas for grain	36	293	—	197	31	2	n.c.	**558**
Crops for hay								
Oats	226	190	n.c.	169	346	n.c.	n.c.	**931**
Wheat	65	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	**65**
Other cereals	18	16	23	57	44	10	1	**169**
Oilseeds								
Linseed	2	3	—	3	1	n.c.	n.c.	**9**
Canola	193	47	—	18	47	—	n.c.	**305**
Safflower	11	24	—	10	n.c.	n.c.	n.c.	**45**
Soybeans	48	4	29	n.c.	n.c.	n.c.	n.c.	**81**
Sunflower	47	4	52	1	n.c.	n.c.	n.c.	**105**
Other crops								
Sugar cane	1 674	n.c.	29 638	n.c.	n.c.	n.c.	n.c.	**31 312**
Cotton	771	n.c.	311	n.c.	n.c.	n.c.	n.c.	**1 081**
Peanuts (in shell)	1	n.c.	44	n.c.	—	n.c.	—	**45**
Tobacco	—	4	4	n.c.	n.c.	n.c.	n.c.	**8**
Pastures								
Cut for hay	938	1 752	262	356	427	229	13	**3 979**
Harvested for seed	3	7	1	9	3	1	—	**24**

[1] Australia total incorporates the Australian Capital Territory.

Source: Australian Bureau of Statistics n.d. (a) and (e).

2.33 LIVESTOCK PRODUCTS, AT 30 JUNE 1994

	NSW	*Vic.*	*Qld*	*SA*	*WA*	*Tas.*	*NT*	***Aust.*** [1]
Shorn wool (including crutchings) ('000t)	252.6	137.4	57.6	99.2	209.4	19.1	—	**775.8**
Other wool ('000t)	16.5	15.0	2.4	8.3	8.8	1.5	—	**52.6**
Total wool produced ('000t)	*269.1*	*152.4*	*60.1*	*107.4*	*218.2*	*20.6*	—	***828.3***
Whole milk intake by factories (mill. litres)	1 097	4 967	764	456	344	447	—	**8 076**
Total eggs produced ('000 doz.)	67 802	39 493	n.c.	12 705	n.c.	3 755	1 742	**128 813**
Honey produced (t)	11 270	4 905	2 919	4 096	2 172	623	—	**25 990**

[1] Australia total incorporates the Australian Capital Territory.

Source: Australian Bureau of Statistics n.d. (a).

2.34 LIVESTOCK SLAUGHTERING, 1993–94

Number slaughtered

	NSW	Vic.	Qld	SA	WA	Tas.	**Aust.**[1]
	'000	'000	'000	'000	'000	'000	**'000**
Cattle	1 987.9	1 393.9	2 781.8	400.3	438.8	187.0	**7 290.1**
Calves	221.4	583.4	148.7	8.8	4.4	23.2	**991.6**
Sheep	6 066.9	3 975.9	856.6	3 078.3	2 952.2	526.1	**17 641.0**
Lambs	3 991.7	5 600.8	669.6	2 363.8	1 553.2	437.8	**14 967.2**
Pigs	1 490.9	1 188.5	1 207.9	562.1	550.4	95.8	**5 190.2**
Chickens	129 736.0	85 798.0	54 133.0	28 376.0	31 482.0	n.p.	[2]**329 525.0**

1 Australia total incorporates the Northern Territory and the Australian Capital Territory.
2 Excludes Tasmania, Northern Territory and Australian Capital Territory.

Source: Australian Bureau of Statistics n.d. (d).

Between 1952–53 and 1992–93, 'the volume of production increased by 150% (representing an average annual rate of increase of 3.2%)' (Chisholm 1992), with output of crops and livestock slaughterings contributing most. Technological advances (for example, introduction of bulk grain handling, increased mechanisation, the introduction of new crop varieties and improved rotations using legumes) have played an important part in this consistent growth.

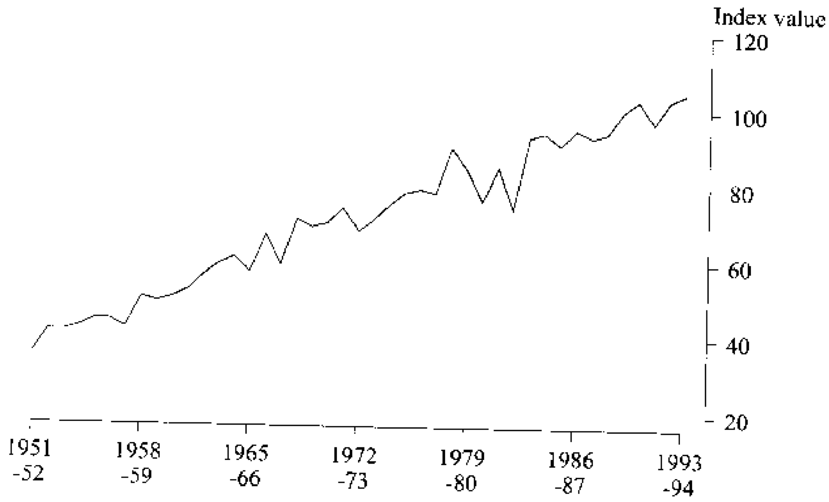
2.35 INDEXES OF VOLUME OF AGRICULTURAL PRODUCTION[1]

Time period	*Crops*	*Livestock slaughterings*	*Livestock products*	*Total*
1955–56 to 1959–60	34	45	72	46
1960–61 to 1964–65	43	51	79	56
1965–66 to 1969–70	59	57	85	65
1970–71 to 1974–75	65	75	84	72
1975–76 to 1979–80	78	99	73	82
1980–81 to 1984–85	92	86	73	84
1985–86 to 1989–90	100	94	89	95
1990–91 to 1992–93	107	106	90	101
1991–92	101	106	86	97
1992–93	113	108	88	103
1993–94	118	110	86	105

1 The index value for each time period represents the average index value of the time period concerned. Base 1989–90 = 100.

Source: ABARE 1994.

2.36 INDEX OF VOLUME OF PRODUCTION



Source: ABARE 1994.

Crop yields

Australia's ability to maintain growth in the volume of agricultural commodities produced has been enhanced by improvements in crop yields over time. As table 2.37 illustrates, crop yields for a selection of Australia's more important crop varieties have increased. However, a study of Australian wheat yields has indicated that wheat yield increases have not been universal. 'Although some cropping areas have yield trends greater than 20 kg per hectare per year others show no gain and some have declining trends despite major improvements in crop varieties, agronomic practices and technological advances' (Hamblin & Kyneur 1993). The regions in which yields have not risen much or declined tend to be those which are drier and/or experience higher rainfall variability.

2.37 YIELDS OF SELECTED CROPS

	1960–61	*1965–66*	*1970–71*	*1975–76*	*1980–81*	*1985–86*	*1990–91*	*1992–93*	*1993–94*
Crop	tonnes/ha	tonnes/ha	tonnes/ha	tonnes/ha	tonnes/ha	tonnes/ha	tonnes/ha	tonnes/ha	tonnes/ha
Wheat for grain	1.36	1.00	1.22	1.40	0.96	1.37	1.63	1.78	1.97
Barley for grain	1.38	1.02	1.19	1.37	1.09	1.48	1.61	1.83	1.95
Oats for grain	0.94	0.72	1.04	1.16	1.03	1.24	1.47	1.69	1.74
Grain sorghum	1.58	1.11	2.35	2.23	1.83	1.93	1.99	1.28	2.17
Rice	6.00	7.00	7.86	5.57	7.00	6.75	8.31	8.06	8.34
Cotton	—	—	1.64	2.69	3.04	5.27	4.05	3.48	2.69
Sugar cane for crushing	66.06	54.03	80.01	85.51	83.17	63.93	74.98	85.33	92.74

Source: Australian Bureau of Statistics n.d. (a).

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CHAPTER 3 AGRICULTURE AND THE ECONOMY

INTRODUCTION

The agricultural sector is a significant contributor to Australia's economic well-being. Increasingly, it is the outlook for the broad economy and the state of world markets which are influencing the condition of the agricultural sector. World commodity prices and increased costs (particularly, interest payments in the 1980s) have played an important role in a long-term deterioration of agriculture's terms of trade and profitability. This chapter examines in some detail these and other links between agriculture and the economy. The next section focuses on the importance of agriculture to the economy by looking at the income (both domestic and export) and employment that it generates. An insight into the overall economic prosperity of the agricultural sector and the factors shaping its current state and future prospects are then presented in the section on economic performance of the agricultural sector. The economic performance of agriculture at the farm business level is examined in the section agricultural finance at the farm business level. To conclude, supplementary sources of income are discussed.

CONTRIBUTION OF AGRICULTURE TO THE ECONOMY

Agricultural production has been pivotal to the economic prosperity of Australia. Although its current economic contribution domestically is not large, agriculture remains a substantial contributor to Australia's export income. When there is loss of export earnings, because production is sharply reduced as a result of drought or if prices received for agricultural produce are low, the balance of payments situation is often impacted with these unsatisfactory results having an impact on general macroeconomic policy. With the multiplier factor for agriculture estimated at between 1.5 and 2, there is some impact on the overall economy when agricultural production is substantially reduced.

Gross value of production

The gross value of agricultural commodities produced represents the value placed on recorded production at the wholesale prices realised in the market place. For the year ending 30 June 1994, the gross value of agricultural commodities produced in Australia was $23,479 million (table 3.1). Of this, 46% was accounted for by three commodities, cattle and calf slaughterings ($4,353 million), wheat ($2,867 million) and wool ($2,449 million). Historically, these three commodities have been the most important contributors to Australia's gross value of production. In recent years the combined value of sugar cane, cotton and wine-grapes has increased to rival wheat.

3.1 GROSS VALUE OF AGRICULTURAL COMMODITIES PRODUCED, 1993–94

	NSW	*Vic.*	*Qld*	*SA*	*WA*	*Tas.*	*NT*	*ACT*	*Aust.*
	$m	$m	$m	$m	$m	$m	$m	$m	$m
Crops									
Barley for grain	161.7	196.4	37.2	271.3	172.3	6.1	—	—	844.9
Oats for grain	55.4	32.9	1.4	11.5	45.1	1.5	—	—	147.9
Wheat for grain	893.1	348.9	101.8	365.2	1 156.9	0.9	—	—	2 866.8
Rice	261.4	—	—	—	—	—	—	—	261.4
Cotton	483.3	—	168.9	—	—	—	—	—	652.2
Sugar cane	43.5	—	914.5	—	—	—	—	—	958.0
Fruit and nuts	279.4	344.6	362.2	190.6	91.8	37.0	11.2	—	1 316.7
Grapes	90.5	175.6	7.1	153.6	17.6	1.7	3.9	—	450.1
Vegetables	181.9	413.2	413.3	178.3	139.0	115.1	2.8	—	1 443.7
All other crops n.e.i.	613.5	661.3	535.5	240.9	435.8	89.3	7.4	3.6	2 583.7
Total crops	*3 063.7*	*2 172.9*	*2 541.9*	*1 411.4*	*2 058.5*	*251.6*	*25.3*	*3.6*	*11 528.8*
Livestock slaughterings and other disposals									
Cattle and calves	1 088.8	830.6	1 829.0	174.9	217.6	112.5	97.3	2.0	4 352.7
Sheep and lambs	201.5	243.6	28.7	120.1	185.3	13.9	—	0.4	793.6
Pigs	187.0	169.9	165.4	69.6	68.6	—	—	—	660.5
Poultry	420.3	241.7	128.4	67.2	71.8	—	—	—	929.3
Total livestock slaughterings and other disposals	*1 903.2*	*1 485.8*	*2 151.6*	*434.4*	*545.7*	*148.5*	*100.5*	*2.4*	*6 772.1*
Livestock products									
Wool	877.4	439.8	179.6	271.8	604.7	74.2	—	1.6	2 449.1
Milk	403.5	1 381.1	282.4	132.5	121.2	126.8	—	0.4	2 448.0
Eggs	78.0	49.3	47.6	14.9	32.4	7.2	n.p	4.5	233.9
Other products	15.0	7.6	3.9	5.7	2.6	1.1	—	—	35.9
Total livestock products	*1 373.9*	*1 877.8*	*513.5*	*424.9*	*760.9*	*209.3*	*n.p*	*6.5*	*5 166.7*
Total gross value of production	**6 340.8**	**5 536.5**	**5 206.9**	**2 270.6**	**3 365.1**	**609.4**	**137.6**	**12.5**	**23 479.3**

Source: Australian Bureau of Statistics n.d. (d).

Irrigation areas contribute significantly to the total value of agricultural production in Australia. Table 3.2 shows that in 1988–89 the value of irrigated production was $4,580 million (20% of the total value of agricultural production). Obviously, regions favoured by suitable climatic conditions or specialising in high value crops are likely to contribute more to the gross value of production. Map 3.4 shows the percentage contribution by each agro-ecological region to the gross value of agricultural production in 1993–94.

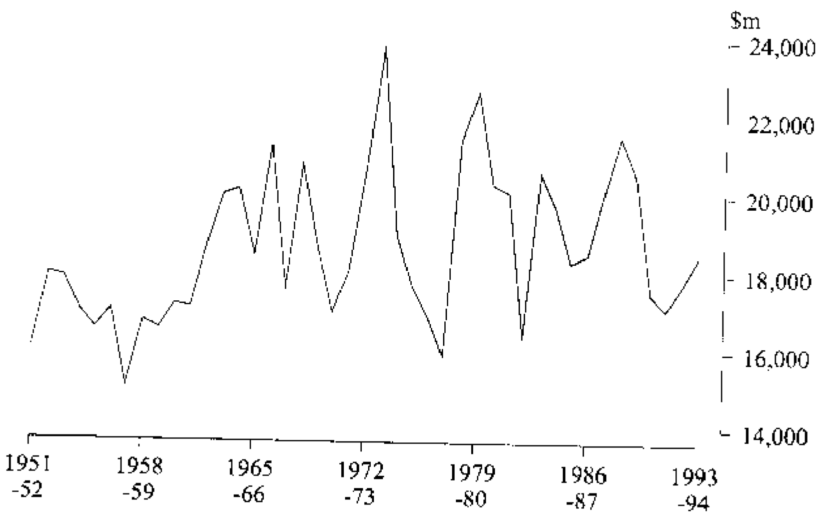
3.2 VALUE OF IRRIGATION PRODUCTION, 1988–89

State/ Territory	Trees, vines	Vegetables and other horticulture	Cereals, rice	Livestock pastures	Oilseeds, cotton, sugar	Total
	$m	$m	$m	$m	$m	$m
NSW	332	185	212	285	390	1 404
Vic.	375	333	2	468	4	1 182
Qld	181	382	25	54	467	1 109
SA	286	15	—	53	—	496
WA	62	121	—	20	—	203
Tas.	31	109	—	39	—	179
NT	—	7	—	—	—	7
ACT	—	—	—	—	—	—
Aust.	**1 267**	**1 294**	**239**	**919**	**861**	**4 580**

Source: Industry Commission 1992.

In real terms, the gross value of production has fluctuated considerably since the mid-1970s despite continued growth in output over this period. These fluctuations reflect the volatility of world commodity prices and variation in seasonal conditions.

3.3 GROSS VALUE OF AGRICULTURAL PRODUCTION, AT CONSTANT PRICES

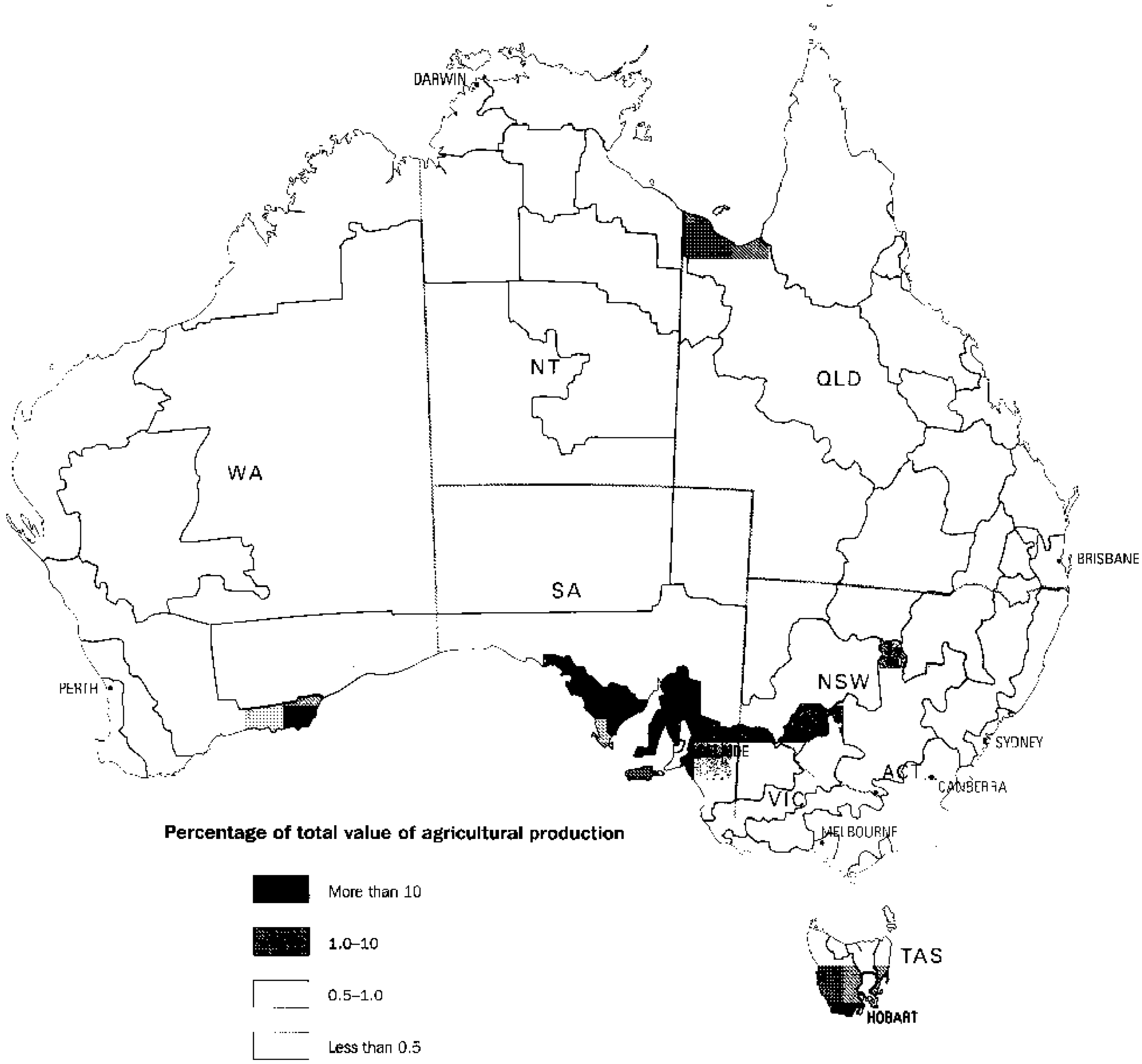


Source: ABARE 1994.

Farm exports

Agriculture is an export-oriented industry. In 1993–94 the recorded value of Australia's farm exports was $17,618 million (on a balance of payments basis). Wool ($3,368 million), meat ($3,922 million), and wheat ($2,311 million) were the most important export earning commodities, accounting for more than half of all rural export income. Other significant export earning commodities included cotton ($732 million), dairy products ($1,273 million), sugar ($1,231 million) and rice ($322 million).

3.4 *GROSS VALUE OF AGRICULTURAL PRODUCTION, BY AGRO-ECOLOGICAL REGION, 1993–94*



Source: Map prepared by Australian Bureau of Statistics based on Agriculture Census data.

In 1993–94, agricultural exports represented 21% of the total value of Australia's exports of goods and services while in terms of merchandise trade alone, 27% of exports were from the rural sector. Although still contributing significantly to total exports, these proportions are far less than those recorded in the 1950s and 1960s. In 1951–52, farm exports were about 81% of total merchandise exports and 74% of total exports. The lesser relative contribution by agriculture to total exports can be explained by the rapid expansion in Australia's mineral exports since the late 1960s and also some growth in the service and manufacturing sectors.

Contribution to gross domestic product

Although Australia is highly dependent on agriculture for export income, the sector now contributes only a small proportion of gross domestic product. This share has been declining steadily over a long period of time. Gross farm product accounted for just 3.2% of gross domestic product in 1993–94 compared with 16.1% of gross domestic product in 1951–52 (table 3.5).

3.5 CONTRIBUTION OF GROSS FARM PRODUCT TO GDP

Year	*Gross farm product* $m	*GDP(I)* %	*Proportion of GDP* %
1951–52	1 225	7 590	16.1
1956–57	1 664	11 785	14.1
1961–62	1 611	15 593	10.3
1966–67	2 326	23 838	9.8
1971–72	2 218	39 288	5.6
1976–77	4 046	87 594	4.6
1981–82	7 066	158 722	4.5
1986–87	9 273	255 761	3.6
1991–92	10 453	376 578	2.8
1992–93	11 556	392 558	2.9
1993–94	13 736	416 488	3.3

Source: Australian Bureau of Statistics n.d. (b).

Although the contribution to gross domestic product of the agricultural sector is relatively small, there remains potential for the sector to influence activity in the broader economy. Short-term fluctuations in rural commodity prices and rural production can dampen consumer spending by farm households and alter demand for farm inputs, including capital investment. 'It has been estimated that a change in the gross value of agricultural production of $1 thousand million causes a change in gross domestic product of between $1.5 and $2 thousand million in the same direction in the short term' (Tie, Bartley & O'Mara 1994).

Employment

ABS labour force data showed an estimated 382,200 persons (267,000 males and 115,200 females) were employed in agriculture or services to agriculture in August 1991. This represented 5% of all those in the workforce at that time.

Employment in agriculture peaked in the mid-1950s. Labour force data indicated that 476,800 persons were employed in agriculture in 1956 and that they represented about 12.5% of all those employed at that time. Since the mid-1950s, the number of persons employed in the agricultural sector has steadily declined while total employment has expanded. As a result, the relative contribution of the agricultural sector to total employment has diminished over time (table 3.6). The decline in the number of persons employed in agriculture appears to have halted in the early 1990s.

3.6 PERSONS EMPLOYED IN AGRICULTURE, SELECTED YEARS

	Employment in agriculture			*Proportion employed in agriculture*	
	Males	*Females*	*Persons*	*Total persons employed*	
Year	no.	no.	no.	no.	%
1956	—	—	476.8	3 813.0	12.5
1961	—	—	480.7	4 225.1	11.4
1966	361.5	59.5	421.0	4 837.1	8.7
1971	333.8	66.3	400.1	5 480.5	7.3
1976	282.4	72.2	354.6	6 011.8	5.9
1981[1]	*307.0*	*107.2*	*414.2*	*6 356.3*	*6.5*
1986	278.4	112.1	390.5	6 885.7	5.7
1991	267.0	115.2	382.2	7 669.2	5.0
1994[2]	*280.0*	*121.9*	*401.9*	*7 879.2*	*5.1*

1 Includes agriculture, forestry and mining rather than just agriculture and services to agriculture.
2 Reference month May rather than August.

Source: Australian Bureau of Statistics n.d. (c) and unpublished data for 1956.

ECONOMIC PERFORMANCE OF THE AGRICULTURAL SECTOR (SCARM INDICATOR)

Although there has been a 150% increase in the volume of production between 1952–53 and 1993–94, the agricultural sector has had a deterioration in its terms of trade. This means that, over time, the gap between the prices received by farmers for their produce and the prices paid by farmers for their inputs has diminished. To illustrate this point, in the twelve years from 1980–81 to 1993–94, prices paid by farmers doubled whereas prices received by farmers increased by 44%. As a result, farmers terms of trade were approximately 30% worse in 1993–94 than they were in 1980–81 (table 3.7).

3.7 TERMS OF TRADE (BASE 1987–88 = 100)

Year	*Price received*	*Price paid*	*Terms of trade*
1980–81	70	58	120
1981–82	70	65	107
1982–83	73	72	102
1983–84	77	78	99
1984–85	79	82	96
1985–86	79	88	88
1986–87	85	96	89
1987–88	100	100	100
1988–89	112	109	103
1989–90	109	116	94
1990–91	95	117	81
1991–92	98	117	84
1992–93	96	117	82
1993–94	101	120	84

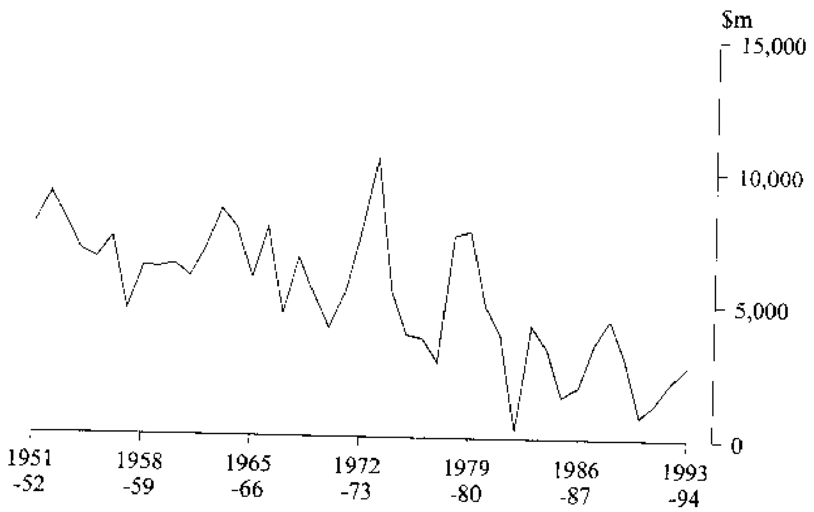
Source: ABARE 1994.

Net value of agricultural production measures the gross value of agricultural production less farm costs (that expenditure incurred in producing farm output). It is a broad indicator of the profitability of the agricultural sector. Reflecting the sector's deteriorating terms of trade, there has been a downward trend in the net value of agricultural production over the past four decades (at constant prices). This trend has only been interrupted by occasional net production peaks, such as early in the seventies and again later in that decade (graph 3.8).

The prolonged decline in Australia's net value of agricultural production reflects the fact that there has been, in real terms, considerable fluctuation in the gross value of production since 1951–52 but a steady increase in farm costs over the same period. Many factors, including changes in world commodity prices, variability in seasonal conditions and movements in exchange rates, have contributed to the volatility in the gross value of agricultural production while increased mechanisation and input use and more recently high interest rates have explained the escalation in farm costs. Graph 3.9 shows the convergence between the gross value of agricultural production and farm costs which helps explain the long-term decline in the net value of agricultural production.

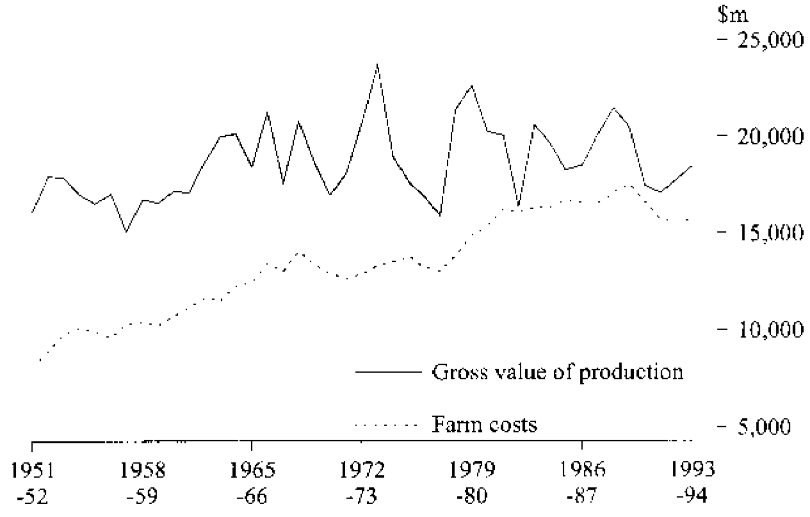
Since 1980–81, the net value of agricultural production, in real terms, has rarely exceeded $4,000 million and occasionally fallen below $2,000 million (graph 3.8). Some of the factors which have played an important role in shaping the pattern of net agricultural production over this period are discussed below.

3.8 NET VALUE OF AGRICULTURAL PRODUCTION



Source: ABARE 1994.

