Horticultural audit of production and sustainability

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Horticulture Australia Limited

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April 2000

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Summary

The horticultural industry operates in most catchments and climates that make up the Australian landscape. Both the environmental efficacy and economic viability of its production systems are integral components in sustaining our natural resources and in maintaining many regional communities.

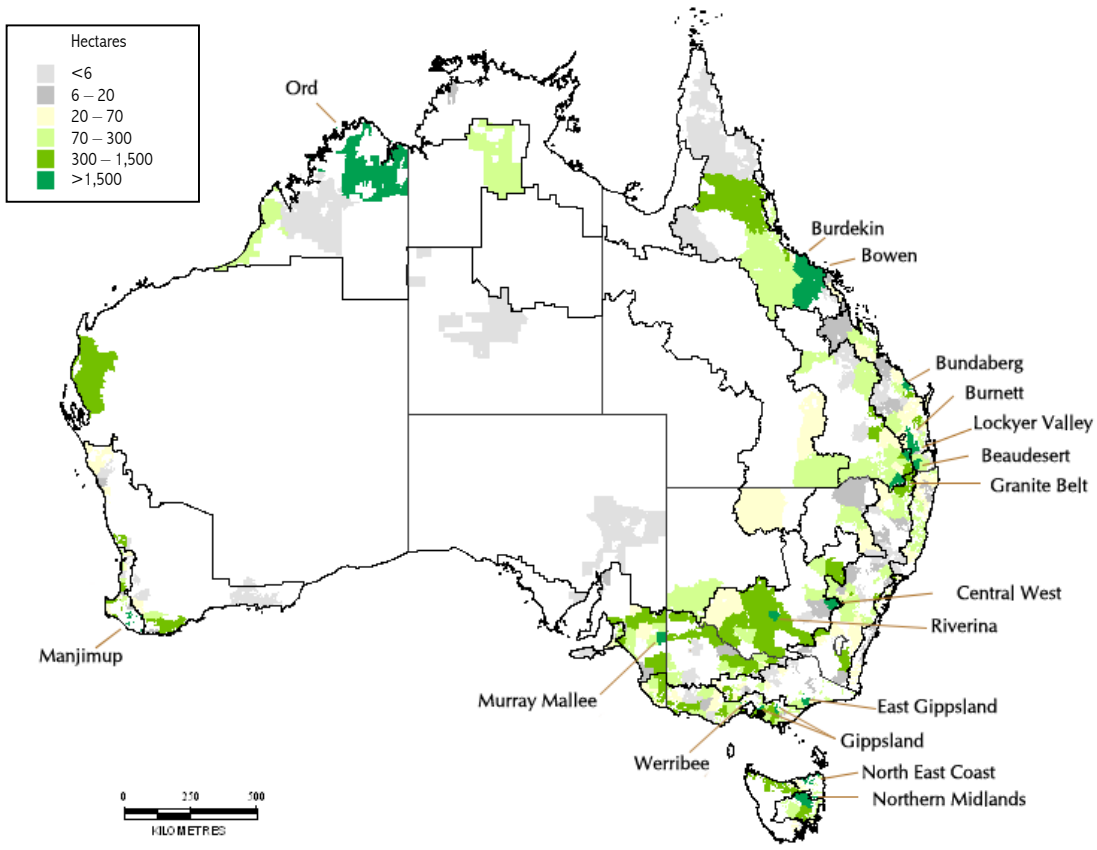
The Horticultural Research and Development Corporation together with the joint industry R&D Committee, AUSHORT commissioned this environmental audit of the horticultural industry. The National Land and Water Resources Audit (NLWRA) has also contributed funding and guidance to the project.

Scope of Audit

The horticulture industry comprises 80,000 enterprises across an intensive and diverse industry of over 100 crops types and employs 93,000 people. The second largest agricultural industry, horticulture in 1995/96 had a farm gate value of $3.1 billion (AHC, 1998) generated throughout the coastal regions of Queensland and New South Wales, the Murray Darling Basin, southern Victoria, central Tasmania, south east South Australia and pockets of Western Australia and the Northern Territory (Figures I and II). The industry is comprised of approximately two equal parts by value of production; annual and perennial crops.

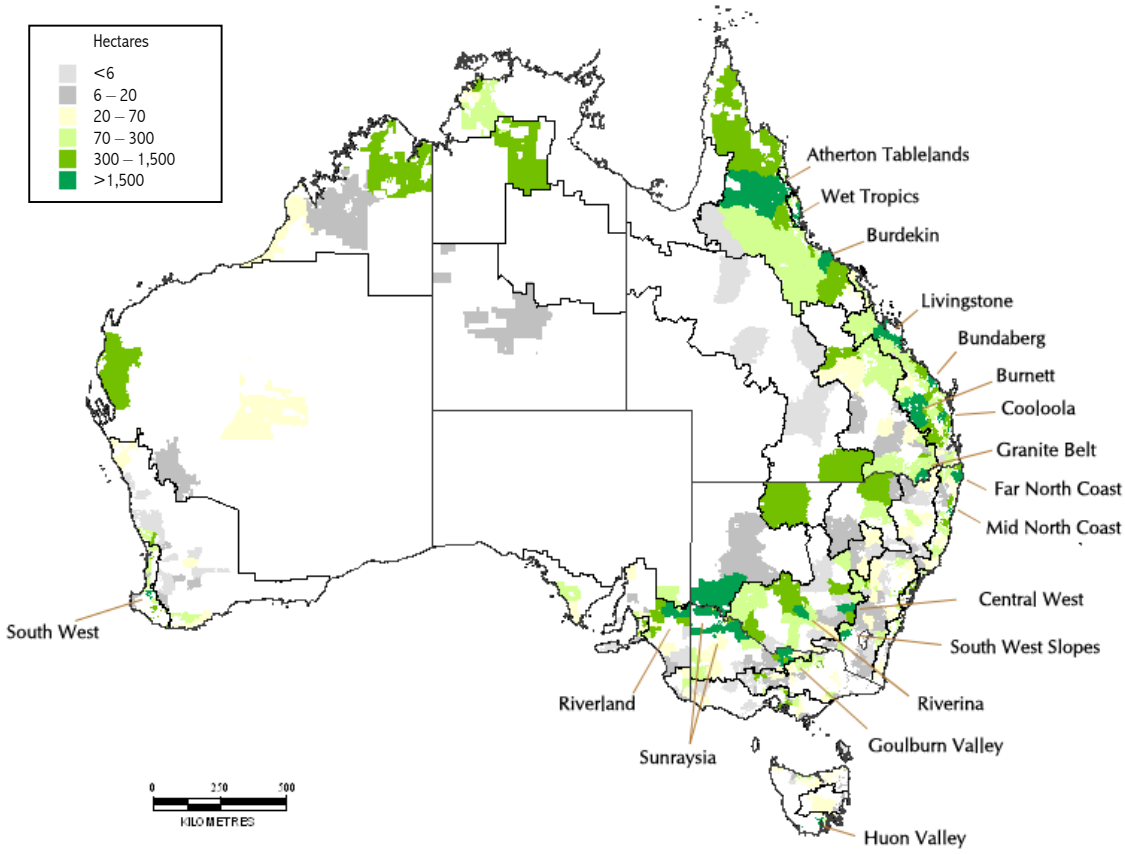
Areas of agricultural production in Australia can be grouped into 11 agro-ecological regions (AER) as identified by the Standing Committee on Agriculture (SCARM) (Figure 1.2). These regions define similarities in climate, landscape, geology and soil type. AERs are used as the basis for spatial and statistical regional assessment of industry and environmental indicators in this study.

Figure I Annual Horticultural Crops



Source: ABS *AgStats 1996-97.* with non-agricultural land mask from *Distribution of Agricultural Land Use in Australia* (BRS 1994).

Figure II Perennial Horticultural Crops



Source: ABS *AgStats 1996-97.* with non-agricultural land mask from *Distribution of Agricultural Land Use in Australia* (BRS 1994).

The crops included in Stage 1 of the environmental audit encompassed the major commercial annual and perennial crops (Table 1).

Table I Classification of Annual Crops

Annual Crop Groups	Crop Name
Beans and Peas	Beans - Broad, Beans – French & Runner , Peas-Green, Peas – Snow
Brassicas	Broccoli, Brussel Sprouts, Cabbages, Cauliflower, Chinese Cabbage,
Cucurbits	Cucumbers, Gherkins, Marrows and Squashes, Melons - Bitter, Pumpkins, Zucchini
Leaf Vegetable	Celery, Lettuce & French Endive, Silverbeet & Spinach
Melons	Melons – Other, Melons - Rock, Melons – Water
Nurseries	Nurseries
Onions and Garlic	Garlic, Leeks, Spring Onions, White & Brown Onions
Peppers	Capsicum / Chilli
Potatoes	Potatoes
Root Vegetable	Beetroot, Carrots, Parsnips, Radish, Swedes, Sweet Potatoes, Turnips
Sweet Corn	Sweet Corn
Tomatoes	Tomatoes – Fresh & Processing

Table II Classification of Perennial Crops

Perennial Crop Groups	Crop Name
Asparagus	Asparagus
Bananas	Bananas
Berry Fruit	Blackcurrants, Blueberries, Gooseberries, Loganberries, Raspberries, Strawberries
Citrus	Grapefruit, Lemon/Lime, Mandarins, Oranges, Tangelos
Nuts	Almonds, Cashews, Chestnuts, Hazelnuts, Macadamia, Pecans, Pistachios, Walnuts
Pome Fruit	Apples, Nashi, Pears
Pyrethrum	Pyrethrum
Stone Fruit	Apricots, Cherries, Nectarines, Peacharines, Peaches, Plums & Prunes
Tropical Fruit	Avocados, Carambola, Custard Apples, Guava, Jackfruit, Longans, Lychees, Mangoes, Papaws, Passionfruit, Pineapples, Rambutan

Approach and Methodology

The environmental audit focussed on the production end of the value chain for three reasons:

- this is the primary interface with the soils, water and air resources;
- the bulk of industry people are employed in the farming process; and
- the management of environmental performance must occur at farm level.

A four stage methodology was undertaken by the study team comprising: comprehensive written surveys and interviews of relevant State Agencies; written surveys to a representative sample of 100 Growers nationally; desk research of existing databases and research held or underway by industry bodies and associations, and relevant State and Federal Agencies; and an expert panel interview process.

A lack of industry data relating to environmental impact at regional level required primary research to be undertaken through Grower and State Agency surveys. As part of the survey, respondents were asked to rate the status/significance (low, medium and high) of 15 environmental indicators, and identify the trend (improving, no change or deteriorating) for those indicators. A number was then assigned to each environmental status (Low = 1, Medium = 2, High = 3) and trend (improving = 1, no change = 0, deteriorating = -1) rating. A weighted average response was then calculated for status and trend with respect to each environmental indicator. Outcomes of the survey process were assessed in conjunction with supporting industry environmental and industry data, which were then crosschecked through the expert panel interview process. An experienced industry Steering Committee guided the work of the study over a 12-month period.

National Environmental Indicators

The survey found that the process of improving environmental performance is under way across all crop groups. Importantly, industry changes are being driven by new and revised Codes of Practice (eg. best management practices and quality assurance standards), an increasing focus on integrated solutions to pest and disease management, improvements to the structure, management and planning of organisations, greater investment in environmental R&D projects on an enterprise and regional basis, and specific development of industry awareness programs. Not all crop groups and regions are progressing at the same rate, and the larger professionally managed groups are typically further advanced than others. But the process of cultural change and improved environmental performance is evolutionary by nature. At the moment, there appears to be few strong signals for improved environmental management coming from the marketplace, and little from legislation. As these signals strengthen, incentive for Grower adoption will increase.

Weakness in environmental performance relate to poor linkages between programs (particularly R&D and Codes), the generally poor and inadequate industry databases to monitor environmental and economic performance, and the lack of resources and skills in some crop groups, especially the smaller ones, to adopt better practices. Perennial crops are generally better prepared for improved environmental performance than annual crop sectors.

The survey also assessed the status and trend in natural resource condition both on farm and within the industry and on the external environment and other stakeholders.

Of the 15 environmental indicators assessed, State Agencies and Growers concurred strongly on the high priority indicators, as follows:

Table III The Top 5 Environmental Indicators Identified from the Surveys

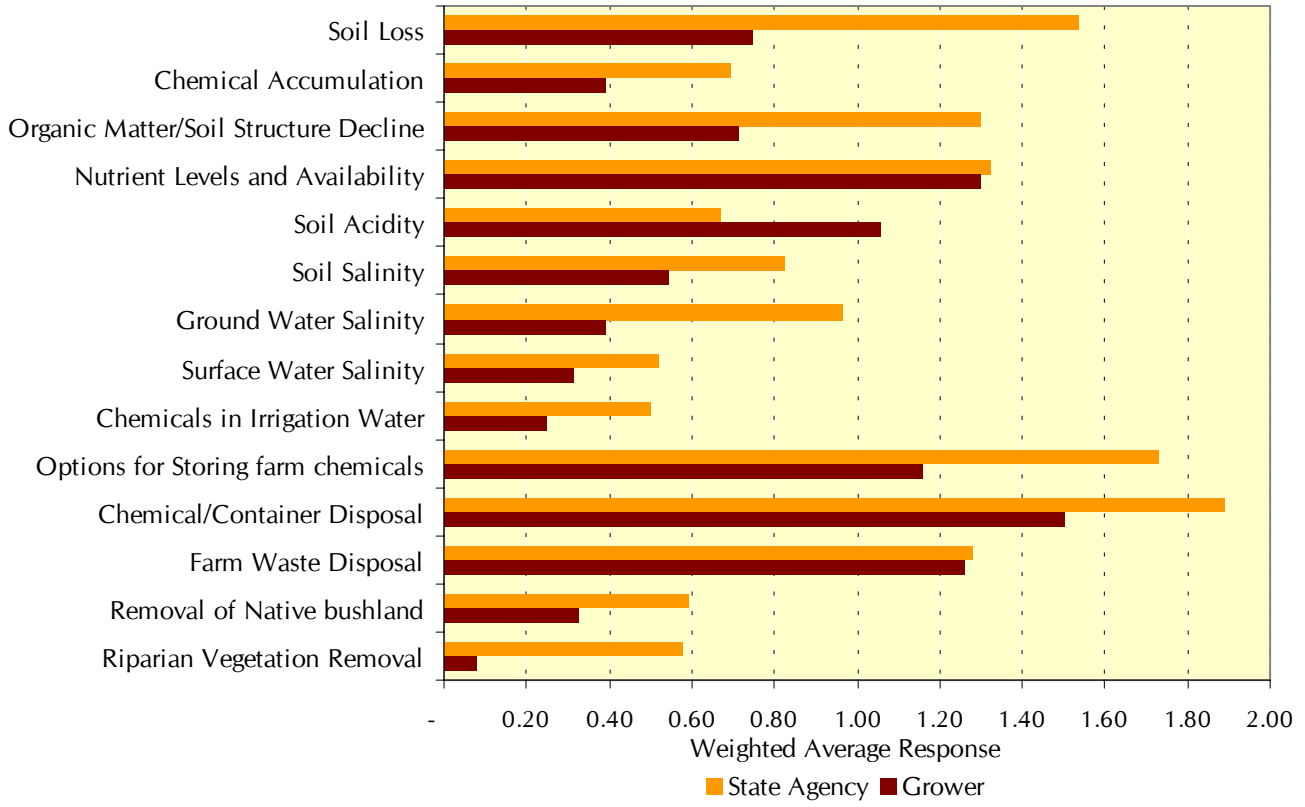
Rank	State Agency	Grower
1	Chemical/Container Disposal	Chemical/Container Disposal
2	Options for Storing Farm Chemicals	Soil Nutrient Levels and Availability
3	Soil Loss	Farm Waste Disposal
4	Soil Nutrient Levels and Availability	Options for Storing Farm Chemicals
5	Organic Matter/Soil Structure Decline	Soil Acidity

Source: Survey Data, 1999

While there is broad stakeholder agreement on the priority indicators, considerable variance exists in the perceived occurrence and severity of horticultural impacts across the national landscape (Figure III).

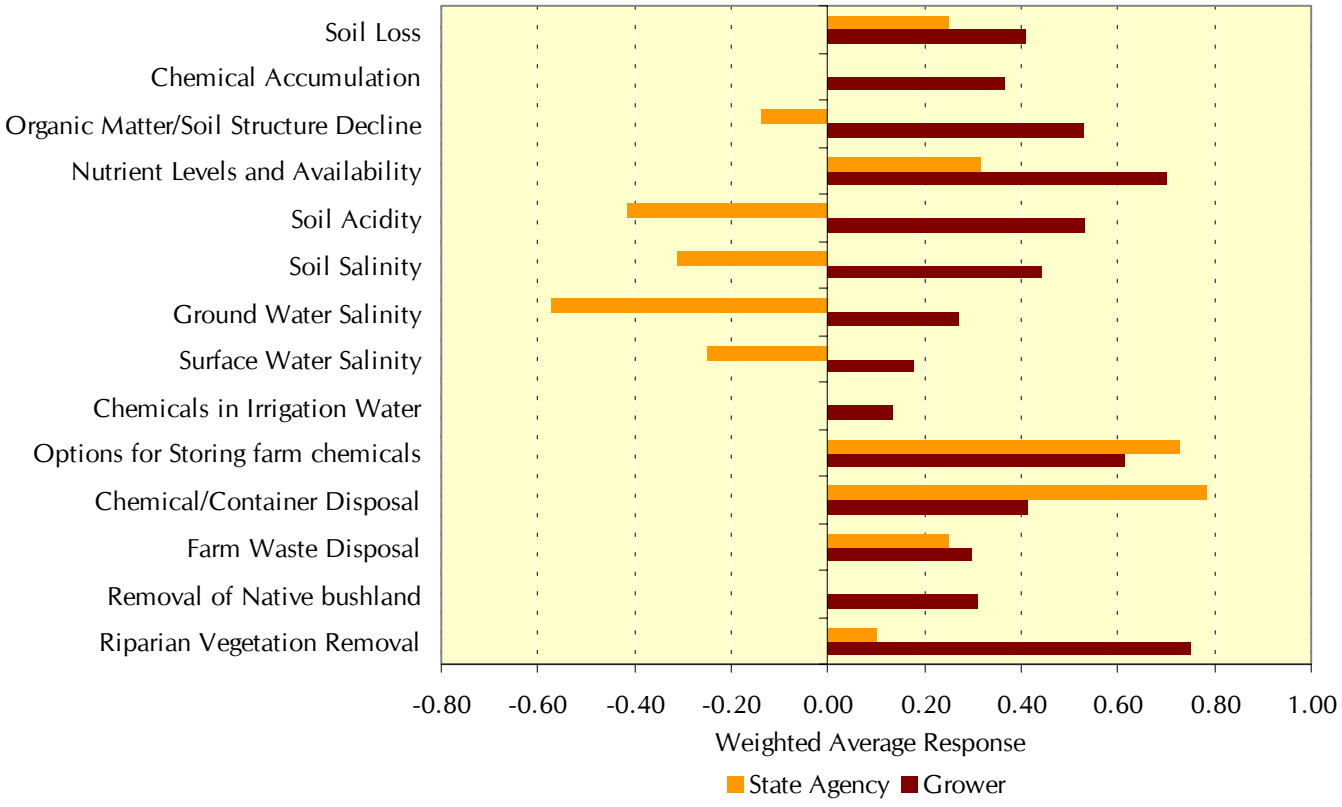
This consultation process also identified that State Agencies consider some environmental indicators to be deteriorating, while Growers recognise no deterioration across any indicators surveyed (Figure IV).

Figure III Comparison of the Status of Environmental Indicators



Source: Survey Data, 1999

Figure IV Comparison of Trend in Environmental Indicators



Source: Survey Data, 1999

Regional Environmental Indicators

Survey responses identified key environmental indicators on both a regional and Agro-ecological Region (AER) basis including improving or deteriorating environmental trends. Grower and State agency responses varied from region to region.

Soil loss for example, was considered an important indicator in most production regions of Queensland, Tasmania, Victoria and the Northern Territory. Soil loss in the production regions within the temperate highlands and north coast wet/dry tropics was considered to be increasing whereas other regions identified a reduced incidence of soil loss.

Similarly, chemicals in irrigation water was identified as an indicator by most Growers and State Agencies in Queensland's far north, the Moreton region of southern Queensland, Victoria's south region and the Sunraysia region. Growers identified the indicator as improving whereas State Agencies identified deterioration on the wet temperate coasts.

Growers did not consider any environmental indicators to be deteriorating. State Agencies, on the other hand, noted a number of situations where environmental indicators are deteriorating, identifying 6 regions where environmental indicators were considered to be of high importance and to be deteriorating:

- Queensland Far North region - organic matter/soil structure decline (AER 4).
- Queensland Moreton region - organic matter/soil structure decline and Nutrient levels and availability (AER 7).
- South Victoria region - organic matter/soil structure decline (AER 8).
- New South Wales Western region - salt accumulation in soil (AER 10).
- South Australia Murray Lands region - ground water salinity levels (AER 10).
- Victoria Sunraysia region - salt accumulation in soil and soil salinity levels (AER 10).

Desk Research

Limited data is held by Growers or industry associations to support the responses received from the survey process. State Agencies hold some data but it is region specific, and not easily mapped according to Agro-ecological Region (AERs) or Statistical Local Area (SLAs). This is a major constraint in data management and interpretation, and it severely limits the effectiveness of industry and regional environmental planning.

Extensive desk research has identified a number of horticultural projects that address environmental impacts. These are detailed in the full report.

The development and implementation of environmental Codes of Practice and QA systems, and the inclusion of environmental indicators in strategic planning are becoming more common. Most industries have some coverage of environmental management issues. However, water management appears to be an issue that has been neglected by industry plans. While improved industry planning in environmental management remains a need, a greater challenge for industry is to encourage more monitoring by Growers so that environmental change can be measured. This is critical to achieving real practice change.

Evidence of historical and ongoing research across the majority of environmental indicators was found. The majority of research is directed at soil issues, namely soil loss, chemical accumulation in the soil, organic matter and soil structure decline, nutrient levels and availability, and soil acidity.

Integrated pest and disease management research is currently in progress in the majority of larger horticulture industries. This indicates that horticultural industries are seeking better alternatives to traditional pest and disease management practices. Other areas of research include spray management and waste disposal. Generally there was less evidence of horticultural specific research of water, salt, salinity and riparian issues, but considerable work in these areas is covered on a catchment basis by programs managed by national research agencies. Horticultural research institutions should continue to improve research linkages to these national programs.

Industry Development and Sustainability

As a means of crosschecking primary and secondary data, independent experts were interviewed by telephone about the main elements affecting the continued environmental performance of the horticulture industry.

These were identified as:

- meeting market requirements for product specifications, food safety, residues and quality;
- establishing environmental credentials with overseas clients;
- the need to recognise environmental management as an issue;
- the capability of the industry to remain viable amid world market liberalisation; and
- the capacity of industry to measure environmental performance effectively at farm level.

Some specific items of concern included tree clearing guidelines, chemicals and the ongoing impact of salinity.

The expert panel suggested that the horticultural industry's rating on environmental performance is comparable with other agricultural industries. It is generally ahead of other industries on QA issues and on a par with other industries for environmental management practice. However, its fragmented and multi-commodity nature creates some commercial barriers for wholesale introduction of environmental initiatives. Variation between states in legislative requirements and political climate inhibits a national approach to better environmental performance, but this is not confined to horticulture alone.

Other findings of desk research suggest that the implementation of sustainable environmental management indicators will require a substantial cultural change among managers. Low membership of industry organisations is a major limitation that creates difficulties for promoting a shift in thinking.

Future expansion of the industry is considered to be constrained by access to viable markets more than by environmental limitations. Accountability for food safety and environmental compliance will be increasingly important to future markets, however, the complexity of industry organisational structures inhibits close liaison and coordinated planning. Both of these structural constraints are currently being resolved by industry.

Natural resources were not recognised as a major constraint to industry development, but access to resources, especially water, is considered to be the key risk for all of agriculture, including horticulture. In this regard horticulture is very resource competitive based on its capacity to use water efficiently and its economic viability relative to other lower value industries.

Sustainable industry expansion in the future will be based on market requirements, and access to water resources. The scale of horticultural investments will likely be larger in the future as technology and plant breeding become completely integrated with consumer markets and supply chains serving dedicated domestic and export markets. Given that the existing horticultural industry is equivalent to an area approximately 50 km by 50 km (roughly the area of the ACT), land will not be a limiting factor. However, wherever expansion occurs it will probably be achieved through the reallocation of existing agricultural land based on higher marginal returns, rather than virgin clearing of new land.

Technology is increasingly important to expansion of agriculture, including horticulture. Not only does technology provide rapid access to information on markets and innovations; but Growers are increasingly using technology to assist in improving management and environmental practice by monitoring crop yield, water use efficiency, soil health, spray applications, waste stream reuse, impacts on neighbours and the environment, and employee productivity.

Concluding Comments

Horticultural production can result in on site and off site impacts, both on farm and at catchment level, which require short, medium and long term amelioration strategies. These issues are quite complex and dynamic; effective management requires a more integrated planning approach by industry jointly with regional communities, Government and other stakeholder industries.

To effectively address these issues the management of environmental performance must be addressed at both a strategic level and at operational level, according to the source of environmental risks, and the location and severity of impacts. Strategic issues will require more time and industry planning to implement. Operational issues will focus more on the enterprise or farm level and can be initiated through increased Grower affiliation and adoption of relevant Codes of Practice, and Good Management Practices.

National improvement will result from a bottom up approach driven by change at the enterprise level by motivated farmers and employees. Formal research and development in environmental issues is increasing, but it is at an early stage in evolutionary terms. R&D has a clear role in guiding and continuing to support this evolutionary process, but it must be have strong links to industry organisations and Growers, similar programs across other agricultural industries, and collaborative environmental R&D programs at catchment level, to deliver long term environmental sustainability across Horticultural industries.

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1 Introduction

1.1 The Need for this Study

1.1.1 Horticultural Industry Impact

Horticulture is a major industry across the Australian landscape. The horticultural industry is the second largest agricultural industry after wheat, and in 1996 had a Gross Value of Production (GVP) of $3.8 billion, and a farm gate value of $3.1 billion (AHC, 1998).

In developing this study the consulting team considered the need to establish the scale of the horticultural industry relative to other large agricultural resource based industries sharing the same landscapes. The following points give some context within which these industries operate:

- In simple terms the horticultural industry is a cropping business with an area (2,972 sq km or 297,224 ha) a little larger than the Australian Capital Territory, or alternately, the industry is only 65 percent of the area of greater Brisbane (population 1.3 million).
- For the year ending June 1996, horticultural industries used 1,640 GL of water, a volume equivalent to 3.25 times that of Sydney Harbour. In 2020 it is projected that the industry usage will have increased by around 60 percent to 2,600 GL, or 5.16 times Sydney Harbour.
- The cotton industry (3,039 sq km) covered an area roughly equivalent to horticulture (2,972 sq km) but consumed 25 percent more water than horticulture. The value of horticulture at the farm gate ($3.1 billion) was more than three times the value of ginned cotton.

Structurally, the industry is more complex and diverse than other rural industries. It comprises around 130 produce sectors (eg, bananas, tomatoes, nuts, etc) located across numerous soil types, landforms, water catchments, rural and semiurban environments and climates. A further complication is that the industry produces both annual and perennial crops and operates according to the various resource management laws of the eight members of the Council of Australian Governments (COAG).

The impact of the horticultural industry on the soils, water, air and species in our natural resource base, both on and off farm, is therefore potentially complex and substantial.

1.1.2 Sustainability Must be Managed

Community awareness is increasing regarding the impact that agriculture has on the environment. This presents industry with the challenge to identify, document, measure and manage its impacts going forward. The core of the matter is to encourage individual farming and processing enterprises to implement new measures, practices and systems that are both sustainable and profitable on and off farm.

Horticultural industry and the Horticultural Research and Development Corporation (HRDC) have commissioned this study to document its use of natural resources, assess current impacts and practices where possible, and determine the need to move to a more sustainable basis. The industry's complexity and spatial distribution, and some reticence to share relevant information are difficulties addressed in the study. The findings of this study are to be interpreted in the context of the industry's current and long-term economic and natural resource management performance, potential production capacity and potential benefits to the Australian economy and community, and in relation to the environmental management of other rural industries.

1.2 Methodology

This study was conducted to gain a better understanding of the environmental impacts of horticultural industry in Australia. The study draws together two components:

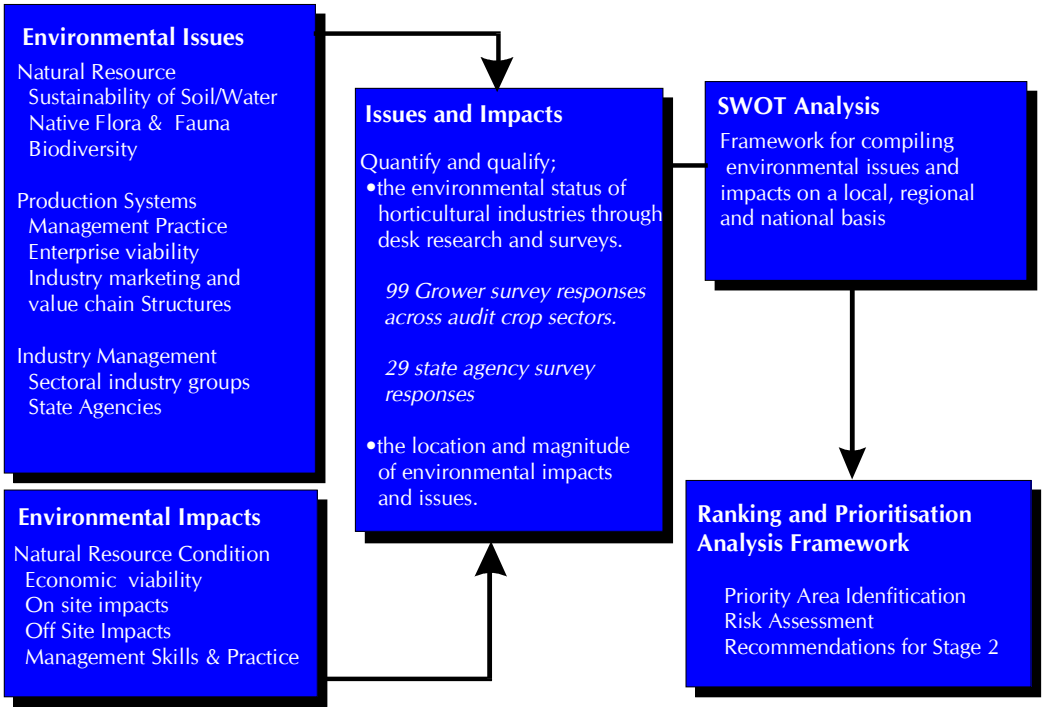
1. a detailed knowledge of the Australian natural resource base, and
2. a detailed knowledge of the horticultural industry, by sector, including enterprise and regional economics, employment and the skills base, resource management policy and on-farm practices.

Data collection and analyses were based on reasonably coarse category classifications to enable spatial location identification, impact analysis on a number of resource elements and their attendant sustainability indicators, and interpretation by industry.

The output of this process is to include the production of electronic data sets to be used by the horticultural industry and the National Land and Water Resource Audit (NLWRA) to guide industry and agricultural policy and future qualitative and quantitative assessment and research of environmental degradation. This additional knowledge and policy implication assessment will enable, Stage 2 of the study to develop and expand on particular impacts and conclusions through a series of selected case studies.

The consulting team developed the methodology illustrated in Figure 1.1.

Figure 1.1 Project Methodology



1.2.1 Rationale

The Terms of Reference require that the project "document the use of natural resources by Australian horticulture, assess the extent of current impacts on those resources, both positive and negative, and assess industry's current adoption of good management practices and its need to move to a more sustainable basis".

To achieve this objective a combination of spatial and statistical analysis, desk research and surveys of key industry players and State Agencies was undertaken to produce a profile of the horticultural environment, production systems and management practice. Other data relating to natural resource condition were assessed to determine the current status and the trend across various environmental indicators relating to soils, water, biodiversity, air and noise, waste and contamination. Assessment of the use of external production system inputs in conjunction with resource management practices assists in explaining the linkages of industry processes to the resource base. Key points from this analysis were compiled into a comprehensive environmental SWOT analysis for horticulture, providing the basis for priority development for the ongoing management of the natural resources in horticulture.

1.2.2 Data Sources and Constraints

Stage 1 of the Terms of Reference envisaged the use of existing data sources to establish a profile of horticultural industry in Australia. No new data generation was to be undertaken. The consulting team has confirmed the existence of a large volume of data on the natural resource base (climate, soils, landforms and biodiveristy), and agricultural logistics and demographics, however this data is generally not related specifically to horticultural industry. Even less information is available on a sectoral basis, and most industry associations do not hold information relevant to the objectives of this study. This is a recognised constraint to developing valuable conclusions on the use of natural resources by horticultural industry, and on short and long-term environmental and economic impact.

Information is variously held in printed and electronic form (written, tabular and graphic) by governments, both State (Departments of Agriculture and Natural Resources) and Federal (BRS, ABS, ABARE etc), and research agencies such as the CSIRO. A considerable body of historical and ongoing horticulture-specific research relevant to improving environmental management practices has also been documented. These data sets and existing reports have been accessed where commercially available, and where relevant to the study.

Commodity statistics cited in this report are sourced from the Australian Bureau of Statistics (ABS) AgStats Database 1996-1997 (Small Area Agricultural Commodity Data 1996/1997) which provides data drawn from the Agricultural Census conducted by ABS for the year ended March 31, 1997 (ABS, 1997). Data are represented by Statistical Local Areas (SLA), however regional and crop-specific lack of response by Growers to the Census is a known, and significant weakness of the dataset. The Australian Standard Geographical Classification - 1216.0 (1998) defines the SLA as a general purpose spatial unit. "It is the base spatial unit used to collect and disseminate statistics other than those collected from the Population Censuses. In non-census years, the SLA is the smallest defined unit. In census years, an SLA consists of one or more whole collection districts. SLAs cover the whole of Australia without gaps or overlaps."

The boundaries for classification of survey responses and regional assessment of industry and environmental indicators are defined as 11 agro-ecological regions (AER) as identified by the Standing Committee on Agriculture and Resource Management (SCARM) (Figure 1.2). These regions define similarities in climate, landscape, geology and soil type.

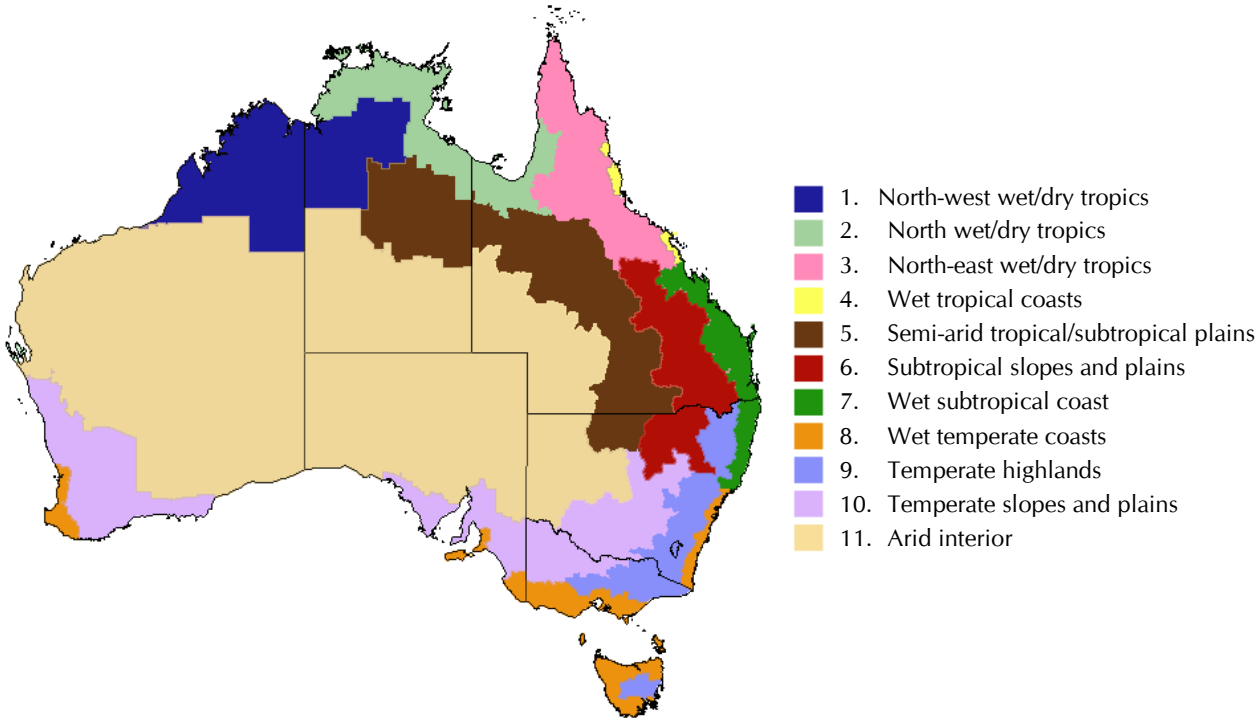
Crop density and irrigation distribution maps were derived from ABS AgStats 1996/1997 data and represent the percentage of total crop area within each SLA. Areas of non-agricultural land were excluded using masks derived from the *Distribution of Agricultural Land Use in Australia* data set (1994), held by the Bureau of Rural Sciences. The coverage in its native format shows the distribution of agricultural and non-agricultural land use in Australia at a nominal scale of 1:5 million, based on the 1993 AUSLIG Land Tenure map. Non-agricultural areas include all public

land (including national parks, forestry reserves etc), except for some of the areas termed, "Other crown land" and "Vacant crown land" that have been included as agricultural land based on information from States. Aboriginal land (freehold, leasehold and crown land reserved for aboriginal people) has been classified partly as non-agricultural land and partly as agricultural land, and is based on information provided by each State.

Metadata for all data collected and generated in the project has been recorded to enable future traceability.

This Report goes beyond the audit requirements of Stage 1. The consulting team is of the view that Stage 2 and all subsequent derivative policy implications and assessments will be constrained, if not flawed, unless the initial data sets and impact interpretations are based on comprehensive and quantifiable inputs in Stage 1.

Figure 1.2 Agro-Ecological Regions of Australia



Source: SCARM, 1998

1.2.3 Industry Survey Process

The deficiency in industry and sectoral data was largely overcome by comprehensive written surveys of industry enterprises across 81 key horticultural sectors. The remaining 50 or so sectors were discounted due to their small size or relatively insignificant interaction with the resource base. Surveys were also developed and documented for all State and Territory Governments, and a selection of horticultural processing enterprises.

The survey is limited in its capacity to yield concrete inferences regarding the use of natural resources due to sample size constraints (135 responses from 484 surveys sent). However, it assists in providing indicative insights into natural resource management in horticulture. Survey responses should be interpreted as perceptions of natural resource condition only, however the outcomes do provide indications of where environmental indicators might be more significant. State Agency regional based surveys have been compared to Grower responses where possible to provide a balanced perspective on all indicators.

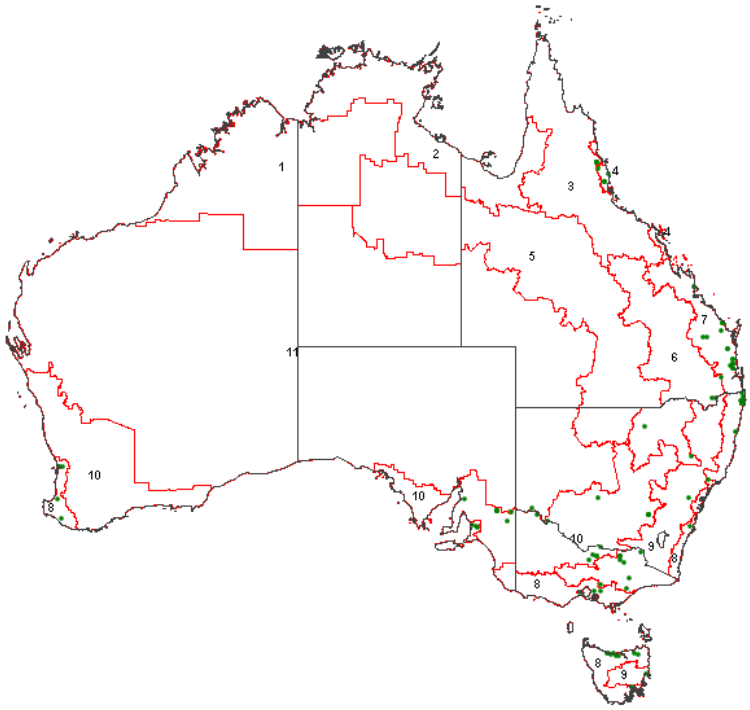
Survey information on horticultural production and environmental and resource management indicators were distributed to Growers (both directly, or via industry organisations), processors and State Agencies. Examples of the surveys are attached in Appendices 2 to 5. A total of 484 surveys were distributed, 410 to Growers (including nurseries), 16 to processors and 58 to State Agencies (Table 1.1). Processors, and fruit, nut and nursery Growers were contacted directly by the consulting team, and surveys were sent following communication. Of the 268 surveys distributed to vegetable and pyrethrum Growers, 194 were sent via industry organisations, and the remainder were sent directly to Growers contacted by the consulting team. With the exception of nursery Growers, response rates were significantly higher where the consulting team contacted Growers directly (56 percent for the fruit and nut sector and 44 percent for processors) (Table 1.1). Only 8 percent of vegetable Growers responded to the survey (Table 1.1).

Figure 1.3 below shows the geographical distribution of survey respondents. Eighty five percent of respondents are located in AERs 7 – 10 (Table 1.2), which together represent around 80 percent of the area and value of both annual and perennial horticultural production. Around 60 percent of all responses were from the tropical fruit, nut, potato and berry fruit industries (Table 2.1) which together represent 33 percent of the area and 23 percent of the value of horticultural production.

The sampling strategy for Growers targeted larger, progressive production and processing operations so as to document each industry response as efficiently as possible. As a result, information presented in this report is likely to be skewed in favour of a more positive outlook with regard to resource use and management and the environmental status of horticulture than would otherwise be the case in a broader based survey.

State Agencies were targeted to provide a broader view on regional environmental conditions, however no information was provided by Western Australian State Agencies for this purpose.

Figure 1.3 Locations of Growers Surveyed



Source: Survey Data, 1999.

Table 1.1 Number of Surveys Sent and Received

Survey Group	No. Surveys Sent	No. Surveys Received	% Response
Growers (Fruit)	135	76	56
Growers (Vegetable and Pyrethrum)	268	22	8
Nurseries	7	1	14
Processors	16	7	44
State Agencies	58	29	50
Total	484	135	28

Table 1.2 AER Distribution of Different Crops Grown by Survey Respondents

Crop Group	1 North-west wet/dry tropics	2 North wet/dry tropics	3 North-east wet/dry tropics	4 Wet tropical coasts	5 Semi-arid tropical/ subtropical plains	6 Subtropical slopes and plains	7 Wet subtropical coast	8 Wet temperate coasts	9 Temperate highlands	10 Temperate slopes and plains	11 Arid interior	Grand Total
Asparagus							1					1
Bananas				3			2					5
Berry Fruit								8		2		10
Citrus							1			5	1	7
Leaf Vegetable						1		1		1		3
Melons						1				1		2
Nurseries										1		1
Nuts				1			7	1	6	2		17
Onions and Garlic						2		1	1	1		5
Pome Fruit								1	1	4		6
Potatoes								9	2	1		12
Pyrethrum								1				1
Stone Fruit							3	1		3		7
Tomatoes							1					1
Tropical Fruit			5			1	14	1				21
Total	**0**	**0**	**5**	**4**	**0**	**5**	**29**	**24**	**10**	**21**	**1**	**99**

Source: Project Survey Data, 1999.

1.3 Report Structure

The report is based on 5 steps to achieve agreed project outcomes. These are:

Section 2: To develop a profile of the Australian Horticultural industry;

Section 3: To document the status and trend in natural resource condition;

Section 4: Resource Management Practice and Issues;

Section 5: Strategic and SWOT analysis;

Section 6: Horticultural Environmental Priorities, and;

Section 2 presents an overview of horticultural crop sectors grouped and analysed to determine the location, volume and density of production on an agro-ecological region basis. The analyses assesses the contribution of horticulture from an environmental context by documenting the environmental characteristics in the main growing regions for each crop group, including growing conditions, climate, soils and landforms. Consideration is also given to the export market exposure of horticultural products to determine the export contributions as a percentage of annual crop production. Gross margins were also assessed to provide a view of an approximate range of gross returns across various industries. Likely future changes to industry structure were examined in view of changes to global competitive positions and environmental resource management. Industry employment trends were also assessed as part of the profile.

Outputs from Section 2:

- documentation of a crop group profile consisting of economic and environmental characteristics described within defined agro-ecological boundaries;
- contribution of horticulture to the Australian economy;
- export status and industry trends in horticulture;
- gross returns of crops across different regions;
- industry structure and future likely trends, and;
- employment trends.

Section 3 outlines the current perceived status and trend in natural resource condition of the horticultural environment in terms of soils, water, biodiversity, air and noise, waste and contamination. This Section relies on survey data and desk research to determine the relative importance of key environmental management indicators across agro-ecological boundaries, and where possible interpretations have been regionalised within AERs to State Agency regional boundary level.

External inputs were assessed using survey data and desk research, to document the relative application of fertilisers and chemicals (insecticides, fungicides and herbicides) on horticultural crops. Irrigation data was then analysed to determine the current and future water use trends, irrigation techniques in use, volume of water applied to crops, water use by crop group, sources of irrigation water, water quality and irrigation timing and storage. Residues in horticultural products were then assessed to determine the extent of residue contamination. Section 3 concludes with a summary of environmental indicators by region to allow Growers to identify key regional environmental indicators.

Outputs from Section 3:

- Documentation of the status and trend of natural resource condition from survey responses and desk research;
- An assessment of the effects of external inputs on natural resources;
- Documentation of horticulture's performance in water management and usage,and;
- Summary of environmental indicators for major horticultural regions.

Section 4 commences with an analysis of industry based research and development plans, and the development of Codes of Practice. Environmental indicators were then assessed by documenting historical and on going research into environmental resource management practices. Attention is directed to assessing the capacity of horticultural industries to implement industry best practice supported by relevant case studies. Managerial skills in horticulture are assessed in this Section, complemented by further assessment of industry training, education levels, quality assurance and participation levels in resource management programs.

Outputs from Section 4 are:

- Analysis of current status of industry management and its capacity to plan, develop, and implement sustainable resource management practices, and;
- Analysis of available and ongoing research to address key environmental indicators.

Section 5 presents a SWOT analysis, which takes all key points from the report to provide a summary of environmental indicators and impacts facing horticulture. Strengths, Weaknesses, Opportunities and Threats were also documented together with supporting actions to manage these indicators.

Outputs from Section 5 are:

- Key strategic environmental indicators affecting horticulture, and;
- Environmental SWOT analysis of Australian horticulture.

Section 6 details the implications of environmental impacts for horticultural industries, and concludes with the identified environmental priorities across key strategic planning areas.

2 Australian Horticultural Industry Profile

2.1 Horticultural Industries Investigated

This project investigates the productivity and sustainability of 81 different horticultural industries operating across Australia. These industries comprise vegetables, fruits, nuts, pyrethrum and nursery products for vegetable, fruit and nut production (Table 2.1).

For analytical purposes these 81 industries are examined as groups based on crop species, crop physiology and climatic distribution similarities. There are 21 different crop groups (Table 2.1). Crop groups are also characterised by similarities in management practice, seasonal production cycle and environmental requirements, and are further grouped into annual and perennial categories.

Table 2.1 Horticultural Industries Investigated

Category	Crop Group	Crop Name
Annual	Beans and Peas	Beans - Broad, Beans - French&Runner (incl. Seed), Peas-Green (incl.Seed), Peas - Snow
Annual	Brassicas	Broccoli, Brussel Sprouts, Cabbages, Cauliflower (incl. Seed), Chinese Cabbage (incl. Seed),
Annual	Cucurbits	Cucumbers, Gherkins, Marrows and Squashes, Melons - Bitter, Pumpkins (incl. Seed), Zucchini
Annual	Leaf Vegetable	Celery, Lettuce & French Endive, Silverbeet & Spinach
Annual	Melons	Melons - Other, Melons - Rock, Melons - Water
Annual	Nurseries	Nurseries – Vegetables, Fruit and Nut
Annual	Onions and Garlic	Garlic, Leeks, Onions - Spring, Onions - White & Brown, Onions - Seed
Annual	Peppers	Capsicum / Chilli
Annual	Potatoes	Potatoes (incl. Seed)
Annual	Root Vegetable	Beetroot, Carrots (incl. Seed), Parsnips, Radish (incl. Seed), Swedes, Sweet Potatoes, Turnips
Annual	Sweet Corn	Sweet Corn
Annual	Tomatoes	Tomatoes - Fresh & Processing
Perennial	Asparagus	Asparagus
Perennial	Bananas	Bananas
Perennial	Berry Fruit	Blackcurrants, Blueberries, Gooseberries, Loganberries, Raspberries, Strawberries
Perennial	Citrus	Grapefruit, Lemon/Lime, Mandarins, Oranges, Tangelos
Perennial	Nuts	Almonds, Cashews, Chestnuts, Hazelnuts, Macadamia, Pecans, Pistachios, Walnuts
Perennial	Pome Fruit	Apples, Nashi, Pears
Perennial	Pyrethrum	Pyrethrum
Perennial	Stone Fruit	Apricots, Cherries, Nectarines, Peacharines, Peaches, Plums & Prunes
Perennial	Tropical Fruit	Avocados, Carambola, Custard Apples, Guava, Jackfruit, Longans, Lychees, Mangoes, Papaws, Passionfruit, Pineapples, Rambutan

2.2 Horticulture and the Australian Economy

2.2.1 Contribution to the Australian Economy

Horticultural production areas are geographically aligned to regional areas and are generally labour intensive. The horticultural industry contributes significantly to socio-economic imperatives associated with maintaining employment in regional Australia. Employment contributions by horticulture are likely to rise in the future as innovation in the development of value added products become increasingly important in parallel with the growth in processed food and beverage products.

In order to sustain existing growth and to capitalise on future opportunities, the projected economic contributions must be balanced with broader environmental resource management objectives. Sustainable industry management is potentially the most limiting factor to the future of cropping industries. Horticultural in conjunction with other broadacre land users must be responsible to ensure that on farm activities are sustainable so greater contributions to the economy, society and the environment can be achieved.

In dollar terms, the gross value of production (GVP) of the horticultural industry in Australia in 1995/96 was $3.8 billion. The farm gate value of production for the same period was $3.1 billion. This comprised vegetables ($1.3 b), fruit and nuts ($1.2 b) and nursery production ($0.6 b) (AHC, 1998). From the 1988/89 to 1995/96, average per capita consumption of fruit increased from 89 to 101 kg per person whilst average per capita consumption of vegetables increased from 148 to 163 kg per person (AHC, 1998).

The labour intensive nature of horticulture highlights its importance in sustaining regional employment.

2.2.2 Contribution to Balance of Trade

Total horticultural exports for the financial year 1996/97 was $577 M, an increase of 4 percent over the previous year (AHC, 1998). Australia exports a variety of horticultural products to the world. Table 2.2 presents export market statistics and major destinations for crops included in the project. The top 5 Australian horticulture crop exports for 1996-97 in descending order were citrus ($138.5 M), asparagus ($30.4 M), carrots ($29.8 M), pears ($29.8 M), mangoes ($29.8 M), and apples($28 M).

Of the annual crops, chinese cabbage, cauliflower, onions and carrots supply the largest proportion of product to export markets (Figure 2.1) and asparagus, strawberries, citrus, plums/prunes are the largest perennial export crops (Figure 2.2). Negative export market growth was evident in many crops between financial years 1996/97 and 1997/98. Strawberries experienced a large fall of 70 percent in export market volumes followed by apricots, which experienced a 64 percent fall. Favourable export market conditions were evident for nectarines which achieved a 202 percent increase in export volumes followed by nashi with an increase of 145 percent.

Table 2.2 Major Export Market Destinations, Volume and Value of Exports and Export Market Growth for Selected Crops.

Crop	Export Volume (Tonnes)	% of Total Prod'n	Export Value ($M)	Export Market Growth (%) F97 - F98	Major Market Destinations
Citrus	143,330	22.2	138.5	-3.6	Malaysia, Singapore, U.S.A., Hong Kong
Asparagus	5,210	66.1	30.4	6.2	Japan, Singapore, Taiwan, Hong Kong
Carrots	44,901	17.4	29.8	19.2	Malaysia, Singapore, Hong Kong
Pears	23,432	14.0	29.8	-11.5	Singapore, Malaysia
Apples	24,811	3.2	28.0	45.3	Malaysia, Singapore, U.K., Phillipines
Cauliflower	19,357	30.1	25.2	-10.5	Malaysia, Singapore, Hong Kong
Broccoli	7,942	19.6	16.2	17.4	Singapore, Malaysia, Japan, Hong Kong, Taiwan
Strawberries	3,930	35.0	12.6	-69.9	Hong Kong, Singapore, Malaysia, United Arab Emirates, U.K.
Plums and Prunes	5,357	21.3	11.9	0.4	Hong Kong, Singapore, Taiwan
Melons	9,090	18.8	11.6	36.1	Hong Kong, New Zealand, Singapore
Onions - White and Brown	36,993	18.8	11.5	37	Germany, U.K., Japan, France
Mangoes	3,793	11.7	10.5	20.7	Hong Kong, Singapore, Japan
Macadamia	2,290	14.3	9.2	-10.1	Hong Kong, China, U.S.A.
Potatoes	17,807	1.4	7.4	-15	Korea, Singapore, Malaysia, Papua New Guinea
Chinese Cabbage	4,693	44.3	4.9	9.7	Hong Kong, Singapore, Taiwan
Cherries	906	13.6	4.3	13.4	Hong Kong, Taiwan
Cabbages	2,970	4.9	2.6	-22.6	Japan, Indonesia, Taiwan, Hong Kong
Celery	2,505	5.6	2.0	39.9	Malaysia, Singapore, Taiwan
Beetroot	1,540	5.3	1.9	0.32	U.K., Hong Kong, New Zealand
Peaches	703	1.0	1.9	-11.7	Singapore, United Arab Emirates
Capsicum / Chilli	589	1.8	1.6	25.6	New Zealand
Nectarines	668	3.1	1.6	202.5	Taiwan, Hong Kong
French and Runner Beans	646	1.7	1.4	-9.4	New Zealand
Nashi	323	5.4	0.9	144.6	Singapore, Malaysia
Bananas	502	0.3	0.7	93.8	Indonesia, Japan, New Zealand
Brussel Sprouts	391	6.9	0.6	-33.2	New Zealand, Singapore
Apricots	281	1.1	0.6	-64.1	Hong Kong, United Arab Emirates
Avocados	122	0.6	0.4	64	Singapore, United Arab Emirates, Hong Kong
Cucumbers	178	1.1	0.4	102.81	New Zealand
Pineapples	384	0.3	0.2	-2.1	New Zealand
Chestnuts	19	3.6	0.1	-45.3	Thailand, Japan

Source: AHC, 1999

Figure 2.1 Percentage of Production Supplied to Domestic and Export Markets – Annual Crops

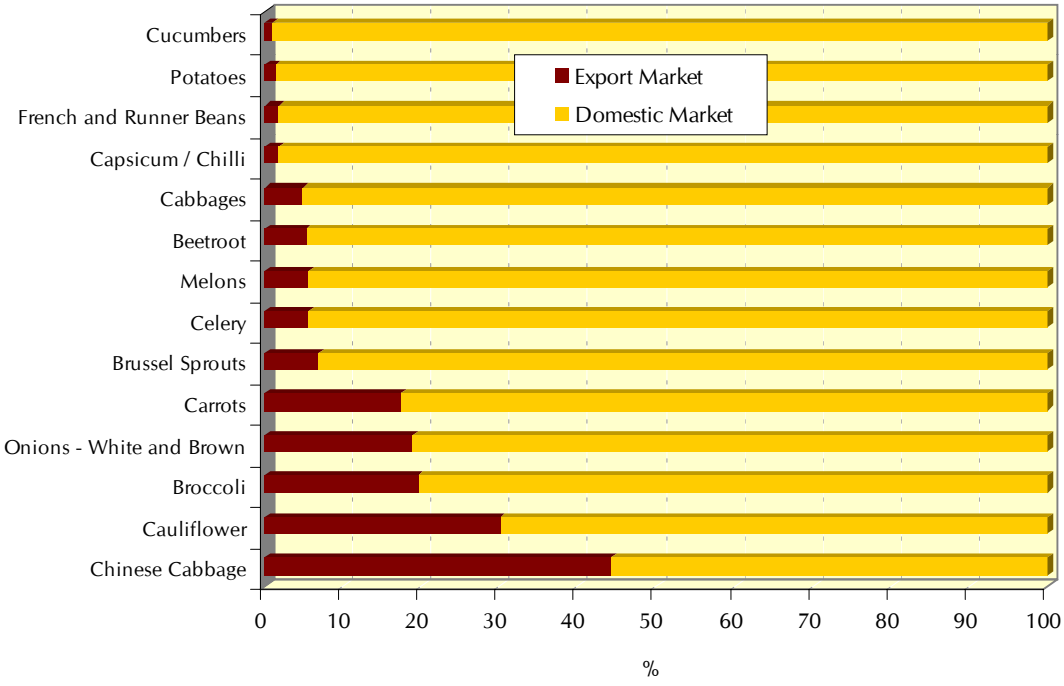
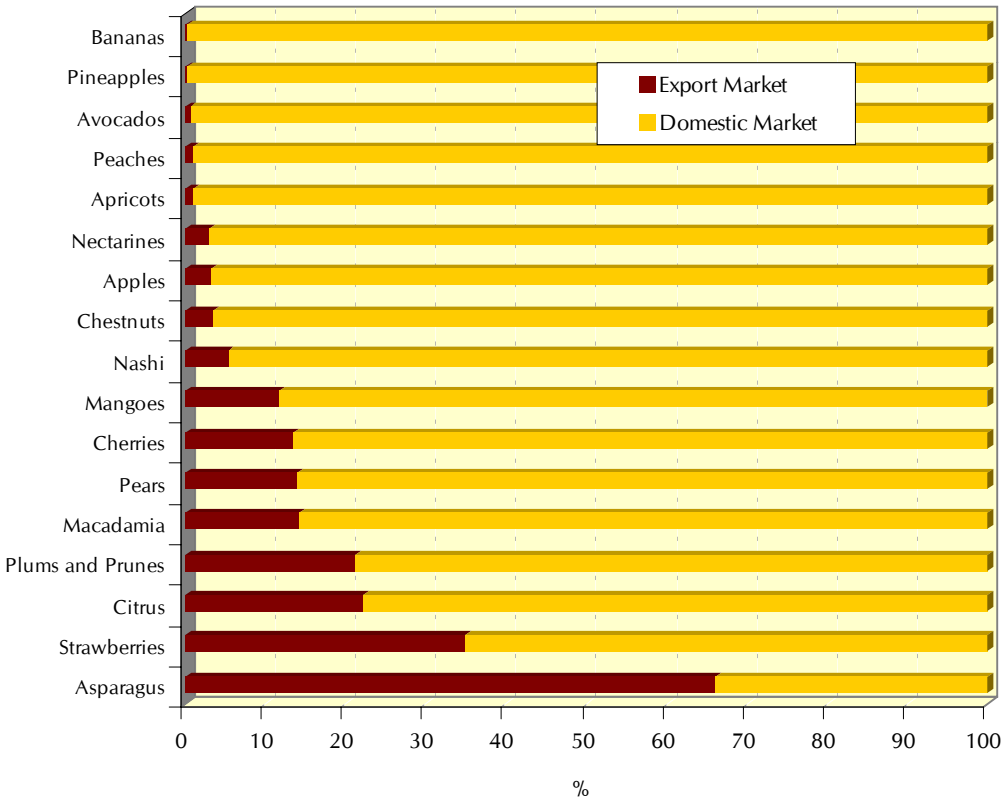


Figure 2.2 Percentage of Production Supplied to Domestic and Export Markets – Perennial Crops



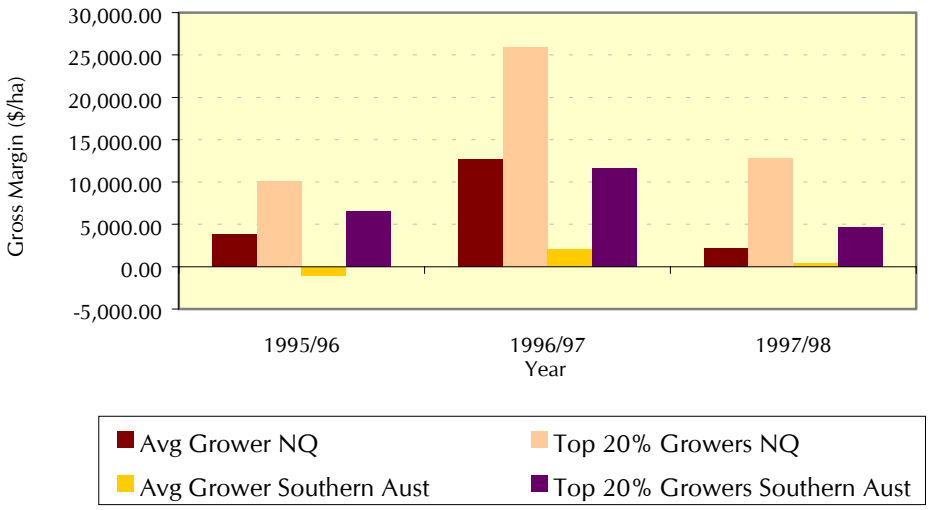
Source: ABS, 1997 and AHC, 1999 (Export Market Data).

2.2.3 Gross Margins

Gross margin analysis at production level is not commonly performed or recorded in the horticultural industry. However many regional agencies do provide gross margin models for various crops to assist Growers to determine cropping requirements and calculate profitability (Appendix 7).

Where gross margin information does exist, it is generally not benchmarked across industries, regions or time scales. Some exceptions include the banana, citrus, apple and pear industries. The Australian Banana Growers Council for example has produced a gross margin comparison for banana production in 4 different regions across three seasons. This gross margin comparison is illustrated in Figure 2.3, and demonstrates potential regional variation in crop returns.

Figure 2.3 Comparison of Banana Gross Margins for North Queensland and Southern Australia



Source: Australian Banana Growers Council

Gross margin analysis is critical to enterprise viability, today and in planning for tomorrow. However it is the cost and revenue breakdowns in a gross margin that will reveal the environmental costs and impacts over time. For example the return per megalitre of water can be monitored to expand on the physical assessment of water use efficiency (yield per megalitre). Similar and more detailed analysis are possible based on the use of other natural resources and artificial inputs. This study finds little evidence to indicate that this type of resource efficiency analysis is widely practiced by horticultural production enterprises.

2.2.4 Industry Structure and Growth

Although the Australian horticultural industry is a significant contributor to the Australian economy in terms of the gross value of production and employment in both rural and urban regions, it faces many challenges that are not apparent in other industries. The horticultural industry is a collection of many crop sectors that vary substantially in critical mass of production and geographic distribution. It is therefore a challenge to manage these industries in a cohesive manner due to differences in levels of industry development, location, planning and strategic priorities.

Organisational structures within the industry are typically arranged by crop (e.g. Bananas, tomatoes) or in crop groups (e.g. pome fruit, nuts, citrus, berryfruit). Crop specific organisations are increasingly emerging as markets focus on individual species while crop groups have greater critical mass. The organisational structure of small crops (e.g. cucurbits, asparagus) is less well-developed. This lack of effective organisational and administrative structure tends to constrain sectoral development.

Other agencies variously support horticultural industry organisations. The National Farmers Federation (NFF) with a national office and state offices has a charter across agriculture. Federal Government Departments, ABARE, BRS, CSIRO, ABS and others undertake research and/or hold broadscale data relevant to horticulture. State governments maintain some data and support research and extension, although the latter role is changing in focus. Other state based agencies variously exist to support horticulture and manage political issues. Previously some representative bodies have had a statutory charter (e.g. Queensland Fruit and Vegetable Growers) specifically related to horticulture however requirements of National Competition Policy require that these bodies become industry based, while others are broadly focussed across agriculture (e.g. Farmers' and Grazier Associations).

Industry information systems are generally fragmented and difficult to access. During this study extensive consultation of industry groups and State agencies was undertaken to collect industry data and additional contacts. The experience of the project team was that quality information is not collected or is not available at the industry organisation level, particularly financial and economic performance data. Although most industry groups were pleased to support the project, the quality of environmental and economic information across horticultural industry groups was generally poor.

From a global perspective, crowding of markets is occurring across the world due to a more liberal free trading environment. This trend results in the consumer gaining more power and global supply chains and processes are becoming increasingly demand driven. Increased competition and an increasingly discerning and demanding consumer are making differentiation, on a global scale, essential to achieve sustainable global competitiveness. Sustainable global competitiveness will only be achieved in the future through the effective participation in global chains. The collaborative strength of the chain will be the source of competitive strength for individual organisations (Pinnacle, 1998).

Trends in modern food production systems continue to confirm the growth in horticultural exports. Cross border supply chains will become more common place. Growth of large domestic retail structures and the integration of these structures towards the farm gate have necessitated the need to manage food safety risk through quality assurance and best practice protocols. Adoption of good environmental practice is growing but is limited by industry fragmentation and economic constraints. The progressive development and introduction of quality assurance and marketing systems that place a value on good environmental practice will hasten broad based best practice adoption. It is through these supply chains that best practice systems will be adopted if not mandated. The evolutionary changes to the industry will lead to better balance between business viability and improvements in the natural resource management.

2.2.5 Employment in Horticultural Industries

Horticultural production in Australia is dominated by small-scale family operations. The industries are labour intensive, but the requirements for labour input are seasonal in nature. Around 80,000 Growers are engaged in horticultural production, with a further 11,500 employed in fruit and vegetable processing (Horticulture Australia, 1995).

Employment in agriculture has remained relatively stable over the last three years (Table 2.3), however over the last 3 decades there has been a large decrease in agricultural workforce numbers. The replacement of labour through the development and application of new technologies is a significant factor influencing the change in employment levels, as are market price fluctuations, and reduced access to services in regional areas.

Value adding generally assists in improving employment opportunities, however extensive value adding is less likely to occur in the production sector as the marketing chain is dominated by fresh produce. In isolation, value adding is unlikely to assist in the maintenance or expansion of rural communities, however, as part of any wider regional development program, it will most likely be a major contributor to employment and wealth generation.

Table 2.3 Employment in Agriculture and Services to Agriculture in 1995, 1996 and 1997.

Category	1995 ('000)	1996 ('000)	1997 ('000)
Males	256.4	272.9	268.9
Females	121.8	123.9	125.6
Total	378.4	396.8	394.5

Source: AHC

Data providing a sectoral breakdown and analysis of employment across horticulture is not available. Employer/employee productivity and cost is a critical issue in such a labour intensive industry and its absence is a significant constraint to a full understanding of the quantum, analysis of efficiency, skills retention, and review of potential on site impacts. A relevant factor for example is the significant number of horticultural farm workers who are transient low skill tourists and holiday visitors.

2.3 Legislative Framework Affecting Horticulture

The horticultural industry, as part of the Australian agricultural sector, operates within a myriad of legislative frameworks. The aims of the environmental legislation are to set up administrative structures to protect the public interest in the maintenance of environmental quality for both present and future generations. The public interest issues that affect the horticultural industry include:

- protection of public health and safety,
- allocation of property rights and access,
- limiting or eliminating environmental impacts,
- conserving biodiversity, and
- enhancing productivity/ sustainability.

Regulations typically provide the mechanisms to enforce the legislation.

2.3.1 Levels of Statutes

There are four distinct levels of statute that apply to Australian agricultural industry and to the horticultural industry. These statute levels are:

1. International,
2. Commonwealth,
3. State, and
4. Local government.

International

Australia is a signatory to a number of international treaties and conventions that will likely have some impact on the horticultural industry. The prominent conventions are:

- The Stockholm Declaration on the Human Environment 1972
- Convention for the Protection of the World's Cultural and Natural Heritage 1972
- World Conservation Strategy: Living Resource Conservation for Sustainable Development 1980
- The Montreal Protocol on Substances that Deplete the Ozone Layer 1987
- Convention on the Transboundary Movements of Hazardous Wastes and their Disposal (Basel Convention) 1989
- The Framework Convention on Climate Change 1992
- The Rio Declaration on Environment and Development 1992
- Convention on Biological Diversity 1992
- Framework Convention on Climate Change 1992
- Convention on Combating Desertification in those Countries Experiencing Serious Drought and/or Desertification, particularly in Africa (1994)

These conventions need to be taken into account when planning industry directions.

Commonwealth

The Commonwealth intervenes in matters related to most agricultural industries via its financial powers such as taxation, grants to the States, and duties of custom and excise. Horticulture industry products and enterprises are subject to federal corporations, trade and commerce powers that potentially allow intervention to regulate production, processing, marketing and exports. The Australian Quarantine Inspection Service (AQIS) is an example of an institution with such powers.

The Intergovernmental Agreement on the Environment (IGAE) nominates the following Commonwealth responsibilities and interests:

- ensuring policies or practices of one State do not result in significant adverse external effects on another;
- facilitating co-operative development of national environmental standards and guidelines, and;
- coordinating of nature conservation across all jurisdictions.

State

States generally have responsibility for the development and implementation of environmental policy matters. Schedule 2 (4) of the IGAE specifies that the "development and administration of the policy and legislative framework will remain the responsibility of the States and Local Government." The majority of agricultural legislation is therefore within the power of each State.

Environmental issues included in State legislation include:

- use and distribution of chemicals;
- soil conservation;

- native vegetation clearing;
- pollution;
- catchment management, and;
- rivers and water use.

Local Government

Local governments manage environmental and planning issues from legislation delivered from the State level. The IGAE states that local government is responsible for regional and local issues but with cooperation from State Agencies. For example, town planning laws of each State are enforced at local government level. These laws are the main focus of local environmental legislation and need to be considered in any local industry planning.

2.3.2 Implications for Horticulture

The horticulture industry is operating within a legislative environment that is increasingly complex. This complexity is occurring largely in response to greater flows of products , by-products, waste streams and funds across regional, state and national boundaries. The environmental building blocks for the industry are foot prints of landforms, microclimates and soil types that do not fit neatly into state or regional borders. Water courses and rivers flow across or traverse regional and state borders. The challenge facing legislators and industry is to strike a balance between competing land uses, risks of off site impacts and on farm operations. Some of the issues that have legislative support and need to be considered by industry include:

- management of conflicting land uses;
- spraying of chemical insecticides, and;
- natural resource access and allocation.

At the ***global trade level***, legislative implications for horticulture are that national governments will be increasingly under market access pressure to comply with international sustainability (e.g global warming) and trade regimes mandating import and environmental protocols. Foreign consumer power in international trade is increasing significantly (eg. the current debate regarding GMO's (genetically modified organisms)). The horticultural industry which forms part of Australia's highly export intensive agricultural economy, must observe and respond to this trend if it is to maintain both market access in dominant northern hemisphere markets, and viable industries at home.

At the ***national level***, Australia's governments will continue to balance the political mood of voters regarding the health of the environment, against the social and economic viability driven by profitable businesses employing people. That is the political challenge, and it prescribes a dynamic legislative environment for the Federation and the States.

In addition, the roles of national and state governments are changing as resource use (eg. COAG water reform), national pest and disease management (eg. pest incursions from fire blight and fruit fly), domestic marketing and industry management issues (eg. National Competition Policy, labelling of genetically modified foods, etc), and the competitive implications of economic status/decisions of our major trading partners and competitors in export markets (eg. market collapses in key Asian economies and currency fluctuations). The policy framework for natural resource management will, therefore, increasingly be a joint effort by national and state governments. The National role will be to lead and coordinate the policy framework, while the states will focus on issue development, local interpretation and compliance.

At the ***state level***, governments have the power to prepare and implement land and water resources legislation and policies. Legislative developments in the areas of water resource diversion and development, land management and its effects on water quality, application of agricultural pesticides and vegetation protection through tree clearing guidelines will impact on horticultural operations and decisions. In addition, the withdrawal over the last decade of

traditional government extension services to agricultural industries will result in increasing "user pays" services.

At the ***industry level***, horticultural industry groups will seek to gain leverage over the natural resource agenda for their members. To achieve this they will, and increasingly are, establishing national peak sectoral bodies and regional associations run by professional executives to manage off-farm issues. The need for these structure is now recognised by the bulk of producers. Such organisational development has been standard practice across other agricultural industries for decades but it is only in the last ten years that many of the horticultural sectoral commodities have sought to move to national management structures (eg. melons, strawberries, mangoes, passionfruit, lychees, nursery). The impact of legislative changes at the national level has directed horticultural industries to collectively manage for today and plan for the future. While change will continue at the margin (eg. HRDC and AHC merging) ongoing legislative changes will continue to be driven through national structures and legislative frameworks by the global and international imperatives and industry / community issues.

At the ***enterprise level*** most farmers see the benefits in collective action and, usually, collective investment through voluntary administrative and research levies. Access to professional advice on both production and natural resource matters is critical to partially replace the traditional extension services withdrawn by governments, but also to give producers the information needed to manage a viable sustainable horticultural business.