3.9 GROSS VALUE AND FARM COSTS OF AGRICULTURAL PRODUCTION, (in 1987–88 dollars)



Source: ABARE 1994.

In 1982–83, Australia was afflicted by a severe drought which had an extremely adverse affect on the economic well-being of the agricultural sector. Many crops could not be planted or, if planted, failed. As a result, the volume of production was well below average and consequently the economic returns from production were poor. The net value of production, in real terms, was lower in that year than for any other year on record.

'For all primary industries, except wool, Australia is a price taker on world commodity markets' (Chisholm 1992). The global economic setting significantly influences Australia's returns from agriculture because of the large proportion of agricultural produce which is exported. Over the period 1989–90 and 1991–92, 'prices for Australian commodities were falling in aggregate on world markets in response to a downturn in world economic growth and ample supplies of many products' (Fisher 1992). Reflecting this subdued global economic setting, the gross value of agricultural production, and as a consequence the net value of agricultural production, were extremely low.

Domestic economic conditions also affected the economic well-being of the agricultural sector. The high interest rates in the late eighties increased the operating costs of the farm sector and discouraged further capital investment by farmers which may have had associated productivity gains. Studies by Knopke and Harris (1991) and Knopke and Towner (1992) indicate that the composition of farm costs altered during the 1980s. They found the most obvious differences were the increased importance of interest payments and expenditure on farm chemicals and the decline in capital investment. 'Between the late seventies and late eighties, the relative contribution to expenditure, in real terms, of interest payments and farm chemicals increased by 8 percentage points and 2 percentage points, respectively. Over the same period the relative contribution of capital investment declined by 8%' (Knopke & Harris 1991).

3.10 REAL EXPENDITURE ON INPUTS BY THE FARM SECTOR

	Annual average					
	1977–78 to 1979–80		*1987–88 to 1989–90*		*1990–91*	
Expense	$m	%	$m	%	$m	%
Fuel	907	5.0	1 070	5.1	1 110	5.7
Fertiliser	951	5.2	1 112	5.3	890	4.6
Chemicals	420	2.3	884	4.2	820	4.2
Seed and fodder	2 064	11.4	2 115	10.2	1 950	9.7
Marketing	2 605	14.4	2 196	10.6	2 180	11.2
Repairs and maintenance	1 425	7.9	1 753	8.4	1 545	7.2
Other	2 405	13.3	2 879	13.8	3 585	18.4
Wages	1 968	10.9	2 585	12.4	2 660	13.7
Interest paid	1 050	5.8	2 839	13.6	2 450	11.6
Capital expenses	4 325	23.9	3 363	16.2	2 250	11.6
Total	**18 118**	**100.0**	**20 796**	**100.0**	**19 440**	**100.0**

Source: Knopke and Harris 1991.

Occurring in parallel to the change in the composition of farm costs in the late eighties was a decline, in real terms, in the total farm costs of the agricultural sector. This decline continued until recently and was contrary to the long-term trend of farm costs in Australia. It is likely this short-term tightening of farm costs was an attempt by farmers to alleviate the impact of depressed world commodity prices at this time. However, the low net value of production levels over this period suggest the cutbacks in farm costs only had limited success in offsetting poor returns from production.

Having endured a long-term deterioration in its terms of trade and a particularly difficult economic period between 1989–90 and 1991–92 the agricultural sector has begun to show some signs of recovery. The net value of production improved considerably, in real terms, in 1992–93 and is 'projected to recover further over the remainder of the nineties but remain somewhat below the level recorded in the late 1980s when world commodity prices last peaked' (Tie, Bartley & O'Mara 1994). Clearly, the drought conditions still impacting some areas in 1994–95 will have an impact on these projections.

AGRICULTURAL FINANCE AT THE FARM BUSINESS LEVEL

Cash operating surplus and profit margin of farm businesses (SCARM indicator)

The ABS uses cash operating surplus as an indicator of the 'profit' generated by farm businesses. However, this measure is only a guide to farm business profit because depreciation and income tax have not been deducted.

For 1993–94, the cash operating surplus of farm businesses in aggregate was $4,442 million (table 3.11). About half of this aggregate cash operating surplus was accounted for by farm businesses from the grain ($922 million), dairy ($689 million) and mixed grain–sheep–beef ($541 million) industries. This continues the trend of the past 20 years which has seen these industries tend to contribute most to the aggregate cash operating surplus of farm businesses.

3.11 AGGREGATE CASH OPERATING SURPLUS OF FARM BUSINESSES, FOR SELECTED YEARS

	Aggregate cash operating surplus			
	1974–75	*1980–81*	*1985–86*	*1993–94*
Industry	$m	$m	$m	$m
Poultry	29.9	52.2	68.8	109.2
Fruit	123.0	175.6	231.4	352.0
Vegetables	65.7	125.5	205.1	261.1
Grain	256.9	496.5	457.3	921.6
Grain–sheep–beef	524.6	941.7	732.5	541.4
Sheep–beef	69.1	241.5	306.2	179.9
Sheep	133.2	271.0	469.9	196.1
Beef	– 38.3	214.7	359.0	521.8
Dairy	156.3	371.1	436.2	689.2
Pigs	22.8	26.1	78.8	93.7
Sugar	—	—	181.9	301.3
Other	—	—	151.7	274.5
Total	**1 658.7**	**3 419.1**	**3 678.9**	**4 441.8**

Source: Australian Bureau of Statistics n.d. (b).

In real terms, cash operating surplus in 1993–94 was 7.2% higher than in 1992–93 (table 3.12). Real estimates exclude the direct effects of inflation and are derived by deflating the current price estimates with the implicit price deflator of domestic final demand, published with the quarterly national accounts.

3.12 REAL ESTIMATES OF CASH OPERATING SURPLUS (BASE YEAR = 1989–90)

	1986–87	*1987–88*	*1988–89*	*1989–90*	*1990–91*	*1991–92*	*1992–93*	*1993–94*
Industry	$m	$m	$m	$m	$m	$m	$m	$m
Poultry	87.4	96.1	73.1	43.6	72.1	80.0	70.0	98.9
Fruit	291.2	313.9	225.1	321.6	267.1	295.8	253.7	318.9
Vegetables	246.0	302.6	237.6	243.7	n.p.	n.p.	157.7	236.5
Grain	562.2	341.4	492.6	426.0	215.4	364.6	612.7	834.9
Grain–sheep–beef cattle	893.6	1 422.4	1 483.4	1 427.4	585.7	546.3	670.2	490.5
Sheep–beef cattle	379.6	459.2	336.9	232.4	199.4	92.6	124.5	163.0
Sheep	578.3	1 320.2	1 309.7	1 135.4	354.9	36.2	170.2	177.7
Beef cattle	448.7	389.7	322.8	373.0	427.8	220.6	396.5	472.7
Dairy cattle	533.1	534.2	609.9	544.6	401.8	497.8	691.0	624.4
Pigs	96.4	50.9	64	98.8	96.5	63.4	43.0	84.9
Sugar	222.5	232.5	265	332.6	226	188.7	252.1	273.0
Cotton	n.c.	n.c.	n.c.	n.c.	n.c.	181.6	160.2	138.7
Other agricultural	133.7	128.7	119.3	151.5	n.p.	n.p.	153.2	110.0
Total	**4 535.6**	**5 648.2**	**5 539.4**	**5 330.6**	**3 274.3**	**2 903.5**	**3 755.1**	**4 024.1**

Source: Australian Bureau of Statistics unpublished statistics.

In 1993–94, an estimated 20% of farm businesses had a negative cash operating surplus (table 3.13). Twelve years earlier, the same proportion of farm businesses had a negative cash operating surplus while in 1986–87, 17% of farm businesses had a negative cash operating surplus. This suggests that there were a relatively stable proportion of farm businesses in economic difficulty over this period, although the farm businesses comprising this group would have altered over time. Clearly, some farm businesses would have been forced to leave the industry while the economic well-being of others would have worsened over this time. An estimated 12% of farm businesses had a cash operating surplus of $100,000 or more. These farm businesses accounted for 63% of the aggregate cash operating surplus of farm businesses and had an average cash operating surplus of $223,200.

3.13 FARM BUSINESSES BY SIZE OF CASH OPERATING SURPLUS, SELECTED VARIABLES, 1993–94

Size of cash operating surplus	Farm businesses	Turnover	Cash operating surplus	Profit margin	Gross indebt-edness	Net capital expenditure	Interest coverage ratio
	no.	$m	$m	%	$m	$m	
$<0	21,142	2 586.3	–878.2	–33.96	4 395.6	323.9	–1.50
$0–$9 999	13 716	1 069.7	69.1	6.46	1 180.4	91.0	1.67
$10 000–$19 999	12 000	1 099.4	172.1	15.66	802.5	71.9	3.50
$20 000–$29 999	11 058	1 148.7	261.1	22.73	772.8	106.6	4.92
$30 000 $39 999	9 497	1 332.4	324.5	24.35	865.2	90.5	4.93
$40 000–$49 999	6 792	1 053.7	287.3	27.27	591.7	86.6	6.26
$50 000–$99 999	20 808	4 731.2	1 408.7	29.77	2 678.1	430.4	6.96
$>100 000	12 532	8 543.4	2 797.2	32.74	4 635.3	744.1	9.23

Source: Australian Bureau of Statistics n.d. (a).

The average cash operating surplus per farm business in 1993–94 was $41,300 (table 3.14). On an industry basis, average cash operating surplus was much higher for the cotton industry ($268,600) than all other agricultural industries. Other agricultural industries with a relatively high average cash operating surplus included the poultry ($93,900), grain ($68,700), sugar ($65,700) and dairy industries ($51,400). Just six years earlier many of the other agricultural industries, including the pig, sheep–beef and vegetable industries had a higher average cash operating surplus than the grain, dairy and sugar industries. This highlights the way in which the relative economic well-being of farm businesses from different agricultural industries can vary over short periods of time.

Table 3.14 also shows the percentage profit margin (that is cash operating surplus divided by turnover, expressed as a percentage) of farm businesses from different agricultural industries for selected years between 1980–81 and 1993–94. Across all industries, the farm business profit margin has declined from 32.8% to 20.6% over this period.

Since 1980–81, the dairy and sugar industries have regularly been among those industries with the highest profit margins. The high profit margins of both industries relative to other industries may relate to their ability to maintain reasonably stable production levels because of the more reliable climatic conditions which occur in regions where they dominate.

Some other industries (for example, the grain industry in 1985–86 and the sheep industry in 1993–94) have had particularly low profit margins at times when seasonal conditions or world commodity prices have not been favourable. Similarly, those industries with high operating costs (for example, the pig and poultry industries) have tended to be among those industries with the lowest profit margins, even in years when their average cash operating surplus was high relative to other industries.

3.14 AVERAGE CASH OPERATING SURPLUS AND PROFIT MARGIN OF FARM BUSINESSES, SELECTED YEARS

	Average cash operating surplus			*Profit margin*[1]		
	1980–81	*1985–86*	*1993–94*	*1980–81*	*1985–86*	*1993–94*
Industry	$'000	$'000	$'000	%	%	%
Poultry	30.1	60.8	93.9	18.0	14.9	18.6
Fruit	13.0	28.2	39.1	31.9	23.8	23.7
Vegetables	19.4	42.9	66.2	31.4	25.7	21.5
Grain	29.7	34.1	68.7	36.2	20.6	26.2
Grain–sheep–beef	—	—	34.0	—	—	19.2
Sheep–beef	18.4	43.7	20.4	25.0	24.9	13.9
Sheep	14.5	30.7	18.5	27.9	23.7	15.0
Beef	6.6	31.7	26.7	23.6	23.6	16.6
Dairy	19.0	28.1	51.4	38.5	28.3	26.7
Pigs	8.7	51.1	58.7	12.0	18.5	15.9
Sugar	—	35.4	65.7	—	30.9	28.6
Cotton	—	—	268.6	—	—	19.7
Total	**20.2**	**33.5**	**41.3**	**32.8**	**22.9**	**20.6**

[1] Cash operating surplus divided by turnover, expressed as a percentage.

Source: Australian Bureau of Statistics n.d. (a).

Assets, debt and net worth of farm businesses

In 1993–94 the total value of farm business assets (which cover the estimates for the value of land, buildings and other structures, vehicles, machinery, equipment, livestock and investments) was $116.5 thousand million (table 3.15). The beef cattle ($26 thousand million), grain–sheep–beef ($17 thousand million), sheep–beef ($12 thousand million) and sheep ($11 thousand million) industries, as they have done for a long time, contributed most to the total value of assets because they not only account for over half of all farm businesses but also comprise most of the larger farm businesses in terms of physical size. These farm businesses can have land assets which are particularly high in value.

Due to the importance of using highly technical capital equipment, farm businesses in the cotton industry had a significantly higher average value for their assets ($4.4 million) than did farm businesses in all other agricultural industries, at 30 June 1994. Beef cattle ($1.3 million) and sheep–beef cattle ($1.4 million) farm businesses had the next highest average value for assets.

3.15 AGGREGATE AND AVERAGE VALUE OF FARM BUSINESS ASSETS, DEBT AND NET WORTH, 1993–94

	Value of assets		*Gross indebtedness*		*Net worth*	
	Total	*Average per farm*	*Total*	*Average per farm*	*Total*	*Average per farm*
Industry	$m	$'000	$m	$'000	$m	$'000
Poultry	1 305.7	1 122.7	374.2	321.7	931.5	801.0
Fruit	5 298.0	587.9	841.4	93.4	4 456.6	494.5
Vegetables	3 746.3	950.6	652.9	165.7	3 093.5	784.9
Grain	14 042.3	1 047.2	2 319.2	173.0	11 723.1	874.3
Grain–sheep–beef	16 857.7	1 057.4	2 204.8	138.3	14 652.9	919.1
Sheep–beef cattle	12 134.3	1 377.0	1 305.0	148.1	10 829.3	1 142.8
Sheep	11 165.9	1 055.0	1 283.2	121.2	9 882.6	933.7
Beef cattle	26 403.5	1 348.6	2 860.9	146.1	23 542.6	1 202.4
Dairy cattle	12 190.9	908.8	1 791.9	133.6	10 399.0	775.2
Pigs	1 694.4	1 061.7	314.6	197.1	1 379.8	864.5
Sugar	5 155.9	1 124.0	611.3	133.3	4 544.6	990.8
Cotton	2 503.2	4 391.5	620.5	1 088.6	1 882.7	3 303.0
Other agriculture	4 000.0	811.2	741.8	150.4	3 258.2	660.8
All industries	**116 498.1**	**1 083.3**	**15 921.7**	**148.1**	**100 576.4**	**935.3**

Source: Australian Bureau of Statistics n.d. (a).

The total value of assets of farm businesses is offset by their gross indebtedness. This refers to the amounts owed by farm businesses to financial and other institutions. At 30 June 1994, the aggregate gross indebtedness of the farm sector was $15.9 thousand million, representing an average gross indebtedness of $148,100 per farm business. However, this debt is not evenly distributed across farm businesses or agricultural industries. At 30 June 1994, an estimated 20% of farm businesses owed $200,000 or more. These farm businesses owed 77% of aggregate farm business debt and had an average gross indebtedness of $564,900. In contrast, about one-quarter of farm businesses were debt free at the end of 1993–94 (table 3.16).

3.16 FARM BUSINESSES BY SIZE OF GROSS INDEBTEDNESS, SELECTED VARIABLES, 1993–94

Size of gross indebtedness	*Farm businesses*	*Gross indebt-edness*	*Cash operating surplus*	*Turnover*	*Value of assets*
	no.	$m	$m	$m	$m
Nil	26 193	—	886.9	3 159.4	22 691.4
$1–$4 999	6 161	11.7	192.4	665.7	4 495.3
$5 000–$9 999	3 891	28.3	110.4	433.4	3 355.1
$10 000–$24 999	9 222	151.9	328.4	1 155.4	8 160.9
$25 000–$49 999	10 475	356.1	369.0	1 510.7	8 696.6
$50 000–$99 999	13 945	991.1	518.8	2 046.0	11 628.8
$100 000–$199 999	16 017	2 160.9	527.8	2 862.3	15 663.1
$200 000 and over	21 634	12 221.8	1 508.1	9 731.7	41 806.9
Total	**107 538**	**15 921.7**	**4 441.8**	**21 564.7**	**116 498.1**

Source: Australian Bureau of Statistics n.d. (a).

It is important to stress that farm business debt in itself is not necessarily an indicator of pending financial collapse. Debt only becomes a serious financial concern when farm businesses find their ability to meet repayments compromised. Many farm businesses with high levels of debt also have high levels of capital investment and/or turnover which allow them to service their debt. For example, the relatively capital intensive agricultural industries of cotton ($1,088,600), poultry ($321,700), pigs ($197,100), grain ($173,000) and vegetables ($165,700) have higher average debt levels than other agricultural industries. Those farm businesses which had turnover exceeding $300,000 during the year ending 30 June 1994 accounted for 51% of the agricultural sector's total gross indebtedness.

The debt to asset ratio has fallen from 7.8 in 1989–90 to 7.3 in 1993–94, that is, every dollar of indebtedness is covered by $7.30 of assets. This suggests one scenario that the debt overall may be increasing and not being matched by an increase in the value of assets, possibly because the indebtedness is not for investment purposes but to maintain production because of poor returns from drought. Another scenario could be that with high interest rates for some of the period, farm businesses reduced their indebtedness but the value of assets decreased at a faster rate because of no equipment investment and reduced value of land through drought effects.

Net worth represents the total value of assets of farm businesses less their gross indebtedness. At 30 June 1994, in real terms, the aggregate real net worth of farm businesses was $91.1 thousand million (table 3.17).

3.17 REAL ESTIMATES OF FARM BUSINESS NET WORTH (BASE YEAR = 1989–90)

	1986–87	*1987–88*	*1988–89*	*1989–90*	*1990–91*	*1991–92*	*1992–93*	*1993–94*
Industry	$m	$m	$m	$m	$m	$m	$m	$m
Poultry	1 025.8	1 060.9	1 090.9	1 112.1	1 127.8	1 283.4	1 022.1	843.9
Fruit	3 922.9	4 084.7	4 070.7	3 777.9	4 135.0	3 412.5	4 198.4	4 037.4
Vegetables	2 723.9	3 205.8	2 678.6	2 647.1	n.p.	n.p.	2 890.4	2 802.5
Grain	10 351.2	5 958.8	5 754.4	4 919.4	4 664.7	6 251.3	7 370.0	10 620.4
Grain–sheep–beef cattle	20 223.6	22 572.2	24 839.0	18 556.5	15 756.7	14 643.3	15 061.5	13 274.6
Sheep–beef cattle	9 962.9	9 457.1	11 112.4	10 005.8	9 558.8	11 452.0	9 560.1	9 810.7
Sheep	14 474.8	24 310.6	25 615.0	22 418.4	15 824.6	12 203.7	11 340.9	8,953.0
Beef cattle	14 872.6	16 429.5	19 920.9	19 593.8	18 110.4	17 614.0	17 628.5	21 894.1
Dairy cattle	9 208.4	9 674.0	9 989.8	8 628.3	9 619.5	9 544.1	9 800.4	9 420.8
Pigs	1 195.4	1 108.8	1 120.8	1 000.2	1 371.7	1 108.9	984.4	1,250.0
Sugar	2 938.0	2 809.7	3 603.3	2 987.2	2 865.4	2 992.3	3 635.4	4 117.1
Cotton	n.c.	n.c.	n.c.	n.c.	n.c.	1 723.7	1 995.3	1 705.6
Other agriculture	2 925.4	3 044.7	2 522.7	2 592.5	n.p.	n.p.	2 677.7	2 951.7
Total	**94 617.4**	**104 395.0**	**112 318.3**	**98 239.0**	**89 002.7**	**87 805.8**	**88 164.9**	**91 115.9**

Source: Australian Bureau of Statistics unpublished statistics.

SUPPLEMENTARY SOURCES OF INCOME

Farm businesses often obtain income from other sources to supplement the income derived from farm operations. Seeking off-farm work is the most common way of augmenting farm income. The owner of a farm may work a second job or another member of the family (for example, the farmer's spouse) may return to the workforce in a regional centre. Farm tourism is another alternative, and farm businesses are branching into this as a means of supplementing returns from agriculture.

Off-farm income

According to ABARE data, family-operated farms accounted for 86% of broadacre establishments in 1992–93. Increasingly, farms of this kind have been seeking off-farm income to supplement their returns from agriculture. 'In 1992–93, 31% of broadacre family farms earned income from off-farm wages compared with 23% in 1988–89' (Peterson 1994). As the proportion of farms earning off-farm income has increased so has the amount of off-farm income derived. In the five years to 1992–93, there was a 40% increase in the amount of off-farm income derived by broadacre family farms. Over the same period, there was also an increase in the proportion of farms where the operator and spouse were both earning off-farm income.

The ABARE data indicate off-farm wage income can account for a substantial component of farm household income. 'For those broadacre farms which earned more than $500 from wages and salaries during 1992–93, average income was around $16,000, representing 37% of farm household income' (Peterson 1994). It also suggests the average off-farm wage income, when spread across all broadacre family farms, varies considerably according to agricultural region (table 3.18).

3.18 REAL BROADACRE AVERAGE OFF-FARM WAGES FOR FAMILY FARMS (IN 1993–94 DOLLARS)

	Pastoral zone		*Wheat-sheep zone*		*High rainfall zone*	
	Off-farm wages	*Proportion of farm cash income*	*Off-farm wages*	*Proportion of farm cash income*	*Off-farm wages*	*Proportion of farm cash income*
	$	%	$	%	$	%
1988–89	1 470	1.0	3 240	5.0	5 140	10.0
1989–90	2 820	4.0	2 950	5.0	6 440	18.0
1990–91	2 340	6.0	4 060	13.0	6 380	34.0
1991–92	2 280	10.0	4 080	11.0	6 400	47.0
1992–93	3 660	22.0	4 570	10.0	6 590	35.0

Source: Peterson 1994.

Farm tourism

'Farm tourism refers to working farms that supplement their primary agricultural function with some form of tourism business' (Jenkins 1993). In Australia the industry is only just beginning to develop. Reflecting this, coarse estimates have suggested there were just 1,500 farm tourism establishments in Australia in 1993, with total income approaching $50 million. The most common kind of establishment is one which acts as a rural guest house. Others offer an assortment of activities including cattle mustering and expeditions.

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CHAPTER 4 AGRICULTURE AND SOCIETY

INTRODUCTION

This chapter looks at some aspects of the relationship between agriculture and the wider community, including some aspects of the social structure of the farm community. In the first section the benefits that agriculture pass on to the Australian population by meeting the majority of their food and nutritional requirements is examined. Subsequent sections describe the demographic characteristics, education and qualifications of farmers; farm health and safety; and the place of agriculture in rural society.

SOURCE OF FOOD

When Europeans first settled in Australia, one of their first priorities was to become self-sufficient through the establishment of a food supply. 'Given an unfamiliarity with Australian conditions, lack of capital and distance to markets, this priority was not achieved without significant heartache and modification to the landscape' (Shaw 1993).

The agricultural sector provides food and fibres, such as wool and cotton, for an Australian population which was about 17.7 million in the middle of 1993. In 1992–93, Australians consumed over 9.3 million tonnes of food and 5.5 thousand million litres of market milk, aerated and alcoholic drinks. In average terms, this represented over 530 kilograms of food and 310 litres of beverages per person (table 4.1). Domestic production was sufficient to supply a large part of domestic demand as well as export markets.

With Australia's population projected to reach 19 million by the year 2000, and based on the 1992–93 pattern of consumption, Australians would consume over 10 million tonnes of food and nearly 6 thousand million litres of market milk, aerated and alcoholic drinks in the year 2000. This projected population increase to the year 2000 would, in the absence of other events, be unlikely to affect Australia's ability to maintain production at a level sufficient to meet domestic and export needs. However, any population increase exerts pressure on output so the need for efficient production and appropriate management of the natural resource base is essential to ensure the nation's position of production surplus is preserved in the long term.

The greatest single quantity of foodstuff consumed by the average Australian during 1992–93 was vegetables (145 kg). This was followed by fruit and fruit products (123 kg) and meat and meat products (77 kg). The ready availability and affordability of foodstuffs has meant that the nutrients available for consumption more than satisfies the recommended level (table 4.2).

4.1 ESTIMATED SUPPLY AND UTILISATION OF AGRICULTURAL FOODSTUFFS, 1992–93

Product	Commercial production	Imports	Total supply[1]	Exports	Apparent consumption Total	Apparent consumption Per person
	tonnes	tonnes	tonnes	tonnes	tonnes	kg
Meat and meat products	2 922 184	10 356	2 909 437	1 552 857	1 252 579	77.0
Poultry	467 824	464	472 064	6 394	465 670	26.5
Seafood	109 449	83 697	209 231	29 738	170 513	9.7
Dairy products (converted to milk solids)	n.a.	n.a.	n.a.	n.a..	405 493	23.1
Fresh fruit	1 990 094	201 270	2 279 218	207 664	1 773 632	100.9
Vegetables	2 480 874	189 292	2 850 404	160 335	2 554 232	145.3
Grain products	1 627 397	62 918	1 688 216	96 613	1 591 604	90.5
Egg and egg products[2]	—	—	—	—	145 610	8.3
Nuts (in shells)	44 079	69 493	113 441	12 432	94 759	5.4
Butter	n.a.	n.a.	n.a.	n.a.	45 576	2.6
Margarine	159 668	541	159 632	19 729	139 903	8.0
Sugars	1 399 280	107 878	1 519 436	92 805	818 004	46.5
Tea and coffee	979	60 385	61 364	4 825	56 540	3.2
	'000 litres	'000 litres	'000 litres	'000 litres	'000 litres	litres
Market milk	—	—	—	—	1 777 519	101.1
Aerated and carbonated waters	1 678 041	41 762	1 719 803	13 011	1 706 792	97.1
Beer	n.a.	12 849	n.a.	n.a.	1 713 205	97.5
Wine	n.a.	7 832	n.a.	n.a.	321 926	18.3
Spirits (litres alcohol)	n.a.	15 313	n.a.	n.a.	20 448	1.16

1 Includes net change in stocks, home production, commercial production and imports.
2 Calculated as number of eggs by 55 grams.

Source: Australian Bureau of Statistics n.d. (a).

4.2 NUTRIENTS AVAILABLE FOR CONSUMPTION IN AUSTRALIA COMPARED WITH RECOMMENDED DIETARY INTAKES (RDI), 1992–93

	Unit	Nutrients available	In excess of RDI
		%	%
Protein	g	99.70	118.0
Calcium	mg	856.00	2.0
Iron	mg	12.70	39.0
Retinol equivalent	mg	2 178.00	218.0
Vitamin C	mg	109.00	224.0
Thiamin	mg	1.78	100.0
Riboflavin	mg	2.37	74.0
Niacin equivalent	mg	42.40	179.0
Energy value	kJ	12 986.00	40.0

Source: Australian Bureau of Statistics n.d. (a)

FARM LABOUR FORCE

The 1991 Population Census data showed that 288,690 persons worked as farmers and farm managers or agricultural labourers. Most of these farmers (78%) worked in businesses classified to the agriculture industry (table 4.3), with the remainder undertaking agricultural activities classified to other industries.

4.3 FARM LABOUR FORCE BY INDUSTRY OF EMPLOYMENT, 1991

	Agriculture	*Other*	*All industries*
	persons	persons	persons
Farmers and farm managers	184 586	27 918	212 504
Agricultural labourers	39 525	36 661	76 186
Total	**224 111**	**64 579**	**288 690**

Source: Australian Bureau of Statistics 1991.

Farming has traditionally been considered a male dominated activity. The 1991 Census showed that 71% of farmers were male and 29% were female. In comparison, across all occupations, 57% of workers were male and 43% were female. There has been a gradual increase over time in the number of women working on farms as a proportion of the total farm workforce. Between the 1981 and 1991 Censuses, the proportion of all farmers who were female increased from 26% to 29%.

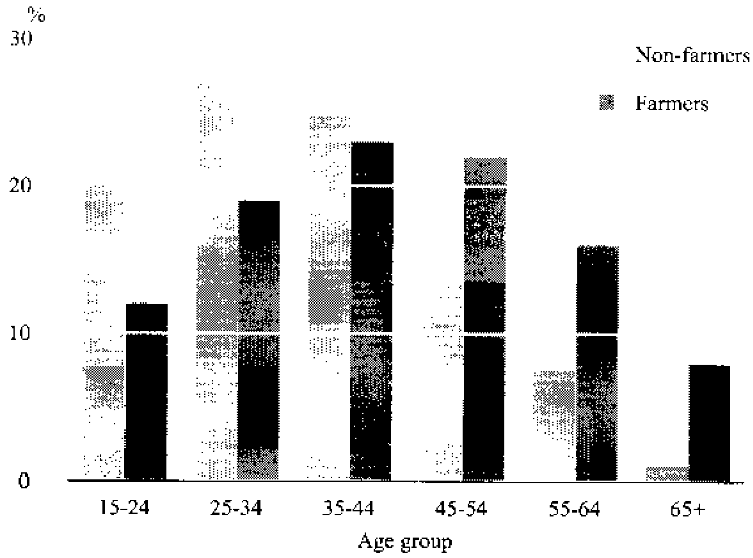
Economic pressures seem to have contributed to the increase in female farm employment. In many cases male farmers have sought off-farm income and transferred a range of farm duties to their partner. 'Women on farms are more likely to hold higher educational qualifications than male farmers and are also more likely to undertake retraining to provide financial security for families' (Cameron 1994).

Age profile

Farmers have an older age profile than other persons in the workforce, with around one-quarter of the farm labour force aged 55 years or over (graph 4.4). Furthermore, they account for approximately 11% of the male workforce and 9.5% of the female workforce aged 55 years and over (graph 4.5). Some reasons for the older age profile include:

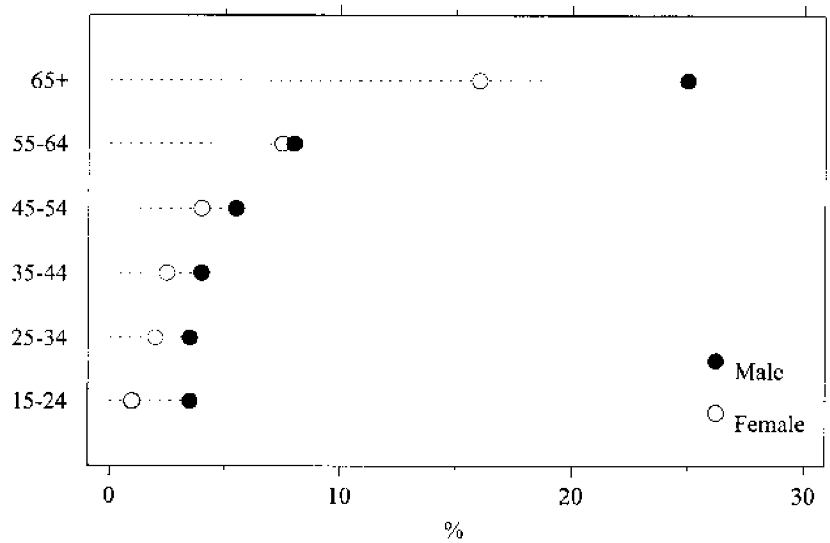
- a reluctance of young people to enter farming;
- difficulties associated with inter-generational transfer of farm property;
- the prohibitive cost of purchasing a farm; and
- the lack of a compulsory retirement age that allows farmers to keep operating their farm through personal choice ('way of life') or financial necessity.

4.4 AGE PROFILE OF FARMERS COMPARED WITH OTHER EMPLOYED PERSONS, 1991



Source: Australian Bureau of Statistics 1991.

4.5 MALE AND FEMALE FARMERS AS A PROPORTION OF ALL WORKERS IN SPECIFIC AGE GROUPS, 1991



Source: Australian Bureau of Statistics 1991.

Marital and family status

Farmers as a group appear to conform more to traditional concepts of the family. Table 4.6 shows that farmers are more likely to be married than is the case for all workers.

4.6 MARITAL STATUS OF FARMERS COMPARED WITH ALL WORKERS, 1991

	Never married	Married	Separated or divorced	Widowed
	%	%	%	%
Farmers	20.8	73.2	4.0	2.0
All workers	29.6	55.7	8.3	6.4

Source: Australian Bureau of Statistics 1991.

The traditional two-parent family with dependent offspring is the most common household type for farmers and non-farmers alike. However, in line with an older age profile, two-parent families with no dependent offspring and couple-only families account for a substantially higher proportion of farm households. There is a low proportion of single-parent farming families (table 4.7).

4.7 HOUSEHOLD TYPE OF FARMERS COMPARED WITH ALL WORKERS, 1991

	Two-parent family with dependent offspring[1]	Two-parent family with no dependant offspring[2]	Couple only	One-parent family with dependant offspring[2]	Single	Other
	%	%	%	%	%	%
Farmers	40.8	16.4	23.0	1.3	14.7	3.8
All workers	47.0	8.6	15.2	6.6	19.2	3.4

1 May include other members of household in addition to dependent offspring (e.g. independent offspring, dependent non-offspring and other related or non-related individuals).
2 May include other members of the household such as independent offspring, dependent individuals over 15 years of age and other related or non-related individuals.

Source: Australian Bureau of Statistics 1991.

Education and qualifications (SCARM Indicator)

Generally, a good education can assist farmers to develop competent managerial skills. Managerial skills may not only cover 'finance and trading activities but also decision making about choice of products to grow, management of the physical enterprise (including operational and landcare planning) and capacity to realise personal and societal goals' (SCARM 1993). The possession of good managerial skills is regarded as important in ensuring the sustainability of the agricultural establishment.

Farmers are less educated than Australian workers in general. Tables 4.8 and 4.9 compare the age left school and qualifications of farmers with those of all workers. The proportion of farmers who had not gone to school or had left school before they were fifteen (20%) was double that of all workers while the proportion of farmers who had attained a recognised qualification (18%) was less than half the rate for all workers (40%).

4.8 AGE AT WHICH FARM WORKERS AND ALL WORKERS LEFT SCHOOL[1], 1991

	Farm workers	All workers
	%	%
Still at school	0.5	1.7
Did not go to school	0.6	0.5
14 or younger	19.9	9.5
15	27.3	23.8
16	24.3	24.8
17	17.4	23.2
18	7.1	13.3
19 years or older	2.8	7.6

[1] Excludes those respondents who did not respond to the 'Age left school' question in the 1991 Census.

Source: Australian Bureau of Statistics 1991.

4.9 QUALIFICATIONS OF FARM WORKERS COMPARED WITH ALL WORKERS, 1991[1]

	Farm workers			All workers		
	Males	Females	Persons	Males	Females	Person
	%	%	%	%	%	%
Higher degree/ post graduate diploma	0.5	1.0	0.6	3.4	3.4	3.4
Bachelor degree/ undergraduate diploma	4.0	10.6	6.0	12.7	18.9	15.4
Associate diploma	1.0	1.9	1.3	2.3	1.8	2.1
Skilled vocational	11.2	2.3	8.6	25.3	3.2	15.9
Basic vocational	2.7	4.1	3.1	3.4	6.7	4.8
No qualifications	80.6	80.2	80.4	53.0	66.1	58.6

[1] Excludes those respondents who did not respond to the 'Qualifications' questions in the 1991 Census.

Source: Australian Bureau of Statistics 1991.

There are a range of factors which have contributed to the education level of Australian farmers. These include the:

- perception held by many farmers, especially in the past, that formal education (particularly higher secondary and tertiary education) was not necessary for those working on the land;
- practice of farmers' children learning to farm on the job rather than attending school, either through financial necessity or as an apprenticeship for the subsequent inter-generational passing on of the farm; and
- problems with accessibility to education in rural areas.

Today, many parents 'aware of the difficulties facing the agricultural industry, encourage their children to broaden their training. Many who train with a view to returning to the land subsequently find that a degree or experience in business management is a sufficiently versatile qualification to permit employment in non-farm areas' (Epps 1993). Of all students at post-secondary institutions, 6.4% of males and 3.6% of females study farm-related courses (i.e. agriculture, animal husbandry or veterinary science) and 4.3% of male and 1.6% of female graduates of vocational education centres were in paid employment in agriculture, forestry, fishing or hunting industries on 30 April 1993 (Dawe 1993).

During the 1992–93 financial year, 588 farming apprentices commenced employment on farms. Of these, 61% were employed in Victoria and 94% of all commencements were male. Farming apprentices in training at 30 June 1993 numbered 1,632 (table 4.10). In addition to farming, there were 3,357 apprentices in horticulture (Blythe & Weston 1994).

4.10 FARMING APPRENTICES IN TRAINING AT 30 JUNE 1993[1]

	Males	*Females*	*Persons*
State/Field of study	no.	no.	no.
New South Wales			
Dairying	109	11	120
Victoria			
Farming	777	42	819
Fruit	69	4	73
Vegetables	52	1	53
Total	*898*	*47*	945
South Australia			
Farming	419	36	455
Western Australia			
Farming	17	2	19
Tasmania			
Cropping	29	2	31
Dairying	27	7	34
Fruit	3	0	3
Grazing	25	0	25
Total	*84*	9	93
Total	**1 527**	**105**	**1 632**

1 There are no farming apprentices in Queensland, Australian Capital Territory or Northern Territory.

Source: National Centre for Vocational Education Research Ltd., unpublished statistics.

FARM SAFETY AND HEALTH

There does not appear to be specific data to describe health issues of Australians who live on farms. However, research done by the Australian Institute of Health and Welfare for the 1995 Australian State of the Environment Report has provided some data about the rural health situation as distinct from metropolitan and other cities and remote regions. 'The main known differences are that death rates resulting from motor vehicle accidents and respiratory disease are higher for rural residents and that death rates from cancer are lower' (Mathers 1994).

On-farm fatalities and injuries

The incidence of work-related fatalities in the agricultural sector is above the national average for all industries. 'A major study conducted between 1982 and 1984 estimated the annual rural work-related fatality rate to be 22.09 per 100,000 persons' (Clarke 1993). More recent data, for three States, indicate that tractors are the agent accounting for most fatalities (table 4.11).

4.11 NUMBER AND PERCENTAGE OF FARM FATALITIES BY AGENT, NEW SOUTH WALES, QUEENSLAND AND SOUTH AUSTRALIA

	New South Wales		*South Australia*		*Queensland*	
	January 1988 to April 1991		*January 1988 to April 1991*		*January 1988 to April 1991*	
Agent of fatality	no.	%	no.	%	no.	%
Vehicle						
Truck	1		1		2	
Agbike	—		1		..	
Aircraft	1		—		—	
Other	4		—		1	
All vehicles	*6*	*14.0*	*2*	*11.0*	*3*	*3.0*
Farm machinery						
Tractor	14		6		54	
Earth moving	1		—		—	
Loader	2		1		—	
Posthole digger	—		1		—	
Other	5		—		2	
Farm tools or other electrical	1		—		1	
Other plant/equipment	3		—		10	
All plant and equipment	*26*	*59.0*	*8*	*44.0*	*67*	*74.0*
Farm structure						
Windmill	—		1		—	
Silo/grain bin	—		1		3	
All farm structures	—		*2*	*11.0*	*3*	*3.0*
All animals	1	2.0	—	—	8	9.0
Other agents						
Electricity	—		2		3	
Gas/vapour fumes	2		1		—	
Water	1		—		7	
Timber beams	—		1		—	
Fuel tank	—		1		—	
Hay bale	—		1		—	
Other	8		—		—	
All other agents	*11*	*25.0*	*6*	*33.0*	*10*	*11.0*
Total	**44**	**100.0**	**18**	**100.0**	**91**	**100.0**

Source: Clarke 1993.

In addition to work-related deaths, other deaths occur which are farm specific but not work related. These deaths often involve children. The chief cause of child fatalities on farms in New South Wales and Victoria between 1988 and 1990 was drowning but other agents causing death included motor vehicle accidents, farm equipment, poisoning, horses and firearms.

Accidents causing injury are also common on farms. From analysis of 1991–92 New South Wales hospital separations data, the following have been identified as the main agents of on-farm injury:

- motor cycles;
- animals ridden;
- falls from structures;
- machines;

- cutting and piercing implements; and
- other vehicles (Clarke 1993).

Pesticide exposure

Pesticide exposure can occur when pesticides are absorbed through the skin, swallowed or breathed-in. Some common acute ill-effects associated with exposure include headaches, blurred vision or sore eyes, itching or rash, dizziness and nausea. More long-term effects of exposure are not known for most pesticides but links to genetic malformation, damage to developing foetuses and cancers have been suggested (Clarke 1993).

There is no national or State data currently available to indicate the nature and extent of pesticide exposure for those involved in Australia's farm sector. However, it is recognised that there is a high risk of exposure in agricultural activities with high levels of pesticide use. These include:

- vegetable production;
- stone and pome fruit growing;
- cotton production;
- rice production;
- banana production;
- greenhouse production (for example, mushrooms); and
- sheep husbandry.

Stress and suicides

With the rural recession of the late 1980s and early 1990s, most commodity groups in most parts of Australia were impacted. With many farmers faced with a combination of difficult economic circumstances, the increased stress and family breakdown led to the national Government and State Governments establishing or enlarging a variety of counselling services. There appears to be a high incidence of stress-related illnesses like hyper-tension, heart attacks, asthma, ulcers, back and chest pain in the non-metropolitan group compared to the metropolitan group (Mathers 1994).

Males in the 15–24 years age group have a considerably higher age specific suicide rate for rural areas than does its urban counterpart. Tables 4.12 shows that the age specific suicide rate for this group was 24 deaths per 100,00 of mid-year population in 1986 rising to 36 in 1988 and remaining around that level in subsequent years.

4.12 SUICIDES BY USUAL RESIDENCE[1]

Year	Urban no.	Rural no.	Total no.	Urban rate[1]	Rural rate[1]	Total rate[1]
			MALES			
1986	1 218	313	1 531	19	29	19
1987	1 397	376	1 773	22	23	22
1988	1 361	369	1 730	21	23	21
1989	1 306	352	1 658	19	22	20
1990	1 342	393	1 735	20	24	20
1991	1 465	382	1 847	21	24	21
1992	1 406	414	1 820	20	26	20
			FEMALES			
1986	405	46	451	6	3	6
1987	404	63	467	6	4	6
1988	408	59	467	6	4	6
1989	375	63	438	5	4	5
1990	353	73	426	5	5	5
1991	449	64	513	6	4	6
1992	404	70	474	5	4	5
			PERSONS			
1986	1 623	359	1 982	13	12	12
1987	1 801	439	2 240	14	14	14
1988	1 769	428	2 197	13	14	13
1989	1 681	411	2 096	12	13	12
1990	1 695	466	2 161	12	14	13
1991	1 914	446	2 360	13	14	13
1992	1 810	484	2 294	12	15	13

1 Standardised per 100 000 estimated mid-year 1986 population.

Source: Australian Bureau of Statistics 1994.

In the years 1986 to 1992 the most common method of suicide in rural areas resulted from the use of firearms and explosives (45%). Table 4.13 shows the distribution of suicide methods between urban and rural areas.

4.13 SUICIDES BY USUAL RESIDENCE, LEADING METHODS, 1986–92

	Urban		Rural		Total	
Method of suicide	no.	%	no.	%	no.	%
Hanging, strangulation and suffocation	3 022	24.6	616	20.2	3 638	23.7
Firearms and explosives	2 207	18.0	1 374	45.0	3 579	23.3
Gases	2 557	20.8	545	17.9	3 102	20.2
Poisoning by solid or liquid substances	2 432	19.8	324	10.6	2 756	18.0
Other methods	2 059	16.8	196	6.4	2 255	14.7
Total	**12 277**	**100.0**	**3 053**	**100.0**	**15 330**	**100.0**

Source: Australian Bureau of Statistics 1994.

Other medical conditions

A range of other medical problems and conditions have been associated with agricultural work. These include:

- noise-induced hearing loss;
- respiratory diseases such as asthma; and
- an assortment of infectious diseases transmittable from animals to humans (for example, hydatid disease and brucellosis).

AGRICULTURE AND RURAL SOCIETY

At the time of the 1991 Population Census, 233,668 farmers, farm managers and agricultural labourers (81%) lived in rural areas (table 4.14). Approximately 85% of the farm workers in rural areas were married and 42% had dependent children, adding further to the number of people whose lives were directly linked to agriculture.

4.14 FARMING LABOUR FORCE IN RURAL AND URBAN AUSTRALIA, 1991

	Farmers and farm managers		*Agricultural labourers*		*Total*
	no.	%	no.	%	no.
Rural	188 283	89.0	45 385	60.0	233 668
Urban	24 221	11.0	30 801	40.0	55 022
Total	**212 504**	**100.0**	**76 186**	**100.0**	**288 690**

Source: Australian Bureau of Statistics 1991.

Most farmers in rural areas (209,593) worked in the agriculture industry. Map 4.16 highlights the importance of farm workers in terms of employment, on an agro-ecological region basis.

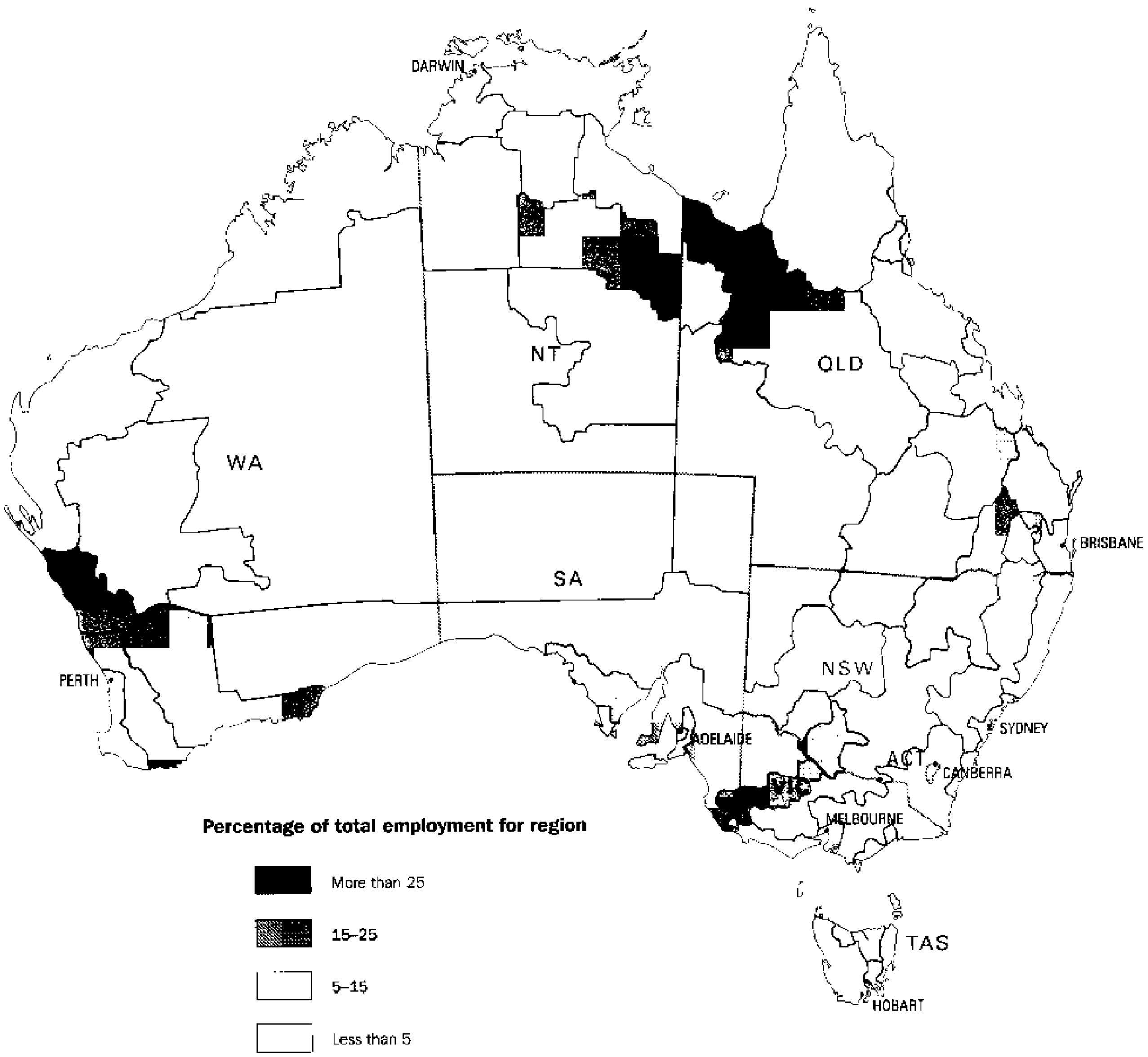
While agriculture is clearly important in rural areas, the stereotype of the rural population being overwhelmingly dependant on the sector for its prosperity is misleading. The population of rural Australia has become much more diverse as has its industrial mix. Between 1976 and 1991, the size of the manufacturing, mining and tertiary industries has expanded considerably in rural areas while the size of the agricultural sector has contracted (table 4.15).

4.15 EMPLOYED PERSONS IN RURAL AREAS

	1976		*1991*	
	Persons employed	*Proporation of all those employed*	*Number employed*	*Proportion of all those employed*
Industry	no.	%	no.	%
Agriculture	327 949	47.9	254 183	23.9
Mining	8 222	1.2	18 777	1.8
Manufacturing	55 266	8.0	97 395	9.1
Other	293 686	42.9	694 408	65.2
Total	**685 123**	**100.0**	**1 064 763**	**100.0**

Source: Australian Bureau of Statistics 1991.

4.16 FARM WORKERS CONTRIBUTION TO EMPLOYMENT BY AGRO-ECOLOGICAL REGION, 1992–93



Source: Australian Bureau of Statistics unpublished data.

Many country towns across Australia grew to service the needs of agricultural workers in surrounding districts by providing a broad mixture of industrial, retail, personal, financial, recreational, and government services. Despite industrial diversification in rural areas, estimates indicate that the primary function of just over 50% of country towns remains to act as agricultural service centres (table 4.17).

4.17 A FUNCTIONAL CLASSIFICATION OF NON-METROPOLITAN TOWNS

Type	no.	%
Major rural service centres	456	38.0
Smaller rural service centres	192	16.0
Transport/communication centres	89	7.0
Manufacturing/processing centres	178	15.0
Mining centres	52	4.0
Metropolitan fringe centres	57	5.0
Resorts	90	8.0
Miscellaneous	82	7.0
Total	**1 196**	**100.0**

Source: Budge and Associates 1992.

Rural areas and smaller country towns of inland Australia, where dryland farming or pastoral activity dominate, have been most affected by downturns in the farm sector. Data from the Taxation Office on average taxable incomes showed that, in 1993–94, the ten postcode regions with the lowest mean taxable incomes in Australia were in rural areas (Australian Taxation Office 1995). The lowest, Kyancutta (postcode 5651 in South Australia) at a mean taxable income of $15,613 was about one-quarter of the highest postcode area — Edgecliff (postcode 2027 in New South Wales) at $64,283.

These inland rural areas have also seen a decline in population of between 0% and 5% between the 1986 and 1991 Population Censuses. Population decline undermines the economic viability of these communities.

In contrast to the inland dryland farming and pastoral areas of rural Australia, there has been significant population increases in other rural areas, most notably:

- along the east, south-east, and south-west coasts;
- surrounding the major capital cities; and
- in and around large non-metropolitan centres.

Population growth has diversified the composition of the population and complicated the economic structure of these areas. Industries other than agriculture (for example, tourism or manufacturing) are growing in importance and agriculture is facing a range of competing land uses.

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CHAPTER 5 AGRICULTURE AND WASTES

INTRODUCTION

Agricultural activity generates many highly desirable outputs including agricultural commodities, export income, employment and tourism. Not all outputs however, have been so positive. Waste outputs may flow into the wider environment and interact with the natural ecosystems. These wastes include run-off or seepage of fertilisers and manure, greenhouse gas emissions and a range of manufactured chemicals which may stay in the soil, enter waterways or remain in agricultural products. Excessive agricultural chemicals in the environment may place export markets in jeopardy, are a potential threat to human health and have a wide range of well-documented effects on native flora and fauna.

This chapter describes some of the wastes generated by agricultural activities. In particular, the chapter examines some data about the residues from the use of chemicals; the composition of fertilisers used in Australia with some description about the impacts of overuse and run-off; some estimates of the generation of animal wastes from livestock farming; and calculations of greenhouse gas emissions from agricultural activities.

AGRICULTURAL CHEMICAL USE

There are many types of agricultural activity conducted within Australia and each of these has an individual chemical use profile. A variety of pesticides and fertilisers are employed by farmers to increase production by facilitating rapid, healthy growth of their crops and livestock and eliminating competing species of plants and animals. The range of agricultural chemicals includes pesticides to kill or control insects (insecticides), mould (fungicides), weeds (herbicides), parasitic worms (anthelmintics), rodents (rodenticides), antibiotics to control micro-organisms, and hormones to promote growth. The quantity, strength and type of chemicals applied depends not only on the breed or crop variety, but also on factors such as geography, climate, season and soil structure. Factors such as the type of pest, virus or disease to be controlled, its life cycle and that of the crop or livestock to be protected are also important.

About 2,500 farm chemicals and 2,000 animal health products containing about 400 active ingredients are used in Australia to control over 5,000 economically significant pests (Bewley 1992). During 1991–92, 14.9 million hectares of land were treated with herbicides, 3.1 million hectares with insecticides and 0.8 million hectares with fungicides. In addition, farmers treated 159.4 million animals with dips or drenches (see table 2.12). The Agricultural and Veterinary Chemicals Association of Australia Limited has estimated net productivity gains to Australian agriculture from using such chemicals, at $2.5 thousand million annually (Cribb 1989) while ABARE estimated benefits in 1987–88 to be as high as $5 thousand million (Primary Tasks Pty Ltd 1991).

The major application of pesticides is by direct spraying of crops although some herbicides are added directly to the soil. The nature of spraying (especially aerial spraying) makes contamination of adjacent non-target areas such as pastures and water bodies a potential problem. The extent of spray drift is related to the size of the vapour droplets, weather conditions and the presence of buffer vegetation. Where excess pesticide is applied, this usually enters the soil but can also be washed into river systems, particularly during wet weather or when irrigation follows spraying too soon.

Pesticides usually remain securely bound to soil particles and are degraded by chemical or biological processes at various rates ranging from half lives measured in days to years (table 5.1). However, pesticides can also be degraded or evaporated by sunlight or, in permeable soils, be leached into groundwater reserves if soluble. Where pesticides enter waterways through run-off, they either form a surface film, if insoluble, or attach to suspended particles and eventually settle in sediments, if soluble. Pesticides in surface films break down through the action of sunlight (photolysis), those in the water column decay or are transformed by hydrolysis, while those in sediments are changed by bacteria. Most products from these actions are non-toxic while a few may be as toxic as the source chemicals. Some organophosphates may become more toxic than the substances already applied (Barrett, Peterson & Batley 1991).

Chemicals may be absorbed by plants or translocated through the root system of target and non-target plants thereby becoming available to herbivorous fauna. Animals may also ingest or absorb through their skin, polluted soil or water; inhale gaseous or dust particles or ingest chemicals deposited on their skin, fur or feathers when grooming themselves. Insects which prey on the target pest are also affected by insecticides. Bio-magnification of these effects can cause the population of predatory insects to be worse affected than the target insect population. The reduction of this natural control system can cause more severe infestations at a later time.

5.1 PERSISTENCE OF AGRICULTURAL CHEMICALS IN SOIL

Insecticides	*Period for 75–100% loss*[1]	*Herbicides*	*Period for 75–100%*
Chlorinated hydrocarbon		Atrazine	10 months
Aldrin	2 years	Bensulide	10 months
BHC	3 years	Dicamba	2 months
Chlordane	5 years	Dichlobenil	4 months
DDT	4 years	Diphenamid	8 months
Dieldrin	3 years	Diuron	8 months
Heptachlor	2 years	2,4–D	4 weeks
		2,2–DPA	2 months
Organophosphate		EPTC	4 weeks
Diazinon	12 weeks	Linuron	4 months
Disulfoton	4 weeks	MCPA	3 months
Malathion	7 days	Picloram	18 months
Parathion	7 days	Prometryne	3 months
Phorate	2 weeks	Propazine	18 months
		TCA	3 months
		Triflurain	6 months

[1] The values shown result from normal rates of application and normal agricultural conditions. Other studies (under laboratory conditions) have indicated that the chlorinated hydrocarbon group may take up to 17 years to degrade about 60% of the chemical.