In addition to the market driven imperatives of returns, costs and labour, farmers must actively pursue and improve market access, water access, and legislative change. Collective action is the most cost-effective way to progress the latter three issues.

But the ultimate benefit to farmers including horticulturists, in securing industry friendly legislation is in maintaining the right to farm. Societal norms are shifting – the community will only allow rural industries to access the natural and human resource base if their stewardship meets agreed environmental sustainability standards. The Grower survey conducted for this study confirms that the issue of chemical contamination of the resource base is the top priority for most Growers. And horticultural producers are increasingly aware that the best way to meet community expectations and maintain a viable and sustainable farm is to support their national industry bodies in a dialogue that results in acceptable legislation.

Key Points

- **Horticulture is a large industry spread across the nation's arable landscape. It is a major contributor to the national economy, but occupies only a small part of the total land area used for agriculture.**
- **Crops are disparately fragmented across the nation, thereby constraining the development of effective industry associations.**
- **Limited employment data is available for horticultural industries specifically.**
- **Economic/financial and environmental priorities need to be balanced.**
- **It is necessary to measure both financial/economic and environmental performance to effectively monitor the benefits and costs of environmental management change. Ongoing financial benchmarking is occurring in the Citrus, Pome Fruit and Banana industries, but the measurement of environmental performance on farm should be promoted.**
- **There is a lack of administrative, environmental, economic and employment data across most horticultural sectors. Without a formal management framework it will not be possible to manage environmental impacts effectively.**
- **Legislation impacting horticulture is increasing beyond the control of individual enterprises and crop groups. Larger better managed organisational structures are emerging.**

2.4 Industry Distribution and Performance

Horticulture is Australia's second largest agricultural industry in terms of gross value of production generating $3.7 billion annually. However it is an intensive industry with a land use area comprising less than 3 percent of the total area of land used for agricultural production (ABS, 1997).

Analysis of the distribution, land use area, volume and value of production of the 81 different horticultural crops investigated in this study was undertaken using data sourced from the ABS AgStats 1996/1997 database, and is data collected by the ABS Agricultural Census for the year ended March 1997. Data were accessed from all SLAs and were aggregated to AER level for reporting. Spatial distribution and cropping density was mapped by SLA with non-agricultural area land masks sourced from *Distribution of Agricultural Land Use in Australia* (BRS, 1994).

Land use area for crops considered in this study totals 273,372 hectares and was approximately equal for annual and perennial crops (Table 2.4). Gross annual production was 5,280,667 tonnes with annual crops yielding 943,627 tonnes more product than perennial crops (Table 2.4). The gross value of production at farm gate was $3,624 million with annual crops generating $186 million more than perennial crops (Table 2.4).

Horticultural production occurs across a wide range of environmental conditions, however distribution is restricted primarily by access to water, either from natural rainfall or irrigation, quality of soils and topographical features. The major growing regions are concentrated in fertile areas with high annual precipitation or abundant water resources from rivers, streams or reticulated irrigation scheme areas. A considerable volume of irrigation water is provided from domestic supplies of cities and towns, and this supports a high concentration of vegetable (annual) crop production in settled areas.

The largest areas of horticultural production are located the temperate slopes and plains agro-ecological region (78,486 hectares) (Table 2.4) and are concentrated predominantly in the Murray-Darling Basin (Figure 2.4). Perennial crop production is greater than annual crop production in this AER and is valued at $628m annually (Table 2.4). The wet temperate coast AER is the largest annual crop-growing region with 51,357 hectares devoted to production, and a total value at farm gate of $736m (Table 2.4).

In Queensland, the major areas of horticultural production are the Atherton Tablelands region, the Wet Tropics around the towns of Cardwell, Innisfail and Tully where perennial crop production is dominant (Figure 2.6), the dry tropics region between Townsville and Bowen, the Rockhampton region, the Burnett from Bundaberg to Kingaroy, the Lockyer Valley where annual crops are mainly produced (Figure 2.5), and the Stanthorpe region in the Granite Belt.

The Riverina district within the Murrumbidgee Irrigation Area supports a large horticultural industry in N.S.W. The upper Sunraysia area around Wentworth, Young, Cowra, Tumut and Batlow, and the North Coast region around Lismore are other key production regions.

In Victoria, production is associated with intensive irrigation schemes, particularly the Riverland district along the Murray, the Sunraysia area around Mildura, and the Goulburn Valley region. Werribee and the Gippsland region in southern Victoria are other major growing regions supporting predominantly annual crop production (Figure 2.5).

In South Australia, the Riverland along the Murray River, and the Lower South East are dominant production regions. Perennial crop production is dominant in these regions (Figure 2.6).

The Huon Valley in Tasmania supports a large perennial crop industry (Figure 2.6). The North-East Coast and Northern Midlands are the largest annual crop-growing regions in this state (Figure 2.5).

The Manjimup and Donnybrook areas in the south, the regions around Perth and Gin Gin, the Carnarvon / Gascoyne region on the mid-west coast and the Kununurra region around the Ord River Irrigation Area comprise Western Australia's largest horticultural production regions. The production of annual crops is significantly larger than perennial crops in Kununurra.

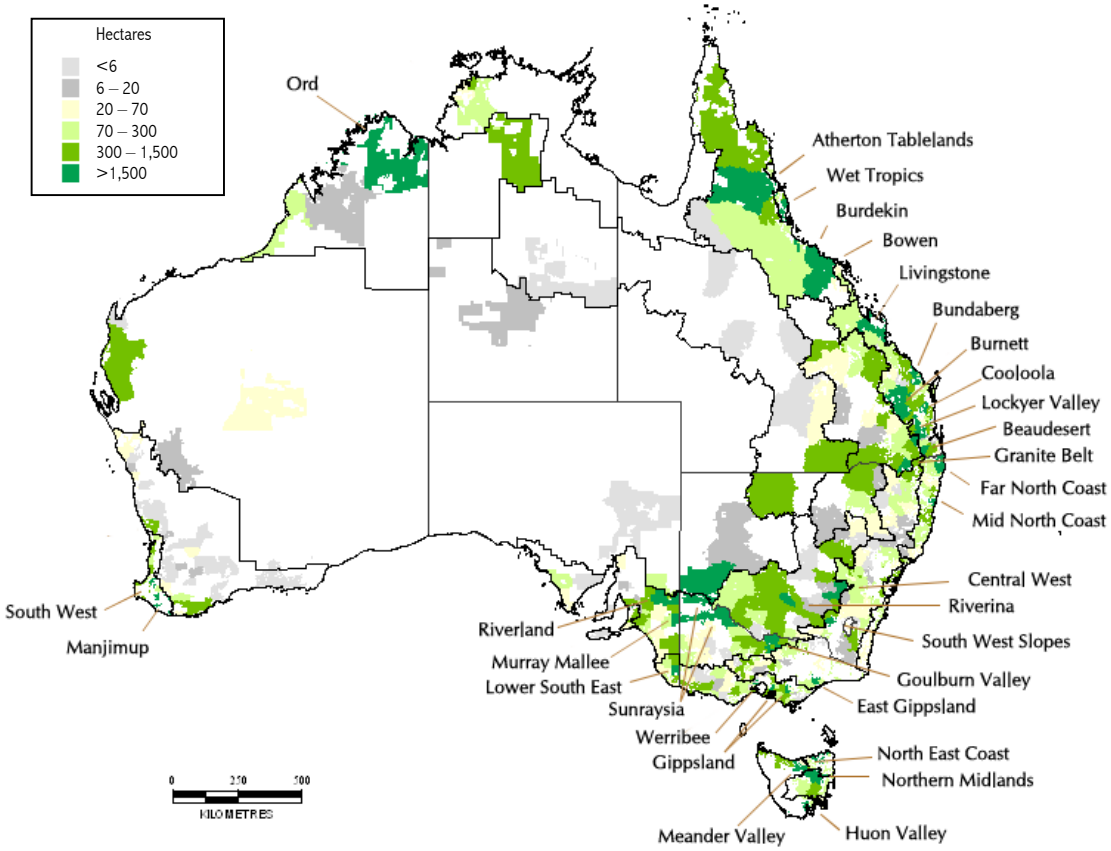
Production in the Northern Territory totals only 2,109 hectares and is located mainly around Darwin, and the Katherine region.

Table 2.4 Gross Area, Volume and Value of Production of Annual and Perennial Crops in AERs

	Area (Ha)		Yield (Tonnes)		Value ($M)	
Agro-Ecological Region	Annual	Perennial	Annual	Perennial	Annual	Perennial
North-west wet/dry tropics	2,094	966	42,405	6,070	30.1	12.4
North wet/dry tropics	71	1,221	516	5,122	3.1	9.7
North-east wet/dry tropics	9,461	8,128	159,559	34,331	143.0	57.4
Wet tropical coasts	1,409	8,509	23,137	144,766	32.6	147.8
Semi-arid tropical/subtropical plains	198	68	5,243	435	3.4	0.5
Subtropical slopes and plains	9,729	5,549	189,032	79,054	122.1	54.6
Wet subtropical coast	16,872	32,502	274,294	264,268	273.2	290.9
Wet temperate coasts	51,357	18,337	1,267,799	401,262	736.3	303.3
Temperate highlands	14,314	9,709	260,274	257,700	162.5	159.2
Temperate slopes and plains	30,550	47,936	875,035	904,671	387.2	628.1
Arid interior	734	3,660	14,882	70,871	12.0	55.2
Total	136,787	136,585	3,112,177	2,168,550	$1,905	$1,719

Source: ABS, 1997

Figure 2.4 Distribution and Density of Horticultural Production



Source: ABS *AgStats 1996-97.* with non-agricultural land mask from *Distribution of Agricultural Land Use in Australia* (BRS 1994).

Figure 2.5 Distribution and Density of Annual Crop Production.

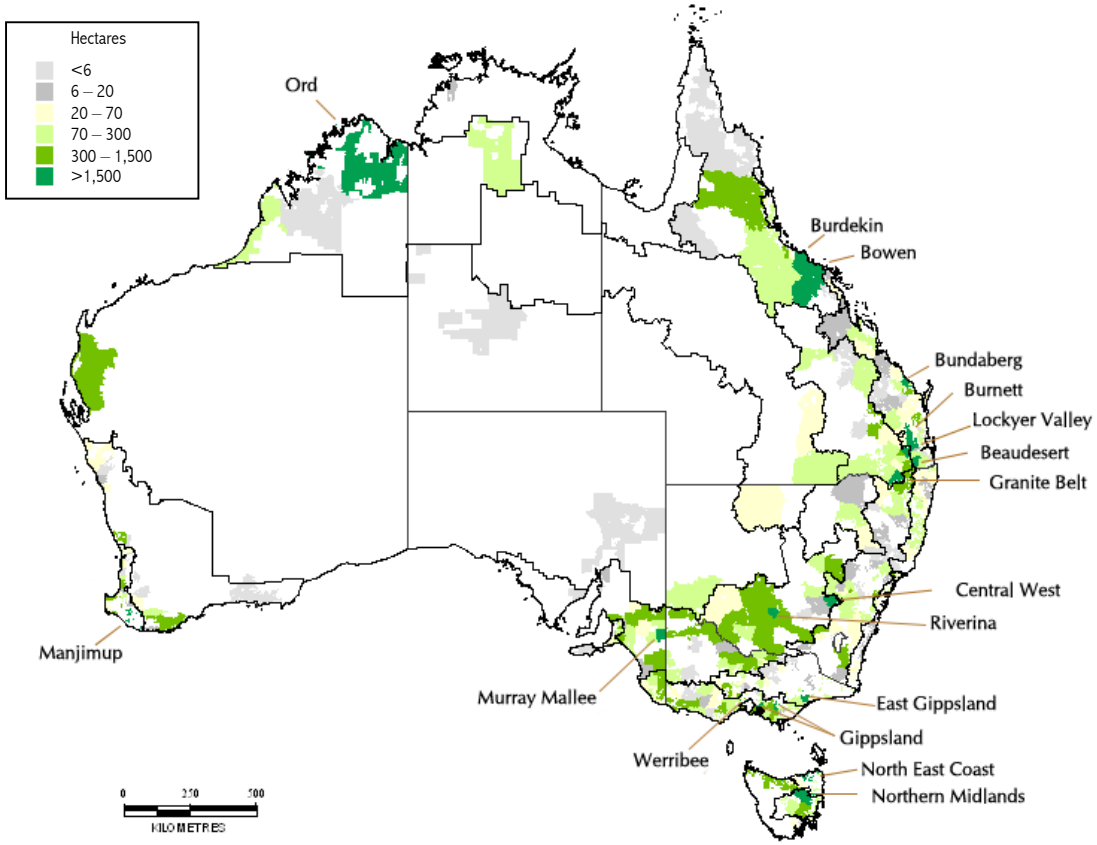
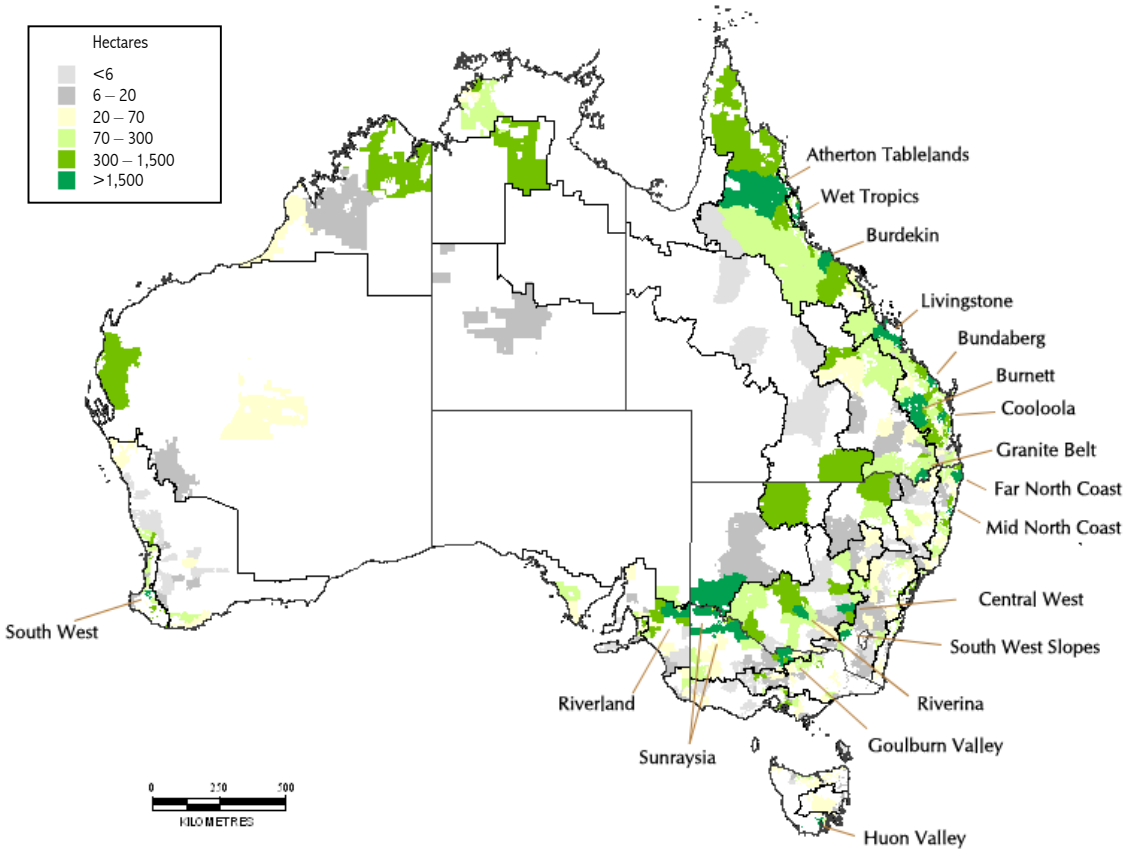


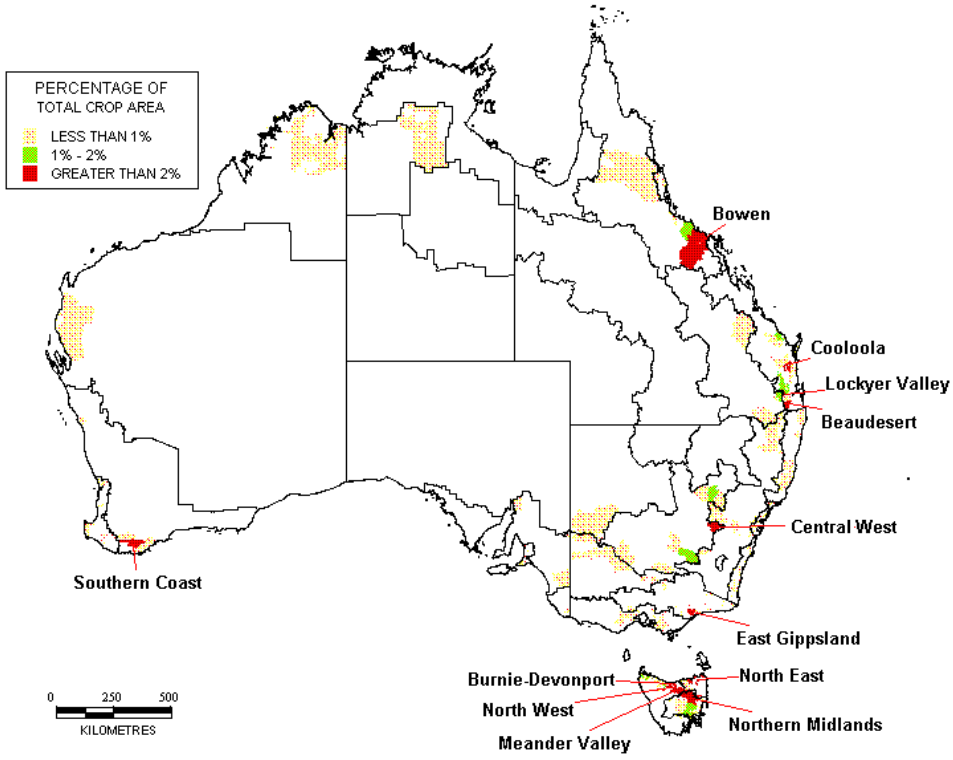
Figure 2.6 Distribution and Density of Perennial Crop Production.

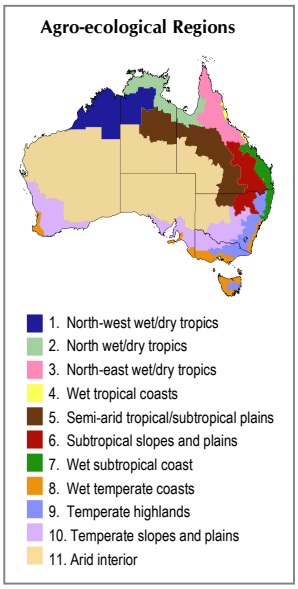


Maps Source: ABS *AgStats 1996-97.* with non-agricultural land mask from *Distribution of Agricultural Land Use in Australia* (BRS 1994).

2.4.1 Industry Distribution and Performance - Annual Crops

Beans and Peas





Map Source: *ABS AgStats 1996-97* with non-agricultural land mask from *Distribution of Agricultural Land Use in Australia* (BRS 1994).

Production by Agro-Ecological Region

Agro-Ecological Region	Area (Ha)	Yield (Tonnes)	Yield per Ha (T / Ha)	Value ($M)
North-west wet/dry tropics	126	267	2.1	0.76
North-east wet/dry tropics	2,435	10,085	4.1	16.67
Wet tropical coasts	45	129	2.8	0.22
Subtropical slopes and plains	539	2,180	4.0	2.32
Wet subtropical coast	2,734	11,270	4.1	18.26
Wet temperate coasts	7,024	40,265	5.7	22.39
Temperate highlands	2,536	10,970	4.3	7.82
Temperate slopes and plains	2,538	7,871	3.1	5.83
Arid interior	63	220	3.5	0.33

Crops Produced

Crop	Area (Ha)	Yield (Tonnes)	Yield per Ha (T / Ha)	Value ($M)
Broad Beans	39	121	3.1	0.12
French & Runner Beans - Fresh	4,891	18,380	3.8	34.28
French & Runner Beans- Process	3,008	19,229	6.4	7.16
French & Runner Beans- Seed	32	174	5.5	1.68
Green Peas - Fresh	581	1,380	2.4	2.61
Green Peas - Processing	8,737	42,207	4.8	15.52
Green Peas - Seed	388	859	2.2	8.28
Snow Peas	365	907	2.5	4.94
Overall	**18,040**	**83,258**	**4.6**	**74.60**

Production and Value Statistics Source: *ABS AgStats 1996 - 97.* Data is available in the electronic version of the Australian Natural Resource Atlas located on the National Land and Water Resources Audit Web Site - www.nlwra.gov.au

Major Production Regions

Region	Agro-Ecological Region	% of Total Crop Area	Area (Ha)	Yield (Tonnes)	Yield per Ha (T / Ha)	Value ($M)
Bowen	North-east wet/dry tropics	12.2	2,202	9,278	4.2	15.31
Northern Midlands	Temperate highlands / Wet temperate coasts	10.1	1,829	8,786	4.8	4.08
Burnie-Devonport	Wet temperate coasts	7.4	1,339	8,958	6.7	4.03
Meander Valley	Wet temperate coasts	5.8	1,054	5,815	5.5	3.40
North West	Wet temperate coasts	5.8	1,038	6,597	6.4	2.99
Southern Coast	Temperate slopes and plains	4.8	867	1,813	2.1	2.83
Cooloola	Wet subtropical coast	3.8	678	3,249	4.8	5.75
Central West	Temperate highlands / Temperate slopes and plains	3.1	563	1,969	3.5	0.88
Beaudesert	Wet subtropical coast	3.0	549	1,956	3.6	1.77
East Gippsland	Temperate highlands	2.7	489	1,386	2.8	3.22
North East	Wet temperate coasts	2.4	427	1,908	4.5	0.98
Lockyer Valley	Subtropical slopes and plains / Wet subtropical coast	2.3	415	2,040	4.9	1.87

Bowen - Queensland

Climate Statistics	
Mean* Annual Min. and Max. Temp.	19.8°C -28.5°C
Range* in Mean Annual Rainfall	461 – 1672mm
Rainfall Distribution	Summer dominant
Mean Annual Pan Evaporation	no data available

Source: BOM. Bowen Airport

Crops Grown	% of Total Land Area
Beans - French & Runner - Fresh	11.4
Beans - French & Runner - Processing	0.8
Beans - French & Runner - Seed	0.02
Total	**12.2%**

Northern Midlands - Tasmania

Climate Statistics	
Mean* Annual Min. and Max. Temp.	4.1°C / 16.8°C
Range* in Mean Annual Rainfall	498 - 1065mm
Rainfall Distribution	Winter dominant
Mean Annual Pan Evaporation	1606.0mm

Source: BOM. Lake Leake (Elizabeth River)

Crops Grown	% of Total Land Area
Peas - Green - Processing	9.2
Beans - French & Runner - Processing	0.6
Peas - Green - Fresh	0.2
Peas - Green - Seed	0.1
Beans - French & Runner - Fresh	0.0005
Total	**10.1%**

Burnie-Devonport - Tasmania

Climate Statistics	
Mean* Annual Min. and Max. Temp.	6.8°C / 16.3°C
Range* in Mean Annual Rainfall	791 - 1359mm
Rainfall Distribution	Winter dominant
Mean Annual Pan Evaporation	no data available

Source: BOM. Wynyard Airport

Crops Grown	% of Total Land Area
Peas - Green - Processing	4.6
Beans - French & Runner - Processing	2.3
Peas - Green - Fresh	0.2
Peas - Green - Seed	0.1
Beans - Broad	0.1
Beans - French and Runner - Fresh	0.02
Total	**7.4%**

Meander Valley - Tasmania

Climate Statistics	
Mean* Annual Min. and Max. Temp.	6.2°C / 15.8°C
Range* in Mean Annual Rainfall	840 - 1534mm
Rainfall Distribution	Winter dominant
Mean Annual Pan Evaporation	no data available

Source: BOM. Sheffield Shire

Crops Grown	% of Total Land Area
Peas - Green - Processing	4.4
Beans - French & Runner - Processing	1.1
Peas - Green - Seed	0.3
Peas - Green - Fresh	0.007
Total	**5.8%**

North West - Tasmania

Climate Statistics	
Mean* Annual Min. and Max. Temp.	6.2°C / 15.8°C
Range* in Mean Annual Rainfall	840 - 1533mm
Rainfall Distribution	Winter dominant
Mean Annual Pan Evaporation	no data available

Source: BOM. Sheffield Shire

Crops Grown	% of Total Land Area
Peas - Green - Processing	3.8
Beans - French & Runner - Processing	1.9
Peas - Green - Seed	0.1
Beans - Broad	0.02
Beans - French & Runner - Fresh	0.02
Peas - Snow	0.003
Total	**5.8%**

Southern Coast – Western Australia

Climate Statistics	
Mean* Annual Min. and Max. Temp.	9.3°C / 20.1°C
Range* in Mean Annual Rainfall	585 - 898mm
Rainfall Distribution	Winter dominant
Mean Annual Pan Evaporation	No data available

Source: BOM. Mt Barker Shire

Crops Grown	% of Total Land Area
Peas - Green - Processing	4.1
Peas - Green - Seed	0.7
Beans - French & Runner - Fresh	0.001
Total	**4.8%**

Cooloola - Queensland

Climate Statistics	
Mean* Annual Min. and Max. Temp.	12.9°C / 26.4°C
Range* in Mean Annual Rainfall	809 - 1664mm
Rainfall Distribution	Summer dominant
Mean Annual Pan Evaporation	no data available

Source: BOM. IMBIL Forestry

Crops Grown	% of Total Land Area
Beans - French & Runner - Fresh	3.0
Beans - French & Runner - Processing	0.4
Peas - Snow	0.1
Peas - Green - Fresh	0.1
Peas - Green - Processing	0.04
Beans - French & Runner - Seed	0.01
Peas - Green - Seed	0.005
Total	**3.8%**

Central West – New South Wales

Climate Statistics	
Mean* Annual Min. and Max. Temp.	6.8°C / 21.8°C
Range* in Mean Annual Rainfall	361 - 1283mm
Rainfall Distribution	Winter dominant
Range* in Mean Annual Pan Evaporation	1351 - 1460mm

Source: BOM. Bathurst Agricultural Station, Cowra Research Station and Orange Agricultural Institute

Crops Grown	% of Total Land Area
Peas - Green - Processing	1.5
Beans - French & Runner - Processing	1.3
Beans - French and Runner - Fresh	0.2
Peas - Green - Fresh	0.1
Total	**3.1%**

Beaudesert - Queensland

Climate Statistics	
Mean* Annual Min. and Max. Temp.	12.7°C / 26.5°C
Range* in Mean Annual Rainfall	271 - 1225mm
Rainfall Distribution	Summer dominant
Mean Annual Pan Evaporation	no data available

Source: BOM. Beaudesert Composite

Crops Grown	% of Total Land Area
Beans – French & Runner - Fresh	1.7
Beans – French & Runner-Processing	0.7
Peas - Green - Processing	0.6
Peas - Green - Fresh	0.1
Peas – Snow	0.002
Total	**3.0%**

East Gippsland - Victoria

Climate Statistics	
Mean* Annual Min. and Max. Temp.	8.0°C / 19.6°C
Range* in Mean Annual Rainfall	529 - 892mm
Rainfall Distribution	Summer dominant
Mean Annual Pan Evaporation	no data available

Source: BOM. Bairnsdale Airport

Crops Grown	% of Total Land Area
Beans – French & Runner - Fresh	2.5
Beans – French & Runner-Processing	0.1
Peas – Snow	0.1
Peas - Green - Fresh	0.003
Total	**2.7%**

North East - Tasmania

Climate Statistics	
Mean* Annual Min. and Max. Temp.	7.2°C / 17.8°C
Range* in Mean Annual Rainfall	737 - 1369mm
Rainfall Distribution	Winter dominant
Mean Annual Pan Evaporation	1022.0mm

Source: BOM. Scottsdale (West Minstone Road)

Crops Grown	% of Total Land Area
Peas - Green - Processing	1.7
Beans - French & Runner - Processing	0.5
Peas - Green - Fresh	0.1
Peas - Green - Seed	0.05
Total	**2.4%**

Lockyer Valley - Queensland

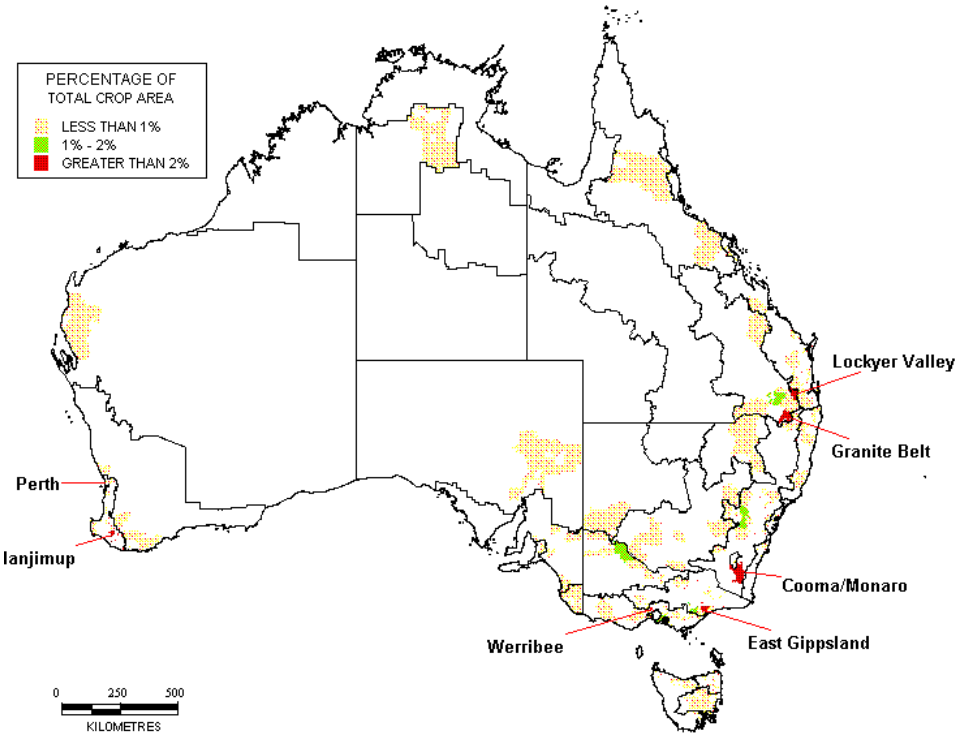
Climate Statistics	
Mean* Annual Min. and Max. Temp.	12.9°C / 26.5°C
Range* in Mean Annual Rainfall	544 - 1131mm
Rainfall Distribution	Summer dominant
Mean Annual Pan Evaporation	1898.0mm

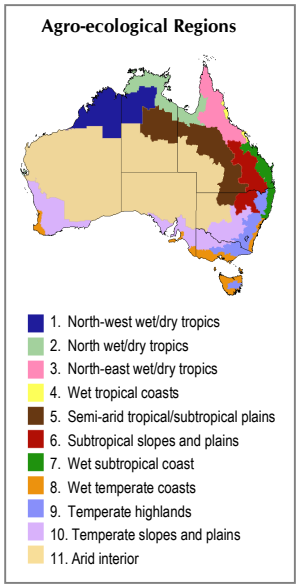
Source: BOM. Gatton QDPI Research Station

Crops Grown	% of Total Land Area
Peas - Green - Processing	0.9
Beans - French & Runner - Fresh	0.7
Beans - French & Runner - Processing	0.6
Peas - Green - Seed	0.1
Total	**2.3%**

**Temperatures are mean annual daily minimum and maximums across all stations used as sources. Rainfall data is the annual rainfall range expressed by the 1st and 9th decile rainfall bands. Evaporation is the range across all stations used as sources.*

Brassicas





Map Source: *ABS AgStats 1996-97* with non-agricultural land mask from *Distribution of Agricultural Land Use in Australia* (BRS 1994).

Production by Agro-Ecological Region

Agro-Ecological Region	Area (Ha)	Yield (Tonnes)	Yield per Ha (T / Ha)	Value ($M)
North-west wet/dry tropics	5	55	11.0	0.04
North-east wet/dry tropics	26	284	10.9	0.20
Wet tropical coasts	7	154	21.9	0.06
Subtropical slopes and plains	2,009	2,5910	12.9	22.07
Wet subtropical coast	765	13,388	17.5	8.29
Wet temperate coasts	7,187	97,074	13.5	87.22
Temperate highlands	2,883	33,860	11.7	23.09
Temperate slopes and plains	986	10,808	11.0	11.39
Arid interior	42	196	4.7	0.26

Crops Produced

Crop	Area (Ha)	Yield (Tonnes)	Yield per Ha (T / Ha)	Value ($M)
Broccoli	6,961	40,546	5.8	60.78
Brussel Sprouts	267	5,635	21.1	8.73
Cabbages	1,885	60,367	32.0	24.14
Cauliflower	3,997	64,392	16.1	48.07
Cauliflower – Seed	35	6	0.2	0.06
Chinese Cabbage	487	10,587	21.7	8.94
Chinese Cabbage – Seed	277	198	0.7	1.91
Overall	**13,910**	**181,730**	**13.1**	**152.63**

Production and Value Statistics Source: *ABS AgStats 1996 - 97.* Data is available in the electronic version of the Australian Natural Resource Atlas located on the National Land and Water Resources Audit Web Site - www.nlwra.gov.au

Major Production Regions

Region	Agro-Ecological Region	% of Total Crop Area	Area (Ha)	Yield (Tonnes)	Yield per Ha (T / Ha)	Value ($M)
Werribee	Wet temperate coasts	16.7	2,327	23,854	10.2	21.64
East Gippsland	Temperate highlands	8.3	1,149	9,667	8.4	7.65
Manjimup	Wet temperate coasts	6.0	837	11,262	13.5	13.78
Granite Belt	Subtropical slopes and plains	5.0	700	12,304	17.6	8.97
Lockyer Valley	Subtropical slopes and plains / Wet subtropical coast	3.9	545	6,759	12.4	6.06
Cooma-Monaro	Temperate highlands	2.9	410	2,500	6.1	3.69
Perth	Wet temperate coasts	2.8	389	6,334	16.3	5.38

Werribee - Victoria

Climate Statistics	
Mean* Annual Min. and Max. Temp.	13.2°C / 27.3°C
Range* in Mean Annual Rainfall	120 - 347mm
Rainfall Distribution	Summer dominant
Mean Annual Pan Evaporation	no data available

Source: BOM. Laverton RAAF

Crops Grown	% of Total Land Area
Broccoli	9.6
Cauliflower	6.4
Cabbages	0.8
Total	**16.7%**

East Gippsland - Victoria

Climate Statistics	
Mean* Annual Min. and Max. Temp.	8.0°C / 19.6°C
Range* in Mean Annual Rainfall	529 - 892mm
Rainfall Distribution	Summer dominant
Mean Annual Pan Evaporation	no data available

Source: BOM. Bairnsdale Airport

Crops Grown	% of Total Land Area
Broccoli	6.6
Cauliflower	0.9
Cabbages	0.7
Chinese Cabbage	0.1
Total	**8.3%**

Manjimup – Western Australia

Climate Statistics	
Mean* Annual Min. and Max. Temp.	9.6°C / 20.2°C
Range* in Mean Annual Rainfall	806 - 1267mm
Rainfall Distribution	Winter dominant
Mean Annual Pan Evaporation	2226.5mm

Source: BOM. Manjimup Shire

Crops Grown	% of Total Land Area
Cauliflower	5.3
Broccoli	0.4
Chinese Cabbage	0.3
Cabbages	0.009
Total	**6.0%**

Granite Belt - Queensland

Climate Statistics	
Mean* Annual Min. and Max. Temp.	8.7°C / 21.6°C
Range* in Mean Annual Rainfall	529 – 1018mm
Rainfall Distribution	Summer dominant
Mean Annual Pan Evaporation	no data available

Source: BOM. Stanthorpe Post Office

Crops Grown	% of Total Land Area
Broccoli	2.3
Cauliflower	1.5
Chinese Cabbage	0.7
Cabbages	0.4
Brussel Sprouts	0.1
Total	**5.0%**

Lockyer Valley - Queensland

Climate Statistics	
Mean* Annual Min. and Max. Temp.	12.9°C / 26.5°C
Range* in Mean Annual Rainfall	544 - 1131mm
Rainfall Distribution	Summer dominant
Mean Annual Pan Evaporation	1898.0mm

Source: BOM. Gatton QDPI Research Station

Crops Grown	% of Total Land Area
Broccoli	2.6
Cauliflower	0.9
Cabbages	0.3
Chinese Cabbage	0.1
Total	**3.9%**

Cooma-Monaro - Victoria

Climate Statistics	
Mean* Annual Min. and Max. Temp.	4.7°C / 19.6°C
Range* in Mean Annual Rainfall	349 - 695mm
Rainfall Distribution	Summer dominant
Mean Annual Pan Evaporation	no data available

Source: BOM. Cooma (Lambie Street)

Crops Grown	% of Total Land Area
Broccoli	2.9
Cabbages	0.1
Total	**2.9%**

Perth – Western Australia

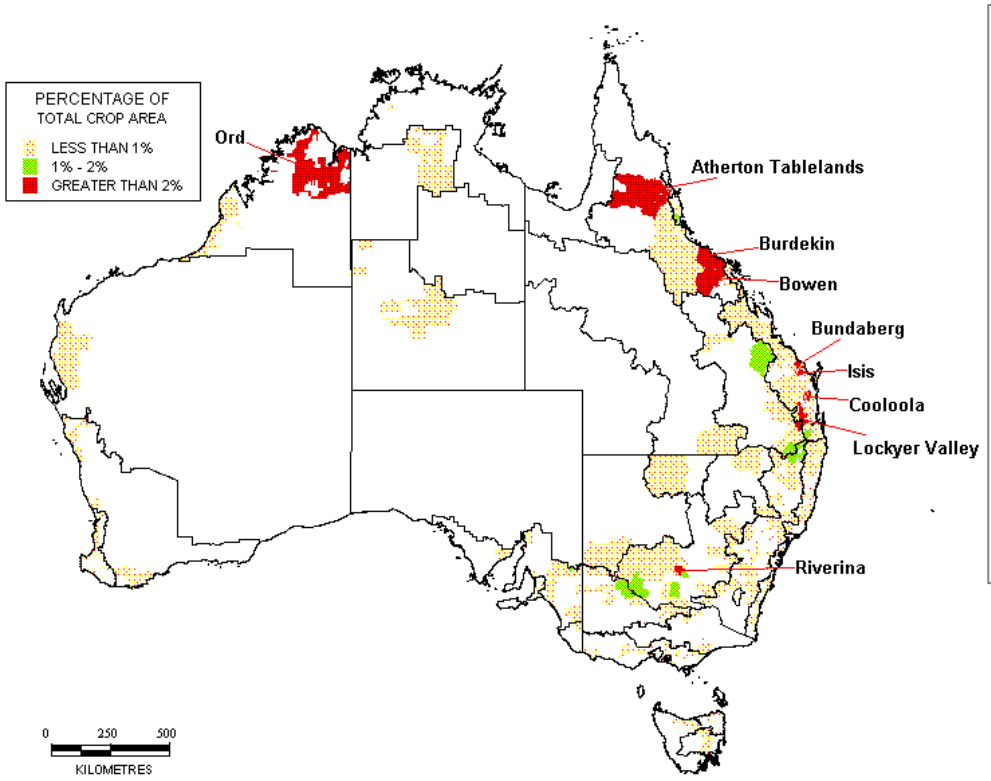
Climate Statistics	
Mean* Annual Min. and Max. Temp.	13.3°C / 23.3°C
Range* in Mean Annual Rainfall	666 - 1051mm
Rainfall Distribution	Winter dominant
Mean Annual Pan Evaporation	1752.0mm

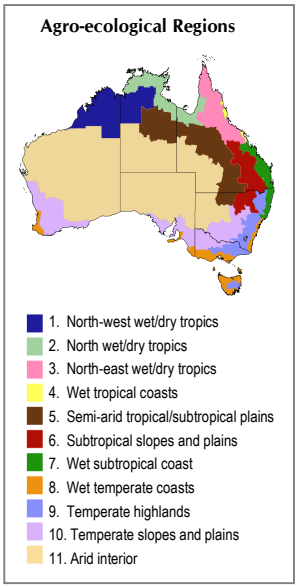
Source: BOM. Perth Regional Office

Crops Grown	% of Total Land Area
Broccoli	1.4
Cabbages	0.6
Cauliflower	0.6
Chinese Cabbage	0.3
Cauliflower - Seed	0.01
Total	**2.8%**

**Temperatures are mean annual daily minimum and maximums across all stations used as sources. Rainfall data is the annual rainfall range expressed by the 1st and 9th decile rainfall bands. Evaporation is the range across all stations used as sources.*

Cucurbits





Map Source: *ABS AgStats 1996-97* with non-agricultural land mask from *Distribution of Agricultural Land Use in Australia* (BRS 1994).

Production by Agro-Ecological Region

Agro-Ecological Region	Area (Ha)	Yield (Tonnes)	Yield per Ha (T / Ha)	Value ($M)
North-west wet/dry tropics	601	11,136	18.5	6.20
North wet/dry tropics	4	29	7.7	0.03
North-east wet/dry tropics	1,164	15,581	13.4	8.66
Wet tropical coasts	166	2,214	13.3	1.12
Semi-arid tropical/subtropical plains	3	56	17.0	0.03
Subtropical slopes and plains	974	9,200	9.4	4.63
Wet subtropical coast	3,090	29,509	9.5	21.04
Wet temperate coasts	862	12,451	14.4	10.79
Temperate highlands	501	6,078	12.1	4.05
Temperate slopes and plains	1,846	29,083	15.8	16.68
Arid interior	124	1,576	12.7	1.71

Crops Produced

Crop	Area (Ha)	Yield (Tonnes)	Yield per Ha (T / Ha)	Value ($M)
Cucumbers	1,002	15,876	15.9	16.35
Gherkins	33	503	15.2	0.53
Marrows and Squashes	443	2,269	5.1	5.67
Melons - Bitter	4	dns	-	dns
Pumpkin - Seed	1	5	4.2	0.05
Pumpkins	6,289	87,086	13.8	37.77
Zucchini	1,563	11,173	7.1	14.56
Overall	**9,335**	**116,912**	**12.5**	**74.93**

dns – data not supplied

Production and Value Statistics Source: *ABS AgStats 1996 - 97.* Data is available in the electronic version of the Australian Natural Resource Atlas located on the National Land and Water Resources Audit Web Site - www.nlwra.gov.au

Major Production Regions

Region	Agro-Ecological Region	% of Total Crop Area	Area (Ha)	Yield (Tonnes)	Yield per Ha (T / Ha)	Value ($M)
Lockyer Valley	Subtropical slopes and plains / Wet subtropical coast	11.9	1,112	11,737	10.6	5.50
Bundaberg / Isis	Wet subtropical coast	11.7	1,095	10,833	9.9	9.27
Riverina	Temperate slopes and plains	7.6	712	10,147	14.3	5.68
Burdekin	North-east wet/dry tropics	6.1	568	7,065	12.4	4.31
Ord	North-west wet/dry tropics	5.8	539	10,257	19.0	5.53
Atherton Tablelands	North-east wet/dry tropics / Wet tropical coasts	2.7	250	3,968	15.9	1.65
Bowen	North-east wet/dry tropics	2.2	204	3,198	15.7	2.07
Cooloola	Wet subtropical coast	2.0	187	1,415	7.5	1.67

Lockyer Valley - Queensland

Climate Statistics	
Mean* Annual Min. and Max. Temp.	12.9°C / 26.5°C
Range* in Mean Annual Rainfall	544 - 1131mm
Rainfall Distribution	Summer dominant
Mean Annual Pan Evaporation	1898.0mm

Source: BOM. Gatton QDPI Research Station

Crops Grown	% of Total Land Area
Pumpkins	10.8
Cucumbers	0.9
Zucchini	0.2
Marrows and Squashes	0.01
Total	**11.9%**

Bundaberg / Isis- Queensland

Climate Statistics	
Mean* Annual Min. and Max. Temp.	16.0°C / 26.1°C
Range* in Mean Annual Rainfall	670 - 1654mm
Rainfall Distribution	Summer dominant
Mean Annual Pan Evaporation	no data available

Source: BOM. Bundaberg Aero

Crops Grown	% of Total Land Area
Zucchini	6.2
Pumpkins	3.9
Marrows and Squashes	0.8
Cucumbers	0.6
Gherkins	0.3
Total	**11.7%**

Riverina – New South Wales

Climate Statistics	
Mean* Annual Min. and Max. Temp.	9.6°C / 24.2°C
Range* in Mean Annual Rainfall	217 - 587mm
Rainfall Distribution	Consistent
Mean Annual Pan Evaporation	1788.5mm

Source: BOM. Griffith CSIRO and Hay CSIRO

Crops Grown	% of Total Land Area
Pumpkins	3.9
Cucumbers	3.7
Total	**7.6%**

Burdekin - Queensland

Climate Statistics	
Mean* Annual Min. and Max. Temp.	17.7°C / 28.9°C
Range* in Mean Annual Rainfall	455 - 1519mm
Rainfall Distribution	Summer dominant
Mean Annual Pan Evaporation	2080.5mm

Source: BOM. Ayr DPI Research Station

Crops Grown	% of Total Land Area
Pumpkins	4.1
Cucumbers	0.9
Zucchini	0.6
Marrows and Squashes	0.5
Total	**6.1%**

Ord – Western Australia

Climate Statistics	
Mean* Annual Min. and Max. Temp.	20.6°C / 34.9°C
Range* in Mean Annual Rainfall	490 – 1097mm
Rainfall Distribution	Summer dominant
Mean Annual Pan Evaporation	2883.5mm

Source: BOM. Kununurra Aero

Crops Grown	% of Total Land Area
Pumpkins	5.1
Marrows and Squashes	0.4
Zucchini	0.2
Cucumbers	0.04
Total	**5.8%**

Isis - Queensland

Climate Statistics	
Mean* Annual Min. and Max. Temp.	16.0°C / 26.1°C
Range* in Mean Annual Rainfall	670 - 1654mm
Rainfall Distribution	Summer dominant
Mean Annual Pan Evaporation	no data available

Source: BOM. Bundaberg Aero

Crops Grown	% of Total Land Area
Zucchini	1.5
Pumpkins	0.6
Marrows and Squashes	0.4
Gherkins	0.3
Cucumbers	0.2
Total	**3.1%**

Atherton Tablelands - Queensland

Climate Statistics	
Mean* Annual Min. and Max. Temp.	15.5°C / 25.2°C
Range* in Mean Annual Rainfall	783 - 1876mm
Rainfall Distribution	Summer dominant
Mean Annual Pan Evaporation	1569.5mm

Source: BOM. Kairi Research Station

Crops Grown	% of Total Land Area
Pumpkins	2.5
Zucchini	0.1
Cucumbers	0.1
Marrows and Squashes	0.03
Total	**2.7%**

Bowen - Queensland

Climate Statistics	
Mean* Annual Min. and Max. Temp.	19.8°C / 28.5°C
Range* in Mean Annual Rainfall	461 – 1672mm
Rainfall Distribution	Summer dominant
Mean Annual Pan Evaporation	no data available

Source: BOM. Bowen Airport

Crops Grown	% of Total Land Area
Pumpkins	1.5
Cucumbers	0.6
Zucchini	0.1
Marrows and Squashes	0.04
Total	**2.2%**

Cooloola - Queensland

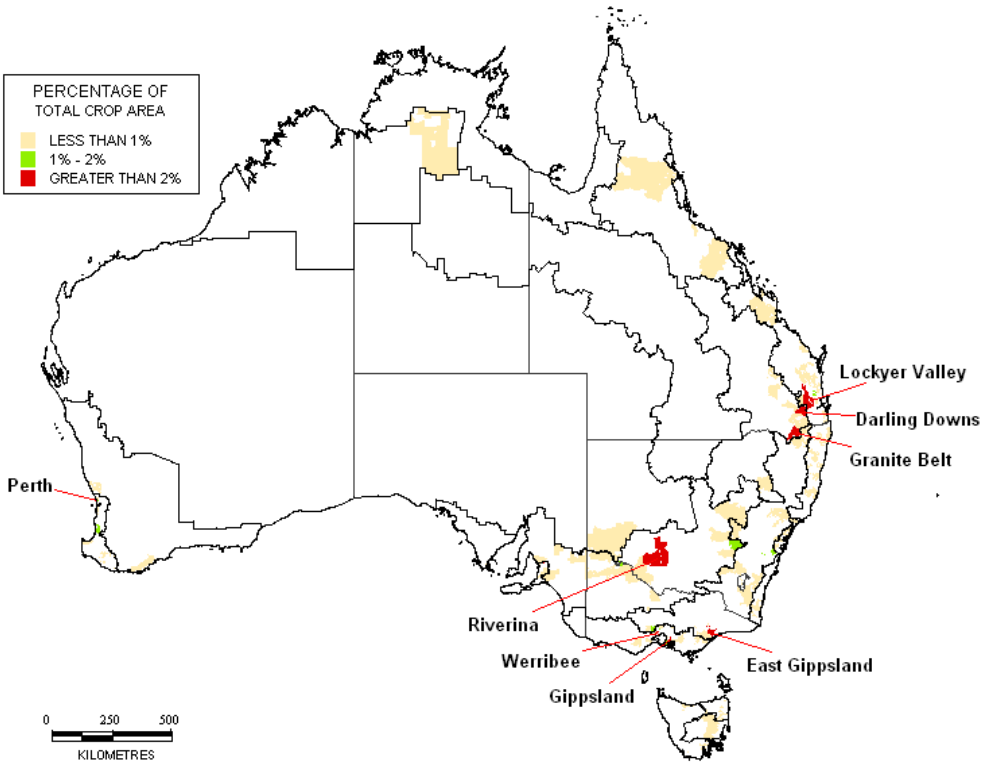
Climate Statistics	
Mean* Annual Min. and Max. Temp.	12.9°C / 26.4°C
Range* in Mean Annual Rainfall	809 - 1664mm
Rainfall Distribution	Summer dominant
Mean Annual Pan Evaporation	no data available

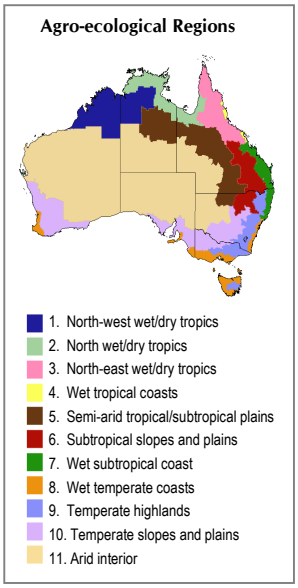
Source: BOM. IMBIL Forestry

Crops Grown	% of Total Land Area
Zucchini	1.3
Marrows and Squashes	0.6
Cucumbers	0.1
Pumpkins	0.1
Total	**2.0%**

**Temperatures are mean annual daily minimum and maximums across all stations used as sources. Rainfall data is the annual rainfall range expressed by the 1st and 9th decile rainfall bands. Evaporation is the range across all stations used as sources.*

Leaf Vegetables





Map Source: *ABS AgStats 1996-97* with non-agricultural land mask from *Distribution of Agricultural Land Use in Australia* (BRS 1994).

Production by Agro-Ecological Region

Agro-Ecological Region	Area (Ha)	Yield (Tonnes)	Yield per Ha (T / Ha)	Value ($M)
North-west wet/dry tropics	16	181	11.1	0.28
North-east wet/dry tropics	6	423	67.2	0.30
Wet tropical coasts	13	230	17.7	0.16
Subtropical slopes and plains	1,009	34,929	34.6	22.90
Wet subtropical coast	631	20,531	32.5	14.32
Wet temperate coasts	3,402	85,002	25.0	64.15
Temperate highlands	425	7,583	17.8	5.26
Temperate slopes and plains	529	11,214	21.2	8.37
Arid interior	4	27	6.7	0.02

Crops Produced

Crop	Area (Ha)	Yield (Tonnes)	Yield per Ha (T / Ha)	Value ($M)
Celery	953	44,873	47.1	31.08
Lettuce & French Endive	4,786	112,407	23.5	79.67
Silverbeet and Spinach	296	2,841	9.6	5.01
Overall	**6,035**	**160,121**	**26.5**	**115.77**

Production and Value Statistics Source: *ABS AgStats 1996 - 97.* Data is available in the electronic version of the Australian Natural Resource Atlas located on the National Land and Water Resources Audit Web Site - www.nlwra.gov.au

Major Production Regions

Region	Agro-Ecological Region	% of Total Crop Area	Area (Ha)	Yield (Tonnes)	Yield per Ha (T / Ha)	Value ($M)
Werribee	Wet temperate coasts	16.0	967	19,729	20.4	11.20
Lockyer Valley	Subtropical slopes and plains / Wet subtropical coast	14.6	881	29,572	33.6	19.84
Gippsland	Wet temperate coasts	13.7	828	18,738	22.6	13.67
Granite Belt	Subtropical slopes and plains	3.7	223	8,042	36.0	5.28
Perth	Wet temperate coasts	3.4	203	6,852	33.8	5.61
Darling Downs	Subtropical slopes and plains	2.9	178	8,184	46.1	5.11
Riverina	Temperate slopes and plains	2.5	152	2,620	17.3	2.20
East Gippsland	Temperate highlands	2.3	139	2,474	17.8	1.40

Werribee - Victoria

Climate Statistics	
Mean* Annual Min. and Max. Temp.	13.2°C / 27.3°C
Range* in Mean Annual Rainfall	120 - 347mm
Rainfall Distribution	Summer dominant
Mean Annual Pan Evaporation	no data available

Source: BOM. Laverton RAAF

Crops Grown	% of Total Land Area
Lettuce and French Endive	16.0
Silverbeet and Spinach	0.04
Total	**16.0%**

Lockyer Valley - Queensland

Climate Statistics	
Mean* Annual Min. and Max. Temp.	12.9°C / 26.5°C
Range* in Mean Annual Rainfall	544 - 1131mm
Rainfall Distribution	Summer dominant
Mean Annual Pan Evaporation	1898.0mm

Source: BOM. Gatton QDPI Research Station

Crops Grown	% of Total Land Area
Lettuce and French Endive	13.0
Celery	1.5
Silverbeet and Spinach	0.1
Total	**14.6%**

Gippsland - Victoria

Climate Statistics	
Mean* Annual Min. and Max. Temp.	7.6°C / 19.1°C
Range* in Mean Annual Rainfall	650 - 1039mm
Rainfall Distribution	Winter dominant
Mean Annual Pan Evaporation	985.5mm

Source: BOM. Tooradin Shire

Crops Grown	% of Total Land Area
Celery	6.4
Lettuce & French Endive	5.9
Silverbeet and Spinach	1.4
Total	**13.7%**

Granite Belt - Queensland

Climate Statistics	
Mean* Annual Min. and Max. Temp.	8.7°C / 21.6°C
Range* in Mean Annual Rainfall	529 – 1018mm
Rainfall Distribution	Summer dominant
Mean Annual Pan Evaporation	no data available

Source: BOM. Stanthorpe Post Office

Crops Grown	% of Total Land Area
Lettuce and French Endive	2.3
Celery	1.3
Silverbeet and Spinach	0.1
Total	**3.7%**

Perth – Western Australia

Climate Statistics	
Mean* Annual Min. and Max. Temp.	13.3°C / 23.3°C
Range* in Mean Annual Rainfall	666 - 1051mm
Rainfall Distribution	Winter dominant
Mean Annual Pan Evaporation	1752.0mm

Source: BOM. Perth Regional Office

Crops Grown	% of Total Land Area
Lettuce and French Endive	2.7
Celery	0.5
Silverbeet and Spinach	0.2
Total	**3.4%**

Darling Downs - Queensland

Climate Statistics	
Mean* Annual Min. and Max. Temp.	11.9°C / 26.2°C
Range* in Mean Annual Rainfall	453 - 909mm
Rainfall Distribution	Summer dominant
Mean Annual Pan Evaporation	2007.5mm

Source: BOM. Dalby Post Office

Crops Grown	% of Total Land Area
Lettuce and French Endive	2.0
Celery	0.9
Silverbeet and Spinach	0.02
Total	**2.9%**

Riverina – New South Wales

Climate Statistics	
Mean* Annual Min. and Max. Temp.	9.6°C / 24.2°C
Range* in Mean Annual Rainfall	217- 587mm
Rainfall Distribution	Consistent
Mean Annual Pan Evaporation	1788.5mm

Source: BOM. Griffith CSIRO and Hay CSIRO

Crops Grown	% of Total Land Area
Lettuce and French Endive	2.5
Total	**2.5%**

East Gippsland - Victoria

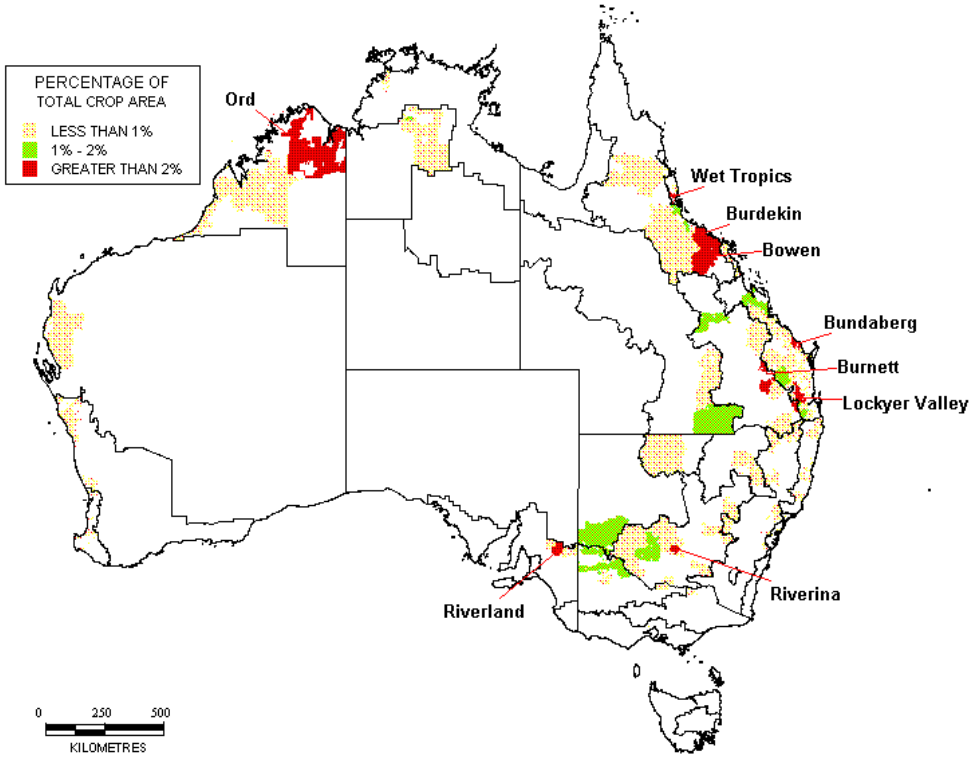
Climate Statistics	
Mean* Annual Min. and Max. Temp.	8.0°C / 19.6°C
Range* in Mean Annual Rainfall	529 - 892mm
Rainfall Distribution	Summer dominant
Mean Annual Pan Evaporation	no data available

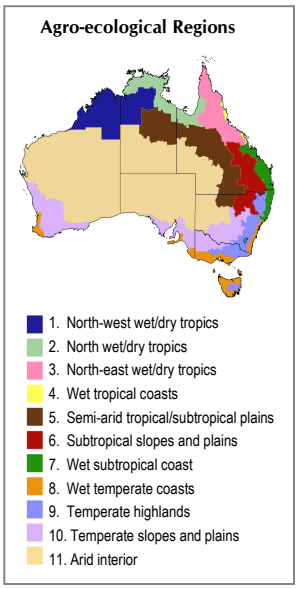
Source: BOM. Bairnsdale Airport

Crops Grown	% of Total Land Area
Lettuce and French Endive	2.3
Total	**2.3%**

**Temperatures are mean annual daily minimum and maximums across all stations used as sources. Rainfall data is the annual rainfall range expressed by the 1st and 9th decile rainfall bands. Evaporation is the range across all stations used as sources.*

Melons





Map Source: *ABS AgStats 1996-97* with non-agricultural land mask from *Distribution of Agricultural Land Use in Australia* (BRS 1994).

Production by Agro-Ecological Region

Agro-Ecological Region	Area (Ha)	Yield (Tonnes)	Yield per Ha T / Ha)	Value ($M)
North-west wet/dry tropics	1,277	30,044	23.5	20.87
North wet/dry tropics	21	487	23.5	0.40
North-east wet/dry tropics	1,225	31,013	25.3	17.74
Wet tropical coasts	208	3,293	15.9	1.30
Semi-arid tropical/subtropical plains	193	5,187	26.8	3.28
Subtropical slopes and plains	1,467	26,249	17.9	11.08
Wet subtropical coast	1,566	32,460	20.7	13.93
Wet temperate coasts	192	3,641	18.9	2.13
Temperate highlands	94	1,492	16.0	0.48
Temperate slopes and plains	1,289	25,219	19.6	17.54
Arid interior	176	4,288	24.4	2.39

Crops Produced

Crop	Area (Ha)	Yield (Tonnes)	Yield per Ha (T / Ha)	Value ($M)
Melons – Other	199	4,838	24.3	3.56
Melons – Rock	3,162	71,873	22.7	57.70
Melons – Water	4,346	86,658	19.9	29.89
Overall	**7,707**	**163,370**	**21.2**	**91.15**

Production and Value Statistics Source: *ABS AgStats 1996 - 97.* Data is available in the electronic version of the Australian Natural Resource Atlas located on the National Land and Water Resources Audit Web Site - www.nlwra.gov.au

Major Production Regions

Region	Agro-Ecological Region	% of Total Crop Area	Area (Ha)	Yield (Tonnes)	Yield per Ha (T / Ha)	Value ($M)
Ord	North-west wet/dry tropics	14.5	1,118	25,759	23.0	17.61
Burnett	Subtropical slopes and plains / Wet subtropical coast	13.0	999	17,783	17.8	8.07
Burdekin	North-east wet/dry tropics	7.4	568	17,470	30.8	10.99
Bundaberg	Wet subtropical coast	6.1	469	12,208	26.0	6.78
Bowen	North-east wet/dry tropics	6.0	463	8,953	19.3	4.76
Lockyer Valley	Subtropical slopes and plains / Wet subtropical coast	5.6	432	8,046	18.6	2.83
Riverina	Temperate slopes and plains	4.7	365	7,713	21.1	3.98
Riverland	Temperate slopes and plains	2.7	206	3,711	18.0	3.12
Wet Tropics	Wet tropical coasts	2.3	177	2,715	15.3	1.12

Ord – Western Australia

Climate Statistics	
Mean* Annual Min. and Max. Temp.	20.6°C / 34.9°C
Range* in Mean Annual Rainfall	490 - 1097mm
Rainfall Distribution	Summer dominant
Mean Annual Pan Evaporation	2883.5mm

Source: BOM. Kununurra Aero

Crops Grown	% of Total Land Area
Melons - Water	8.7
Melons - Rock	5.8
Total	**14.5%**

Burnett - Queensland

Climate Statistics	
Mean* Annual Min. and Max. Temp.	11.2°C / 24.7°C
Range* in Mean Annual Rainfall	508 - 1037mm
Rainfall Distribution	Summer dominant
Mean Annual Pan Evaporation	1606.0mm

Source: BOM. Kingaroy (Prince Street)

Crops Grown	% of Total Land Area
Melons - Water	10.0
Melons - Rock	2.8
Melons - Other	0.1
Total	**13.0%**

Burdekin - Queensland

Climate Statistics	
Mean* Annual Min. and Max. Temp.	17.7°C / 28.9°C
Range* in Mean Annual Rainfall	455 - 1519mm
Rainfall Distribution	Summer dominant
Mean Annual Pan Evaporation	2080.5mm

Source: BOM. Ayr DPI Research Station

Crops Grown	% of Total Land Area
Melons - Rock	4.2
Melons - Water	1.9
Melons - Other	1.2
Total	**7.4%**

Bundaberg - Queensland

Climate Statistics	
Mean* Annual Min. and Max. Temp.	16.0°C / 26.1°C
Range* in Mean Annual Rainfall	670 - 1654mm
Rainfall Distribution	Summer dominant
Mean Annual Pan Evaporation	no data available

Source: BOM. Bundaberg Aero

Crops Grown	% of Total Land Area
Melons - Water	2.9
Melons - Rock	2.8
Melons - Other	0.3
Total	**6.1%**

Bowen - Queensland

Climate Statistics	
Mean* Annual Min. and Max. Temp.	19.8°C / 28.5°C
Range* in Mean Annual Rainfall	461 – 1672mm
Rainfall Distribution	Summer dominant
Mean Annual Pan Evaporation	no data available

Crops Grown	% of Total Land Area
Melons - Rock	3.8
Melons - Water	2.1
Melons - Other	0.0
Total	**6.0%**

Source: BOM. Bowen Airport

Lockyer Valley - Queensland

Climate Statistics	
Mean* Annual Min. and Max. Temp.	12.9°C / 26.5°C
Range* in Mean Annual Rainfall	544 - 1131mm
Rainfall Distribution	Summer dominant
Mean Annual Pan Evaporation	1898.0mm

Crops Grown	% of Total Land Area
Melons - Water	5.0
Melons - Rock	0.6
Melons - Other	0.0
Total	**5.6%**

Source: BOM. Gatton QDPI Research Station

Riverina – New South Wales

Climate Statistics	
Mean* Annual Min. and Max. Temp.	9.6°C / 24.2°C
Range* in Mean Annual Rainfall	217 - 587mm
Rainfall Distribution	Consistent
Mean Annual Pan Evaporation	1788.5mm

Crops Grown	% of Total Land Area
Melons - Rock	3.6
Melons - Water	1.1
Melons - Other	0.0
Total	**4.7%**

Source: BOM. Griffith CSIRO and Hay CSIRO

Riverland – South Australia

Climate Statistics	
Mean* Annual Min. and Max. Temp.	9.2°C / 24.2°C
Range* in Mean Annual Rainfall	124 - 475mm
Rainfall Distribution	Consistent
Mean Annual Pan Evaporation	1679.0mm

Crops Grown	% of Total Land Area
Melons - Rock	2.5
Melons - Water	0.1
Total	**2.7%**

Source: BOM. Renmark Shire and Loxton Research Centre

Wet Tropics - Queensland

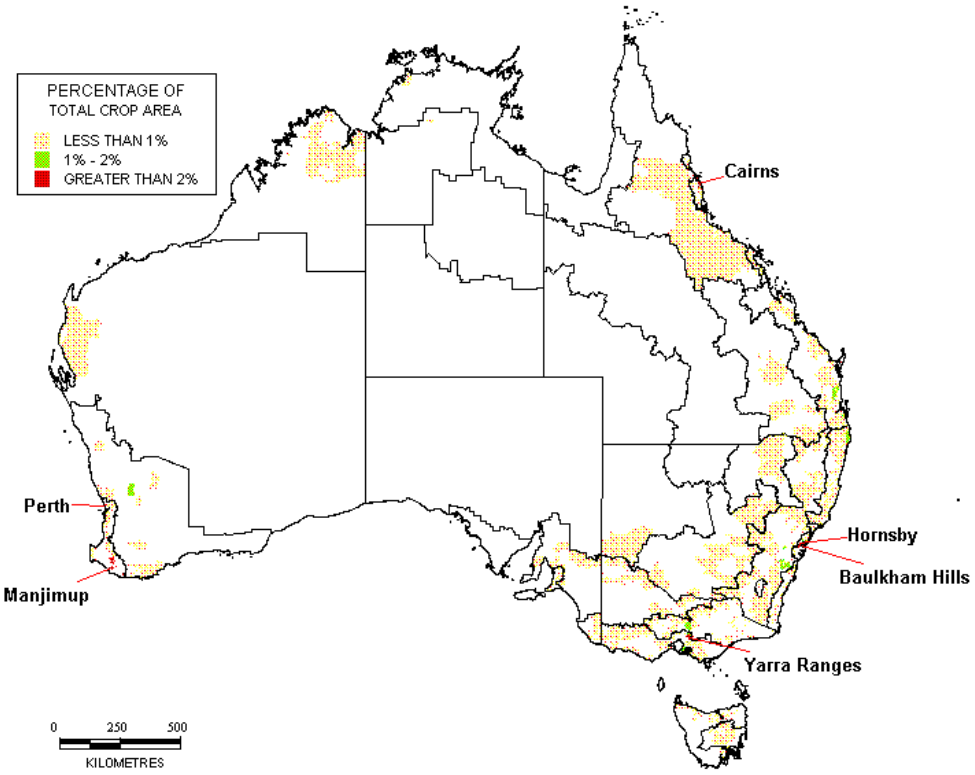
Climate Statistics	
Mean* Annual Min. and Max. Temp.	18.7°C / 28.8°C
Range* in Mean Annual Rainfall	1383 - 4747mm
Rainfall Distribution	Summer dominant
Mean Annual Pan Evaporation	1715.5mm

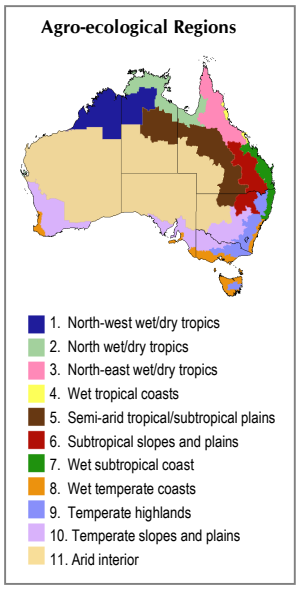
Crops Grown	% of Total Land Area
Melons - Water	1.8
Melons - Rock	0.5
Total	**2.3%**

Source: BOM. Cardwell (Eden Street), Innisfail Shire and South Johnston Exp. Station

**Temperatures are mean annual daily minimum and maximums across all stations used as sources. Rainfall data is the annual rainfall range expressed by the 1st and 9th decile rainfall bands. Evaporation is the range across all stations used as sources.*

Nurseries





Map Source: *ABS AgStats 1996-97* with non-agricultural land mask from *Distribution of Agricultural Land Use in Australia* (BRS 1994).

Production by Agro-Ecological Region

Agro-Ecological Region	Area (Ha)	Yield (Tonnes)	Yield per Ha (T / Ha)	Value ($M)
North-west wet/dry tropics	15	dns	-	0.89
North wet/dry tropics	47	dns	-	2.72
North-east wet/dry tropics	52	dns	-	4.51
Wet tropical coasts	250	dns	-	21.81
Semi-arid tropical/subtropical plains	1	dns	-	0.04
Subtropical slopes and plains	60	dns	-	5.21
Wet subtropical coast	1,201	dns	-	100.64
Wet temperate coasts	1,998	dns	-	160.61
Temperate highlands	511	dns	-	38.38
Temperate slopes and plains	520	dns	-	42.50
Arid interior	13	dns	-	0.94
Overall	**4,667**	**dns**	**-**	**378.24**

dns – data not supplied

Major Production Regions

Region	Agro-Ecological Region	% of Total Crop Area	Area (Ha)	Yield (Tonnes)	Yield per Ha (T / Ha)	Value ($M)
Yarra Ranges	Wet temperate coasts	6.4	298	dns	-	27.72
Hornsby / Baulkam Hills	Wet temperate coasts	4.1	190	dns	-	14.16
Cairns	Wet tropical coasts	2.5	115	dns	-	10.00
Manjimup	Wet temperate coasts	2.4	111	dns	-	6.94
Perth	Wet temperate coasts	2.1	99	dns	-	6.15

dns – data not supplied

Production and Value Statistics Source: *ABS AgStats 1996 - 97.* Data is available in the electronic version of the Australian Natural Resource Atlas located on the National Land and Water Resources Audit Web Site - www.nlwra.gov.au

Yarra Ranges - Victoria

Climate Statistics	
Mean* Annual Min. and Max. Temp.	7.8°C / 15.1°C
Range* in Mean Annual Rainfall	912 - 1439mm
Rainfall Distribution	Winter dominant
Mean Annual Pan Evaporation	no data available

Source: BOM. Mount Dandenong

Hornsby / Baulkham Hills – New South Wales

Climate Statistics	
Mean* Annual Min. and Max. Temp.	12.1°C / 22.9°C
Range* in Mean Annual Rainfall	609 - 1450mm
Rainfall Distribution	Summer dominant
Mean Annual Pan Evaporation	no data available

Source: BOM. Parramatta (North Masons Drive)

Cairns - Queensland

Climate Statistics	
Mean* Annual Min. and Max. Temp.	20.7°C / 28.9°C
Range* in Mean Annual Rainfall	1313 - 2790mm
Rainfall Distribution	Summer dominant
Mean Annual Pan Evaporation	2263.0mm

Source: BOM. Cairns A.M.O.