Source: Office of the Commissioner for the Environment 1991.

CHEMICAL RESIDUES (SCARM INDICATOR)

Chemical residues exist in a number of forms: rural producers hold unwanted stocks on-farm; government storage facilities house a range of illegal, intractable and unidentified stocks as a result of recall programs; residue persists in some farm produce; and some flows through the ecosystem. In most cases, the amount of detailed data available on a national, State or regional basis is minimal.

Measuring stocks of recalled and identified agricultural chemicals held in government storage facilities should be a relatively simple compilation if administrative information is available. However, the cost of chemical analysis has meant that many of these stocks are as yet unidentified. Stocks held by farmers, either in containers or in on-farm dumps are unknown, although the results of various recall programs and surveys, provide some indication.

Chemical packaging is a significant agricultural waste issue. Avcare Ltd has estimated that approximately 12 million containers are sold each year, representing about 5,000 tonnes of steel and plastic. This is equivalent to approximately 3–4% (by weight) of Australia's plastic container waste (McGuffog 1994). This represents another source of chemical residues and is a critical element when looking at container disposal and recycling. Other wastes generated by the industry include unwanted and obsolete product; accidental spillage; contaminated water, filters and absorbents used in the manufacturing process.

An overview of the environmental presence of farm chemicals and residues can be obtained by:

- food residue surveys;
- rural chemical recall programs; and
- an analysis of the cattle tick dip site problem in New South Wales and Queensland.

Food residue surveys

The 1992 Australian Market Basket Survey monitored the level of pesticides and other contaminants in the diet. Food was peeled and/or cooked in the normal way and the results were based on the estimated average intakes for various age groups and sex. Using the intakes of food and the average levels of residues found in food, the contribution of each food to the dietary load of pesticides and contaminants can be estimated. The foods included in the sample represent each major food group. Dietary intakes were estimated for all residues. Table 5.2 and table 5.3 show that no internationally specified intake of metals or pesticides were exceeded (National Food Authority 1994).

5.2 ESTIMATED WEEKLY INTAKES OF METALS (DIETS BASED ON THE AVERAGE ENERGY INTAKE) (BODYWEIGHT PER WEEK)

	Adult male	*Adult female*	*Boy aged 12 years*	*Girl aged 12 years*	*Child aged 2 years*	*Infant 9 months*	*PTWI*[1]
	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg
Cadmium	1.78	1.79	2.67	2.45	3.11	1.29	7.00
Lead	4.30	3.72	4.76	3.90	36.94	3.59	25.00
Copper	190.37	254.89	295.80	265.58	475.78	522.61	3 500.00
Mercury	0.30	0.43	0.39	0.45	0.73	0.55	5.00

[1] The Provisional Tolerable Weekly Intake (PTWI) of contaminants are set for heavy metals which accumulate in the biosphere.

Source: National Food Authority 1994.

5.3 ESTIMATED DAILY INTAKE OF CONTAMINANTS (DIETS BASED ON THE AVERAGE ENERGY INTAKE) (BODYWEIGHT)

	Adult male	*Adult female*	*Boy aged 12 years*	*Girl age 12 years*	*Child aged 2 years*	*Infant 9 months*	*ADI*
	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
BHC total	0.0001	0.0003	0.0003	0.0001	0.0005	[1]	20
DDT analogs	0.0070	0.0054	0.0053	0.0051	0.0152	1.1035	20
Dicloran	0.0236	0.0268	0.0314	0.0262	0.0634	0.0518	30
Dicofol	0.0172	0.0200	0.0107	0.0124	0.0342	0.0308	2
Dieldrin	0.0048	0.0050	0.0048	0.0048	0.0068	0.0041	0.1
Endosulphan Sulphate	0.0054	0.0064	0.0053	0.0045	0.0117	0.0077	6
Heptachlor Epoxide	0.0003	0.0004	0.0002	0.0003	0.0003	0.0004	0.1
Azinphos-methyl	0.0186	0.0234	0.0261	0.0274	0.0471	0.0371	5
Chlorfenvinphos	0.0010	0.0020	0.0007	0.0008	0.0058	0.0036	2
Chlorpyrifos	0.2160	0.2720	0.2920	0.3140	0.5440	0.4440	10
Chlorpyrifos-methyl	0.0802	0.0774	0.135	0.110	0.321	0.0561	10
Diazinon	0.0054	0.0046	0.0127	0.0071	0.0020	0.0048	2
Dichlorvos	0.0168	0.0176	0.0389	0.0300	0.120	0.0136	4
Dioxathion	0.0008	0.0013	0.0017	0.0016	0.0061	0.0004	1.5
Enthion	0.0005	0.0005	0.0006	0.0005	0.0013	0.0011	1
Fenitrothion	0.3810	0.3240	0.5290	0.4330	1.01	0.2300	5
Malathion	0.0023	0.0029	0.0024	0.0028	0.0043	0.0029	20
Methamidophos	0.0403	0.0226	0.0655	0.0450	0.0747	0.0028	4
Mevinphos	0.0061	0.0048	0.0115	0.0105	0.0238	0.0102	1.5
Parathion	0.0097	0.0121	0.0138	0.0149	0.0259	0.0206	5
Parathion-methyl	0.0214	0.0223	0.0267	0.0272	0.0793	0.0225	30
Cypermethrin	0.0002	0.0002	0.0001	0.0001	0.0003	0.0003	50
Permethrin	0.0072	0.0079	0.0031	0.0032	0.0121	0.0090	50
Chlorothalonil	0.0008	0.0012	0.0006	0.0008	0.0014	0.0002	30
Dithiocarbamates	0.0977	0.1290	0.121	0.130	0.243	0.194	2
Vinclozolin	0.0976	0.0124	0.132	0.143	0.245	0.200	70
PCB's	0.0007	0.0007	[1]	[1]	[1]	[1]	40

[1] No consumption of foods containing this residue by this age-sex category.

Notes: The Acceptable Daily Intake (ADI) is the level of pesticide intake, at or below which there will be no appreciable health effects, if consumed over a whole lifetime. Pesticides tested for which no residues were detected include: a-BHC, chlordane, DDD, heptachlor, hexachloro-benzene, azinphos-ethyl, trithion, deltamethrin, cyfluthrin, cyhalothrin, atrazine, 2,4D, 2,4,5–T, fluazifop-butyl, haloxyfop, simazine.

Source: National Food Authority 1994.

The National Residue Survey is conducted by the Bureau of Rural Resources to monitor chemical residues in Australian raw food commodities. Meat, grains, eggs, honey, dairy produce, fruit and vegetables are tested. Over 50,000 analyses of chemical residues are performed each year. These are mainly for chemicals used in food production, such as insecticides, fungicides and antibiotics. Due to the high costs involved, not all commodity–chemical combinations are tested. Risk profiles are used to ensure the most important combinations are covered.

Combined results from the 1991 and 1992 calendar years, indicate that from over 95,000 samples analysed, less that 1% exceeded the set standard (table 5.4). The majority of the samples (86%) did not contain any of the chemicals for which they were tested and most of the residues detected were below the permissible maximum residue limit.

5.4 SUMMARY OF NATIONAL RESIDUE SURVEY RESULTS

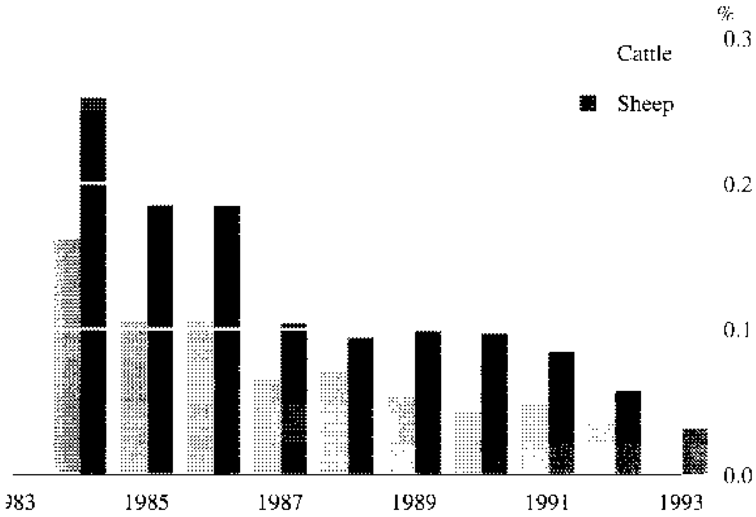
	Samples	*Samples with detectable residues*		*Residues above MRL/MPC1*	
Commodity group	no.	no.	%	no.	%
1991					
Meat	42 421	5 132	12.1	368	0.9
Grains	3 429	1 195	34.8	10	0.3
Fruit and vegetables	2 014	458	23.0	8	0.4
Eggs, honey and dairy products	1 437	30	2.1	1	0.1
Total	*49 301*	*6 813*	*13.8*	*387*	*0.8*
1992					
Meat	39 807	4 185	10.0	390	1.0
Grains	2 811	776	27.6	14	0.5
Fruit and vegetables	1 863	1 290	69.2	16	0.9
Eggs, honey and dairy products	1 363	35	2.6	2	0.1
Total	*45 884*	*6 286*	*13.7*	*422*	*0.9*
Combined total 1991 and 1992	**95 185**	**13 099**	**13.7**	**809**	**0.8**

[1] Maximum residue limits (MRL) for food stuffs in Australia are set out in Standard A14 of the food standards code published in 1991 by the NFA. Maximum permitted concentration (MPC) refers to acceptable levels of heavy metal or other contamination in foods and not pesticide levels. MPCs are set out in Standard A12 of the food standards code.

Source: Bureau of Resource Sciences 1996.

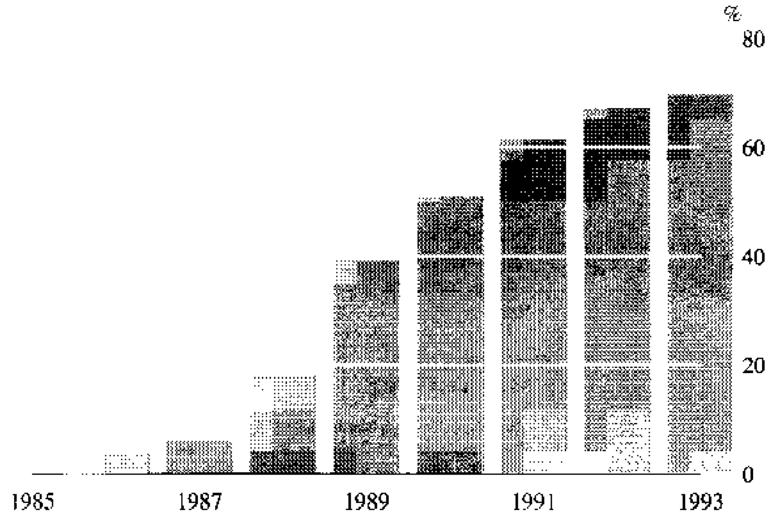
Other results, shown in graph 5.5 and graph 5.6, indicate that the levels of contaminating residues in food continues to decline.

5.5 CATTLE AND SHEEP FAT SAMPLES WITH ORGANOCHLORIDE RESIDUES



Source: Bureau of Rural Resources, unpublished data.

5.6 GRAIN SAMPLES TESTED FOR ORGANOPHOSPHATES WITH NIL DETECTED



Source: Bureau of Rural Resources, unpublished data.

Chemical recall programs

Rural producers often find themselves with a store of unwanted chemicals. In recent years, there have been a number of rural chemical recall programs run throughout Australia. These recalls have allowed farmers to remove unwanted and dangerous chemicals from their properties. The United States Department of Agriculture (USDA) was a catalyst for the most extensive of these. In May 1987, the USDA detected levels of organochlorine insecticide (DDT), heptachlor and dieldrin in Australian beef, above the US maximum residue limits (MRL). In addition to this, the US Food and Drug Administration detected violating levels of DDT in Australian sultanas (Primary Tasks Pty Ltd 1991).

New South Wales Although recall programs have been run in New South Wales, there seems to be very little data available. According to the Department of Agriculture, a major program was run in 1988–89 in response to beef shipments being rejected, but no report seems to have been produced. The Department estimated that 160,000 kg of organochlorines, 34,000 kg of arsenic and 4,000 kg of assorted other chemicals were collected. These chemicals have all been shipped overseas for high temperature incineration.

Victoria In 1987, the Victorian Department of Agriculture and Rural Affairs used sales data to estimate that approximately 10,000 litres of DDT was held by farmers. A three month recall program was conducted yielding 85,290 litres of liquid and 5,238 kg of powdered DDT. These stocks were shipped to Wales in 1988 for high temperature incineration (Roberts 1988). Between 1989 and 1992, several additional recall programs were conducted in Victoria. As table 5.7 shows, these yielded another 75 tonnes of organochlorines. In total, these four regional collections resulted in 338 tonnes of unwanted chemicals, the majority of which is still held in storage.

5.7 SUMMARY OF MATERIAL COLLECTED AT RURAL CHEMICAL COLLECTION DEPOTS IN VICTORIA

Collection point	year	Heavy metals kg	Organochlorines kg	Other pesticides kg	Other[1] kg
North Central Region	1989	5 029	9 796	23 301	16 955
North East & Barwon	1990	27 015	34 993	61 764	39 735
Gippsland	1992	7 492	9 814	13 708	14 501
Western District	1992	23 265	20 970	17 231	12 639
Total		**62 801**	**75 573**	**116 004**	**83 830**

[1] Includes: poisons, oils and paints, acids and alkalis, other substances and unknown materials.

Source: Environment Protection Authority Victoria 1992.

Queensland Between October 1987 and March 1988, about 540 tonnes of BHCs (chlorinated hydrocarbons) (0.5% concentration) were collected. In late 1989 and early 1990, another recall yielded 400 tonnes of assorted chemicals. Most of these chemicals have been sent to Wales for high temperature incineration. Some arsenic remains in storage on Department of Primary Industry sites.

South Australia By December 1988, use of organochlorines in agriculture had been banned under the Agricultural Chemicals Act. A recall program of all organochlorines (and other unwanted chemicals) was conducted by the Department of Agriculture, utilising 60 local council depots. A total of 52,000 litres of liquid and 5,000 kg of powder were collected. These stocks were repackaged and sent overseas for high temperature incineration.

Western Australia

In 1987, farm and distributor held stocks of organochlorine insecticides were recalled. In early 1988, these recalled chemicals were consolidated into new 205 litre steel drums and placed in storage at Wongan Hills, Merredin and Katanning (table 5.8).

5.8 INVENTORY OF PESTICIDES HELD AT KATANNING, WONGAN HILLS AND MERREDIN, WESTERN AUSTRALIA, 1988

	Quantity
Description/Site	200 litre drums (unless otherwise specified)
Wongan Hills	
PCBs	6
DDT liquid	355
Unknown or mixed organochlorines	13
Merredin	
Arsenic	2
Organochlorines	390 + 8 small tins
Trifenmorph	1 x 112 litre drum
Sodium cyanide	1 x 150 litre drum
Katanning	
Arsenic sheep dip waste	100 x 205 litre drums
Arsenic liquid	8
Arsenic powder	99
PCBs	1 x 20 litre drum
PCPs	20 x 20 litre drums
Unknown/mixed pesticides	48
DDT liquid	218
DDT powder	74

Source: Department of Agriculture, Western Australia 1993.

Tasmania

A recent survey of stocks of unwanted or unusable chemicals was characterised by low returns of survey forms. This survey asked farmers to note details of all unwanted farm chemicals. The Department of Environment and Land Management estimated from the results that at least 70 tonnes of unwanted or unusable pesticides were held on Tasmanian farms.

Northern Territory

There has been no attempt to measure the extent of chemicals stored on farms because of the small number of farms and vast distances involved.

Australian Capital Territory

The Australian Capital Territory Government runs regular chemical recall programs, however, they do not distinguish farm chemical sources from industry or households.

Cattle tick dip sites

The cattle tick (Boophilus microplus) probably came to Australia on Brahman cattle from Java, landed at Darwin in 1872. Thriving in tropical and sub-tropical environments, the tick spread across Northern Australia, south through Queensland and into New South Wales. The first infestation recorded in New South Wales, was at Tweed Heads in 1906. Its spread was accompanied by massive outbreaks of illness and death in cattle populations.

Cattle ticks cause serious economic losses to the cattle industry. They have direct effects on host animals and are a vector for the blood borne cattle disease, tick fever. Tick infestation can cause loss of stock condition leading to condemning of carcasses at abattoirs, reduced milk production and death. In addition, a large proportion of hides that are tick affected are not marketable. Other costs directly attributable to the cattle tick include maintaining quarantine areas, mustering, and restrictions on stock and fodder movement. Many of these costs have proven extremely difficult to quantify. Mustering costs, for example, have been put at between a few cents and ten dollars per head.

The Commonwealth Scientific and Industrial Research Organisation has estimated that the value of production losses as a result of uncontrolled tick infestations in tick affected areas is in the range of $82 million to $133 million annually (Collins 1992).

Chemical dips have been widely used in Australia to control cattle tick numbers and to limit their spread. Treatment in a chemical dip, involves yarding the cattle and running them through a chemical bath. Once dipped, the stock pass through a draining pen before being released (diagram 5.11).

Arsenic dips were first used in the late 1800s and were very successful for a long period. The chlorinated hydrocarbons (DDT and BHC) were introduced in 1955, as many ticks had become resistant to arsenic. These were discarded, mainly because of concerns over residues in meat and dairy produce, although resistance was becoming a problem in Queensland. Table 5.9 shows some of the wide range of chemicals that have been employed as tickicides.

5.9 HISTORY OF CHEMICALS USED IN NEW SOUTH WALES DIPS

Tickicide	*Period of use*
Arsenic (Trioxide)	–1955
DDT	1955–1962
BHC	1955–1962
Carbaryl	1963–1970
Coumaphos	1962–1965
Carbophenothion	1962
Chlorpyrifos	1969–1974
Bromophos ethyl	1969?
Dioxothion	1962–1976
Ethion	1962–1976
Chlordimeform	1973–1976
Cymyazole	1977–1986
Chloromethiuron	1977
Amitraz	1976–present
Promacyl	1977–present
Cypermethrin	1979–present
Chlorofenvinphos	1979–present
Flumethrin	1986–present

Source: Cattle Tick Dip Site Management Committee 1992.

The practice of dipping cattle, has resulted in areas of land being contaminated with chemical residues. Areas around the dip bath and draining pen are generally the worst effected. Used chemicals were usually buried on-site or sprayed directly onto the surrounding soil and allowed to soak in. Both arsenic and DDT (an organochlorine insecticide) are environmentally persistent and high residue levels remain in the soil to this day.

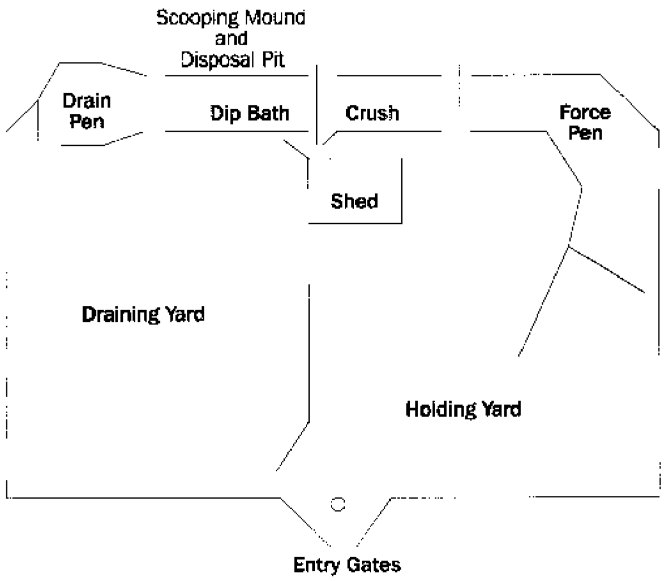
Table 5.10 provides an average residue profile for selected tickicides in New South Wales dip sites. DDT levels averaged 5,463 mg/kg soil tested in the disposal pit.

5.10 DDT RESIDUES IN SOIL FROM CATTLE TICK DIP SITES, NEW SOUTH WALES, 1980 TO 1992

Location within dip site	DDT mg/kg soil (average)
Adjacent to bath	1 513
Out from bath	367
Draining yard	130
Draining pen — 2m	786
Draining pen — 10m	84
Disposal area — 2m	2 269
Disposal area — 10m	330
Scooping mound	4 717
Mound — 2m	2 440
Crush — 2m	924
Disposal pit	5 463

Source: Cattle Tick Dip Site Management Committee 1992.

5.11 TYPICAL LAYOUT OF A CATTLE DIP SITE



Source: Cattle Tick Dip Site Management Committee 1992.

The number of dip sites in Northern Australia has not been determined. The large area ranged by cattle has meant that small, temporary dips were constructed when needed and no central records of these are available. There are 1,607 known dip sites in New South Wales, of which 1,041 are still operating in the Tick Quarantine Area. The estimated number of sites in Queensland is within a quite wide range. Most sources have indicated the presence of between ten and twenty thousand sites. A partial list compiled by the Waste Management Branch of the Queensland Department of Environment and Heritage has listed 2,181 sites in 94 local government areas. No graphs are available for the Northern Territory or Western Australia. Based on these numbers and the Dip Site Management Committee recommended buffer zone (200 metre radius), at least

476 square kilometres and perhaps up to 2,700 square kilometres of land in New South Wales and Queensland has been contaminated with various tickicides.

FERTILISER USE

Many of Australia's soils are deficient or marginal in several nutrients. The major nutrients applied in fertiliser programs are phosphorus and nitrogen in grain crops, phosphorus and sulphur in pasture, and phosphorus, nitrogen and potassium in sugar cane and horticulture. The section on page 33 provides information on area fertilised and the quantity used in the 1993–94 season.

The significance of phosphorus was first realised by Australian farmers during the 1890s when after a period of continuous cropping and grazing, wheat yields fell to a little over half of what they had been thirty years earlier. Experiments at that time showed that the application of superphosphate at about 65 kilograms per hectare could raise yields by 70% (Cribb 1989). The use of single superphosphate on pastures allows legumes to flourish, which fix atmospheric nitrogen in the nodules on their root systems. This allows soil organic matter and nitrogen to be increased. Australian agriculture also utilises nitrogenous and potassic fertilisers as well as mixtures containing other important nutrients and trace elements such as calcium, magnesium, zinc, boron, cobalt and molybdenum. Table 5.12 shows the approximate nutrient content of these fertilisers.

5.12 APPROXIMATE NUTRIENT CONTENT OF MAJOR FERTILISERS

Fertiliser	Nitrogen %	Phosphorus %	Potassium %	Sulphur %
Phosphatic				
Single superphosphate	—	9	—	11
Double superphosphate	—	18	—	4
Triple superphosphate	—	21	—	2
Nitrogenous				
Anhydrous ammonia	82	—	—	—
Urea	46	—	—	—
Ammonium nitrate	34	—	—	—
Ammonium sulphate	21	—	—	—
Compound				
Mono-ammonium phosphate	10	22	—	3
Di-ammonium phosphate	18	20	—	3
Potassic				
Muriate of potash	—	—	50	—
Sulphate of potash	—	—	41	16

Source: Fertiliser Industry Federation of Australia Inc. 1994.

Table 5.13 shows that pastures were the largest recipient of superphosphate applications in Australia and that Western Australia applied the greatest quantity of that type of fertiliser. Queensland was the largest user of nitrogenous fertiliser and almost half of that was applied in sugar cane production (table 5.14). Table 5.15 shows the use of mixtures and compounds of fertilisers including those containing nitrogen and/or phosphorus. These data were drawn from the 1989–90 ABS Agricultural Census, being the most recent detail available.

5.13 SUPERPHOSPHATE FERTILISER APPLIED, 1989–90

State/Territory	Superphosphate fertiliser applied Pastures '000 tonnes	Wheat '000 tonnes	Sugar cane '000 tonnes	Other crops '000 tonnes	Total '000 tonnes
New South Wales	410.2	48.1	—	53.6	511.9
Victoria	330.0	70.8	—	80.6	481.4
Queensland	24.7	4.4	16.0	18.1	63.2
South Australia	201.7	74.7	—	70.0	346.4
Western Australia	621.5	106.6	—	131.8	859.9
Tasmania	68.2	0.1	—	12.1	80.4
Northern Territory	0.3	—	—	0.6	0.9
Australian Capital Territory	1.0	—	—	—	1.0
Australia	**1 657.6**	**304.7**	**16.0**	**366.8**	**2 345.1**

Source: Australian Bureau of Statistics 1989–90 Agricultural Census.

5.14 NITROGENOUS FERTILISER APPLIED, 1989–90

State/Territory	Nitrogenous fertiliser applied Pastures '000 tonnes	Wheat '000 tonnes	Sugar cane '000 tonnes	Other crops '000 tonnes	Total '000 tonnes
New South Wales	17.5	30.5	—	92.0	140.0
Victoria	12.3	5.1	—	14.2	31.6
Queensland	21.2	14.1	88.7	72.3	196.3
South Australia	2.8	7.0	—	13.8	23.6
Western Australia	7.4	64.7	—	16.2	88.3
Tasmania	0.8	—	—	12.1	12.9
Northern Territory	—	—	—	0.5	0.5
Australian Capital Territory	—	—	—	—	—
Australia	**62.0**	**121.4**	**88.7**	**221.1**	**493.2**

Source: Australian Bureau of Statistics 1989–90 Agricultural Census.

5.15 OTHER FERTILISER COMPOUNDS AND MIXTURES APPLIED, 1989–90

State/Territory	Nitrogenous fertiliser applied Pastures '000 tonnes	Wheat '000 tonnes	Sugar cane '000 tonnes	Other crops '000 tonnes	Total '000 tonnes
New South Wales	13.7	49.0	—	57.4	120.1
Victoria	176.8	20.5	—	42.5	239.8
Queensland	11.1	3.6	119.3	46.4	180.4
South Australia	18.4	54.5	—	53.4	126.3
Western Australia	43.1	186.8	—	63.1	293.0
Tasmania	28.4	0.1	—	19.8	48.3
Northern Territory	0.5	—	—	0.8	1.3
Australian Capital Territory	—	—	—	—	—
Australia	**292.0**	**314.5**	**119.3**	**283.4**	**1 009.2**

Source: Australian Bureau of Statistics 1989–90 Agricultural Census.

By world standards, Australia applies very little nitrogenous and potassic fertiliser per hectare of arable land while its use of phosphatic fertilisers is significantly less than most countries (table 5.16).

5.16 CONSUMPTION OF FERTILISER NUTRIENTS PER HECTARE OF ARABLE LAND AND PERMANENT CROPLAND, 1991

	Nitrogenous	*Phosphatic*	*Potassic*
	kg	kg	kg
Australia	**10**	**14**	**3**
Asia	89	36	14
North America	50	19	20
South America	17	18	15
Africa	13	6	3
Europe	98	39	43
Former USSR	33	30	22
World	**56**	**26**	**18**

Note: Arable land is defined as land under temporary crops (double cropped areas are cropped only once), temporary meadows for mowing or pasture, land under market and kitchen gardens (including cultivation under glass) and land temporarily fallow (less than five years). The abandoned land resulting from shifting cultivation is not included in this category.

Source: Food and Agriculture Organisation 1993.

In any fertiliser program, the objective is to maximise the recovery of applied nutrients by crops and pasture and to minimise their loss in all other ways. Fertiliser nutrients can be fixed or immobilised in the soil. Nutrients, be they from fertiliser, the decomposition of organic matter, or the mineralisation of soil particles can also be lost to the atmosphere or in water, and with eroded soil. In Australia, normally very little phosphorus is lost through leaching (percolation through the soil beyond the reach of plant roots) as it is attracted to and held tightly on the surface of clay particles and organic colloids in the soil (Kuhn 1993). As a consequence of this bonding, the movement of phosphorus within river systems is closely related to the movement of fine particles which hold it. In other words, fertilisers and manures applied to soils do not normally find their way into streams through leaching except for a few places which have very sandy soils. The main way in which this occurs is through the erosion of fertile top soil.

Unlike phosphorus, nitrogen is much more mobile in the soil and the environment. It occurs in gaseous forms in the atmosphere and can be leached from the soil in the nitrate form. Leaching is more likely to occur on sandy soils in areas of high rainfall or where the soil is over-irrigated. The presence of blue-green algae is linked to the availability of nutrients. Soil erosion deposits phosphorus (both naturally occurring as well as from fertilisers and manure) into streams, and under certain conditions, nutrients deposited into streams and rivers contribute to blue–green algae outbreaks. Farming practices which reduce soil erosion will benefit agriculture by reducing fertiliser costs as well as reducing the availability of nutrients to blue–green algae.

Interactions of treatments are also an important consideration. For example, the residual trash left following cane harvesting acts as an effective mulch reducing erosion and conserving soil moisture. Where urea fertiliser is applied on top of the trash however, 40% or more of the nitrogen content may be lost. This loss is caused by an enzyme in the trash which converts the urea into carbon dioxide and ammonia with the addition of moisture (such as light rain or dew). The ammonia which evaporates could represent a substantial proportion of the 88,700 tonnes of nitrogenous fertiliser applied to cane fields in Australia (table 5.14). The loss is preventable by ensuring that the urea is washed through the trash area by heavy irrigation or rain or by broadcasting the fertiliser just prior to harvesting the previous crop.

ANIMAL WASTES

Solid wastes

The rearing of animals as an agricultural activity removes nutrients from the soil through feeding, which are almost simultaneously replaced in the form of manure. Table 5.17 provides an estimation of animal excreta production (based on coefficients that come from United Nations data). The nutrient content is also based on United Nations data.

5.17 AGRICULTURAL ANIMALS EXCRETA PRODUCTION AND NUTRIENT CONTENT

	Number at 31 March	*Dry matter per animal*	*Total dry matter*	*Nitrogen*	*Phosphate*
	'000	kg/year	'000t/year	'000t/year	'000t/year
Cattle	24 062	2 090	50 290	2 515	905
Poultry	65 586	15	984	52	34
Pigs	2 646	250	662	29	17
Sheep and goats	138 343	250	34 586	1 038	208
Horses	272	1 200	326	14	5
Total			**86 848**	**3 648**	**1 169**

Note: These statistics are calculated on the basis of European data which relate to intensively reared animals. Generally speaking, the nutrient content of the feed is the most important determinant of the production of nutrients as compounds of animal manures. Therefore, it would be reasonable to assume that the amounts of phosphorus and nitrogen produced are somewhat overstated due to the higher nutrient contents of animal feeds.

Source: United Nations Statistical Commission 1992; Australian Bureau of Statistics 1992–93 Agricultural Census.

Wastes from feedlots

A survey of cattle feedlot activity in Australia indicated the existence of approximately 630 feedlots having a capacity of approximately 485,000 cattle. Over 60% of this capacity is located in the Murray–Darling Basin (Young et al. 1994). Potential sources of contaminants include the feedpens, drains, retention ponds, solid waste stockpiles and land disposal areas for solid and liquid waste.

European data indicate that slurries which result from cleaning pens are a major source of waste. The volume ranges from approximately 1,700 litres per year for a fattening pig, up to 22,000 litres per year for a single dairy cow (Van Eerdt 1992).

In July 1992, the Agricultural Council of Australia and New Zealand endorsed the National Guidelines for Beef Cattle Feedlots in Australia. The principle aim of the guidelines is to encourage the establishment of agriculturally and environmentally sustainable feedlots. Not all of the commercial cattle feedlots have a complete complement of effluent structures (table 5.18). It has been estimated that compliance with the guidelines would cost $5 million each year for those feedlots in the Murray–Darling Basin alone with a potential to reduce the supply of grainfed beef by about 3% (Young et al. 1994).

5.18 PROPORTION OF COMMERCIAL FEEDLOTS WITH VARIOUS EFFLUENT STRUCTURES

Structure	%
System of drains	87.0
Sedimentation pond	74.0
Retention ponds	76.0
Equipment for land disposal of waste	61.0

Source: Young et al. 1994.

GREENHOUSE GAS EMISSIONS

It should be recognised that no baseline has been determined with respect to agricultural activity and greenhouse gases. The following data relate to the gross emissions of gases as a result of agriculture. If the previous natural level of emissions were known, that is from the previous natural regime of fires, rotting vegetation, termites and other creatures, then the additional greenhouse gas output as a result of agricultural activity could be calculated.

In addition to solid wastes deposited by farm animals, gases such as carbon dioxide, methane, nitrous oxide and ammonia are also emitted. The agricultural sector contributes 15.2% of all greenhouse gases in Australia (NGGIC 1994). It is worthwhile noting that comparatively little information is available about the role of agriculture as a sink of greenhouse gases. Soils are both a source and a sink of greenhouse gases. Soils release nitrous oxide by microbial and non-biological processes (more so when fertilised) but act as a sink for methane (Houghton, Jenkins & Ephraums 1991). The best estimate for Australian soils is that about 2.3 million tonnes of methane per year is absorbed (CSIRO 1991).

Methane is emitted from the microflora in the digestive systems of ruminant livestock while manures are the source of nitrous oxide. Fermentation in the gut of ruminants enables these animals to derive energy and nutrients from feeds of low digestibility. Ruminants give off methane mainly by belching (Howden & Munroe 1994).

Sheep and cattle are the main agricultural sources of methane emissions contributing an estimated 2.8 million tonnes in 1994 (table 5.19). Belched gases are about 27% methane and 65% carbon dioxide (Howden & Munroe 1994). (It should be remembered that simply ceasing agricultural activities will not reduce greenhouse gas emissions by the levels shown in table 5.19 because natural systems also are greenhouse gas emitters.)

5.19 AGRICULTURAL GREENHOUSE GAS EMISSIONS

	1991		1994	
	Nitrous Oxide	Methane	Nitrous Oxide	Methane
	'000 tonnes	'000 tonnes	'000 tonnes	'000 tonnes
Enteric fermentation	n.e.	2 818.4	n.e.	2 761.6
Animal wastes	n.e.	78.6	n.e.	83.0
Rice cultivation	n.e.	25.0	n.e.	28.9
Agricultural soils	8.8	n.e.	10.3	n.e.
Agricultural waste burning	0.2	7.2	0.1	5.4
Savanna burning	15.3	299.1	13.6	265.7

Source: NGGIC 1996, personal communication.

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CHAPTER 6

INTRODUCTION

AGRICULTURAL RESTRUCTURING OF THE ENVIRONMENT

This chapter examines the interactions between agricultural activities and the natural assets, specifically soil, water resources and biodiversity, using the concept of restructuring. This term is used to summarise the range of impacts humans have on the environment through their economic and social activities. There are three basic expressions of these impacts: physical restructuring from construction activity and other changes to the natural landscape; chemical restructuring resulting from the release of pollutants and wastes; and biological restructuring as a result of harvesting, introduction of exotic species and loss of species.

In this chapter various aspects of restructuring resulting from agricultural activity are addressed. In the following section the focus is on land resources. Later sections cover surface water; groundwater; biological diversity; and introduced species.

Table 6.1 outlines many of the environmental impacts associated with agricultural activity. In the timeframe since this list was prepared, some of the issues and suggested best practices may have changed.

6.1 MORE ENVIRONMENTALLY SUSTAINABLE AGRICULTURAL PRACTICES

Issue	*Contributing practice*	*'Sustainable' practice*
Decline in soil nutrients	Rotations lacking legumes	Use of wider range of alternative crops in rotations to control soil pathogens and maintain fertility
	Insufficient/inadequate fertiliser use	Choice of appropriate fertilisers and management of pastures for maintenance of soil fertility
Soil structural decline	Excessive cultivation	Minimum tillage
	Bare soil and fallowing practices	Stubble retention
	Overgrazing and loss of groundcover	Use of integrated rotation and grazing management for cover and weed control
	Animal/machinery traffic on wet soils	Matching tillage and stocking to soil type and condition
		Use of gypsum on degraded soils
Soil acidification	Non-use of lime on acid soils	Regular lime applications
	Use of acidifying fertilisers	Use of appropriate fertilisers
	Use of shallow-rooting pastures	Use of deep-rooting perennial pastures where possible
Soil erosion	Poor cultivation techniques	Use of deep ripping, minimum tillage, pasture rotations to restore fragile soils
		Use of appropriate earthworks to control water flow
	Overgrazing	Retention of cover by stocking adjustment, wildlife management, stubble and roughness retention
	Insufficient vegetation cover	Use of vegetation to control wind erosion
	Poor matching of enterprise to capability of land	Improved land capability assessment
Water quality	Inadequate waste/effluent disposal systems in intensive enterprises	Improved engineering for effluent disposal and animal housing
		Provision of adequate health inspection procedures

... *continued*

6.1 MORE ENVIRONMENTALLY SUSTAINABLE AGRICULTURAL PRACTICES — *continued*

Issue	*Contributing practice*	*'Sustainable' practice*
Water quality — *continued*	Contamination of surface and groundwaters by fertilisers and pesticides	Care in pesticide usage and application methods near open waters
		Optimise chemical usage to reduce accessions to groundwater
		Change in fertiliser type and application to improve uptake by plants
		Application of fertiliser according to soil analysis
	Sediment and salt run-off into surface waters	Management to minimise soil erosion and secondary salinity
Soil salinity waterlogging (irrigated)	Inefficient/excessive water use	Improved water scheduling
		Conjunctive re-use of groundwater
		Drainage and gypsum to improve infiltration
	Deteriorating infrastructures	Improved infrastructure
	Poor site selection for irrigation areas	Site selection consistent with soil and land capability
Soil salinity waterlogging (dryland)	Excessive clearing of deep-rooted perennial native species causing rise in groundwater levels	Identification and revegetation of recharge areas
		Strategic tree and shrub planting/management/ preservation
		Use of deep-rooted perennials
Pesticides residues and resistance	Over-reliance and persistent use/overuse of pesticides	Whole-farm integrated pest management Biological control of pests
		Selection of genetically resistant plants and animals
	Over-reliance on chemical control of crop weeds	Low pesticide use farming Biodegradable pesticides
		Development and use of vaccines
		Use of rotations to reduce pest/weed/pathogen burdens
Vegetation degradation	Over-grazing	Stocking rates consistent with land capability
	Poor use of grazing management to control weeds in pastures	Improved grazing/stock management to gain maximum pasture benefit
		Improved management for drought
		Utilisation of soil fertility as it builds up
	Poor weed control	Adequate weed control and quarantine measures
Remnant vegetation decline	Insufficient fencing to exclude stock	Refencing on land use basis
	Stock pressures	Reduce grazing pressure
		Strategic tree/shrub planting
Fire management	Insufficient and excessive use of fire in certain grazing lands	Appropriate use of fire to maintain native grasses and to control woody weeds
Feral and native animals	Inadequate control of feral and native pest animals	Control of feral pests
Consequences of crop monocultures	Reliance on a single crop without rotation	Use of 'break' crops and pastures in rotations
Land use competition	Lack of consultation in planning and appropriate dispute resolution	Proper consultation in planning

Source: Standing Committee on Agriculture 1991.

LAND RESOURCES

Agricultural processes (with the exception of hydroponics) are intimately linked with the soil. Animals and machinery may compact the soil; crops and livestock extract nutrients and replace them to some extent through leaf litter or manures; and water flows over and through soils, carrying away minerals and organic matter. Processes such as grazing, irrigation, ploughing and harvesting which impact on soils may cause or accelerate erosion and affect soil salinity, soil acidity (pH) and soil structure. Results from the 1992–93 Agricultural Census indicate farmers believe that over 16 million hectares of agricultural land is affected by land degradation (table 6.2).

6.2 FARMER PERCEPTIONS OF THE AREA OF LAND DEGRADATION, 31 MARCH 1993

Area of land affected by	NSW '000 ha	Vic. '000 ha	Qld '000 ha	SA '000 ha	WA '000 ha	Tas. '000 ha	NT '000 ha	ACT '000 ha	Aust. '000 ha
Water/wind erosion	715	59	1 366	130	1 053	8	601	—	3 931
Soil salinity									
Dry land	95	66	232	88	636	4	—	—	1 120
Irrigation related	10	23	3	2	3	—	—	—	41
Other degradation[1]	3 487	325	4 994	1,178	491	70	744	1	11 289
Total	**4 307**	**473**	**6 595**	**1 398**	**2 183**	**82**	**1 345**	**1**	**16 381**

[1] Includes acidity, compaction, scalding, weed infestation, feral animal invasion; however, these were not separately identified.

Source: Australian Bureau of Statistics n.d.

Soil erosion

The soil formation rates of most Australian soils are extremely low. Although 'poorly defined, they are certainly less than 1 tonne/hectare/year and more likely to be less than 0.5 tonnes/hectare/year' (Edwards 1991). Soil loss rates in most agricultural regions of Australia exceed this level of soil building potential. A net loss of soil resources is likely to have an adverse effect on agricultural productivity in the future. While this loss of soil resources can initially be masked by applying fertilisers, there comes a time when the amount of top soil being removed limits the effectiveness of such a process.

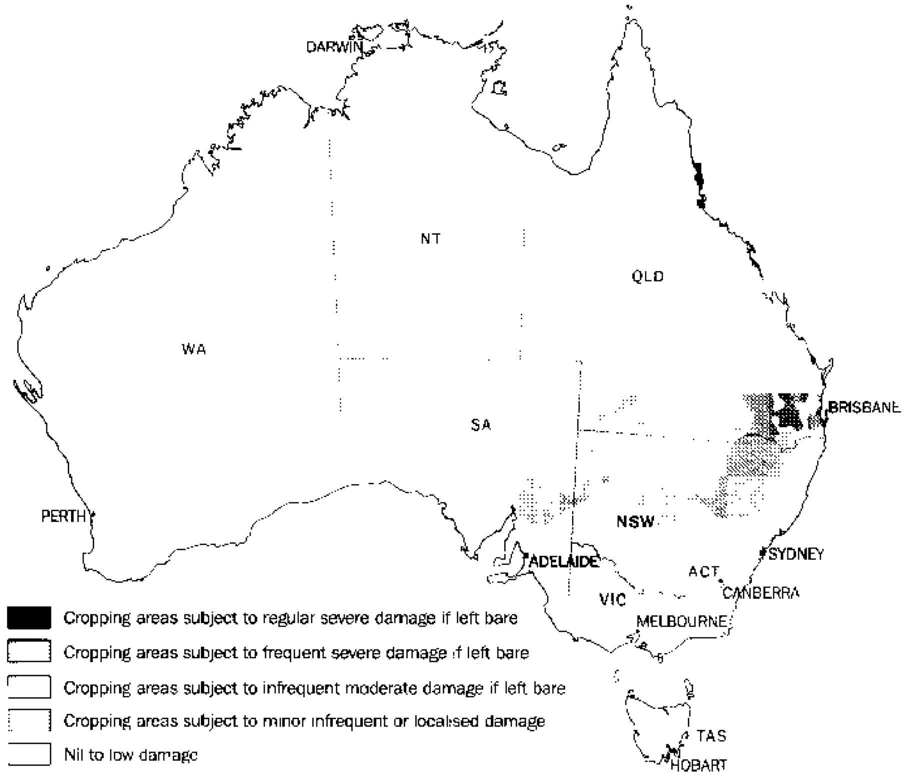
Data from the 1992–93 Agricultural Census indicate that farmers perceive approximately 3.9 million hectares of agricultural land in Australia is affected by water and/or wind erosion. This represents almost 1% of all agricultural land in Australia. Although a subjective assessment, this number provides an indication of the extent of the problem.

Soil erosion by water

Erosion by water is a major force in changing landscapes. The process involves soil displacement by rainfall or running water. 'Most soil eroded by water is transported downslope by surface runoff, which is the portion of rainfall which becomes surface flow. Runoff does not occur until rainfall intensity exceeds the infiltration rate of the soil and the surface storage capacity has been satisfied' (Charman & Murphy 1991). Erosion is most severe when raindrop impact and surface flow act concurrently.

Map 6.3 shows those areas most susceptible to water erosion in Australia. It indicates there is a tendency for land to be more liable to erosion as one moves from the south to the north and from the interior to the coastline of the continent (Edwards 1991).

6.3 *AREA OF LAND SUSCEPTIBLE TO WATER EROSION*



Source: Australian Bureau of Statistics 1992

Water erosion can be accelerated by a number of factors. These include:

- lack of vegetation;
- rainfall intensity and force of overland flow;
- surface slope;
- soil characteristics; and
- high temperatures.

Water erosion can be particularly severe during and soon after intense rainfall episodes. Such events account for most long-term soil loss from agricultural land, often causing soil loss several times greater than the mean annual rate for a given area. A study of erosion caused by a major storm in the south-east cropping zone of New South Wales illustrates this point. Some 81 millimetres of rain fell in three-quarters of an hour, leading to soil loss far exceeding the mean annual soil loss rates of the three land management regimes under analysis.

6.4 COMPARISON OF MEASURED SOIL LOSS DURING INTENSE RAINFALL WITH PREDICTED SOIL LOSS, COWRA RESEARCH CENTRE, NEW SOUTH WALES

Treatment	*Slope* %	*Soil eroded* tonnes/hectare	*Effective depth of soil eroded* millimetres	*Mean average annual soil loss from SOILOSS* tonnes/hectare
Traditional tillage	7.5	342	26	46
Reduced tillage	7.5	364	28	42
Direct drill	7.5	65	5	28

Source: Hairsine et al. 1993.

Maintenance of a 30% plant cover on agricultural land is usually considered sufficient to substantially inhibit erosion. For example, 'in the Darling Downs, it has been estimated that erosion is 75% less on soil with 30% cover than it is for bare soil' (Wylie 1993). Table 6.5 presents data showing a clear trend towards decreased soil erosion with fallow management techniques that result in increased ground cover. While data also indicate no apparent reduction in wheat yield associated with the reduced and zero tillage practices, it is recognised that 'there are many soil and climatic environments where reduced tillage practices lead to an interim period of lower crop yields' (Hamblin & Kyneur 1993).

6.5 FALLOW MANAGEMENT TECHNIQUES AND THEIR EFFECTS, SOUTHERN QUEENSLAND[1]

	Fallow management technique			
	Bare fallow burnt	*Stubble incorporated*	*Stubble mulch*	*Zero tillage*
Cover (%)[2]	<10.0	50.0–10.0	<40.0	<70.0
Runoff (mm)	98.0	75.0	71.0	81.0
Fallow efficiency (%)[3]	16.0	17.0	20.0	21.0
Soil erosion (t/ha)	64.00	20.00	8.00	4.00
Wheat yield (t/ha)	2.78	2.78	2.95	2.77

1 Mean of eight years, 1978–79 to 1983–84, 1986–87 to 1987–88.
2 Cover during the summer fallow period (November–May).
3 Fallow efficiency is the percentage of fallow rainfall stored in the soil at planting.

Source: Wylie 1993.

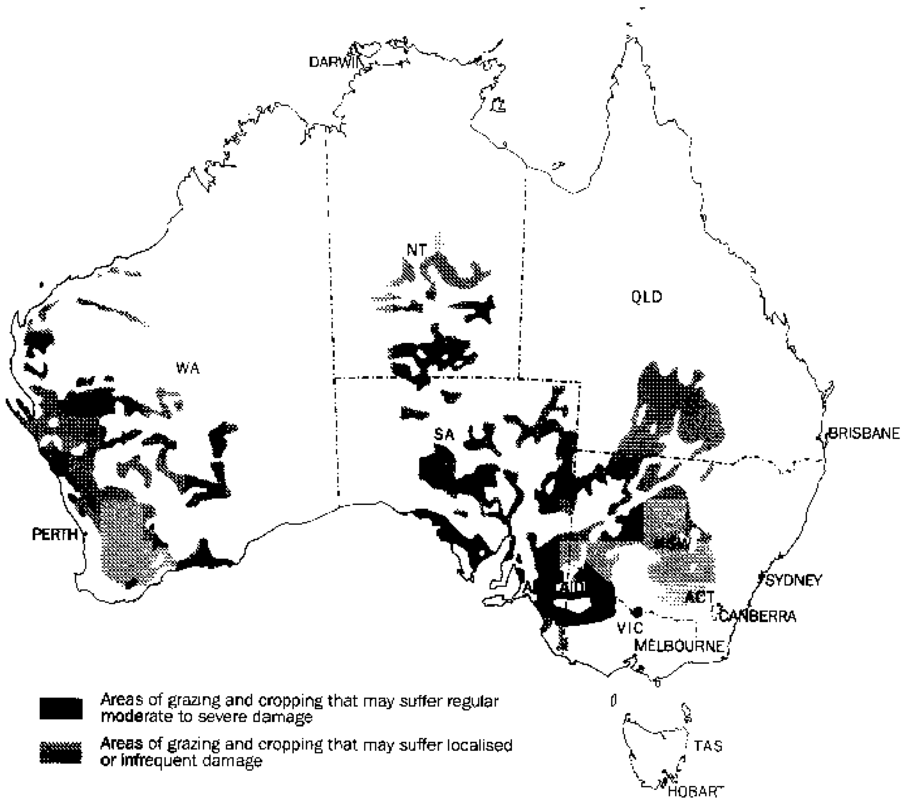
Appropriate earthworks may be employed in the amelioration and prevention of soil erosion. Estimates of farm business expenditure on earthworks primarily for the control, treatment or prevention of erosion or salinity or drainage control amounted to $61.1 million in 1991–92 and $50.4 million in 1992–93 (Australian Bureau of Statistics, unpublished data). This included expenditure on conservation earthworks such as drop structures and contour banks; dams for the purpose of treating/preventing land degradation; gully stabilisation; grassed waterways and land levelling and grading primarily for land care purposes. Contour banks reduce slope length, and reduce gullies and silt deposition (Wylie 1993).

Wind erosion

Wind erosion is the process whereby soil particles are detached from the soil surface and blown away by wind. Soil detachment occurs when wind strength reaches a threshold velocity at which soil resistance is overcome. The moment at which this threshold velocity is reached can be influenced by many factors which include the following:

- weather (particularly the windiness);
- soil state (i.e. the composition, texture, and particle size characteristics of the soil);
- surface roughness;
- vegetation cover; and
- land management practices in use.

6.6 *WIND EROSION*



Source: Australian Bureau of Statistics 1992.

The area of agricultural land affected by wind erosion is much less than that susceptible to water erosion. Map 6.6 shows the agricultural regions most adversely affected by wind erosion are the 'inland cropping and grazing areas (particularly in Western Australia and South Australia) where soil types are mainly sandy and rainfall is less than 375 mm per annum' (Charman & Murphy 1991).

Meteorological records of dust storms are a useful indicator of major wind erosion events. Dust storm frequency has been proposed by SCARM as an attribute to its indicator of off-site environmental impacts of agriculture.

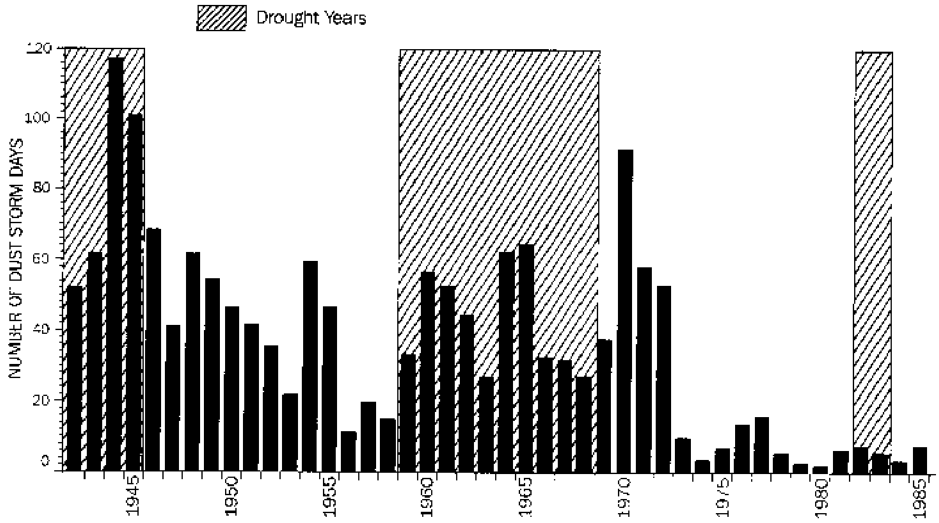
Graph 6.7 shows the results of a study of dust storm days for 28 weather stations across Australia. 'It indicates a trend of diminishing dust storm activity over the period (1942 to 1985)' (McTainsh & Leys 1993). Improved agricultural land management practices are likely to have been one of many factors contributing to this decline. The spread of woody shrubs in semi-arid landscapes, brought about by overgrazing, has also been important. 'These are not palatable to stock so their spread has produced more complete ground cover in sensitive regions and seemingly reduced wind erosion rates' (McTainsh & Leys 1993).

An assortment of land management options are available to farmers to control wind erosion. These include maintenance of adequate vegetation cover, appropriate adjustment of grazing pressure, use of wind breaks and specific crop types, and careful attention to farm layout. Trees, shrubs, crops, pastures, grasses and stubble all absorb wind energy.

The amount of stubble necessary to minimise soil loss on bare fields varies. 'A soil mobilisation rate of 0.7 tonne per hectare per minute is the threshold at which visible erosion damage becomes noticeable. Researchers have found that on sandy loam soils, 0.33 tonnes of stubble per hectare can prevent soil loss at that threshold. In sandier cropped soils, the same result is achievable using between 1.5 and 2.6 tonnes of straw' (Ralph 1993).

Trampling of soil by livestock also increases the erodibility of fine textured soils. This is due to the capacity of these soils to form a protective crust. Measurements of soil loss in the mulga lands of south-west Queensland showed that trampling of heavily grazed land increased soil loss from 2.8 to 5.2 tonnes per ha per year. Trampling of bare soil by sheep and kangaroos in a similar area resulted in a soil loss of 89.5 tonnes per ha per year (Miles & McTainsh 1994).

6.7 DUST STORM DAYS AT 28 STATIONS AROUND AUSTRALIA, 1942–85

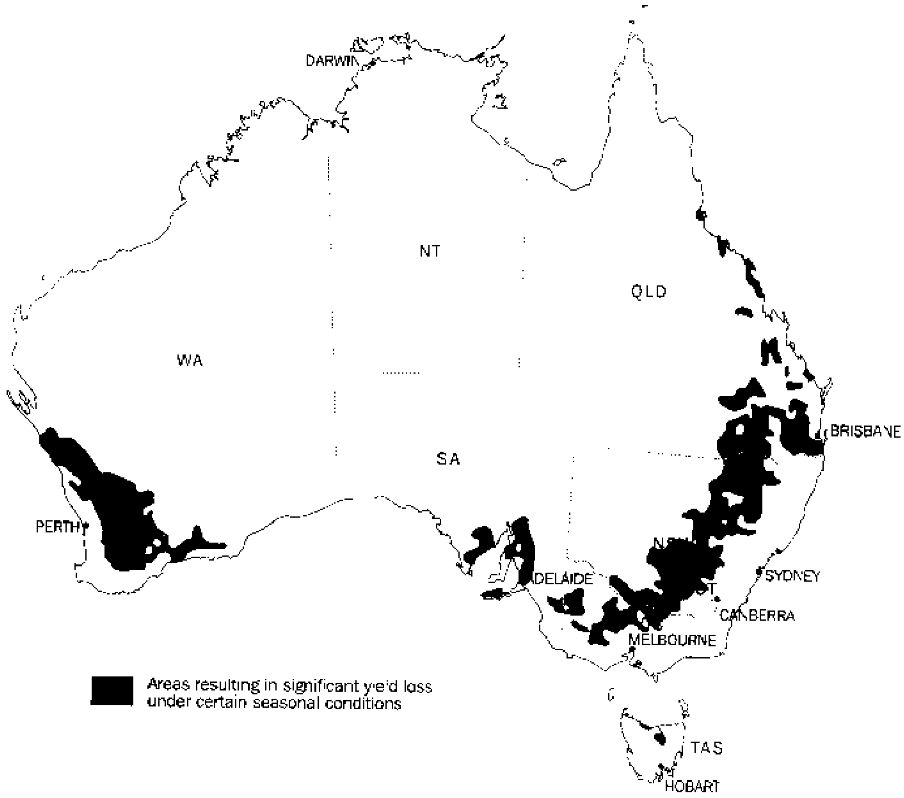


Source: McTainsh and Leys 1993.

Soil structure decline

Soil structure decline is an undesirable change or breakdown in soil structure (the arrangement of soil particles to form aggregates or clods). 'Characteristics of soil structure include bulk density and pore size distribution (usually measured by water infiltration rate, air permeability, measures of soil strength and organic matter content)' (Nulsen 1993). Soil structure decline is a widespread land degradation problem in Australia, second only in prevalence to water erosion. Areas particularly liable are shown in map 6.8.