Manjimup – Western Australia

Climate Statistics	
Mean* Annual Min. and Max. Temp.	9.6°C / 20.2°C
Range* in Mean Annual Rainfall	806 - 1267mm
Rainfall Distribution	Winter dominant
Mean Annual Pan Evaporation	2226.5mm

Source: BOM. Manjimup Shire

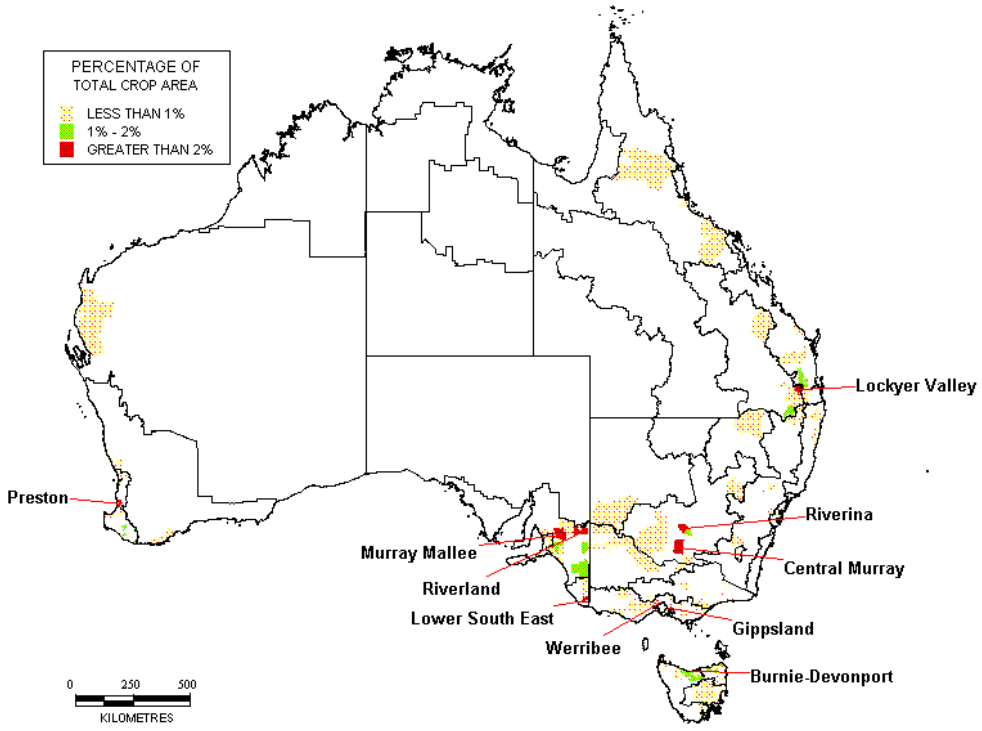
Perth – Western Australia

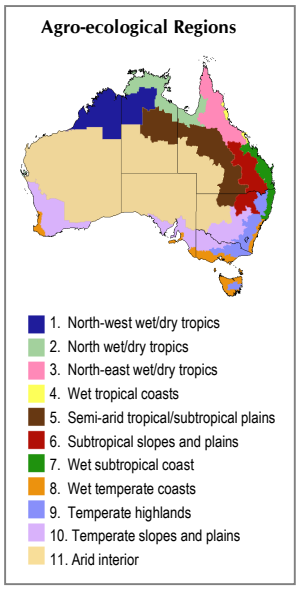
Climate Statistics	
Mean* Annual Min. and Max. Temp.	13.3°C - 23.3°C
Range* in Mean Annual Rainfall	666 - 1051mm
Rainfall Distribution	Winter dominant
Mean Annual Pan Evaporation	1752.0mm

Source: BOM. Perth Regional Office

**Temperatures are mean annual daily minimum and maximums across all stations used as sources. Rainfall data is the annual rainfall range expressed by the 1st and 9th decile rainfall bands. Evaporation is the range across all stations used as sources.*

Onions and Garlic





Map Source: *ABS AgStats 1996-97* with non-agricultural land mask from *Distribution of Agricultural Land Use in Australia* (BRS 1994).

Production by Agro-Ecological Region

Agro-Ecological Region	Area (Ha)	Yield (Tonnes)	Yield per Ha (T / Ha)	Value ($M)
North-west wet/dry tropics	0.1	6	60.0	0.003
North-east wet/dry tropics	13	254	19.0	0.23
Wet tropical coasts	7	153	22.8	0.09
Subtropical slopes and plains	459	14,003	30.5	8.82
Wet subtropical coast	417	9,839	23.6	7.91
Wet temperate coasts	2,696	103,593	38.4	45.32
Temperate highlands	149	3,355	22.5	1.62
Temperate slopes and plains	1,861	72,408	38.9	43.11
Arid interior	29	1,457	50.4	0.62

Crops Produced

Crop	Area (Ha)	Yield (Tonnes)	Yield per Ha (T / Ha)	Value ($M)
Garlic	43	272	6.3	1.85
Leeks	305	4,671	15.3	7.77
Onions – Seed	116	60	0.5	0.58
Onions – Spring	411	3,574	8.7	6.05
Onions - White and Brown	4,756	196,491	41.3	91.47
Overall	**5,631**	**205,068**	**36.42**	**107.72**

Production and Value Statistics Source: *ABS AgStats 1996 - 97.* Data is available in the electronic version of the Australian Natural Resource Atlas located on the National Land and Water Resources Audit Web Site - www.nlwra.gov.au

Major Production Regions

Region	Agro-Ecological Region	% of Total Crop Area	Area (Ha)	Yield (Tonnes)	Yield per Ha (T / Ha)	Value ($M)
Burnie-Devonport	Wet temperate coasts	10.2	575	29,612	51.5	8.25
Lockyer Valley	Subtropical slopes and plains / Wet subtropical coast	7.2	403	12,907	32.0	7.83
Riverina	Temperate slopes and plains	6.9	388	9,175	23.6	3.93
Murray Mallee	Temperate slopes and plains	6.1	342	20,196	59.1	12.94
Gippsland	Wet temperate coasts	3.7	207	2,943	14.2	4.30
Central Murray	Temperate slopes and plains	3.6	200	1,000	5.0	0.42
Werribee	Wet temperate coasts	2.1	121	4,533	37.6	1.72
Riverland	Temperate slopes and plains	2.1	121	5,013	41.6	3.29
Preston	Wet temperate coasts	2.1	120	7,181	59.9	3.14
Lower South East	Wet temperate coasts	2.1	119	3,795	32.0	2.44

Burnie-Devonport - Tasmania

Climate Statistics	
Mean* Annual Min. and Max. Temp.	6.8°C / 16.3°C
Range* in Mean Annual Rainfall	791 - 1359mm
Rainfall Distribution	Winter dominant
Mean Annual Pan Evaporation	no data available

Source: BOM. Wynyard Airport

Crops Grown	% of Total Land Area
Onions - White and Brown	10.0
Leeks	0.1
Onions - Seed	0.1
Onions - Spring	0.02
Total	**10.2%**

Lockyer Valley - Queensland

Climate Statistics	
Mean* Annual Min. and Max. Temp.	12.9°C / 26.5°C
Range* in Mean Annual Rainfall	544 - 1131mm
Rainfall Distribution	Summer dominant
Mean Annual Pan Evaporation	1898.0mm

Source: BOM. Gatton QDPI Research Station

Crops Grown	% of Total Land Area
Onions - White and Brown	6.8
Onions - Seed	0.2
Onions - Spring	0.1
Total	**7.2%**

Riverina – New South Wales

Climate Statistics	
Mean* Annual Min. and Max. Temp.	9.6°C / 24.2°C
Range* in Mean Annual Rainfall	217 - 587mm
Rainfall Distribution	Consistent
Mean Annual Pan Evaporation	1788.5mm

Source: BOM. Griffith CSIRO and Hay CSIRO

Crops Grown	% of Total Land Area
Onions - White and Brown	6.6
Onions - Seed	0.3
Total	**6.9%**

Murray Mallee – South Australia

Climate Statistics	
Mean* Annual Min. and Max. Temp.	9.2°C / 23.4°C
Range* in Mean Annual Rainfall	124 - 475mm
Rainfall Distribution	Consistent
Mean Annual Pan Evaporation	1679.0mm

Source: BOM. Loxton Research Centre

Crops Grown	% of Total Land Area
Onions - White and Brown	6.1
Onions - Seed	0.0
Total	**6.1%**

Gippsland - Victoria

Climate Statistics	
Mean* Annual Min. and Max. Temp.	7.6°C / 19.1°C
Range* in Mean Annual Rainfall	650 - 1039mm
Rainfall Distribution	Winter dominant
Mean Annual Pan Evaporation	985.5mm

Source: BOM. Tooradin Shire

Crops Grown	% of Total Land Area
Onions - Spring	1.9
Leeks	1.4
Onions - White and Brown	0.4
Total	**3.7%**

Central Murray – New South Wales

Climate Statistics	
Mean* Annual Min. and Max. Temp.	9.4°C / 22.1°C
Range* in Mean Annual Rainfall	285 - 578mm
Rainfall Distribution	Winter dominant
Mean Annual Pan Evaporation	no data available

Source: BOM. Echuca Aerodrome

Crops Grown	% of Total Land Area
Onions - White and Brown	3.6
Total	**3.6%**

Werribee - Victoria

Climate Statistics	
Mean* Annual Min. and Max. Temp.	13.2°C / 27.3°C
Range* in Mean Annual Rainfall	120 - 347mm
Rainfall Distribution	Summer dominant
Mean Annual Pan Evaporation	no data available

Source: BOM. Laverton RAAF

Crops Grown	% of Total Land Area
Onions - White and Brown	2.1
Onions - Seed	0.1
Total	**2.1%**

Riverland – South Australia

Climate Statistics	
Mean* Annual Min. and Max. Temp.	9.2°C / 24.2°C
Range* in Mean Annual Rainfall	124 - 475mm
Rainfall Distribution	Consistent
Mean Annual Pan Evaporation	1679.0mm

Source: BOM. Renmark Shire and Loxton Research Centre

Crops Grown	% of Total Land Area
Onions - White and Brown	2.1
Garlic	0.03
Onions - Spring	0.02
Total	**2.1%**

Preston – Western Australia

Climate Statistics	
Mean* Annual Min. and Max. Temp.	9.5°C / 22.9°C
Range* in Mean Annual Rainfall	799 - 1229mm
Rainfall Distribution	Winter dominant
Mean Annual Pan Evaporation	no data available

Source: BOM. Donnybrook Post Office

Crops Grown	% of Total Land Area
Onions - White and Brown	2.1
Total	**2.1%**

Lower South East – South Australia

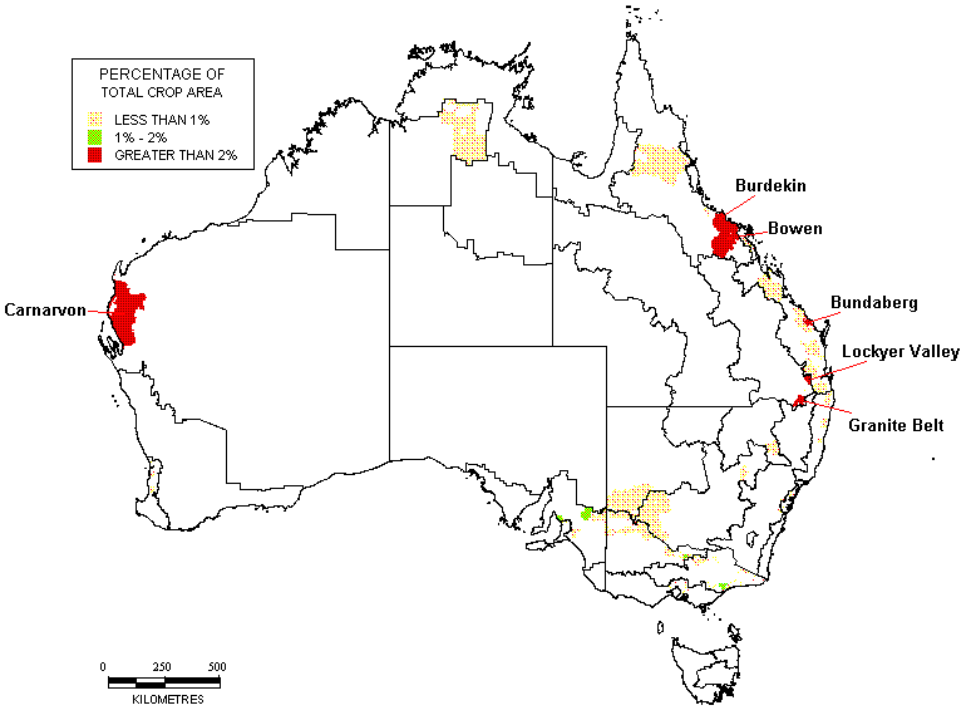
Climate Statistics	
Mean* Annual Min. and Max. Temp.	7.8°C / 20.4°C
Range* in Mean Annual Rainfall	409 - 868mm
Rainfall Distribution	Winter dominant
Mean Annual Pan Evaporation	1387.0mm

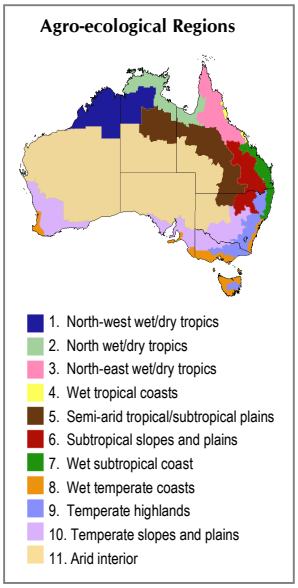
Source: BOM. Mount Gambier AERO

Crops Grown	% of Total Land Area
Onions - White and Brown	2.1
Onions - Seed	0.04
Total	**2.1%**

**Temperatures are mean annual daily minimum and maximums across all stations used as sources. Rainfall data is the annual rainfall range expressed by the 1st and 9th decile rainfall bands. Evaporation is the range across all stations used as sources.*

Peppers





Map Source: *ABS AgStats 1996-97* with non-agricultural land mask from *Distribution of Agricultural Land Use in Australia* (BRS 1994).

Production by Agro-Ecological Region

Agro-Ecological Region	Area (Ha)	Yield (Tonnes)	Yield per Ha (T / Ha)	Value ($M)
North-west wet/dry tropics	12	131	10.7	0.32
North-east wet/dry tropics	714	14,657	20.5	17.17
Wet tropical coasts	2	16	7.3	0.02
Subtropical slopes and plains	260	3,210	12.4	3.75
Wet subtropical coast	362	6,607	18.3	7.73
Wet temperate coasts	137	1,850	13.5	3.34
Temperate highlands	125	2,167	17.4	2.19
Temperate slopes and plains	160	2,131	13.3	4.03
Arid interior	103	1,451	14.1	2.06

Crops Produced

Crop	Area (Ha)	Yield (Tonnes)	Yield per Ha (T / Ha)	Value ($M)
Capsicum / Chilli	1,875	32,221	17.2	40.59

Major Production Regions

Region	Agro-Ecological Region	% of Total Crop Area	Area (Ha)	Yield (Tonnes)	Yield per Ha (T / Ha)	Value ($M)
Bowen	North-east wet/dry tropics	28.9	542	11,154	20.6	13.06
Bundaberg	Wet subtropical coast	13.2	248	4,643	18.8	5.44
Burdekin	North-east wet/dry tropics	8.6	161	3,329	20.7	3.90
Granite Belt	Subtropical slopes and plains	8.1	153	1,942	12.7	2.27
Lockyer Valley	Subtropical slopes and plains / Wet subtropical coast	5.2	98	1,188	12.1	1.39
Carnarvon	Arid interior	4.9	92	1,310	14.2	1.93

Production and Value Statistics Source: *ABS AgStats 1996 - 97.* Data is available in the electronic version of the Australian Natural Resource Atlas located on the National Land and Water Resources Audit Web Site - www.nlwra.gov.au

Bowen - Queensland

Climate Statistics	
Mean* Annual Min. and Max. Temp.	19.8°C / 28.5°C
Range* in Mean Annual Rainfall	461 – 1672mm
Rainfall Distribution	Summer dominant
Mean Annual Pan Evaporation	no data available

Source: BOM. Bowen Airport

Bundaberg - Queensland

Climate Statistics	
Mean* Annual Min. and Max. Temp.	16.0°C / 26.1°C
Range* in Mean Annual Rainfall	670 - 1654mm
Rainfall Distribution	Summer dominant
Mean Annual Pan Evaporation	no data available

Source: BOM. Bundaberg Aero

Burdekin - Queensland

Climate Statistics	
Mean* Annual Min. and Max. Temp.	17.7°C / 28.9°C
Range* in Mean Annual Rainfall	455 - 1519mm
Rainfall Distribution	Summer dominant
Mean Annual Pan Evaporation	2080.5mm

Source: BOM. Ayr DPI Research Station

Granite Belt - Queensland

Climate Statistics	
Mean* Annual Min. and Max. Temp.	8.7°C / 21.6°C
Range* in Mean Annual Rainfall	529 – 1018mm
Rainfall Distribution	Summer dominant
Mean Annual Pan Evaporation	no data available

Source: BOM. Stanthorpe Post Office

Lockyer Valley - Queensland

Climate Statistics	
Mean* Annual Min. and Max. Temp.	12.9°C / 26.5°C
Range* in Mean Annual Rainfall	544 - 1131mm
Rainfall Distribution	Summer dominant
Mean Annual Pan Evaporation	1898.0mm

Source: BOM. Gatton QDPI Research Station

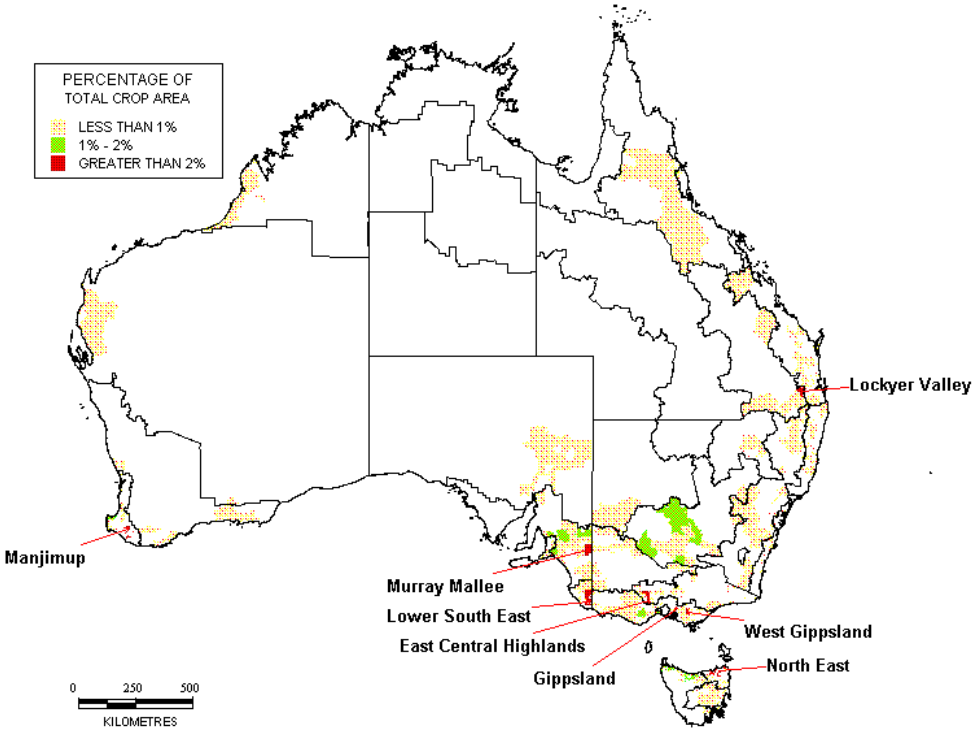
Carnarvon – Western Australia

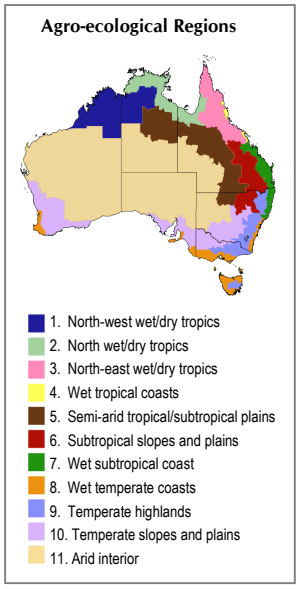
Climate Statistics	
Mean* Annual Min. and Max. Temp.	17.2°C / 27.0°C
Range* in Mean Annual Rainfall	107 - 367mm
Rainfall Distribution	Winter dominant
Mean Annual Pan Evaporation	2591.5mm

Source: BOM. Carnarvon Airport

**Temperatures are mean annual daily minimum and maximums across all stations used as sources. Rainfall data is the annual rainfall range expressed by the 1st and 9th decile rainfall bands. Evaporation is the range across all stations used as sources.*

Potatoes





Map Source: *ABS AgStats 1996-97* with non-agricultural land mask from *Distribution of Agricultural Land Use in Australia* (BRS 1994).

Production by Agro-Ecological Region

Agro-Ecological Region	Area (Ha)	Yield (Tonnes)	Yield per Ha (T / Ha)	Value ($M)
North-west wet/dry tropics	6	dns	-	dns
North-east wet/dry tropics	749	18,750	25.0	8.39
Wet tropical coasts	683	16,637	24.4	7.53
Subtropical slopes and plains	1,846	46,883	25.4	21.02
Wet subtropical coast	2,405	55,589	23.1	23.64
Wet temperate coasts	23,542	802,936	34.1	264.39
Temperate highlands	5,474	164,478	30.0	61.45
Temperate slopes and plains	10,739	288,364	26.9	102.91
Arid interior	4	23	6.6	0.01

dns – data not supplied

Crops Produced

Crop	Area (Ha)	Yield (Tonnes)	Yield per Ha (T / Ha)	Value ($M)
Potatoes	41,083	1,286,130	31.3	448.51
Potatoes – Seed	4,363	107,531	24.6	40.82
Overall	**45,446**	**1,393,661**	**30.7**	**489.34**

Production and Value Statistics Source: *ABS AgStats 1996 - 97.* Data is available in the electronic version of the Australian Natural Resource Atlas located on the National Land and Water Resources Audit Web Site - www.nlwra.gov.au

Major Production Regions

Region	Agro-Ecological Region	% of Total Crop Area	Area (Ha)	Yield (Tonnes)	Yield per Ha (T / Ha)	Value ($M)
West Gippsland	Wet temperate coasts	6.5	2,935	84,740	28.9	33.25
East Central Highlands	Temperate highlands	5.1	2,332	73,593	31.6	28.90
Lower South East	Wet temperate coasts	5.1	2,311	86,831	37.6	30.47
Gippsland	Wet temperate coasts	4.0	1,811	46,652	25.8	18.27
Murray Mallee	Temperate slopes and plains	3.5	1,593	55,821	35.0	19.60
Manjimup	Wet temperate coasts	3.4	1,527	69,747	45.7	22.77
North East	Wet temperate coasts	2.7	1,214	48,056	39.6	13.24
Lockyer Valley	Subtropical slopes and plains / Wet subtropical coast	2.4	1,088	25,603	23.5	11.58

West Gippsland - Victoria

Climate Statistics	
Mean* Annual Min. and Max. Temp.	7.6°C / 19.1°C
Range* in Mean Annual Rainfall	650 - 1039mm
Rainfall Distribution	Winter dominant
Mean Annual Pan Evaporation	985.5mm

Source: BOM. Tooradin Shire

Crops Grown	% of Total Land Area
Potatoes	5.6
Potatoes - Seed	0.9
Total	**6.5%**

East Central Highlands - Victoria

Climate Statistics	
Mean* Annual Min. and Max. Temp.	8.9°C / 20.4°C
Range* in Mean Annual Rainfall	357 - 720mm
Rainfall Distribution	Winter dominant
Mean Annual Pan Evaporation	no data available

Source: BOM. Bendigo Prison

Crops Grown	% of Total Land Area
Potatoes	4.0
Potatoes - Seed	1.1
Total	**5.1%**

Lower South East – South Australia

Climate Statistics	
Mean* Annual Min. and Max. Temp.	7.8°C / 20.4°C
Range* in Mean Annual Rainfall	409 - 868mm
Rainfall Distribution	Winter dominant
Mean Annual Pan Evaporation	1387.0mm

Source: BOM. Mount Gambier Aero

Crops Grown	% of Total Land Area
Potatoes	4.9
Potatoes - Seed	0.2
Total	**5.1%**

Gippsland - Victoria

Climate Statistics	
Mean* Annual Min. and Max. Temp.	7.6°C / 19.1°C
Range* in Mean Annual Rainfall	650 - 1039mm
Rainfall Distribution	Winter dominant
Mean Annual Pan Evaporation	985.5mm

Source: BOM. Tooradin Shire

Crops Grown	% of Total Land Area
Potatoes	3.8
Potatoes - Seed	0.2
Total	**4.0%**

Murray Mallee – South Australia

Climate Statistics	
Mean* Annual Min. and Max. Temp.	9.2°C / 23.4°C
Range* in Mean Annual Rainfall	124 - 475mm
Rainfall Distribution	Consistent
Mean Annual Pan Evaporation	1679.0mm

Source: BOM. Loxton Research Centre

Crops Grown	% of Total Land Area
Potatoes	3.4
Potatoes - Seed	0.1
Total	**3.5%**

Manjimup – Western Australia

Climate Statistics	
Mean* Annual Min. and Max. Temp.	9.6°C / 20.2°C
Range* in Mean Annual Rainfall	806 - 1267mm
Rainfall Distribution	Winter dominant
Mean Annual Pan Evaporation	2226.5mm

Source: BOM. Manjimup Shire

Crops Grown	% of Total Land Area
Potatoes	3.2
Potatoes - Seed	0.1
Total	**3.4%**

North East - Tasmania

Climate Statistics	
Mean* Annual Min. and Max. Temp.	7.2°C / 17.8°C
Range* in Mean Annual Rainfall	737 - 1369mm
Rainfall Distribution	Winter dominant
Mean Annual Pan Evaporation	1022.0mm

Source: BOM. Scottsdale (West Minstone Road)

Crops Grown	% of Total Land Area
Potatoes	2.5
Potatoes - Seed	0.2
Total	**2.7%**

Lockyer Valley - Queensland

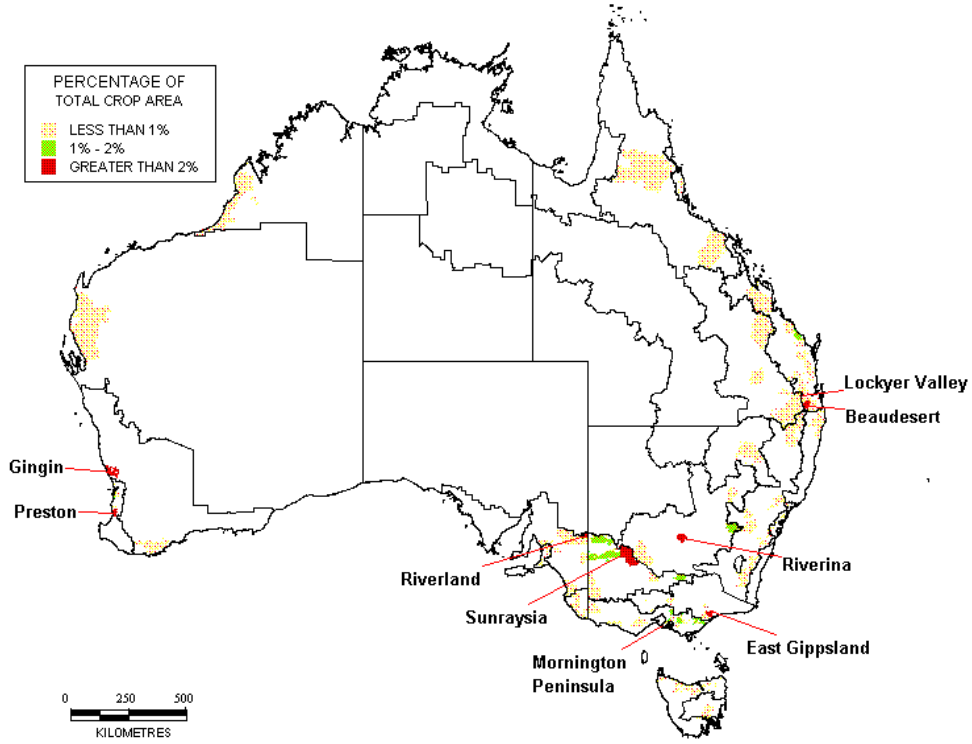
Climate Statistics	
Mean* Annual Min. and Max. Temp.	12.9°C / 26.5°C
Range* in Mean Annual Rainfall	544 - 1131mm
Rainfall Distribution	Summer dominant
Mean Annual Pan Evaporation	1898.0mm

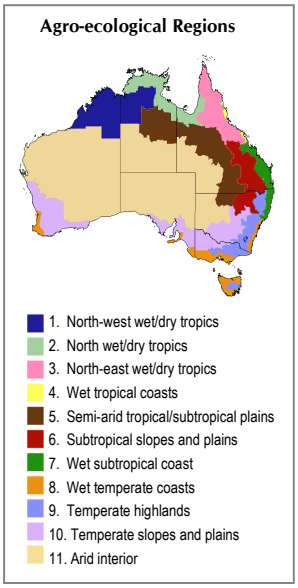
Source: BOM. Gatton QDPI Research Station

Crops Grown	% of Total Land Area
Potatoes	2.3
Potatoes - Seed	0.1
Total	**2.4%**

**Temperatures are mean annual daily minimum and maximums across all stations used as sources. Rainfall data is the annual rainfall range expressed by the 1st and 9th decile rainfall bands. Evaporation is the range across all stations used as sources.*

Root Vegetables





Map Source: *ABS AgStats 1996-97* with non-agricultural land mask from *Distribution of Agricultural Land Use in Australia* (BRS 1994).

Production by Agro-Ecological Region

Agro-Ecological Region	Area (Ha)	Yield (Tonnes)	Yield per Ha (T / Ha)	Value ($M)
North-west wet/dry tropics	22	480	21.8	0.65
North-east wet/dry tropics	52	816	15.7	0.61
Wet tropical coasts	12	176	14.6	0.13
Subtropical slopes and plains	192	6,996	36.5	3.18
Wet subtropical coast	2,094	55,030	26.3	21.76
Wet temperate coasts	3,424	104,583	30.5	64.57
Temperate highlands	664	17,758	26.8	10.55
Temperate slopes and plains	3,390	131,279	38.7	75.13
Arid interior	29	816	27.8	0.53

Crops Produced

Crop	Area (Ha)	Yield (Tonnes)	Yield per Ha (T / Ha)	Value ($M)
Beetroot	894	29,304	32.8	5.42
Carrots	7,046	257,405	36.5	142.07
Carrots – Seed	92	45	0.5	0.43
Parsnips	464	10,263	22.1	11.43
Radish	171	1,359	7.9	2.32
Radish – Seed	261	163	0.6	1.57
Swedes	318	5,580	17.5	3.18
Sweet Potatoes	535	9,105	17.0	7.44
Turnips	98	4,709	48.3	3.25
Overall	**9,879**	**317,933**	**32.2**	**177.12**

Production and Value Statistics Source: *ABS AgStats 1996 - 97.* Data is available in the electronic version of the Australian Natural Resource Atlas located on the National Land and Water Resources Audit Web Site - www.nlwra.gov.au

Major Production Regions

Region	Agro-Ecological Region	% of Total Crop Area	Area (Ha)	Yield (Tonnes)	Yield per Ha (T / Ha)	Value ($M)
Sunraysia	Temperate slopes and plains	9.6	945	47,020	49.8	29.00
Beaudesert	Wet subtropical coast	7.7	765	19,188	25.1	9.87
Gingin	Temperate slopes and plains	7.7	759	31,994	42.1	19.52
Lockyer Valley	Subtropical slopes and plains / Wet subtropical coast	6.9	686	23,541	34.3	4.48
Riverina	Temperate slopes and plains	4.6	455	11,280	24.8	4.87
Riverland	Temperate slopes and plains	4.5	444	21,000	47.3	10.61
Mornington Peninsula	Wet temperate coasts	3.4	337	11,119	33.0	8.11
East Gippsland	Temperate highlands	2.7	270	9,720	36.0	6.00
Preston	Wet temperate coasts	2.1	210	10,137	48.3	6.32

Sunraysia - Victoria

Climate Statistics	
Mean* Annual Min. and Max. Temp.	9.7°C / 22.8°C
Range* in Mean Annual Rainfall	198 - 456mm
Rainfall Distribution	Consistent
Mean Annual Pan Evaporation	1642.5mm

Source: BOM. Walpeup Research Station

Crops Grown	% of Total Land Area
Carrots	9.6
Total	**9.6%**

Beaudesert - Queensland

Climate Statistics	
Mean* Annual Min. and Max. Temp.	12.7°C / 26.5°C
Range* in Mean Annual Rainfall	271 - 1225mm
Rainfall Distribution	Summer dominant
Mean Annual Pan Evaporation	no data available

Source: BOM. Beaudesert Composite

Crops Grown	% of Total Land Area
Carrots	7.2
Beetroot	0.3
Carrots - Seed	0.2
Swedes	0.1
Parsnips	0.1
Total	**7.7%**

Gingin – Western Australia

Climate Statistics	
Mean* Annual Min. and Max. Temp.	13.6°C / 25.8°C
Range* in Mean Annual Rainfall	317 - 625mm
Rainfall Distribution	Winter dominant
Mean Annual Pan Evaporation	6.8mm

Source: BOM. Geraldton (A.M.O)

Crops Grown	% of Total Land Area
Carrots	7.6
Beetroot	0.1
Swedes	0.1
Turnips	0.02
Total	**7.7%**

Lockyer Valley - Queensland

Climate Statistics	
Mean* Annual Min. and Max. Temp.	12.9°C / 26.5°C
Range* in Mean Annual Rainfall	544 - 1131mm
Rainfall Distribution	Summer dominant
Mean Annual Pan Evaporation	1898.0mm

Source: BOM. Gatton QDPI Research Station

Crops Grown	% of Total Land Area
Beetroot	5.5
Carrots	0.9
Carrots - Seed	0.4
Sweet Potatoes	0.1
Swedes	0.1
Parsnips	0.01
Total	**6.9%**

Riverina – New South Wales

Climate Statistics	
Mean* Annual Min. and Max. Temp.	9.6°C / 24.2°C
Range* in Mean Annual Rainfall	217 - 587mm
Rainfall Distribution	Consistent
Mean Annual Pan Evaporation	1788.5mm

Crops Grown	% of Total Land Area
Carrots	4.2
Parsnips	0.4
Swedes	0.1
Total	**4.6%**

Source: BOM. Griffith CSIRO and Hay CSIRO

Riverland – South Australia

Climate Statistics	
Mean* Annual Min. and Max. Temp.	9.2°C / 24.2°C
Range* in Mean Annual Rainfall	124 - 475mm
Rainfall Distribution	Consistent
Mean Annual Pan Evaporation	1679.0mm

Crops Grown	% of Total Land Area
Carrots	4.5
Total	**4.5%**

Source: BOM. Renmark and Loxton Research Centre

Mornington Peninsula - Victoria

Climate Statistics	
Mean* Annual Min. and Max. Temp.	10.0°C / 17.7°C
Range* in Mean Annual Rainfall	530 - 870mm
Rainfall Distribution	Consistent
Mean Annual Pan Evaporation	no data available

Crops Grown	% of Total Land Area
Carrots	1.8
Parsnips	1.6
Beetroot	0.006
Total	**3.4%**

Source: BOM. Portsea Quarantine Station

East Gippsland - Victoria

Climate Statistics	
Mean* Annual Min. and Max. Temp.	8.0°C / 19.6°C
Range* in Mean Annual Rainfall	529 - 892mm
Rainfall Distribution	Summer dominant
Mean Annual Pan Evaporation	no data available

Crops Grown	% of Total Land Area
Carrots	2.7
Total	**2.7%**

Source: BOM. Bairnsdale Airport

Preston – Western Australia

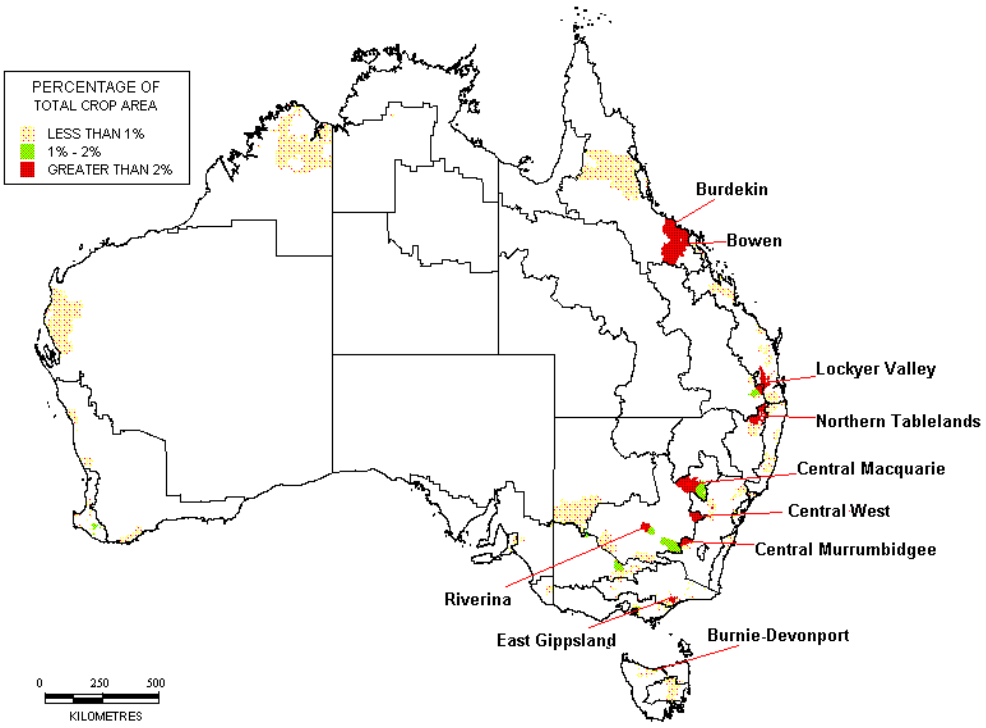
Climate Statistics	
Mean* Annual Min. and Max. Temp.	9.5°C / 22.9°C
Range* in Mean Annual Rainfall	799 - 1229mm
Rainfall Distribution	Winter dominant
Mean Annual Pan Evaporation	no data available

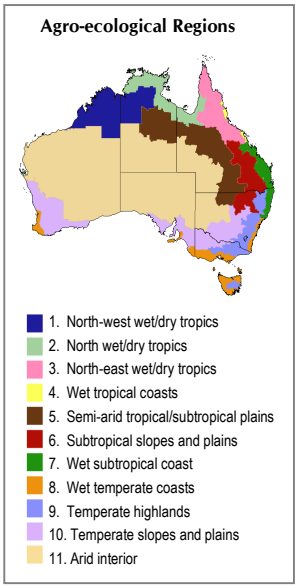
Crops Grown	% of Total Land Area
Carrots	1.9
Parsnips	0.2
Swedes	0.005
Total	**2.1%**

Source: BOM. Donnybrook Post Office

**Temperatures are mean annual daily minimum and maximums across all stations used as sources. Rainfall data is the annual rainfall range expressed by the 1st and 9th decile rainfall bands. Evaporation is the range across all stations used as sources.*

Sweet Corn





Map Source: *ABS AgStats 1996-97* with non-agricultural land mask from *Distribution of Agricultural Land Use in Australia* (BRS 1994).

Production by Agro-Ecological Region

Agro-Ecological Region	Area (Ha)	Yield (Tonnes)	Yield per Ha (T / Ha)	Value ($M)
North-west wet/dry tropics	12	64	5.3	0.07
North-east wet/dry tropics	764	3,793	5.0	1.72
Wet tropical coasts	10	59	6.2	0.03
Semi-arid tropical/subtropical plains	0	1	1.3	0.0005
Subtropical slopes and plains	422	5,600	13.3	2.54
Wet subtropical coast	530	5,565	10.5	2.49
Wet temperate coasts	608	7,637	12.6	3.46
Temperate highlands	923	11,590	12.6	6.46
Temperate slopes and plains	2,145	30,284	14.1	9.56
Arid interior	21	193	9.2	0.15
Overall	**5,434**	**64,785**	**11.9**	**26.48**

Production and Value Statistics Source: *ABS AgStats 1996 - 97.* Data is available in the electronic version of the Australian Natural Resource Atlas located on the National Land and Water Resources Audit Web Site - www.nlwra.gov.au

Major Production Regions

Region	Agro-Ecological Region	% of Total Crop Area	Area (Ha)	Yield (Tonnes)	Yield per Ha (T / Ha)	Value ($M)
Central West	Temperate highlands / Temperate slopes and plains	14.1	765	9,746	12.7	2.41
Lockyer Valley	Subtropical slopes and plains / Wet subtropical coast	12.0	654	7,894	12.1	3.59
Riverina	Temperate slopes and plains	11.9	647	12,552	19.4	3.10
Bowen	North-east wet/dry tropics	10.9	595	3,597	6.0	1.63
East Gippsland	Temperate highlands	5.1	277	3,674	13.3	3.60
Central Macquarie	Temperate slopes and plains	5.0	271	4,518	16.7	1.12
Burdekin	North-east wet/dry tropics	2.6	140	140	1.0	0.06
Central Murrumbidgee	Temperate highlands	2.5	138	2,300	16.7	0.57
Northern Tablelands	Temperate highlands	2.2	120	960	8.0	0.24
Burnie-Devonport	Wet temperate coasts	2.2	119	2,231	18.7	0.36

Central West – New South Wales

Climate Statistics	
Mean* Annual Min. and Max. Temp.	6.8°C / 21.8°C
Range* in Mean Annual Rainfall	361 - 1283mm
Rainfall Distribution	Winter dominant
Range* in Mean Annual Pan Evaporation	1351 - 1460mm

Source: BOM. Bathurst Agricultural Station, Cowra Research Station and Orange Agricultural Station

Lockyer Valley - Queensland

Climate Statistics	
Mean* Annual Min. and Max. Temp.	12.9°C / 26.5°C
Range* in Mean Annual Rainfall	544 - 1131mm
Rainfall Distribution	Summer dominant
Mean Annual Pan Evaporation	1898.0mm

Source: BOM. Gatton QDPI Research Station

Riverina – New South Wales

Climate Statistics	
Mean* Annual Min. and Max. Temp.	9.6°C / 24.2°C
Range* in Mean Annual Rainfall	217 - 587mm
Rainfall Distribution	Consistent
Mean Annual Pan Evaporation	1788.5mm

Source: BOM. Griffith CSIRO and Hay CSIRO

Bowen - Queensland

Climate Statistics	
Mean* Annual Min. and Max. Temp.	19.8°C / 28.5°C
Range* in Mean Annual Rainfall	461 – 1672mm
Rainfall Distribution	Summer dominant
Mean Annual Pan Evaporation	no data available

Source: BOM. Bowen Airport

East Gippsland - Victoria

Climate Statistics	
Mean* Annual Min. and Max. Temp.	8.0°C / 19.6°C
Range* in Mean Annual Rainfall	529 - 892mm
Rainfall Distribution	Summer dominant
Mean Annual Pan Evaporation	no data available

Source: BOM. Bairnsdale Airport

Central Macquarie – New South Wales

Climate Statistics	
Mean* Annual Min. and Max. Temp.	10.2°C / 24.5°C
Range* in Mean Annual Rainfall	251 - 811mm
Rainfall Distribution	Consistent
Mean Annual Pan Evaporation	1971.0mm

Source: BOM. Trangie Research Station

Burdekin - Queensland

Climate Statistics	
Mean* Annual Min. and Max. Temp.	17.7°C / 28.9°C
Range* in Mean Annual Rainfall	455 - 1519mm
Rainfall Distribution	Summer dominant
Mean Annual Pan Evaporation	2080.5mm

Source: BOM. Ayr DPI Research Station

Central Murrumbidgee – New South Wales

Climate Statistics	
Mean* Annual Min. and Max. Temp.	8.6°C / 22.4°C
Range* in Mean Annual Rainfall	454 - 938mm
Rainfall Distribution	Consistent
Mean Annual Pan Evaporation	no data available

Source: BOM. Gundagai (William Street)

Northern Tablelands – New South Wales

Climate Statistics	
Mean* Annual Min. and Max. Temp.	8.1°C / 22°C
Range* in Mean Annual Rainfall	930 - 1692mm
Rainfall Distribution	Summer dominant
Mean Annual Pan Evaporation	1496.5mm

Source: BOM. Tenterfield (Derby Street) and Tabulam

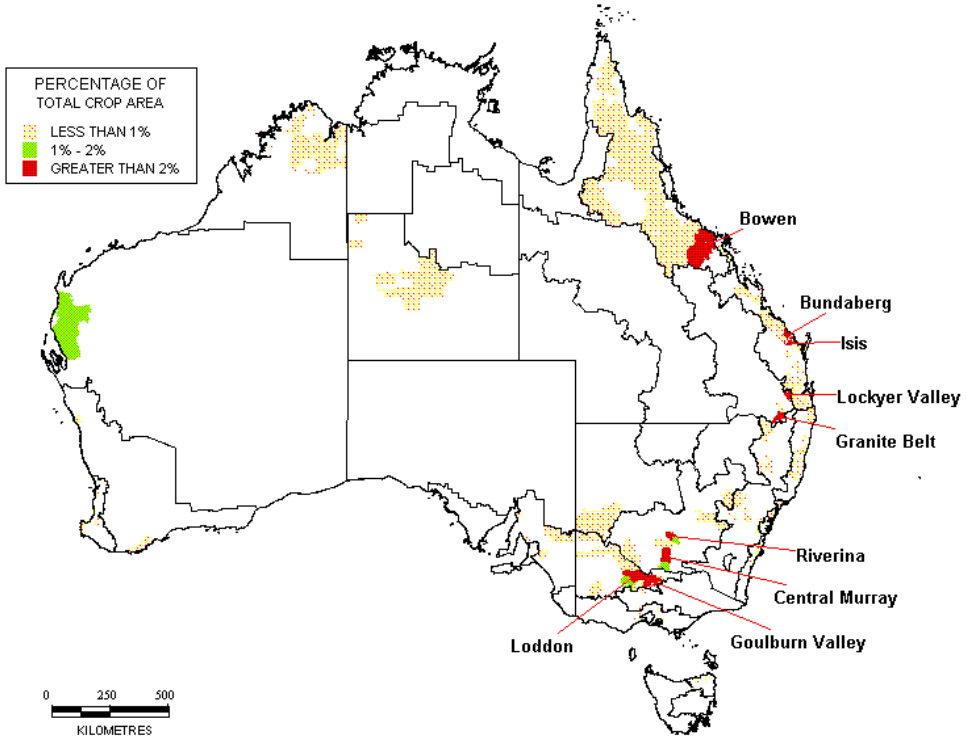
Burnie-Devonport - Tasmania

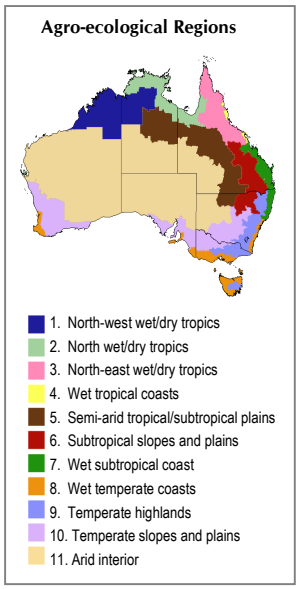
Climate Statistics	
Mean* Annual Min. and Max. Temp.	6.8°C / 16.3°C
Range* in Mean Annual Rainfall	791 - 1359mm
Rainfall Distribution	Winter dominant
Mean Annual Pan Evaporation	no data available

Source: BOM. Wynyard Airport

**Temperatures are mean annual daily minimum and maximums across all stations used as sources. Rainfall data is the annual rainfall range expressed by the 1st and 9th decile rainfall bands. Evaporation is the range across all stations used as sources.*

Tomatoes





Map Source: *ABS AgStats 1996-97* with non-agricultural land mask from *Distribution of Agricultural Land Use in Australia* (BRS 1994).

Production by Agro-Ecological Region

Agro-Ecological Region	Area (Ha)	Yield (Tonnes)	Yield per Ha (T / Ha)	Value ($M)
North-west wet/dry tropics	2	42	24.6	0.03
North-east wet/dry tropics	2,261	63,902	28.3	66.77
Wet tropical coasts	7	78	12.0	0.08
Subtropical slopes and plains	494	13,872	28.1	14.58
Wet subtropical coast	1,078	34,505	32.0	33.24
Wet temperate coasts	286	8,766	30.7	7.95
Temperate highlands	29	944	32.2	1.11
Temperate slopes and plains	4,548	266,374	58.6	50.17
Arid interior	126	4,634	36.7	2.96

Crops Produced

Crop	Area (Ha)	Yield (Tonnes)	Yield per Ha (T / Ha)	Value ($M)
Tomatoes – Fresh	4,490	138,928	30.9	148.19
Tomatoes – Processing	4,340	254,189	58.6	28.71
Overall	**8,830**	**393,117**	**44.5**	**176.90**

Production and Value Statistics Source: *ABS AgStats 1996 - 97.* Data is available in the electronic version of the Australian Natural Resource Atlas located on the National Land and Water Resources Audit Web Site - www.nlwra.gov.au

Major Production Regions

Region	Agro-Ecological Region	% of Total Crop Area	Area (Ha)	Yield (Tonnes)	Yield per Ha (T / Ha)	Value ($M)
Bowen	North-east wet/dry tropics	24.6	2,175	62,787	28.9	65.63
Goulburn Valley	Temperate slopes and plains	19.0	1,677	106,671	63.6	13.47
Central Murray	Temperate slopes and plains	8.7	765	41,500	54.2	4.81
Bundaberg / Isis	Wet subtropical coast	8.2	727	26,369	36.3	24.96
Riverina	Temperate slopes and plains	7.7	681	32,183	47.2	3.73
Loddon	Temperate slopes and plains	4.7	415	31,912	76.9	3.13
Granite Belt	Subtropical slopes and plains	3.1	273	5,975	21.9	6.46
Lockyer Valley	Subtropical slopes and plains / Wet subtropical coast	2.5	219	7,893	36.0	8.12

Bowen - Queensland

Climate Statistics	
Mean* Annual Min. and Max. Temp.	19.8°C / 28.5°C
Range* in Mean Annual Rainfall	461 – 1672mm
Rainfall Distribution	Summer dominant
Mean Annual Pan Evaporation	no data available

Source: BOM. Bowen Airport

Crops Grown	% of Total Land Area
Tomatoes - Fresh	23.3
Tomatoes - Processing	1.3
Total	**24.6%**

Goulburn Valley – New South Wales

Climate Statistics	
Mean* Annual Min. and Max. Temp.	8.3°C / 21.2°C
Range* in Mean Annual Rainfall	283 - 666mm
Rainfall Distribution	Consistent
Mean Annual Pan Evaporation	1606.0mm

Source: BOM. Kyabram (Institute of Sustainable Agriculture)

Crops Grown	% of Total Land Area
Tomatoes - Processing	17.8
Tomatoes - Fresh	1.2
Total	**19.0%**

Central Murray – New South Wales

Climate Statistics	
Mean* Annual Min. and Max. Temp.	9.4°C / 22.1°C
Range* in Mean Annual Rainfall	285 - 578mm
Rainfall Distribution	Winter dominant
Mean Annual Pan Evaporation	no data available

Source: BOM. Echuca Aerodrome

Crops Grown	% of Total Land Area
Tomatoes - Processing	8.7
Total	**8.7%**

Bundaberg / Isis - Queensland

Climate Statistics	
Mean* Annual Min. and Max. Temp.	16.0°C / 26.1°C
Range* in Mean Annual Rainfall	670 - 1654mm
Rainfall Distribution	Summer dominant
Mean Annual Pan Evaporation	no data available

Source: BOM. Bundaberg Aero

Crops Grown	% of Total Land Area
Tomatoes - Fresh	7.4
Tomatoes - Processing	0.9
Total	**8.2%**

Riverina – New South Wales

Climate Statistics	
Mean* Annual Min. and Max. Temp.	9.6°C / 24.2°C
Range* in Mean Annual Rainfall	217 - 587mm
Rainfall Distribution	Consistent
Mean Annual Pan Evaporation	1788.5mm

Source: BOM. Griffith CSIRO and Hay CSIRO

Crops Grown	% of Total Land Area
Tomatoes - Processing	7.7
Tomatoes - Fresh	0.002
Total	**7.7%**

Loddon - Victoria

Climate Statistics	
Mean* Annual Min. and Max. Temp.	8.8°C / 21.9°C
Range* in Mean Annual Rainfall	415 - 879mm
Rainfall Distribution	Winter dominant
Mean Annual Pan Evaporation	no data available

Source: BOM. Wangaratta Composite

Crops Grown	% of Total Land Area
Tomatoes - Processing	4.7
Total	**4.7%**

Granite Belt - Queensland

Climate Statistics	
Mean* Annual Min. and Max. Temp.	8.7°C / 21.6°C
Range* in Mean Annual Rainfall	529 – 1018mm
Rainfall Distribution	Summer dominant
Mean Annual Pan Evaporation	no data available

Source: BOM. Stanthorpe Post Office

Crops Grown	% of Total Land Area
Tomatoes - Fresh	3.1
Tomatoes - Processing	0.02
Total	**3.1%**

Lockyer Valley - Queensland

Climate Statistics	
Mean* Annual Min. and Max. Temp.	12.9°C / 26.5°C
Range* in Mean Annual Rainfall	544 - 1131mm
Rainfall Distribution	Summer dominant
Mean Annual Pan Evaporation	1898.0mm

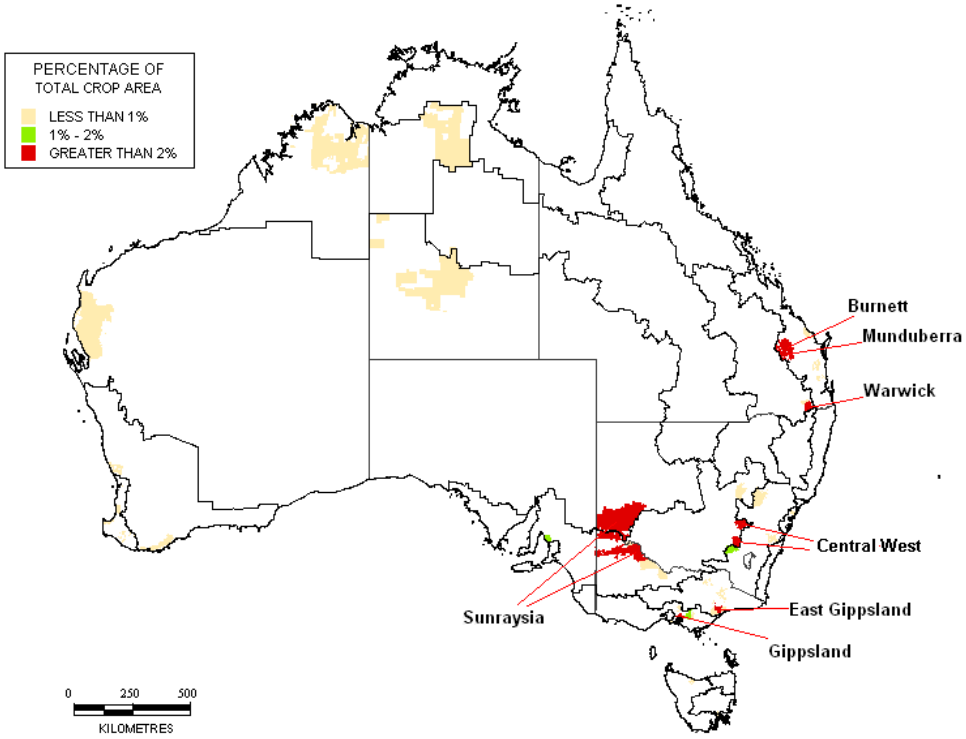
Source: BOM. Gatton QDPI Research Station

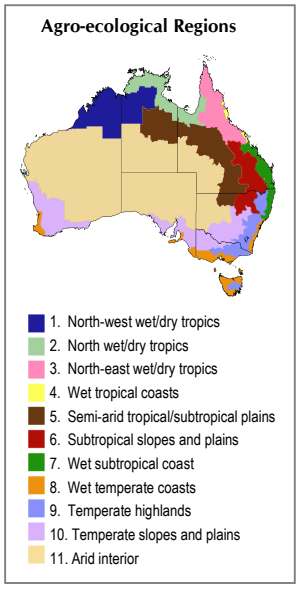
Crops Grown	% of Total Land Area
Tomatoes - Fresh	2.1
Tomatoes - Processing	0.3
Total	**2.5%**

**Temperatures are mean annual daily minimum and maximums across all stations used as sources. Rainfall data is the annual rainfall range expressed by the 1st and 9th decile rainfall bands. Evaporation is the range across all stations used as sources.*

2.4.2 Industry Distribution and Performance - Perennial Crops

Asparagus





Map Source: *ABS AgStats 1996-97* with non-agricultural land mask from *Distribution of Agricultural Land Use in Australia* (BRS 1994).

Production by Agro-Ecological Region

Agro-Ecological Region	Area (Ha)	Yield (Tonnes)	Yield per Ha (T / Ha)	Value ($M)
North-west wet/dry tropics	8	4	0.4	0.02
Subtropical slopes and plains	112	505	4.5	3.02
Wet subtropical coast	167	316	1.9	1.89
Wet temperate coasts	921	3,173	3.4	13.68
Temperate highlands	158	536	3.4	2.38
Temperate slopes and plains	637	2,599	4.1	12.75
Arid interior	136	752	5.5	3.80
Overall	**2,139**	**7,884**	**3.7**	**37.54**

Major Production Regions

Region	Agro-Ecological Region	% of Total Crop Area	Area (Ha)	Yield (Tonnes)	Yield per Ha (T / Ha)	Value ($M)
Gippsland	Wet temperate coasts	39.2	838	3,069	3.7	13.20
Sunraysia	Arid interior / Temperate slopes and plains	16.2	347	1,357	3.9	6.29
Central West	Temperate slopes and plains	15.5	331	1,712	5.2	8.47
Burnett	Wet subtropical coast	6.6	141	259	1.8	1.55
Warwick	Subtropical slopes and plains	4.7	100	475	4.7	2.84
East Gippsland	Temperate highlands	4.6	97	368	3.8	1.58

dns – data not supplied

Production and Value Statistics Source: *ABS AgStats 1996 - 97.* Data is available in the electronic version of the Australian Natural Resource Atlas located on the National Land and Water Resources Audit Web Site - www.nlwra.gov.au

Gippsland - Victoria

Climate Statistics	
Mean* Annual Min. and Max. Temp.	7.6°C / 19.1°C
Range* in Mean Annual Rainfall	650 - 1039mm
Rainfall Distribution	Winter dominant
Mean Annual Pan Evaporation	985.5mm

Source: BOM. Tooradin Shire

Sunraysia – New South Wales / Victoria

Climate Statistics	
Mean* Annual Min. and Max. Temp.	9.7°C / 22.8°C
Range* in Mean Annual Rainfall	198 - 456mm
Rainfall Distribution	Consistent
Mean Annual Pan Evaporation	1642.5mm

Source: BOM. Walpeup Research Station

Central West – New South Wales

Climate Statistics	
Mean* Annual Min. and Max. Temp.	6.8°C / 21.8°C
Range* in Mean Annual Rainfall	361 - 1283mm
Rainfall Distribution	Winter dominant
Range* in Mean Annual Pan Evaporation	1351mm-1460mm

Source: BOM. Bathurst Agricultural Station, Cowra Research Station and Orange Agricultural Station

Burnett - Queensland

Climate Statistics	
Mean* Annual Min. and Max. Temp.	11.2°C / 24.7°C
Range* in Mean Annual Rainfall	508 - 1037mm
Rainfall Distribution	Summer dominant
Mean Annual Pan Evaporation	1606.0mm

Source: BOM. Kingaroy (Prince Street)

Warwick – New South Wales

Climate Statistics	
Mean* Annual Min. and Max. Temp.	10.7°C / 24.1°C
Range* in Mean Annual Rainfall	521 - 982mm
Rainfall Distribution	Summer dominant
Mean Annual Pan Evaporation	no data available

Source: BOM. Warwick Shire

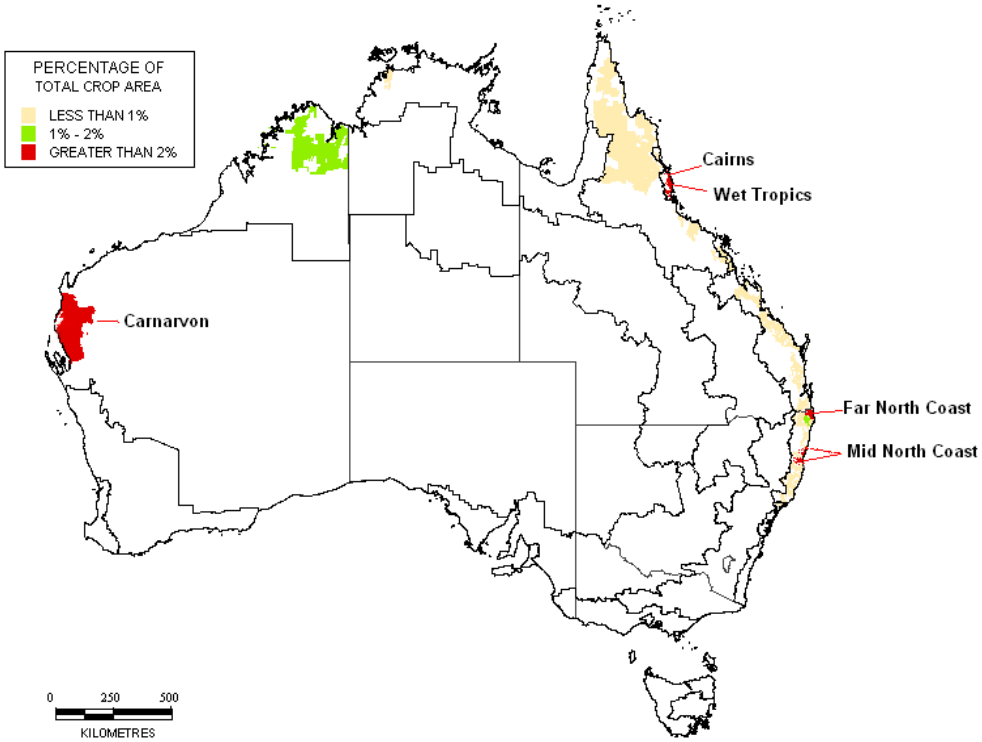
East Gippsland - Victoria

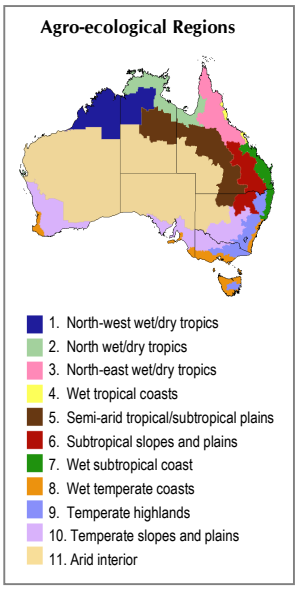
Climate Statistics	
Mean* Annual Min. and Max. Temp.	8.0°C / 19.6°C
Range* in Mean Annual Rainfall	529 - 892mm
Rainfall Distribution	Summer dominant
Mean Annual Pan Evaporation	no data available

Source: BOM. Bairnsdale Airport

**Temperatures are mean annual daily minimum and maximums across all stations used as sources. Rainfall data is the annual rainfall range expressed by the 1st and 9th decile rainfall bands. Evaporation is the range across all stations used as sources.*

Bananas





Map Source: *ABS AgStats 1996-97* with non-agricultural land mask from *Distribution of Agricultural Land Use in Australia* (BRS 1994).

Production by Agro-Ecological Region

Agro-Ecological Region	Area (Ha)	Yield (Tonnes)	Yield per Ha (T / Ha)	Value ($M)
North-west wet/dry tropics	155	4,290	27.7	6.07
North wet/dry tropics	175	3,559	20.4	4.08
North-east wet/dry tropics	104	2,675	25.7	2.62
Wet tropical coasts	6567	135,227	20.6	132.30
Wet subtropical coast	4300	44,760	10.4	58.73
Wet temperate coasts	1	dns	-	dns
Arid interior	310	9,070	29.2	12.82
Overall	**11,613**	**199,581**	**17.2**	**216.62**

dns – data not supplied

Major Production Regions

Region	Agro-Ecological Region	% of Total Crop Area	Area (Ha)	Yield (Tonnes)	Yield per Ha (T / Ha)	Value ($M)
Wet Tropics	Wet tropical coasts	53.0	6,154	127,837	20.8	125.07
Mid North Coast	Wet subtropical coast	15.1	1,759	22,632	12.9	30.83
Far North Coast	Wet subtropical coast	11.1	1,284	10,527	8.2	14.34
Carnarvon	Arid interior	2.7	310	9,070	29.2	12.82
Cairns	Wet tropical coasts	2.3	266	5,682	21.4	5.56

Production and Value Statistics Source: *ABS AgStats 1996 - 97.* Data is available in the electronic version of the Australian Natural Resource Atlas located on the National Land and Water Resources Audit Web Site - www.nlwra.gov.au

Wet Tropics - Queensland

Climate Statistics	
Mean* Annual Min. and Max. Temp.	18.7°C / 28.8°C
Range* in Mean Annual Rainfall	1383 - 4747mm
Rainfall Distribution	Summer dominant
Mean Annual Pan Evaporation	1715.5mm

Source: BOM. Cardwell (Eden Street), Innisfail Shire and South Johnstone Exp. Station

Mid North Coast – New South Wales

Climate Statistics	
Mean* Annual Min. and Max. Temp.	13.9°C / 23.2°C
Range* in Mean Annual Rainfall	1158- 2309mm
Rainfall Distribution	Summer dominant
Mean Annual Pan Evaporation	no data available

Source: BOM. Coffs Harbour Shire

Far North Coast – New South Wales

Climate Statistics	
Mean* Annual Min. and Max. Temp.	13.2°C / 25.5°C
Range* in Mean Annual Rainfall	881 - 2328mm
Rainfall Distribution	Summer dominant
Mean Annual Pan Evaporation	no data available

Source: BOM. Lismore Shire and Murwillumbah Shire

Carnarvon – Western Australia

Climate Statistics	
Mean* Annual Min. and Max. Temp.	17.2°C / 27.0°C
Range* in Mean Annual Rainfall	107 - 367mm
Rainfall Distribution	Winter dominant
Mean Annual Pan Evaporation	2591.5mm

Source: BOM. Carnarvon Airport

Cairns - Queensland

Climate Statistics	
Mean* Annual Min. and Max. Temp.	20.7°C - 28.9°C
Range* in Mean Annual Rainfall	1313 - 2790mm
Rainfall Distribution	Summer dominant
Mean Annual Pan Evaporation	2263.0mm

Source: BOM. Cairns A.M.O.

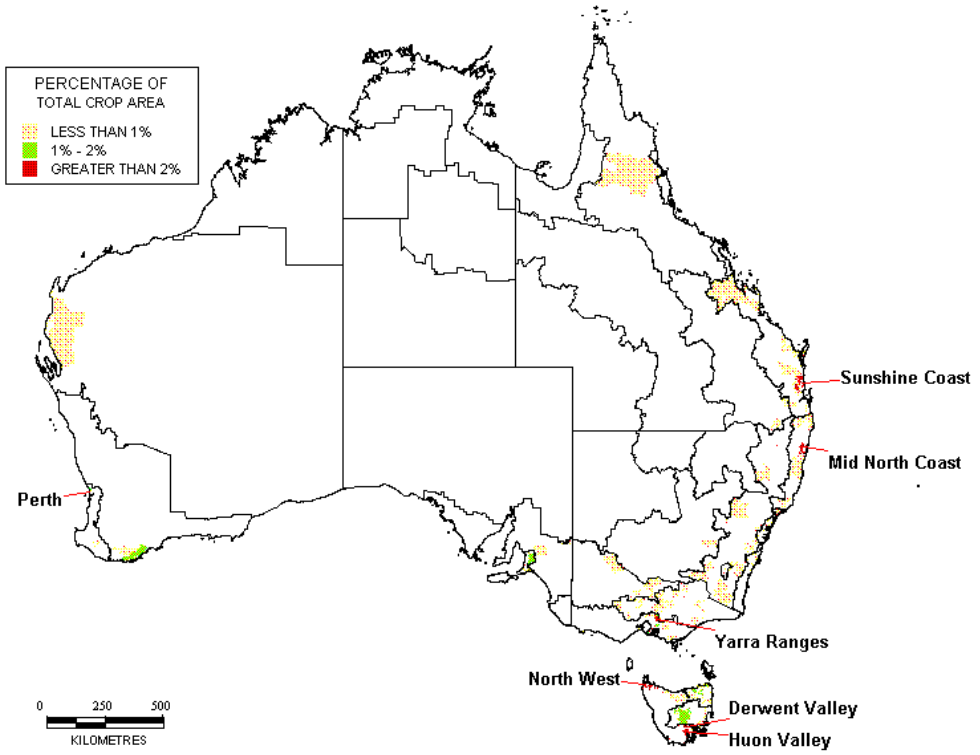
Sunshine Coast - Queensland

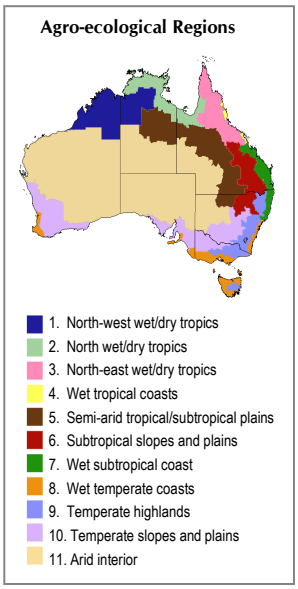
Climate Statistics	
Mean* Annual Min. and Max. Temp.	13.5°C / 25.6°C
Range* in Mean Annual Rainfall	1124 - 2348mm
Rainfall Distribution	Summer dominant
Mean Annual Pan Evaporation	1387.0mm

Source: BOM. Nambour DPI

**Temperatures are mean annual daily minimum and maximums across all stations used as sources. Rainfall data is the annual rainfall range expressed by the 1st and 9th decile rainfall bands. Evaporation is the range across all stations used as sources.*

Berry Fruit





Map Source: *ABS AgStats 1996-97* with non-agricultural land mask from *Distribution of Agricultural Land Use in Australia* (BRS 1994).

Production by Agro-Ecological Region

Agro-Ecological Region	Area (Ha)	Yield (Tonnes)	Yield per Ha (T / Ha)	Value ($M)
North-east wet/dry tropics	5	34	7.3	0.20
Wet tropical coasts	2	20	8.5	0.12
Subtropical slopes and plains	6	20	3.7	0.26
Wet subtropical coast	570	4,105	7.2	27.80
Wet temperate coasts	761	7,375	9.7	32.22
Temperate highlands	223	825	3.7	4.46
Temperate slopes and plains	56	755	13.5	3.31
Arid interior	1	2	1.9	0.01

Crops Produced

Crop	Area (Ha)	Yield (Tonnes)	Yield per Ha (T / Ha)	Value ($M)
Blackcurrants	164	933	5.7	1.08
Blueberries	346	594	1.7	7.91
Gooseberries	5	9	1.7	0.06
Loganberries	3	1	0.4	0.01
Raspberries	202	361	1.8	3.33
Strawberries	904	11,242	12.4	55.98
Overall	**1,624**	**13,138**	**8.1**	**68.38**

Production and Value Statistics Source: *ABS AgStats 1996 - 97.* Data is available in the electronic version of the Australian Natural Resource Atlas located on the National Land and Water Resources Audit Web Site - www.nlwra.gov.au

Major Production Regions

Region	Agro-Ecological Region	% of Total Crop Area	Area (Ha)	Yield (Tonnes)	Yield per Ha (T / Ha)	Value ($M)
Sunshine Coast	Wet subtropical coast	14.7	238	3,081	12.9	18.11
Mid North Coast	Wet subtropical coast	13.0	212	348	1.6	5.40
Yarra Ranges	Wet temperate coasts	10.8	176	2,122	12.1	8.67
North West	Wet temperate coasts	3.3	54	180	3.4	0.21
Derwent Valley	Wet temperate coasts	2.9	47	251	5.4	0.29
Perth	Wet temperate coasts	2.6	42	875	20.8	3.85
Huon Valley	Wet temperate coasts	2.1	34	236	6.9	0.68

Sunshine Coast - Queensland

Climate Statistics	
Mean* Annual Min. and Max. Temp.	13.5°C / 25.6°C
Range* in Mean Annual Rainfall	1124 - 2348mm
Rainfall Distribution	Summer dominant
Mean Annual Pan Evaporation	1387.0mm

Source: BOM. Nambour DPI

Crops Grown	% of Total Land Area
Strawberries	14.6
Raspberries	0.1
Total	**14.7%**

Mid North Coast – New South Wales

Climate Statistics	
Mean* Annual Min. and Max. Temp.	13.9°C / 23.2°C
Range* in Mean Annual Rainfall	1158 - 2309mm
Rainfall Distribution	Summer dominant
Mean Annual Pan Evaporation	no data available

Source: BOM. Coffs Harbour Shire

Crops Grown	% of Total Land Area
Blueberries	12.9
Raspberries	0.1
Strawberries	0.03
Total	**13.0%**

Yarra Ranges - Victoria

Climate Statistics	
Mean* Annual Min. and Max. Temp.	7.8°C / 15.1°C
Range* in Mean Annual Rainfall	912 - 1439mm
Rainfall Distribution	Winter dominant
Mean Annual Pan Evaporation	no data available

Source: BOM. Mount Dandenong

Crops Grown	% of Total Land Area
Strawberries	9.3
Raspberries	1.3
Blueberries	0.2
Total	**10.8%**

North West - Tasmania

Climate Statistics	
Mean* Annual Min. and Max. Temp.	6.2°C / 15.8°C
Range* in Mean Annual Rainfall	840 - 1533mm
Rainfall Distribution	Winter dominant
Mean Annual Pan Evaporation	no data available

Source: BOM. Sheffield Shire

Crops Grown	% of Total Land Area
Blackcurrants	3.1
Blueberries	0.1
Strawberries	0.1
Total	**3.3%**

Derwent Valley - Tasmania

Climate Statistics	
Mean* Annual Min. and Max. Temp.	5.1°C / 16.2°C
Range* in Mean Annual Rainfall	967 - 1568mm
Rainfall Distribution	Winter dominant
Mean Annual Pan Evaporation	803.0mm

Source: BOM. Maydena Post Office

Crops Grown	% of Total Land Area
Blackcurrants	2.8
Raspberries	0.1
Total	**2.9%**

Perth – Western Australia

Climate Statistics	
Mean* Annual Min. and Max. Temp.	13.3°C / 23.3°C
Range* in Mean Annual Rainfall	666 - 1051mm
Rainfall Distribution	Winter dominant
Mean Annual Pan Evaporation	1752.0mm

Source: BOM. Perth Regional Office

Crops Grown	% of Total Land Area
Strawberries	2.6
Total	**2.6%**

Huon Valley - Tasmania

Climate Statistics	
Mean* Annual Min. and Max. Temp.	5.7°C / 16.8°C
Range* in Mean Annual Rainfall	563 - 970mm
Rainfall Distribution	Winter dominant
Mean Annual Pan Evaporation	985.5mm

Source: BOM. Grove Research Station

Crops Grown	% of Total Land Area
Blackcurrants	0.8
Raspberries	0.6
Strawberries	0.5
Blueberries	0.2
Total	**2.1%**

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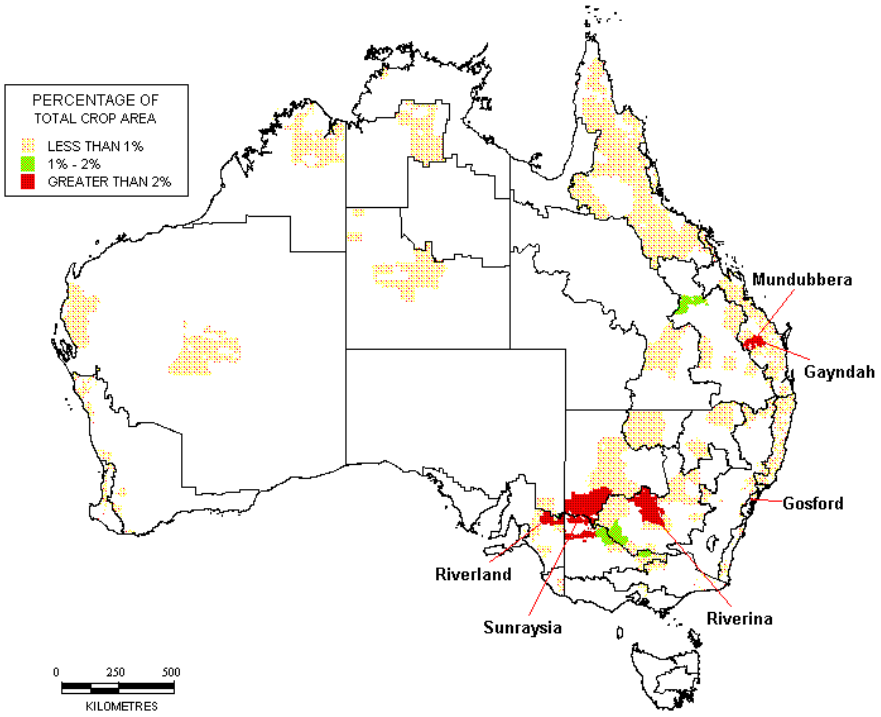
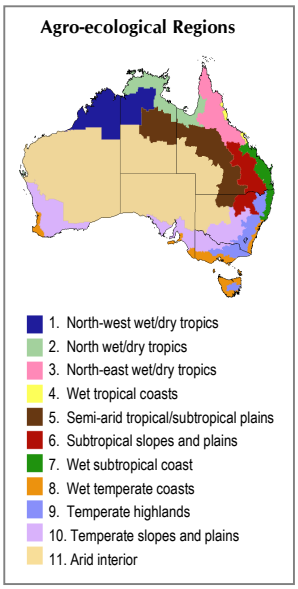
Citrus





Map Source: *ABS AgStats 1996-97* with non-agricultural land mask from *Distribution of Agricultural Land Use in Australia* (BRS 1994).

Production by Agro-Ecological Region

Agro-Ecological Region	Area (Ha)	Yield (Tonnes)	Yield per Ha (T / Ha)	Value ($M)
North-west wet/dry tropics	11	12	1.1	0.02
North wet/dry tropics	11	19	1.7	0.07
North-east wet/dry tropics	159	1,740	10.9	1.94
Wet tropical coasts	126	185	1.5	0.21
Semi-arid tropical/subtropical plains	58	379	6.5	0.37
Subtropical slopes and plains	621	8,978	14.5	11.09
Wet subtropical coast	3,006	58,295	19.4	64.13
Wet temperate coasts	1,590	17,721	11.1	13.67
Temperate highlands	272	3,029	11.1	1.94
Temperate slopes and plains	21,812	495,764	22.7	264.90
Arid interior	2,733	59,138	21.6	33.43

Crops Produced

Crop	Area (Ha)	Yield (Tonnes)	Yield per Ha (T / Ha)	Value ($M)
Grapefruit	484	13,714	28.3	6.34
Lemon/Lime	1,722	32,991	19.2	31.13
Mandarins	4,587	72,937	15.9	86.86
Oranges	23,459	522,622	22.3	263.65
Tangelos	148	2,997	20.2	3.80
Overall	**30,400**	**645,260**	**21.2**	**391.77**

Production and Value Statistics Source: *ABS AgStats 1996 - 97.* Data is available in the electronic version of the Australian Natural Resource Atlas located on the National Land and Water Resources Audit Web Site - www.nlwra.gov.au

Major Production Regions

Region	Agro-Ecological Region	% of Total Crop Area	Area (Ha)	Yield (Tonnes)	Yield per Ha (T / Ha)	Value ($M)
Riverina	Temperate slopes and plains	25.2	7,667	153,541	20.0	77.69
Riverland	Temperate slopes and plains	21.8	6,630	185,147	27.9	97.99
Sunraysia	Arid interior / Temperate slopes and plains	19.4	5,900	133,798	22.7	77.68
Gayndah / Mundubbera	Wet subtropical coast	5.9	1,783	39,562	22.2	45.43
Gosford	Wet temperate coasts	2.3	713	9,173	12.9	7.50

Riverina – New South Wales

Climate Statistics	
Mean* Annual Min. and Max. Temp.	9.6°C / 24.2°C
Range* in Mean Annual Rainfall	217 - 587mm
Rainfall Distribution	Consistent
Mean Annual Pan Evaporation	1788.5mm

Source: BOM. Griffith CSIRO and Hay CSIRO

Crops Grown	% of Total Land Area
Oranges	24.5
Mandarins	0.3
Lemon/Lime	0.3
Grapefruit	0.2
Tangelos	0.02
Total	**25.2%**

Riverland – South Australia

Climate Statistics	
Mean* Annual Min. and Max. Temp.	9.2°C / 24.2°C
Range* in Mean Annual Rainfall	124 - 475mm
Rainfall Distribution	Consistent
Mean Annual Pan Evaporation	1679.0mm

Source: BOM. Renmark and Loxton Research Centre

Crops Grown	% of Total Land Area
Oranges	18.0
Mandarins	2.4
Lemon/Lime	0.9
Grapefruit	0.3
Tangelos	0.2
Total	**21.8%**

Sunraysia – New South Wales / Victoria

Climate Statistics	
Mean* Annual Min. and Max. Temp.	9.7°C / 22.8°C
Range* in Mean Annual Rainfall	198 - 456mm
Rainfall Distribution	Consistent
Mean Annual Pan Evaporation	1642.5mm

Source: BOM. Walpeup Research Station

Crops Grown	% of Total Land Area
Oranges	16.5
Mandarins	1.9
Lemon/Lime	0.6
Grapefruit	0.3
Tangelos	0.1
Total	**19.4%**

Gayndah / Mundubbera - Queensland

Climate Statistics	
Mean* Annual Min. and Max. Temp.	13.5°C / 28.0°C
Range* in Mean Annual Rainfall	506 - 1039mm
Rainfall Distribution	Summer dominant
Mean Annual Pan Evaporation	no data available

Source: BOM. Gayndah Post Office

Crops Grown	% of Total Land Area
Mandarins	4.6
Oranges	0.9
Lemon/Lime	0.2
Grapefruit	0.05
Tangelos	0.006
Total	**5.9%**

Gosford – New South Wales

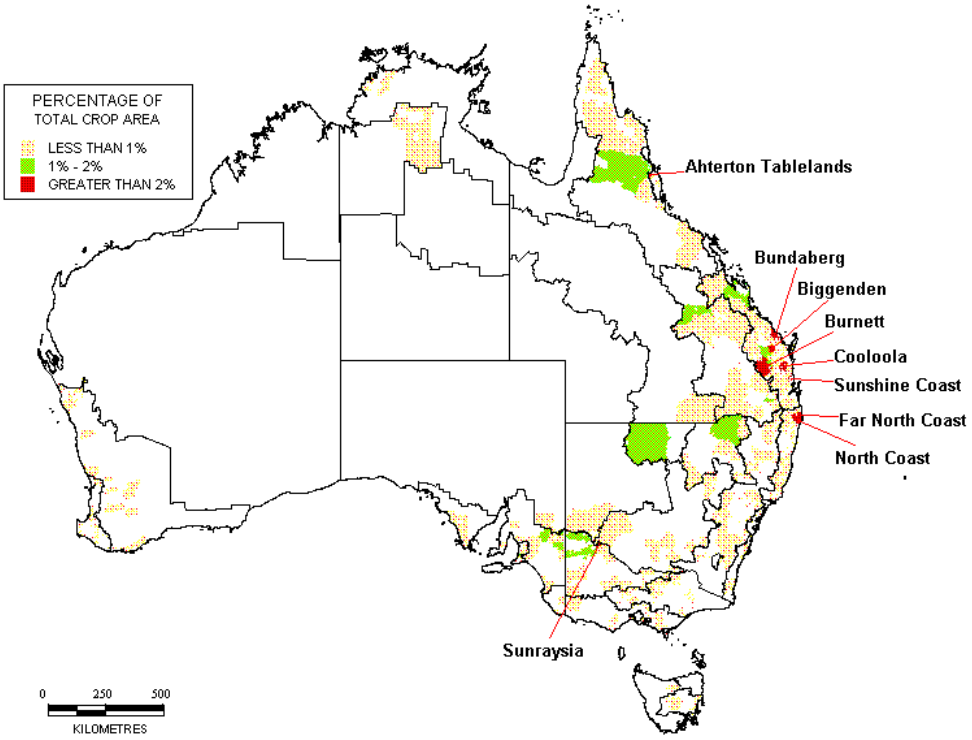
Climate Statistics	
Mean* Annual Min. and Max. Temp.	11.2°C / 21.6°C
Range* in Mean Annual Rainfall	848 - 1964mm
Rainfall Distribution	Summer dominant
Mean Annual Pan Evaporation	1241.0mm

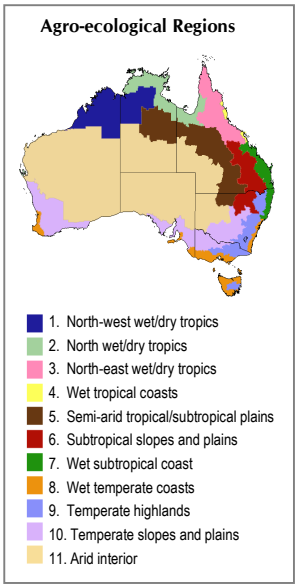
Source: BOM. Peats Ridge (Waratah Road)

Crops Grown	% of Total Land Area
Oranges	1.6
Lemon/Lime	0.7
Mandarins	0.04
Tangelos	0.03
Grapefruit	0.0002
Total	**2.3%**

**Temperatures are mean annual daily minimum and maximums across all stations used as sources. Rainfall data is the annual rainfall range expressed by the 1st and 9th decile rainfall bands. Evaporation is the range across all stations used as sources.*

Nuts





Map Source: *ABS AgStats 1996-97* with non-agricultural land mask from *Distribution of Agricultural Land Use in Australia* (BRS 1994).

Production by Agro-Ecological Region

Agro-Ecological Region	Area (Ha)	Yield (Tonnes)	Yield per Ha (T / Ha)	Value ($M)
North-west wet/dry tropics	5	1	0.2	0.00
North wet/dry tropics	91	21	0.2	0.02
North-east wet/dry tropics	208	208	1.0	0.60
Wet tropical coasts	331	523	1.6	1.48
Semi-arid tropical/subtropical plains	0	0	0.0	0.00
Subtropical slopes and plains	825	134	0.2	0.66
Wet subtropical coast	10,887	15,201	1.4	52.32
Wet temperate coasts	1,460	716	0.5	4.30
Temperate highlands	908	530	0.6	1.19
Temperate slopes and plains	4,939	6,065	1.2	41.04
Arid interior	97	41	0.4	0.28

Crops Produced

Crop	Area (Ha)	Yield (Tonnes)	Yield per Ha (T / Ha)	Value ($M)
Almonds (kernel wt)	5,031	5,893	1.2	39.13
Cashews	97	22	0.2	0.02
Chestnuts	747	537	0.7	1.21
Hazelnuts	37	15	0.4	0.06
Macadamia	11,009	16,053	1.5	54.81
Pecans	1,573	138	0.1	0.67
Pistachios	943	720	0.8	5.86
Walnuts	312	63	0.2	0.12
Overall	**19,750**	**23,440**	**1.6**	**101.89**

Production and Value Statistics Source: *ABS AgStats 1996 - 97.* Data is available in the electronic version of the Australian Natural Resource Atlas located on the National Land and Water Resources Audit Web Site - www.nlwra.gov.au

Major Production Regions

Region	Agro-Ecological Region	% of Total Crop Area	Area (Ha)	Yield (Tonnes)	Yield per Ha (T / Ha)	Value ($M)
North / Far North Coast	Wet subtropical coast	12.3	5,372	9,132	1.7	34.71
Bundaberg	Wet subtropical coast	2.4	1,054	631	0.6	1.78
Sunshine Coast	Wet subtropical coast	2.3	995	972	1.0	2.75
Cooloola	Wet subtropical coast	2.1	904	853	0.9	2.42
Sunraysia	Arid interior / Temperate slopes and plains	2.0	891	1,833	2.1	12.33

North / Far North Coast – New South Wales

Climate Statistics	
Mean* Annual Min. and Max. Temp.	13.2°C / 25.5°C
Range* in Mean Annual Rainfall	881 - 2328mm
Rainfall Distribution	Summer dominant
Mean Annual Pan Evaporation	no data available

Source: BOM. Lismore Shire and Murwillumbah Shire

Crops Grown	% of Total Land Area
Macadamia	11.9
Pecans	0.4
Total	**12.3%**

Bundaberg - Queensland

Climate Statistics	
Mean* Annual Min. and Max. Temp.	16.0°C / 26.1°C
Range* in Mean Annual Rainfall	670 - 1654mm
Rainfall Distribution	Summer dominant
Mean Annual Pan Evaporation	no data available

Source: BOM. Bundaberg Aero

Crops Grown	% of Total Land Area
Macadamia	2.4
Pecans	0.0001
Total	**2.4%**

Sunshine Coast - Queensland

Climate Statistics	
Mean* Annual Min. and Max. Temp.	13.5°C / 25.6°C
Range* in Mean Annual Rainfall	1124 - 2348mm
Rainfall Distribution	Summer dominant
Mean Annual Pan Evaporation	1387.0mm

Source: BOM. Nambour DPI

Crops Grown	% of Total Land Area
Macadamia	2.3
Pecans	0.004
Total	**2.3%**

Cooloola - Queensland

Climate Statistics	
Mean* Annual Min. and Max. Temp.	12.9°C / 26.4°C
Range* in Mean Annual Rainfall	809 - 1664mm
Rainfall Distribution	Summer dominant
Mean Annual Pan Evaporation	no data available

Source: BOM. IMBIL Forestry

Crops Grown	% of Total Land Area
Macadamia	2.0
Pecans	0.05
Total	**2.1%**

Sunraysia - Victoria

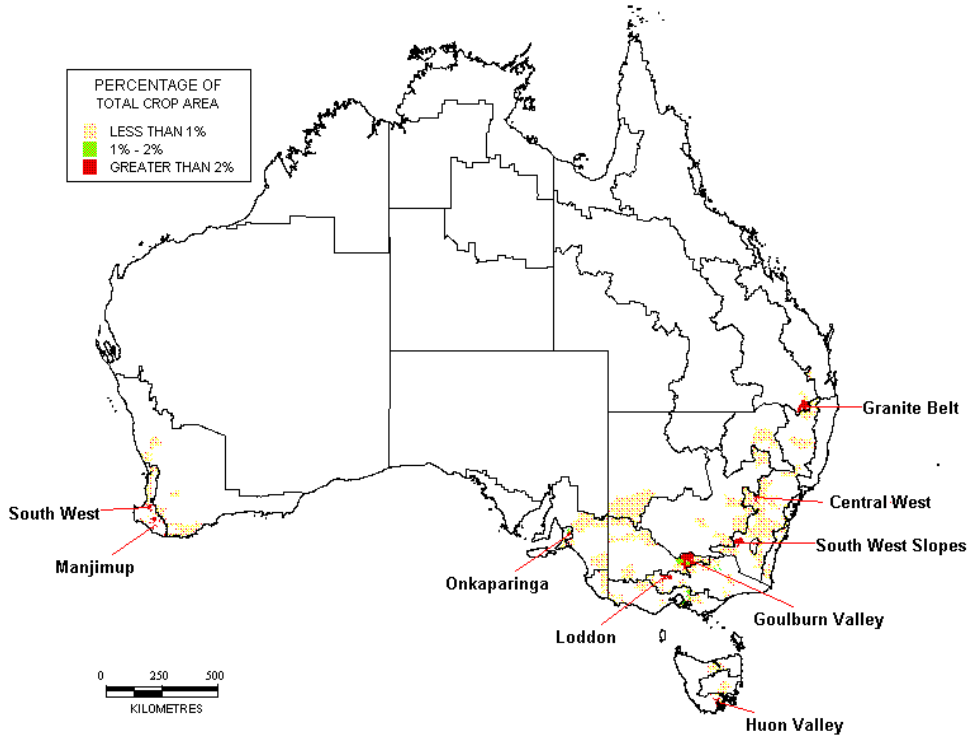
Climate Statistics	
Mean* Annual Min. and Max. Temp.	9.7°C / 22.8°C
Range* in Mean Annual Rainfall	198 - 456mm
Rainfall Distribution	Consistent
Mean Annual Pan Evaporation	1642.5mm

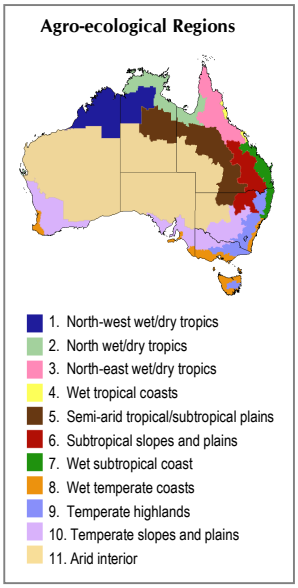
Source: BOM. Walpeup Research Station

Crops Grown	% of Total Land Area
Almonds	1.8
Pistachios	0.2
Walnuts	0.004
Total	**2.0%**

**Temperatures are mean annual daily minimum and maximums across all stations used as sources. Rainfall data is the annual rainfall range expressed by the 1st and 9th decile rainfall bands. Evaporation is the range across all stations used as sources.*

Pome Fruit





Map Source: *ABS AgStats 1996-97* with non-agricultural land mask from *Distribution of Agricultural Land Use in Australia* (BRS 1994).

Production by Agro-Ecological Region

Agro-Ecological Region	Area (Ha)	Yield (Tonnes)	Yield per Ha (T / Ha)	Value ($M)
Subtropical slopes and plains	1,424	62,533	43.9	27.91
Wet subtropical coast	3	11	3.7	0.01
Wet temperate coasts	7,622	352,696	46.3	194.10
Temperate highlands	4,387	240,207	54.8	127.00
Temperate slopes and plains	5,253	284,771	54.2	163.88
Arid interior	3	251	73.7	0.10

Crops Produced

Crop	Area (Ha)	Yield (Tonnes)	Yield per Ha (T / Ha)	Value ($M)
Apples	13,296	766,879	57.7	393.45
Nashi	630	6,028	9.6	13.51
Pears	4,766	167,562	35.2	106.05
Overall	**18,691**	**940,469**	**50.3**	**513.01**

Production and Value Statistics Source: *ABS AgStats 1996 - 97.* Data is available in the electronic version of the Australian Natural Resource Atlas located on the National Land and Water Resources Audit Web Site - www.nlwra.gov.au

Major Production Regions

Region	Agro-Ecological Region	% of Total Crop Area	Area (Ha)	Yield (Tonnes)	Yield per Ha (T / Ha)	Value ($M)
Goulburn Valley	Temperate slopes and plains	22.6	4,233	239,695	56.6	137.33
Huon Valley	Wet temperate coasts	9.4	1,762	87,914	49.9	39.32
Central West	Temperate highlands / Temperate slopes and plains	7.7	1,431	75,489	52.7	41.50
Granite Belt	Subtropical slopes and plains	7.5	1,410	62,031	44.0	27.68
Onkaparinga	Wet temperate coasts	4.8	891	39,289	44.1	32.02
South West	Wet temperate coasts	4.4	825	34,555	41.9	18.90
South West Slopes	Temperate highlands	4.1	767	72,991	95.2	39.55
Loddon	Temperate highlands	3.4	634	25,158	39.7	12.53
Manjimup	Wet temperate coasts	2.4	457	29,820	65.2	15.74

Goulburn Valley - Victoria

Climate Statistics	
Mean* Annual Min. and Max. Temp.	8.3°C / 21.2°C
Range* in Mean Annual Rainfall	283 - 666mm
Rainfall Distribution	Consistent
Mean Annual Pan Evaporation	1606.0mm

Crops Grown	% of Total Land Area
Pears	14.9
Apples	5.4
Nashi	2.3
Total	**22.6%**

Source: BOM. Kyabram (Institute of Sustainable Agriculture)

Huon Valley - Tasmania

Climate Statistics	
Mean* Annual Min. and Max. Temp.	5.7°C / 16.8°C
Range* in Mean Annual Rainfall	563 - 970mm
Rainfall Distribution	Winter dominant
Mean Annual Pan Evaporation	985.5mm

Crops Grown	% of Total Land Area
Apples	9.3
Pears	0.1
Nashi	0.003
Total	**9.4%**

Source: BOM. Grove Research Station

Central West – New South Wales

Climate Statistics	
Mean* Annual Min. and Max. Temp.	6.8°C / 21.8°C
Range* in Mean Annual Rainfall	361 - 1283mm
Rainfall Distribution	Winter dominant
Range* in Mean Annual Pan Evaporation	1351 - 1460mm

Crops Grown	% of Total Land Area
Apples	6.8
Pears	0.9
Nashi	0.002
Total	**7.7%**

Source: BOM. Bathurst Agricultural Station, Cowra Research Station and Orange Agricultural Station

Granite Belt - Queensland

Climate Statistics	
Mean* Annual Min. and Max. Temp.	8.7°C / 21.6°C
Range* in Mean Annual Rainfall	529 – 1018mm
Rainfall Distribution	Summer dominant
Mean Annual Pan Evaporation	no data available

Crops Grown	% of Total Land Area
Apples	7.0
Pears	0.5
Nashi	0.03
Total	**7.5%**

Source: BOM. Stanthorpe Post Office

Onkaparinga – South Australia

Climate Statistics	
Mean* Annual Min. and Max. Temp.	9.5°C / 18.3°C
Range* in Mean Annual Rainfall	768 - 1330mm
Rainfall Distribution	Winter dominant
Mean Annual Pan Evaporation	1277.5mm

Source: BOM. Lenswood Research Centre

Crops Grown	% of Total Land Area
Apples	4.5
Pears	0.2
Nashi	0.04
Total	**4.8%**

South West – Western Australia

Climate Statistics	
Mean* Annual Min. and Max. Temp.	9.5°C / 22.9°C
Range* in Mean Annual Rainfall	799 - 1229mm
Rainfall Distribution	Winter dominant
Mean Annual Pan Evaporation	no data available

Source: BOM. Donnybrook Post Office

Crops Grown	% of Total Land Area
Apples	3.0
Pears	1.3
Nashi	0.1
Total	**4.4%**

South West Slopes – New South Wales

Climate Statistics	
Mean* Annual Min. and Max. Temp.	3.9°C / 11.4°C
Range* in Mean Annual Rainfall	1087 - 2249mm
Rainfall Distribution	Winter dominant
Mean Annual Pan Evaporation	no data available

Source: BOM. Cabramurra Shire

Crops Grown	% of Total Land Area
Apples	4.1
Pears	0.05
Nashi	0.001
Total	**4.1%**

Loddon - Victoria

Climate Statistics	
Mean* Annual Min. and Max. Temp.	8.8°C / 21.9°C
Range* in Mean Annual Rainfall	415 - 879mm
Rainfall Distribution	Winter dominant
Mean Annual Pan Evaporation	no data available

Source: BOM. Wangaratta Composite

Crops Grown	% of Total Land Area
Apples	3.1
Pears	0.2
Nashi	0.002
Total	**3.4%**

Manjimup – Western Australia

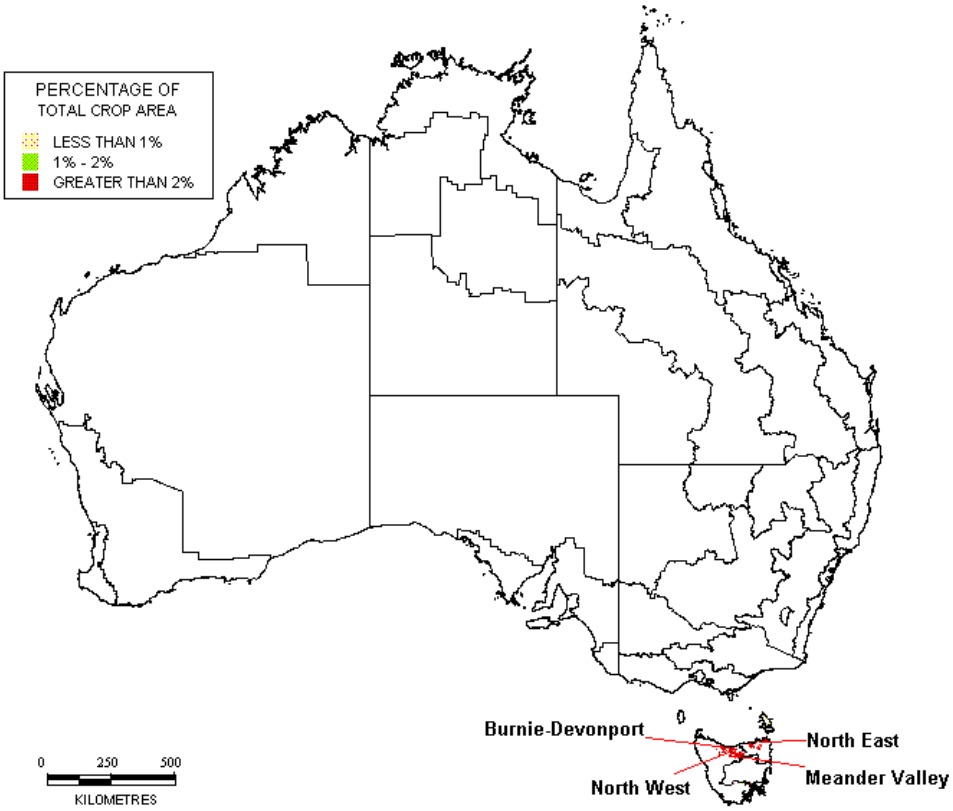
Climate Statistics	
Mean* Annual Min. and Max. Temp.	9.6°C / 20.2°C
Range* in Mean Annual Rainfall	806 - 1267mm
Rainfall Distribution	Winter dominant
Mean Annual Pan Evaporation	2226.5mm

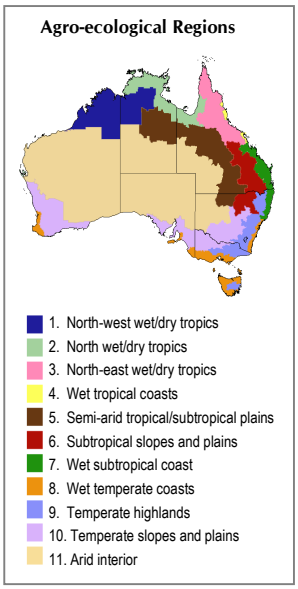
Source: BOM. Manjimup Shire

Crops Grown	% of Total Land Area
Apples	2.1
Pears	0.3
Nashi	0.005
Total	**2.4%**

**Temperatures are mean annual daily minimum and maximums across all stations used as sources. Rainfall data is the annual rainfall range expressed by the 1st and 9th decile rainfall bands. Evaporation is the range across all stations used as sources.*

Pyrethrum





Map Source: *ABS AgStats 1996-97* with non-agricultural land mask from *Distribution of Agricultural Land Use in Australia* (BRS 1994).

Production by Agro-Ecological Region

Agro-Ecological Region	Area (Ha)	Yield (Tonnes)	Yield per Ha (T / Ha)	Value ($M)
Wet temperate coasts	744	589	0.8	dns

dns – data not supplied

Production and Value Statistics Source: *ABS AgStats 1996 - 97.* Data is available in the electronic version of the Australian Natural Resource Atlas located on the National Land and Water Resources Audit Web Site - www.nlwra.gov.au

Major Production Regions

Region	Agro-Ecological Region	% of Total Crop Area	Area (Ha)	Yield (Tonnes)	Yield per Ha (T / Ha)	Value ($M)
Burnie-Devonport	Wet temperate coasts	78.8	586	488	0.8	dns
North West	Wet temperate coasts	13.8	103	71	0.7	dns
North East	Wet temperate coasts	3.3	25	0	0.0	dns
Meander Valley	Wet temperate coasts	2.2	16	17	1.1	dns

dns – data not supplied

Burnie-Devonport - Tasmania

Climate Statistics	
Mean* Annual Min. and Max. Temp.	6.8°C / 16.3°C
Range* in Mean Annual Rainfall	791 - 1359mm
Rainfall Distribution	Winter dominant
Mean Annual Pan Evaporation	no data available

Source: BOM. Wynyard Airport

North West / Meander Valley- Tasmania

Climate Statistics	
Mean* Annual Min. and Max. Temp.	6.2°C / 15.8°C
Range* in Mean Annual Rainfall	840 - 1533mm
Rainfall Distribution	Winter dominant
Mean Annual Pan Evaporation	no data available

Source: BOM. Sheffield Shire

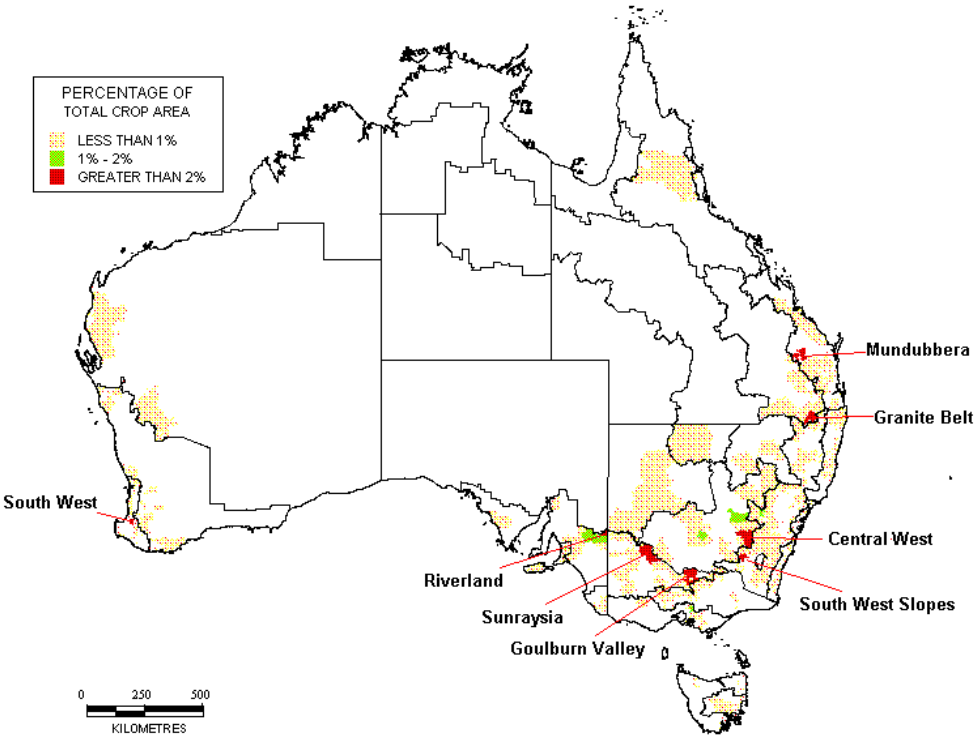
North East - Tasmania

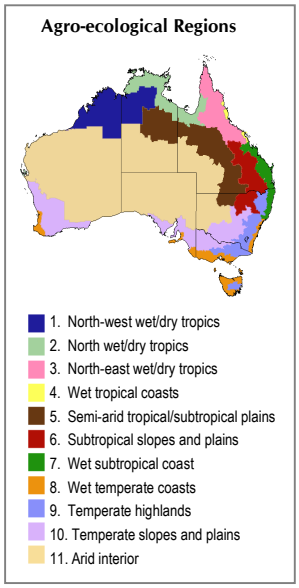
Climate Statistics	
Mean* Annual Min. and Max. Temp.	7.2°C / 17.8°C
Range* in Mean Annual Rainfall	737 - 1369mm
Rainfall Distribution	Winter dominant
Mean Annual Pan Evaporation	1022.0mm

Source: BOM. Scottsdale (West Minstone Road)

**Temperatures are mean annual daily minimum and maximums across all stations used as sources. Rainfall data is the annual rainfall range expressed by the 1st and 9th decile rainfall bands. Evaporation is the range across all stations used as sources.*

Stone Fruit





Map Source: *ABS AgStats 1996-97* with non-agricultural land mask from *Distribution of Agricultural Land Use in Australia* (BRS 1994).

Production by Agro-Ecological Region

Agro-Ecological Region	Area (Ha)	Yield (Tonnes)	Yield per Ha (T / Ha)	Value ($M)
North-east wet/dry tropics	22	28	1.3	0.05
Wet tropical coasts	3	6	2.1	0.01
Semi-arid tropical/subtropical plains	8	50	6.4	0.11
Subtropical slopes and plains	2,312	6,470	2.8	10.85
Wet subtropical coast	1,395	3,049	2.2	4.98
Wet temperate coasts	4,821	17,773	3.7	42.09
Temperate highlands	3,756	12,569	3.3	22.21
Temperate slopes and plains	14,527	111,685	7.7	135.55
Arid interior	67	193	2.9	0.36

Crops Produced

Crop	Area (Ha)	Yield (Tonnes)	Yield per Ha (T / Ha)	Value ($M)
Apricots	3,751	25,920	6.9	42.35
Cherries	4,205	6,683	1.6	33.99
Nectarines	4,849	21,887	4.5	41.20
Peacharines	9	47	5.1	dns
Peaches	7,913	72,099	9.1	60.09
Plums and Prunes	6,183	25,187	4.1	38.59
Overall	**26,910**	**151,824**	**5.6**	**216.21**

dns – data not supplied

Production and Value Statistics Source: *ABS AgStats 1996 - 97.* Data is available in the electronic version of the Australian Natural Resource Atlas located on the National Land and Water Resources Audit Web Site - www.nlwra.gov.au

Major Production Regions

Region	Agro-Ecological Region	% of Total Crop Area	Area (Ha)	Yield (Tonnes)	Yield per Ha (T / Ha)	Value ($M)
Goulburn Valley	Temperate slopes and plains	15.7	4,215	50,193	11.9	33.22
Central West	Temperate highlands / Temperate slopes and plains	12.1	3,265	8,219	2.5	19.39
Granite Belt	Subtropical slopes and plains	7.8	2,110	6,077	2.9	10.18
Riverland	Temperate slopes and plains	6.2	1,664	17,640	10.6	30.14
South West Slopes	Temperate highlands	5.8	1,567	5,236	3.3	9.18
Sunraysia	Arid interior / Temperate slopes and plains	4.6	1,245	6,871	5.5	10.05
South West	Wet temperate coasts	3.1	831	2,419	2.9	4.97
Mundubbera	Wet subtropical coast	2.0	546	15	0.003	0.03

Goulburn Valley - Victoria

Climate Statistics	
Mean* Annual Min. and Max. Temp.	8.3°C / 21.2°C
Range* in Mean Annual Rainfall	283 - 666mm
Rainfall Distribution	Consistent
Mean Annual Pan Evaporation	1606.0mm

Source: BOM. Kyabram (Institute of Sustainable Agriculture)

Crops Grown	% of Total Land Area
Peaches	9.2
Apricots	2.6
Plums and Prunes	1.9
Nectarines	1.2
Cherries	0.8
Total	**15.7%**

Central West – New South Wales

Climate Statistics	
Mean* Annual Min. and Max. Temp.	6.8°C / 21.8°C
Range* in Mean Annual Rainfall	361 - 1283mm
Rainfall Distribution	Winter dominant
Range* in Mean Annual Pan Evaporation	1351 - 1460mm

Source: BOM. Bathurst Agricultural Station, Cowra Research Station and Orange Agricultural Station

Crops Grown	% of Total Land Area
Cherries	6.3
Plums and Prunes	4.7
Peaches	0.6
Nectarines	0.4
Apricots	0.2
Total	**12.1%**

Granite Belt - Queensland

Climate Statistics	
Mean* Annual Min. and Max. Temp.	8.7°C / 21.6°C
Range* in Mean Annual Rainfall	529 – 1018mm
Rainfall Distribution	Summer dominant
Mean Annual Pan Evaporation	no data available

Source: BOM. Stanthorpe Post Office

Crops Grown	% of Total Land Area
Peaches	2.8
Nectarines	2.3
Plums and Prunes	2.3
Apricots	0.3
Cherries	0.05
Total	**7.8%**

Riverland – South Australia

Climate Statistics	
Mean* Annual Min. and Max. Temp.	9.2°C / 24.2°C
Range* in Mean Annual Rainfall	124 - 475mm
Rainfall Distribution	Consistent
Mean Annual Pan Evaporation	1679.0mm

Source: BOM. Renmark and Loxton Research Centre

Crops Grown	% of Total Land Area
Apricots	3.1
Plums and Prunes	1.3
Peaches	1.2
Nectarines	0.6
Peacharines	0.01
Cherries	0.01
Total	**6.2%**

South West Slopes – New South Wales

Climate Statistics	
Mean* Annual Min. and Max. Temp.	3.9°C / 11.4°C
Range* in Mean Annual Rainfall	1087 - 2249mm
Rainfall Distribution	Winter dominant
Mean Annual Pan Evaporation	no data available

Source: BOM. Cabramurra Shire

Crops Grown	% of Total Land Area
Nectarines	2.3
Peaches	2.2
Plums and Prunes	1.3
Cherries	0.1
Apricots	0.03
Total	**5.8%**

Sunraysia - Victoria

Climate Statistics	
Mean* Annual Min. and Max. Temp.	9.7°C / 22.8°C
Range* in Mean Annual Rainfall	198 - 456mm
Rainfall Distribution	Consistent
Mean Annual Pan Evaporation	1642.5mm

Source: BOM. Walpeup Research Station

Crops Grown	% of Total Land Area
Nectarines	2.1
Peaches	1.0
Plums and Prunes	0.9
Apricots	0.6
Cherries	0.008
Total	**4.6%**

South West – Western Australia

Climate Statistics	
Mean* Annual Min. and Max. Temp.	9.5°C / 22.9°C
Range* in Mean Annual Rainfall	799 - 1229mm
Rainfall Distribution	Winter dominant
Mean Annual Pan Evaporation	no data available

Source: BOM. *Donnybrook Post Office*

Crops Grown	% of Total Land Area
Plums and Prunes	1.8
Nectarines	0.8
Peaches	0.2
Cherries	0.2
Apricots	0.1
Total	**3.1%**

Mundubbera - Queensland

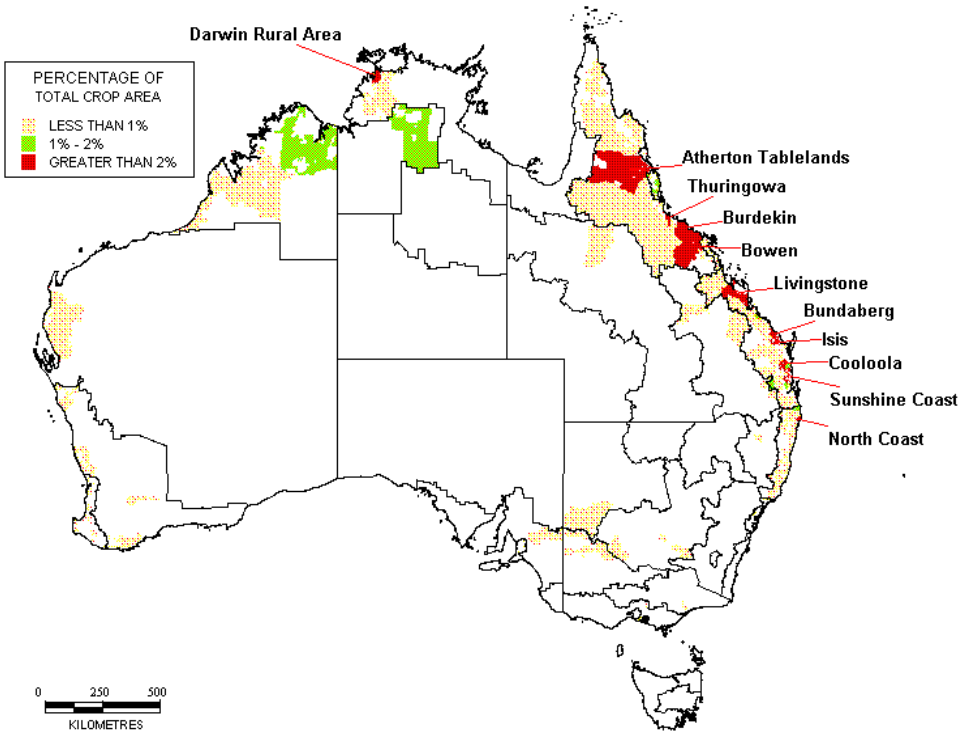
Climate Statistics	
Mean* Annual Min. and Max. Temp.	13.5°C / 28.0°C
Range* in Mean Annual Rainfall	506 - 1039mm
Rainfall Distribution	Summer dominant
Mean Annual Pan Evaporation	no data available

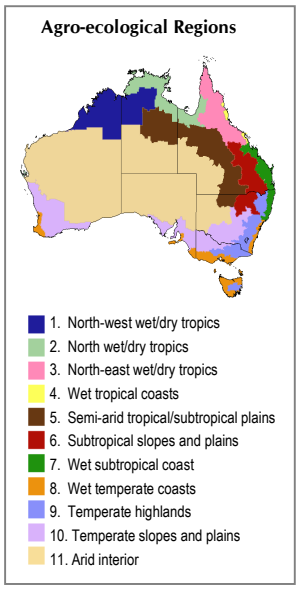
Source: BOM. Gayndah Post Office

Crops Grown	% of Total Land Area
Plums and Prunes	1.2
Nectarines	0.4
Peaches	0.4
Total	**2.0%**

**Temperatures are mean annual daily minimum and maximums across all stations used as sources. Rainfall data is the annual rainfall range expressed by the 1st and 9th decile rainfall bands. Evaporation is the range across all stations used as sources.*

Tropical Fruit





Map Source: *ABS AgStats 1996-97* with non-agricultural land mask from *Distribution of Agricultural Land Use in Australia* (BRS 1994).

Production by Agro-Ecological Region

Agro-Ecological Region	Area (Ha)	Yield (Tonnes)	Yield per Ha (T / Ha)	Value ($M)
North-west wet/dry tropics	787	1,763	2.2	6.32
North wet/dry tropics	944	1,523	1.6	5.50
North-east wet/dry tropics	7,631	29,646	3.9	52.03
Wet tropical coasts	1,480	8,805	5.9	13.70
Semi-arid tropical/subtropical plains	2	6	2.6	0.01
Subtropical slopes and plains	250	414	1.7	0.85
Wet subtropical coast	12,174	138,531	11.4	81.02
Wet temperate coasts	417	1,218	2.9	3.19
Temperate highlands	5	3	0.6	0.01
Temperate slopes and plains	713	3,033	4.3	6.72
Arid interior	310	1,424	4.6	4.36

Crops Produced

Crop	Area (Ha)	Yield (Tonnes)	Yield per Ha (T / Ha)	Value ($M)
Avocados	5,105	20,072	3.9	42.05
Carambola	29	108	3.7	0.42
Custard Apples	639	1,408	2.2	3.49
Guava	69	359	5.2	1.29
Jackfruit	51	76	1.5	0.15
Longans	139	122	0.9	dns
Lychees	836	1,342	1.6	6.83
Mangoes	12,046	32,403	2.7	69.61
Papaws	502	6,108	12.2	6.29
Passionfruit	220	1,238	5.6	3.03
Pineapples	4,634	122,981	26.5	39.33
Rambutan	443	149	0.3	1.24
Overall	**24,714**	**186,366**	**7.5**	**174**

dns – data not supplied

Major Production Regions

Region	Agro-Ecological Region	% of Total Crop Area	Area (Ha)	Yield (Tonnes)	Yield per Ha (T / Ha)	Value ($M)
Atherton Tablelands	North-east wet/dry tropics / Wet tropical coasts	15.4	3,794	11,368	3.0	22.32
Sunshine Coast	Wet subtropical coast	13.7	3,376	63,958	18.9	26.37
Burdekin	North-east wet/dry tropics	5.9	1,460	7,812	5.4	15.13
Bundaberg / Isis	Wet subtropical coast	4.9	1,215	4,961	4.1	7.0
Cooloola	Wet subtropical coast	4.8	1,176	18,199	15.5	7.71
Thuringowa	North-east wet/dry tropics	4.4	1,094	8,109	7.4	9.73
Livingstone	Wet subtropical coast	3.9	975	14,592	15.0	5.83
Darwin Rural Area	North wet/dry tropics	3.0	740	1,394	1.9	5.01
Bowen	North-east wet/dry tropics	2.3	575	1,378	2.4	2.67
North Coast	Wet subtropical coast	2.1	510	2,097	4.1	5.30

Atherton Tablelands - Queensland

Climate Statistics	
Mean* Annual Min. and Max. Temp.	15.5°C / 25.2°C
Range* in Mean Annual Rainfall	783 - 1876mm
Rainfall Distribution	Summer dominant
Mean Annual Pan Evaporation	1569.5mm

Source: BOM. Kairi Research Station

Crops Grown	% of Total Land Area
Mangoes	13.2
Avocados	1.2
Lychees	0.5
Longans	0.3
Papaws	0.1
Custard Apples	0.1
Passionfruit	0.01
Pineapples	0.004
Jackfruit	0.004
Carambola	0.002
Total	**15.4%**

Sunshine Coast - Queensland

Climate Statistics	
Mean* Annual Min. and Max. Temp.	13.5°C / 25.6°C
Range* in Mean Annual Rainfall	1124 - 2348mm
Rainfall Distribution	Summer dominant
Mean Annual Pan Evaporation	1387.0mm

Source: BOM. Nambour DPI

Crops Grown	% of Total Land Area
Pineapples	8.5
Avocados	2.7
Mangoes	1.1
Custard Apples	0.7
Lychees	0.4
Papaws	0.2
Passionfruit	0.1
Longans	0.02
Carambola	0.01
Guava	0.004
Total	**13.7%**

Burdekin - Queensland

Climate Statistics	
Mean* Annual Min. and Max. Temp.	17.7°C / 28.9°C
Range* in Mean Annual Rainfall	455 - 1519mm
Rainfall Distribution	Summer dominant
Mean Annual Pan Evaporation	2080.5mm

Source: BOM. Ayr DPI Research Station

Crops Grown	% of Total Land Area
Mangoes	5.8
Avocados	0.04
Lychees	0.02
Carambola	0.004
Total	**5.9%**

Bundaberg / Isis Queensland

Climate Statistics	
Mean* Annual Min. and Max. Temp.	16.0°C / 26.1°C
Range* in Mean Annual Rainfall	670 - 1654mm
Rainfall Distribution	Summer dominant
Mean Annual Pan Evaporation	no data available

Source: BOM. Bundaberg Aero

Crops Grown	% of Total Land Area
Mangoes	1.9
Avocados	2.0
Pineapples	0.5
Custard Apples	0.2
Lychees	0.2
Passionfruit	0.1
Papaws	0.01
Longans	0.01
Carambola	0.001
Total	**4.9%**

Cooloola - Queensland

Climate Statistics	
Mean* Annual Min. and Max. Temp.	12.9°C / 26.4°C
Range* in Mean Annual Rainfall	809 - 1664mm
Rainfall Distribution	Summer dominant
Mean Annual Pan Evaporation	no data available

Source: BOM. IMBIL Forestry

Crops Grown	% of Total Land Area
Pineapples	2.9
Mangoes	0.8
Avocados	0.5
Papaws	0.3
Custard Apples	0.2
Lychees	0.1
Passionfruit	0.03
Jackfruit	0.02
Guava	0.006
Carambola	0.006
Longans	0.005
Total	**4.8%**

Thuringowa - Queensland

Climate Statistics	
Mean* Annual Min. and Max. Temp.	18.6°C / 29.0°C
Range* in Mean Annual Rainfall	1273 - 3138mm
Rainfall Distribution	Summer dominant
Mean Annual Pan Evaporation	no data available

Source: BOM. Ingham Composite

Crops Grown	% of Total Land Area
Mangoes	3.7
Pineapples	0.6
Lychees	0.04
Custard Apples	0.03
Passionfruit	0.02
Avocados	0.02
Jackfruit	0.007
Papaws	0.004
Total	**4.4%**

Livingstone - Queensland

Climate Statistics	
Mean* Annual Min. and Max. Temp.	16.5°C / 28.2°C
Range* in Mean Annual Rainfall	509 - 1229mm
Rainfall Distribution	Summer dominant
Mean Annual Pan Evaporation	2044.0mm

Source: BOM. Rockhampton A.M.O.

Crops Grown	% of Total Land Area
Pineapples	2.2
Mangoes	1.2
Custard Apples	0.1
Lychees	0.1
Avocados	0.1
Longans	0.1
Papaws	0.02
Carambola	0.01
Passionfruit	0.001
Total	**3.9%**

Darwin Rural Area – Northern Territory

Climate Statistics	
Mean* Annual Min. and Max. Temp.	21.0°C / 33.1°C
Range* in Mean Annual Rainfall	1091 - 1680mm
Rainfall Distribution	Summer dominant
Mean Annual Pan Evaporation	2044.0mm

Source: BOM. Middle Point

Crops Grown	% of Total Land Area
Mangoes	2.7
Rambutan	0.2
Carambola	0.03
Guava	0.02
Jackfruit	0.02
Custard Apples	0.009
Papaws	0.002
Total	**3.0%**

Bowen - Queensland

Climate Statistics	
Mean* Annual Min. and Max. Temp.	19.8°C / 28.5°C
Range* in Mean Annual Rainfall	461 – 1672mm
Rainfall Distribution	Summer dominant
Mean Annual Pan Evaporation	no data available

Source: BOM. Bowen Airport

Crops Grown	% of Total Land Area
Mangoes	2.3
Avocados	0.0
Total	**2.3%**

North Coast – New South Wales

Climate Statistics	
Mean* Annual Min. and Max. Temp.	13.2°C / 25.5°C
Range* in Mean Annual Rainfall	881 - 2328mm
Rainfall Distribution	Summer dominant
Mean Annual Pan Evaporation	no data available

Source: BOM. Lismore Shire and Murwillumbah Shire

Crops Grown	% of Total Land Area
Avocados	1.0
Custard Apples	0.5
Lychees	0.3
Guava	0.1
Mangoes	0.1
Passionfruit	0.1
Papaws	0.0008
Total	**2.1%**

**Temperatures are mean annual daily minimum and maximums across all stations used as sources. Rainfall data is the annual rainfall range expressed by the 1st and 9th decile rainfall bands. Evaporation is the range across all stations used as sources.*

Production and Value Statistics Source: *ABS AgStats 1996 - 97.* Data is available in the electronic version of the Australian Natural Resource Atlas located on the National Land and Water Resources Audit Web Site - www.nlwra.gov.au

3 Status and Trend in Natural Resource Condition

Analysis of the current status and trend in the natural resource base of horticultural production regions was undertaken to assess the industry's ability to sustain long-term productivity and profitability. A similar study by SCARM (1998) examined natural resource condition across all agricultural sectors, and although this study included horticulture, results are generally presented at an aggregate level. Research conducted and collected by the Department of Primary Industries and Energy (DPIE) in 1991 for the "Decade of Landcare Plan" also provides some information on land degradation and biophysical limitations to production.

This study complements existing industry information by contributing the following:

- a comparison of national survey responses from horticulture (State Agencies and Growers) with respect to identified environmental indicators;
- a review of historical land care research, and;
- a review of specific horticultural research and industry literature.

A component of the literature review included a desk search of R&D undertaken by State Agencies and R&D organisations to compare survey issues with current industry responses. While a large number of projects and research activities have been undertaken across a spectrum of environmental indicators, there is minimal research specifically on horticulture and the impact of horticultural production on natural resources. Generic research on agricultural resources may provide the information required by the horticultural industry but this is not apparent from the review of R&D activities.

The study aims to draw the outcomes of each area of research together to provide additional insights into the current status and trend in specific environmental indicators. Outcomes from this research are far from conclusive, however in the absence of a structured framework of historical environmental databases, this approach represents the first attempt to identify indicators of natural resource condition in horticulture.

It must be noted that sample size constraints throughout the data sets make survey outcomes indicative only and should be considered relevant for guiding further research rather than identifying environmental status of horticulture in absolute terms. The State Agency survey does not include an analysis of Western Australian environmental issues, as the Department did not contribute data to the project. A summary of survey responses by AER for State Agencies and Growers is presented in Table 3.1.

Table 3.1 Summary of Grower and State Agency Survey Responses

AER	Grower	State Agency
(AER 4) Wet Tropical Coasts	4	2
(AER 6) Subtropical slopes and plains	5	3
(AER 7) Wet subtropical coast	29	9
(AER 8) Wet temperate coasts	24	6
(AER 9) Temperate highlands	10	1
(AER 10) Temperate slopes and plains	20	9
Total	**92**	**30**

Source: Survey Data, 1999

3.1 Environmental Indicators

Environmental indicators were determined on the basis of factors that directly affect horticultural production systems. These factors include:

- the productivity of horticultural production system building blocks, namely soil and water;
- inputs to productive systems, namely chemicals, machinery and water; and
- the integrity of the surrounding natural environment, namely land, water and biodiversity values that surround the productive system.

Other indirect factors that influence both the long-term productivity of horticultural production and the integrity of the surrounding natural environment relate to management operations. These factors include impacts on the surrounding air and noise levels and the potential for contamination caused by waste generated from production and processing operations. In summary, the following environmental indicators were identified as relevant to horticulture:

Soil

- Soil loss
- Agricultural chemical accumulation in soil
- Organic matter/soil structure decline
- Nutrient levels and availability in soils
- Soil acidity levels
- Soil salinity levels

Water

- Ground water salinity levels
- Surface water salinity levels
- Agricultural chemical levels in irrigation water

Biodiversity

- Removal of native bushland
- Removal of riparian vegetation

Air and Noise

- Dust and noise control
- Spray and odour drift

Waste and Contamination

- Options for storing farm chemicals
- Options for disposing of chemical containers
- Options for plastic and other waste disposal

3.2 Status and Trend Analysis Methodology

The analysis of status and trend was compiled from Grower and state agency survey responses to Question 1C (Section D) (see Appendix 2) and Question 31 (see Appendix 5) respectively. Growers were asked the following question:

Is there any evidence of the following environmental changes occurring on your property?

State Agencies were asked the same question but were asked to respond in a regional context. Environmental indicators assessed in the survey are listed above in Section 3.1.

There were two parts to this question:

1. To classify the environmental status of each environmental indicator; and
2. To classify the environmental status of change (Trend) of each environmental indicator.

The following sections describe how the data from survey responses was analysed and interpreted.

3.2.1 Status of Environmental Indicators

Growers and State Agencies were asked to rate the significance of each environmental indicator as; No (ie. not significant); Low; Medium; and High. For the purposes of analysis, a number was assigned to each response on the following basis; Low = 1; Medium = 2; High = 3; No = 0 and No Response = 0. The objective of this analysis was to develop a quantitative measure to compare the relative significance of each environmental indicator.

The weighted average response was then calculated for each environmental indicator across the six key agro ecological regions where horticulture operates. Null responses were not included in the weighted average calculations. The weighted average was calculated using the following formula:

$$StatusIndex = \frac{\left[(Low\,\mathrm{Re}sponses * 1) + (Medium\,\mathrm{Re}sponses * 2) + (High\,\mathrm{Re}sponses * 3) + (No\,\mathrm{Re}sponses * 0)\right]}{(Total\,\mathrm{Re}sponses - Null\,\mathrm{Re}sponses)}$$

Interpretation

The calculation combines all survey responses into an aggregate value between 0 and 3 for each environmental indicator. Higher values represent higher levels of significance.

3.2.2 Status of Change (Trend) in Environmental Indicators

A similar process was adopted as described in Section 3.2.1 to analyse the environmental trend responses. In this analysis, the survey sample was restricted to only those responses where a Low, Medium or High response was measured (ie. all responses where an environmental indicator was considered significant). Growers and State Agencies were given three choices to classify environmental trend; Improving; No Change; and Deteriorating. To analyse this data in a quantitative framework, a number was assigned to each classification as follows; Improving = 1, No Change = 0, Deteriorating = -1.

The weighted average trend response for each environmental indicator was calculated across key horticultural agro ecological regions. Null responses were not included in the weighted average calculations. The weighted average for environmental trend is presented below:

$$TrendIndex = \frac{\left[(\mathrm{Im}\,proving * 1) + (NoChange * 0) + (Deteriorating * -1) + (No\,\mathrm{Re}sponses * 0)\right]}{(Significant\,\mathrm{Re}sponses - Null\,\mathrm{Re}sponses)}$$

Interpretation

The calculation combines all survey responses into an aggregate value between -1 and 1 for each environmental indicator. Aggregate negative values indicate a perceived deterioration in environmental trend. Conversely, aggregate positive values indicate a perceived improvement in environmental trend.

The above analysis methodology was chosen as it is the most practical way to summarily compare Grower and state agency responses with a limited data set. The analysis results should be interpreted as summary insights into the indicators of environmental trend across all non-null responses. Where appropriate, the composition of survey responses is discussed in the analysis of survey outcomes.

3.2.3 Limitations

The environmental analysis contains the following limitations:

- The values reported cannot be linked to a tangible environmental measurement in the field, but rather are perceptions of the state of physical environmental indicators.
- Data deficiencies exist, and limit the interpretation of all results at AER and sub AER level. The project team is of the view that the interpretation of survey data in conjunction with desk research and industry knowledge is sufficient to provide an insight into the status and trend of environmental indicators for all significant horticulture production regions.
- The responses received from State Agencies and Growers have not been statistically analysed due to the low survey response rate and the focus on trends in environmental indicators rather than statistically significant results.
- Response rates from both Growers and State Agencies for: dust and noise control; drift of sprays and odours; and options for plastic and other waste disposal, were such that graphical representation was not possible. In these cases responses received are incorporated into discussion on the significance of the environmental indicator.
- The analysis represents the majority of responses in the survey and correspondingly the major horticultural regions. This does not imply that horticulture in other AERs is not important but rather that the number of responses received did not allow a useful comparison with those regions where larger survey samples were recorded.

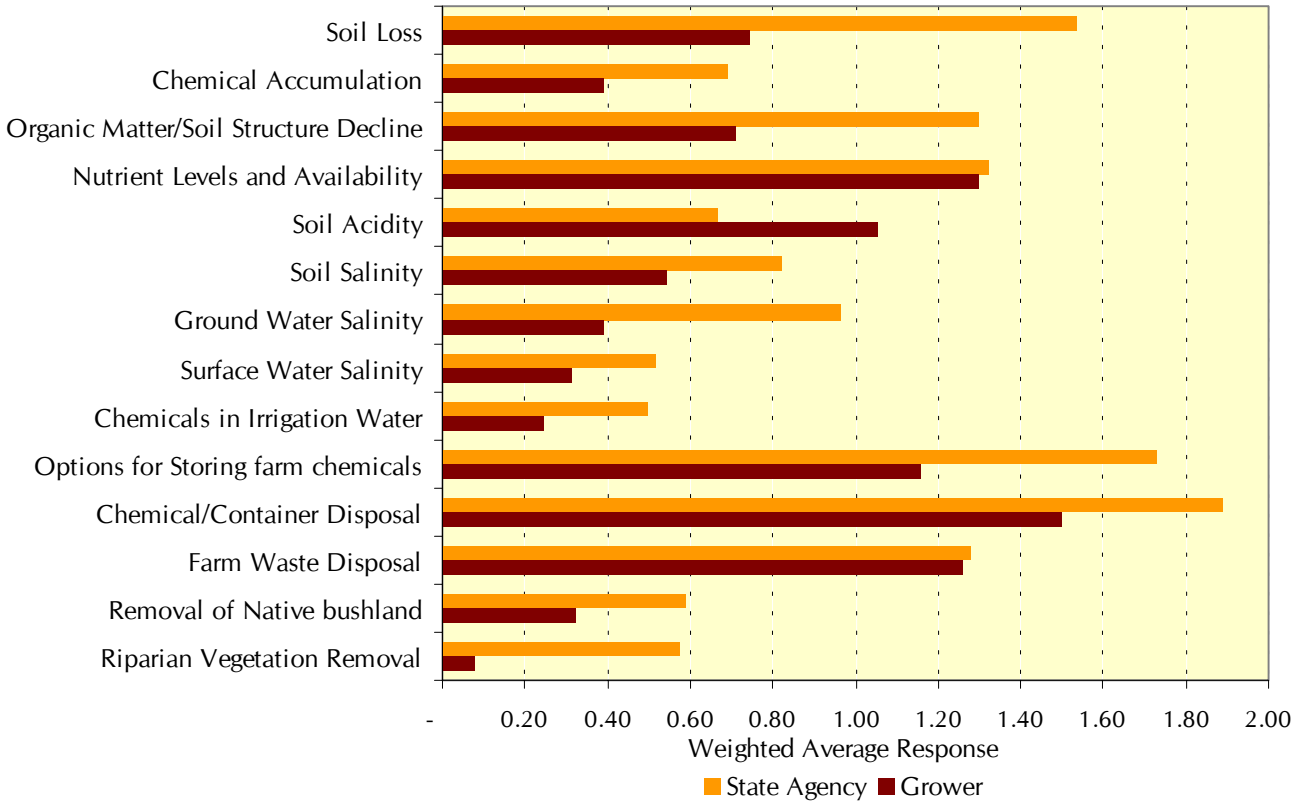
3.1 Overview of Environmental Indicators

3.3.1 Status and Trend

The results on environmental status and trend as perceived by Growers and State Agencies includes data from respondents located in, or responsible for horticultural research or education in, AERs 4, 6, 7, 8, 9, and 10. These AERs constitute the major horticultural production regions in Australia. Responses from industry or State Agencies in the 5 remaining AERs was small (see Table 1.2), and as such the data was not used for analysis. While no attempt is made in this study to quantify affected areas, this preliminary analysis offers summary insights into the location and the perceived significance of environmental indicators for prioritisation and further research in Stage 2 of the project.

Environmental indicator status, ie. the degree to which Growers and State Agencies perceive each indicator to affect production systems and the environment is illustrated in Figure 3.1. Table 3.2 shows the top five priority ranking of these indicators for both groups. The survey results show that both groups identified chemical/container disposal, options for storing farm chemicals, and nutrient levels and availability as high priority indicators. Soil loss was an indicator of high importance for State Agencies, but not for Growers, whilst soil acidity and farm waste disposal were identified by Growers, but not State Agencies as a key priority indicators. Although both groups identified similar indicators, the magnitude of the importance of these indicators was markedly different. Grower responses were consistently lower (Figure 3.1). Overall the Grower response index is about half the value of the State Agency index.

Figure 3.1 Comparison of Environmental Indicators Status (Grower and State Surveys)



Source: State Agency and Grower Surveys, 1999

Table 3.2 The Top 5 Environmental Indicators Identified by Growers and State Agencies

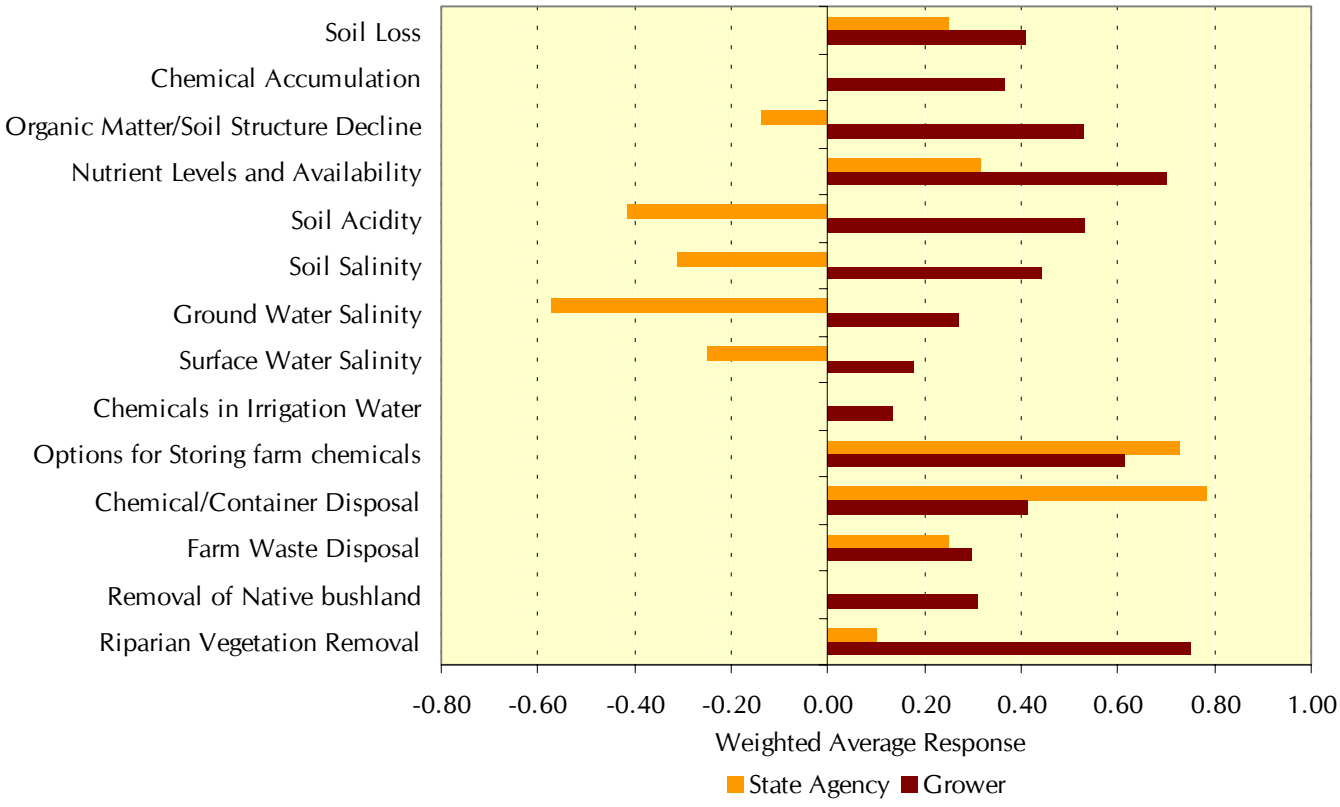
Rank	State Agency	Grower
1	Chemical/Container Disposal	Chemical/Container Disposal
2	Options for Storing Farm Chemicals	Soil Nutrient Levels and Availability
3	Soil Loss	Farm Waste Disposal
4	Soil Nutrient Levels and Availability	Options for Storing Farm Chemicals
5	Organic Matter/Soil Structure Decline	Soil Acidity

Source: Survey Data, 1999

Environmental trend, ie. whether the indicator is becoming more or less significant for production systems and the environment, is illustrated in Figure 3.2. The results indicate substantial differences in Growers' and State Agencies' perceptions of indicator trend, with Growers reporting positive change for all indicators (ie. environmental indicators are generally improving), and State Agencies reporting both positive and negative change (Figure 3.2). In addition, the magnitude of State Agency response indices is consistently greater than for Growers. Exceptions to this finding were found for soil acidity where Growers considered this indicator to be more important than State Agencies.

Both groups agreed on positive environmental trend for indicators of soil loss, soil nutrient levels and availability, options for storing farm chemicals, chemical/container disposal, farm waste disposal and riparian vegetation removal. With the exception of riparian vegetation removal, Growers and/or State Agencies (Table 3.2) identified all these indicators as priorities, and that improvement to priority environmental indicators is evident. Directly opposing responses (positive Grower vs negative State Agency) are greatest for soil and water based indicators such as organic matter/soil structure decline, soil acidity, soil salinity, ground water salinity and surface water salinity.

Figure 3.2 Comparison of Environmental Indicators Trend (Grower and State Surveys)



Source: State Agency and Grower Surveys, 1999

3.3 Analysis of Environmental Indicators by Agro-Ecological Region

3.3.1 Soils

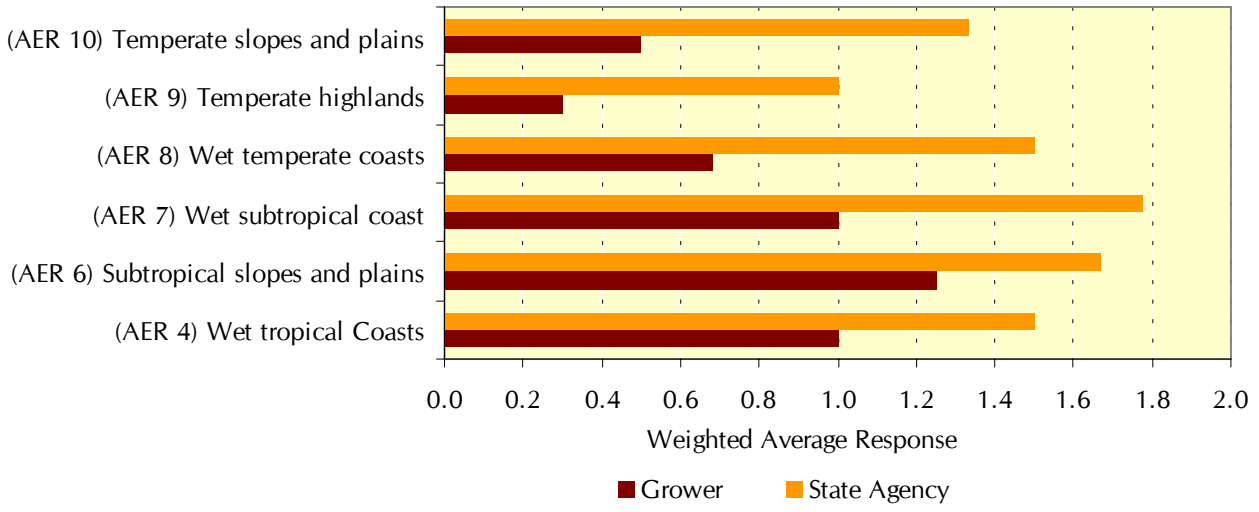
Soil Loss

The horticultural industry occupies some of the most productive land in Australia utilising soils that, compared to the majority of Australia, are deep, well-drained and well-structured with relatively high fertility and water-holding capacity (SCARM, 1998). Soil loss in these areas is predominantly due to water erosion and generally results on sloping land where the soil has been left bare after clean cultivation. The extent of soil loss is primarily dependent upon the steepness of the slope, and the intensity of the rainfall event. Incidence of this combination of rainfall and land use/management increases in northern latitudes where the summer is characterised by high intensity, monsoonal rainfall and substantial areas are clean cultivated.

National-scale erosion maps prepared for The Decade of Landcare Plan (DPI, 1991) indicate that erosion by water is a significant issue in virtually all cropping regions, notably AERs 6, 9 and 10. Soil losses occur in coastal and sub-coastal AERs 3, 4 and 7 where high rainfall erosivity intensifies run-off and erosion under horticultural cropping. Research into minimisation of soil losses is predominantly undertaken on a catchment or soil type basis, such as Agriculture Western Australia's focus on sustainable production of horticulture crops on sandy soils (AgWest, 1997). Crop specific research has been undertaken in instances where crop characteristics predispose soil loss such as shading by macadamias (McFadden, 1999).