6.8 SOIL STRUCTURE DECLINE



Source: Australian Bureau of Statistics 1992.

Structural decline can occur in either the topsoil or subsoil. 'In the topsoil, it usually arises when there is a decline in organic matter in the soil caused by excessive cultivation, stubble burning or overgrazing. In contrast, subsoil degradation usually results from compaction caused by compression of the land surface by animals and/or heavy machinery' (Standing Committee on Agriculture 1991).

Soil structure decline varies in severity and type with different physical properties of soils and different land management practices. For example, light textured soils are particularly susceptible to structural decline when cultivated; soils cultivated at the same depth for many years are prone to hardpanning; and constant wetting of clayey soils by irrigation can lead to slaking or soil dispersion. Common problems associated with soil structure decline include sowing delays, poor germination and seedling emergence, waterlogging, retarded root growth, increased susceptibility to disease, poor infiltration of water and increased run-off. As soil structure declines, run-off increases, plant growth and soil cover are reduced and erosion increases. Indications of soil structure decline include wet, boggy soils with large clods and water ponding. They usually become 'difficult to work when wet or dry and this causes increased wear and tear on machinery and increased fuel consumption' (Nulsen 1993).

Table 6.9 shows the effect of more conservative tillage methods such as direct drilling and minimum tillage on various soil properties. These can be summarised as decreasing bulk density; increasing per cent organic matter; and decreasing run-off coefficient and erodibility factors, when compared with conventional cultivation.

6.9 EFFECT OF TILLAGE METHODS ON SOIL PROPERTIES

Soil property	*Direct drilling*[1]	*Minimum tillage*[2]	*Conventional cultivation*[3]
Bulk density (0–100cm, g/cu. cm)	1.22	1.36	1.41
Organic matter (%)	2.55	2.00	1.70
Hydraulic conductivity[4] (mm/hr)	54.20	12.50	16.40
Run-off coefficient	—	0.40	0.50
Erodibility factor	0.01	0.03	0.05

1 Grazing; knockdown herbicide before sowing.
2 Two cultivations before sowing.
3 Three or more cultivations before sowing.
4 A measure of how easily water moves through the soil pores.

Source: Ralph 1986.

Rainfall simulation experiments have also highlighted the improvements in soil physical properties under tillage systems incorporating different stubble management practices (table 6.10). Under such conditions direct drilled, stubble retention treatments decreased sediment in run-off by over half, and increased the wetting depth of the soil three-fold compared with conventional tillage, stubble burnt.

6.10 IMPROVEMENTS IN SOIL PHYSICAL PROPERTIES UNDER DIFFERENT TILLAGE SYSTEMS

	Tillage system		
Rainfall simulation experiments	*Conventional tillage, stubble burnt*	*Direct drilled, stubble burnt*	*Direct drilled, stubble retained*
Bulk density (g/cm3)	1.41	1.33	1.23
Sorptivity (mx10–5/s1/2)	22.80	24.30	49.90
Time to steady-state run-off (min)	25.20	37.70	64.00
Sediment in run-off (g/mm)	3.29	3.71	1.53
Wetting depth	58.30	84.30	170.50

Source: Steed, Ellington & Pratley 1993.

It is generally recognised that with few exceptions, organic matter (and biological activity) is restricted to the top few centimetres of the soil profile for Australian soils. This is in contrast to nutrient-rich European or North American soils which can boast organic matter to depths of a metre or more. Practices which retain and increase soil organic matter improve microbial activity and hence, soil biological activity. Table 6.11 represents the difference in organic carbon content in the topsoils of direct drilled and conventionally cultivated soils.

6.11 COMPARISON OF PERCENTAGE ORGANIC CARBON IN THE TOPSOILS OF DIRECT DRILLED AND CONVENTIONALLY CULTIVATED SOILS, WESTERN AUSTRALIA

	Earthy sand		*Sandy loam*		*Sandy clay loam*	
Year	*Direct drilled*	*Conventionally cultivated*	*Direct drilled*	*Conventionally cultivated*	*Direct drilled*	*Conventionally cultivated*
1976	0.79	0.79	1.55	1.55	1.03	1.03
1980	0.84	0.80	1.60	1.37	1.03	0.94
1983	0.80	0.70	1.57	1.35	1.02	0.92
1986	0.64	0.51	1.52	1.30	0.92	0.85

Source: Hamblin & Kyneur 1993.

On each soil type studied, the loss of organic carbon content over a ten year period was greater for conventionally cultivated soils. The difference was most pronounced on the sandy loam, where the percentage of organic carbon lost over this period was eight times greater in the conventionally cultivated soils than those directly drilled.

Soil acidification

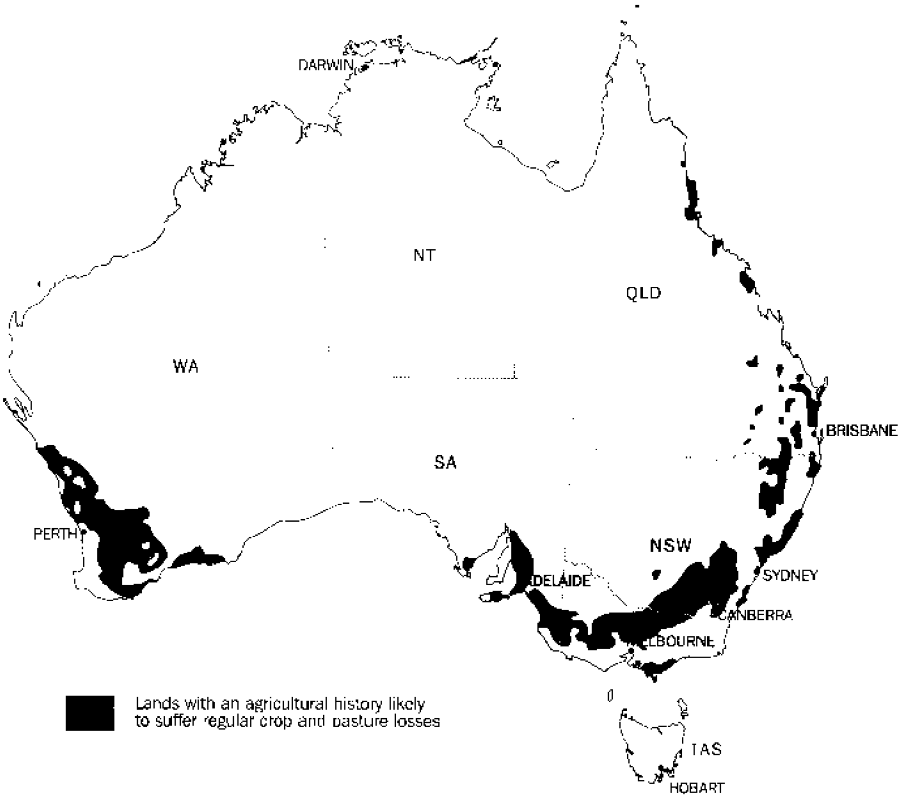
The majority of plants grow best when the pH of a soil is in the range of 5.5 to 7.0. Soil with a pH below this range is considered acidic. In this context, it has been estimated that the total area of acid soils in Australia is approximately 29 million hectares. Over 80% of this land (24 million hectares) is currently used for agricultural purposes. Although the soils of a substantial proportion of this agricultural land are naturally acidic, there are many areas where the agricultural systems in use are leading to accelerated acidification. 'The areas of most immediate concern are the cropping zone of southern Australia and the non-arable grazing country of the same region' (Evans 1991).

6.12 AREA AFFECTED BY SOIL ACIDIFICATION, LATE 1980s

State	*Area affected* million hectares
New South Wales	9.5
Victoria	4.8
Queensland	7.0
South Australia	2.8
Western Australia	4.0
Tasmania	1.0
Australia	**29.1**

Source: Chartres et al. 1992.

6.13 AREAS AFFECTED BY SOIL ACIDIFICATION



Source: Australian Bureau of Statistics 1992.

Farming systems which use nitrogen fixing annual legumes in crops and pasture along with acidifying fertilisers tend to encourage accelerated acidification. In such systems, the dry summer conditions which prevail over most of the continent limit plant growth and lead to the accumulation of mineralised nitrogen in organic matter.

Initially, accelerated acidification leads to reduced productivity of agricultural land. As acidity increases, the range of crops that a farmer can grow also becomes restricted. For example, it may become necessary for a farmer to plant an acid tolerant crop, such as oats, in preference to wheat which is a more sensitive species. Toxic elements (aluminium and magnesium) increase as a result of acidification and impede plant growth while essential nutrients (phosphorus and molybdenum) are rendered unavailable (Evans 1991).

Acid addition to soil is expressed in terms of the amount of calcium carbonate needed to neutralise the effect of adding one kilogram of nitrogen to the soil. Acid addition resulting from the removal of alkali in products can be determined with some precision. Figures reported for farm produce in north-eastern Victoria are in table 6.14. The removal of wool and sheep meat contributes little acid to soil, yet the pastures on which this form of agricultural production is based are the major cause of accelerated acidification over wide areas of southern Australia (Evans 1991).

6.14 CALCIUM CARBONATE REQUIRED TO REPLACE THE ALKALI REMOVED IN FARM PRODUCTS

Product	*Yield/hectare/year* tonnes	*Acid addition* Kg Calcium Carbonate/ha/yr
Hay — lucerne	3.50	210.00
Hay — mixed grasses	3.40	150.00
Lupin	1.62	32.40
Barley	3.59	28.70
Triticale	3.51	24.60
Wheat	2.50	22.50
Lamb (DSE)	10.00	6.00
Wool (kg)	10.00	0.80

Note: DSE — dry sheep equivalent.

Source: Evans 1991.

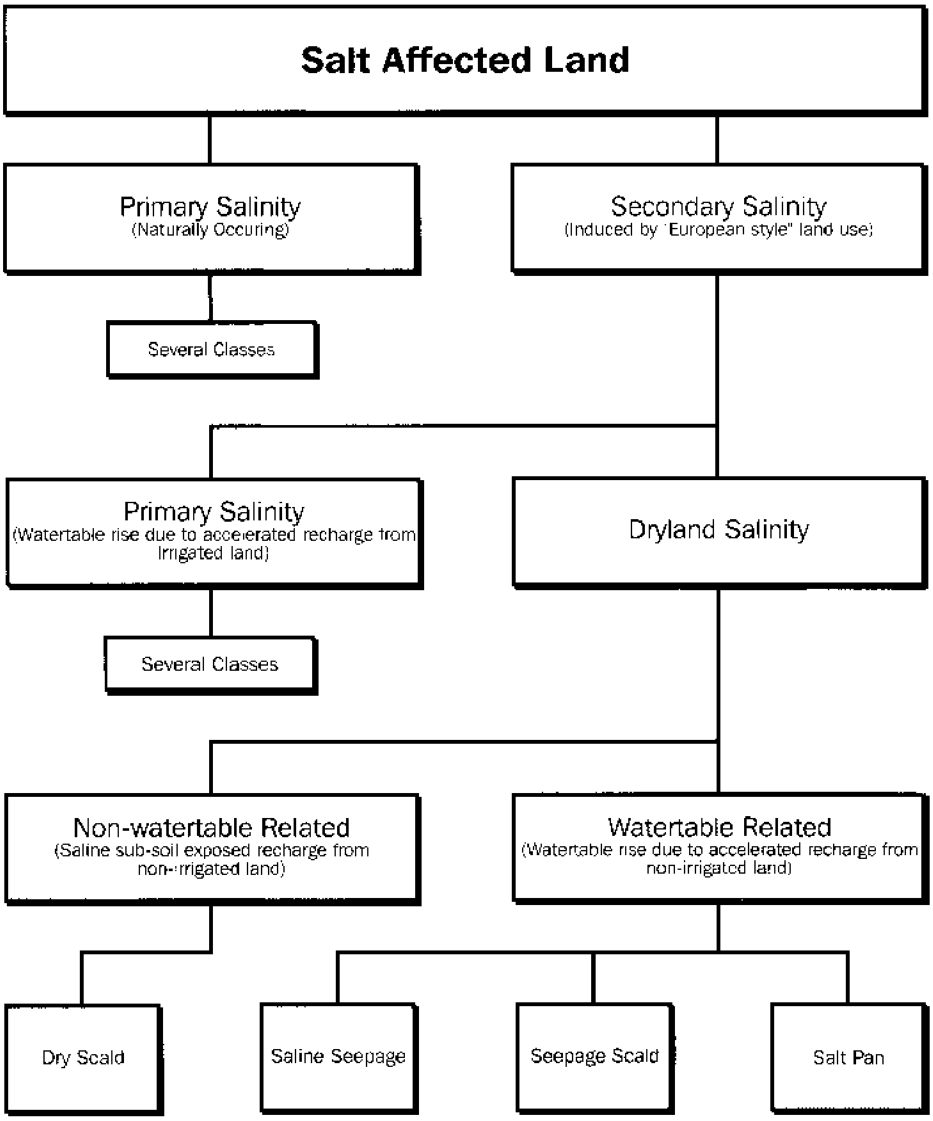
Soil salinity

Salinisation is the process whereby salt accumulates in soil or water to such an extent that it affects the use of the soil for plant growth and/or water supply for humans, stock or industry. There are two main forms of salinity:

- Primary salinity — where affected areas have naturally occurring high levels of salinity; and
- Secondary salinity — where affected areas have increased salt levels induced by human activity.

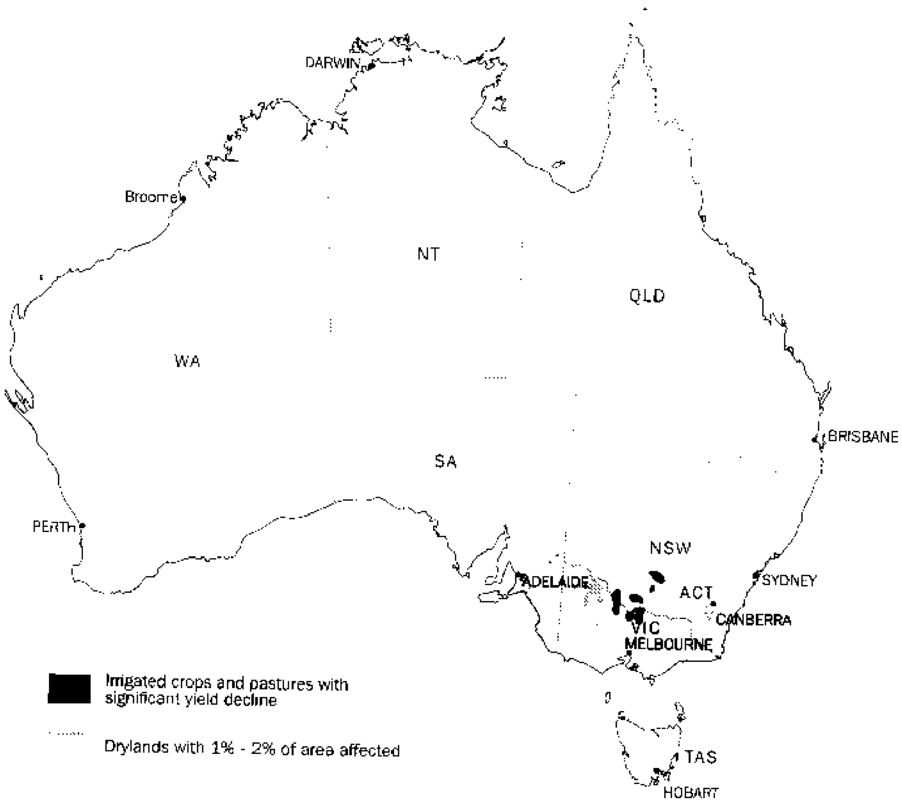
Agriculture has often been thought to be the most common human activity which induces salinity, however, other activities, for example, human activity in urban areas, could also be a cause. The salinity can occur in both dryland farming and irrigation farming environments. Its presence in either type of farming system usually leads to reduced crop yields or severe symptoms of plant ill-health. In extreme circumstances, salt-affected land can be lost to agriculture altogether because the plant species are not tolerant enough to withstand the osmotic and toxic effects caused by the salt levels present in the soil.

6.15 *CLASSES OF SALT-AFFECTED LAND*



Source: Murray–Darling Basin Commission 1993.

6.16 *SOIL SALINITY*



Source: Australian Bureau of Statistics 1992.

In 1988, the Standing Committee on Soil Conservation estimated the total area of land lost to agriculture because of dryland salting, induced by saline seepage, to be approximately 639,000 hectares. This area is likely to increase in the years to come as it does not take into account the 'potential effects of more recent clearing which have yet to become apparent' (Standing Committee on Agriculture 1991). A working group established by the Murray–Darling Basin Commission in 1990 seems to support such a view, having estimated 'dryland salinity to be spreading at the rate of between 2% and 15% per annum in the basin as a whole' (Powell 1993). Table 6.17 summarises the current extent of dryland salinity in the Murray–Darling Basin, its rate of growth and the area of land at risk from dryland salinity in the future. Graph 6.16 shows the Murray–Darling Basin, along with the south-west corner of Western Australia are the two regions most severely affected by dryland salinity.

6.17 ESTIMATED AREA OF LAND AFFECTED AND AREA OF LAND AT RISK FROM DRYLAND SALINITY IN THE MURRAY–DARLING BASIN, 1992

State	*Extent of affected land* '000 ha	*Growth rate of affected land* % per year	*Estimated area at risk* '000 ha
New South Wales	[1]20.0	10.0–15.0	?
Victoria	74.3	2.0–5.0	400
Queensland	1.2	4.0	3
South Australia	[2]2.5	?	?
	[3]100.0	?	450.0
Total	**198.0**	**—**	**>1 000**

[1] This number is acknowledged as a gross underestimate, as significant occurrences were documented in various areas after the compilation of the data, an indication of how quickly the situation can change.
[2] Mount Lofty Ranges component of the Murray–Darling Basin.
[3] Upper South East component of the Murray–Darling Basin.

Source: Murray–Darling Basin Commission 1993.

Irrigation farming is particularly susceptible to salinity problems. Salinity occurs because of the build up of salts resulting from the repeated use of saline river water for irrigation. When more water is applied than is needed, excess water passes through the soil to the water table, raising it, adding salts and increasing returns of salt to river systems by natural drainage. The effect can be multiplied as water is reused downstream. If less water than required is applied, retained salts build up with repeated applications causing adverse effects.

6.18 EXTENT OF IRRIGATION SALINITY IN AUSTRALIA

State/Territory	*Irrigated saline soil* '000 ha	*Area of shallow groundwater* '000 ha
New South Wales	10.0	260.0
Victoria	144.0	385.0
Queensland	1.0	0.5
South Australia	0.5	4.5
Western Australia	0.5	—
Tasmania	—	—
Northern Territory	—	—
Australia	**156.0**	**650.0**

Source: Williamson 1990.

The on-site cost of soil salinisation to Australian agriculture is appreciable. Much of this cost is concentrated in a few salt-prone regions where the problem can have grave implications on individual farmers, the environment and the regional community. Farmers may suffer a loss in production, decline in the capital value of their land, reduced water quality, and increases in their on-farm infrastructure and crop and livestock management costs. The Dryland Salinity Management Working Group (Murray–Darling Basin Commission 1993) estimated the loss of land values in the region as a result of salinity to be about $68 million.

Salinisation is a long-term problem and difficult to reverse. Ameliorative measures include the diversion of extraneous surface water; revegetation by salt-tolerant vegetation; mulching; heavy fertilisation and exclusion of stock (fencing); avoidance of fallowing in cropping areas; the use of deep-rooted crops such as lucerne; and tree replacement on higher slopes (Charman & Murphy 1991). The usual option in controlling salinity is to plant trees on recharge sites and salt tolerant plants on the discharge site. Trees planted on the recharge site will prevent water entering the groundwater system and the resulting retreat of the water table will allow salt to be leached back to a deeper level in the soil profile. At the discharge site, successful planting may reduce the flow of salty water into surrounding streams and creeks and reduce erosion potential (Ralph 1993).

SURFACE WATER RESOURCES

The quality of surface water in Australia varies greatly from place to place. It is influenced by many factors including: climate, geology, flow rate, biological activity and land use.

Agricultural processes can have many deleterious effects on water quality. Regulation of river flows (for purposes including irrigation), alters river hydrology and has associated water quality implications. Clearing of land (including riparian zones to allow livestock access to river frontage) has increased the potential for run-off of soil and soil nutrients into river systems. It, along with irrigation farming, has also caused a rise in watertables which has led to greater accession of saline groundwater into river systems.

River regulation

Many of Australia's more important river systems have been regulated by constructing reservoirs (see Chapter 2). The dams have altered the flow regime of the rivers to a more constant rate throughout the year, and lower than a natural flow regime. For example, table 6.19 shows the situation for the Central Murray River.

6.19 FLOOD REGIME — NATURAL VERSUS REGULATED FLOWS, CENTRAL MURRAY

Flood regime	*Natural flow regime*	*Regulated flow regime*
Estimated average frequency of effective flood (%)	80	40
Estimated longest period without effective floods (years)	2	10
Duration of effective flood (months)	3 to 6	2 to 5
Period of peak flow (season)	Winter–Spring	Summer

Source: Murray–Darling Basin Commission 1987.

The Murray–Darling Basin is both Australia's most important and regulated river system. When water is diverted for irrigation purposes approximately 'half can be lost during conveyance by seepage, evaporation and transpiration' (McMahon, Gan & Finlayson 1992). This rather inefficient feature of irrigation water use becomes particularly critical during dry periods. Table 6.20 shows the proportion of flow diverted/lost from some of the main rivers in the Murray–Darling system.

The use of large quantities of water for irrigation purposes reduces the ability to address these water quality issues.

6.20 PROPORTIONAL DIVERSION/LOSSES FROM RIVERS IN THE MURRAY–DARLING BASIN IN AN AVERAGE YEAR

River	*Volume diverted/lost from long-term average flow* %
McIntyre-Barwon	20
Gwydir	40
Namoi	25
Macquarie	85
Lachlan	80
Murrumbidgee	65
Goulburn (at Goulburn weir)	50
Campaspe	30
Loddon	75

Source: Murray–Darling Basin Commission 1992.

It has been estimated that the 'large scale diversion of river water for irrigation has led to an increase of more than 50% in the expected median salinity of the Lower Murray' (McMahon, Gan & Finlayson 1992). This is because the reduction in flow of the river system caused by diversion reduces the ability of the river system to dilute saline groundwater inflows. Reduced river flow has also been identified as a factor contributing to the increased incidence of algal blooms in the Murray–Darling Basin in recent years.

River turbidity

'Turbidity measures the scattering of light through water caused by materials in suspension or solution' (Office of the Commissioner for the Environment 1991). It increases with the amount of material entrained and can vary depending on the kind of particles carried. For example, rivers in the agricultural areas of south west Queensland and western New South Wales and Victoria carry fine particles of clay which make them naturally highly turbid.

High turbidity levels can be a limiting factor on many species of aquatic life and can restrict human use of water resources. Turbidity also causes wear on pipes and fittings in irrigation systems and, for domestic supplies reduces the effectiveness of disinfection. To compensate for this, increased use of chlorine occurs which also leads to corrosion of pipes and fittings.

While many rivers are naturally turbid, there is evidence that agricultural land use has also contributed to increased river turbidity. Erosion of agricultural land caused by such activities as vegetation clearance, overgrazing, cultivation and fallow has increased run-off of organic and inorganic material into river systems. Reduction of riparian vegetation (usually to allow livestock access to river frontages) has been a particularly important factor because it reduces the filtering of sediments from riverbank run-off.

In Victoria, data collected from monitoring stations over a ten year period (table 6.21) indicate approximately '75% of sites adjacent to freehold land (i.e. usually agricultural land) reported excellent conditions for turbidity' (Office of the Commissioner for the Environment 1991). At almost one-quarter of the sites adjacent to freehold land, turbidity conditions were found to be deteriorating.

6.21 TURBIDITY TRENDS AND CONDITIONS ON FREEHOLD LAND, VICTORIA, 1981–91

Condition	*Turbidity trend*	*Sites* no.	*Sites* %
Excellent	Increasing	51	18.1
	Stable	140	49.8
	Decreasing	21	7.5
		212	*75.4*
Good	Increasing	8	2.8
	Stable	13	4.6
	Decreasing	1	0.4
		22	*7.8*
Moderate	Increasing	1	0.4
	Stable	5	1.8
	Decreasing	1	0.4
		7	*2.5*
Poor	Increasing	4	1.4
	Stable	9	3.2
	Decreasing	2	0.7
		15	*5.3*
Degraded	Increasing	3	1.1
	Stable	21	7.5
	Decreasing	1	0.4
		25	*8.9*
Total		**281**	**100.0**

Source: Office of the Commissioner for the Environment 1991.

River salinity

While many areas of Australia have natural inflows of saline groundwater to surface waters, irrigation and land clearing for agriculture in dryland areas have accentuated river salinity levels. In irrigation areas, there is usually an increase in groundwater accession and groundwater mounds often form as watertables rise. Groundwater mounds can discharge saline water into a river when they are located close enough to the river. 'Saline irrigation water is also often returned to the river via tributary systems' (Murray–Darling Basin Ministerial Council 1987).

Table 6.22 provides examples of salt load increase in rivers following clearing for agriculture.

6.22 EXAMPLES OF SALT LOAD INCREASES IN RIVERS FOLLOWING CLEARING FOR AGRICULTURE

River catchment	*Factor by which salt load has increased*
Dale River (Western Australia)	19
Collie River (Western Australia)	15
Axe Creek (Victoria)	10
Avoca River (Victoria)	10
Finniss River (South Australia)	8
Brenner River (South Australia)	6
Hughes Creek (Victoria)	4
North Para River (South Australia)	4

Source: Williamson 1990.

Salt levels in river systems are at their most critical during extended dry periods. When these occur there is usually inadequate stream flow to dilute salt levels in the river. In years where water required to irrigate crops reach critical levels of salt concentration there are usually associated yield losses.

Nutrient loads

Nitrogen and phosphorous are the most common nutrients which enter river systems. They enter river systems from a range of point and diffuse sources. Some of these are presented in table 6.23.

6.23 SOURCES OF NUTRIENTS IN RIVER SYSTEMS

Point sources	*Diffuse sources*
Irrigation drains	Run-off from grazing pasture
Intensive animal industries	Run-off from crops
Sewerage treatment works	Forests
Stormwater drains	

Source: Murray–Darling Basin Commission 1992.

Nutrients from agricultural land use usually find their way into river systems when soil and soil nutrients are removed during erosion events. They are either suspended in solution or absorbed to soil particles displaced during run-off. Nutrient inputs may also be significant when:

- high levels of fertiliser are used in conjunction with irrigation; and
- animal manure from livestock is washed into river systems.

During periods of high rainfall, nutrient inputs from agricultural land use enter river systems at their highest rate. This is not surprising because it corresponds with the time when run-off from agricultural land is usually at its peak. In contrast, during dry periods nutrient loads from agriculture are substantially less. Table 6.24 summarises the level of nutrient inputs from agricultural land use and their contribution to total nutrient inputs in the Murray–Darling Basin during wet, average and dry years.

6.24 NUTRIENT INPUTS FROM LAND USED FOR CROPS AND PASTURE LAND, MURRAY–MURRUMBIDGEE BASIN AND DARLING BASIN

	Nutrient load											
	Dry year				*Average year*				*Wet year*			
	Phosphorous		*Nitrogen*		*Phosphorous*		*Nitrogen*		*Phosphorous*		*Nitrogen*	
Category	t/yr	%	t/yr	%	t/yr	%	t/yr	%	t/yr	%	t/yr	%
Diffuse sources												
Forest	45	4.9	900	16.6	220	13.0	4 400	39.4	850	16.6	17 000	51.7
Pasture	95	10.3	450	8.3	360	21.3	1 800	16.1	1 550	30.2	7 800	23.7
Crops	110	12.0	220	4.1	360	21.3	540	4.8	1 850	36.1	2 800	8.5
Total[1]	*250*	*27.2*	*1 570*	*28.9*	*940*	*55.6*	*6 740*	*60.4*	*4 250*	*82.8*	*27 600*	*84.0*
Point sources												
Sewerage	500	54.3	2780	51.2	500	29.6	2780	24.9	500	9.7	2 780	8.5
Irrigation drainage	110	12.0	630	11.6	170	10.1	980	8.8	260	5.1	1 480	4.5
Urban stormwater	60	6.5	450	8.3	80	4.7	660	5.9	120	2.3	1 000	3.0
Total	*670*	*72.8*	*3 860*	*71.1*	*750*	*44.4*	*4 420*	*39.6*	*880*	*17.2*	*5 260*	*16.0*
Total	**920**	**100.0**	**5 430**	**100.0**	**1 690**	**100.0**	**11 160**	**100.0**	**5 130**	**100.0**	**32 860**	**100.0**

[1] Assumes 'dry', 'average' and 'wet' conditions occur in the same year in both the Darling and Murray–Murrumbidgee regions of the basin.