Grower and State Agency survey responses to soil loss status are shown in Figure 3.3 and Table 3.3. Overall, the results show that Growers generally perceived soil loss to be an indicator of low concern, whilst State Agencies considered the indicator to be of medium concern. The status of soil loss was identified by State Agencies as of highest concern in the Burnett and Mackay regions of AER 7 (Wet Subtropical Coast), and by Growers in the Liverpool Plains region of AER 6 (Subtropical Coasts and Plains). Both groups identified the Temperate Highlands (AER 9) to be the region of least concern.

Figure 3.3 Environmental Status of Soil Loss in the Major Horticultural AERs



Source: Survey Data, 1999

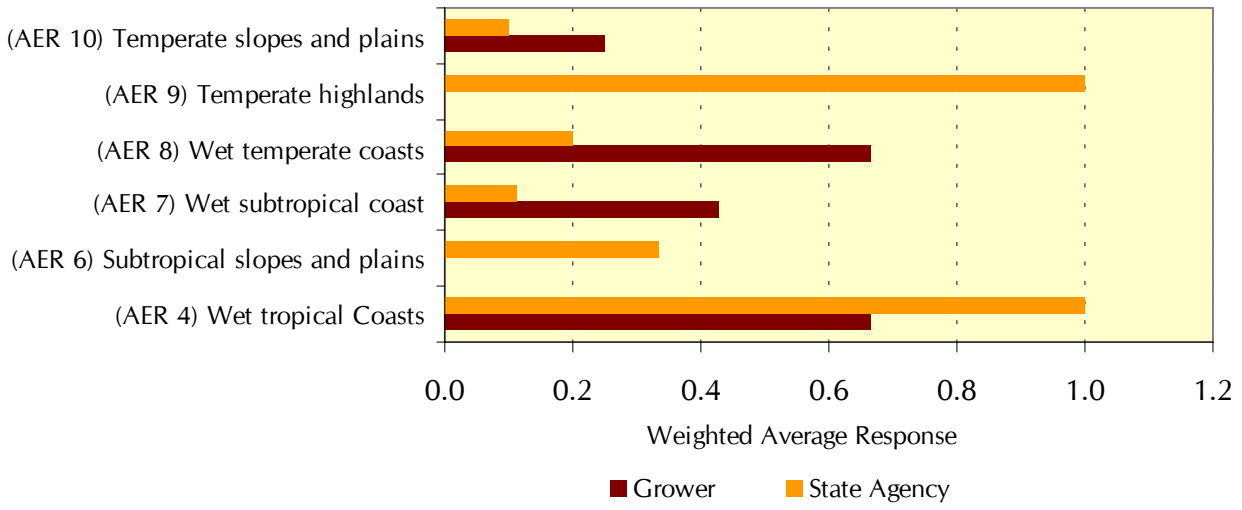
Table 3.3 Analysis of Responses: Environmental Status of Soil Loss

AER	Grower (% of sample)				Sample	State (% of sample)				Sample
	No	Low	Med	High	(n)	No	Low	Med	High	(n)
(AER 4) Wet tropical Coasts	0	100	0	0	**3**	0	50	50	0	**2**
(AER 6) Subtropical slopes and plains	0	75	25	0	**4**	0	33	67	0	**3**
(AER 7) Wet subtropical coast	19	65	12	4	**26**	0	22	78	0	**9**
(AER 8) Wet temperate coasts	47	37	16	0	**19**	17	17	67	0	**6**
(AER 9) Temperate highlands	80	10	10	0	**10**	0	100	0	0	**1**
(AER 10) Temperate slopes and plains	60	30	10	0	**10**	22	33	33	11	**9**

Source: Survey Data

Soil loss trend as perceived by Growers and State Agencies is shown in Figure 3.4 and Table 3.4. Both groups reported positive trends (ie. soil loss problems are decreasing) across all AERs. Reduced soil loss problems were shown to be particularly evident for the Wet Tropical Coast (AER 4).

Figure 3.4 Environmental Trend in Soil Loss



Source: Survey Data, 1999

Table 3.4 Analysis of Responses: Environmental Trend in Soil Loss

AER	Grower (% of sample)			Sample	State (% of sample)			Sample
	Imp	N. C	Det	(n)	Imp	N. C	Det	(n)
(AER 4) Wet tropical Coasts	67	33	0	**3**	100	0	0	**2**
(AER 6) Subtropical slopes & plains	25	50	25	**4**	33	67	0	**3**
(AER 7) Wet subtropical coast	52	38	10	**21**	33	44	22	**9**
(AER 8) Wet temperate coasts	67	33	0	**9**	20	80	0	**5**
(AER 9) Temperate highlands	0	100	0	**2**	100	0	0	**1**
(AER 10) Temperate slopes & plains	25	75	0	**4**	29	57	14	**7**

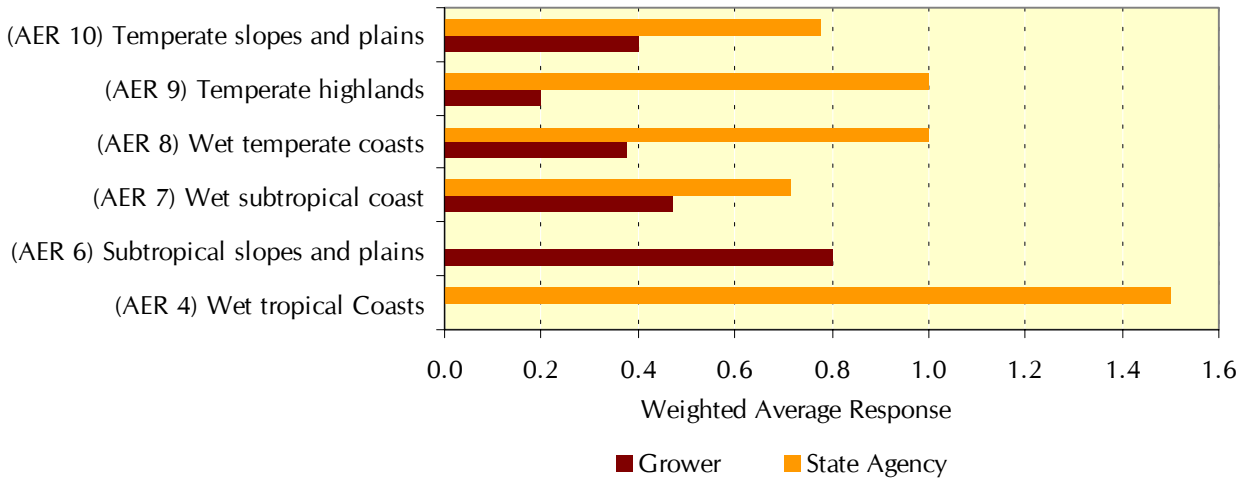
Source: Survey Data. Imp: = Improving, N.C: = No Change, Det: = Deteriorating

Agricultural Chemical Accumulation in Soil

Agricultural chemical accumulation in soils is defined, for the purposes of this study, as the presence of chemical contaminants from pesticide and herbicide use. Pesticide and herbicide contamination in horticultural soils is an area currently under study, with a national project funded by HRDC and LWRRDC reviewing the impact of pesticides used in vegetable production on soil and water quality (SARDI Riverlink Program, 1999). At present, however, soil contamination has not been reported on a national scale and the fragmented nature of state records on this indicator do not allow for a summation of its significance to horticulture.

Survey analysis results of soil chemical accumulation status are shown in Figure 3.5 and Table 3.5. The results show that both groups considered the indicator to be of low concern across AERs 7, 8, 9 and 10. Growers also found the indicator to be of low concern in AER 6, whilst 100 percent of State Agency responses indicated that soil chemical accumulation was not significant in this region. The South Johnstone region of AER 4 was the only region of medium concern identified by State Agencies. Only one Grower response was provided for this AER, the Grower indicating that soil chemical accumulation was not a problem.

Figure 3.5 Environmental Status of Chemical Accumulation in Soil



Source: Survey Data, 1999

Table 3.5 Analysis of Responses: Environmental Status of Chemical Accumulation in Soil

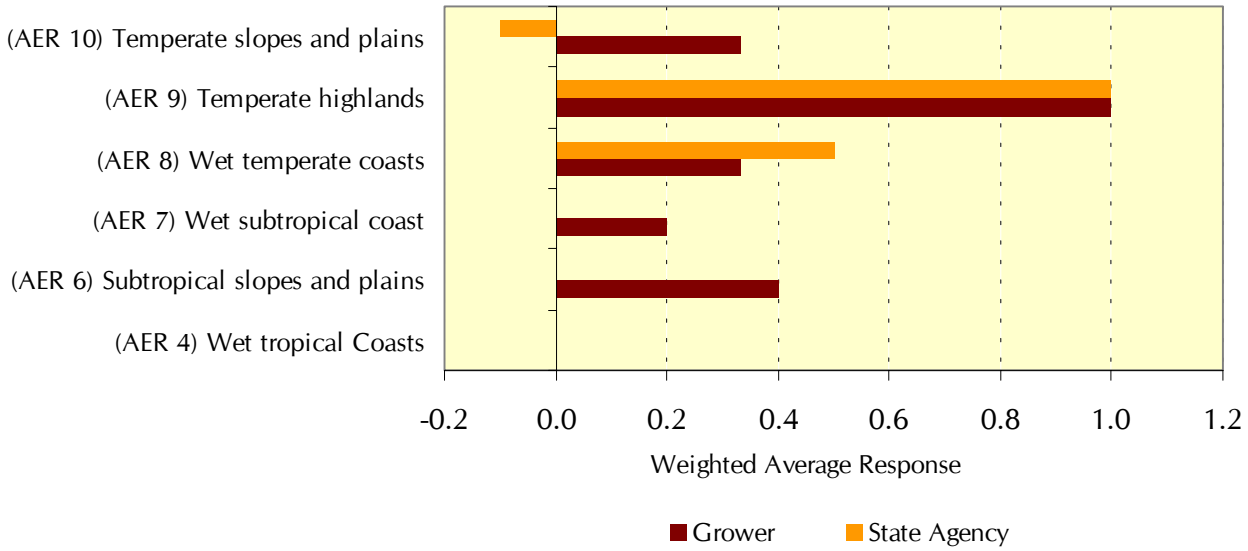
AER	Grower (% of sample)				Sample	State (% of sample)				Sample
	No	Low	Med	High	(n)	No	Low	Med	High	(n)
(AER 4) Wet tropical Coasts	100	0	0	0	**1**	0	50	50	0	**2**
(AER 6) Subtropical slopes and plains	20	80	0	0	**5**	100	0	0	0	**2**
(AER 7) Wet subtropical coast	65	24	12	0	**17**	43	43	14	0	**7**
(AER 8) Wet temperate coasts	69	25	6	0	**16**	0	100	0	0	**4**
(AER 9) Temperate highlands	90	0	10	0	**10**	0	100	0	0	**1**
(AER 10) Temperate slopes and plains	70	20	10	0	**10**	33	56	11	0	**9**

Source: Survey Data, 1999

Results of the trend in soil chemical accumulation across each AER are presented in Figure 3.6 and Table 3.6. The results show predominantly, a positive response by Growers, indicating perceived general improvement in horticultural soil systems. State Agency groups concurred with Growers on the trend in soil chemical accumulation for AERs 8 and 9 (ie. reduced farm chemical

accumulation), and AER 4 (neither reducing nor increasing farm chemical accumulation). However, where Growers identified improvements in soil chemical accumulation in AERs 6 and 7, State Agencies report neutral change. The greatest difference in perceived soil chemical accumulation trend was found for the Adelaide Coastal Plains and Goulburn/Murray region of AER 10 where State Agencies, but not Growers report an increase in the problem.

Figure 3.6 Environmental Trend in Chemical Accumulation in Soil



Source: Survey Data, 1999

Table 3.6 Analysis of Responses: Environmental Trend in Chemical Accumulation in Soil

AER	Grower (% of sample)			Sample	State (% of sample)			Sample
	Imp	N. C	Det	(n)	Imp	N. C	Det	(n)
(AER 4) Wet tropical Coasts				**0**	50	0	50	**2**
(AER 6) Subtropical slopes & plains	50	50	0	**4**				**0**
(AER 7) Wet subtropical coast	20	80	0	**5**	50	0	50	**4**
(AER 8) Wet temperate coasts	33	67	0	**6**	50	50	0	**4**
(AER 9) Temperate highlands	100	0	0	**1**	100	0	0	**1**
(AER 10) Temperate slopes & plains	33	67	0	**3**	33	17	50	**6**

Source: Survey Data. Imp: = Improving, N.C: = No Change, Det: = Deteriorating

Organic Matter and Soil Structure Decline

Soil organic matter content affects soil structure, fertility and water holding capacity and has enormous impact on the productivity of agricultural land. Organic matter loss and subsequent soil structure decline is a major problem for horticultural industry which is intensive in many of its management practices. Annual (vegetable) crop production systems are at greater risk than perennial crops (fruit and nuts) due to multiple crop turnover, and the complete removal of plants at harvest and/or before tillage.

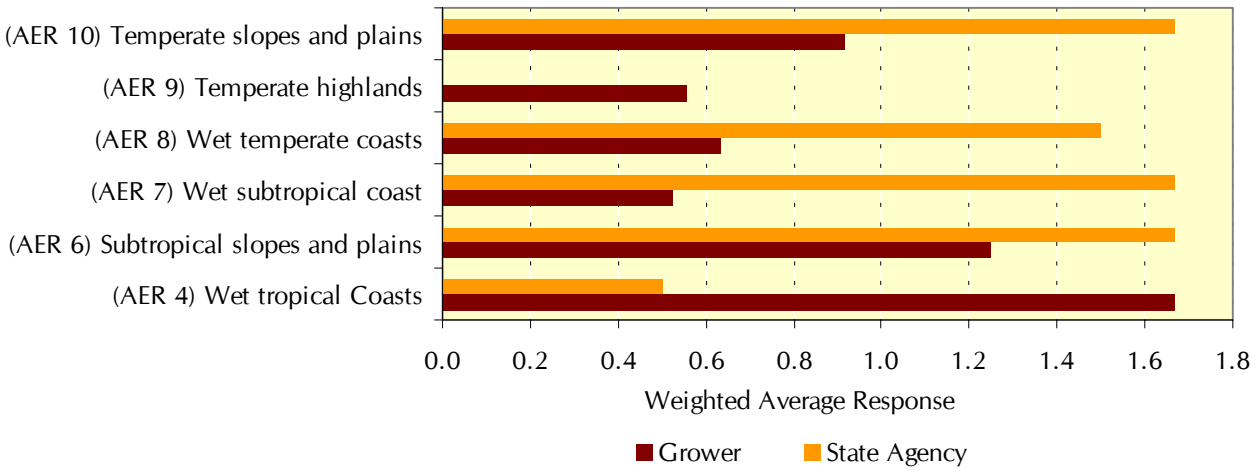
The Tasmanian Institute of Agricultural Research undertook a benchmarking study to review the status of organic matter and soil structure in krasnozem soil in regions of horticultural production (Sparrow, 1999b). The study found that although there was evidence that soil structure had changed with intensive cropping activity, soils covered by the study were reported to be in good condition. Soil erosion was highlighted as an important soil management issue in these soil conditions and climates. Other work in this area includes the HRDC funded carrot sustainability

workshops (SARDI Riverlink 1999), and a review of management practices for non-wetting soils for potato production (SARDI 1999).

Results on the status of soil organic matter and soil structure decline are presented in Figure 3.7 and Table 3.7. The results show that Growers consider this indicator to be of low to moderate concern in all regions of Australia. State Agencies identify this indicator as being a significant problem only in AERs 6, 7, 8 and 10. Contrasts in Grower and State Agency response are evident for AER 9 (but Grower and State Agency responses did not relate to the same sub regions in this AER) and the Tully region of AER 4 with Growers perceiving much higher levels of concern. This result is partially due to a lack of survey data from State Agencies in these regions.

Growers located in the Wet Tropical Coast (AER 4) in which banana and tropical fruit production are the dominant horticultural industries, indicate a particularly high level of concern. State Agencies perceived this indicator to be of low priority, however trend analysis indicates that the indicator was noted as being an increasing problem (Figure 3.8 and Table 3.8). AERs 7 (Lockyer Valley and Burnett regions) and 8 (Northern Tasmanian regions) were also identified as regions with negative (reduced soil organic matter and increased structure decline) trends in soil organic matter and structure decline by State Agencies (Figure 3.8 and Table 3.8). Growers did not identify any regions with negative trends in soil organic matter and structure decline, however Table 3.8 indicates that some Growers perceived deteriorating organic matter and soil structure in AERs 7 and 8.

Figure 3.7 Environmental Status of Organic Matter and Soil Structure Decline



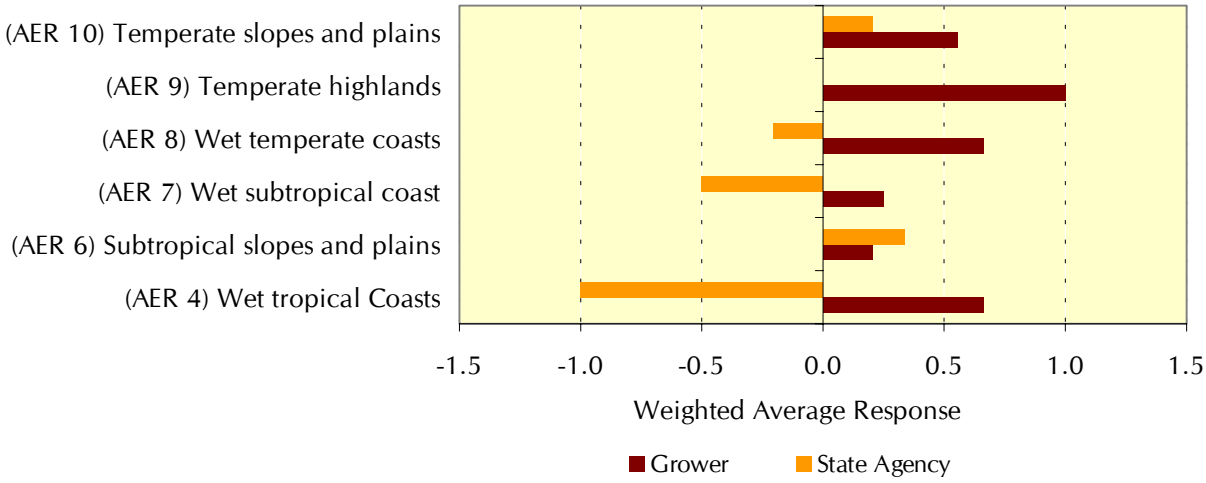
Source: Survey Data, 1999

Table 3.7 Analysis of Responses: Status of Organic Matter and Soil Structure Decline

AER	Grower (% of sample)				Sample	State (% of sample)				Sample
	No	Low	Med	High	(n)	No	Low	Med	High	(n)
(AER 4) Wet tropical Coasts	0	33	67	0	**3**	50	50	0	0	**2**
(AER 6) Subtropical slopes and plains	0	75	25	0	**4**	0	33	67	0	**3**
(AER 7) Wet subtropical coast	58	32	11	0	**19**	22	11	44	22	**9**
(AER 8) Wet temperate coasts	63	21	5	11	**19**	17	33	33	17	**6**
(AER 9) Temperate highlands	67	11	22	0	**9**	100	0	0	0	**1**
(AER 10) Temperate slopes and plains	33	42	25	0	**12**	0	44	44	11	**9**

Source: Survey Data, 1999

Figure 3.8 Environmental Trend in Organic Matter and Soil Structure Decline



Source: Survey Data, 1999

Table 3.8 Analysis of Responses: Environmental Trend in Organic Matter and Soil Structure Decline

AER	Grower (% of sample)			Sample	State (% of sample)			Sample
	Imp	N. C	Det	(n)	Imp	N. C	Det	(n)
(AER 4) Wet tropical Coasts	67	33	0	**3**	0	0	100	**1**
(AER 6) Subtropical slopes & plains	25	75	0	**4**	50	50	0	**2**
(AER 7) Wet subtropical coast	38	50	13	**8**	17	17	67	**6**
(AER 8) Wet temperate coasts	83	0	17	**6**	20	40	40	**5**
(AER 9) Temperate highlands	100	0	0	**3**				**0**
(AER 10) Temperate slopes & plains	67	22	11	**9**	44	33	22	**9**

Source: Survey Data. Imp: = Improving, N.C: = No Change, Det: = Deteriorating

Nutrient Levels and Availability in Soils

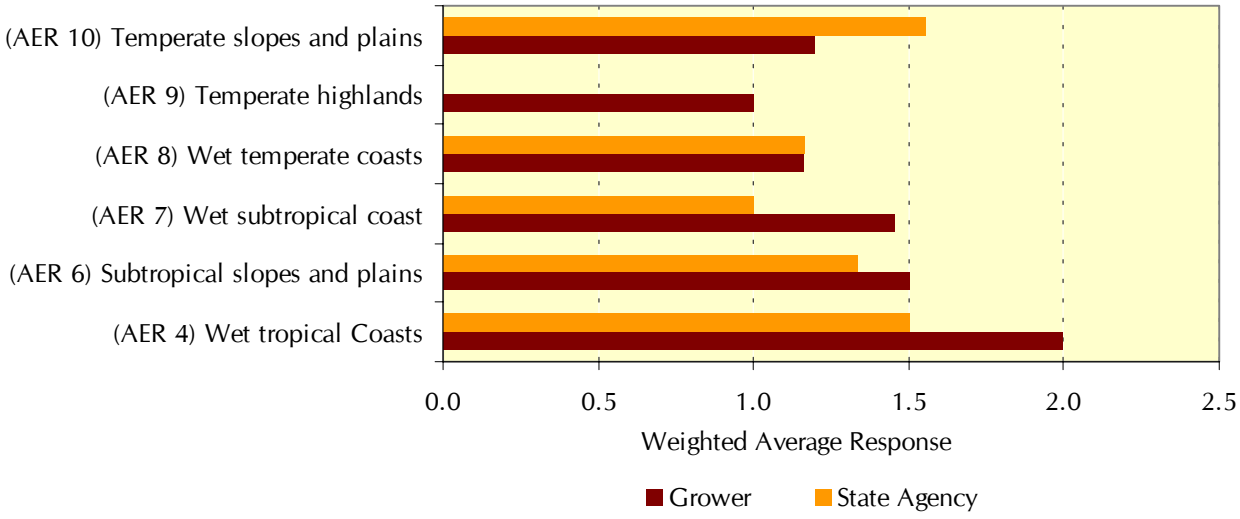
Soil nutrient levels, and the availability of those nutrients for plant growth are two major factors affecting horticultural crop productivity. Nutrient export through crop harvest has a significant impact on the soil nutrient pool, and high levels of horticultural crop production are supported primarily through the application of inorganic fertilisers. Irrespective of the concentration of nutrients essential for plant growth in soils, the uptake of those nutrients is dependant on soil chemical characteristics, and physical and biological attributes. Australian soils are characterised by various chemical and physical limitations that affect the availability of nutrients for plant growth. Intensive production processes can increase the severity of these limitations. Over-cultivation causes loss of organic matter, soil compaction and top soil erosion affecting both nutrient levels and availability. Excessive fertiliser application can affect the availability of nutrients by altering mineral ratios and causing nutrient imbalance and toxicities.

In this section, the results of Grower and State Agency response on the status and trend in nutrient levels and availability in soils used for horticultural production are described. All production regions were identified by Growers as deficient in soil nutrient levels and availability, although the indicator was seen as significantly less severe by Growers in AER 4 (Wet Tropical Coasts) (Figure 3.9 and Table 3.9). The response by State Agencies was similar to Growers, although AER 4 was seen as the region with the largest problem.

Consensus on the general level of importance of this indicator was found across Grower and State Agency responses. Growers indicated that soil nutrient levels and availability was affecting production in all AERs, and ranged from an indicator of moderate concern in the Tully region of AER 4 to an indicator of low to moderate concern in AERs 6,7,8 and 10 (Figure 3.9). With the exception of AER 9 in which the only State Agency response provided found soil nutrient levels and availability not to be a problem, State Agency responses generally showed low to medium levels of concern.

Overall, State Agencies and Growers perceived nutrient levels and availability to be improving in most regions where data were available (Figure 3.10 and Table 3.10). Responses were not provided by State Agencies for AER 9. AER 4 (2 responses) and AER 9 (5 responses) were the only regions in which soil nutrient levels were found to be improving by Growers only.

Figure 3.9 Environmental Status of Nutrient Levels and Availability in Soils



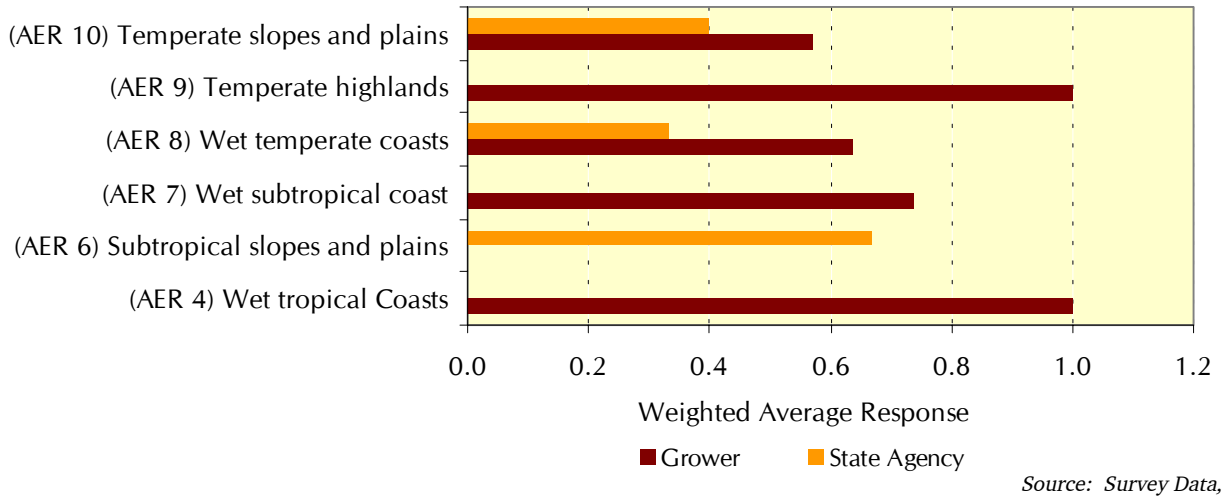
Source: Survey Data, 1999

Table 3.9 Analysis of Responses: Status of Nutrient Levels and Availability in Soils

AER	Grower (% of sample)				Sample	State (% of sample)				Sample
	No	Low	Med	High	(n)	No	Low	Med	High	(n)
(AER 4) Wet tropical Coasts	0	33	33	33	**3**	0	50	50	0	**2**
(AER 6) Subtropical slopes and plains	25	0	75	0	**4**	33	0	67	0	**3**
(AER 7) Wet subtropical coast	18	27	45	9	**22**	43	29	14	14	**7**
(AER 8) Wet temperate coasts	47	5	32	16	**19**	50	0	33	17	**6**
(AER 9) Temperate highlands	44	11	44	0	**9**	100	0	0	0	**1**
(AER 10) Temperate slopes and plains	30	30	30	10	**10**	11	44	22	22	**9**

Source: Survey Data, 1999

Figure 3.10 Environmental Trend in Nutrient Levels and Availability



Source: Survey Data, 1999

Table 3.10 Analysis of Responses: Trend in Nutrient Levels and Availability in Soil

AER	Grower (% of sample)			Sample	State (% of sample)			Sample
	Imp	N. C	Det	(n)	Imp	N. C	Det	(n)
(AER 4) Wet tropical Coasts	100	0	0	**2**	50	0	50	**2**
(AER 6) Subtropical slopes & plains	33	33	33	**3**	100	0	0	**2**
(AER 7) Wet subtropical coast	74	26	0	**19**	25	50	25	**4**
(AER 8) Wet temperate coasts	64	36	0	**11**	33	67	0	**3**
(AER 9) Temperate highlands	100	0	0	**5**				**0**
(AER 10) Temperate slopes & plains	57	43	0	**7**	50	50	0	**8**

Source: Survey Data. Imp: = Improving, N.C: = No Change, Det: = Deteriorating

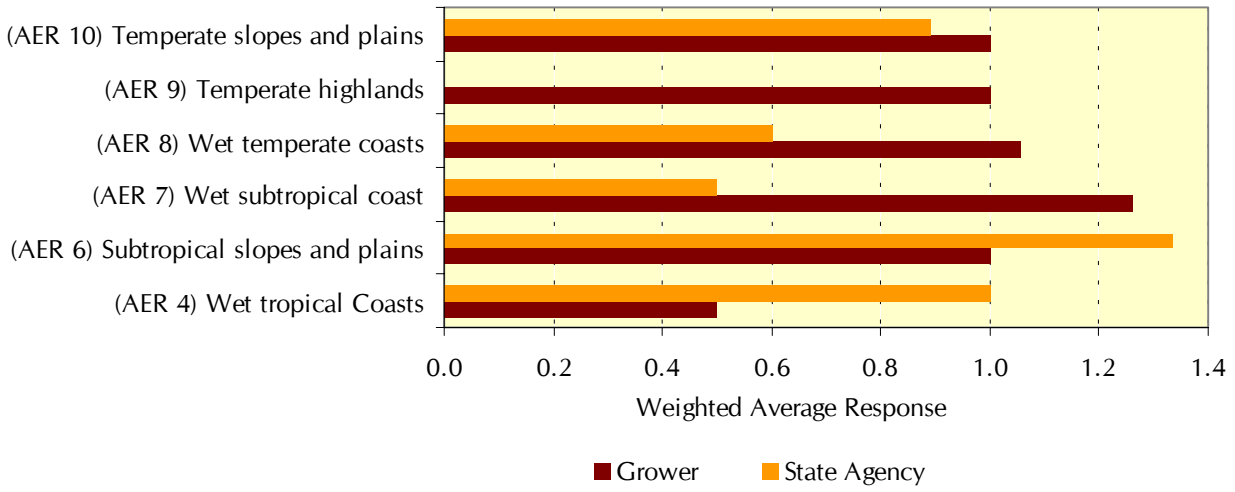
Soil Acidity Levels

Acidic soils are widespread across large areas of agriculturally productive land in Australia. Approximately 35 million hectares of land in the higher rainfall regions of coastal and sub coastal Australia is currently affected by strongly acidic soils (pH<4.8) (Slattery et. al. 1999). A further 55 million hectares of moderately or slightly acidic soil (pH 4.8-6.0) has the potential to degrade to this state (Slattery et. al. 1999). Acidic soils occur in agricultural regions as a result of natural processes, however acidification is being accelerated by agricultural practices including the use of acidifying nitrogen fertilisers and the removal of calcium in produce without being replaced by lime (SCARM, 1998). This problem is worse in higher rainfall regions where the leaching increases soil pH imbalances.

Many horticultural production systems operate on soils with low pH levels (acidic) at the surface and in the subsoil. Horticulture is well positioned to manage soil acidity compared to broadacre and grazing industries. The intensive nature of horticulture on smaller land holdings allows for more effective monitoring and management of soil acidity. Further, horticulture generally has a greater capacity to afford lime and dolomite soil amendment strategies because its markets are of higher value compared to most broadacre industries.

Generally, responses indicated on average that respondents considered soil acidity to be either not significant, or of low importance (Figure 3.11 and Table 3.11), although Growers generally perceived soil acidity to be of higher importance than State Agencies. This was particularly evident in AER 7 (Burnett (QLD), Northern Rivers (NSW)) and AER 8 (Northern Tasmania, Bellarine Peninsula (VIC) and Onkaparinga (SA)) where a higher proportion of Growers considered soil acidity to be of medium to high importance (Table 3.11).

Figure 3.11 Environmental Status of Soil Acidity



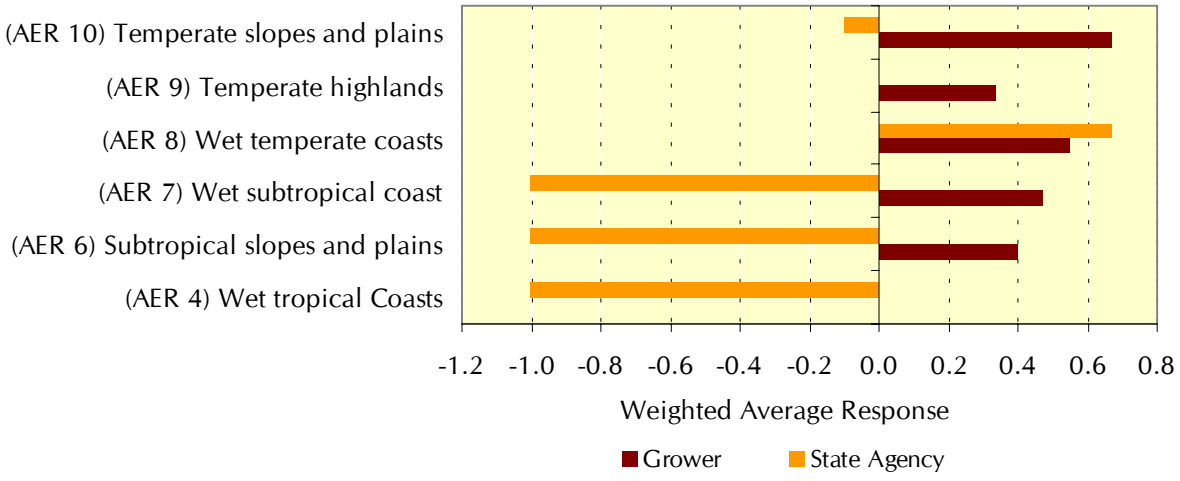
Source: Survey Data, 1999

Table 3.11 Analysis of Responses: Status of Soil Acidity

AER	Grower (% of sample)				Sample	State (% of sample)				Sample
	No	Low	Med	High	(n)	No	Low	Med	High	(n)
(AER 4) Wet tropical Coasts	50	50	0	0	**2**	50	0	50	0	**2**
(AER 6) Subtropical slopes and plains	40	20	40	0	**5**	0	67	33	0	**3**
(AER 7) Wet subtropical coast	22	30	48	0	**23**	67	17	17	0	**6**
(AER 8) Wet temperate coasts	44	17	28	11	**18**	40	60	0	0	**5**
(AER 9) Temperate highlands	33	33	33	0	**9**	100	0	0	0	**1**
(AER 10) Temperate slopes and plains	33	33	33	0	**12**	44	33	11	11	**9**

Source: Survey Data, 1999

Figure 3.12 Environmental Trend in Soil Acidity



Source: Survey Data, 1999

Table 3.12 Analysis of Responses: Trend in Soil Acidity

AER	Grower (% of sample)			Sample	State (% of sample)			Sample
	Imp	N. C	Det	(n)	Imp	N. C	Det	(n)
(AER 4) Wet tropical Coasts				**0**	0	0	100	**1**
(AER 6) Subtropical slopes & plains	67	33	0	**3**	0	0	100	**3**
(AER 7) Wet subtropical coast	63	21	16	**19**	0	0	100	**2**
(AER 8) Wet temperate coasts	55	45	0	**11**	67	33	0	**3**
(AER 9) Temperate highlands	50	33	17	**6**				**0**
(AER 10) Temperate slopes & plains	67	33	0	**9**	20	40	40	**5**

Source: Survey Data. Imp: = Improving, N.C: = No Change, Det: = Deteriorating

Environmental trend in soil acidity presented mixed responses from Growers and State Agencies (Figure 3.12). State Agencies perceived soil acidity to be deteriorating in AERs 4, 6, 7 and to a lesser extent in AER 10. Growers generally perceived soil acidity to be improving (ie. reduced soil acidity levels) although some responses in AER 7 (Burnett and Northern Rivers) and AER 9 (Ovens Murray (VIC)) indicated a deteriorating trend (ie. increased soil acidity levels)(Table 3.12). Growers and State Agencies both indicated that soil acidity was improving in AER 8.

Soil Salinity Levels

The concentration of soluble salts in soil water determines soil salinity. Saline soils have salt concentrations that limit plant growth predominantly by restricting soil water uptake. Natural salinity occurs in soils developed from parent rocks that release salts upon weathering, in areas that were once marine beds, and in areas where there is temporary restriction of water movement. Soil salinity is also induced by the rise of ground water tables into the crop root zone. Evaporation and plant capillary action cause the salts to accumulate near the soil surface. Watertable rise is caused by an increase in deep drainage below the crop root zone. Deep drainage can be caused by the replacement of deep rooted trees with more shallow rooted cultivated plants, or by changes in water movement in the landscape. Irrigation however, acts to increase deep drainage and the problem of soil salinity is particularly significant in the irrigated areas of the Murray Darling Basin. Research conducted by Stirzaker (1999) indicates that good irrigation management alone will not resolve the problem of deep drainage, and that both perennial and annual systems could benefit from a specialist plant such as lucerne to dry out the soils at strategic times (Stirzaker, 1999).

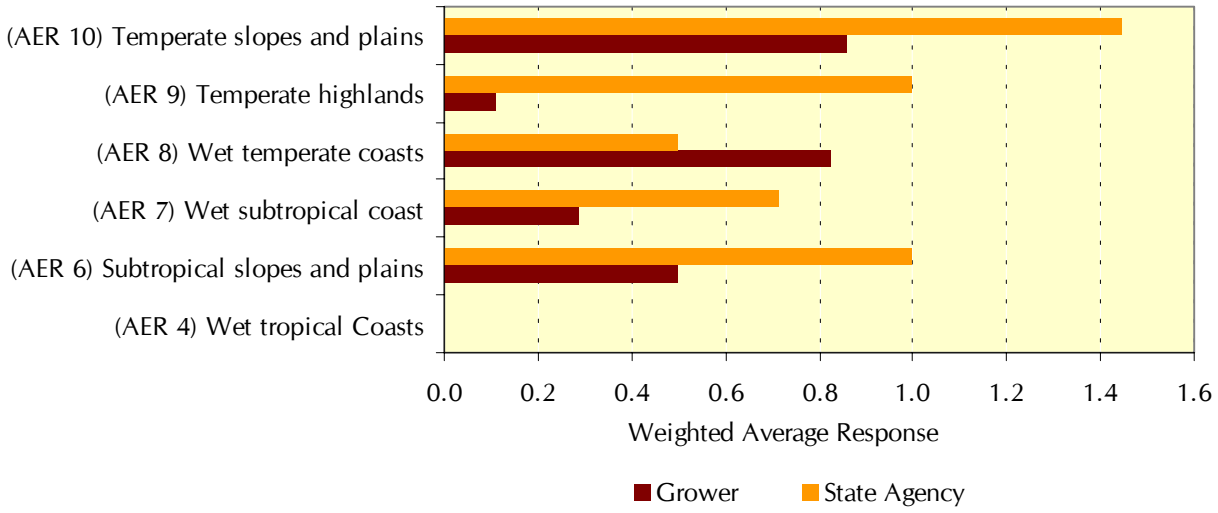
Salinity affects soils across Australia, but is greatest in the low annual rainfall regions where evaporation exceeds rainfall for much of the year. Soils in high rainfall areas have low salt accumulation as increased leaching removes the salts from the soil profile.

The analysis of soil salinity was constrained by a higher number of null responses in the survey sample. Figure 3.13 and Table 3.13 present survey results on the environmental status of soil salinity. Results generally indicated that average responses to the status of soil salinity were higher for State Agencies compared to Growers, although average responses were between 0 and 1 indicating that soil salinity was either not significant, or of low significance. Small proportions of Grower responses in the medium and high range were found in AER 8 (Onkaparinga (SA), North Coast (TAS)) and AER 10 (Riverland (SA) and Murrumbidgee Irrigation Area (NSW)). State Agencies perceived soil salinity to be most significant in the Sunraysia, Goulburn/Murray/Lodden and Murray Darling Basin regions of AER 10.

Average trend analysis results suggest that Growers and State Agencies differ in perceptions of soil salinity trends (Figure 3.14 and Table 3.14). Across all AERs assessed, on average Growers indicated that soil salinity was either not changing, or was improving (ie. reduced soil salinity levels), whereas State Agencies indicated that soil salinity is either not changing or deteriorating (ie. increased soil salinity levels). Regions identified by State Agencies where soil salinity is perceived to be deteriorating include the North East and Meander Valley regions of Tasmania, Murray Darling Basin (NSW), Adelaide Coastal Plains, Goulburn/Murray Loddon (VIC) and

Burnett region (QLD). No responses by Growers and State Agencies were received for this indicator in AER 4.

Figure 3.13 Environmental Status of Soil Salinity Levels



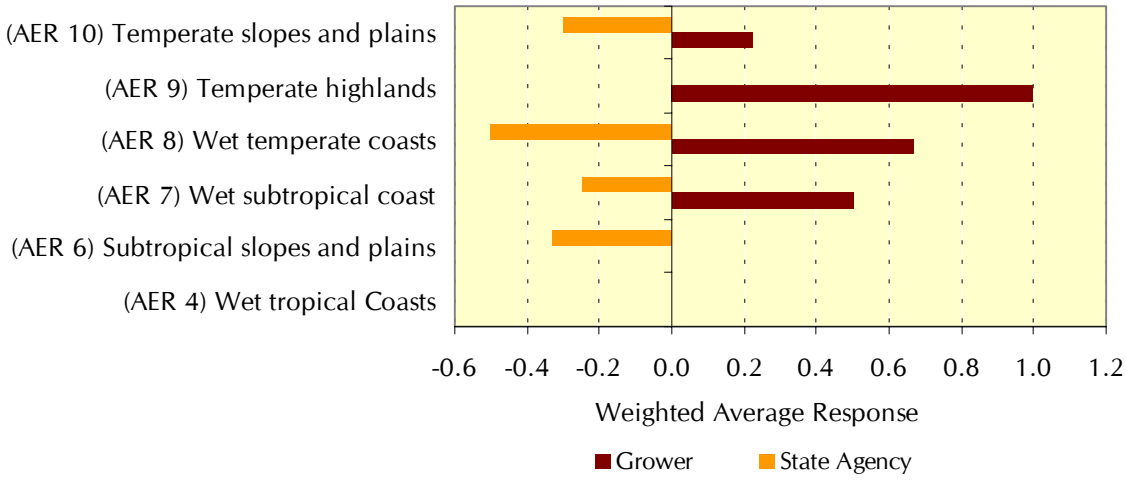
Source: Survey Data, 1999

Table 3.13 Analysis of Responses: Status of Soil Salinity

AER	Grower (% of sample)				Sample	State (% of sample)				Sample
	No	Low	Med	High	(n)	No	Low	Med	High	(n)
(AER 4) Wet tropical Coasts	100	0	0	0	**1**	100	0	0	0	**2**
(AER 6) Subtropical slopes and plains	50	50	0	0	**4**	33	33	33	0	**3**
(AER 7) Wet subtropical coast	71	29	0	0	**14**	29	71	0	0	**7**
(AER 8) Wet temperate coasts	53	18	24	6	**17**	50	50	0	0	**6**
(AER 9) Temperate highlands	89	11	0	0	**9**	0	100	0	0	**1**
(AER 10) Temperate slopes and plains	43	36	14	7	**14**	22	22	44	11	**9**

Source: Survey Data, 1999

Figure 3.14 Environmental Trend in Soil Salinity Levels



Source: Survey Data, 1999

Table 3.14 Analysis of Responses: Trend in Soil Salinity

AER	Grower (% of sample)			Sample	State (% of sample)			Sample
	Imp	N. C	Det	(n)	Imp	N. C	Det	(n)
(AER 4) Wet tropical Coasts				**0**				**0**
(AER 6) Subtropical slopes & plains	0	100	0	**2**	0	50	50	**2**
(AER 7) Wet subtropical coast	50	50	0	**4**	0	75	25	**4**
(AER 8) Wet temperate coasts	67	33	0	**9**	0	50	50	**2**
(AER 9) Temperate highlands	100	0	0	**1**	0	100	0	**1**
(AER 10) Temperate slopes & plains	22	78	0	**9**	14	29	57	**7**

Source: Survey Data. Imp: = Improving, N.C: = No Change, Det: = Deteriorating

3.3.2 Water

Ground water Salinity Level

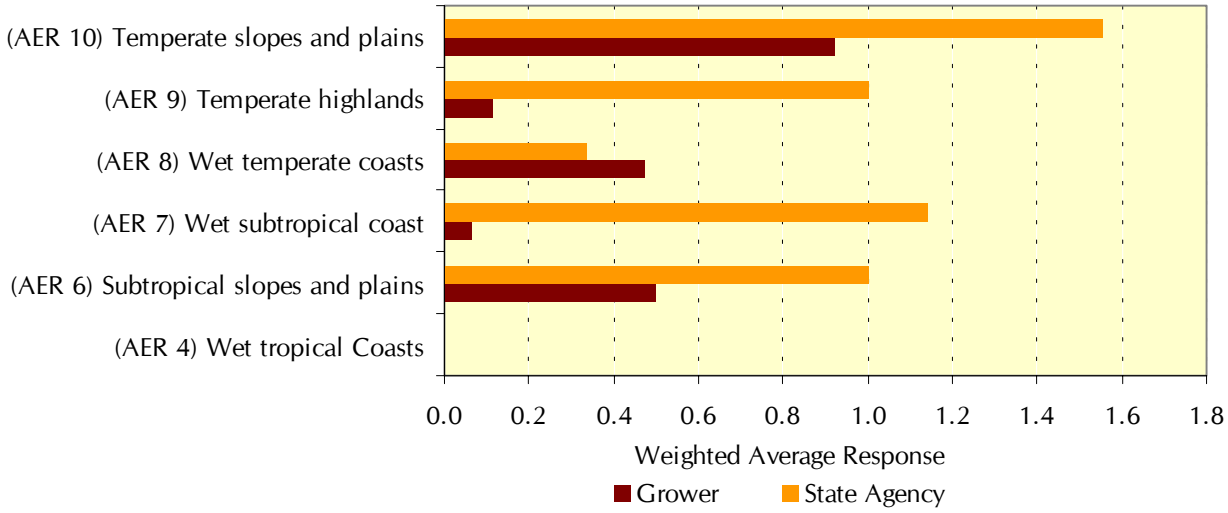
A slight degree of salinity (eg. EC 1.5 dS/m) may not cause serious production problems provided the rate of extraction from the aquifers does not exceed the average recharge rates of the underground system concerned (Crabb, 1997). The problem of saline ground water arises, however when the system is over-pumped and the original salinity levels rise to above approximately EC 7 dS/m (Crabb, 1997).

In some horticultural regions, the salinity of ground water reduces significantly after years of good rainfall. Conversely, the lack of recharge of aquifers in dry years appears to concentrate ground water salinity. The occurrence of saline ground water in horticultural regions such as Queensland's Lockyer Valley and South Australia's Riverland is a major limiting factor to horticultural production.

Salinity is limited to ground water in much of the high rainfall wet subtropical coast (AER 7) (Wet Temperate coast) where soils are largely volcanic in the vicinity of the Great Dividing Range. Ground water salinity is commonly associated with those AERs where large-scale clearing has occurred in landscapes that contain saline deposits at depth. Ground water and soil salinity are significant indicators in much of the Great Artesian Basin, and nutrients in run off have long been recognised in the Darling section of the Murray Darling Basin. Ground water salinity in Victorian irrigation areas and the Riverland of South Australia (AER 10) (Temperate slopes and plains) are well known problems, as is soil salinity in these two regions. These salt problems are related to both saline irrigation water and inherently saline soils in the lower Murray and parts of the Murray Irrigation Area.

Results of the analysis of ground water salinity are shown in Figure 3.15 and Table 3.15. Generally average responses for both Growers and State Agencies were between 0 and 1, indicating that ground water salinity is either not a priority, or is a priority of low significance. State Agencies perceived this indicator to be of low to medium significance in AER 10 (Temperate slopes and plains) where 33 percent of responses considered ground water salinity to be a high priority indicator, particularly in the Riverland and Sunraysia regions of South Australia and Victoria respectively.

Figure 3.15 Environmental Status of Ground Water Salinity Levels



Source: Survey Data, 1999

Table 3.15 Analysis of Responses: Environmental Status of Ground Water Salinity

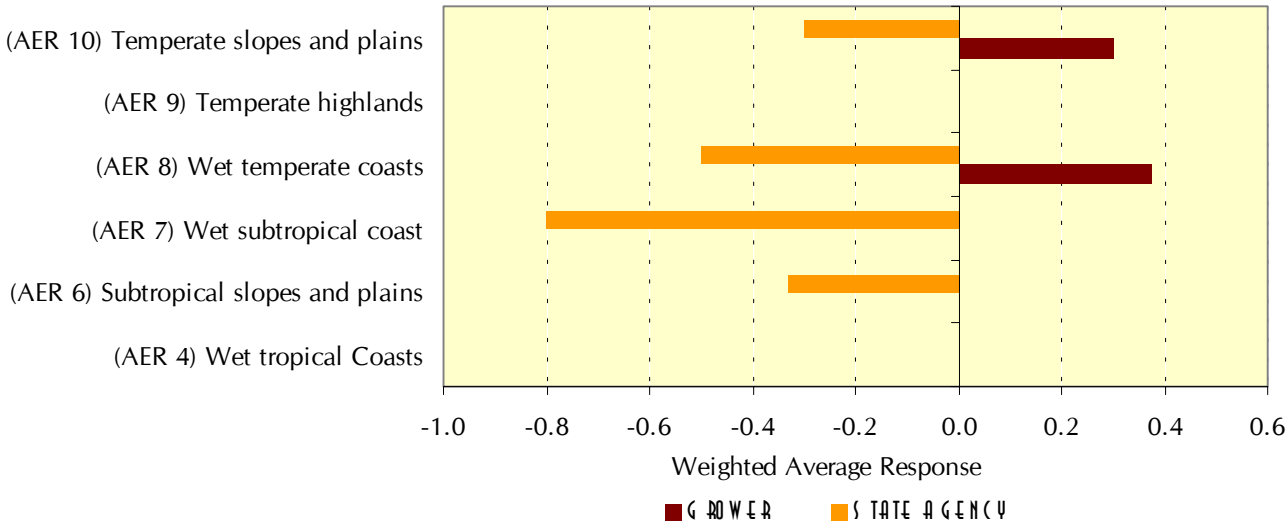
AER	Grower (% of sample)				Sample	State (% of sample)				Sample
	No	Low	Med	High	(n)	No	Low	Med	High	(n)
(AER 4) Wet tropical Coasts	100	0	0	0	**1**	100	0	0	0	**2**
(AER 6) Subtropical slopes & plains	50	50	0	0	**4**	33	33	33	0	**3**
(AER 7) Wet subtropical coast	93	7	0	0	**15**	29	29	43	0	**7**
(AER 8) Wet temperate coasts	59	35	6	0	**17**	67	33	0	0	**6**
(AER 9) Temperate highlands	89	11	0	0	**9**	0	100	0	0	**1**
(AER 10) Temperate slopes & plains	31	54	8	8	**13**	22	33	11	33	**9**

Source: Survey Data, 1999

Survey results on ground water salinity trends in horticulture are shown in Figure 3.16 and Table 3.16. A small sample size was collated for the analysis of this indicator which limits the reliance that can be placed on the outcomes of this analysis. No responses were reported in AER 4 (Wet tropical coast) for both Growers and State Agencies, and in AER 9 (Temperate highlands) for State Agencies only.

Contrasts in the perception of trend in ground water salinity between Growers (indicating reduced ground water salinity) and State Agencies (indicating increasing ground water salinity) were found. State Agency responses indicated stronger perceptions of increasing ground water salinity in the Burnett, Coastal Burnett and Pioneer (Mackay) regions of AER 7 (Wet tropical coast), and in the Riverland/Sunraysia and Adelaide Coastal Plains of AER 10 (Temperate slopes and plains) (see Table 3.17). In AERs 7 and 10, 80 percent and 43 percent of responses respectively indicated that ground water salinity was deteriorating (ie. ground water salinity is increasing).

Figure 3.16 Environmental Trend in Ground Water Salinity Levels



Source: Survey Data, 1999

Table 3.16 Analysis of Responses: Environmental Trend in Ground Water Salinity

AER	Grower (% of sample)			Sample	State (% of sample)			Sample
	Imp	N. C	Det	(n)	Imp	N. C	Det	(n)
(AER 4) Wet tropical Coasts				**0**				**0**
(AER 6) Subtropical slopes & plains	0	100	0	**2**	0	50	50	**2**
(AER 7) Wet subtropical coast	0	100	0	**1**	0	20	80	**5**
(AER 8) Wet temperate coasts	38	63	0	**8**	0	50	50	**2**
(AER 9) Temperate highlands	0	100	0	**1**				**0**
(AER 10) Temperate slopes & plains	30	70	0	**10**	0	57	43	**7**

Source: Grower and State Agency Survey Data. Imp: Improving, N.C: No Change, Det: Deteriorating

Surface Water Salinity Levels

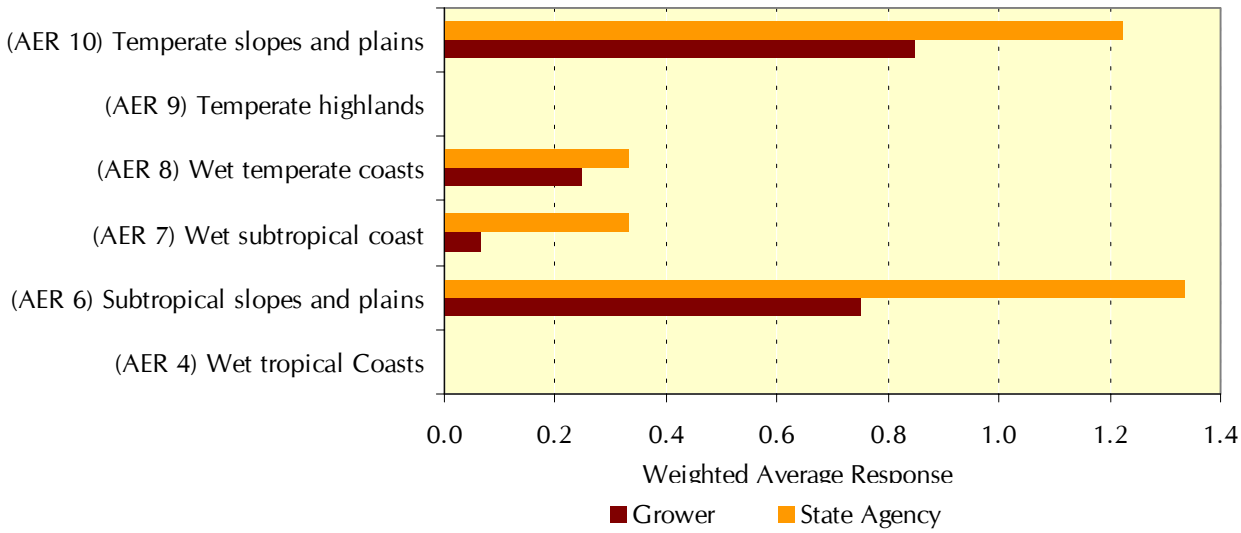
Salinity in natural river systems is typically derived from weathering rocks and ground water seepage. Salinity levels in streams may be elevated by human activities such as irrigating with highly saline surface or ground water, replacing deep rooting vegetation with shallow rooting vegetation with low water requirements, or combinations of each. Horticultural productivity is significantly diminished when land is irrigated with highly saline water (ie. > 7dS/cm) (Crabb. 1997). River regulation also reduces the flushing/dilution benefits of high flow events, in effect increasing water salinity levels.

High salinity levels in surface water are common over large areas of the Western Australian horticultural regions and southern section of the Murray Darling basin covering the Riverland of South Australia, the Mallee of Victoria and Southern New South Wales.

The geology of the Queensland border regions in AER 6 (Subtropical slopes and plains) would promote naturally high salt levels in rivers. Irrigation in this region may be contributing to this problem. Crabb (1997) shows the trend in surface water salinity in the major rivers in this area to be increasing. Portions of AERs 6 and 7 (Wet subtropical coast) which cover the north-east coast of Queensland display a different trend from the Murray Darling basin in that the upper reaches show increasing salinity while lower reaches appear to be declining in salinity (SCARM, 1998).

Results of the analysis of the status of surface water salinity are shown in Figure 3.17 and Table 3.17. Generally, responses indicated that surface water salinity is of higher significance in AERs 6 and 10 (Temperate slopes and plains), particularly for State Agencies. In AER 10 where 9 State Agency responses were received, 44 percent and 11 percent of State Agency responses respectively indicated that surface water salinity is of medium and high significance in the Riverland/Sunraysia and Murray Darling regions. Growers in AER 10 generally considered this indicator to be of low significance with 45 percent and 38 percent respectively indicating a no and low response.

Figure 3.17 Environmental Status of Surface Water Salinity Levels



Source: Survey Data, 1999

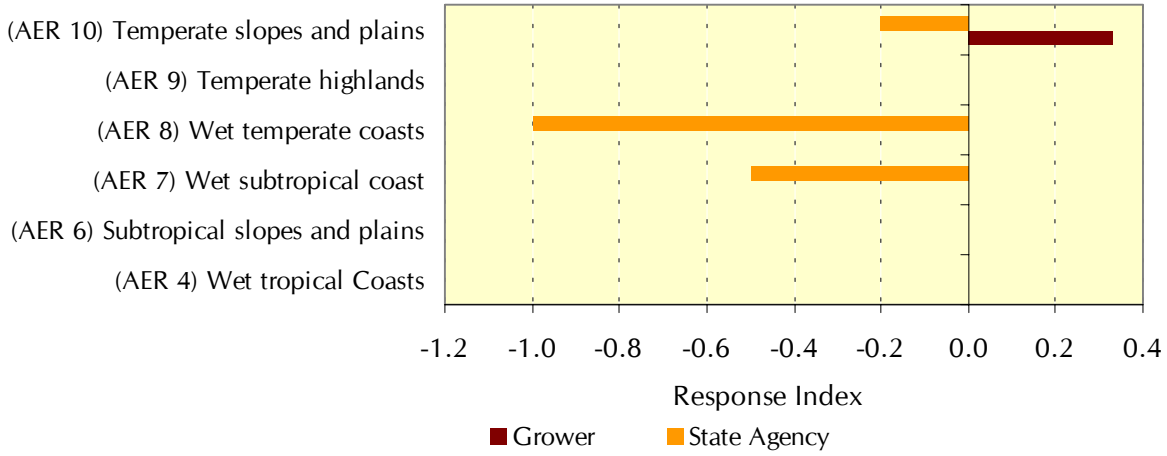
Table 3.17 Analysis of Responses: Environmental Status of Surface Water Salinity

AER	Grower (% of sample)				Sample	State (% of sample)				Sample
	No	Low	Med	High	(n)	No	Low	Med	High	(n)
(AER 4) Wet tropical Coasts	100	0	0	0	**1**	100	0	0	0	**2**
(AER 6) Subtropical slopes and plains	50	25	25	0	**4**	0	67	33	0	**3**
(AER 7) Wet subtropical coast	93	7	0	0	**15**	67	33	0	0	**6**
(AER 8) Wet temperate coasts	75	25	0	0	**16**	83	0	17	0	**6**
(AER 9) Temperate highlands	100	0	0	0	**9**	100	0	0	0	**1**
(AER 10) Temperate slopes and plains	38	38	23	0	**13**	44	0	44	11	**9**

Source: Survey Data, 1999

Results of the analysis of trends in surface water salinity are presented in Figure 3.18 and Table 3.18. A small sample of responses was collated for this indicator (Table 3.18), which limits the interpretation of the analysis. In AER 10 (Temperate slopes and plains) where most responses on this indicator were received, the analysis found contrasting perceptions between Growers and State Agencies. The analysis found that 60 percent of State Agency responses identified increased surface water salinity in this region (Riverland/Sunraysia/Murray Darling/Adelaide coastal plains) compared to 67 percent of Growers who indicated no change in this trend.

Figure 3.18 Environmental Trend in Surface Water Salinity Levels



Source: Survey Data, 1999

Table 3.18 Analysis of Responses: Environmental Trend in Surface Water Salinity

AER	Grower (% of sample)			Sample	State (% of sample)			Sample
	Imp	N.C	Det	(n)	Imp	N.C	Det	(n)
(AER 4) Wet tropical Coasts				**0**				**0**
(AER 6) Subtropical slopes & plains	0	100	0	**2**	33	33	33	**3**
(AER 7) Wet subtropical coast	0	100	0	**1**	0	50	50	**2**
(AER 8) Wet temperate coasts	0	100	0	**5**	0	0	100	**1**
(AER 9) Temperate highlands				**0**				**0**
(AER 10) Temperate slopes & plains	33	67	0	**9**	20	20	60	**5**

Source: Grower and State Agency Survey Data. Imp: Improving, N.C: No Change, Det: Deteriorating

Chemical Levels in Irrigation Water

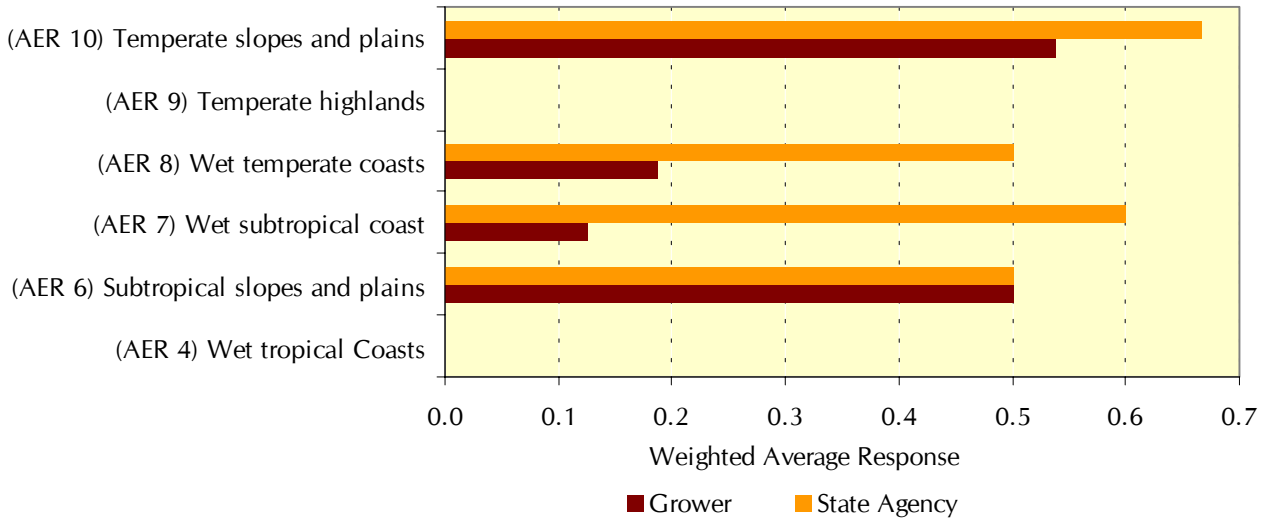
Farm chemicals in irrigation water are usually a problem where heavily fertilised crops contribute to eutrophication of streams resulting from unnaturally high nitrogen (N) and phosphorus (P) levels in run off. In addition to these nutrients, chemicals such as pesticides are causing a decline in irrigation water quality in some rivers, associated with the intensive use of insecticides.

The impacts of waterborne chemicals depend on whether they are biocides or fertilisers. While certain pesticides may be lethal to aquatic life, several of the plant nutrients (especially N and P) lead to eutrophication of stream water. Extensive algal blooms are the most obvious symptoms of high nutrient loads. Where N and P drain from horticultural land into public streams the combination of nutrients and biocides have the potential for widespread negative impacts.

A number of research projects are being undertaken to monitor and address chemical residues in both water and soil, including a nation wide horticulture specific study to minimise impacts of pesticides on soil and water quality funded by the HRDC and LWRRDC. (SARDI Riverlink, 1999).

Results of the analysis of the status of chemicals in irrigation water are presented in Figure 3.19 and Table 3.19. Generally the results indicate that this indicator is either not significant, or is a priority of low significance. State Agencies considered this indicator to be of higher significance compared to Growers, particularly in the Mildura region of Victoria. Sample size constraints limit any useful interpretation of the survey results as shown in Table 3.20, although a deteriorating situation was identified by State Agencies in the Burnett region of Queensland. More quantification is required in this area to produce a better profile of the status, trend and location of agricultural chemicals in irrigation water before a reliable assessment can be made.

Figure 3.19 Environmental Status of Chemical Levels in Irrigation Water



Source: Survey Data, 1999

Table 3.19 Analysis of Responses: Environmental Status of Chemicals in Irrigation Water

AER	Grower (% of sample)				Sample	State (% of sample)				Sample
	No	Low	Med	High	(n)	No	Low	Med	High	(n)
(AER 4) Wet tropical Coasts	100	0	0	0	**1**	100	0	0	0	**2**
(AER 6) Subtropical slopes and plains	50	50	0	0	**4**	50	50	0	0	**2**
(AER 7) Wet subtropical coast	88	13	0	0	**16**	60	20	20	0	**5**
(AER 8) Wet temperate coasts	81	19	0	0	**16**	75	0	25	0	**4**
(AER 9) Temperate highlands	100	0	0	0	**9**	100	0	0	0	**1**
(AER 10) Temperate slopes and plains	54	38	8	0	**13**	67	11	11	11	**9**

Source: Grower and State Agency Survey Data

Table 3.20 Analysis of Responses: Environmental Trend in Chemicals in Irrigation Water

AER	Grower (% of sample)			Sample	State (% of sample)			Sample
	Imp	N.C	Det	(n)	Imp	N.C	Det	(n)
(AER 4) Wet tropical Coasts				**0**				**0**
(AER 6) Subtropical slopes & plains	0	100	0	**2**	0	100	0	**1**
(AER 7) Wet subtropical coast	0	100	0	**2**	50	0	50	**2**
(AER 8) Wet temperate coasts	0	100	0	**4**	0	0	100	**1**
(AER 9) Temperate highlands				**0**				**0**
(AER 10) Temperate slopes & plains	33	67	0	**6**	33	33	33	**3**

Source: Grower and State Agency Survey Data. Imp: Improving, N.C: No Change, Det: Deteriorating

3.3.3 Biodiversity

Native Bushland Removal

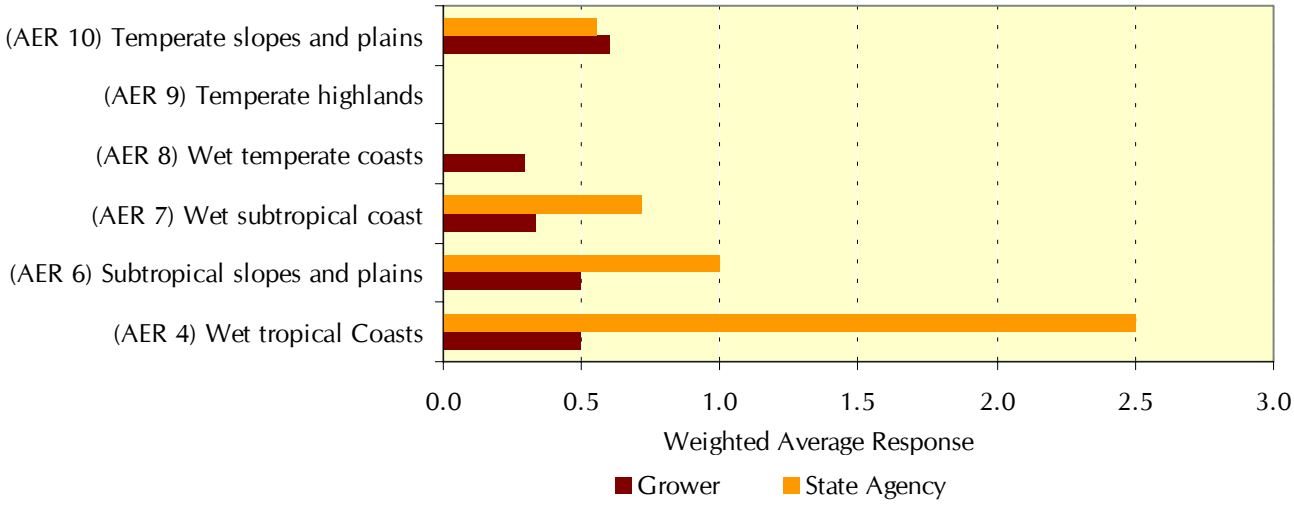
In all but areas of native grassland or previously cleared scrub, conversion of land to horticultural cropping may involve the removal of some trees and shrubs. Land clearing is important for horticultural production as its growing areas are generally concentrated on the better quality soils, usually on the most productive and complex terrestrial ecosystems in rural Australia. Horticulture may also expand into many established broadacre agricultural regions where native bushland has been previously cleared by other industries, particularly in regions closer to capital cities and domestic consumer markets.

Where horticulture is planned to expand in line with state development strategies, the significance of bushland clearing will be largely dependent on the extent to which this bushland includes rare flora or constitutes the habitat of rare and threatened fauna in the region concerned.

The removal of bushland specifically for horticulture has mostly occurred in a historic context and is mainly a current issue where new orchards are being developed in emerging agricultural cropping regions. This is occurring to the largest extent in AER 1 (North-west dry tropics), notably on the expanded Ord River Scheme. Similarly the horticultural industry in the NT has expanded by about 30 percent in recent years (Howe, 1999). This is occurring mostly in the Katherine and Darwin areas (AER 2 North wet/dry tropics) and to a lesser extent in the Alice Springs area according to the Northern Territory State Agency response.

Results of the analysis of the status of native bushland removal are shown in Figure 3.20 and Table 3.21. Overall, average responses for each AER considered native bushland removal to be either not a priority, or a priority of low importance to horticulture. State Agencies considered that this indicator was of medium to high concern in the South Johnstone/Tully region of AER 4 (Wet tropical coasts), but the trend is improving (ie. native bushland removal is reducing) (Figure 3.21 and Table 3.22). 20 percent of Growers in AER 10 (Temperate slopes and plains) indicated that native bushland removal was a significant indicator (Riverland and Goulburn Valley), however a higher proportion of no responses in this region (see Table 3.22) masked this result.

Figure 3.20 Environmental Status of Native Bushland Removal



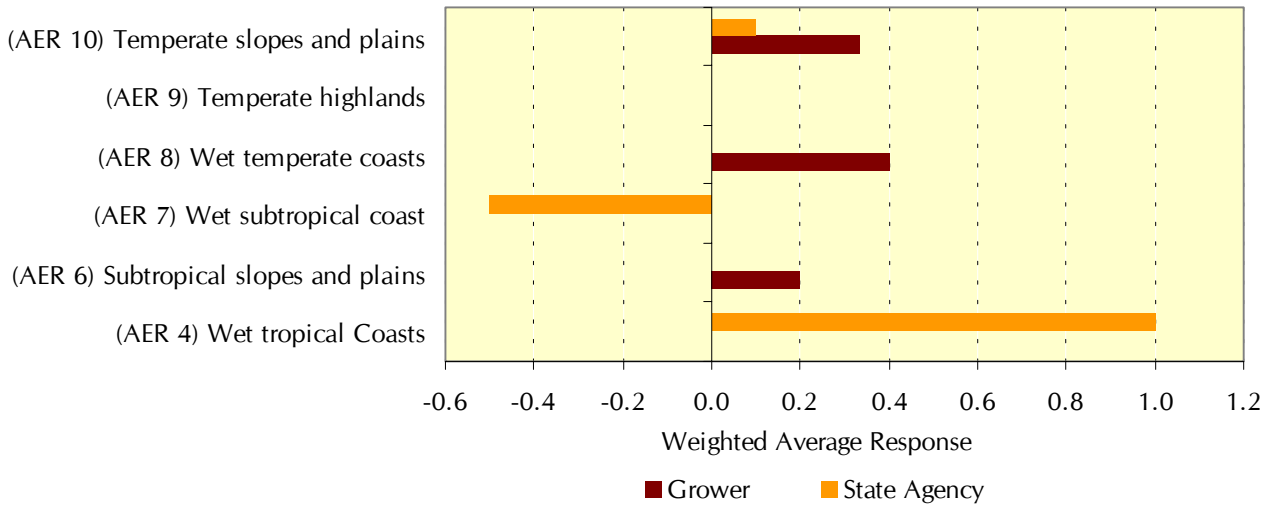
Source: Survey Data, 1999

Table 3.21 Analysis of Responses: Environmental Status of Native Bushland Removal

AER	Grower (% of sample)				Sample	State (% of sample)				Sample
	No	Low	Med	High	(n)	No	Low	Med	High	(n)
(AER 4) Wet tropical Coasts	50	50	0	0	**2**	0	0	50	50	**2**
(AER 6) Subtropical slopes and plains	75	0	25	0	**4**	33	33	33	0	**3**
(AER 7) Wet subtropical coast	80	7	13	0	**15**	43	43	14	0	**7**
(AER 8) Wet temperate coasts	76	18	6	0	**17**	100	0	0	0	**6**
(AER 9) Temperate highlands	100	0	0	0	**9**	100	0	0	0	**1**
(AER 10) Temperate slopes and plains	80	0	0	20	**10**	67	11	22	0	**9**

Source: Grower and State Agency Survey Data

Figure 3.21 Environmental Trend in Native Bushland Removal



Source: Survey Data, 1999

Table 3.22 Analysis of Responses: Environmental Trend in Native Bushland Removal

AER	Grower (% of sample)			Sample	State (% of sample)			Sample
	Imp	N.C	Det	(n)	Imp	N.C	Det	(n)
(AER 4) Wet tropical Coasts	0	100	0	1	100	0	0	2
(AER 6) Subtropical slopes & plains	100	0	0	1	50	0	50	2
(AER 7) Wet subtropical coast	33	33	33	3	0	50	50	4
(AER 8) Wet temperate coasts	40	60	0	5				0
(AER 9) Temperate highlands				0				0
(AER 10) Temperate slopes & plains	33	67	0	3	67	0	33	3

Source: Grower and State Agency Survey Data. Imp: Improving, N.C: No Change, Det: Deteriorating

Survey responses to trends in native bushland removal by Growers and State Agencies is shown in Figure 3.21 and Table 3.22. A limited sample size constrains the interpretation of this analysis and more research is required in this area before more robust assessments can be made. Overall, the majority of responses reported no change or reduced native bushland removal. Evidence of deteriorating trends (ie. increased vegetation removal) were found in State Agency responses in AER 6 (Tropical slopes and plains) in the Mackay region, and AER 10 (Temperate slopes and plains) in the Goulburn Valley. This trend was found in AER 7 (Wet subtropical coast) for State Agency (in the Mackay and Caboolture regions) and Grower (in the Nambour region) responses in AER 7 (Wet sub tropical coast).

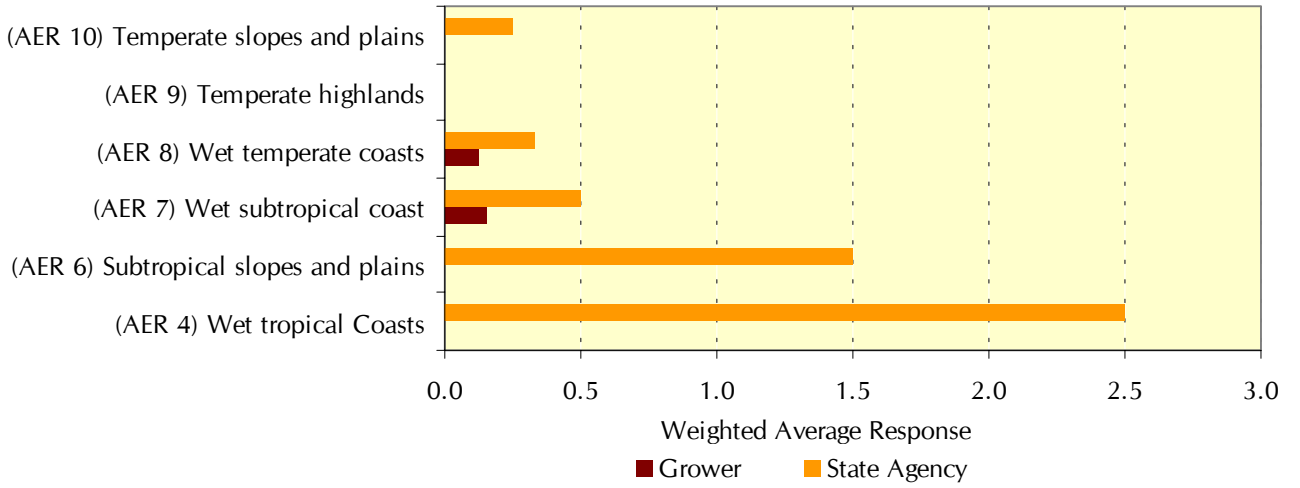
Riparian Vegetation Removal

The general pattern of horticultural development has been to concentrate fruit and vegetable production on the deeper and more fertile alluvial soils, often close to sources of irrigation water in rivers, creeks and alluvial beds of ground water. Preservation of riparian vegetation for habitat or erosion control purposes was not a priority during early land development. Because the most fertile soils were selected for the most valuable crops, the horticultural industry is now situated in many regions where riparian vegetation management is becoming increasingly important.

Survey analysis results of riparian vegetation removal status are presented in Figure 3.22 and Table 3.23. Grower responses indicated that this indicator was generally not a priority across surveyed regions. State Agency average responses in tropical regions considered riparian

vegetation removal to be a higher priority (Figure 3.22), particularly in the South Johnstone/Tully region (AER 4 Wet Tropical Coasts), and the Mackay region of AER 6 (Subtropical slopes and plains). A small sample of responses received for this indicator constrains the reliability of this result (Table 3.23).

Figure 3.22 Environmental Status of Riparian Vegetation Removal



Source: Survey Data, 1999

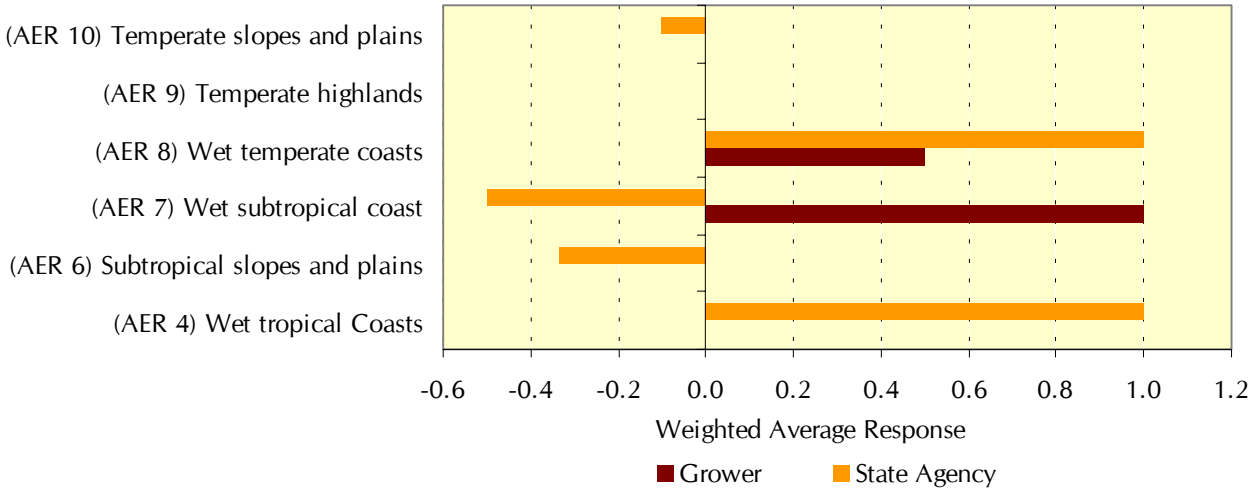
Table 3.23 Analysis of Responses: Environmental Status of Riparian Vegetation Removal

AER	Grower (% of sample)				Sample	State (% of sample)				Sample
	No	Low	Med	High	(n)	No	Low	Med	High	(n)
(AER 4) Wet tropical Coasts	100	0	0	0	**1**	0	0	50	50	**2**
(AER 6) Subtropical slopes and plains	100	0	0	0	**3**	0	50	50	0	**2**
(AER 7) Wet subtropical coast	85	15	0	0	**13**	67	17	17	0	**6**
(AER 8) Wet temperate coasts	88	13	0	0	**16**	67	33	0	0	**6**
(AER 9) Temperate highlands	100	0	0	0	**9**	100	0	0	0	**1**
(AER 10) Temperate slopes and plains	100	0	0	0	**8**	75	25	0	0	**8**

Source: Grower and State Agency Survey Data

Results of the trend analysis in riparian vegetation removal across AERs show a positive average response in AERs 8 (Wet temperate coast) and AER 4 (Wet tropical coast) for State Agencies and AER 7 (Wet subtropical coast) for Growers (Figure 3.23 and Table 3.24). This indicates that in these regions riparian vegetation removal is decreasing thereby contributing to the maintenance of biodiversity in these regions. Negative average responses were reported by State Agencies for the Goulburn Valley region of AER 10 (Temperate slopes and plains), and the Pioneer catchment region spanning portions of AER 7 (Wet subtropical coast) and AER 6 (Subtropical slopes and plains). The greatest difference in perceived riparian vegetation removal was found in AER 7 where State Agencies, but not Growers reported an increase in the problem.

Figure 3.23 Environmental Trend in Riparian Vegetation Removal



Source: Survey Data, 1999

Table 3.24 Analysis of Responses: Environmental Trend in Riparian Vegetation Removal

AER	Grower (% of sample)			Sample	State (% of sample)			Sample
	Imp	N.C	Det	(n)	Imp	N.C	Det	(n)
(AER 4) Wet tropical Coasts				**0**	100	0	0	**2**
(AER 6) Subtropical slopes & plains				**0**	0	50	50	**2**
(AER 7) Wet subtropical coast	100	0	0	**2**	0	50	50	**2**
(AER 8) Wet temperate coasts	50	50	0	**2**	100	0	0	**2**
(AER 9) Temperate highlands				**0**				**0**
(AER 10) Temperate slopes & plains				**0**	0	50	50	**2**

Source: Grower and State Agency Survey Data. Imp: Improving, N.C: No Change, Det: Deteriorating

3.3.4 Air and Noise

Dust and Noise Control

In this report, dust and noise are treated as off-site effects of horticulture, that is factors that may annoy neighbours. These factors are generic to cropping practices and are not regionally specific. Nuisance factors impacting on neighbours from both dust and noise are potential sources of land use conflict. This is particularly so in areas of dense settlement where rural residential blocks are developed adjacent to horticulture. This matter is dealt with in more detail later in this report.

Dust is generally associated with the working of dry soil, notably dry fine clay soils, predominantly for annual cropping. Dust from horticulture is not a major environmental priority in most regions for short periods in very localised situations near populated areas.

Dust minimisation is based on the principle of avoiding the working of dry soil whenever practical. In addition, the principle of reducing the number of workings to a minimum or of replacing mechanical weed control with safe chemical weed control can reduce dust problems to a negligible level. Where dusty operations cannot be avoided by the above approach, the planting of windbreaks to act as buffers can minimise the drift of dust onto neighbouring properties.

Drift of Sprays and Odours

Spray drift can occur from either ground rigs or aerial application. While certain chemical sprays have both health and odour impacts, some odours originate from other operations such as composting, use of fish-based fertilisers, manures, retention ponds or the by-products of processing. These factors are generic to cropping practices and are not regionally specific. The geographical importance of spray and odour drift is largely focussed on those horticultural regions where residential subdivisions are adjacent to productive blocks.

In the AERs where horticulture is practiced within comparatively densely populated local government areas, special provision is made to inform prospective purchasers of rural residential blocks or new suburban layouts, of the off-site effects associated with adjacent horticultural land.

3.3.5 Waste and Contamination

Options for Storing Farm Chemicals

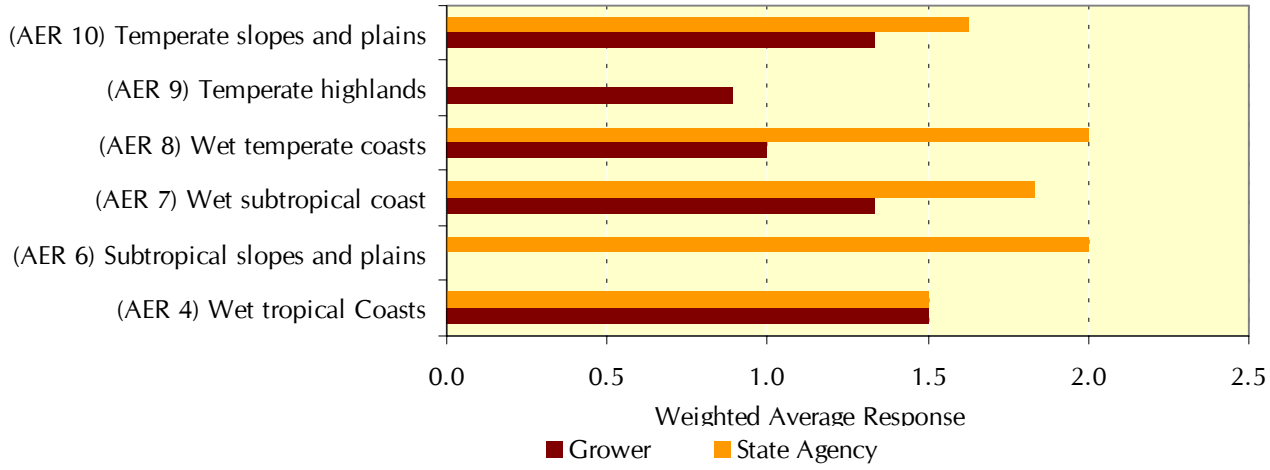
Storage of chemicals on horticulture farms is in the same category as disposal of unused chemicals and containers. These indicators relate to human health and safe practice. They also fall under the general heading of "Duty of Care" within Codes of Practice, Best Practice Guidelines and legislation.

Most states now have comprehensive descriptions of the way in which chemicals can be securely stored both for human health safety and for wildlife protection. The location, design, use and maintenance of on-farm storage facilities are well covered in a range of State publications and a number of Commonwealth guides (eg. NRA and NFF farm safe guides). Each State has Health and Safety guidelines and offer 'Chem-Safe' or similar courses on the safe storage and handling of agricultural chemicals.

Survey analysis results for the status of options for storing farm chemicals are shown in Figure 3.24 and Table 3.25. Overall, survey responses suggest that this indicator is of low to medium importance across State Agencies and Growers. However, greater than 20 percent of Grower responses in AER 7 (Wet subtropical coast) and AER 8 (Wet temperate coast), and over 30 percent of State Agency responses in AER 8 and AER 10 (Temperate slopes and plains) report that this indicator is a high priority. State Agencies generally considered this indicator to be a higher environmental priority than Growers.

Results of the trend in options for storing farm chemicals show that both Growers and State Agencies identified an improving trend in farm chemical storage (Figure 3.25 and Table 3.26). No responses from either group reported a deteriorating trend in farm chemical storage. Improvements in the management of farm chemicals have been achieved through the development of a national approach for the management of agricultural and veterinary chemicals across all agricultural industries, where Government and industry have worked together to introduce programs which reduce the impact of management practices on the environment.

Figure 3.24 Status of Options for Storing Farm Chemicals



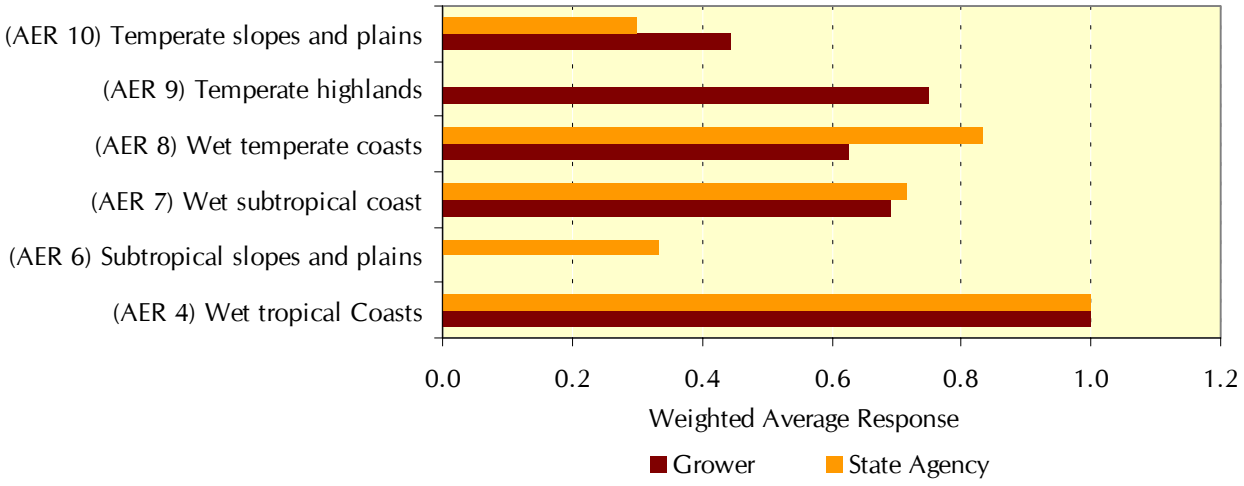
Source: Survey Data, 1999

Table 3.25 Analysis of Responses: Status of Options for Storing Farm Chemicals

AER	Grower (% of sample)				Sample	State (% of sample)				Sample
	No	Low	Med	High	(n)	No	Low	Med	High	(n)
(AER 4) Wet tropical Coasts	25	25	25	25	**4**	50	0	0	50	**2**
(AER 6) Subtropical slopes and plains	100	0	0	0	**3**	0	0	100	0	**2**
(AER 7) Wet subtropical coast	33	22	22	22	**18**	0	33	50	17	**6**
(AER 8) Wet temperate coasts	55	10	15	20	**20**	0	33	33	33	**6**
(AER 9) Temperate highlands	56	11	22	11	**9**	100	0	0	0	**1**
(AER 10) Temperate slopes and plains	25	25	42	8	**12**	25	25	13	38	**8**

Source: Grower and State Agency Survey Data

Figure 3.25 Trend in Options for Storing Farm Chemicals



Source: Survey Data, 1999

Table 3.26 Analysis of Responses: Trend in Options for Storing Farm Chemicals

AER	Grower (% of sample)			Sample	State (% of sample)			Sample
	Imp	N.C	Det	(n)	Imp	N.C	Det	(n)
(AER 4) Wet tropical Coasts	100	0	0	**2**	100	0	0	**1**
(AER 6) Subtropical slopes & plains				**0**	50	50	0	**2**
(AER 7) Wet subtropical coast	69	31	0	**13**	71	29	0	**7**
(AER 8) Wet temperate coasts	63	38	0	**8**	83	17	0	**6**
(AER 9) Temperate highlands	75	25	0	**4**				**0**
(AER 10) Temperate slopes & plains	44	56	0	**9**	50	50	0	**6**

Source: Grower and State Agency Survey Data. Imp: Improving, N.C: No Change, Det: Deteriorating

Disposal of Chemical Containers

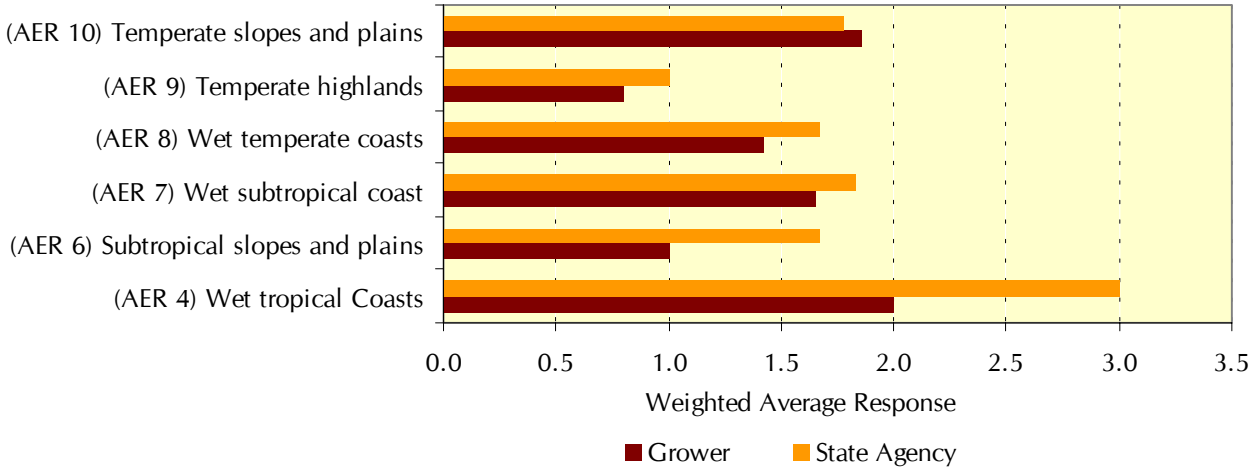
Inadequate disposal of chemical containers constitutes a health hazard on many horticultural farms. The principles of triple washing and delivery of containers to designated secure dump sites has been widely advocated and accepted by the horticultural industry. Turrell et al, 1996 undertook an analysis of the rinsing practices of Australian farmers, to determine the characteristics of farmers who do not rinse chemical residues from empty containers. Amongst many other defining characteristics, it was found that farmers who do not rinse empty chemical containers were more likely to be a livestock producer or (to a lesser extent) a horticulturalist (Turrel et al, 1996). While this finding is not substantive in its conclusions for horticulture it highlights that horticultural industries need to improve its performance in this area.

Adoption of the principles of safe disposal of both unused chemicals and empty containers is largely dependent on public education of the hazards of chemical residues. Many State programs aimed at both adults and children have emphasised the principles of safe chemical disposal.

Avcare, Australia's agricultural and veterinary chemical industry association launched "drumMUSTER" to address chemical container disposal. The program provides financial and planning support to local councils wishing to reduce chemical container disposal at local tips and assist rural communities with container disposal and promote a cleaner environment for the community. The higher survey response rates for this indicator may be a result of the nationwide marketing by Avcare of the "drumMUSTER" program, and other supporting programs associated with improving the management of chemicals on farm.

Results on the status of chemical and container disposal indicate that both Growers and State Agencies generally consider this indicator to be of low to medium priority (Figure 3.26 and Table 3.27). Both State Agency responses in AER 4 (Wet tropical coasts) report this indicator to be a high priority. Over 30 percent of State Agency and Grower responses in AER 10 (Temperate slopes and plains) and AER 4 (Wet tropical coast) reported chemical container disposal to be a high priority. State Agencies also considered chemical container disposal to be a high priority in AER 8 (Wet temperate coast).

Figure 3.26 Status of Chemical and Container Disposal



Source: Survey Data, 1999

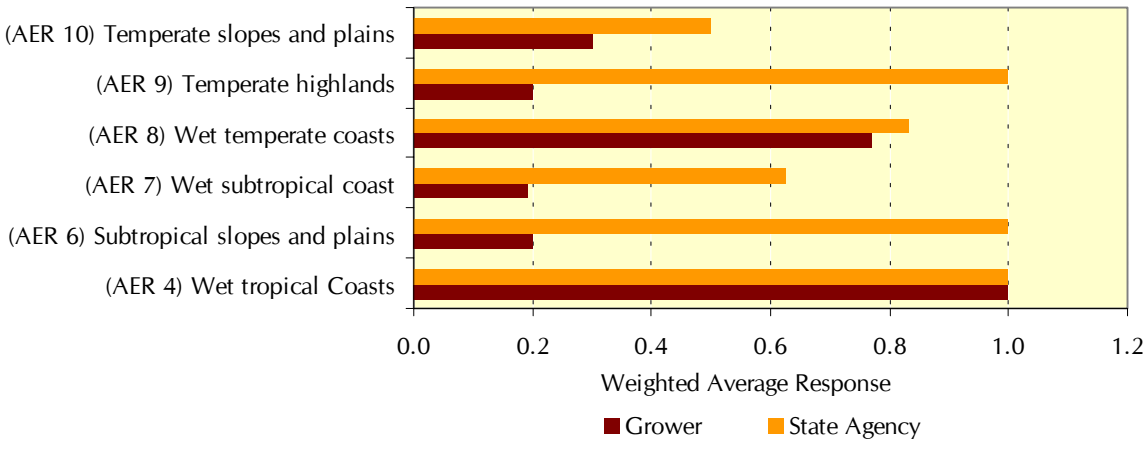
Table 3.27 Analysis of Responses: Status of Chemical Container Disposal

AER	Grower (% of sample)				Sample	State (% of sample)				Sample
	No	Low	Med	High	(n)	No	Low	Med	High	(n)
(AER 4) Wet tropical Coasts	0	33	33	33	**3**	0	0	0	100	**2**
(AER 6) Subtropical slopes and plains	50	25	0	25	**4**	0	33	67	0	**3**
(AER 7) Wet subtropical coast	9	35	39	17	**23**	0	33	50	17	**6**
(AER 8) Wet temperate coasts	32	11	42	16	**19**	0	67	0	33	**6**
(AER 9) Temperate highlands	50	30	10	10	**10**	0	100	0	0	**1**
(AER 10) Temperate slopes and plains	14	21	29	36	**14**	11	33	22	33	**9**

Source: Grower and State Agency Survey Data

Results of the trend analysis in chemical container disposal indicate a positive trend across State Agency and Grower responses (Figure 3.27 and Table 3.28). In general State Agency responses considered this improvement to be higher than reported by Growers. Although, most responses indicated an improvement in chemical container disposal, 19 percent of Growers in AER 7 (Wet subtropical coast), and 13 percent of State Agencies in AER 10 (Temperate slopes and plains) indicated negative trends.

Figure 3.27 Trends in Chemical and Container Disposal



Source: Survey Data, 1999

Table 3.28 Analysis of Responses: Trend in Chemical Container Disposal

AER	Grower (% of sample)			Sample	State (% of sample)			Sample
	Imp	N.C	Det	(n)	Imp	N.C	Det	(n)
(AER 4) Wet tropical Coasts	100	0	0	**3**	100	0	0	**2**
(AER 6) Subtropical slopes & plains	50	50	0	**2**	100	0	0	**3**
(AER 7) Wet subtropical coast	38	43	19	**21**	63	38	0	**8**
(AER 8) Wet temperate coasts	77	23	0	**13**	83	17	0	**6**
(AER 9) Temperate highlands	20	80	0	**5**	100	0	0	**1**
(AER 10) Temperate slopes & plains	40	50	10	**10**	75	13	13	**8**

Source: Grower and State Agency Survey Data. Imp: Improving, N.C: No Change, Det: Deteriorating

Options for Plastic and Other Waste Disposal

Wastes such as plastic sheeting used for inter-row soil coverage, or damaged plastic bags as used for protection of ripening banana bunches, are used in many horticultural industries in all States. Plastic sheeting is used in particularly large volumes in many row-cropped fruit and vegetables (e.g. strawberries). This material is inert (does not decompose) and as such, must be responsibly disposed of if it is not to become a semi-permanent pollutant of the environment.

Solid waste disposal is an increasingly important issue wherever plastic materials are used on a large scale. These impacts are most notable in the vicinity of capital cities where high input costs are associated with high technology methods involving greater volumes of plastic materials. As with chemical storage and disposal, solid wastes in horticulture constitute both a biodiversity threat and an aesthetic nuisance. The geographic distribution of the solid wastes closely parallels the distribution of intensive vegetable production, largely close to urban regions where other solid waste disposal mechanisms are well developed.

Many of Queensland's and the Northern Territory's production regions were listed by the State Agencies or Growers as being of a high or medium level of concern with respect to disposal of farm waste. Other production areas identified as being of concern, include AER 10's (Temperate slopes and plains) southern Victoria, north central Victoria, the Murray lands regions and coastal New South Wales in AERs 7 (Wet subtropical coast) and 8 (Wet temperate coasts).

State Agency survey responses listed Queensland's far north region (AER 3: North-east wet /dry tropics and AER 4: Wet tropical coasts) and northern Adelaide and north central Victoria regions in AER 10 (Temperate slopes and plains) as having a deteriorating trend in options for disposing of farm waste. Growers highlighted no regions with a deteriorating trend in this indicator.

3.3.6 Regional Summary of Environmental Indicators

The previous discussion presented and compared State Agency and Grower responses across the key environmental indicators on an AER basis. It is also useful to represent the State Agency data on a regional basis so that horticultural industry can identify indicators of environmental importance that may have direct impact on local production systems. Tables 3.29 to 3.34 summarise the indicators within each production region ranked by the State Agencies as high or medium significance with a deteriorating trend. Western Australian regions are not included, as this information was not supplied.

Table 3.29 New South Wales Regions Indicators Summary

Region	Indicator	Status	Trend
Coastal	none of high significance [1]		
Tablelands and Slopes	none of high significance [1]		
Western	**Salt accumulation in soil**	**high**	**deteriorating**
	Soil salinity levels	medium	deteriorating
	Surface water salinity	medium	deteriorating

[1] *'high significance' indicates high or medium status with deteriorating trend.*

Source: State Agency Surveys, 1999.

Table 3.30 Northern Territory Regions Indicators Summary

Region	Indicator	Status	Trend
Alice Springs	none of high significance [1]		
Darwin	none of high significance [1]		
Katherine	none of high significance [1]		

[1] *'high significance' indicates high or medium status with deteriorating trend.*

Source: State Agency Surveys, 1999.

Table 3.31 Queensland Regions Indicators Summary

Region	Indicator	Status	Trend
Border	none of high significance [1]		
Burnett	Ground water salinity levels	medium	deteriorating
	Options for storing farm waste	medium	deteriorating
Far North	**Organic matter/soil structure decline**	**high**	**deteriorating**
	Options for disposal of farm chemicals and containers	high	improving
	Chemical accumulation in soil	medium	deteriorating
	Nutrient levels and availability	medium	deteriorating
	Soil acidity levels	medium	deteriorating
	Ground water salinity	medium	deteriorating
	Options for disposal of farm waste	medium	deteriorating
Mackay	Soil acidity levels	medium	deteriorating
	Ground water salinity levels	medium	deteriorating
	Native bushland removal	medium	deteriorating
	Riparian vegetation removal	medium	deteriorating
Moreton	**Organic matter/soil structure decline**	**high**	**deteriorating**
	Nutrient levels and availability	**high**	**deteriorating**
	Options for storing farm chemicals	high	improving
	Options for disposal of farm chemicals and containers	high	improving
Rockhampton	none of high significance [1]		
Metropolitan	Soil loss	medium	deteriorating
	Organic matter/soil structure decline	medium	deteriorating

[1] *'high significance' indicates high or medium status with deteriorating trend.*

Source: State Agency Surveys, 1999.

Table 3.32 South Australian Regions Indicators Summary

Region	Indicator	Status	Trend
Adelaide Hills	Options for storing farm chemicals	high	improving
	Options for disposal of farm chemicals and containers	high	improving
Murraylands	**Ground water salinity levels**	**high**	**deteriorating**
	Options for storing farm chemicals	high	improving
	Options for disposal of farm chemicals and containers	high	improving
	Salt accumulation in soil	medium	deteriorating
Northern Adelaide	Options for storing farm chemicals	high	improving
	Options for disposal of farm chemicals and containers	high	improving
	Surface water salinity	medium	deteriorating
South Eastern	Nutrient levels and availability	high	no change
	Options for storing farm chemicals	high	improving
	Options for disposal of farm chemicals and containers	high	improving

Source: State Agency and Grower Surveys, 1999.

Table 3.33 Tasmanian Regions Indicators Summary

Region	Indicator	Status	Trend
North Western	none of high significance [1]		
Northern	Organic matter/soil structure decline	medium	deteriorating
Other	no survey response for this region		

[1] *'high significance' indicates high or medium status with deteriorating trend.*

Source: State Agency and Grower Surveys, 1999.

Table 3.34 Victorian Regions Indicators Summary

Region	Indicator	Status	Trend
North Central	Salt accumulation in soil	medium	deteriorating
	Organic matter/soil structure decline	medium	deteriorating
	Soil acidity levels	medium	deteriorating
	Soil salinity levels	medium	deteriorating
	Ground water salinity levels	medium	deteriorating
	Options for disposal of farm wastes	medium	deteriorating
	Removal of native bushland	medium	deteriorating
Sunraysia	**Salt accumulation in soil**	**high**	**deteriorating**
	Soil salinity levels	**high**	**deteriorating**
	Nutrient levels and availability	high	no change
	Ground water salinity levels	high	no change
	Surface water salinity levels	high	no change
	Chemical levels in irrigation water	high	no change
	Options for disposal of farm chemicals and containers	medium	deteriorating
	Chemical accumulation in soil	medium	deteriorating
Swan Hill	Ground water salinity levels	high	no change
South Victoria	**Organic matter/soil structure decline**	**high**	**deteriorating**
	Surface water salinity levels	medium	deteriorating
	Chemical levels in irrigation water	medium	deteriorating

Source: State Agency and Grower Surveys, 1999.

The results indicate that 6 regions are considered by that State Agencies to be at risk with regard to environmental status (high) and trend (deteriorating). These are Western New South Wales, the Far North and Moreton regions in Queensland, Murraylands district in South Australia, Sunraysia in Victoria and South Victoria. In isolation, the responses by Growers and State Agencies are able to identify regional environmental hot spots and related key indicators. The potential to link these to specific horticultural practices and crops is addressed in Chapter 4.

3.4 Horticultural Processing

Waste and contamination management issues are becoming increasingly important to the horticultural industry. International trade across industries and the evolution of quality standards or quality assurance programs has placed pressure on all industries to establish best practice standards to maintain access to markets. Implementation of quality assurance systems and the emergence of interdependent supply chains have seen companies leverage performance on a platform of environmental competence.

The approach to the safe disposal of processing wastes is in line with the "Duty of Care" that applies to all land holders whose operations may generate by-products that negatively impact on others or the environment.

The principles that apply to the discharge of nutrients, salt, heavy metals or chemicals into waterways by horticultural producers, apply equally to canneries and other processors.

The concepts of on-site storage, dilution or remediation before release, or re-use on site, all have a part to play in processing waste. Similarly, the proper disposal of solid wastes including metals, (eg canning materials), uses the same guidelines as other industries responsible for such materials in urban settings.

A survey of key fruit and vegetable processors was undertaken as part of this project to provide some insight into the environmental issues further along the value chain. Although sample size constraints (6 responses were received) prohibit the full presentation of the data in a meaningful context, the following observations were made:

- All respondents reported 3rd party quality assurance systems.
- All respondents have adopted waste management programs.
- In general, all respondents had employee training programs across the areas of skills-based chemical handling, quality assurance, waste disposal, workplace health and safety and machinery operations. Key information sources for the processors were Industry Bodies, Industry Publications and Government Departments. The Internet was the main source of information for one respondent.
- Waste water was directed to treatment facilities either on- or off-site. Waste water quality was usually adequate for processing uses.
- Biodegradable processing waste is generally sold as cattle feed or sent to another processing facility for further treatment.
- Processing and packaging waste was generally recycled for use within the processing facility or sent to a refuse disposal facility.
- Half of the respondents treated chemical processing waste on-site. Other treatment options included wetland treatment, off-site treatment facilities and off-site disposal facilities.

Key Points

- Limited horticulture specific research on environmental issues was identified as opposed to general agricultural research. In some cases direct application of general environmental research results can be applied to horticulture, however this may impact on horticulture Grower adoption levels. Further specific research (by region and crop type) in environmental issues should be pursued.
- State Agency responses represent a regional viewpoint whereas Grower responses reflect personal on-farm experience. The responses from both groups reflect individual perspective with Growers focussing on economic issues and State Agencies focussing on environmental issues. While these stakeholder opinions continue to diverge it will be difficult to implement industry change in environmental management issues.
- Growers and State Agencies generally concur on 3 *major* environmental indicators facing the horticulture industry. State Agencies consider organic matter/soil structure and soil loss to be more significant, whereas Growers identified farm waste disposal and soil acidity as more significant priority environmental indicators. Greatest divergence in perceived trends between State Agencies and Growers occurred in soil indicators involving salinity and soil structure, and water indicators involving salinity. Generally, other indicators where Growers and State Agencies diverge are considered by both to be of *lesser* significance.
- Grower responses did not identify any deterioration in the identified environmental indicators. This does not concur with available research, suggesting that either the individual Growers who responded did not experience these environmental problems, or that there is a lack of recognition or acceptance of the impact of environmental degradation at the farm level.
- State Agency responses identified 6 regions where environmental indicators are deteriorating, including:
  - Queensland far north region - organic matter/soil structure decline (AER 4).
  - Queensland Moreton region - organic matter/soil structure decline and Nutrient levels and availability (AER 7).
  - South Victoria region - organic matter/soil structure decline (AER 8).
  - New South Wales western region - salt accumulation in soil (AER 10).
  - South Australia Murray lands region - ground water salinity levels (AER 10).
  - Victoria Sunraysia region - soil salinity levels (AER 10).

3.5 Impacts from External Production System Inputs

3.5.1 Fertilisers

Australia's ancient and highly weathered soils are generally lacking in sufficient nutrient reserves to sustain intensive horticultural production without significant inputs from fertiliser application. Horticultural crops inherently have a high nutrient input requirement, and in 1996, 64,010 tonnes of nitrogen (N), 36,910 tonnes of phosphorus (P) and 52,670 tonnes of potassium (K) was consumed by horticultural enterprise (Table 3.35). Horticultural applications of phosphorus and potassium accounted for around 18 percent of national agricultural consumption in 1996 (SCARM, 1998).

Adequate soil nutrient supply is a critical measure of sustainability affecting both on-farm productivity and off-farm environmental impacts (SCARM, 1998). The nutrient profile of horticultural farming systems in many regions of Australia is subject to imbalance without effective sustainable resource management. Nutrient losses through crop produce export from the farming system must be balanced with nutrient replacement to correct deficiencies and to ensure long term industry profitability.

Table 3.35 Consumption of Nitrogen, Phosphorus and Potassium by Horticulture – 1996

		Tonnes ('000)		
State	Area ('000 ha)	N	P	K
NSW & Qld	162	33.48	9.90	22.41
WA	24	4.80	0.70	1.33
Tas	25	1.71	3.68	5.24
Vic & SA	158	24.02	22.63	23.70
Total	**369**	**64.01**	**36.91**	**52.67**

Source – FIFA, 1996

Nutrient balance – the difference between nutrients entering and leaving the farm system – was identified by SCARM (1998) as a key indicator of the sustainability of agricultural production. The nutrient balance of horticultural production in this project was estimated using a simple input/output model and is calculated as the difference in the quantity of fertiliser nutrient applied, and the quantity of nutrients exported off-farm in harvested product.

The quantity of nutrients derived from non-fertiliser sources, and the quantity lost from the production system through other processes such as leaching, immobilisation or erosion were not assembled. The addition of nutrients from non-fertiliser sources is typically minimal in horticultural production systems. This is in contrast to broad scale cropping, or livestock production systems where crop stubble and animal waste are used to replace nutrients consumed. One exception is legume crops such as peas and peanuts, which contribute significant amounts of nitrogen to the soil nutrient pool through fixation of atmospheric nitrogen.

Data for six essential plant nutrients were assessed – nitrogen (N), phosphorus (P), potassium (K), sulfur (S), calcium (Ca) and magnesium (Mg). Nutrient input was calculated from actual fertiliser nutrient application data from Grower surveys, and recommended fertiliser application data presented in State Agency gross margin models. In some cases, data for different crops belonging to the same crop group were not supplied by Growers, and were not available from State Agency gross margins. Available data for other crops was used to characterise those crop groups as a whole. This is a recognised weakness to the analysis.

The average rates of nutrient application per hectare are shown in Table 3.36. Figure 3.28 shows the average application of nitrogen per hectare in annual and perennial crop groups. Overall, 73% of annual crop groups applied more than 100 kg/Ha of nitrogen, compared to 44% of perennial crop groups. The application of nitrogen was 3 times that of phosphorus and almost 2 times that of potassium (Table 3.36). Calcium (applied predominantly as lime and dolomite) had the highest

rate of input of all nutrients, and was exceptionally high for bananas and potatoes (Table 3.36). Lime is used to correct soil acidity, which often constrains production especially in fine-textured clay soils which are naturally more acidic. The judicious use of lime in humid areas (such as in the wet tropical coasts where banana production is concentrated) is important to avoid the creation of high soil pH conditions, and deficiencies of trace elements such as iron, manganese, copper and zinc. Over liming may also reduce the availability of phosphates.

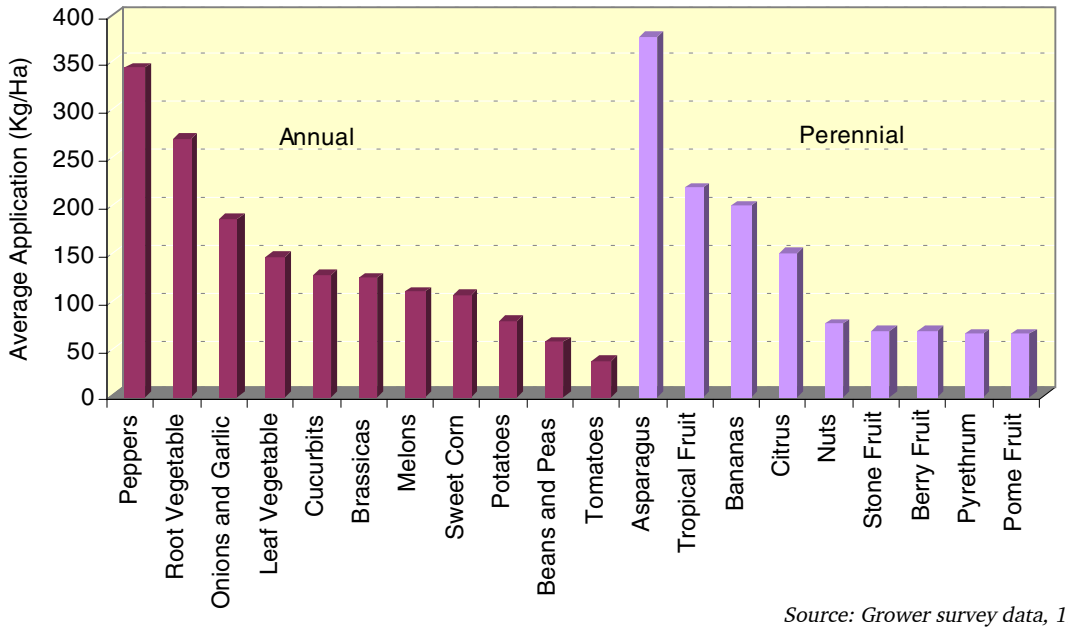
Data on the nutrient concentrations of different fruit and vegetable commodities was sourced from The Fertiliser Industry Federation of Australia (FIFA, 1998). This data was used to estimate the off-farm export of nutrients in harvested horticultural produce, and showed that nutrient removal is greatest in leaf vegetables, potatoes, beans and peas, and bananas (Table 3.36).

Nutrient balance across all elements was positive for tropical fruits, citrus, cucurbits and peppers, and was positive across all elements except potassium for brassicas and leaf vegetables (Table 3.36 and Figures 3.31 to 3.34). Nutrient balance was negative or neutral for beans/peas, and negative across all elements except sulfur and calcium for tomatoes (Table 3.36 and Figures 3.1 to 3.4). Across all crop groups, average nutrient balance was shown to be positive for all nutrients except potassium (Table 3.36). These results concur with the findings of SCARM (1998) in which a national audit of Australia's broad acre industries estimated a positive on-farm P balance and a negative K balance. Negative potassium balance is evident for most annual crops in comparison to perennial crops in which only pome fruit and bananas demonstrate a negative K balance (Figure 3.31).

A neutral, or low positive or low negative balance indicates a state of environmental balance. Where nutrient balance is negative, particularly in areas reported to possess existing deficiencies, significant pressure on soil resources is expected. This is an indicator of unsustainable long-term production if appropriate land use and management practices are ignored. Soils in the northern regions of Australia generally have a lower nutrient status than the soils of southern and eastern Australia. The regular application of fertilisers in the southern and eastern regions is a factor affecting this difference (SCARM, 1998).

Extreme positive nutrient balance poses a different threat to environmental quality. The on and off-site effects of nutrient toxicity include adverse changes to soil fertility and structure, decreased water quality, and biodiversity loss.

Figure 3.28 Average application of nitrogen per hectare in annual and perennial crop groups



Source: Grower survey data, 1999; State Agency gross margin models, 1996-1999.

Table 3.36 Application and Removal of Nutrients in Horticultural Crop Groups

		Element Applied as Fertiliser (Kg/Ha) [1]						Element Removed in Harvested Product (Kg/Ha) [2]						Nutrient Balance (Input minus Removal) (Kg/Ha)					
Crop Group	Yield (Kg/Ha)	N	P	K	S	Ca	Mg	N	P	K	S	Ca	Mg	N	P	K	S	Ca	Mg
Asparagus	5149	377.0	151.3	85.2	68.9	117.0	65.9	No data						No data					
Bananas	28846	199.7	29.4	259.0	91.4	815.3	73.7	96.6	22.4	376.4	54.8	253.8	95.2	103.1	7.1	-117.5	36.6	561.4	-21.5
Beans and Peas	5000	57.5	0.0	0.0	0.0	0.0	0.0	178.0	4.5	11.1	0.0	2.2	2.2	-120.5	-4.5	-11.1	0.0	-2.2	-2.2
Berry Fruit	20276	69.3	18.3	54.4	12.7	76.5	5.2	58.8	10.0	73.9	8.1	9.8	8.1	10.5	8.3	-19.5	4.5	66.7	-2.9
Brassicas	10000	125.0	80.5	6.7	8.8	232.0	200.0	92.0	14.1	77.0	0.0	16.1	3.1	33.0	66.4	-70.3	8.8	215.9	196.9
Citrus	41297	151.1	31.5	146.8	18.0	56.4	20.0	62.3	6.7	79.3	0.0	21.7	5.9	88.9	24.8	67.6	18.0	34.7	14.1
Cucurbits	20000	128.1	48.6	59.5	59.4	396.0	200.0	32.0	5.6	50.0	0.0	4.4	2.2	96.1	43.0	9.5	59.4	391.6	197.8
Leaf Vegetable	52681	146.5	37.4	104.7	93.7	195.4	101.2	131.7	19.0	208.6	0.0	50.4	13.9	14.8	18.5	-104.0	93.7	145.0	87.3
Melons	31455	110.2	72.7	29.4	0.0	2.3	0.2	No data						No data					
Nuts	4585	76.5	30.7	147.4	26.5	11.2	0.6	43.1	7.3	21.5	0.0	14.2	2.3	33.4	23.4	125.8	26.5	-3.0	-1.7
Onions and Garlic	29039	186.7	66.8	14.2	1.4	0.0	0.2	52.3	11.6	58.1	14.5	11.6	3.5	134.4	55.2	-43.8	-13.1	-11.6	-3.3
Peppers	30000	345.0	10.8	117.0	13.2	215.0	100.0	63.0	6.0	103.5	0.0	78.0	10.5	282.0	4.8	13.5	13.2	137.0	89.5
Pome Fruit	42884	65.6	28.6	0.4	16.6	211.8	0.0	31.1	10.1	75.5	0.0	6.6	4.5	34.5	18.5	-75.1	16.6	205.1	-4.5
Potatoes	38507	79.4	49.4	55.6	8.5	526.1	0.0	127.1	14.6	173.3	0.0	9.6	3.1	-47.7	34.8	-117.7	8.5	516.5	-3.1
Pyrethrum	45	66.5	42.0	39.0	0.0	0.0	0.0	No data						No data					
Root Vegetable	40000	270.0	88.0	8.0	0.0	0.0	0.0	108.0	17.9	130.4	0.0	11.0	5.4	162.0	70.1	-122.4	0.0	-11.0	-5.4
Stone Fruit	9855	69.4	18.5	187.2	12.9	25.4	0.0	12.7	1.5	16.8	0.0	0.6	9.9	56.7	17.0	170.5	12.9	24.8	-9.9
Sweet Corn	15000	107.0	33.0	3.0	0.0	0.0	0.0	No data						No data					
Tomatoes	50000	37.8	18.0	31.2	22.0	55.2	0.0	82.5	25.3	145.0	0.0	7.0	7.3	-44.7	-7.3	-113.8	22.0	48.2	-7.3
Tropical Fruit	24977	218.5	105.4	246.4	166.5	90.7	8.8	56.6	6.7	49.9	9.5	4.3	5.2	161.9	98.8	196.5	157.0	86.4	3.6
Average	**24980.8**	**144.4**	**48.1**	**79.8**	**31.0**	**151.3**	**38.8**	**76.7**	**11.5**	**103.1**	**5.4**	**31.3**	**11.4**	**67.6**	**36.6**	**-23.4**	**25.6**	**120.0**	**27.4**

[1] Data from Grower surveys (1999) and recommended fertiliser application data presented in State Agency gross margin models (1996-1999).

[2] Calculated using nutrient concentrations of different fruit and vegetable commodities sourced from The Fertiliser Industry Federation of Australia (FIFA,1998) and applied to product yield data from Grower surveys and State Agency gross margin models.

Figure 3.29 Nitrogen Balance

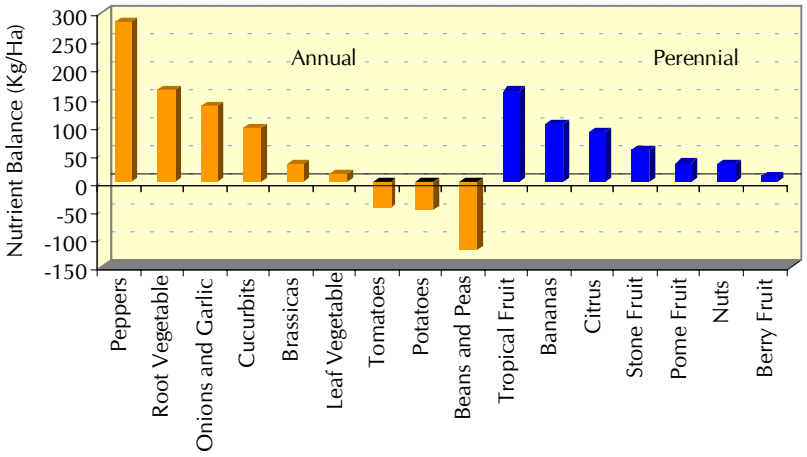


Figure 3.30 Phosphorus Balance

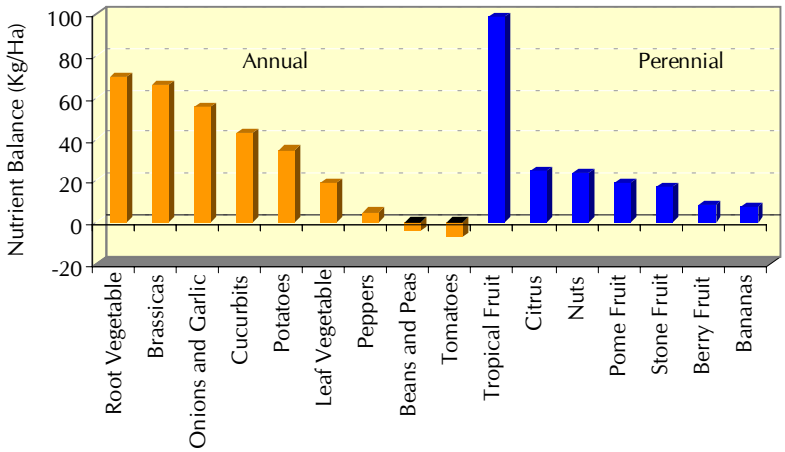
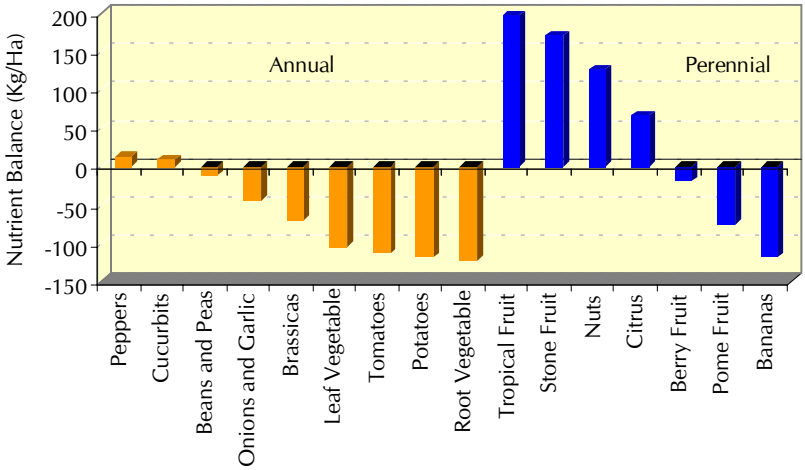


Figure 3.31 Potassium Balance



Data Source for Figures 3.29 – 3.31: Grower survey data, 1999; State Agency gross margin models, 1996-1999; The Fertiliser Industry Federation of Australia (FIFA, 1998).

Figure 3.32 Sulfur Balance

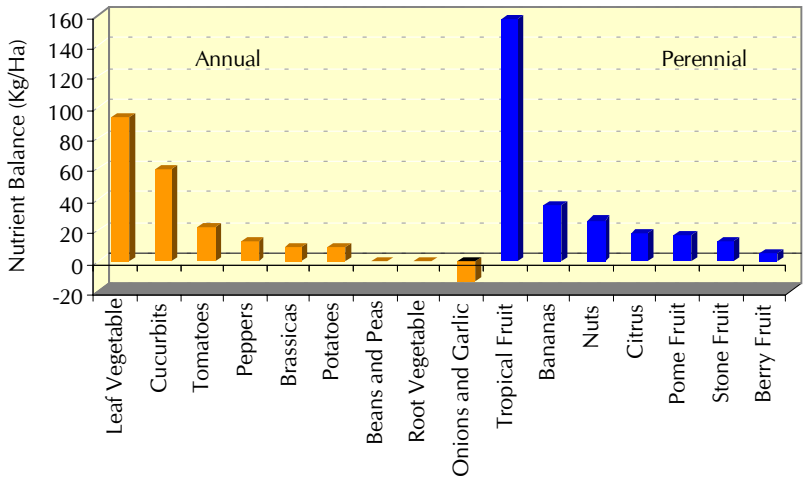


Figure 3.33 Calcium Balance

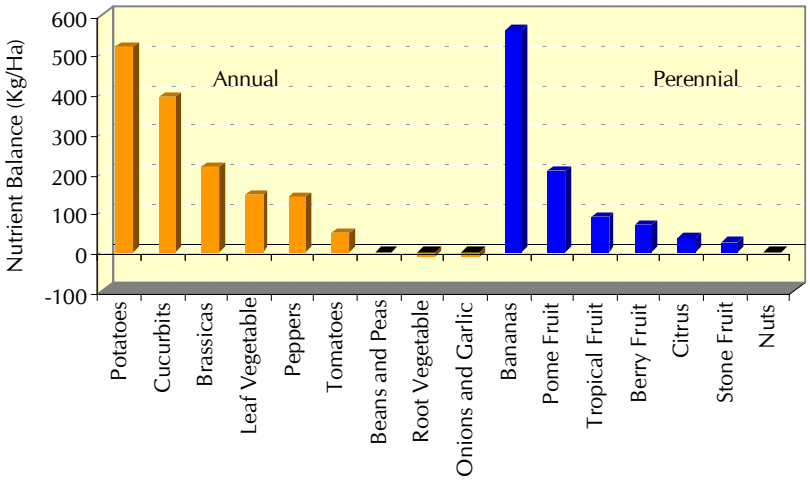
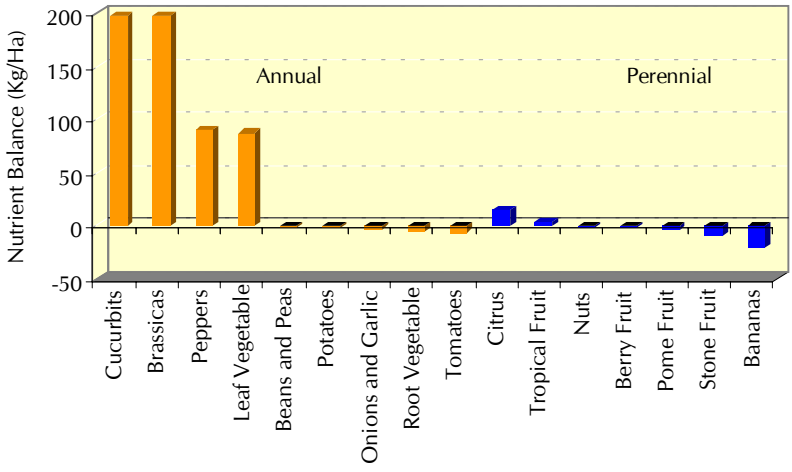


Figure 3.34 Magnesium Balance



Data Source for Figures 3.32 – 3.34: Grower survey data, 1999; State Agency gross margin models, 1996-1999; The Fertiliser Industry Federation of Australia (FIFA, 1998).

3.5.2 Agricultural Chemicals

Horticulture is an intensive production industry with a high dependency on chemical use for pest, disease and weed control. Chemical pest and disease control has resulted in significant increases in product yield and quality, and has been integral in maintaining the viability and competitiveness of horticultural production in Australia. Each year, around 20 percent of the world's crops are lost to untreated pests and diseases (Avcare, 1995). This loss in productivity has a huge impact on the profitability of horticultural production. Agricultural productivity will also become increasingly important to ensure food security as global population levels increase.

Consumer concerns about the dangers of agricultural chemicals to health and the environment has increased industry's awareness of the need to supply safe food to maintain confidence in horticultural products. Increasing productivity, whilst minimising the risks of agricultural chemical use to human health, the environment and product trade is a goal many horticultural industries are striving to achieve through best practice management.

There is also increasing recognition of pest and disease resistance and the need to develop strategies to ensure that chemical products remain effective. The development and implementation of Integrated Pest Management (IPM) programs, and alternatives to chemicals are becoming adopted as strategies to reduce industry reliance on chemicals.

Agricultural chemicals are subject to rigorous assessment for their environmental and health impact, and all agricultural chemicals used in Australia must be registered by the National Registration Authority. However, the use of chemicals formulated to kill pests and diseases carries potential risks to the people applying the chemicals, their neighbours, other living organisms in the environment, and to consumers of produce (ARMCANZ, 1998). The misuse and overuse of agricultural chemicals constitutes the largest risk to food products and environmental contamination. Unwanted chemicals and chemical containers pose another potential risk to environmental health.

Tables 3.37 – 3.39 show the results of data collected on insecticide, fungicide and herbicide use as part of the Grower survey conducted for this study. Chemicals that could not be classified due to incorrect reporting of chemical product names by respondents are grouped as "not defined". Chemicals that differ in their composition from the major categories reported are grouped as "miscellaneous".

Organophosphate insecticides were the most widely used with 60 percent of Growers applying chemicals of this category (Figure 3.35). Organochlorines were used by 30 percent of Growers, with notable exceptions in the banana and potato crop groups (Table 3.37). Endosulfan was the dominant chemical of this category reported, and is one of the few organochlorine chemicals still registered for use. Organochlorines are characterised by their resistance to degradation and persistence in the environment, however Endosulfan is recognised as having short residual activity, largely disappearing from soil in 3 to 6 months. However, Endosulfan has a high acute or immediate toxicity to humans which is a matter of concern for agricultural workers, and is toxic to fish and other aquatic organisms (NRA, 1998).

Carbamates were used across more than half the commodities for which responses were received, and 20 percent of all insecticide applications were made using carbamate products (Figure 3.35).

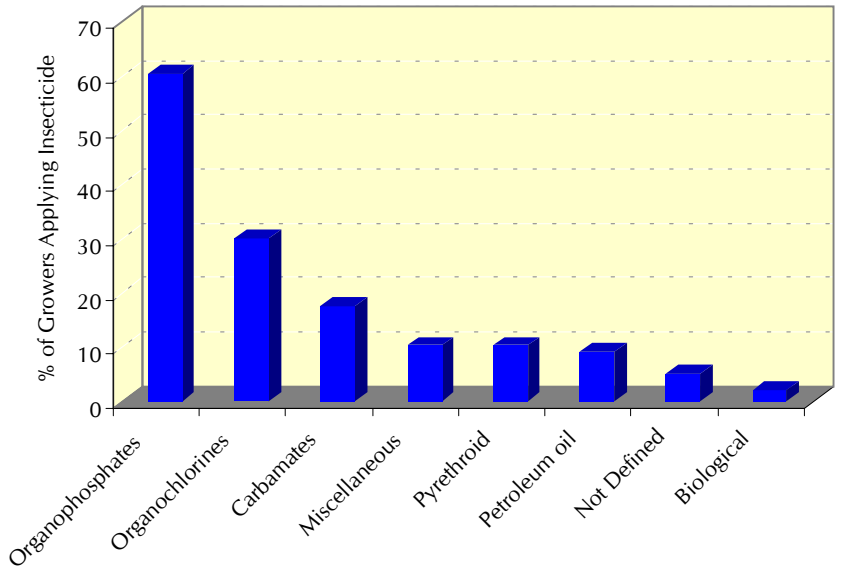
Fungicides were widely used by all industries with azoles, copper-based products and dithiocarbamates the most commonly used (Figure 3.36). Organophosphates were not commonly used with only 1 melon Grower reporting the use of an organophosphate fungicide (Table 3.38).

Herbicides belonging to 7 different categories were identified in the Grower survey responses. Organophosphorus-based products, including RoundUp, Basta and Touchdown were used by 65 percent of Growers (Figure 3.37 and Table 3.39). Diphenyl-ether was the least widely used chemical.

Table 3.37 Percentage of Growers in each Crop Group Applying Insecticides

Crop Group	No. Respondents	Biological	Carbamates	Miscellaneous	Organochlorines	Organophosphates	Petroleum Oil	Pyrethroid	Not Defined
Bananas	5	0	20	40	0	100	0	0	0
Berry Fruit	10	10	50	0	10	60	0	0	10
Citrus	7	0	14	29	29	71	57	0	0
Leaf Vegetable	3	0	67	0	33	67	0	100	33
Melons	2	0	0	0	50	100	0	0	0
Nuts	17	0	0	0	41	18	6	0	0
Onions and Garlic	5	0	0	0	20	0	0	60	0
Pome Fruit	6	0	33	50	17	100	0	0	17
Potatoes	12	0	8	8	0	42	0	33	8
Stone Fruit	7	14	14	0	29	86	43	0	14
Tomatoes	1	0	100	0	100	100	0	0	0
Tropical Fruit	21	0	14	10	57	81	5	0	0
Overall	**96**	**2**	**18**	**10**	**30**	**60**	**9**	**10**	**5**

Figure 3.35 Overall Percentage of Growers Applying Insecticides

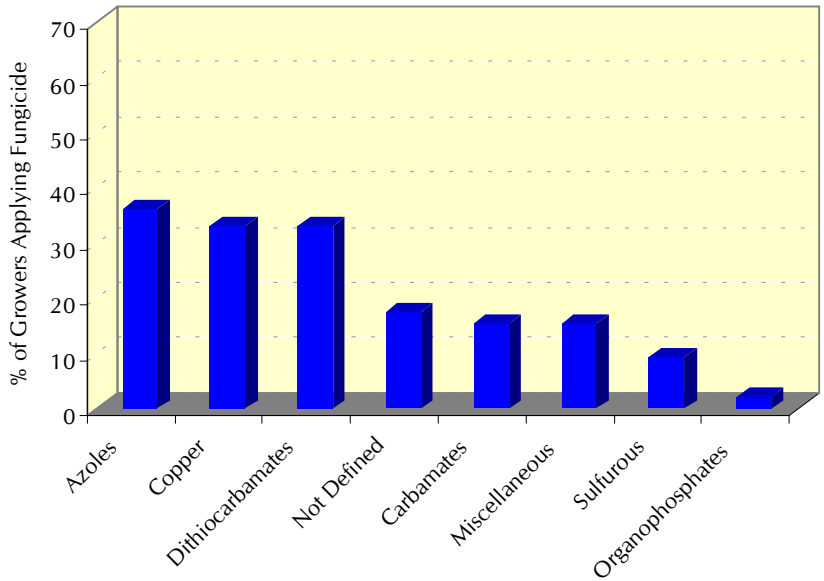


Source: Survey Data, 1999

Table 3.38 Percentage of Growers in each Crop Group Applying Fungicides

Crop Group	No Respondents	Azoles	Carbamates	Copper	Dithiocarbamates	Organophosphates	Sulfurous	Miscellaneous	Not Defined
Bananas	5	80	0	0	40	0	0	0	40
Berry Fruit	10	30	70	30	40	0	50	10	60
Citrus	7	0	0	57	14	0	0	0	14
Leaf Vegetable	3	67	0	33	67	0	33	33	0
Melons	2	0	0	0	100	100	50	100	50
Nuts	17	12	18	24	0	0	0	6	18
Onions and Garlic	5	60	0	0	60	0	0	0	0
Pome Fruit	6	50	17	33	100	0	17	33	50
Potatoes	12	75	0	0	33	0	0	17	8
Pyrethrum	1	100	0	0	0	0	0	100	0
Stone Fruit	7	86	14	71	29	0	14	14	0
Tomatoes	1	100	0	100	100	0	0	0	0
Tropical Fruit	21	5	14	57	24	0	0	19	0
Overall	**97**	**36**	**15**	**33**	**33**	**2**	**9**	**15**	**18**

Figure 3.36 Overall Percentage of Growers Applying Fungicides

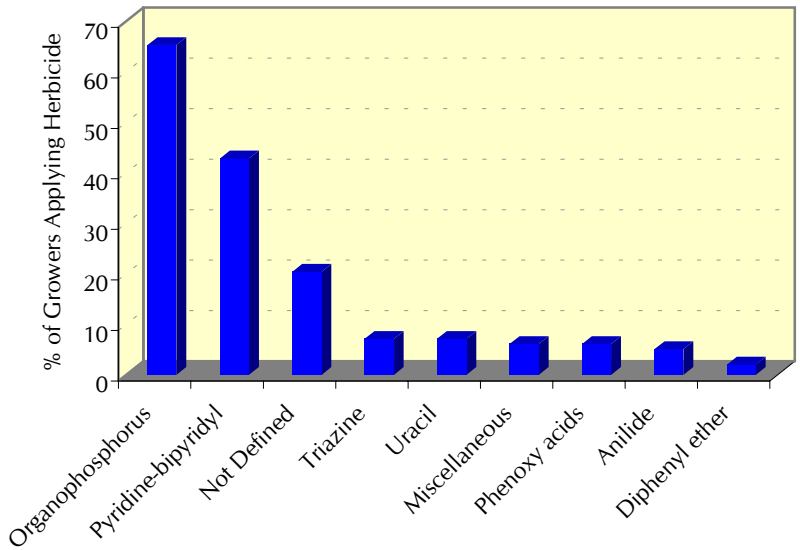


Source: Survey Data, 1999

Table 3.39 Percentage of Growers in each Crop Group Applying Herbicides

Crop Group	No. Respondents	Anilide	Diphenyl Ether	Miscellaneous	Organophosphorus	Phenoxy Acids	Pyridine-bipyridyl	Triazine	Uracil	Not Defined
Asparagus	1	0	0	0	0	0	0	100	0	0
Bananas	5	0	0	0	40	20	30	0	0	10
Berry Fruit	10	0	0	0	47	5	42	0	0	5
Citrus	7	0	0	7	43	0	0	14	14	21
Leaf Vegetable	3	0	0	25	0	0	0	25	0	50
Melons	2	0	50	0	50	0	0	0	0	0
Nuts	17	0	0	0	54	0	33	0	4	8
Onions and Garlic	5	17	0	25	8	17	17	0	0	17
Pome Fruit	6	17	0	0	50	0	33	0	0	0
Potatoes	12	0	0	0	24	6	41	6	0	24
Pyrethrum	1	50	0	50	0	0	0	0	0	0
Stone Fruit	7	0	8	0	50	0	33	0	0	8
Tomatoes	1	0	0	0	0	0	0	100	0	0
Tropical Fruit	21	0	0	0	48	0	21	3	14	14
Overall	**98**	**5**	**2**	**6**	**65**	**6**	**43**	**7**	**7**	**20**

Figure 3.37 Overall Percentage of Growers Applying Herbicides



Source: Survey Data, 1999

3.5.3 Residues in Horticultural Products

Environmental and food safety concerns are prompting producers to focus on the production of safe horticultural products, and the adoption and implementation of integrated pest and disease management systems is becoming essential to industry good management practice. Increased community awareness of environmental health issues is also driving industries to become more accountable for their impact on the environment.

Pesticide residues in horticultural products have been monitored over the past decade by three major government funded programs. The Victorian Department of Natural Resources and Environment funds the Victorian Produce Monitoring Program, which began in 1987. This program tests a wide array of insecticides and fungicides in over 40 different fruit and vegetable products. In the 10 year testing period from 1987 to 1996, over 7006 analyses were conducted. Overall, 99.51 percent of those samples complied with Australian Standards for Maximum Residue Limits (MRL) (Table 3.40). Violations of the MRL limit were detected in apples, nectarines, onions, spring onions, broccoli, chinese cabbage, lettuce, parsnip, potato and carrots (Dunn et al, 1998). Most violations in fruit related to organophosphate insecticides, whilst dithiocarbamate was the most commonly detected residue in vegetables (Table 3.40).

The Sydney Markets Residue Survey commenced in 1989 as a joint project between the Sydney Market Authority and NSW Agriculture (Plowman, et.al. 1998). The program monitors 30 different horticultural commodities sold through the Sydney Markets and sourced from all Australian States. In the 4-year testing period from 1987 to 1986, 1556 samples were tested for the residues of 25 different insecticides and fungicides. Testing for dithiocarbamate residues was only conducted in the second and third years of the program (1,010 samples). Overall compliance to MRL standards for all pesticides except dithiocarbamate was 98.4 percent. Violations in MRL standards mainly involved organochlorines and organophosphates (Table 3.40). Over 50 percent of the breaches of MRLs were for the detection of residues of chemicals on crops for which they were not registered (Plowman, et.al. 1998). Dithiocarbamates were detected exceeding the MRL in 9.9 percent of samples, and were more common in fruit than vegetables (Table 3.40). Violations of MRL limit (all analytes) were detected in apples, beans, capsicum, carrot, lettuce, peaches, rockmelons, silverbeet, strawberries, tomatoes and zucchini (Plowman, et.al. 1998).

The National Residue Survey is part of the Bureau of Resource Sciences of the Commonwealth Department, Agriculture Forestry and Fisheries Australia. This program ceased broad scale testing of horticultural commodities in 1992 and now only analyses product for the onion, macadamia and pecan nut industries. The results of this program are not reported here.

Generally, insecticide and fungicide violations detected in both the NSW and Victorian Programs involved very low residue levels. There was no significant difference in the occurrence of residue violations among fruit and vegetable groups (Table 3.40). These results indicate that producers are generally following good chemical management practice.

Where violations did occur, the three major causes for breach of MRL standards were -

1. The use of pesticides on crops that were not registered,
2. Uptake of residues of persistent pesticides from the soil, and
3. The incorrect use of pesticides on crops for which they are registered.

(Sydney Markets Pesticide Residue Survey, 1998).

Table 3.40 Percentage Compliance with Australian MRL Standards for Pesticides and Fungicides

Analyte Group	Sydney Markets Residue Survey Program (1992-1995) [1]		Vic Produce Monitoring Program (1987-1996) [2]	
	Fruit	Vegetables	Fruit	Vegetables
Organochlorines	99.34	99.58	100.00	100.00
Organophosphates	99.00	99.06	98.79	99.94
Carbamates	100.00	100.00	100.00	99.02
Dithiocarbamates	87.10	91.90	99.79	98.66
Pyrethroides	100.00	99.89	100.00	100.00
Miscellaneous Fungicides	100.00	98.11	-	-
Miscellaneous Pesticides	-	-	100.00	98.91

[1] *Plowman et. al, 1998*
[2] *Dunn e. al, 1998*

Organic Systems

Organic, including biodynamic, agriculture production systems offer alternatives to use of chemicals. Worldwide, horticulture is by far the dominant adopter of these chemicals for production systems. In Australia the beef, pork, dairy, grain and sugar industries are now undertaking conversion of a small number of enterprises (both in production and processing) from traditional to organic systems. However less than 1 percent of Australia's 116,000 farms are currently certified organic. Organic systems can be broadly defined as production systems that contribute to healthy soils and/or people. It does not use synthetic chemicals, but rather promotes enhanced biological activity and encourages sustainability.

3.5.4 Irrigation Water

The water industry in Australia is undergoing rapid change. Reforms are being driven predominantly by the COAG water reform agenda and National Competition Policy. With a view to implementing an appropriate resource management framework to underpin water resources, the Government objectives are to encourage greater efficiency of water resources and the need for balanced development to ensure economic, social and environmental sustainability (Eastgate, 1999). Eastgate (1999) summarised the following issues faced by the water industry–

- The future role of Government;
- Private sector investment and ownership of water infrastructure;
- More commercial focus by water service providers;
- Commercial focus versus customer service;
- Viability of irrigation schemes;
- Water allocation: environmental needs versus consumptive industrial use;
- Inequities in rural pricing arrangements;
- Water use efficiency; and
- Security of entitlements.

Change in the water industry is a complex issue requiring a significant shift in the way users view the resource. Horticulture will be affected by these changes as adjustments are made to the economic, financial and production systems to move forward under the new operating environment. Perhaps the greatest potential challenge for the water industry is the implementation of a transferable water entitlements scheme in conjunction with Water Allocation Management Planning (WAMP) to ensure a sustainable balance is achieved between water for the environment, the community and commercial uses.

COAG Water Reform

The Council of Australian Governments' (COAG) framework for water reform includes a wide range of interrelated measures in relation to water pricing, water entitlements and trading, environmental requirements, institutional reform, public consultation and education and research. This section of the report was compiled after discussions with key state agency representatives in each State.

The COAG reforms cover both urban and rural areas and are being applied across the board to all sectors of the community, not just irrigators. The agreement requires governments to set in place arrangements to consult with local governments and the wider community of water users in individual catchments. The package of reforms agreed to by COAG involve:

- pricing based on principles of full-cost recovery and transparency (or removal of) cross-subsidies;
- future investment in new schemes, or extensions to existing schemes, to be undertaken only after appraisal indicates it is economically viable and ecologically sustainable;
- comprehensive systems of water allocations or entitlements, backed by separation of water property rights from land title and clear specification of entitlements in terms of ownership, volume, reliability, transferability and, if appropriate, quality;
- formal determination of water allocations or entitlements, including allocations for the environment as a legitimate user of water;
- trading, including cross-border sales, of water allocations or entitlements, within the social, physical and ecological constraints of catchments;
- administration and decision making to provide an integrated catchment management approach to water resource management;
- the separation of resource management, standard setting and regulatory roles of government from the roles of providing water services;
- a greater degree of responsibility for local management of water use;
- public education about water use and consultation in implementing the water reforms; and
- appropriate water related research and use of efficient technologies.

COAG has set a five to eight year implementation period; the overall target being 2001.

These reforms will mean significant changes in water supply, usage, cost and management throughout Australia. As a result there will be a number of impacts upon the economic and environmental performance of the horticulture industry.