Source: Murray–Darling Basin Commission 1992.

Elevated nutrient loads (particularly phosphorous) in water have been identified as one of a host of factors contributing to eutrophication of waterways. Other factors include:

- conditions where water is still or flowing very slowly;
- extended hot, dry conditions with an abundance of sunlight; and
- scope for high light penetration.

Eutrophication occurs when an oversupply of nutrients simulates rapid growth in photosynthetic plankton and algae which dies and decomposes thereby using up oxygen. The decrease in the amount of dissolved oxygen in the water means that larger organisms, such as fish, which depend on dissolved oxygen may then die. This situation can in turn lead to further loss of dissolved oxygen and so the region becomes devoid of life, apart from the decomposers (Australian Academy of Science 1994).

The occurrence of blue-green algal blooms is the most well known result of increased nutrient loads. Blue-green algae (more properly called cyanobacteria) produce toxins when they decompose and these toxins can kill livestock and harm humans. Given this, there is a need to cease all use of waterways (including domestic and stock water use and recreational use) affected by blue-green algae until the problem is overcome. This can be a long process as the toxins are difficult to remove from water supplies.

GROUNDWATER RESOURCES

There is limited information on the volume of groundwater resources that have degraded. The major impact associated with over exploitation is the intrusion of salt water into previously good quality aquifers. However, many of Australia's groundwater resources are naturally saline making it even more difficult to determine which resources have been degraded.

The extent of salinity in the major groundwater resources is provided in the table 6.25.

6.25 EXTENT OF SALINITY IN MAJOR GROUNDWATER RESOURCES

	Divertible groundwater resources with 1 500 mg/l TSS[1]			
	Surficial aquifers	*Sedimentary aquifers*	*Fractured rock aquifers*	*Proportion of total resource*
State/Territory	mill. m^3 per year	mill. m^3 per year	mill. m^3 per year	%
New South Wales	165	570	—	34.0
Victoria	—	92	7	11.0
Queensland	320	43	36	14.0
South Australia	—	456	5	38.0
Western Australia	321	508	84	33.0
Tasmania	6	2	—	6.0
Northern Territory	2	51	—	1.0
Australia	**814**	**1 722**	**132**	**19.0**

[1] TSS: Total Soluble Salts.

Source: Australian Bureau of Statistcs 1992.

BIOLOGICAL DIVERSITY

Since European settlement, vegetation clearance and modification associated with agricultural land use, in particular, has impacted on native habitats. Agriculture has, in some way, been linked to the disappearance of many of the approximately one hundred and twenty vascular plant, twenty mammal, three bird and one lizard species which have become extinct over the past 200 years. When Europeans first arrived in Australia in 1788, forests covered 10% and woodlands covered 23% of Australia. They now cover about 5% and 15% of the country, respectively. Table 6.26 shows the changes in the area of major vegetation types since European settlement.

6.26 CHANGE IN THE AREA OF MAJOR FOREST VEGETATION TYPES SINCE EUROPEAN SETTLEMENT, 1990

	Forest type					
Structural form	*Height m*	*% cover*	*Natural area (10^3 ha)*	*Present area (10^3 ha)*	*Change (10^3 ha)*	*Biomass (t ha^{-1})*
Tall closed forest	>30	>70.0	100	5	- 95	450
Tall open forest	>30	30.0–70.0	6 200	5 100	- 100	279
Closed forest	10–30	>70.0	3 700	3 400	- 300	356
Open forest	10–30	30.0–70.0	54 700	27 400	- 27 300	272
Woodland	10–30	10.0–30.0	100 300	61 400	- 38 900	150
Open woodland	10–30	<10.0	17 400	40 200	22 800	55
Low closed forest	<10	>70.0	800	200	- 600	300
Low open forest	<10	30.0–70.0	3 300	3 400	100	200
Low woodland	<10	10.0–30.0	57 100	45 200	- 11 900	100
Low open woodland	<10	<10.0	147 600	158 300	10 700	50
Tall shrubland	<2	10.0–30.0	113 800	74 100	- 39 700	22
Tall open shrubland	<2	<10.0	136 300	162 300	26 000	10

Source: Gifford, Cheney, Noble, Russell, Wellington and Zammit 1992.

Most of the vegetation has been cleared to make way for agricultural land use. The impact has been most intense in the eastern and south-western parts of the continent, where it has been estimated that 90% of native vegetation has been replaced by crops or improved pasture for grazing. These regions, along with the rainforests of northern Queensland, contain the greatest number of endangered species of all areas across Australia.

While clearing for agricultural purposes is often viewed as a past practice which is now infrequent, it still occurs quite extensively at the regional level. For example, across three regions of the New South Wales wheatbelt (St George, Moree and Goondiwindi) approximately 70% of the remaining native woody vegetation was cleared between 1977 and 1985 (table 6.27).

6.27 CLEARING RATES FOR WOODY NATIVE VEGETATION ON THE ST GEORGE, GOONDIWINDI AND MOREE MAPPING SHEETS BETWEEN 1977 (TIME A) AND 1985 (TIME B)

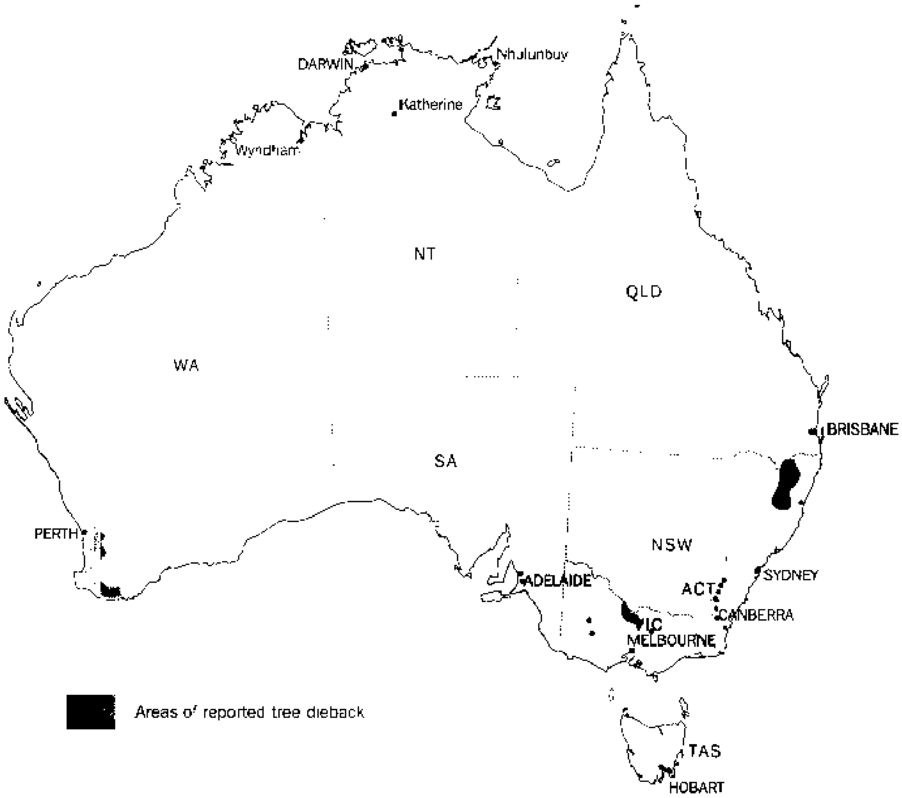
	Mapping area		
	St George	*Goondiwindi*	*Moree*
Native woody vegetation at time A (ha)	212 890	184 280	856 410
Native woody vegetation at time B (ha)	105 380	60 224	460 920
Total area cleared between time A and time B (ha)	107 512	124 060	395 500
Annual average clearing between time A and time B (ha)	13 440	17 720	49 440
Total clearing of native vegetation at time A (%)	50.5	67.0	46.0
Annual average clearing of vegetation at time A (%)	6.3	9.6	5.8

Source: Sivertson 1994.

In areas where clearing has been extensive, the remaining vegetation has taken on a fragmented appearance. The agricultural activities which surround many fragmented vegetation systems often contribute to dieback within the fragmented system. Where cropping occurs, exotic plant species may spread into adjacent remnant vegetation and begin to compete with the native species. In grazing areas, where livestock have access to remnant vegetation, the same can happen. Stock pick up seed from introduced plant species which they disperse over areas where they graze. The interaction of a number of other factors affecting rural land are also associated with dieback. These include insect attack, changes in soil conditions (due in part to the use of chemical sprays and fertilisers) and changes in fire regimes.

As a result of dieback, some species which are common today may become rare and endangered in the future. The symptoms of dieback include a loss of foliage at the crown and death of the primary and secondary shoots. The areas of forest in Australia affected by dieback are shown in map 6.28.

6.28 *OCCURRENCE OF DIEBACK*



Source: Australian Bureau of Statistics 1992.

Australia-wide the extent and abundance of introduced plant species is increasing. Many of these are considered to be environmental weeds with the potential to alter native vegetation systems. Some of the grasses which have been introduced for agriculture are among the most serious weeds afflicting Australia. Table 6.29 provides information on some of Australia's more serious environmental weeds.

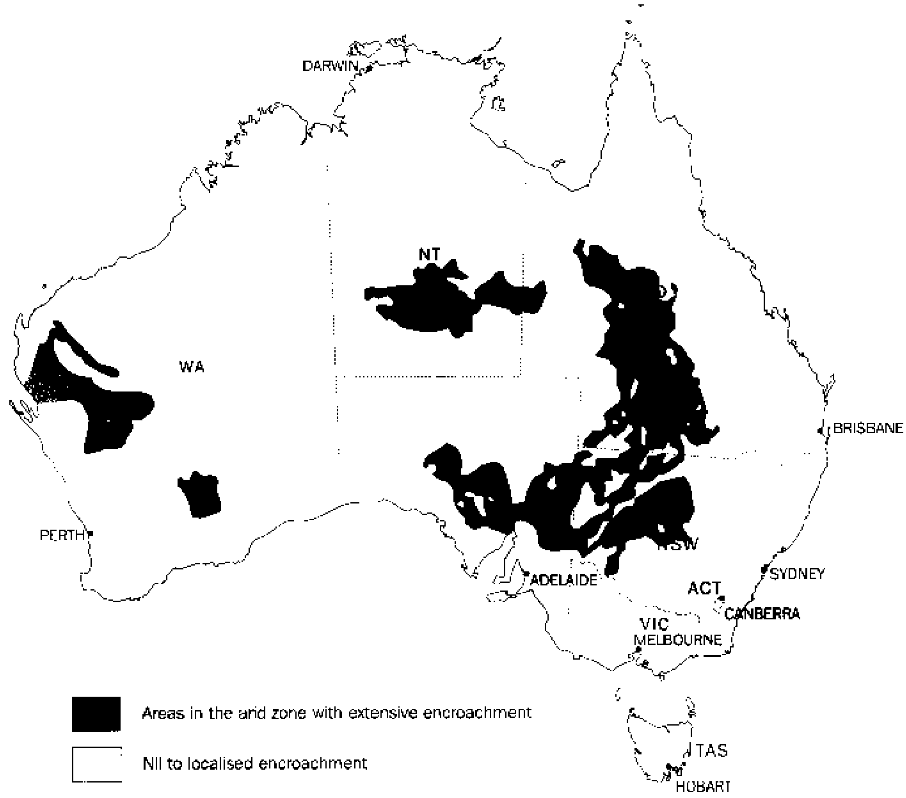
6.29 SOME OF AUSTRALIA'S MOST THREATENING ENVIRONMENTAL WEEDS

Common name	*Habitat impacted*	*Nature of impact/threat*
Prickly acacia (small tree/shrub)	Mitchell grasslands	Replaces perennial with annuals or bare soil and is a long-term threat to the Mitchell grass biome; converts grassland to shrubland.
Buffel grass (groundcover)	Moist 'refuges' and river banks in the arid zone	Threatening key habitats by displacing native vegetation and altering fire regimes; likely to reduce fauna resources.
Bitou bush and boneseed (shrub)	Range of coastal systems: foredune, heath, littoral rainforest	Displaces native vegetation with unknown effects on fauna.
Rubber vine (shrub/vine)	Gallery and other riparian communities in wet-dry tropics; dry rainforest	Smothers trees, shrubs and shades out the ground layer; destroys riparian vegetation including gallery forests threatening associated fauna; forms impenetrable thickets in Queensland gulf river systems.
Bridal creeper (creeper)	Spreading through wide range of habitats in southern Australia	Smothers ground and shrub layers.
Parkinsonia (small tree/shrub)	Ephemeral wetlands and riparian communities in wet-dry tropics	Invades mesic habitats and seasonal wetlands threatening waterbird habitats.
Mission grass (groundcover)	Dry forests and woodlands of wet-dry tropics	Displaces native sorghum changing the fire regime.
Smesquite (small tree/shrub)	Mainly semi-arid and arid riparian	Similar to prickly acacia but has a wider range of soil tolerances.
Athel pine (small tree)	Dryland River systems; currently small infestations	Displaces native trees; salinise soil; changes hydrology and geomorphology; reduces fauna resources.
Blue thunbergia (vine)	Tropical lowland rainforest in far north Queensland, especially along watercourses	Vigorous vine rapidly spreading and smothering native vegetation to the canopy.

Source: Australian Bureau of Statistics 1992.

A common ecosystem modification associated with pastoral activity in Australia's temperate rangelands has been invasion by native woody shrubs. The shrubs occur naturally in the areas they encroach and thrive in the unbalanced landscape which has evolved since European land management practices were introduced. As a result, the shrubs render land unproductive and make stock mustering difficult. Map 6.30 shows the land affected by woody shrub encroachment.

6.30 AREA OF WOODY SHRUB ENCROACHMENT



Source: Australian Bureau of Statistics 1992.

The impact of agriculture on native fauna has been most pronounced in the arid and semi-arid areas where Australia's main pastoral and agricultural lands are located. These areas have the greatest rate of extinction for native mammals Australia-wide, with medium-sized ground dwelling mammals most affected. 'To date, in arid areas, 33 species of mammals are extinct and 90% of medium sized species are either extinct or vulnerable' (National Rangelands Management Working Group 1994).

While most native wildlife have suffered as a result of agricultural land use, there are a few species which have benefited. Populations of some kangaroo and wallaby species, cockatoos and corellas have increased as a result of the food and water sources that agricultural land use has provided.

INTRODUCED ANIMAL PESTS

The impact of introduced animals is quite large and includes competition with native species for shelter, food and water; changes to habitats; increase in soil erosion; unnatural predation on smaller native species; and the spread of disease. Table 6.31 lists some of the introduced animals to Australia and from the 'reason for introduction' column the reader could identify those introductions associated with agriculture.

6.31 INTRODUCED ANIMALS TO AUSTRALIA, REASON AND IMPACT

Feral animal	*Reason for introduction*	*Impact*
Horse	Draught, transport	Damage to farm property; grazing on native wildlife food supplies.
Donkey	Draught	Prevention of other animals from using waterholes; grazing on wide variety of native wildlife food supplies.
Camel	Draught, transport	Eating selectively on fresh growth desert trees; damage to farm property.
Goat	Meat, milk	Compete for shelter with native fauna; compete with domestic stock for pasture; carry the foot rot disease.
Cat	Commensal	Prey on a wide range of native species for food.
Dog	Commensal	Prey on native species for food; attack stock.
Fox	Hunt	Prey on native ground-dwelling wildlife.
Cattle	Meat	Carry diseases such as brucellosis and tuberculosis; feed on native vegetation to the point of overgrazing.
Pig	Meat	Eat and damage crops and pastures; prey on lambs and native animals; damage to farm property; potential to carry exotic diseases; destruction of native animal food and nesting sites.
Water buffalo	Draught, meat	Overgraze areas near waterholes; near elimination of the water couch plant from swamps; erosion increased; creation of unnatural canals.

Source: Australian Bureau of Statistics 1992.

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CHAPTER 7

RESPONSES TO AGRICULTURAL RESTRUCTURING OF NATURAL ASSETS

INTRODUCTION

This chapter explores some of the responses by the farming community, as well as the Government to the issues raised in earlier chapters of this publication. The sections of this chapter, in turn, examine the adoption of sustainable management techniques, farm planning, risk management, attitudes to the environment, information sources, government policies and strategies, particularly Landcare, and research and development expenditures.

ADOPTION RATE OF SUSTAINABLE MANAGEMENT TECHNIQUES BY FARMERS

There are a range of factors which can explain why farmers do not adopt agricultural practices which are more sustainable. These include:

- 'difficulties associated with financing conversion to new alternative agricultural systems;
- lack of viable alternative systems due to technical, economic or other factors;
- insufficient local information on which to make a decision;
- lack of incentive to change (particularly relevant to farmers who may be reaching retirement age);
- perceived risks associated with change;
- lack of awareness of the need for and/or benefits of change and the means by which this can be achieved; and
- presentation of new technologies and information to farmers as isolated items rather than as part of a whole viable system' (Standing Committee on Agriculture 1991).

Despite the existence of such barriers, data from the ABARE on land management indicates widespread adoption of a range of encouraged agricultural practices across broadacre and dairy farming industries. For example, the data indicate that approximately three-quarters of all farmers adopted a conservative stocking rate, about 70% of livestock farmers used perennial pastures and regularly monitored their pasture and more than two-thirds of broadacre crop farmers managed crop rotations and used minimum/reduced tillage and stubble retention or mulching to minimise land degradation (table 7.1).

7.1 ADOPTION LEVELS BY FARMERS OF SELECTED FARM PRACTICES, 1992–93

Farm practices which are part of the farmer's farm management program	*Wheat and other crops* %	*Mixed livestock crops* %	*Sheep* %	*Beef* %	*Sheep-beef* %	*Dairy* %
Conservative stocking rate	74.0	80.0	86.0	83.0	80.0	81.0
Use perennial pasture species	34.0	54.0	69.0	80.0	70.0	88.0
Subdivision of different land classes	36.0	42.0	43.0	34.0	34.0	29.0
Minimum/reduced tillage	68.0	73.0	35.0	26.0	32.0	27.0
Direct drilling	37.0	37.0	26.0	11.0	21.0	26.0
Diversification of production	56.0	36.0	21.0	22.0	23.0	26.0
Tree and shrub planting	43.0	56.0	53.0	30.0	41.0	54.0
Regular soil testing	57.0	39.0	32.0	20.0	22.0	45.0
Regular monitoring of water quality	25.0	21.0	17.0	21.0	19.0	20.0
Regular monitoring of pasture	54.0	80.0	73.0	79.0	64.0	89.0
Exclude stock from areas affected by land degradation	30.0	40.0	33.0	26.0	22.0	21.0
Placement of watering points to minimise land degradation	34.0	37.0	36.0	31.0	27.0	26.0
Manage crop rotation to minimise land degradation	88.0	79.0	28.0	22.0	26.0	30.0
Stubble retention or mulching to minimise land degradation	82.0	69.0	29.0	17.0	16.0	10.0
Other practices	10.0	10.0	15.0	8.0	7.0	11.0

Source: Mues, Roper & Ockerby 1994.

State-based studies also reflect the prevalence of more sustainable agricultural practices. Such studies have shown that '70% of farmers in Western Australia were employing soil conservation and Landcare measures in 1988; grain and sugar producers in Queensland are using conservation tillage regimes widely; regional communities in Victoria are implementing management plans based on adoption of sustainable irrigation and drainage practices; and some agricultural industries in Tasmania have been adopting conservation cropping techniques developed by the Tasmanian Department of Primary Industry' (Standing Committee on Agriculture 1991).

Other studies have been conducted on the adoption rate of control measures for issues specific to a region. Table 7.2 presents data from one such study on the adoption of salinity control technologies in the Goulburn catchment of Victoria. This particular study found that 'around 25% of landholders affected by salinity were implementing some measures that contribute to salinity control' (Price 1993).

7.2 SALINITY CONTROL TECHNOLOGY ADOPTION LEVELS

	Area involved (hectares)			
	10–99	*100–249*	*250–499*	*Over 500*
Activity	%	%	%	%
Trees	9–29	24–27	15–31	19–28
Pastures	5	21	18	25
Pumping	1	3	—	—
Fencing discharge	1	1	1	7

Source: Price 1993.

FARM PLANNING (SCARM INDICATOR)

A whole farm plan is widely recognised as a valuable tool for assessing and managing farm resources with a view to lessening degradation. The farm plan can focus on particular aspects of managing a farm or cover a broad range of management issues. It often includes a mechanism to handle financial and production trends which may eventuate in the future; a strategy to deal with periods of drought and/or a program which sets out future crop rotations or pasture improvements. However, the most common kind of farm plan tends to be one with a primary focus on planning farm layout to reduce, control or prevent land degradation. Farm plans of this kind usually include a map and often show the location of different land classes and the fences required to separate these different land classes.

Results from the 1992–93 Agricultural Finance Survey (AFS) indicate that at 30 June 1993, 32,494 farm businesses (31%) had a farm plan of some kind. Of these, 17,071 farm businesses (16%) had a documented farm plan (i.e. a farm plan which included aerial photographs, maps and/or other written documentation). Less still had a documented farm plan which showed the location of different land classes (11,173 farm businesses) and/or the fences required to separate these land classes (7,458 farm businesses) (table 7.3).

Farm businesses in Western Australia were more likely to have a documented farm plan than farm businesses from other States in Australia. An estimated 29% of farm businesses in Western Australia had a documented farm plan. In Western Australia 'Land Conservation District Committees were established as early as 1982 and self-help farm planning courses were introduced for landholders prior to their commencement in most other states' (Campbell 1992). South Australia and Tasmania (17%) were the only other States where the proportion of farm businesses with a documented farm plan exceeded the national average (16%).

7.3 USE OF FARM PLANS AMONG FARM BUSINESSES BY STATE, 1992–93

	Farm businesses							
					With a documented farm plan showing			
	With a farm plan of some kind		With a documented farm plan		Land classes		Land classes and fences separating these land classes	
State	no.	%	no.	%	no.	%	no.	%
New South Wales	8 567	29.8	3 603	12.5	2 556	8.9	1 660	5.8
Victoria	6 488	22.6	4 318	15.0	2 442	8.5	1 960	6.8
Queensland	7 419	34.7	3 206	15.0	2 118	9.9	767	3.6
South Australia	3 573	28.8	2 140	17.2	919	7.4	477	3.8
Western Australia	4 920	44.2	3 210	28.8	2 789	25.0	2 318	20.8
Tasmania	1 377	43.9	525	16.7	307	9.8	234	7.5
Australia[1]	**32 494**	**30.6**	**17 071**	**16.1**	**11 173**	**10.5**	**7 458**	**7.0**

[1] Australia incorporates Territories.

Source: Australian Bureau of Statistics unpublished data.

At 30 June 1993, over one-third of farm businesses in the grain, grain–sheep–beef, sheep and sugar industries had a farm plan of some kind. The grain and grain–sheep–beef industries, along with the cotton industry, also had a higher proportion of farm businesses with a documented farm plan than farm businesses from other agricultural industries. Intensive agricultural industries (for example, poultry, pigs and vegetables) tended to have a lower proportion of farm businesses with a farm plan of some kind and a far lower proportion of farm businesses with a documented farm plan than farm businesses from any of the broadacre industries (table 7.4).

7.4 USE OF FARM PLANS AMONG FARM BUSINESSES BY INDUSTRY, 1992–93

Industry	Farm businesses: With a farm plan of some kind no.	With a farm plan of some kind %	With a documented farm plan no.	With a documented farm plan %	With a documented farm plan showing: Land classes no.	Land classes %	Land classes and fences separating these land classes no.	Land classes and fences separating these land classes %
Poultry	169	14.6	57	4.9	3	0.3	3	0.3
Fruit	1 998	21.8	1 212	13.2	636	6.9	323	3.5
Vegetables	1 051	25.3	187	4.5	53	1.3	44	1.1
Grain	3 809	36.7	2 301	22.2	1 410	13.6	919	8.9
Grain–sheep–beef	7 069	37.6	4 088	21.8	2 930	15.6	1 935	10.3
Sheep–beef	2 710	30.4	1 625	18.2	1 269	14.2	991	11.1
Sheep	5 311	36.4	2 839	19.5	2 166	14.8	1 807	12.4
Beef	3 975	27.9	1 688	11.8	1 103	7.7	537	3.8
Dairy	2 806	21.4	1 767	13.5	650	5.0	620	4.7
Pigs	349	24.8	125	8.9	78	5.5	42	3.0
Sugar	1 781	38.2	478	10.2	408	8.7	—	—
Cotton	244	32.8	160	21.5	88	11.8	67	9.0
Other	1 213	25.6	540	11.4	377	8.0	166	3.5
All industries	**32 494**	**30.6**	**17 071**	**16.1**	**11 173**	**10.5**	**7 458**	**7.0**

Source: Australian Bureau of Statistics unpublished data.

Under existing legislation, farm businesses with a documented farm plan can have their plan approved by an authorised State or Territory land conservation agency for taxation purposes. However, 1992–93 AFS data indicated that only 5,304 farm businesses (5%) had their farm plan approved for taxation purposes. At the State level, Western Australia had the highest proportion of farm businesses with a farm plan which had been approved for taxation purposes (15%) (table 7.5).

7.5 DOCUMENTED FARM PLANS WHICH HAVE BEEN APPROVED FOR TAXATION PURPOSES, 1992–93

State	Farm businesses with a documented farm plan no.	Farm businesses with a documented farm plan %	Farm businesses with a documented farm plan approved for taxation purposes no.	Farm businesses with a documented farm plan approved for taxation purposes %	Proportion of documented farm plans which have been approved for taxation purposes %
New South Wales	3 603	12.5	982	3.4	27.3
Victoria	4 318	15.0	1 408	4.9	32.6
Queensland	3 206	15.0	947	4.4	29.5
South Australia	2 140	17.2	183	1.5	8.6
Western Australia	3 210	28.8	1 704	15.3	53.1
Tasmania	525	16.7	75	2.4	14.3
Australia[1]	**17 071**	**16.1**	**5 304**	**5.0**	**31.1**

[1] Australra incorporates Territories.

Source: Australian Bureau of Statistics unpublished data.

ABARE also collected data on farm plans in their Landcare and land management survey but differences in scope and definitions exist between the ABARE and ABS surveys, hence any comparison between the two is not possible. Table 7.6 presents 1992–93 ABARE land management data for the broadacre industries by State on the proportion of farmers with a farm plan and the proportion of farmers with farm plans which contain selected key attributes.

7.6 FARM PLANS AND THEIR ATTRIBUTES BROADACRE INDUSTRIES, 1992–93

	NSW	*Vic.*	*Qld*	*SA*	*WA*	*Tas.*	*NT*	*Aust.*
	%	%	%	%	%	%	%	%
Proportion of farmers possessing a farm plan	31.0	29.0	26.0	28.0	39.0	13.0	43.0	30.0
Proportion of farmers possessing a farm plan containing:								
A map	29.0	27.0	25.0	25.0	38.0	13.0	42.0	28.0
Information on soil/land capability	19.0	19.0	17.0	16.0	32.0	8.0	29.0	20.0
Land management plan approved for tax purposes	7.0	5.0	2.0	2.0	12.0	3.0	4.0	6.0
Details of Landcare work	29.0	21.0	13.0	1.0	28.0	8.0	22.0	18.0
Capital improvements	18.0	26.0	17.0	12.0	24.0	9.0	29.0	19.0
Wildlife habitat or natural vegetation	11.0	14.0	13.0	13.0	21.0	8.0	21.0	14.0
Farm operating budget	18.0	15.0	14.0	20.0	27.0	9.0	22.0	18.0
Crop/livestock paddock performance records	12.0	13.0	11.0	15.0	24.0	4.0	21.0	14.0
Alternative drought strategies	12.0	15.0	11.0	12.0	10.0	5.0	18.0	12.0
Timetable for plan implementation	9.0	9.0	7.0	6.0	9.0	4.0	12.0	8.0
Other information	1.0	—	1.0	1.0	2.0	1.0	1.0	1.0

Source: Mues, Roper and Ockerby 1994.

RISK MANAGEMENT

Essential to the concept of farming sustainably in Australia is the need for management practices that can also cope with the variable and often unpredictable climate. Central to this issue is an accurate assessment of the productive capacity of the land and the identification of the risks faced by farmers. 'Government policies on drought management and ecologically sustainable development aim to help achieve these goals and, in addition, the Commonwealth and State/Territory Governments are encouraging farmers to adopt better risk management techniques' (White 1994).

Production risks cover those risks imposed by seasonal variability and unpredictability, certain management inputs, and the impacts of pests and diseases. Environmental risks include those associated with the degrading of soils, water, flora and fauna, and can often be reduced with proper management. These strategies should be combined with financial and marketing strategies in an integrated risk management strategy. Inadequate risk management strategies can aggravate the problem of degradation by applying pressure to adopt short-term remedial measures which are detrimental to the farm resource, and in some cases the surrounding environment in the long term, in an effort to alleviate cash flow problems. Table 7.7 shows the probable change in production, environmental and financial risk in response to a number of practices.

7.7 EFFECT OF CERTAIN PRACTICES ON PRODUCTION, ENVIRONMENTAL AND FINANCIAL RISKS

	Risk		
	Production	*Environmental*	*Financial*
Low stocking rate	Decreases	Decreases	Increases
Medium stocking rate	Increases	Increases	Decreases
Very high stocking rate	Greatly increases	Greatly increases	Greatly increases
Planned stock disposal	Decreases	Decreases	Decreases
Pasture legumes	Decreases	Decreases	Decreases
Drought-resistant pastures	Decreases	Decreases	Decreases
Drought-resistant crops	Decreases	Decreases	Decreases
Shelter	Decreases	Decreases	Decreases
Fodder conservation	Decreases	Decreases	?
Fodder crops	Decreases	Increases	?
Diversify (skilled)	Decreases	Decreases	Decreases
Diversify (unskilled)	Increases	Increases	Increases
Irrigation	Decreases	Increases	Increases
Lot feeding	Decreases	Increases	Increases

Source: Adapted from White 1994.

As can be seen from the table above, strategies that are less risky in terms of production may be more prone to environmental and/or financial risk. Helping farmers to balance the overall financial and environmental risks is an important part of achieving sustainability in agriculture. For example, financial pressures to repay loans quickly may lead to practices such as continuous cropping which are detrimental to sustainable agriculture and long-term productivity.

Drought

As far as agriculture is concerned, drought represents one of the biggest uncertainties facing farmers with regard to risks to the viability of an agricultural enterprise. It is important that producers develop agricultural systems that are both economically and environmentally sustainable by managing within the constraints of prevailing seasonal conditions. According to the Drought Policy Review Task Force 1990, 'Short-term exploitation of production resources, relative to the capability of the land at the time, will generate those circumstances we have traditionally come to regard as drought.'

In a project titled 'Drought Plan', CSIRO scientists have joined with livestock producers, the Queensland Department of Primary Industries and other government agencies to develop specific drought management tools, including methods for applying them. Some of the issues identified include climate prediction and understanding risk; supplementary feeding and stock marketing in drought; the influence of drought policy; how stocking rates affect reproduction and mortality rates in dry and good years; and the effects of drought management on pasture sustainability.

The rate of utilisation of some drought strategies are included in table 7.8, which describes the adoption rate of a number of risk management strategies. Table 7.6 shows that 12% of farmers in 1992–93 possessed a farm plan containing alternative drought strategies.

7.8 RISK MANAGEMENT TECHNIQUES

Tool/technique	*Currently utilise* %	How useful 1 = Very useful 5 = *Useless*
Records: success/failures crops/animals	63.0	1.8
Animal health programs	54.0	1.6
Soil testing for nutrient status	56.0	1.8
Land degradation prevention plan	52.0	1.8
Paddock production levels	52.0	1.8
Farm plan showing future intended development	52.0	1.8
Diversification of production	50.0	1.8
Woody weed control programs	42.0	1.9
Water catchment plan	44.0	1.6
Soil testing for moisture	27.0	1.8
Tissue testing for crop nutrient requirements	23.0	1.8
Use of Breedplan	20.0	1.7
Use of Beefman	4.0	1.8
Water management e.g. bores, on-farm storage	71.0	1.5
Fodder conservation: hay	57.0	1.5
Fodder conservation: on farm grain storage	51.0	1.6
Fodder conservation: silage	12.0	1.5
Detailed rainfall records over time	68.0	2.1
Computer-based climatic data (e.g. Rainman)	10.0	2.2

Source: Solutions Marketing And Research Group 1993.

Technology

Risk management and farm decision-making tools are becoming more widely used as computer technology makes available a range of decision support packages. Some examples include two Western Australian models, MIDAS (Model of an Integrated Dryland Agricultural System), and MUDAS (Model of an Uncertain Dryland Agricultural System). These packages assess the profitability of alternatives incorporating factors such as the long-term effects of certain land use practices on salinity, and soil loss due to wind erosion. Other systems include Victoria's Farm Tree Model which enables the evaluation of the economics of agroforestry, Queensland's Beefman, CSIRO's Rangepack and a cropping simulation model known as PERFECT. Models such as these are being used to analyse the effect of soil erosion on long-term yields under a variety of conditions, and are useful tools in matching crop water use to available water for planning of cropping programs.

Other risk management strategies are also available to farmers, some of which are included in table 7.8. This table presents the results of a study commissioned by the Commonwealth Department of Primary Industries and Energy to determine the extent to which Australian farmers are adopting such management strategies, as well as the farmer's perception of its usefulness.

The non-use of risk management techniques/tools and practices that promote sustainability include financial and attitudinal reasons and lack of knowledge of the products and techniques.

Tables 7.9 and 7.10 provide some of the important factors in farmer decision-making with regard to evaluating and adopting technology. Ease of implementation, information on application and information on economic benefits are the important factors in evaluating technology, with increased productivity and reduced costs being the most important factors in adopting technology.

7.9 FACTORS IMPORTANT TO FARMERS IN EVALUATING TECHNOLOGY

	Farmers			*Lead farmers*		
	Very important	*Important*	*Not important*	*Very important*	*Important*	*Not important*
Factor	%	%	%	%	%	%
Ease of implementation	70.0	23.0	7.0	10.0	70.0	20.0
Disruption to farm practices	39.0	40.0	21.0	20.0	20.0	60.0
Adoption by other farmers	45.0	25.0	30.0	40.0	30.0	30.0
Information on application	81.0	16.0	3.0	80.0	20.0	—
Information on economic benefits	83.0	16.0	1.0	90.0	10.0	—

Source: Alexander 1995.

7.10 FACTORS IMPORTANT TO FARMERS IN ADOPTING TECHNOLOGY

	Farmers			*Lead farmers*		
	Very important	*Important*	*Not important*	*Very important*	*Important*	*Not important*
Factor	%	%	%	%	%	%
Increased productivity	91.0	6.0	1.0	100.0	—	—
Reduced costs	85.0	11.0	4.0	50.0	50.0	—
Reduced farm labour needs	59.0	34.0	8.0	30.0	50.0	20.0
Cost of technology	70.0	28.0	2.0	20.0	60.0	20.0
Availability of support	78.0	21.0	14.0	30.0	60.0	10.0

Source: Alexander 1995.

ATTITUDES

It is acknowledged that farmers' attitudes to the environment are an important element in the success of any sustainable agriculture strategy, and essential to the development and implementation of rural environmental policies. In the past attitudinal changes in farmers often occurred when realisable advantages became quickly obvious. For example, 'the benefits to wheat production of superphosphate were obvious after only one year leading to rapid acceptance and adoption by farmers' (Cary 1992). The advantages to farmers of sustainable land management can be less obvious, particularly when the techniques encouraged often require farmers to 'go against short-term economic self interest; put aside other priorities for capital; reject some of their own ideas and knowledge of their environment; and accept the models and knowledge of extension agencies' (Vanclay 1992).

Table 7.11 represents results of a survey of agricultural establishments Australia-wide conducted by Reeve and Black (1993) of the Rural

Development Centre, University of New England, New South Wales. The main objective of the study was to provide policy makers with survey-based data indicating farmer attitudes towards environmental safeguards. The sample is representative of the membership of the major farmer organisations in Australia and, as such, results may differ in some respects from a representative sample of all rural landholders.

The results presented in table 7.11 indicate a high level of awareness of the existence of land degradation. Nearly 90% of farmers acknowledge some sort of land degradation on agricultural land. Furthermore, it appears there is widespread concern among landholders for the environment with 83% agreeing they have an obligation to look after the land on behalf of the whole community and 77% saying it is worth putting up with a small decrease in farm profits to protect the environment. Over half of the farmers also indicate maximising profit as the most important objective of farming and there is no point in adopting new practices unless they are more profitable. Reeve and Black point out that the significance of profit is particularly important to those with more years of farm experience, small farms, low levels of equity and no off-farm employment.

7.11 FARMER ATTITUDES TO ISSUES RELATING TO SUSTAINABLE AGRICULTURE

	% of respondents		
Statement	*Agree*	*Neutral or not sure*	*Disagree*
Most rural properties have some sort of land degradation, whether it be soil erosion, damage to soil structure, dieback, weed infestation, pollution of soils or streams, or salinity.	89.8	4.3	5.9
It is unfair to expect farmers to bear the cost of repairing land degradation on their properties.	47.9	20.1	31.9
Without financial assistance, there is little farmers can do to prevent land degradation occurring on their properties.	49.2	7.8	42.9
Financial incentives should be made available to encourage farmers to use soil improving practices, e.g. rotation, stubble retention or deep ripping.	79.3	10.5	10.2
The pollution effects of fertilisers are quite unimportant compared to their benefits in increasing production.	48.6	23.6	27.9
Sustainable agriculture in my industry will probably always require extensive use of agricultural chemicals.	52.9	16.1	31.1
There needs to be more testing of all agricultural produce for harmful chemical residues.	50.7	23.3	26.0
All necessary soil conservation measures should be used, whatever the costs.	41.0	23.7	35.3
It is worth putting up with a small decrease in farm profits to protect the environment.	76.7	12.9	10.4
Governments these days pay too much attention to the 'green movement'.	82.4	8.4	9.3
Generally, the root cause of much of the land degradation in Australia can be traced back to government policies that led to farmers using their land unwisely.	56.6	23.4	20.0
Farmers have an obligation to look after the land on behalf of the whole community.	83.3	4.3	12.3
Wider adoption of environmentally-friendly farming practices will not generally reduce profitability.	46.3	26.9	26.8
For the farmer who wants to farm sustainably, it is essential to have a whole farm plan prepared.	68.8	14.0	17.3
Whole farm plans prepared by government agencies are an unnecessary interference with farmers' rights to use their land as they see fit.	56.7	19.3	24.0
The farmer is the best person to decide how land degradation problems on his/her farm should be tackled.	67.6	15.2	17.2
The most important objective of farming is to maximise profit.	58.8	9.0	32.2
There is no point in adopting new practices unless they are more profitable.	53.4	15.4	31.2

Source: Adapted from Reeve and Black 1993.

There is reasonable support among farmers for financial incentives to encourage the use of soil improving practices (77%) and approximately half of the farmers seem to think there is little they can do to prevent land degradation on their properties without such assistance. While generally in favour of financial incentives to prevent land degradation it seems the majority of farmers are wary of excess government intervention. Two-thirds of farmers suggest they are the best person to deal with their land degradation problems and 57% agree that government-prepared whole farm plans interfere with farmer rights to use land as they see fit. Analysis carried out by Reeve and Black suggest attitudes to external influences on farm decision making are more favourable among Landcare group members and those with higher levels of formal education, fewer years of farm experience, and regular off-farm employment or income.

INFORMATION SOURCES OF FARMERS

'To achieve more sustainable agriculture, farmers require detailed information about the ecosystems, the resource base and farm production systems and an awareness of the interrelationships between parts of these systems' (Standing Committee on Agriculture 1991). This information needs to be accessible, useful and understandable. Table 7.12 presents data on the sources of information farmers have used and farmer perceptions of its usefulness.

7.12 INFORMATION SOURCES OF FARMERS

Source of information	*Have used* %	*Users who found the source to be 'very useful'* %
General rural newspapers/magazines	94.0	31.0
Other landholders	89.0	40.0
Field days	88.0	34.0
Accountants	85.0	37.0
Radio (ABC)	85.0	37.0
Dept of Agriculture advisers	77.0	37.0
Agricultural shows	78.0	20.0
Stock and station agents	74.0	32.0
Television	73.0	16.0
Specialist newspaper/magazines	73.0	32.0
Merchandise outlets	69.0	25.0
Manufacturers of agricultural products	63.0	22.0
Workshops and seminars	61.0	30.0
Bank manager (branch level)	50.0	15.0
Radio (commercial)	48.0	10.0
Formal education (TAFE)	27.0	42.0
ABARE	23.0	15.0
Paid specialist consultants	24.0	37.0
Rural counsellors	18.0	27.0
Formal education (other institutions)	17.0	44.0
Computer based information networks (e.g. CALM)	15.0	29.0
Specialist rural bankers	14.0	18.0
Computer based information networks (e.g. Elders LINK)	8.0	31.0

Source: Solutions Marketing And Research Group 1993.

The information sources most frequently used were media sources such as general rural newspapers/magazines and ABC radio, other landholders, field days and accountants. The sources rated the most useful were formal education — both TAFE and other institutions — however, these sources were not highly utilised as an information source (27% and 17% for TAFE and other institutions, respectively).

GOVERNMENT POLICIES/STRATEGIES

The introduction of policies designed to ensure the protection of essential ecosystem functions from degradation by agricultural activities have been brought about by pressures from an increasingly environmentally aware public, a growing scarcity of water and intact riverine ecosystems, and an increased health consciousness of consumers. Many of the resource and environmental issues identified earlier have been the subject of research and policy initiatives from all levels of government. In the past, some inadequate or inappropriate government policies have added to these problems.

In the 1980s, widespread awareness of the need to tackle land degradation problems and pursue a more sustainable approach to agriculture led to increased government support and assistance for farm planning initiatives undertaken by landholders. State government agencies established land management programs which included funding for Landcare groups and the running of courses on farm planning for landholders. This commitment was reinforced in 1990 when an agreement between the Commonwealth Government and State Governments was reached on a coordinated national *Decade of Landcare Plan*. 'One of the most common land management activities of these groups has been property and catchment planning' (Campbell 1992).

National Landcare Program (NLP) (SCARM indicator)

The NLP helps develop and implement integrated approaches to the sustainable management of land, water and related vegetation. The goal of the *Decade of Landcare Plan* is to 'develop and implement systems of land use and management which will sustain individual and community benefits, both now and in the future'. Since the plan's inception, the network of Landcare groups across Australia has continued to expand.

Data from the 1992–93 AFS indicate that 14,271 farm businesses (13.5%) were involved with Landcare Australia and 17,798 farm businesses (16.8%) were involved with other organisations with a Landcare focus. Table 7.13 indicates that the proportion of farm businesses involved with Landcare Australia was highest in New South Wales (15.4%) and Victoria (15.2%) while the proportion of farm businesses involved with other organisations with a Landcare focus was highest in Western Australia (38.6%).

7.13 FARM BUSINESSES INVOLVED WITH LANDCARE AUSTRALIA OR OTHER GROUPS WITH A LANDCARE FOCUS, 1992–93

	Farm businesses involved with Landcare Australia		*Farm businesses involved with an organisation which has a landcare focus*	
State	no.	%	no.	%
New South Wales	4 426	15.4	3 683	12.8
Victoria	4 373	15.2	4 707	16.4
Queensland	3 162	14.8	2 472	11.6
South Australia	1 288	10.4	2 230	18.0
Western Australia	701	6.3	4 293	38.6
Tasmania	284	9.1	331	10.5
Australia[1]	**14 271**	**13.5**	**17 798**	**16.8**

[1] Australia incorporates Territories.

Source: Australian Bureau of Statistics unpublished data.

Table 7.14 shows that farm businesses from the sheep (20%), beef (19%) and grain–sheep–beef (18%) industries were more likely to have an involvement with Landcare Australia than farm businesses from other industries. Similarly, the grain–sheep–beef (25%), grain (22%) and beef (19%) industries were more likely to have an involvement with other organisations with a landcare focus.

7.14 FARM BUSINESSES INVOLVED WITH LANDCARE AUSTRALIA OR OTHER GROUPS WITH A LANDCARE FOCUS BY INDUSTRY, 1992–93

	Farm businesses involved with Landcare Australia		*Farm businesses involved with an organisation which has a landcare focus*	
Industry	no.	%	no.	%
Poultry	2	0.2	36	3.1
Fruit	265	2.9	871	9.5
Vegetables	137	3.3	525	12.6
Grain	1 247	12.0	2 237	21.6
Grain–sheep–beef	3 425	18.2	4 682	24.9
Sheep–beef	1 609	18.0	1 551	17.4
Sheep	2 919	20.0	2 464	16.9
Beef	2 701	18.9	2 720	19.1
Dairy	1 261	9.6	1 624	12.4
Pigs	38	2.7	205	14.6
Sugar	176	3.8	406	8.7
Cotton	101	13.6	154	20.7
Other	387	8.2	321	6.8
All industries	14 271	13.5	17 798	16.8

Source: Australian Bureau of Statistics unpublished data.

The 1992–93 ABARE Landcare and land management survey data estimate that 28% of broadacre farms and 19% of dairy farms have an operator or a family representative holding Landcare membership. For broadacre farms the level of membership varies from a high of 47% in the Northern Territory to a low of 12% in Tasmania. Table 7.15 presents in some detail 1992–93 data on Landcare membership from the ABARE survey.

ABARE found that Landcare members are generally younger, more aware of land degradation problems on their properties, more likely to incur expenditure for Landcare-related works and possess a farm plan. Table 7.16 indicates that Landcare members were more likely to have subdivided different land classes; planted trees and shrubs; regularly monitored water quality; excluded stock from areas affected by land degradation; and adopted conservation tillage techniques. The strong association between Landcare membership and conservative farming practices adds weight to the SCARM recommendation to use the proportion of farmers holding membership in Landcare groups as an indicator for detecting any attitudinal shift toward sustainable agriculture by farmers.

7.15 ASPECTS OF LANDCARE MEMBERSHIP, BROADACRE INDUSTRIES, 1992–93

	State/Territory							
	NSW	*Vic.*	*Qld*	*SA*	*WA*	*Tas.*	*NT*	*Aust.*
Farm plan	%	%	%	%	%	%	%	%
Proportion of farms with the operator a family representative who is a Landcare member	24.0	38.0	20.0	21.0	44.0	12.0	47.0	28.0
Aspects of Landcare groups valued most highly by Landcare members								
Information exchange at meetings	30.0	30.0	57.0	32.0	33.0	54.0	52.0	34.0
Information exchange at field days/demonstration sites	27.0	27.0	12.0	25.0	3.0	7.0	17.0	20.0
New farm management skills	15.0	4.0	10.0	7.0	4.0	4.0	7.0	8.0
Catchment/regional planning	7.0	5.0	—	5.0	23.0	—	7.0	9.0
Monitoring of land and water degradation	10.0	6.0	5.0	1.0	5.0	4.0	4.0	6.0
Tree plantings	1.0	8.0	5.0	9.0	7.0	18.0	—	6.0
Community works	2.0	8.0	—	4.0	5.0	—	—	4.0
Access to specialist machinery	1.0	1.0	2.0	2.0	1.0	—	—	1.0
Peer support/cooperation	2.0	1.0	3.0	2.0	3.0	—	—	2.0
Other	5.0	10.0	6.0	13.0	10.0	13.0	13.0	10.0
Reason given for non-membership								
Only minor problems in area	30.0	32.0	46.0	43.0	48.0	28.0	17.0	37.0
Cannot afford the time	9.0	16.0	20.0	13.0	17.0	30.0	27.0	14.0
Attempts to start a group in the area failed	1.0	1.0	1.0	1.0	3.0	—	—	1.0
No Landcare group in area	34.0	34.0	18.0	17.0	17.0	33.0	42.0	27.0
Not interested in Landcare groups	11.0	6.0	7.0	11.0	3.0	1.0	9.0	8.0
Left a Landcare group	—	—	1.0	1.0	7.0	—	—	1.0
Other	15.0	11.0	7.0	14.0	5.0	8.0	5.0	12.0

Source: Mues, Roper and Ockerby 1994.

7.16 FARM PRACTICES BY LANDCARE MEMBERSHIP

Farm practices which are part of the farmer's farm management program	*All broadacre*		*Dairy*	
	Non-Landcare	*Landcare*	*Non-Landcare*	*Landcare*
	%	%	%	%
Conservative stocking rate	84.0	76.0	81.0	82.0
Use perennial pasture species	63.0	70.0	84.0	93.0
Subdivision of different land classes	33.0	51.0	24.0	52.0
Minimum/reduced tillage	40.0	59.0	27.0	27.0
Direct drilling	21.0	37.0	28.0	18.0
Spring/bare fallow cultivation	28.0	31.0	24.0	34.0
Tree and shrub planting	38.0	64.0	47.0	84.0
Regular soil testing	28.0	40.0	42.0	58.0
Regular monitoring of water quality	14.0	36.0	17.0	33.0
Regular monitoring of pasture	71.0	79.0	88.0	94.0
Exclude stock from areas affected by land degradation	25.0	47.0	14.0	47.0
Placement of watering points to minimise land degradation	29.0	44.0	21.0	45.0
Manage crop rotation to minimise land degradation	42.0	62.0	30.0	32.0
Stubble retention or mulching to minimise land degradation	37.0	46.0	10.0	7.0
Other practices	9.0	14.0	11.0	11.0

Source: Mues, Roper and Ockerby 1994.

Membership in Landcare groups is not restricted to farmers or landholders. In Victoria, the percentage of Landcare membership who are land managers has been estimated at 59% and 34% of members had full-time off-farm jobs (Curtis 1993). This mix of membership varied throughout groups and appears to be related to proximity to urban centres (although this was not examined). A large percentage of non-farming members gives the advantages of broader sources of knowledge to the group and reduces the risk of burnout inherent to small groups. It also reinforces the notion that the causes and solutions to land degradation are not just the concern of farmers but also of the wider community. Table 7.17 provides some information about community Landcare as it operates in each State and Territory. Other programs such as 'Farming for the Future', developed by the New South Wales Government with assistance from the New South Wales Farmers Association are attracting participants in workshop sessions on a variety of farm management topics. Up to 31 March 1994, some 508 participants had attended 39 sessions related to physical and other property planning with a further 4,145 attending 268 sessions devoted to other farm management topics.

7.17 MAIN FEATURES OF COMMUNITY LANDCARE GROUPS, MAY 1995

	NSW	*Vic.*	*QLD*	*SA*	*WA*	*Tas.*	*NT*	*ACT*
Groups (no.)	800	675	128	250	390	132	18	16
Farmers as group members (%)	24.0	38.0	20.0	21.0	44.0	12.0	47.0	—
Group coordinators (no.)	30	41	34	12	23	1	1	—
Facilitators (no.)	14	4	25	11	30	6	—	1
NLP funded people (no.)	148	172	168	186	224	53	36	8

Source: Alexander 1995.

Other government programs/initiatives

The Commonwealth Government can impact on the agricultural sector through a variety of economic policies, marketing and export activities, and funding of programs relating to research, soil conservation and water resources. The Report of the Working Group On Sustainable Agriculture identified several measures which governments can employ to promote sustainable agriculture. Such measures include: pricing mechanisms; transferable property rights; pollution charges; subsidies; income tax deductions or rebates; direct regulation; institutional change; rural adjustment assistance; improving information flows; and knowledge generation. Some government programs are mentioned below, although it is not possible, nor relevant, to describe them all.

Water use and quality

About three-quarters of all water used in Australia is for irrigation (Standing Committee on Agriculture 1991), hence issues relating to irrigation are very important. The major issues include inefficient or excessive use of water, pricing policies, poor irrigation and drainage infrastructure, poor land capability management such as improper matching of crop water requirements and soil types, and the collection and disposal of saline drainage water.

Long-term solutions require management policies and guidelines that address the causes of salinity and lead to the long-term sustainability of agriculture.

The Natural Resources Management Strategy is administered through two funding programs:

- the Investigations and Education Program which assists research, education and monitoring activities in water quality, groundwater salinity, wetlands management and effective water use by State agencies, CSIRO, universities and private bodies; and
- the Integrated Catchment Management Program directed at the development and implementation of district and regional scale integrated management plans to ensure the proper management of resources.

The Country Towns Water Supply Improvement Program aims to deliver water of better quality to small rural communities which often lack the resources needed to ensure effective sewage and waste water treatment.

Biodiversity

Listed as one of the objectives of the draft *National Strategy for the Conservation of Australia's Biological Diversity* is 'achieving the conservation of biological diversity through the adoption of ecologically sustainable agricultural and pastoral management practices'.

Appropriate management of clearing, revegetation and remnant vegetation by the agricultural sector can play an important role in maintaining species diversity in Australia. In addition, there is the potential for the development of agricultural industries based on native species which are better adapted to the Australian environment. For example, perennial native grass pastures are expected to allow more consistent productivity in low rainfall grazing areas (Standing Committee on Agriculture 1991). The maintenance of native species diversity allows for such alternative farming options for the future.

Feral herbivores and domestic stock pose threats to biological diversity through their grazing of critical habitat and consequent degradation of drought refuges for native species (Bennett 1994) in Australia's rangelands. Feral pests such as foxes and cats subsequently put pressure on remnant populations. The 1992–93 Federal Budget provided the Australian Nature Conservation Agency with $1.5 million per year for the control of feral pests. In addition, the Prime Minister's Statement on the Environment, December 1992, pledged funding of $8 million over four years to develop a community education campaign on feral animals. Various Commonwealth initiatives are in place to reduce the impact of feral animals on agricultural production and native flora, fauna and ecosystems.

Greenhouse gas emissions

Part of the Commonwealth Government's 1992 National Greenhouse Response Strategy included an action to 'improve efficiency of energy use in agriculture through more efficient production and transport systems, environmental control in intensive animal and plant industries using alternative energy sources and location of processing operations in proximity to primary production areas.' A report prepared by the Commonwealth Department of Primary Industries and Energy noted that the potential exists to reduce annual greenhouse gas emissions by half a million tonnes or more of carbon dioxide through improved efficiency of such direct energy use in agriculture. Further to this, a reduction of two million tonnes or more may be achieved through minimum tillage practices with their subsequent reduced loss of soil organic matter.

Property Management Planning

This federally-funded campaign is part of the National Drought Policy and incorporates education and training of farmers and advisers in risk management, landcare and drought preparedness using a workshop-based approach.

RESEARCH AND DEVELOPMENT

The Standing Committee on Agriculture in 1991 emphasised the importance of 'effective well focussed research and development to ensure the sustainability of existing practices is fully assessed and further alternatives are developed'. The effort to conduct research and development with such a focus is largely undertaken by the Commonwealth Government and the State Governments. Table 7.18 presents ABS data on the expenditure and human resources devoted to research on primary production by various sectors.

7.18 GROSS EXPENDITURE AND HUMAN RESOURCES DEVOTED TO R&D ON PRIMARY PRODUCTION, 1992–93

	Plant production and primary products		*Animal production and primary products*		*Total*	
	Expen-diture	*Human resources*	*Expen-diture*	*Human resources*	*Expen-diture*	*Human resources*
Sector	$'000s	person years	$'000s	person years	$'000s	person years
General government						
Commonwealth	75 211	767	103 636	1 060	178 847	1 827
State	172 280	2 151	173 568	2 147	345 848	4 298
Total	247 491	2 918	277 204	3 207	524 695	6 125
Higher education	58 537	1 204	42 239	939	100 776	2 134
Business enterprises	45 428	388	25 906	198	71 334	586
Private non-profit	201	3	942	12	1,143	15
Total	**351 655**	**4 513**	**346 291**	**4 356**	**697 946**	**8 869**

Source: Australian Bureau of Statistics 1995.

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