Opportunities for the industry provided by the reform include:

- water trading due to the separation of water property rights from land title;
- equity of entitlement to water and quality of water all along the catchment through integrated catchment management;
- objective management and regulation of water resources through separation of resource management, standard setting and regulatory roles of government from the roles of providing water services;
- a greater degree of responsibility for local management of water use; and
- appropriate water related research and use of efficient technologies that will enable more efficient and effective water use in the long-term.

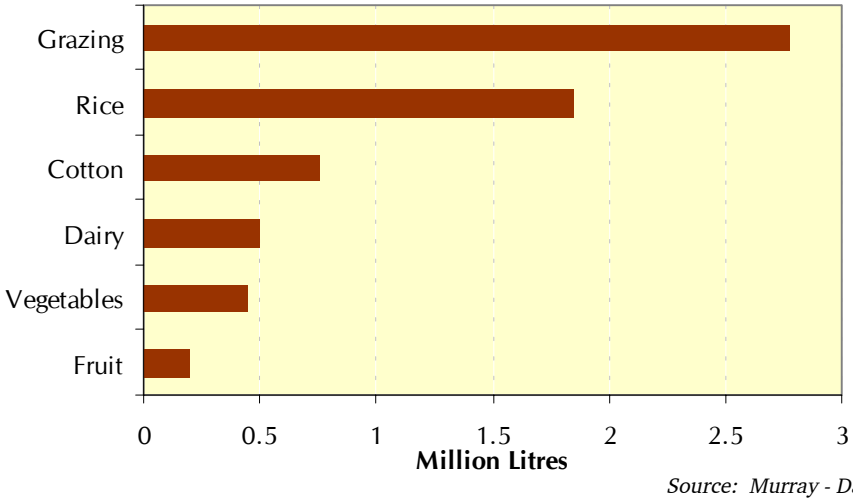
Threats to the future of the horticulture industry provided by the reform include:

- potential for water price increases to recover full cost of supply schemes;
- potential for reduced water allocations with formal determination of water allocations or entitlements and the inclusion of allocations for the environment; and
- a greater degree of responsibility for local management of water use.

How will COAG Affect Horticulture?

Horticulture is a competitive user of irrigation water relative to other agricultural industries. Statistics from the Murray Darling Basin Commission (MDBC) (Figure 3.38) indicate that horticulture uses substantially less water per $100 of gross margin than other irrigated agricultural industries such as rice, cotton or pasture production (HPC, 1995). Fruit Growers are estimated to use some 200,000 litres of irrigation water for every $100 of gross margin, compared to some 2.78 million litres of water used by graziers to earn the same gross margin (HPC, 1995). Vegetable Growers use some 450,000 litres for $100 gross margin compared to 500,000 litres for dairy, 760,000 litres for Cotton growing and 1.85 million litres for rice growing (HPC, 1995).

Figure 3.38 Water Required to Produce $100 Gross Margin



Source: Murray - Darling Basin Commission

Recent research by ABARE also supports the view that horticulture will be positioned favourably in the long term and will not reduce water use in horticulture. The report found that rising irrigation water prices as a result of COAG water reforms are unlikely to lead to major falls in water use as water charges represented only a small proportion of the horticultural Growers' costs - between two and seven percent - and that on average horticultural Growers did not use all of their allocations anyway (Danzi, 1999). It was also found that irrigators in the Loxton and Sunraysia could recover as much as 70 percent of the costs of saving water on farm by selling the water saved, while for Murrumbidgee irrigators such water sales could only cover about a quarter of the cost (Danzi, 1999).

Horticulture: Current and Future Irrigation Water Use

The low cost of water relative to other inputs in horticultural production are well documented. Stirzaker (1999) indicated that because water is cheap, it is likely to be used in excess to provide for crop insurance. He also makes some useful comments on the future role of research in improving irrigation water use management.

"*If excess water use degrades other resources, the cost of the strategy will be borne by the community and the environment. However, if this agro-ecosystem can be expertly managed from the outside via physical and chemical inputs and remain both productive and non polluting, then research should focus primarily on the technology and training that would make management decisions more precise. If not, we will have to address the very biological functioning of the agro-ecosystem as well.*" (Stirzaker, 1999).

Around 70 percent of annual crops and 50 percent of perennial tree crops are grown under irrigation (Horticulture Australia, 1995). The distribution of irrigated vegetable (annual), and irrigated fruit and nut (perennial) crops are shown in Figures 3.39 and 3.40 respectively. The major irrigated vegetable growing regions are located in the Bowen, Bundaberg, Lockyer Valley and Beaudesert regions in Queensland, Gippsland in Victoria and the Kununurra and Manjimup regions in Western Australia (Figure 3.39). The major irrigated fruit growing regions are located in the Atherton Tablelands and Stanthorpe regions in Queensland, the Riverina in the Murrumbidgee Irrigation Area in New South Wales, the Sunraysia in southern New South Wales and north western Victoria, the Riverland district in South Australia and the Huon Valley in Tasmania (Figure 3.40).

Water use requirements of Australian horticulture are expected to rise by more than 50 percent by the year 2020 (Water and the Australian Economy, 1999). Table 3.41 shows that water use in 1995-96 for horticultural industries was 1640 GL and is projected to grow to 2590 GL by the year 2020. The added value of horticultural production is expected to increase at a rate of 2.9 percent per annum to out perform growth in water use (1.8 percent) reflecting in economic terms greater efficiency of water use in the future (Table 3.42).

Table 3.41 Projections of Australian Water Use and Growth of Value Added by Industry, at Constant 1995 -1996 Prices.

Industry	Estimated water use in 1995 - 96 (GL)	Projected water use in 2020	Growth Rate in Water Use	Growth Rate in industry value added (% per year)
Fruit	870	1,300	1.6	2.7
Vegetables	770	1,290	2.1	3.0
Total	**1,640**	**2,590**	**1.8**	**2.9**

Source: Water and the Australian Economy, April 1999

Table 3.42 Estimated Gross Value of Agricultural Output, Rain-Fed and Irrigated Value Added, and Water use in 1995 – 1996.

Industry	Gross Value of Output ($ million)	Rainfed Value Added ($ million)	Irrigated Value Added ($ million)	Total Value Added	Water use (GL)
Fruit	1,401	38	213	250	870
Vegetables	1,589	108	610	718	770
Total	**2,990**	**146**	**823**	**968**	**1,640**

Source: Water and the Australian Economy, April 1999

Figure 3.39 Distribution of Vegetable Crops Grown Under Irrigation

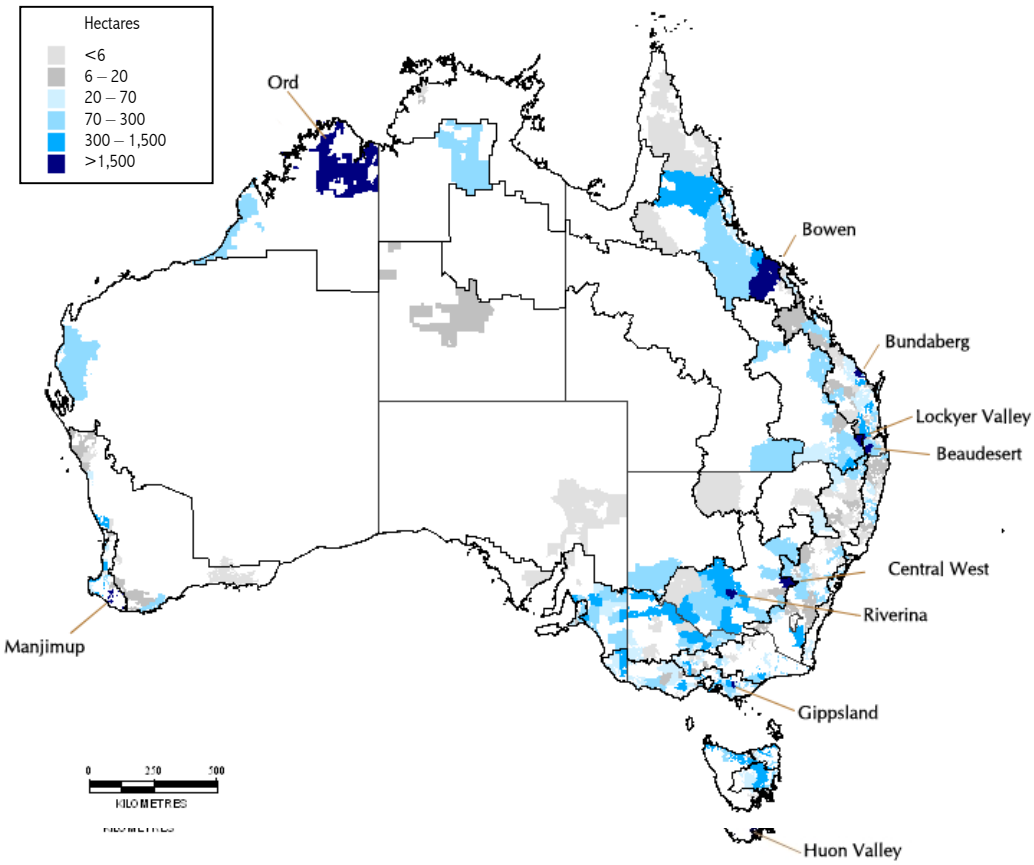
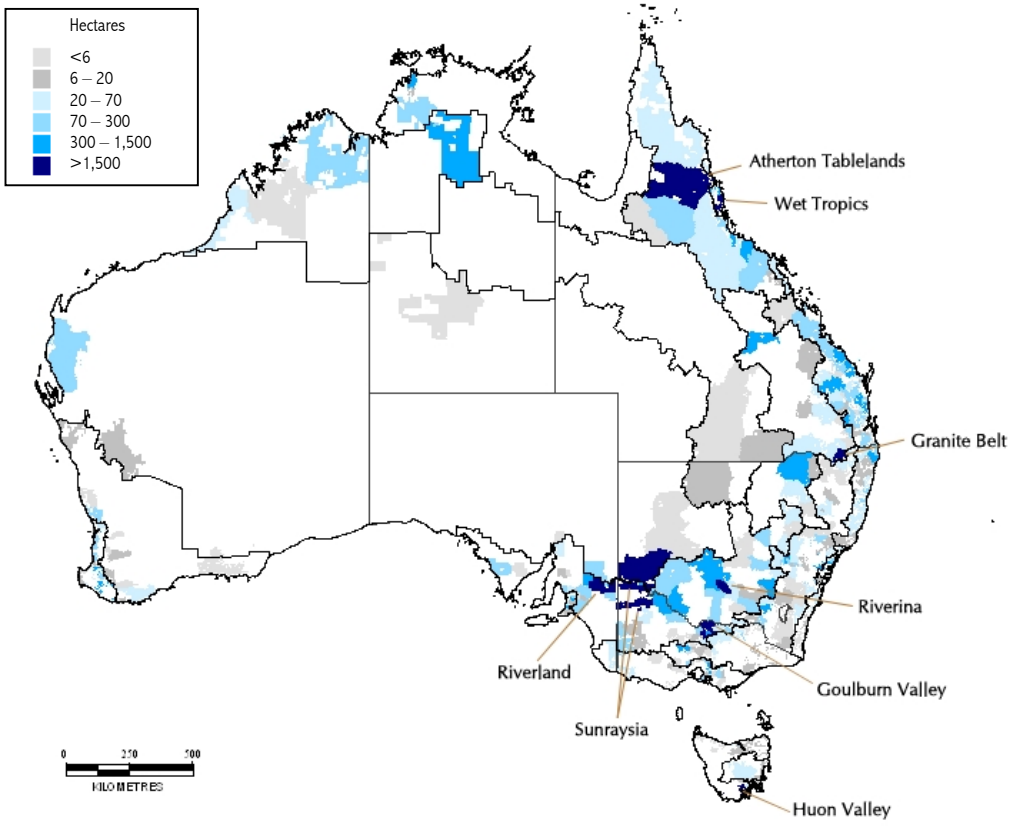


Figure 3.40 Distribution of Fruit and Nut Crops Grown Under Irrigation



Maps Source: ABS *AgStats 1996-97.* with non-agricultural land mask from *Distribution of Agricultural Land Use in Australia* (BRS 1994).

To gain a summary insight into the relationship between the environment and water management at Grower level, a number of water use issues were assessed using data collected from the Grower survey, and from other studies related to horticultural industry. The analyses of these issues presented below.

Volume of Irrigation Water Used

A study conducted by Barraclough and Co. on behalf of Queensland Fruit and Vegetable Growers (QFVG) (1999, unpublished data) found that the volume of irrigated water used in horticultural industries in Queensland averaged 4.1 ML/Ha and ranged from 0.7 ML/Ha for pineapple crops to 8.7 ML/Ha for other crops not categorised (Table 3.43). This data is an indicator of per hectare water use requirements for various horticultural crops. No other data specific to horticulture is available.

Table 3.43 Volume of Water Used per Hectare

Crop	Volume Used (ML/Ha)	Gross Value ($/ML)
Other	8.7	3,396
Citrus	7.6	1,826
Avocado	7.5	1,386
Banana	6.7	2,878
Other fruit	5.7	2,088
Mango	5.5	1,725
Stone fruit	5.2	1,754
Brassica	4.7	2,321
Pome fruit	4.2	5,572
Salad	4.2	5,331
Strawberry	3.8	17,383
Exotic fruit	3.8	3,198
Grape	3.5	3,142
Solanum	2.9	7,486
Root Crop	2.5	4,234
Vege Cucurbit	2.4	4,213
Tomato	2.3	13,082
Melon & Pumpkin	2.3	3,285
Pods & seeds	2.0	2,732
Pineapple	0.7	13,006

Source: Barraclough and Co., 1999

Irrigation Methods

Irrigation methods are a key issue in the water industry currently, as irrigation method in conjunction with timing and volume of water have a significant influence on water use efficiency. In addition some irrigation systems have different environmental impacts depending on the land.

Data collected by Barraclough and Co. showed that annual crops were irrigated mainly by low-pressure sprinklers (47 percent of Growers) and drip / trickle systems (38.5 percent of Growers) (Figure 3.41). The results show that only 1.6 percent of Growers utilise furrow irrigation systems, however descriptions provided by the AHC / Irrigation Associated of Australia in *Horticulture Australia – The Complete Reference on the Horticultural Industry* (1995) suggest that furrow irrigation is widely used in vegetable crop production.

The most common irrigation techniques used in the production of perennial crops were micro spray (67.8 percent) and drip/trickle systems (15.8 percent) (Figure 3.42).

Figure 3.41 Irrigation Methods Used – Annual Crops

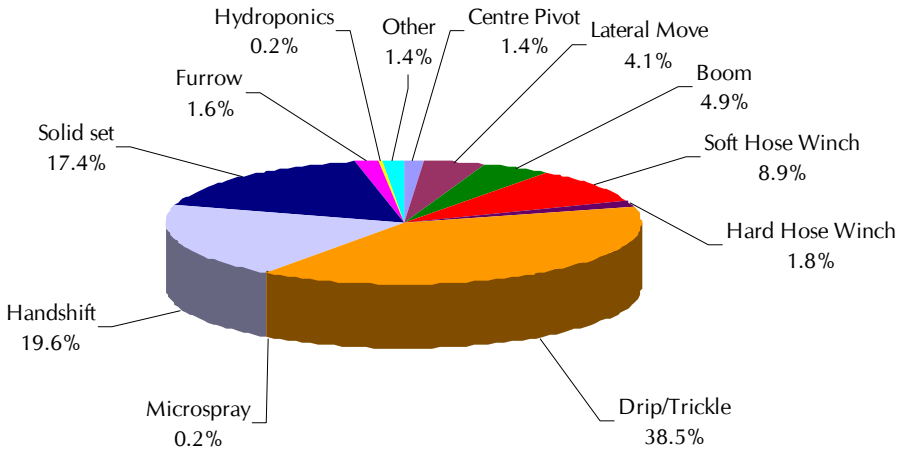
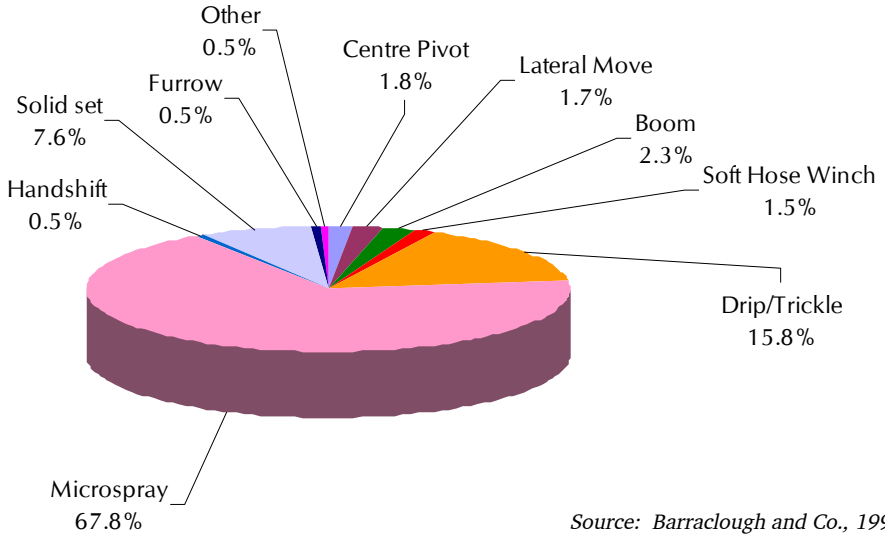


Figure 3.42 Irrigation Methods Used – Perennial Crops

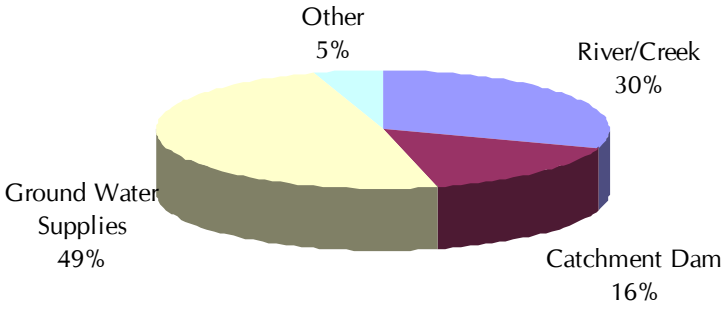


Source: Barraclough and Co., 1999.

Irrigation Water Sources

Data collected as part of the Grower survey conducted for this project showed that 82 percent of Growers used irrigation as part of production practice. The major sources of water used for irrigation identified in the survey were ground water supplies (49 percent) and river/creek water (30 percent) (Figure 3.43). Smaller proportions (16 percent) of industry respondents had established catchment dams. The high reliance (79 percent) of respondents on natural overland flows and river systems suggests that horticulture in conjunction with other major broadacre users of environmental systems could contribute to system stresses during dry periods. Regional and on farm water storage developments are a priority for Governments as a foundation for establishing regional development in rural industries and communities. Reliance on natural water flows can be reduced through sensible on farm and regional infrastructure planning so long as broader environmental systems are not compromised.

Figure 3.43 Sources of Irrigation Water



Responses: 88

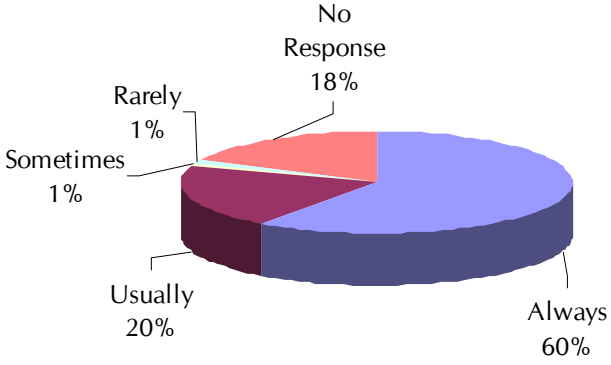
Source: Survey Data, 1999

Water Quality

Access to quality water resources is important for all cropping and environmental systems and is a key indicator of system health. Respondents were asked if the quality of irrigation water was adequate. Although outcomes from this analysis do not have scientific bases, summary assessments of water quality by Growers could provide opportunities for further more rigorous forms of scientific regional analysis.

Analysis of Grower survey data shows that 59 percent of respondents considered water quality to be “always adequate” based on summary assessments with 19 percent of respondents suggesting that water quality was “usually adequate”. In contrast, 1 percent of respondents considered water quality to be “rarely adequate”, with an additional 1 percent suggesting that water quality was “sometimes adequate” (Figure 3.44). Twenty percent of respondents did not respond to questions relating to this issue.

Figure 3.44 Overall Water Quality Rating



Responses: 98

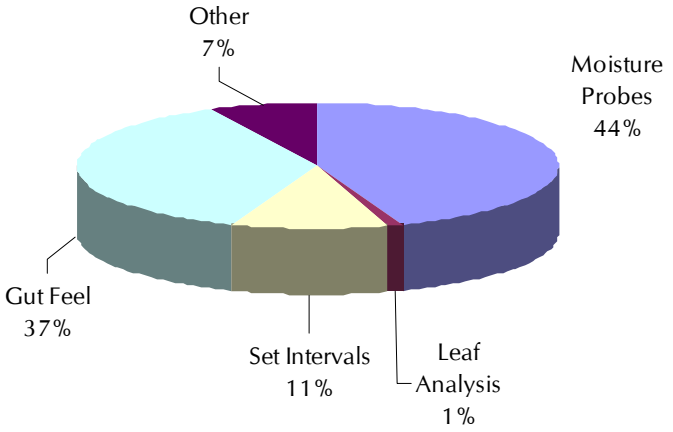
Source: Survey Data, 1999

Timing and Volume of Irrigation

In combination with irrigation method, irrigation timing and volume of water application have an important impact on water use efficiency. Trends towards more objective measures of crop moisture levels such as leaf analysis and moisture probes have assisted Growers in improving irrigation timing and volume decisions.

Figure 3.45 and Table 3.44 show that moisture probes are the most common tool (44 percent) to determine irrigation timing decisions of survey respondents while gut feel remains the second most common method (37 percent) of irrigation timing decisions. Set intervals were the third most common technique adopted by 11 percent of respondents (Table 3.44).

Figure 3.45 Overall Method Used to Determine Timing and Volume of Water Application



Source: Survey Data, 1999

Responses: 84

The results of the survey conducted by Barraclough and Co. demonstrated similar results for Queensland Fruit and Vegetable Growers (QFVG)(Table 3.45). Experience based estimation of irrigation timing was most common, and was also significantly higher for annual crops. This method can be compared to "gut feel" in the Grower survey data collected for this project. Responses categorised as "cycle basis" can be compared to "set intervals, and "technology", which includes the use of devices such as enviroscan, neutron probes etc. these can be compared to Grower survey responses for "leaf analysis" and moisture probes".

Table 3.44 Method Used to Determine Timing and Volume of Water Application

Crop Group	Moisture Probes	Leaf Analysis	Set Intervals	Gut Feel	Other
Annual Crops	47%	0%	0%	47%	6%
Perennial Crops	43%	1%	13%	34%	7%

Source: Survey Data, 1999

Table 3.45 Method for Determining Timing of Irrigation

Crop	Percentage of Growers Using Method		
	Experience Estimated	Cycle Basis	Technology
Annual Crop	72%	3%	25%
Perennial Crops	50%	13%	37%

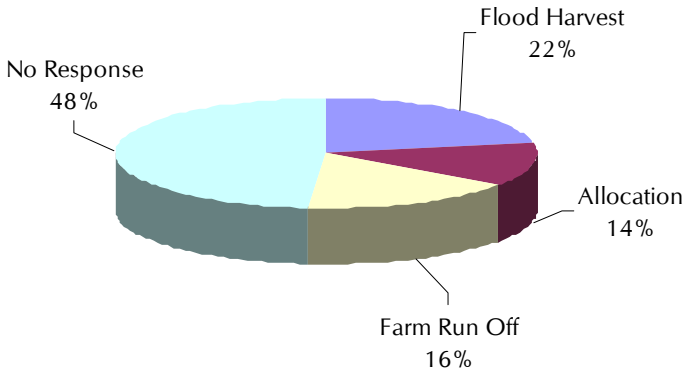
Source: Barraclough and Co., 1999.

Irrigation Storage on Farm

Irrigation storage is growing in importance as Growers attempt to reduce business and production system exposure to seasonal variation, and has the potential to assist Growers to manage peaks and troughs in water supply and demand.

Results of the Grower survey showed that 40 percent of respondents indicated that they stored water on farm. Of that 40 percent, 48 percent provided no information on the source of irrigation water stored, 22 percent indicated that flood harvesting was used to create / replenish on-farm water stocks, 16 percent indicated farm run-off was the source, and 14 percent stored water provided by irrigation water allocations (Figure 3.46).

Figure 3.46 Sources of Storage Water Nominated



Responses: 87

Source: Survey data 1999

Key Points

- Australia's ancient and highly weathered soils are generally lacking in sufficient nutrient reserves to sustain intensive horticultural production without significant inputs from fertiliser application.
- No consistent pattern in nutrient balance among different crop groups can be discerned, however overall nutrient balance is shown to be positive with the exception of potassium.
- Soils in the northern regions of Australia generally have a lower nutrient status than the soils of southern and eastern Australia.
- Organophosphate insecticides were the most widely used with 60 percent of Growers applying chemicals of this category.
- Generally, insecticide and fungicide violations detected in both the NSW and Victorian Programs involved very low residue levels. There was no significant difference in the occurrence of residue violations among fruit and vegetable groups. These results indicate that producers are generally following good chemical management practice.
- Horticulture is a competitive user of irrigation water relative to other agricultural industries.
- COAG Water Reform is expected to have a minimal impact on water use in horticulture.
- Further research by ABARE supports the view that horticulture will be positioned favourably in the long term and will not reduce water use in horticulture.

4 Resource Management Practice and Issues

The sustainable management of soil, biodiversity and water resources is dependent on the management skill and knowledge of the industry's employment base. Training and on going formal education are characteristics of progressive industries and form the foundations for all good management practice. Fragmented policy and decision-making industry structures also contribute to the lack of cohesion in planning management at Grower level.

This Section aims to build on summary insights from Section 3 to determine how horticulture is managing various environmental issues by exploring the status of horticultural industry management practices, education and skill levels, training, quality assurance, and marketing supply structures.

4.1 Industry Management

4.1.1 Codes of Practice and Guidelines

Horticultural Codes of Practice were sourced from State Agency survey responses and desk research. Codes of Practice are generally commissioned and produced with the assistance of State Agencies or other Government bodies. Historically, the best examples of successful implementation of Codes of Practice have occurred where programs are developed within a national framework, such as programs to improve the management of farm chemicals. These programs are generally relevant to all agricultural industries.

Successful implementation of environmental Codes of Practice in the future, will be regional or catchment specific, and will identify management practices that account for unique climate, soils and landforms, customised for interpretation across crop group and industry boundaries. Codes of Practice will need to accommodate differences in the relative environmental health of the natural resource base across regions. A good example of horticulture achieving regionally specific codes of practice is "Codes of Practice for Vegetable Production on the Swan Coastal Plain" produced by the Vegetable Growers, Market Gardeners and Potato Growers Association with the assistance of Agriculture Western Australia.

Co-operation and collaboration between state departments, industry organisations and various research institutions is also essential to source relevant expertise across all key environmental planning areas. The Riverlink scientific network (Department of Natural Resources and Environment Victoria, NSW Agriculture, CSIRO Division of Plant and Industry and the Department of Primary Industries and Resources) is an example of state agencies working with industry to achieve integration in policy and service delivery across the major horticultural centres in the Sunraysia-Riverland region. Examples of research collaboration between HRDC and LWRRDC also demonstrate the increasing capacity of horticulture to contribute to larger national environmental projects.

As a prerequisite, horticulture must achieve co-operation within its own industry across crop groups before it can hope to achieve broader based cooperation with other industries. Queensland Fruit and Vegetable Growers (QFVG) is working towards achieving this goal on environmental sustainability in Queensland, with the development of the Farm Care Code of Practice. This document is the most comprehensive state based Code of Practice relevant to all fruit and vegetable industries in Queensland.

The development of regionally specific codes of practice designed to manage the use of natural resources across different climates, soils and landforms is dependant upon the co-operation of other natural resource users. In the Sugar industry CANEGROWERS has also undertaken an environmental audit of its industry and has developed a similar natural resource management Code of Practice at industry level (CANEGROWERS, 1997). Opportunities exist for agricultural industries to collaborate at the regional level to develop relevant strategies and achieve environmental management goals.

Good examples exist which indicate that horticulture is adapting to the reality that environmental compliance is a key driver of long-term industry sustainability, and that industry recognises that environmental management requires cooperation across crop group sectors. Evidence also exists that regional environmental planning is occurring in some horticultural regions. A good example is the SARDI Riverlink scientific network as discussed on the previous page (SARDI Riverlink, 1999).

However, from a national perspective, current fragmentation evident across and within horticultural industries, particularly in the vegetable industries, will severely constrain the adoption of nationally or state coordinated environmental Codes of Practice. The assessment of adoption of Codes of Practice by industry is essential to monitor the effectiveness of current and future programs to ensure that environmental sustainability goals are achieved.

The measurement of the level of adoption and the overall effectiveness of these programs depends on strong linkages with Growers at farm level. There are many emerging examples indicating that cooperation at farm level could be difficult to achieve, particularly in the vegetable crop groups, as evidenced by poor responses to industry surveys received in this project and a recent project by Harley Juffs and Associates (1999) evaluating IPM in processing and fresh tomatoes. The challenge for industry planning and management institutions is to establish an effective linkage at the Grower level so that environmental management change can be measured and monitored. This is critical to achieving real practice change.

4.1.2 Industry Planning Across Environmental Priority Areas

A review of available HRDC sponsored industry strategic plans was conducted to determine the degree to which industry has included environmental management in priority planning areas. Although the structure of plans varied across industries, it was possible to extract key themes, priority areas, goals and objectives. Most industries have demonstrated a commitment to environmental sustainability in the core values and vision statements of their strategic plans. The degree to which these statements were supported by defined action plans and outcomes varied across industries.

Six key environmental planning areas were identified as a basis for classifying evidence of environmental strategies, these are:

1. Best Practice; identification, documentation and implementation of best practice principles and standards for the purposes of improving industry performance across economic and ecological parameters.
2. Integrated Pest Management; identification, documentation and implementation of management strategies to reduce industry reliance on chemicals.
3. Water Use Efficiency and Quality; evidence of a commitment to improve the utilisation of irrigation water.
4. Quality Assurance; evidence of a commitment to implementing quality assurance.
5. Education; evidence of dedicated programs designed to improve industry knowledge.
6. Benchmarking; commitment to quantify and manage industry performance.

Table 4.1 illustrates existing compliance strategies across key planning areas described above.

The review suggests that best practice, integrated pest management, quality assurance and the need for improved education were more commonly included priorities. Secondary priority areas were water use efficiency, water quality, and industry benchmarking. Many industry plans are due for review and it is very likely that the trend toward higher priority for environmental compliance will continue.

Although strategic plans do in most instances have an acceptable coverage of environmental issues, it is yet to be determined whether such plans are being successfully implemented. Additional research is considered worthwhile to determine whether horticultural industries which develop strategic plans are driven by the "political need to have a document" or that such plans actually assist in the achievement of objectives across all key planning areas.

Table 4.1 Strategic Planning and Environmental Compliance

Industry Research and Development Plan	Year	Environmental Management Areas Identified					
		Best Practice	Integrated Pest Man.	Water Use	Quality Assurance	Education	Benchmarking
Mango Industry Strategic Plan	1996	■			■	■	
Industry Strategic Plan Australian Melon Association		■	■		■	■	
Australian Nursery Industry Research and Development Plan	1996-2001	■	■			■	■
The Australian Pineapple Industry Research and Development Plan	1995-2000	■			■	■	
Australian Potato Industry Strategic Plan	1999	■	■			■	
Processing Tomato Research and Development Plan	1997-2001		■	■	■	■	■
The Pyrethrum Industry Research and Development Plan	1997-2000						
The Strawberries Australia Research and Development Plan	1999-2004	■	■	■	■	■	
Australian Vegetable Industry Research and Development Plan	1997	■	■				■
The Australian Canned Fruits Industry Research and Development Plan	1992 - 1997		■		■		
National R and D Plan for the Australian Banana Industry	1998	■	■	■	■	■	■
Avocado Industry Research and Development Plan	1996-2000	■	■	■	■	■	
Australian Almond Industry Strategic Plan	1996-2001	■	■			■	■
The Macadamia Research and Development Plan	1995-1999	■	■	■			
Australian Fresh Stone Fruit Industry Strategic Plan	1996-2000	■	■		■	■	■
Australian Citrus Industry Research and Development Plan	1996-2000	■	■	■	■	■	■
Chestnut Industry Strategic Plan	1996-1997	■			■		■
Cherry Industry Research and Development Plan	1997	■	■	■	■	■	
Apple and Pear Growers Association Strategic Plan	1998	■	■		■	■	■

■ Evidence of strategies in environmental planning areas.

Several of the States have also developed horticulture plans or strategies, either within their State agriculture plan or as separate industry documents. Table 4.2 lists those documents known to be currently available.

Table 4.2 State Based Strategic Planning Relating to Horticulture

State	Plan
Victoria	Five year horticulture industry programs 1994-99 Five year new and emerging industries program 1994-99
WA	Summary of Agriculture Western Australia's strategic directions 1995-2008 Strategic Plan (for Ag WA) 1996-2002
NSW	Corporate Plan (NSW Agric) 1994-1997
NT	Northern Territory Horticulture Industry – Strategic Plan for Future Development (undated)
SA	South Australia Fruit Crops Industry Development Plan 1995-2000
Queensland	Horticulture Industries – Priorities toward 2000 QFVG Corporate Plan (an ex statutory authority) develops and administers industry priorities on behalf of QDPI.
Federal	Australian Horticulture Corporation – Corporate Plan 1998-2003 Bureau of Resources Services – Strategic Plan for Horticulture (Draft) Horticulture 2000 – Chemical Residue Management Plan. HRDC Corporate Plan.

While these plans and strategies concentrate on areas of possible expansion and consideration of particular crop groups, several of the plans refer to sustainability aspects of the commodities concerned. Environmental factors such as salinity, water tables and agricultural chemicals are included in both the strategies and their objectives. Clearly where it is deemed necessary to take action to ameliorate environmental impacts of the industry, these strategies and plans will need to be considered on a regional basis by the state authorities concerned.

A number of the plans have been developed for a particular five year period while others are open-ended and set general aims and principles rather than quantitative targets to be met by particular achievement dates.

In summary, it is encouraging to see the documented evidence of horticultural industry planning. It suggests industry, as a whole, is thinking as much about where it is going, as what it is doing today. Clearly, many industry crop sectors and groups are grappling with how to define and integrate, and actively deliver, environmentally sustainable practices and benefits on a commercially acceptable basis. But low adoption of technologies and low acceptance and awareness of environmental issues and plans across industry, are significant limits to practice improvement.

Key Points

- Codes of environmental practice are increasingly common across horticulture and are more likely to be developed where:
  - 1. crop sectors have the scale of operations and administrative support to allocate resources to the task. This has typically been undertaken by the high profile crop sectors. (e.g citrus, bananas, and pome fruit).
  - 2. governments are jointly active in supporting regional horticultural industry.
  - 3. there are strong drivers of better environmental management, either from the market or through Government regulation, and often both.
- Small scale industries without professional management are lagging in Code of Practice and strategic planning development.
- Strategic plans are increasingly incorporating environmental management in response to consumer demands.
- The consulting team holds the view that many of the Codes and Good Management Practices documented are driven by "the need to have a document" rather than the need to ameliorate a causal link between degradation and enterprise profitability. There is little evidence or ad hoc industry advice to suggest that horticulture is documenting codes and practices because it is primarily good for the natural resource base. While initially damning, this independent view is tempered, by the fact that :
  - The "need to have a document" is a sound approach to change management where a new philosophy is challenging traditionalism. Big crop sectors are the only ones positioned to develop this new intellectual property.

4.2 Prevention and Control of Negative Environmental Impacts

4.2.1 Soils

Soil Loss

Survey results on status and trends in soil loss indicate that State Agencies, and to a lesser extent Growers perceive soil loss to be a significant indicator. But there is agreement that generally soil loss problems are improving in the industry. Soil loss is generally perceived to be more significant in the tropical coastal regions of Queensland, and the Wet Temperate Coast, which includes regions of Tasmania.

Evidence exists of activities encouraging industry to explore and adopt the use of soil loss minimising strategies exists. Research activity in soil loss by the Tasmanian Department of Primary Industries and Fisheries (TDPIF) and the Tasmanian Institute of Agricultural Research (TIAR) would indicate that soil loss minimisation options are being explored. Current and historical horticulture specific research in Tasmania has focused on environmental amelioration in intensive temperate rotations (Laurence, 1999), the use of graded drains in vegetable cropping (Bruce, 1999), and the sustainable use of intensively cropped Krasnozems for vegetable production (Cotching, 1999). Other crop specific research in soil erosion is currently being undertaken by the NSW Agriculture Tropical Fruit Research Station (TFRS) on behalf of the Macadamia Industry to identify shade adapted cover crop species to minimise soil erosion (McFadyen, 1999).

Improved soil management practices, based upon reduced tillage were evaluated for the production of potato and brassica vegetable crops on sloping land with significant water erosion risks in the Mount Lofty Ranges of South Australia. Outcomes suggest that with only minimal initial capital expenditure, the level of soil erosion and pollution of water catchments can be reduced substantially (Cole et. al., 1992).

Current ratoon and pest management research in paw paws has confirmed soil losses are markedly reduced as a result of mulching. Despite only a few significant rainfall events recorded, mulch was most effective in reducing soil movement down slope. Losses were measured at 5.14 t/ha in the unmulched treatment compared to 0.43 t/ha in the mulched treatments. (Ross, 1999).

Collaborative research between LWRRDC and the Horticultural Research and Advisory Station at Gosford have assessed the "Environmental impact of alternative horticultural production systems in the Hawkesbury-Nepean catchment". An outcome of the project was the development of vegetable production systems with better economic and environmental performance than current approaches. Cover cropping was found to be the most promising technology tested for increasing all round sustainability of the production systems by reducing run off and erosion (Chan, 1997).

More generalised agricultural research specific to soil loss has been undertaken in Queensland by the Australian School of Environmental Studies at Griffith University (ASESGU) in the areas of storm run off induced soil erosion (Rose, 1999) and farmer perceptions of relationships between erosion and crop productivity (Rickson, 1999). QFVG Farm Care Code of Practice documents detailed soil loss minimisation strategies for use in Queensland horticulture (QFVG, 1998), however there is little evidence of horticulture specific research of soil loss in tropical coastal regions of concern identified in the survey outcomes.

Chemical Accumulation in the Soil

Industry has responded to concern about chemical residues on produce, and pesticide resistance in target pests by restricting the volume and type of pesticides applied, improving spraying application techniques and technologies, and looking to alternative biological integrated solutions to manage pests and disease. These efforts help minimise chemical accumulation in the soil. Extensive Integrated Pest Management (IPM) research and development has been undertaken across horticultural industries in recent years. The banana industry is currently developing and implementing integrated pest management systems in Queensland (Lindsay, 1999 and Pinese,

1999). Agriculture Victoria (AV) - Knoxfield (AVK) is currently developing IPM strategies in sweet corn (Ridland, 1999), potatoes (de Boer, 1999) and tomatoes (Minchinton et. al., 1999), and other specific IPM research and development projects in pome and stone fruit (AV, 1999). The Queensland Horticulture Institute (QHI) in collaboration with other research institutions is developing more specific IPM strategies for tropical crops (including bananas)(Akiew, 1999), brassicas (Franklin, 1999 and Deuter, 1999), apples and pears (Stephens, 1999 and Page, 1999), strawberries (Greer, 1999), custard apples (Broadley, 1999) and tomatoes, melons and cucurbits (Kay, 1999). The development of IPM in the Riverland/Sunraysia by SARDI Riverlink in the citrus (Baker, 1999a and Baker, 1999b) and carrot (Davison, 1999) industries are further complemented by a horticulture hotline for IPM support services. The Apple and Pear Growers Association (AAPGA) have also invested considerable resources to the development of IPM practices (Ag Trans, 1999).

The effectiveness of existing IPM strategies requires additional research to measure the level of adoption by industry and the benefit/costs resulting from such programs. Preliminary evaluation of benefits of investment in IPM programs is now complete in some industries. The evaluation of HRDC/AAPGA investment in the Apple and Pear Industry conducted by Ag Trans (1999) assessed the impact, adoption and benefits and costs of implementing IPM strategies. The Report found that:

- the average number of sprays per year to control pests and disease has decreased by 28 percent since the adoption of IPM;
- 80 percent of Growers are using reduced spray volumes;
- overall opinion was there may be improved quality for those Growers that are practicing IPM effectively, and;
- nationally, the level of adoption calculated from surveys is 80 percent, however only 43 percent of respondents from Western Australia have adopted and 100 percent of South Australian respondents have adopted IPM practices.

A similar evaluation was undertaken by Harley Juffs and Associates (1999) to assess the impact of research and development on integrated pest management in the processing and fresh tomato industries. Although, poor response rates to the survey reduced the reliability of results, relevant findings of the report are:

- that Growers from the processing and fresh sectors both achieved about a 60 percent compliance rate;
- that Growers from the processing sectors seem to be on an upward trend in terms of their use of nominated IPM related practices, and;
- that IPM has not yet reached its potential for delivering economic benefits.

IPM is an ongoing management goal and will remain a key management tool and priority for industry. Research and development in horticulture has emphasised the development and adoption of various IPM practices in recent years, and early assessments of the benefits are generally positive. The evaluation of IPM practice is in its early days. Further analysis of the benefits of IPM programs across crop groups are required before more concrete conclusions can be made regarding IPM issues including chemical accumulation in soils.

Of interest also are the recent joint discussions between the Certified Organic industry and horticulture. It is likely that organic farming system modules will be incorporated in most horticultural mainstream IPM programs over the next five years. Apart from addressing the chemical issues, this will allow certified producers to pursue additional market niches.

The broad integration of Codes of Practice generally reflects overseas trends, in such programs as LEAF (UK) and Farm-A-Syst (Canada/USA) which broadly incorporate chemicals, soil loss, water quality and loss of biodiversity (Merriman, P., 1999).

Organic Matter and Soil Structure Decline

The horticultural industry has recognised the negative impacts of declining organic matter levels and soil structure decline. A limited number of case studies exist that demonstrate the relatively recent recognition of the problem and response. Organic matter levels are maintained by one or more of the following management practices:

- green manure crops;
- adding compost or other plant residues;
- cover crops with a dense rooting habit;
- mulching of crop residues into the soil surface, and;
- maintenance of the original organic matter through minimising soil disturbance and aeration.

Earlier research in Victoria near Melbourne by Morgan (1992) aimed to develop a sustainable system of vegetable production which eliminates the use of inorganic fertilisers and uses organic matter and green manure to supply plant nutrient and increase soil biological activity. The results indicated reduced susceptibility to soil borne diseases and pest problems through the promotion of beneficial soil micro organisms (Morgan, 1992). Current relevant research on soils is underway in Tasmania (Hay, 1999) on the use of bark residue as a soil amendment in broadacre intensive vegetable production. Sparrow (1999a) is conducting research on more economic and environmentally responsible use of phosphorus fertiliser in potato cropping on krasnozem soils in Australia. Sparrow et. al. (1999) assessed the attributes of Tasmanian ferrosols under different agricultural management, and Laurence (1999) explored the economics of soil and environmental amelioration in intensive temperate rotations. Additional relevant work by the Tasmanian Department of Primary Industries and Fisheries (TDPIF) includes the publication of “Managing Tasmania’s cropping soils – A Practical guide for farmers”, drainage information packages, and Krasnozem topsoil structure "In the paddock assessment and management" (TDPIF, 1999).

Cockroft (1997) reported on the effects of various soil management strategies on soil structure under tomato crops in the Shepparton area of Victoria. Their response indicates a high implementation of green manure cropping in combination with either mulch retention and/ or incorporation of soil additives such as gypsum in this region.

Evidence of research to better manage and understand organic matter and soil structure decline exists predominantly in Tasmania, supporting vegetable industries such as potatoes and carrots. Isolated examples of activity in horticulture specific soil research exist in Victoria.

Nutrient Levels and Availability

Unmanaged nutrient levels adversely affect crop growth. In addition, if concentrations are at saturation levels, leaching into ground waters can produce toxicity problems. The Swan Coastal Plain Region of Western Australia Code of Practice (AGWA, 1999) provides upper limits for phosphorus and irrigation application rates and gives comparisons between other soil types in the region. Research by the QHI for the Banana industry is focusing on improved monitoring of crops to be used as a tool for the management of nitrogen and potassium nutrition, and the leaching losses under a controlled fertiliser management system (Daniells, 1999). A key objective of the Better Berries Program is to develop cultivar specific nutrition (Greer, 1999). The Cashew industry is also developing nutrition management strategies to determine the influence of nitrogen on vegetative and reproductive development and define optimum leaf sampling time for leaf nutrient analysis (O'Farrell, 1999).

In Tasmania, considerable evidence exists of industry research in the exploration and management of nutrient interactions with various crops. McLaughlin et. al. (1999), assessed cadmium levels in potatoes and Sparrow and Salardini (1997) assessed the effects of residues of lime and phosphorus fertiliser on cadmium uptake and yield in potatoes and carrots. Sparrow (1994)

indicates the risks involved in over-use of soluble fertilisers on the economies and environmental impacts of nitrogen fertilisers on potatoes.

Survey results on this indicator generally indicated that state agencies and Growers perceived nutrient levels and availability to be very important and to be improving. Nutrient management is a key management issue and must be constantly monitored. Research suggests that much crop specific and region work is being undertaken that position industry research delivery organisations well to advise industry on nutrient management issues.

Soil Acidity Levels

Soil acidification is a commonly recognised degradation issue caused by the long-term overuse of nitrogen fertilisers on the same parcel of land. Maheswaran (1993) estimated that about 23 percent of the total agricultural area in Victoria have strongly acid soils. Soil acidity has become a significant problem in low flow irrigated horticulture. Soil acidity has resulted from the intense application of ammonium based nitrogen fertilisers to small volumes of soil (McNab, 1999). A package for the amendment and prevention of soil acidity in low flow irrigated horticultural crops is currently in progress to address this issue in acidity prone horticulture regions around the Goulburn Valley and Mid Murray Areas of Victoria (McNab, 1999). In a recent HRDC funded extension project (Schneider, 1996) conducted in orchards in the Goulburn-Murray Valleys and North East Victoria, soil acidity was shown to be a potential problem. The project revealed that 25 percent of the soils surveyed have topsoil pH values less than 4.4, indicating that nutrient availability and tree performance would be affected. The project report indicated that the low pH values serve as a warning that irrigated horticulture sustainability is threatened. Improvements in management practices relating to fertiliser application and irrigation management are an outcome of this project.

In Queensland, one or more of the following management practices are implemented in response to soil acidification:

- more closely matching nitrogen fertiliser inputs to crop demand;
- using alternative forms of nitrogen fertiliser;
- efficient irrigation management to minimise leaching;
- early sowing after fallow;
- growing deep-rooting perennial species, and;
- regular applications of lime to counter the acidification inherent in the agricultural system (Aitken, 1997).

Fertigation is another management response to soil acidification where soluble sources such as calcium nitrate or potassium nitrate are applied through trickle irrigation (Horticulture Australia, 1995). Another related problem for some horticultural regions occurs on low-lying acid sulphate soils (ASS). These soils are abundant on many low-lying coastal plains in Australia. In Queensland for instance there are an estimated 2.2 M ha of affected ASS.

Soil Salinity Levels

Reduced crop yields due to increasing soil salinity is an increasing problem in Australian agriculture. While salinity is a problem more closely associated with the temperate horticultural zones, important production areas in the subtropics and tropics (eg. Lockyer Valley, Bowen) are now known to have current and potentially serious future salt problems. In addition, some coastal areas (eg. Burdekin, Bundaberg) may suffer increased salt accumulation as a result of sea water replacing ground water when over-extraction in coastal gravel beds occurs.

The three main approaches adopted by industry to manage soil salinity include:

- reducing salt in the soil profile,
- selecting salt-tolerant crops, and

- minimising the impact of salt on crops through management and choice of irrigation system.

Most significant land and water based programs are generally administered by national research agencies such as the Land and Water Resources Audit, Land and Water Resources Research and Development Corporation (LWRRDC) and CSIRO Land and Water. Of the many programs completed or in progress, there is limited evidence of horticultural industry participation in broader national soil salinity research. However there is evidence that horticulture's institutions are now participating with and contributing to national environmental programs such as the National River Health Program, Sustainable Irrigation Systems and Redesigning Agriculture for Australian Landscapes R and D Program.

Areas affected by soil salinity are concentrated around the margins of most large irrigation areas. Irrigation induced soil salinity typically requires either a wider catchment or sub-catchment approach for remediation. In some cases, the best form of remediation is a conversion of land use away from horticulture. It is often difficult to identify a single causal link to elevated soil salinity as the problem is likely to be affected by management practices across many agricultural activities operating in the region. For this reason, management response needs to be site/district specific. Work conducted by SARDI Riverlink in irrigation extension in best practice irrigation management is contributing to the improved management of soil salinity in the Mallee and Sunraysia regions (Gordon, 1999a). The provision of irrigation management courses (Gordon, 1999b), sustainable regional development (Gordon, 1999c) and environmental technical support (Hopkins, 1999) are activities currently in progress to manage soil salinity problems in horticulture. SARDI Riverlink is currently conducting a program to monitor salinity management in horticulture for four Mallee salinity management plans (three irrigation and one dryland)(Hopkins, 1999). The promotion of such programs in other regions where soil salinity is major problem for horticulture is encouraged.

4.2.2 Water

Ground Water Salinity

Crop losses due to increasing ground water salinity are increasing problems for Australian agriculture. Areas most affected by ground water salinity, like the salinity problems in agriculture, are concentrated around the margins of most large irrigation areas. Like other salinity issues, irrigation induced ground water salinity typically requires either a wider catchment or sub-catchment approach for remediation. In some cases, the best form of remediation is a reduction in water extraction from ground water aquifers. This type of response, if widespread throughout the industry, is likely to restrict irrigation water supplies and constrain short-term economic imperatives.

Case studies in the Murrumbidgee Irrigation Area (MIA) indicate that ground water salinity is a major constraint to horticultural production. The Murrumbidgee Catchment Action Plan (Pow 1999) is a good example of a multi-purpose plan designed in part to manage ground water salinity and other natural resource management problems in agriculture. The Monitoring Review of the Northern Irrigation Salinity Group on the Tragoal Plain of Victoria (SKM, 1995) is another useful case study in ground water salinity control for horticulture.

Surface Water Salinity Levels

Best Practice for surface water salinity control cannot be recommended in isolation. Factors that influence surface water salinity levels include the selection of irrigation system (flood, spray and trickle), soil type, ground water qualities, fertiliser application rates, crop selection and land management practice. The Tragowal Plains case study (SKM, 1995) in north central Victoria is a good example of how horticulture can benefit from coordinated irrigation practices aimed at reducing the effects of saline surface water. In that study area high salinity (EC 6.5-8.6 dS/m) soils were changed to moderate salinity (EC 3.5-6.4 dS/m) by means of innovative scheduling of irrigation and other means. Over a five year period EC readings were reduced by up to 1.9 dS/m EC.

Chemical Levels in Irrigation Water

Queensland and New South Wales temperate coasts were highlighted by the State Agencies as having deteriorating chemical levels in irrigation water. Tail water return and recycling in combination with regular monitoring is the management practice recommended by state agencies in Victoria, South Australia and Queensland. Other relevant management practices adopted by Growers include crop, soil and water monitoring to control, and chemical treatment of water to reduce chemical impacts.

Horticulture specific research is currently being conducted by Riverlink and PIRSA in collaboration, funded jointly with HRDC and LWRRDC, to assess strategies to minimise the impact of pesticides on soil and water quality (Naidu and Kookana, 1999). More general examples exist on a regional basis but are not specific to horticulture. IPM programs across many industries, if sufficient levels of adoption are achieved, will assist to ameliorate the impacts of pesticides, herbicides and fungicides in irrigation water and natural waterways.

4.2.3 Biodiversity

Native Bushland Removal

State Agencies and Growers considered this issue, in relation to horticulture, a relatively low priority. Small remnants of habitat exist throughout horticultural growing areas of Australia. For example, the ongoing protection of the mahogany glider in the wet tropics of Queensland has led to the cessation of clearing in the Tully-Murray area. In this area, State government has acquired sufficient remaining rainforest to ensure the future of this threatened species. In the riverine mallee of Victoria, the future of the endangered mallee fowl was ensured through the prohibition of clearing on reserved land, which constitutes the remnants of the mallee fowl's original habitat.

Riparian Vegetation Removal

Riparian vegetation removal is not considered a major environmental indicator by horticultural industries. Survey responses from both State Agencies and Growers indicated that riparian vegetation was one of the lower priority indicators for horticulture. There is limited evidence of specific research activity, which concurs with the survey findings. Considerable catchment based research is currently in progress in the far north coast of New South Wales (McPhee, 1999), the Mary River catchment in south east Queensland (Kelly, 1999), Johnstone River catchment in the Queensland wet tropics (Merrin, 1999) and in Tasmania (Askey-Doran, 1997) to determine management and restoration strategies of riparian lands in these regions.

4.2.4 Air and Noise

Dust and Noise Control

Dust and noise control is directly mitigated by management practice. Dust and noise impacts are most prevalent where horticultural production interfaces with populated areas. Management responses by industry and government along these contact zones include curtailment of times of operations, changes farming operations, changes in machinery use and implementation of vegetation buffers. These forms of management response are strongly evident in the more heavily populated areas around Queensland's south-east region, northern Queensland coastal strips, centres in inland New South Wales and southern Victoria.

Drift of Sprays and Odours

Spray drift is a contentious issue at the rural urban interface. Institutions have been established by industry to reduce the incidence of spray drift across cropping industries (eg. Centre for pesticide application and Safety and the University of Queensland (UQ), Gatton). Spray drift is also a rural/rural issue where multiple crop uses compete for land use (eg. cotton and horticulture).

Horticulture specific activity has been undertaken to reduce pesticide application in pome fruit on behalf of the HRDC. A recently established project, "Pome fruit pesticide reduction strategies for beyond 2000", has also been commissioned. Macadamia and avocado Growers will benefit from industry spray technology workshops to be held in six locations across Australia including North Queensland (Mareeba/Atherton), Bundaberg, South East Queensland (Gympie/Nambour) Gatton/Toowoomba, northern NSW (Lismore) and Western Australia (Battaglia, 1999).

In addition to seeking alternative methods of pest and disease control, research on improved spray application techniques for the pome fruit industries have been explored by the Institute of Horticulture Development. The nub of the projects was to assess the impacts of spraying with lower volumes of concentrated pesticides. Traditional high water volume techniques are now considered wasteful and potentially harmful to the environment through excessive loss of water to the ground and air. Results have consistently shown that medium spray volumes of three to four times less than the normal dilute chemical rate provide equally effective control (Cole, 1997).

4.2.5 Waste and Contamination

Storage and Disposal of Farm Chemicals and Chemical Containers

Both Growers and State Agencies agreed that storage and disposal of farm chemicals is very important and improving over time. All legal chemicals used in horticultural industries are registered with the National Registration Authority. Adequate labelling on use and storage is an essential element of chemical safety.

The Spray Sense series (1995) of advisory leaflets gives useful case studies for container disposal in NSW. Case studies indicate that unwashed containers may contain up to 3 percent of chemical concentrate. Case studies of successful waste disposal sites for chemical containers can also be found in the Queensland shires of Wambo and Jondaryan on the Darling Downs.

The establishment of safe chemical collection and disposal areas assists industry to manage the storage and disposal of farm chemicals and chemical containers. For all regions where the State Agencies indicated their promotion of the establishment of safe collection areas, Grower responses indicate the adoption of this practice. The horticultural industries are also participants in the "Drum Muster" programs across agriculture.

Options for Plastic and Other Waste Disposal

Plastic sheeting and bags are classified as hazardous wastes in some States. In Queensland plastic is designated as having impacts on so-called "sensitive places" under the Environmental Protection Act. Many local authorities offer special disposal services, and Planning Guidelines recommend a buffer width of 150m between residential land and sites where incineration of wastes is undertaken.

Relevant research has been undertaken by Franklin, (1998) to design, develop and evaluate a practical and affordable compaction unit for on farm use to allow efficient handling of waste agricultural plastic material for acceptable disposal or recycling options. Olsen and Gouder (1998), have explored plastic mulch alternatives for intensive vegetable production in Queensland. Although prohibitively expensive relative to conventional methods, the biopolymer material Novamont being assessed, can be ploughed back into the ground where it biodegrades thus obviating the need for disposal (Olsen and Gouder, 1998).

4.2.6 Prevention and Management of Environmental Impact (Survey Findings)

The responses from survey results highlight the following key points:

- A greater proportion of Growers relative to State Agency responses supported the identified management practice. For example, 55 percent of Growers felt that "planned direction of planting" was a management practice that was used to control soil loss. This compared to 31 percent of responses received from State Agencies.
- Data limitations accepted, there is evidence to suggest that Growers are willing to consider implementing practices that ameliorate environmental problems. Typically only two or three main management practice responses were received for each environmental change element.
- The extensive body of ongoing research in the management of environmental practices in horticulture in conjunction with survey responses indicates that there is significant potential for horticultural industries to adopt sustainable farming practices.

Key Points

Soils

- Extensive research in IPM particularly in the larger horticultural industries such as Citrus, Bananas, Pome Fruit, Potatoes and Tomatoes is encouraging. Further research is required to quantify adoption of IPM practices. Broad based support by industry to quantify IPM adoption rates is a major challenge for the industry, particularly in the vegetable industries.
- There are increasingly strong linkages between horticultural industry bodies and national agencies. eg. Funding collaborations between HRDC and LWRRDC.
- Although considerable national research is occurring in soils management generally, there is no evidence of horticultural specific research in North Queensland where survey responses combined with documented high rainfall intensity suggest that soil issues are significant.

Water

- Horticulture specific research in ground and surface water salinity, and chemicals in irrigation water is focused predominantly in the Lockyer Valley (QLD), Riverland (SA) and the Mallee region of Victoria. Despite the documented water problems in the Murrumbidgee Irrigation Area, there is little evidence of horticulture specific water research in this region.
- Horticulture needs to increase ongoing research participation with larger national environmental research and development institutions in water and soil environmental projects. Recent evidence confirming the establishment of stronger linkages between horticulture and key national resource management agencies is encouraging.

Biodiversity

- Biodiversity indicators are considered to be of lower priority than soil and water management indicators. Conservation of native bush land and riparian vegetation areas will remain a significant priority in a national context. It is anticipated that as the competition for land resources intensifies, land transfers will flow to those industries with the most sustainable long-term economic returns. It is therefore expected that future expansion in horticultural production will mainly occur on existing agricultural land rather than in remnant native environments.

Air and Noise

- Noise is not regarded as a significant environmental issue for Horticulture.
- Air quality is being improved through improving the management of spray drift. The adoption of reduced chemical applications, improved spray application techniques, and the development of improved spray technologies, are activities currently being undertaken in horticulture, particularly in the pome fruit industries. Extensive ongoing research to develop integrated pest and disease management solutions across many horticultural industries indicate a general trend toward reduced spray application of farm chemicals.

Waste and Contamination

- Improved disposal of waste and the exploration of biopolymer and biological ground cover options are encouraging. However, the current costs of adoption are considered prohibitive at this stage.

4.3 Managerial Skills

Historically there has been very little research of employment levels, age distribution and training undertaken in horticultural industries. ABARE has conducted considerable research of employment trends at Agriculture level, but virtually no detail pertaining to horticulture employment exists. Discussions with ABS and ABARE indicate that funding to capture this data has not been made available across most horticultural industries. ABS selectively collects data on the farm performance of horticulture industries as a part of its Agricultural Finance Survey (AFS) where crop specific data is collected for the pome fruit, citrus, and kiwi fruit industries. People are an industry's most valuable resource. Higher priority should be given to the measurement of employment and demographic trends, to facilitate improved management of skill development levels and to improve the accuracy of employment contributions from an industry context.

The implementation of practices and new technologies to prevent, or rectify environmental degradation is a measure of commitment by Growers to sustainable production. Improved skill levels lead to increased awareness, adoption and implementation of effective sustainable farming. These are developed through formal education and participation in training programs. The analyses below report on the results of the Grower survey conducted as part of this study and include the level of education of Growers and their employees, participation in farm planning and training programs, and the level of adoption and implementation of good management practice.

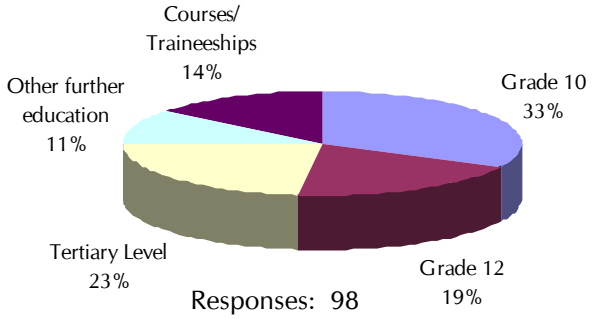
Also reported is the extent of participation in coordinated product marketing, an indicator of Grower recognition of the importance of collective approaches to accessing the most viable and profitable market streams.

4.3.1 Education and Skills Level

Education and management skill at all levels of management drive enterprise viability and sustainable resource management. The assessment of education and training levels will provide a summary insight into the current understanding of this most important driver. Variation in skill levels can be explained to a degree by the seasonality of horticultural production where growing systems are naturally not suited to sustaining employment year round. The following analysis will assist in quantifying education levels in horticultural industries.

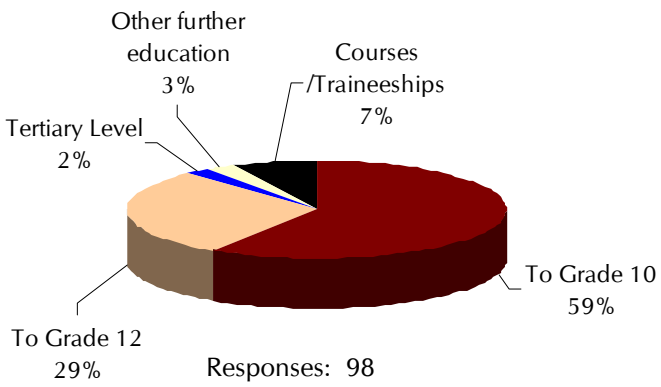
Figures 4.1 and 4.2 show that education levels were significantly higher for owner/managers compared to employees. Twenty three percent of owner/managers had completed tertiary education compared to only 2 percent of farm employees. Completion of other further educational courses was also significantly higher for owner/managers. These results highlight the growing importance of formal education to securing positions of higher responsibility. This trend will continue as the complexities of balancing the more demanding commercial relationships with sustainable resource management increase.

Figure 4.1 Education Levels Among Operation Owners/Managers



Graphs Source: Survey Data, 1999

Figure 4.2 Education Levels Among Farm Employees



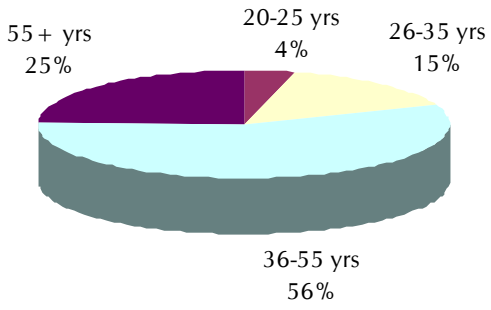
Age Distribution

Australia's agricultural workforce is declining in numbers, and increasing in average age. This is directly related to a decrease in the number of agricultural enterprises. ABARE (1997) statistics indicate that the number of agricultural farm enterprises has fallen by a third since 1980, to 116,000.

The age structure of the workforce is related to managerial skill levels, particularly with regard to sustainable natural resource use practice. The increased ability of farmers to effect change in response to pressures (e.g. seasonal, climatic, market), increases their ability to appropriately manage their underlying natural resources (SCARM, 1998).

Figure 4.3 shows that the greatest percentage of horticultural enterprise owners and managers is between the ages of 36-55. A large proportion of owner / managers (25 percent) are over the age of 55, whilst only 4 percent are between the ages of 20-25. Figure 4.4 indicates a similar age distribution for farm employees.

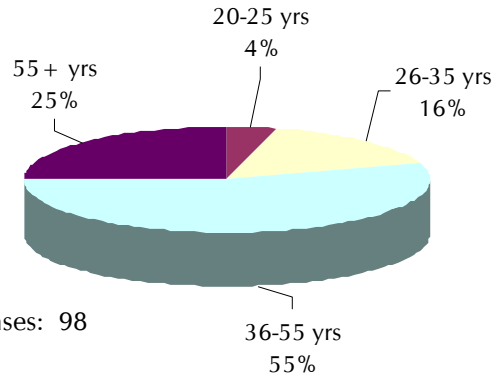
Figure 4.3 Age Distribution of Farm Operations Owners / Managers



Responses: 94

Graphs Source: Survey Data, 1999

Figure 4.4 Age Distribution of Farm Employees



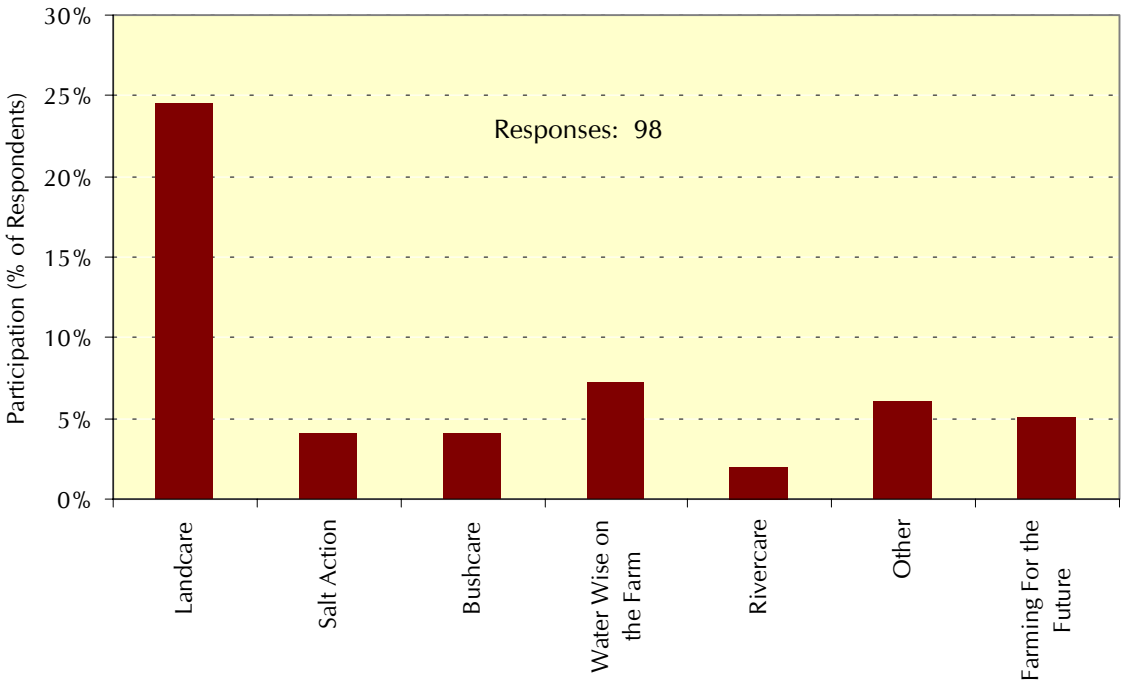
Responses: 98

4.3.2 Participation in Resource Management / Farm Planning Programs

Active affiliation and participation in resource management programs is an indicator of Grower awareness of agricultural practices that may improve the long-term viability and profitability of horticultural production. Analysis of participation in training programs such as Landcare and Farming for the Future does not attempt to predict the extent of adoption of these practices. However increased awareness of industry resource management programs is highly likely to be a precursor to future adoption of sustainable management practices. Research undertaken by the Fertiliser Federation of Australia in 1994 confirms this linkage. Data on the extent of participation in resource management programs is reported by ABARE Farm Surveys Report (1997), but is limited to responses from the broadacre and dairy sectors. SCARM (1998) reports that more intensive agricultural and horticultural industries may have a greater participation rate in training than the broadacre and dairy sectors, but a lack of data restricts this analysis.

Results of the Grower survey showed that 43 percent of all respondents participate in resource management programs. Landcare attracted the largest support (25 percent of respondents) (Figure 4.5). Other programs with lower but still significant support are water, salt, and bush based management programs. These results suggest a growing industry realisation of the need for continual improvement in resource management practices.

Figure 4.5 Percentage Participation in Different Resource Management Programs



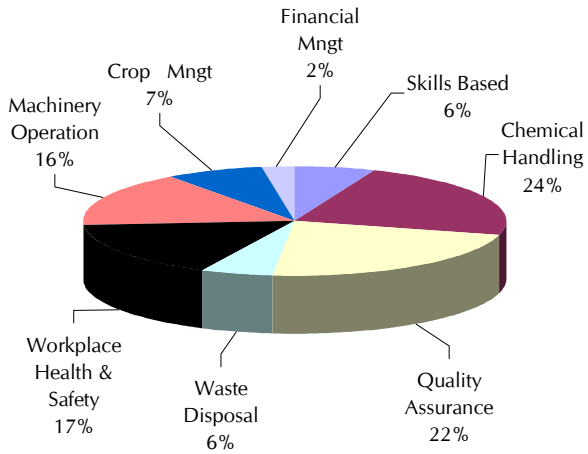
Source: Survey Data, 1999

Supply of Training Programs to Employees

Employer initiatives to provide employees opportunity to improve their skills levels through training programs is a positive step towards ensuring that the agricultural workforce is operating at the levels required to implement and maintain good management practices.

Figure 4.6 shows that employee training is supplied across many skills areas, with a particular focus on chemical handling (24 percent), quality assurance (22 percent), workplace health and safety (17 percent) and machinery operation (16 percent). Secondary priority training areas were crop management (6 percent), waste disposal (6 percent), skill development and financial management.

Figure 4.6 Percentage Respondents Supplying Training Programs to Employees



Responses: 94

Source: Survey Data, 1999

4.3.3 Level of Adoption of Good Management Practice

Recommendations of Good Management Practices by Industry

Grower survey respondents were unanimous in the assertion that industry organisations recommend good management practices (GMP). Results were compared to the level of GMP adoption by industry, and found adoption rates to be generally high. This finding contrasts with industry consultation and discussions which indicate that while GMP in principle is a concept that most industry organisations support, and there is increasing evidence of Code of Practice development, there is little evidence of the physical existence of formally adopted GMP programs in place at farm level.

Adoption and Implementation of Quality Assurance Programs

Sixty six percent of survey respondents were shown to participate in quality assurance (QA) programs. Based on discussion with industry this result is likely to be much higher than actual adoption rates. The incidence of documented QA based on industry discussion and consultation is estimated at less than 5 percent with a further 11 percent of the 20,000 horticultural enterprises in process of developing a documented system.

A quick review of the level of quality assurance documentation and adoption for horticulture is presented in Table 4.3.

Table 4.3 Horticultural Industry Quality Assurance

Estimated number of production enterprises.	20,000
Estimated number of QA certified production enterprises.	54 @ ISO 9002 550 @ SQF2000 70 @ AQIS Certification
Estimated percentage of enterprises with a documented QA system of some kind.	4%
Estimated number of enterprises who have, or are currently in process of documenting and adopting a QA system.	15%

Source: Independent expert opinions

The Australian Horticultural Corporation (AHC) and the Qld Fruit & Vegetable Growers (QFVG) independently advise that they believe around 15 percent of horticultural production enterprises are in the process of documenting a QA scheme for their business. These range across "Fresh Care", Approved Supplier Programs, and specific programs to meet buyer requirements.

Direct comparisons across industries are complex as industries often have a specific focus for their quality and environmental systems. For example the cotton industry has a clear focus on environmental on farm best practice in its "Good Neighbours" and BMP (Best Management Practices) programs (advice from Cotton R&D Corp.). Of the 1600 cotton Growers, only 1 is certified to ISO 9002, 34 have recently completed an independent audit of their BMP programs, and 96 percent have attended a BMP workshop and are variously working through a BMP manual. The cotton BMP program is specific to that industry.

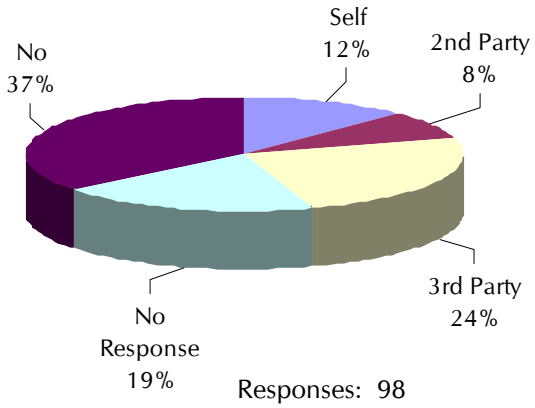
Codes of Practice workshops conducted jointly by HRDC and the RIRDC's Organic program in January 2000, suggest a number of existing horticultural environmental codes (e.g. pome fruit) are well established and with minor amendment would readily comply with certified organic status.

QA aims to establish food safe pathways across food value chains. Many variations of the HACCP concept have been established to provide varying levels of QA compliance. Although all schemes aim to deliver the same quality outcomes, implementation and ongoing management costs have constrained adoption rates. In the food marketplace of the future, premiums will flow to industry players who demand 100 percent adoption of QA programs across value chain boundaries. As the commercial interdependence of supply linkages becomes more important, industry will continue on going efforts to manage food safety risk.

Audit Type

Figure 4.7 shows that 3rd party audits were the most common method of maintaining the integrity of QA systems. The selection of larger more advanced Growers in the survey more than likely skewed the results in favour of 3rd party audits. Growers generally consider high cost a prohibitive factor in initiating farm operations audits, and self audited QA programs are likely to be the most common audit type among the horticultural sector. However, a larger proportion of 2nd and 3rd party audits are expected over time as independent auditing becomes mandatory in the market place.

Figure 4.7 Percentage of Survey Respondents Undertaking Farm Operations Audits

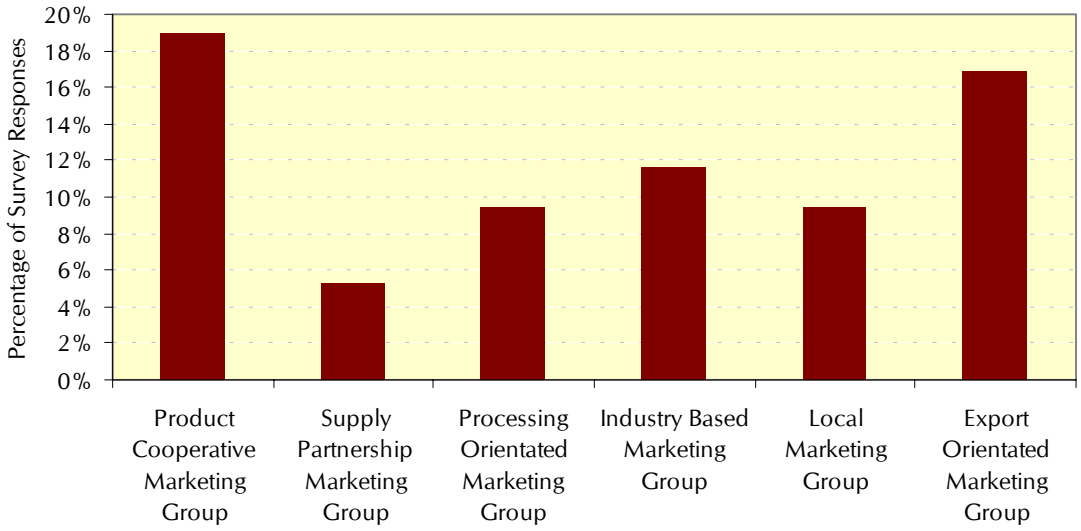


Source: Survey Data, 1999

Product Marketing

Marketing organisations have become more common as Growers, processors, value adders and retailers recognise the importance of collective approaches to the management and coordination of horticultural products. Figure 4.8 suggests that cooperative marketing structures are most common. Export based marketing arrangements are also popular and are likely to continue along this trend as export opportunities are secured by groups that are positioned to exploit Australia's comparative advantage in supplying safe, high quality horticulture to international markets.

Figure 4.8 Percentage Participation in Product Marketing Groups



Source: Survey Data, 1999

Key Points

- There is a lack of available employment data on horticultural industries. More support for the quantification of employment trends needs to be given by all crop sectors.
- Education levels and managerial skills are central to cultural change and increased adoption of GMP across horticulture. The ongoing rationalisation of enterprises and the move to external audits will support to move to increase awareness and adoption.
- GMP in principle is a concept that most industry organisations support, however there is little evidence of formally adopted GMP programs in place at farm level.
- Training of management and employees is becoming increasingly important. This trend will continue as the complexities of balancing the more demanding commercial relationships with sustainable resource management increase.
- An increasing trend in resource management programs indicates a growing industry realisation of the need for continual improvement in resource management practices.
- Indicative survey results suggest that the most common employee training areas are chemical handling (24 percent), quality assurance (22 percent), workplace health and safety (17 percent) and machinery operation (16 percent).
- Industry consultation and discussions indicate that less than 5 percent of horticultural enterprises have a documented quality assurance program, with a further 11 percent in the process of developing one.
- The incidence of documented QA based on industry discussion and consultation is estimated at less than 5 percent with a further 11 percent of the 20,000 horticultural enterprises in process of developing a documented system.
- Export based marketing arrangements are also popular and are likely to continue along this trend as export opportunities are secured by groups that are positioned to exploit Australia's comparative advantage in supplying food safe, high quality horticulture to international markets.

5 Strategic and SWOT Analysis

5.1 Strategic and Planning Outcomes

Three steps were taken in determining the strategic outcomes and recommendations emanating from Stage 1 of the environmental audit of the horticulture industry. These steps were:

- Selection of key environmental indicators;
- consultation with independent industry experts, and;
- SWOT analysis.

Interpretation of the industry consultation, SWOT analysis and other Stage 1 findings enabled key strategic indicators to be identified. These indicators form the basis for recommendations contained in Section 6.

5.1.1 Selection of Key Strategic Environmental Areas

The identification of key strategic environmental areas will be drawn from the summary analyses completed in Sections 2, 3 and 4. Table 5.1 presents the classification of summary environmental issues classified into key strategic environmental areas.

Table 5.1 Classification of Summary Data into Key Strategic Environmental Areas

Summary Issues	Key Environmental Area
Section 2. Horticultural Industry Profile	
Economic/financial and environmental priorities need to be balanced. This will be facilitated through the effective measurement of both financial/economic and environmental performance at farm level to effectively monitor the benefits and costs of environmental management change.	**Resource Sustainability**
Sustainable global competitiveness will be achieved in the future through the effective participation in global chains.	**Export Markets**
Legislation impacting horticulture is increasing beyond the control of individual enterprises and crop groups. Larger better managed organisational structures are emerging.	**Urban Encroachment and Resource Sustainability**
Section 3. Status and Trend in Natural Resource Condition	
General agreement on the relative significance of environmental issues. Differences in the perceptions of trends in soil and water issues.	**Resource Sustainability**
Further specific research (by region and crop type) in environmental issues should be pursued.	**Resource Sustainability**
Points of difference in the trend analysis of environmental issues relate specifically to soil and water based issues.	**Resource Sustainability**
COAG Water reform will allow horticulture to be competitive and efficient water users relative to other agricultural industries.	**Resource Competition**
Section 4. Resource Management Practice and Issues	
Extensive research in IPM particularly in the larger horticultural industries such as Citrus, Bananas, Pome Fruit, Potatoes and Tomatoes is encouraging.	**Resource Sustainability**
More horticultural specific research required in North Queensland where survey responses combined with documented high rainfall intensity suggest that soil issues are significant.	**Resource Sustainability**
Horticulture specific research in ground and surface water salinity, and chemicals in irrigation water should be linked into similar programs in the MIA.	**Resource Sustainability**
Increase ongoing research participation with larger national environmental research and development institutions in water and soil environmental projects.	**Resource Competition**
Conservation of native bush land and riparian vegetation areas will remain a significant priority in a national context.	**Biodiversity**
Reduced chemical applications, improved spray application techniques, and development of improved spray technologies.	**Offsite Pressures**
Improved disposal of waste and the exploration of biopolymer and biological ground cover options are encouraging. However, the current costs of adoption are considered prohibitive at this stage.	**Resource Sustainability**

In order of priority, identified key strategic environmental areas are as follows:

- resource sustainability;
- resource competition;
- biodiversity;
- offsite pressures or trends;
- urban encroachment; and
- export markets.

5.1.2 Independent Expert Opinions

In determining a direction for strategic planning on 'whole of industry' matters, the consulting team sought comments on the above six strategic environmental issues regarding the future environmental performance of the Australian horticultural industry. Informed industry opinions were sought and recorded from:

- Dr Rip Van Velsen, Citrus Board of South Australia;
- Mr Gary Hullin, Austrade;
- Mr Doug McGuffog, Fertiliser Federation of Australia;
- Mr Paul Zeibath, Qld Fruit & Vegetable Growers;
- Dr Liz Humphreys, CSIRO Land and Water;
- Mr Greg Hooper, National Registration Authority; and
- Mr Brian Clarke, Murrumbidgee Irrigation Area Horticultural Council.

Given the specific expertise of the group and the nature of the 6 questions, not all respondents felt able to answer all questions. The following discussion summarises the responses.

Question 1. Considering the horticultural industry along its value chain, what are the two biggest challenges facing the horticultural industry in the next few years?

Meeting market requirements was considered the dominant challenge to industry. This will require ongoing close attention to product specifications, food safety and residues (especially in export products), and quality. In addition, the industry must increasingly seek and secure endorsement by overseas buyers of horticultures' environmental management systems. Debate on this matter has also been intensified due to the emerging GMO issue.

A second strong point was the need for industry to pay closer attention to environmental management - to do more than simply pay it lip service, as is often currently the case. Environmental management was considered to be a "sleeper" for the industry at present as the brunt of community concern is focussed (via the media) on the cotton and meat industries. Horticulture cannot continue to hide from this issue.

A further challenge was the capability for horticultural enterprises to remain viable and competitive in the face of world market liberalisation. Lack of sufficient scale of the export industry, of supply chains, and most enterprises within the industry, was considered a major limitation to remaining viable. Secure access to adequate water supplies of acceptable quality was considered by two respondents as a key element of long term industry viability.

Within the broader challenge of environmental integrity mentioned above, the panel generally recognised three issues:

- land clearing - with implications for industry expansion and carbon trading;
- chemicals and minor use issues – Chemical companies will not invest in research to develop and launch new products where the potential world market is considered too small to provide the sales. There is also little motivation to maintain registration on chemical products that face declining markets and rising community health concern (e.g. endosulphan). The national horticulture industry needs a strategy to identify the

solutions (chemicals, bioinsecticides, IPM, or mixes of these) which it must have ready to address future needs. What is essential, what is not, what gaps will there be?; and

- the impact of salinity on horticultural areas as it affects viability, environmental sustainability, and the communities' expectations regarding the appropriateness of systems used by enterprises to manage the natural resource base.

Question 2. How would you rate horticulture's environmental management against other agricultural industries?

Responses suggest a wide variability in opinion, due partly to less than full knowledge about what other industries are doing behind the industry face presented by the media. Cotton clearly has a high profile as a user of chemicals and water and is a high profile industry in need of environmental management change. Responses were as follows:

- "horticulture is ahead of other agricultural industries on QA issues but on a par with others on natural resource management issues";
- "I give horticulture a rating of 8 out of 10 – they will not move to 9 or 10 until the issues of water use efficiency in intensive horticultural cropping, Integrated Pest Management, and air pollution are addressed";
- "from a QA position, horticulture was behind other industries a decade ago, but has improved dramatically and now has a good standing compared to other industries. This has largely been due to the significant increase in acceptance of environmental issues as genuine enterprise management issues and the consequent influx of new skills to the industry to address these issues specifically for horticulture.";
- "by its very nature as a fragmented, national, intensive, predominantly fresh, multi commodity industry, consistent environmental management in horticulture will be far more difficult than for all other agricultural industries.";
- "horticulture is going OK";
- "horticulture is ahead in water use efficiency management, but behind rice and cotton (at least) in land management and biodiversity";
- "horticulture is ahead of the livestock industries by a fair way, but a fair way behind grains, sugar and cotton."; and
- "horticulture is ahead of livestock and sugar, but not as advanced as cotton or rice".

Quality Certification can take many forms, suited to specific markets serviced by a specific enterprise.

Question 3. Does the industry's culture and / or human resources need to change to enable better environmental performance? If so, how?

All respondents agree there is a need for substantial cultural change among horticultural enterprise managers, employees and industry generally. All, however, recognise that this process has begun at various rates in differing regions, but generally appears to be moving too slowly.

The culture needs to change in both the rate of change and the scope of change. An economic motive / incentive is required to increase this rate of change to the rate required to meet community and customer expectations - and the scope of the cultural acceptance needs to be on a broader catchment by catchment basis (not just enterprise by enterprise). The aim must be to "get beyond the view that horticulture is the most efficient way to mine the natural resource base", and see horticulture as an industry based on production systems that are closely integrated with the natural resource base. The quicker there are economic incentives to horticultural enterprises to change practices, the quicker cultural change will flow through. This means re-considering the cost sharing incentives between actions resulting in private benefit and public good.

The large number of horticultural Growers across many commodity sectors and many land systems is at the heart of the cultural change challenge. One member of the panel noted that a study completed by the agricultural chemical industry in 1994 suggested that the cultural change in horticulture was going to be particularly difficult due to the relatively low affiliation level of the average horticultural Grower with industry organisations and environmental groups (eg Landcare). The study found that the low level of affiliation and therefore low awareness of environmental and natural resource issues was a primary indicator for subsequent low adoption of better environmental management practices.

The comment by one respondent summed up the general view – "horticultural people don't think about environmental performance until they are forced to – there is a lot of talk but not much action yet across the industry".

Question 4. Do you consider horticultural expansion to be constrained by markets, industry structure or natural resource limitations.

Most respondents consider markets constrain horticultural industry expansion. Central markets near large cities were considered to prop up a culture that kept horticulture in the fresh commodity industry rather than promoting supply chain efficiency and opportunities to move into food service and value added markets. It was noted that an estimated 70 percent of horticultural products are sold outside these central markets.

All respondents agree that the structure of the horticultural industry constrains its growth. This is as much a comment about the physical complexity of the industry across its landscape, as it is about the appropriateness of policies and organisational structures in the industry that have evolved and exist today. The sentiment from the panel was reasonably clear - the key to improving both structure and environmental performance is increased environmental awareness and economic incentives at the farm level.

Only one of the respondents considered the natural resource base to be a limit to industry expansion. Water was the scarce resource. The bulk of expert comments support the view that commercially available natural resources will flow to the bidder with the highest economic return. Horticulture is typically the food source that will maximise returns for the human, financial and natural resources available to most of the 20,000 horticultural farming enterprises. The general view was that horticulture could do more with the natural resource base it uses at the moment – ie. through increased efficiency. Such efficiencies would be delivered from improvements in cultivars, irrigation, fertiliser, harvesting, labour use, administration support and information access. As industry rationalisation progresses, (ie. a greater proportion of product volume coming from a smaller number of professional enterprises) the focus for farm practices will swing further toward better natural resource management systems.

One respondent cited societal limits on the right to farm, and endemic fruit fly infestations as significant long-term constraints on horticultural industry growth.

Question 5. In which commodity sectors and regions should expansion of the horticultural industry occur in future?

All respondents suggested key criteria for expansion, as it was not possible to indicate locations for expansion without a more complex discussion. However one respondent suggested a gradual move by horticulture toward subtropical and tropical climates in northern Australia.

Market demand was the primary criteria without which investment and expansion would not occur. This consideration was increasingly global as world trade barriers come down. Larger investors and integrated companies now develop production systems (eg. Chiquita bananas) to suit world supply alliances and markets, which tend to force smaller enterprises to seek expansion via niche products. Economic return based on forecast / actual market demand is central to industry expansion.

Technology was the other criterion cited as critical to horticultural industry expansion. Today the technology to manage the interface between the crop (and its waste streams), its interface with the natural resource base (eg. irrigation systems, soil tests), and the community (eg. tail water quality) can typically be bought off the shelf. The enterprise must provide the people and financial capacity to acquire and use technology. This will only be achieved for enterprises that have sufficient scale of operations to match and manage market demand, technology requirements, human skills, and financial capacity. The social implications of this technology adoption trend will have significant impacts on jobs in regional communities and social structures.

The project team is of the opinion that from a natural resource perspective, industry expansion is only constrained by markets, available cultivars and water, as annual and perennial crops can grow on most soil types. As pressure on natural resources increases, it is expected that horticulture will be in a position to make more economic use of available agricultural land, thereby expanding at the expense of less economically productive agricultural industries. Land areas targeted for future expansion will generally be further from highly populated areas as the trend in urban sprawl continues, and cold chain logistics are refined. The cost of transport and inputs as well as the availability of labour (for labour intensive crops) will all impact on horticulture expansion. As with any competitive industry, economics will play a major role in influencing where and when industry expansion will occur.

Question 6. Industry competition for resources (eg land and water) is increasing. Is horticulture prepared for this competition? What must it do to improve its competitive advantage?

The expert panel agreed that horticulture has come some way but has much further to go in the way it states its claim in the competitive bid for natural resources. The mechanism that achieves this allocation is, of course, the investment market – individuals buying and selling agricultural land or changing from one crop to another.

The common view was that the large number of smaller horticulturists who produce smaller volumes of product need to place more attention on the pricing of natural resources into their enterprise gross margin calculations. Whether it is a “sleeper” issue or not, enterprises must start to incorporate the economic cost of on and off site environmental impacts before community raises the cost of accessing natural resources (e.g. by forcing deregistration of chemicals).

Specific actions suggested by some respondents included the need for a single National industry body with strong leadership, and an ability to raise industry funds from voluntary levies / contributions.

5.2 SWOT Analysis

A SWOT analysis was conducted to build on the informed 'whole of industry' opinion. The following tables present an analysis of strengths, weaknesses, opportunities and threats for the horticultural industry with regard to environmental management. Each of the four elements is divided into three parts – industry, perennial crops / annual crops, and other matters, where relevant.

Table 5.2 Environmental Strengths of Horticulture

Environmental Strengths	How to Build on Strengths
Industry	
1. Resource Sustainability	
Low hazardous waste, in terms of processed by-product and accumulated production inputs (e.g. chemicals, fertilisers) relative to other rural industries.	Develop improved waste management and minimisation technologies and practices.
Crop species highly suitable to organic production systems relative to other agricultural industries.	Growing global market segment to be actively targeted and developed.
Ecological advantages of polycultural farming systems unlike large single species crops such as cotton, wheat or sugar (but most paddocks are still a monoculture in themselves).	Encourage mixed cropping environments within and beyond horticulture.
Intensive production systems – horticulture is an intensive agricultural activity. Intensiveness often motivates commercial operations and promotes adoption of sustainable resource management practices by providing money to fund initiatives.	Increased attention to the management of waste, farm chemical and nutrient loads in soils in regional locations.
Horticulture is located on some of the most productive soils in the Australia. These soils, if managed well, are generally more resistant to degradation than poorer quality soils.	Maintain and improve land management practices.
Low impact on air/climate due to relatively small production areas.	Maintain and improve ongoing practices that minimise emissions impacts.
2. Resource Competition	
Low investment requirements generally enable small businesses to enter the industry. However limited entry barriers are increasingly a weakness to industries where low quality commodity products tend to drag markets down. (The relative attractiveness of competing investments illustrates indirect competition for resources).	Provide information to ensure new industry entrants understand the full costs of both operational and environmental compliance practices.
Horticultural fresh produce is a relatively high value product and a commercially efficient user of increasingly scarce natural resources. Given that markets are available, as the commercial value of agricultural water (and quality land) increases, horticulture's relative competitive advantages and ability to compete for resources will be enhanced.	Encourage new horticultural enterprises that adopt a scale of operations that maximises resource use efficiency on a commercial basis.
Labour intensive – the regional location of industry production and processing provides employment and economy for many country centres. (This is an indirect effect of resource competition).	Provide infrastructure and incentives for producers and processors to base in regional centres.
Innovations in IPM provide horticulture with an advantage over other crops in gaining consumer acceptance of management practices.	Maintain competitive edge in IPM technology development.
3. Domestic and Export Markets	
Eco-friendly markets – consumers are increasingly seeking produce that is safe, residue free, and comes from sustainable production systems. Commercial horticultural enterprises are generally highly responsive to global market signals where they are accurately communicated along supply chains.	Industry should promote eco-friendly product attributes and related aspects of supply chain management systems.
Rising export intensity enables producers to spread marketing risks and adopt internationally competitive practices.	Develop and promote export marketing benefits to industry.

Rationalisation / reorganisation of central markets is being undertaken to more accurately reflect consumer market signals to all Growers, and shorten supply chains. This will help eliminate the commodity supply mentality in the industry.	Ongoing structural changes driven by industry and National Competition Policy.
4. Offsite Pressure	
As an environmentally sound industry horticulture is able to establish management systems to resist off-site pressures. These off-site pressures can take the form of urban encroachment, COAG water reforms, endangered species and regional forestry agreements. These changes are continually developing.	Continue to develop, implement and promote Good Management Practice and to keep a "watching brief" on external policy developments.
5. Urban Encroachment	
Horticulture is an acceptable periurban industry that is capable of operating within the constraints of the rural – urban interface.	Raise awareness of Good Management Practice amongst horticulturists bordering urban centres and continually aim to improve technology bases that minimises these effects (e.g. spray technology).
Horticultural producers now have an awareness that there is a need to maintain buffers and vegetation corridors.	Maintain awareness programs across industry and be watchful of government policy developments.
Horticultural industry is developing a growing awareness of IPM technologies.	Continue to support R&D into IPM so to minimise land use conflicts.
6. Biodiversity	
Growers now have an awareness that there is a need to maintain buffers and vegetation corridors and to establish links with existing biodiversity areas.	Continue to educate the industry and be watchful of government policy developments.
Multiple species suitable for mixed production across many landforms and environments.	Cropping and breeding strategies to balance environmental and commercial viability.
Good management practices, especially IPM, restrict negative impacts on adjoining landholders.	Continue upgrading IPM approaches.
Horticultural production is generally undertaken on small areas thereby limiting the area cleared and the impact on native flora and fauna.	Encourage regional planning processes to incorporate protection of biodiversity in high conservation areas and riparian zones.
7. Other	
Australian farmers, including horticulturists, have one of the world's highest rates of adoption for information technology. This would suggest, on average, that they are more aware of relevant technologies and market signals.	Identify sectors using information technologies and promote the benefits of these systems to all horticulturists.
Perennial & Annual Crops	
1. Resource Sustainability	
The more extensive areas of annual horticultural cropping are located on alluvial valley floors. These areas are generally stable but may suffer from degradation during erosive flooding events.	Develop and maintain coordinated floodplain management planning.
Management practices on steeper slopes have been developed that minimise environmental damage. Machinery adaptation has assisted in the sustainable utilisation of some steep slopes.	Machinery adaptation and improved agronomic techniques should be promoted.
2. Resource Competition	
Annual crops (dominated by vegetable species) are more efficient users of water resources in terms of water requirement/usage per given quantity of water applied than perennial crops. This generally results in greater returns for the same water volume applied.	Provide information to horticulturists on relative water use efficiencies and value adding opportunities.
Vegetable crops have low investment requirements - many smaller holdings result, thereby encouraging the retention of rural towns and social structures.	Good source of investment opportunity. New players need to be aware of changing management practices.

3. Domestic and Export Markets	
The diversity of perennial and annual horticultural produce enables targeted "clean and green" promotion to niche consumers who value this attribute highly. This advantage is not readily available to other fresh food industries.	Promote the clean green image based on a clear understanding of consumer profiles.
4. Offsite Pressure	
Perennial crops typically require larger initial investment requirements, over longer time frames. This investment risk profile encourages better environmental planning and practice.	Encourage business plans to incorporate environmental planning for sustainable and viable ventures.
5. Urban Encroachment	
No substantial strength identified.	
6. Biodiversity	
Perennial crops typically provide a more secure wildlife habitat due to their physical size and infrequent planting cycle.	Where economically and environmentally justified, integrate perennial tree crops into horticultural farm plans.

Table 5.3 Environmental Weaknesses of Horticulture

Environmental Weaknesses of Horticulture	How to Overcome Weakness
Industry	
1. Resource Sustainability	
There is no evidence of any national indicators or measures to assess and monitor horticulture's impact on the natural resource base and the environment.	Design and establish a national system based on mapping and monitoring impacts by production region. This approach will require sectoral and industry organisations to cooperate on a regional level.
Detrimental effect on riparian soils – deep alluvial soils have been / are lost or damaged as a result of vegetation removal for horticulture.	Ensure that catchment planning requirements are met when developing new valley production units. A risk assessment based on catchment planning outputs should determine the need for vegetation replanting and rehabilitation.
Possible uncontrolled / unmonitored use of chemicals.	Encourage industry groups to promote the adoption of IPM practices that are environmentally friendly.
Lack of coordinated databases is limiting industry strategic planning. The diversity of the industry (across crops, climates, soils, markets, financial capacities and skills) compounds this deficiency.	Support cross industry communication and shared contribution to data collection and collation protocols.
2. Resource Competition	
Resource competitiveness between industries and land uses will become more intense. Horticulture industry has a number of inherent characteristics that currently limit its ability to plan and manage this competitive challenge, including many small producers, wide crop and geographic diversity, general lack of critical mass at the production level, few barriers to entry to the industry, and opportunistic behaviour by some smaller producers.	Consolidate peak bodies and ensure strong sectoral participation in industry affairs. Larger supply chains should be encouraged in conjunction with QA and Good Management Practice in regions capable of supporting large production areas. In smaller areas, encourage more cooperative arrangements by way of better planning and industry incentives.
Farm selection and investment is not always completed as a business decision. The decision is often made for lifestyle reasons, by investors who come from outside horticulture.	Incorporate the cost of resource management into the investment analysis decision making when selecting a horticultural property. Educate Growers as to the real costs of property establishment.
Horticulture typically occupies sites with higher conservation values, e.g. fertile soils, proximate to water.	Determine land uses and farming systems in consultation with community and conservation lobby.
3. Domestic and Export Markets	
Consumers expect horticultural products to be fresh and safe. This places the industry at great risk of environmental backlash when expectations re food safety and chemicals, etc are not met.	Ensure that producers can guarantee food safety standards of their products.
Inequitable market competition internationally with other countries that have lower environmental standards.	Identify international environmental performance criteria related to key markets. Encourage all exporters to achieve minimum environmental performance criteria for markets where consumers value these attributes.
Demand for fresh produce puts some remote production areas (much of Australia) at a market disadvantage compared to non-perishable products.	Develop appropriate logistics and cold chain management.
4. Offsite Pressure	
Uncontrolled off-target applications of horticultural chemicals, noise and dust cause conflict with employees, and neighbours and have potential to lead to residue contamination downstream, in a region, or in the food chain.	Develop and apply Good Management Practice to minimise movement of sediment and pesticide off farm.

The small scale and intensive nature of horticulture means it is very difficult to identify individual enterprise non compliance with practices that result in adverse offsite catchment-wide impacts.	Pursue industry awareness, education and self regulation as the basis for enterprise compliance to environmental codes.
5. Urban Encroachment	
Proximity to cities increases land values.	Select cropping systems and agricultural products that are cost effective.
Proximity to cities increases potential for land use conflict.	Select cropping systems and management that incorporate buffers and minimise spray drift, elevated noise levels and contaminated run off.
6. Biodiversity	
Loss of valley floor biodiversity – rich valley bottoms have traditionally been totally cleared to allow for creation or expansion of new horticultural industry. This is not an issue for the modern industry as new lands acquired for expanded horticulture will be predominantly from reallocations from existing agricultural uses.	Industry to introduce environmental programs and biodiversity restoration programs, such as replanting of key riparian / buffer areas and protection of existing conservation areas in traditional horticultural areas. The industry may consider a "green levy" to share the costs of implementing these restoration programs.
7. Other	
Good Management Practice (GMP) is supported as a concept by nearly all horticultural Growers. Industry responses suggest GMP is a modest 43% in horticulture industry. But there is very little evidence in the industry that environmental or GMP systems are actually documented or adopted.	Encourage GMP through an active national horticultural code promoted by industry and governments.
Commodity mentality (limited GMP, low documented QA adoption at 4%) is still evident among too many producers.	Strengthen the economic signals that will motivate cultural and practice change.
Fragmented and generally low adoption of quality assurance systems. (industry advice suggests 3000 enterprises out of 20,000 nationally).	Current rationalisation and additional economic incentives should be given higher priority to encourage adoption.
Large number of smaller Growers in the industry prescribes a slow cultural change in the absence of economic stimuli. Likely low levels of affiliation by these horticulturists with industry and resource management groups means that awareness of issues is too low to drive cultural change.	Increase industry awareness of environmental issues and on and off farm impacts.
Lack of linkage between GMP as an improvement system, and industry R & D programs. While there appear to be a large and growing number of environmental R&D projects underway and planned, there are very few that have direct linkages to specific horticultural commodities or regions.	While R&D is increasingly proactive in the industry, GMP is perceived as an impost not an opportunity to establish a better management system. Advantages of GMP must be emphasised. Clearer stronger linkage between R&D investment in horticultural and regional environmental projects will likely lead to improved GMP adoption and cultural change by producers.
Value adding within the horticultural industry is limited by the high proportion of product preferably consumed fresh. Value adding is therefore typically a packaging and presentation matter only. Disposal of the considerable volumes of packaging and any processing byproducts must be managed.	Some "minimally processed" opportunities exist to service time poor consumers – (salads, fruit pieces for food service). Innovation is required to minimise packaging pollution.
Variable awareness of, and economic capacity to acquire and adopt latest horticultural and natural resource management technologies.	Increased awareness of the benefits and costs of technology adoption at Grower level.
The structure of the horticultural industry continues to evolve. Industry is yet to establish a clear single agro-political voice with governments and its own Grower members.	Industry driven horticultural umbrella organisation needed with the capacity to represent all industry sectors.

Perennial & Annual Crops	
1. Resource Sustainability	
Non degradability of some inputs – plastics used in bed formation and chemical containers.	Encourage adoption of cost effective biodegradable product inputs and reuse / recycling.
Repeated cultivation results in break down of soil structure over time, leading to soil hardening, surface crusting, loss of organic material and water impermeability.	Better soils monitoring and management practices.
Minimal / low organic matter recycling compared to some other agricultural industries where stubble, trash or manures are used. This results in higher inputs of artificial fertiliser nutrients, where legumes are not included in the crop cycle.	Monitoring of fertiliser inputs according to a set of industry endorsed environmental indicators. Increased use of green manuring into crop rotations. Encouragement of principles of organic farming where applicable.
Annual crop fertiliser inputs are typically higher than for perennial crops, resulting in higher potential for nutrient accumulation in soils and ground water.	Monitoring according to a set of industry endorsed environmental indicators.
Soil loss rates are higher for annual crops than perennial crops on sloping ground.	Monitoring according to a set of industry endorsed environmental indicators. Encourage better land management practice adoption.
2. Resource Competition	
Most annuals have a higher water requirement than perennials.	Manage the impact of water prices and water security via crop gross margins.
3. Domestic and Export Markets	
No substantial weakness identified.	
4. Offsite Pressure	
Growers of perennial product are generally larger production units and are located on more exposed positions in the landscape.	Develop regional responses to offsite and downstream effects (eg buffer network, coordinated spraying).
Inconsistency of environmental approach leads to difficulties in identifying polluter if downstream values are affected.	Develop consistent environmental standards for both annual and perennials.
5. Urban Encroachment	
Air (dust) and noise (vehicle) pollution and nuisance are increased through the annual crop cultivation cycle. Land use conflict with off site social impacts exists, particularly in production areas.	Encourage use of buffer zones and informing new neighbours of operations.
6. Biodiversity	
Perennials provide more stable and secure wildlife habitat and are therefore more prone to damage from wildlife.	Adopt wildlife management strategies endorsed by industry codes of practice.

Table 5.4 Environmental Opportunities for Horticulture

Environmental Opportunities
Industry
1. Resource Sustainability
Opportunity to establish a coordinated database for production and environmental performance. This will most likely operate on a regional level.
Opportunity to establish management practices for waste control on farms – especially with regard to used chemical containers and non biodegradable inputs.
Opportunity to develop environmental performance criteria for individual crop sectors to strive for in their environmental management.
Opportunity to incorporate elements of organic farming systems to assist environmental performance, while enabling enterprises to access niche markets that value organic attributes.
Opportunity to incorporate biosolids and acceptable urban wastes into horticultural production systems.
Opportunity to establish improved practices and / or products that overcome the issue of non-degradable inputs such as plastic wastes.
2. Resource Competition
Opportunity to expand production (in response to export demand) in tropical northern Australia through adoption of latest technologies and good management practices.
Opportunity for the national horticultural industry to establish a system of mapping and monitoring of industry use and impacts, by agro-ecological region and regions where data exists.
Opportunity to establish clear riparian buffer zones to sustain ecological functions in all new horticultural expansion / development zones.
Opportunity to work with other agricultural industries to establish a cooperative approach to environmental management on a regional basis. Over time this will ensure the effective catchment wide planning of environmental performance and therefore resolve most proximate offsite impacts.
Opportunity to encourage horticultural enterprises to factor environmental and natural resource costs and benefits into gross margin calculations.
3. Domestic and Export Markets
Opportunity to promote high value products that embody environmental benefits (eg organic, or chemical free) to targeted niche markets – new and existing.
4. Offsite Pressure
Global greenhouse impact will allow horticulture to demonstrate its flexibility and ability to produce healthy food sustainably under changing circumstances.
Opportunity to actively contribute as a united industry to water reform through the national COAG process to secure the best resource access terms for horticulture. Be aware that there will be regional wins and losses as a result of the COAG process and key horticultural regions may suffer loss of access to resources as a result. Trends in water use efficiency place it favourably to compete with other industries that rely on water for irrigation purposes.
5. Urban Encroachment
Opportunity to work with and through community groups to manage urban encroachment issues.
6. Biodiversity
Horticulture can continue to address its pest and disease load - make full use of biological controls, such as bioinsecticides, Integrated Pest Management programs, etc. and other treatments that provide solutions compatible with sustainable production systems. These are well advanced in other industries (e.g. sugar and cotton).
Expansion of salt tolerant crops such as dates through targeted research programs.
7. Other
Opportunity to establish a cohesive industry based organisation to manage horticultural industry issues, raise the awareness nationally of horticulture's role in the environment and remove prevailing sectoral fragmentation.
Electronic tracking systems for food safety are emerging across the livestock food industries. Horticulture industry needs to be part of this worldwide food industry process, particularly where tracking systems can also be used to target key product attributes at high value environmentally motivated consumers. Genetically modified foods are also relevant to this capability.
There is a generally accepted view by experienced observers that industry has made good progress in environmental management over the last decade. However there is concern that existing industry structure and culture, and ongoing low affiliation especially by smaller enterprises to industry and R&D resources will constrain further progress. There is an opportunity to minimise these constraints and enhance environmental adoption and performance.

High potential for sustainable use of GMO's – opportunity to encourage relevant corporate activity and R&D investment and demonstrated health safety.
Opportunity to increase value adding particularly where it supports regional Australian economies and employment.
Opportunity to increase use of technology at all levels to improve efficiency of resource use.
Opportunity to increase adoption of Good Management Practices and QA systems.
Opportunity to improve environmental training and skill development at all levels with an emphasis on the production sector.
Opportunity to self regulate industry environmental management activity in conjunction with Government.
Opportunity to gain a larger share of irrigation allocations as the best value adding rural industry.
Opportunity to expand horticultural production of salt tolerant species into drier areas using ground water.
Perennial & Annual Crops
1. Resource Sustainability
By their nature, perennials offer more stable production and harvesting systems. Encourage codes of practice that recognise and favour perennials in sensitive environments. These sensitive environments include erodible areas, complex landforms, high intensity rainfall areas and physically limiting (eg rock, poorly drained) areas.
2. Resource Competition
Time lag in establishing perennials reduces their short term competitiveness for resources. This will promote use of more effective and longer horizon planning by professional horticultural enterprises.
3. Domestic and Export Markets
Annuals offer opportunity for rapid responses to new market opportunities.
4. Offsite Pressure
Global greenhouse impact will favour perennial (dominated by tree crops) horticultural species rather than non-tree agricultural annuals or crops due to the carbon credits that will be attracted to new tree plantations.
5. Urban Encroachment
Perennials offer a more stable resource use for sensitive urban margins.
6. Biodiversity
Perennials offer more varied and permanent habitat.

Table 5.5 Environmental Threats facing Horticulture

Environmental Threats
Industry
1. Resource Sustainability
Gradual decline in the productivity of environmental resources (e.g. soils) reducing the viability of horticultural production.
Gradual decline in the availability of environmental resources (e.g. soils and water) reducing the viability of horticultural production.
Lack of industry leadership and coordinated planning to drive toward sustainable resource management and environmental practices.
2. Resource Competition
Strong and increasing competition from other industries for natural resources e.g. cotton and sugar. This may result in legislative changes that reduce access by agriculture to resources, especially water.
Decline in available water reserves for broadacre and horticultural production systems. Water resources will flow to users with the highest value use. Relative ability to pay for water will typically be subject to the uncertainties of commodity price cycles, thereby making farm planning more difficult.
3. Domestic and Export Markets
Withdrawal by overseas markets of support for environmental management practices by Australian horticulturists. Loss of export market access unless certain management systems are established. European inspectors have recently decreed operational standards for Australian meat, onion and organic exports to Europe.
Uncertainty associated with GMO's confuses consumers and could reduce market acceptance and / or growth.
Food safety concerns. Growing future requirements for traceability across all food value chains. If traceability is not achieved both domestic and export markets could be lost. Prepare for future market changes by investing in supply chain development and management and trace back systems. Explore the experiences of other food industries.
4. Offsite Pressure
Global greenhouse impact will require horticulture to develop new cultivars to suit changed environmental circumstances.
Government will regulate industry activity in the use of water, soil, and waste management to ensure environmental sustainability if industries do not. Horticulture industries must take control of the management of industry practices through the adoption of best practice programs across industry sectors.
Environmental issues are currently a "sleeper" for horticulture. Media attention is currently more focussed on the cotton industry, but all industries will have to adopt environmental due diligence in the near future, notably in food safety.
Deregistration by governments or chemical companies of the key chemicals used by horticulture, in the absence of any sustainable alternative.
5. Urban Encroachment
Residential expansion, conflicts and land price increases above viable horticultural limits.
6. Biodiversity
Public empathy for pest animals leads to greater production losses.
7. Other
New pests and diseases that are increasingly resistant to traditional chemicals.
Climate change and natural disasters.
Oversupply of horticultural produce following globalisation and tariffs. Industry advice suggests that some parts of the Australian horticultural market may be as much as 20% oversupplied with adverse impacts on average prices.

6 Horticultural Environmental Priorities

This study has reviewed and analysed environmental impacts on the horticultural industry, and by the industry on other stakeholders and the resource base. Chapter 5 presents in detail the constraints and challenges for the industry now, and going forward.

But the strategic environmental priorities for the industry must be more encompassing and go beyond straightforward recommendations that are somewhat clinically based on the 6 key planning areas identified.

It is critical to consider these planning areas within a broader agripolitical and global marketing context within which the industry must operate. This context is shaped by the progress of the industry's evolution, its physical scale and scope, the strength and maturity of its leadership (people and organisations), the long term actions of competitors and its strategic responses, and the changing societal norms that determine what is an acceptable environmental impact today and tomorrow, and what is not. If we fail to link the SWOT outcomes to the industry's big picture, the priorities we set will not only be naive, they will be difficult to implement.

This study finds that the horticultural industry has a generally satisfactory environmental performance. In reaching this conclusion, we briefly consider the context for the horticultural industry's environmental performance, followed by a detailed list of strategic priorities drawn from Chapter 5.

6.1 Contextual Implications for Horticultural Industries

Contextual implications have regard for on and off site environmental impacts resulting from events and actions taken by consumers, the community, governments, and the industry itself. Their impact on the environmental performance of horticulture will typically be at the macro level, it will be evolutionary over longer time frames, and it will be indirect in nature. The consequences resulting from a lack of industry action at the macro level will be no less severe than at the micro or enterprise level.

The stakeholders with the most influence on the fate of the industry are the Australian community, the bulk of whom are urban consumers of horticultural produce. Jointly, with export consumers, domestic consumers either endorse and authorise, or deny through the ballot box, the industry's right to husband the natural resource base on their behalf. Governments provide the fora for debate on these issues and facilitate the policy and legislative mechanisms to achieve compliance.

The influence of international communities and consumers on Australian public and trade policies will increase as globalisation progresses. Recent decrees by the European Union regarding the inadequacy of some aspects of the Australian meat and organic production systems are a recent example; accords on greenhouse gas emissions are a further example. Australia's relatively high export intensity means it will be very difficult for our governments to ignore these external influences.

Leading and Talking to Industry

The consulting team has not found anybody – Grower, stakeholder or other – who disagrees with the need for environmental sustainability. Along with most of agriculture, horticulture has moved to adopt a more sustainable position over the last two decades. This is the case from Growers at the enterprise level, through to the institutional and State Agencies. The industry is now generally prepared to listen, consider and look for benefits through adoption of better environmental practice.

Generally horticultural people (farmers, employees etc.) agree that in the long term better environmental practice is demonstrably good for farmers, for processors, for consumers, for governments and politicians and for the community at large. It is also good for the competitive sustainability of the Australian economy (we have little choice if we are to maintain and build our

intergenerational wealth). But any negative sentiments that were directed to the consulting team (and there were plenty) were more driven by fear borne from lack of awareness of the issues that are coming in the front door of the horticultural industry.

Good clear leadership is needed in horticulture – by people and organisations – to work with farmers, farm employees and processors to discuss issues and demonstrate benefits from greater awareness of environmentally driven practices. Only after the talking and the affiliation and peer group mechanisms are advanced, will the majority of industry participants switch on to implementing better practices that make farmers profits, provide safe food, and provide their customers and community with confidence in their production systems.

This is a far bigger challenge in horticulture than in other agricultural industries because of the large number of products, enterprises and potential natural resource impacts. Therefore it is logical that horticulture has to plan better and work harder as an integrated team to do something different to achieve the same level of awareness for key issues as other agricultural industries that are based on single commodities. To make real progress for their industry, horticultural leaders must be thinking of doing different things, not just doing the same things, differently.

Structure and Voice

The creation of a single national industry structure will enable industry to integrate its management functions and environmental management responsibilities, with its research and development skills and innovative capacity. Duplication of roles and tasks will be minimised. This will also be a single cost effective voice to talk to Federal and State governments and other overseas market or international government contacts.

At the next level the formation of strong national crop specific associations (e.g. AAPGA, ABGC, ASFGA, Strawberries Australia, Australian Passionfruit Industry Association, etc.) is critical. Without the industry specific participation there will be limited or only slow delivery and adoption of environmental practice programs. These organisations should be encouraged wherever possible, and assisted with industry wide templates for good practice design, awareness raising and improved practice delivery. For example the study team have noted the numerous plaudits, within and outside Queensland, for the Farm Care Code of Practice developed by the QFVG. Larger professionally managed horticultural enterprises will move forward more readily as we are seeing in QA, (e.g. the strong growth in SGF2000 adoption) but the reality is it will be some time before the bulk of the industry moves to better environmental performance.

The industry associations have a unique viewpoint. They are in a position to consider all issues, variables and resources, plan the way forward, and act to integrate the needs of the other stakeholders (consumers, governments, catchment managers, etc.) with the needs of disparate producers for their specific commodity. What practices are relevant to melon Growers compared to citrus Growers?; what environmental research is best done for banana Growers with slopes in higher rainfall areas compared to annual lettuce producers that irrigate on flat valley bottoms?; etc.

But the best associations, structures and professional staff will achieve little without the integral support of key Growers and enterprise managers. Democratic industry associations typically end up with a good representation of Growers on their committees. Given the appropriate framework to work with by scientists and national industry leaders, these are the bodies most able to sort out how crop group and individual environmental practices should be promoted and developed in relevant catchments and farms. On this basis alone industry associations warrant the full support of the industry, governments, consumers and the community.

As this study has progressed it has become increasingly clear to the study team that the crop groups that have established organisational and communication structures and programs, have relatively higher Grower affiliation and awareness, and therefore exhibit the best environmental performance.

Linkages to Global Consumers

Australian horticulturists have traditionally been protected, with a relatively remote domestic market that is big enough for locally produced volumes at viable prices. But a number of industry leaders consulted by the study team confirmed that we are increasingly oversupplying our domestic markets with adverse and often unforseen impacts on price and enterprise return on investment (typically at the production end of the supply chain). While some farmers will not survive, the priority is to make sure that the survivors have best practice farms of sufficient scale based on competitive advantage, to service the domestic and international chain stores that will dominate world horticultural trade in the next 30 years.

The mantra has been around for some time – we need greater market demand to boost our scale of production and enable efficiencies that will only be found in large overseas consumer markets. To trade successfully overseas we must have a greater scale of operations and a closer understanding of what our overseas customers (and their governments) want and think of our production systems. In particular we want our production systems to be environmentally endorsed and preferred by these customers.

Part of the price we must pay to retain ongoing access to attractive export market demand is vigilant adherence to international trade protocols and overseas consumer/community preferences regarding the credence of our products and production systems.

6.2 Strategic Priorities

The horticultural industry, like any other agricultural industry in Australia, faces considerable environmental challenges. Stage 1 of the environmental audit identified a number of these challenges. It is on this basis that Stage 2 of the Audit and other environmental research and development activities will need to be conducted in order to acquire and / or retain a competitive advantage in the market place.

The priority actions are numbered for easier reference, but do not mean to imply priority.

Resource Sustainability

In order to satisfy community concerns, government requirements and long-term industry objectives for sustainability of natural resources, the following actions are recommended:

1. implement existing GMPs relating to land and water management;
2. develop GMPs for areas where deficiencies exist;
3. monitor the sustainability of implemented GMPs in terms of land condition and water quality;
4. further develop IPM as a strategy for minimising the application of pesticides;
5. undertake ongoing research and development into GMOs – their application to improved production, regional effects and consumer response;
6. conduct research and development into energy efficiencies on farm;
7. conduct research and development into degradability of farm inputs;
8. implement effluent and waste reuse strategies on farm;
9. develop indicators, monitoring programs and National databases to track resource sustainability performance;
10. facilitate adoption of organic systems where attractive; and
11. provide strong leadership and support to industry bodies facilitating environmental adoption.

Resource Competition

Horticultural industries are but one user of natural resources. The industry competes with other rural industries, urban centres and other non-agricultural users, for land and water. In order to compete within the existing environmental constraints, the horticultural industry must be able to demonstrate it can use its allocation sustainably. To this end, the following actions are recommended:

1. participate in COAG water reforms and input substantiated evidence to support water requirement claims based on efficiency;
2. provide gross margins and other information on the relative returns to water efficiency and value adding to horticulturists to promote increased water use efficiency within the industry;
3. tailor cropping and breeding strategies to balance environmental and commercial viability including consideration of horticultural expansion in tropical Australia;
4. promote mixed production suitable to the many varied landforms and environments throughout Australia to increase the amount of land considered suitable for horticultural production;
5. establish strong industry organisations to represent all industry sectors and manage industry matters, research and development, policy etc, to allow for a strategic approach to competition for land and water resources;
6. establish strong industry organisations to work with broadacre industries to establish a cooperative approach to environmental management and resource use;
7. promote use of recent technology at all levels to improve efficiency of resource use;
8. conduct research into the expansion of horticultural production into drier areas through the use of salt tolerant species irrigated by ground water;
9. promote due diligence and the adoption of GMPs to ensure that the industry is seen to be a 'clean green' industry; and
10. encourage integration across industry environmental planning on a regional or catchment basis

Domestic and Export Marketing

Environmental labelling is increasingly being used as a marketing tool, e.g. Forestry products that emanate from regions that can demonstrate that forestry operations are sustainable are marketed under an eco-label. Similarly, both export and domestic consumers are now requesting food products that are produced using sustainable practices. In response, the following actions are recommended:

1. research and develop GMPs that are demonstrably sustainable and that comply with local and overseas environmental requirements;
2. promote Australian "clean and green" organic and eco-friendly production systems and products where practical and appropriate;
3. develop protocols, including tracking systems, that demonstrate produce is safe and healthy;
4. jointly develop practical QA systems that are responsive to chain store requirements and that are practical in operation;
5. research and identify environmental standards required to produce changing product mixes eg Asian produce;
6. manage value adding operations so that impacts are not environmentally degrading; and
7. continually monitor export and domestic consumer expectations regarding environmental performance (e.g. GMO's).

Offsite Pressures

The Horticultural Industry operates within a framework of regions. These regions are comprised of whole or part sub-catchments. Development of natural resources for any use creates impact and it is the responsibility of resource users to manage offsite impacts of development. The

horticultural industry's offsite impacts relate to downstream effects and adjoining land use effects and the following actions are recommended:

1. research and implement GMP that minimise offsite impacts;
2. research wider application of IPM as a widely adopted practice;
3. research buffering requirements between horticulture and other land uses, including watercourses;
4. implement buffering strategies, including riparian corridors;
5. minimise waste generation on farm and at processing sites;
6. develop organic operations where practical and supported;
7. assist crop group associations to establish better management systems to identify and limit off-site impacts;
8. aim for consistency in managing off-site impacts for annuals and perennials;
9. actively contribute to research associated with carbon sequestration for perennial crops; and
10. actively participate in COAG water reform.

Urban Encroachment

Typically, horticultural production areas are developed near urban centres and near watercourses and supplies. Land use conflict is evident, particularly when intensive operations exist and where competing land uses are in close proximity. The following actions are recommended:

1. research and develop GMPs that minimise potential sources of conflict eg spraying operations, cultivation operations;
2. research and develop GMPs that satisfy environmental standards and EPA compliance requirements;
3. research buffering requirements between horticulture and other land uses, including watercourses and ensure relevant industry participants are made aware of issues;
4. implement buffering strategies, including riparian corridors;
5. develop and implement strategies that minimise waste production;
6. develop information packages for new residential landholders explaining normal horticultural practices, nuisance issues and effects on neighbours; and
7. establish local community groups to manage sensitive urban-farm interfaces.

Biodiversity

Retention of vegetated areas to maintain biodiversity values is of increasing importance to regional communities. Many areas contain rare and threatened fauna and flora species and fragmentation of their habitats reduce biodiversity values. In response, the following actions are recommended:

1. improve knowledge of areas containing high habitat and conservation values;
2. research and develop GMPs that minimise effects of environmental weeds, harmful species, exotic animals;
3. research and develop GMPs to restrict offsite impacts that result in the degradation of critical habitat areas;
4. research and develop strategies to protect riparian vegetation areas; and
5. where appropriate, encourage perennial crop use to preserve habitat for fauna.

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Horticultural Productivity & Sustainablility Project

Project No. AH98002

Appendices

Appendix 1 Project Information Fliers for Industry

Horticultural Research & Development Corporation

Horticultural Productivity & Sustainability Project

The Australian horticultural industry together with the Horticulture Research and Development Corporation (HRDC) funds research into all aspects of the horticultural production and marketing chain. In recent times there has been momentum from the horticultural industry and HRDC to commission projects that are relevant to a large section of the industry. As result, the Australian Horticultural Industries (AusHort) R & D Committee has been formed. The AusHort R & D Committee has agreed to commit funds to a project to assess the productivity and sustainability of horticultural industries across Australia. There has been no previous systematic attempt to conduct such a study from an industry perspective.

In principle agreement has been reached with the National Land and Water Resources Audit (NLWRA), a project funded by the National Heritage Trust, to jointly fund this initiative. Collaboration with State natural resource and agriculture agencies is also expected to yield information relevant to the project.

The outcomes of the project will be to –

1. collect information at both national and regional levels which demonstrates the benefits of Australian horticulture to the economy and society;
2. identify the strengths, weaknesses, opportunities and threats in environmental management in Australian horticulture;
3. strengthen industry's position to enable better policy and decision making and R & D planning through access to up to date information;
4. improve the basis for comparing horticulture with other rural industries;
5. gain an understanding of the capacity of industry members to adopt sustainable practices;
6. better position the horticulture Industry to negotiate on policy in respect to issues of national and international trade.

About the project

National Land & Water Resources Audit

A program of the Natural Heritage Trust

HRDC

Horticultural Productivity & Sustainability Project

Grower Survey

Dear Grower

The Horticultural Research and Development Corporation (HRDC) has instigated a project to undertake a study of the productivity and sustainability of Horticultural Industries across Australia. Macarthur Agribusiness in conjunction with Sinclair Knight Merz has been commissioned to undertake this project. You have been selected to participate in this project by contributing valued information.

The purpose of the study is to assess all aspects of horticultural production and natural resource use to identify key indicators of performance under the following areas:

- Financial and economic performance across horticultural industries and its contribution to local economies;
- Resource management practices, and;
- On and off site impacts, both positive and negative relating to horticultural production.

You will find a survey enclosed. It is very comprehensive in terms of the information and time commitment required to complete it. We greatly value your commitment to the project and the contribution that your response will make in building an information resource which will assist horticultural industries plan and measure future environmental performance to sustain the long term economic and ecological viability on horticulture in Australia.

Thank you for your contribution to the Horticultural Productivity and Sustainability Project.

Yours Sincerely

Brian J Newman

HRDC PROJECT MANAGEMENT TEAM

MACARTHUR AGRIBUSINESS

SINCLAIR KNIGHT MERZ

Appendix 2 Industry (Grower) Survey Form

MACARTHUR AGRIBUSINESS

SINCLAIR KNIGHT MERZ

HORTICULTURAL RESEARCH & DEVELOPMENT CORPORATION

Horticultural Productivity & Sustainability Project

Grower Survey

This survey is comprised of 4 Sections -

SECTION A -	**Locality and Crops Produced**
SECTION B -	**Horticulture Crop Specific Information For Largest Crop Produced (by Volume)**
SECTION C -	**Labour and Management Information**
SECTION D -	**Environmental Change Information**

The survey is very comprehensive, however it has been designed to minimise the time commitment required to complete it. If you would like to discuss any of the Questions, please contact:

Macarthur Agribusiness
Phone: (07) 3831 7330 Fax: (07) 3832 7298 E-mail: macagri@ozemail.com.au

How to Fill Out the Survey

1. **Complete Section A first.**
   - **Question 1. Time Period** ***(THIS IS VERY IMPORTANT)***
     The information you provide will be used in conjunction with data collected in the 1996 / 1997 Financial Year. If you have records for this year please provide information relating to this period in all sections of the survey. If you have records for other years, please indicate this in Question 1.
   - The remainder of Section A asks for your contact details, information about the type of horticultural crops you produce and information on the location of the property on which you grow these crops. ***All data you provide in this survey will be supplied to the Horticultural Research and Development Corporation (HRDC), however your name and address will remain confidential.***
2. **Section B.**
   - Section B covers production information specific to the ***largest crop you produce (by volume). You don't need to provide answers for the other crops you produce.***
   - All questions from Question 3 to Question 7B should be answered considering only one crop production cycle, even if you grow and harvest the crop more than once a year. ***(THIS IS VERY IMPORTANT)***
3. **Section D.**
   - Section D on environmental changes related to horticultural crop production is the last section to complete. This section only needs to be filled in once, irrespective of the number of crops you produce.
   - **Question 3A. Your Region** ***(THIS IS VERY IMPORTANT)***
     Please define the regional area outside your property boundary that you consider affects horticultural production on your property, and that may be affected by your horticultural production system. This area should be based on your expert knowledge and observation as a landholder.

We value your commitment to the project. Your responses will provide valuable information that will assist horticultural industries to measure and plan for long term economically and ecologically sustainable production. Thankyou for your contribution.

SECTION A - LOCALITY & CROPS PRODUCED

1. Time Period *(Please tick the box that relates to the time period for which you will be providing information THROUGHOUT this survey).* ***This is VERY IMPORTANT.***

- ☐ 1996 / 1997 Financial Year
- ☐ 1997 / 1998 Financial Year
- ☐ 1998 / 1999 Financial Year

2. Name of Respondent: _____

3. Organisation (If Any): _____

4. Property Location: Nearest Town _____

Distance from Nearest Town_____

Direction from Nearest Town_____

5. Postal Address: _____

Postcode: _____

6. Phone: _____ **Mobile:** _____

Fax: _____ **E-mail:** _____

7. What horticultural crops do you grow ? *(Please rank crops according to Volume of Production and indicate percentage of total production. Eg. Largest Crop: No.=1, %=60, 2nd Largest Crop: No.=2, %=40)*

Crop Name	No.	%	Crop Name	No.	%	Crop Name	No.	%
Almonds			Gherkin Cucumbers			Peas - Green		
Apples			Gooseberries			Peas - Green - Seed		
Apricots			Grapefruit			Peas - Snow		
Asparagus			Guava			Pecans		
Avocados			Hazelnut / Filberts			Pepinos		
Bananas			Honeydew Melons			Pineapples		
Beans - Broad			Jackfruit			Pistachios		
Beans - French/Runner			Leeks			Plums and prunes		
Beans - French/Runner-Seed			Lemon / Lime			Potatoes - Autumn/Spring		
Beetroot			Lettuce			Potatoes - Seed		
Bitter Melons			Loganberries			Potatoes - Sweet		
Blackcurrants			Longans			Pumpkin		
Blueberries			Lychees			Pumpkin - Seed		
Broccoli			Macadamia			Pyrethrum		
Brussel Sprouts			Mandarins			Radish		
Cabbages			Mangoes			Radish - Seed		
Capscium / Chillie			Marrows and Squashes			Rambutan		
Carambola			Nashi			Raspberries		
Carrots			Nectarines			Rockmelons		
Carrots - Seed			Nurseries			Silverbeet		
Cashews			Onions - Spring			Strawberries		
Cauliflower			Onion - White / Brown			Swedes		
Cauliflower - Seed			Onions - Seed			Sweet Corn		
Celery			Oranges			Tangelos		
Cherries			Parsnips			Tomatoes		
Chestnuts			Passionfruit			Turnips		
Chinese Cabbage			Pawpaws			Walnuts		
Chinese Cabbage - Seed			Peacharines			Water Melons		
Cucumbers			Peaches			Zucchini		
Custard Apples			Peanuts					
Garlic			Pears					

SECTION B - HORTICULTURE CROP SPECIFIC INFORMATION FOR LARGEST CROP PRODUCED *(As identified in Section A)*

1. How many crops per year would you grow ?

☐ One ☐ Two ☐ Three ☐ Other *(Please specify)*_____

2. In addition to growing this horticultural crop, are you involved in any of the following activities ?
(Please tick one or more of the following)

☐ Wholesaler ☐ Retailer ☐ Processor
☐ Exporter ☐ Other *(please specify)* _____

For Questions 3 to 7B following please provide your answers for a single crop production cycle only. (THIS IS VERY IMPORTANT)

3. Area of production _____ Ha

4. Production volume (Kg/T) _____ *(please specify Kg /Tonnes)*

5. Value of production ($) _____

6. Production Inputs

6A. What Fertilisers, and how much do you apply to this crop ?

	Fertiliser *(please specify product name below)*	**Amount Applied**	
1.	_____	_____	Kilograms
2.	_____	_____	Kilograms
3.	_____	_____	Kilograms
4.	_____	_____	Kilograms
5.	_____	_____	Kilograms
6.	_____	_____	Kilograms

6B. What Insecticides, and how much do you apply to this crop ?

	Insecticide *(please specify product name below)* **Amount Applied**		
1.	_____	_____	Litres
2.	_____	_____	Litres
3.	_____	_____	Litres
4.	_____	_____	Litres
5.	_____	_____	Litres
6.	_____	_____	Litres

6C. What Fungicides, and how much do you apply to this crop ?

	Fungicide *(please specify product name below)*	**Amount Applied**	
1.	_____	_____	Litres
2.	_____	_____	Litres
3.	_____	_____	Litres
4.	_____	_____	Litres

6D. What Herbicides, and how much do you apply to this crop ?

	Herbicide *(please specify product name below)*	**Amount Applied**	
1.	_____	_____	Litres
2.	_____	_____	Litres
3.	_____	_____	Litres
4.	_____	_____	Litres

7. Irrigation Use

7A. Do you irrigate this crop? ☐ Yes ☐ No

Please complete the following sections (Questions 7B to 7G) only if you answered "Yes" to this Question.

7B. What volume of water do you use to irrigate this crop ? _____ Megalitres

End of Questions relating to one crop production cycle only

7C. What irrigation methods do you use for this crop ? *(Please tick relevant boxes)*

- ☐ Overhead Spray
- ☐ Flood Irrigation
- ☐ Trickle Irrigation
- ☐ Other *(Please specify)* _____

7D. Where is your irrigation water sourced from ?
(Please tick relevant boxes and indicate the percentage acquired from each source)

- ☐ River / Creek _____ %
- ☐ Catchment Dam _____ %
- ☐ Ground Water Supplies _____ %
- ☐ Other *(Please specify* _____

7E. Is the quality of irrigation water adequate for this crop? *(Please tick one box)*

☐ Always ☐ Usually ☐ Sometimes ☐ Rarely ☐ Never

7F. How do you determine timing/volume of irrigation? *(Please tick relevant boxes)*

- ☐ Moisture Probes
- ☐ Leaf Analysis
- ☐ Set Intervals
- ☐ Gut Feel
- ☐ Other *(Please specify* _____

7G. Do you store irrigation water on-farm?

☐ Yes *If Yes,* Capacity _____ML ☐ No

If Yes, from where is this water sourced ? *(Please tick relevant boxes)*

- ☐ Allocation
- ☐ Water (Flood) Harvest
- ☐ Other *(Please specify* _____

SECTION C - LABOUR & MANAGEMENT INFORMATION

1. Labour

1A. How many People do you employ?
(Please average for the year and include Owner/Management and Family)

1. Full Time _____
2. Casual (part-time) _____
3. Seasonal _____

1B. Average age of Employees *(Please indicate number of Employees that fall into each Age Bracket)*

	1. Owner/Manager	2. Other Employees
15 - 19 yrs	_____	_____
20 - 25 yrs	_____	_____
26 - 35 yrs	_____	_____
36 - 55 yrs	_____	_____
55 yrs +	_____	_____

1C. Education and Skills of Employees
(Please indicate number of Employees that fall into each Category)

	1. Owner/Manager	2. Other Employees
Completed to Grade 10 Secondary	_____	_____
Completed Secondary (to Grade 12)	_____	_____
Completed Tertiary Education Study	_____	_____
Completed Other Further Education	_____	_____
Completed other courses/traineeships	_____	_____

2. Management Practices

2A. Do you participate in Resource Management Programs ?

☐ Yes *(Tick one or more in list below)* ☐ No

☐ Landcare ☐ Water Wise on the Farm
☐ Salt Action ☐ Farming for the Future
☐ BushCare ☐ RiverCare
☐ Other *(Please specify)*_____

2B. Does your Industry Organisation recommend Good Management Practices (GMP)?

☐ Yes ☐ No

If Yes, have you adopted and implemented this Industry GMP?

☐ Yes ☐ No

2C. Have you adopted and implemented a Quality Assurance (QA) program ?

☐ Yes *(Please specify Program)* _____

☐ No

2D. Are your farm operations audited?

☐ Yes ☐ No

If Yes, what type of audit is completed? *(Please tick relevant boxes)*

☐ Self ☐ 2nd party *(e.g industry representative)* ☐ 3rd party *(independent)*

2E. Do you actively market your product?

☐ Yes *(Please explain through what avenues)*_____

_____

☐ No

2F. Are you involved in a Marketing Group?

☐ Yes *(Tick one or more in list below)* ☐ No

☐ Product Cooperative ☐ Industry based

☐ Supply Partnership ☐ Local

☐ Processing Orientated ☐ Export Orientated

☐ Other *(Please specify)*_____

2G. Do you have in place a formal Training Program for your Employees?

☐ Yes *(Tick one or more in list below)* ☐ No

☐ Skills based ☐ Workplace Health and Safety

☐ Chemical Handling ☐ Machinery Operation

☐ Quality Assurance ☐ Crop Management - agronomic

☐ Waste Disposal ☐ Financial Management

☐ Other *(Please specify)*_____

3. Information Sources

3A. Where do you source information on horticultural related subjects ? *(Please tick one or more of the following and indicate the percentage of information received from each source nominated)*

☐ Neighbours _____ % ☐ Television _____ %

☐ Local Newspaper _____ % ☐ Radio _____ %

☐ Rural Newspapers _____ % ☐ Extension Officers _____ %

☐ Industry Bodies _____ % ☐ Government Departments _____ %

☐ Industry Publications _____ % ☐ Government Department

☐ Internet _____ % Publications _____ %

☐ Other *(please specify)* _____

SECTION D - ENVIRONMENTAL CHANGE INFORMATION

1. Property Specific Information

1A. What is the soil type on your property? *(Please tick one or more of the following)*

☐ Sand ☐ Sand or loam over clay subsoil ☐ Light clay

☐ Medium/Heavy Clay ☐ Other *(Please specify)*_____

If you know the actual name of the soil type/s please specify _____

1B. What is the topography of your property ?

☐ Flat ☐ Hilly / Steep

☐ Undulating ☐ Other *(Please specify)*_____

1C. Is there evidence of any of the following environmental changes occurring on your property ?
(If no, please tick the "no" box. If yes, please indicate the extent of occurrence by ticking the high, medium or low box. If yes please also tick the relevant box indicating the status of change).

Example

Environmental Change	No	Yes	Status of Change
1. Soil loss	☐ no	☑ high ☐ medium ☐ low	☑ improving ☐ deteriorating ☐ no change

- There is a high degree of soil loss on Farm A, however the rate of soil loss is decreasing through changes to crop production processes.

Environmental Change	No	Yes	Status of Change
1. Soil loss	☐ no	☐ high ☐ medium ☐ low	☐ improving ☐ deteriorating ☐ no change
2. Chemical accumulation in soil	☐ no	☐ high ☐ medium ☐ low	☐ improving ☐ deteriorating ☐ no change
3. Organic matter / soil structure decline	☐ no	☐ high ☐ medium ☐ low	☐ improving ☐ deteriorating ☐ no change
4. Nutrient levels and nutrient availability	☐ no	☐ high ☐ medium ☐ low	☐ improving ☐ deteriorating ☐ no change
5. Soil acidity levels	☐ no	☐ high ☐ medium ☐ low	☐ improving ☐ deteriorating ☐ no change
6. Soil salinity levels	☐ no	☐ high ☐ medium ☐ low	☐ improving ☐ deteriorating ☐ no change
7. Groundwater salinity levels	☐ no	☐ high ☐ medium ☐ low	☐ improving ☐ deteriorating ☐ no change
8. Surface water salinity levels	☐ no	☐ high ☐ medium ☐ low	☐ improving ☐ deteriorating ☐ no change
9. Chemical levels in irrigation water	☐ no	☐ high ☐ medium ☐ low	☐ improving ☐ deteriorating ☐ no change

1C. Continued

Environmental Change	No	Yes	Status of Change
10. Options for storing farm chemicals	☐ no	☐ high ☐ medium ☐ low	☐ improving ☐ deteriorating ☐ no change
11. Options / means for disposing of farm chemicals and chemical containers	☐ no	☐ high ☐ medium ☐ low	☐ improving ☐ deteriorating ☐ no change
12. Options / means for disposing of farm waste (eg. plastic, mulch)	☐ no	☐ high ☐ medium ☐ low	☐ improving ☐ deteriorating ☐ no change
13. Areas of native bushland being removed that would ordinarily assist with pollination functions	☐ no	☐ high ☐ medium ☐ low	☐ improving ☐ deteriorating ☐ no change
14. Areas of riparian (creek) vegetation being removed	☐ no	☐ high ☐ medium ☐ low	☐ improving ☐ deteriorating ☐ no change
15. Other *(Please specify)*		☐ high ☐ medium ☐ low	☐ improving ☐ deteriorating ☐ no change

1D. Are the crops you produce affected by the environmental changes occurring on your property ?
(Please indicate with a number on a 1 to 4 scale (1=not affected, 2= slightly affected, 3=moderately affected, 4=seriously affected) if the crops you produce are affected.

Example

Environmental Change	Scale Affected
1. Soil loss	4

- Soil loss is seriously affecting the yields Cucumbers on Farm A.

Environmental Change	Scale Affected
1. Soil loss	
2. Chemical accumulation in soil	
3. Organic matter / soil structure decline	
4. Nutrient levels and nutrient availability	
5. Soil acidity levels	
6. Soil salinity levels	
7. Groundwater salinity levels	
8. Surface water salinity levels	
9. Chemical levels in irrigation water	
10. Options for storing farm chemicals	
11. Options / means for disposing of farm chemicals & chemical containers	
12. Options / means for disposing of farm waste (eg plastic, mulch)	
13. Areas of native bushland being removed that would ordinarily assist with pollination functions	
14. Areas of riparian (creek) vegetation being removed	
15. Other *(specify same environmental change as in Question 1C no. 15)*	

2. Prevention and Control of Negative Environmental Impact

2A. What prevention or control measures do you adopt to minimise negative impacts on the environment ? *(Please tick the box that corresponds to the control measure you implement).*

2AB. Soil Loss

- ☐ contour banks
- ☐ planned direction of planting
- ☐ other *(please specify)* _____

2AC. Chemical Accumulation in Soil

- ☐ minimise use of chemicals
- ☐ apply chemicals according to specification
- ☐ other *(please specify)* _____

2AD. Organic Matter / Soil Structure Decline

- ☐ green manure cropping
- ☐ crop rotation
- ☐ addition of soil additives
- ☐ other (*please specify)* _____

2AE. Nutrient Levels and Nutrient Availability

- ☐ legume planting
- ☐ addition of fertiliser
- ☐ other (*please specify)* _____

2AF. Soil Acidity Levels

- ☐ reduce fertiliser applications
- ☐ apply lime
- ☐ other *(please specify)* _____

2AG. Soil Salinity Levels

- ☐ implement drainage works
- ☐ salt tolerant crops
- ☐ plant trees in recharge areas as point of catchment response
- ☐ other *(please specify)* _____

2AH. Groundwater Salinity Levels

- ☐ implement drainage works
- ☐ salt tolerant crops
- ☐ plant trees in recharge areas as point of catchment response
- ☐ other *(please specify)* _____

2AI. Surface Water Salinity Levels

- ☐ implement drainage works
- ☐ salt tolerant crops
- ☐ plant trees in recharge areas as point of catchment response
- ☐ other *(please specify)* _____

2AJ. Chemical levels in Irrigation Water

- ☐ property tailwater return/recycling
- ☐ chemical treatment of water
- ☐ other *(please specify)* _____

2AK. Chemical, Salt and Sediment Levels in Regional Creeks and Rivers

- ☐ regional tailwater/recycling systems
- ☐ catchment approaches (wetlands, treed areas)
- ☐ other *(please specify)* _____

2AL. Chemical Spray Drift

- ☐ control timing of applications
- ☐ modify/change spray equipment
- ☐ plant vegetation buffers
- ☐ other *(please specify)* _____

2AM. Dust drift

- ☐ control timing of cultivation
- ☐ reduce number of cultivations
- ☐ modify cultivation equipment
- ☐ plant vegetated buffers
- ☐ other *(please specify)* _____

2AN. Odour spread

- ☐ control timing of cultivation
- ☐ modify/change spray equipment
- ☐ plant vegetated buffers
- ☐ other *(please specify)* _____

2AO. Noise levels

- ☐ control timing of farming operations
- ☐ plant vegetated buffers
- ☐ other *(please specify)* _____

2AP. Native bushland

- ☐ retain remnant vegetation areas
- ☐ maintain a separation distance between crop and bushland area
- ☐ other *(please specify)* _____

2AQ. Riparian (creek) vegetation

- ☐ retain riparian vegetation
- ☐ maintain a separation distance between crop and riparian areas
- ☐ other *(please specify)* _____

2AR. Storing and disposal of farm chemicals and chemical containers

- ☐ establish safe collection areas
- ☐ establish safe disposal methods with authorities
- ☐ other *(please specify)* _____

2AS. Disposal of farm waste (eg plastic mulch)

- ☐ establish safe collection areas
- ☐ establish safe disposal methods with authorities
- ☐ other *(please specify)* _____

2AT. Other *(Please specify)* _____

- ☐ _____
- ☐ _____
- ☐ _____

3. Regional Information

3A. Your Region

(Please define the regional area outside your property boundary that you consider affects horticultural production on your property, and that may be affected by your horticultural production system). ***THIS IS VERY IMPORTANT.***

Regional Area _____ (Kilometres radius from your property boundary)

If you also know the Catchment or River System to which this region belongs, please specify below

Catchment or River System _____

3B. What are the major soil types in your region? *(Please tick one or more of the following)*

☐ Sand ☐ Sand or loam over clay subsoil ☐ Light clay

☐ Medium/Heavy Clay ☐ Other *(Please specify)*_____

If you know the actual name of the soil type/s please specify _____

3C. What is the topography of your region ?

☐ Flat ☐ Hilly / Steep

☐ Undulating ☐ Other *(Please specify)*_____

3D. Is there evidence of any of the following environmental changes occurring in your region ?

(If no, please tick the "no" box. If yes, please indicate the extent of occurrence by ticking the high, medium or low box. If yes please also tick the relevant box indicating the status of change).

Environmental Change	No	Yes	Status of Change
1. Chemical levels in creeks and rivers	☐ no	☐ high ☐ medium ☐ low	☐ improving ☐ deteriorating ☐ no change
2. Salt levels in creeks and rivers	☐ no	☐ high ☐ medium ☐ low	☐ improving ☐ deteriorating ☐ no change
3. Sediment in creeks and rivers	☐ no	☐ high ☐ medium ☐ low	☐ improving ☐ deteriorating ☐ no change
4. Incidence of chemical spray drift	☐ no	☐ high ☐ medium ☐ low	☐ improving ☐ deteriorating ☐ no change
5. Incidence of dust drift	☐ no	☐ high ☐ medium ☐ low	☐ improving ☐ deteriorating ☐ no change
6. Incidence of odour spread	☐ no	☐ high ☐ medium ☐ low	☐ improving ☐ deteriorating ☐ no change
7. Incidence of noise	☐ no	☐ high ☐ medium ☐ low	☐ improving ☐ deteriorating ☐ no change
8. Other *(Please specify)*		☐ high ☐ medium ☐ low	☐ improving ☐ deteriorating ☐ no change

3E. Are the crops you produce affected by the environmental changes occurring in your region ?

(Please indicate with a number on a 1 to 4 scale (1=not affected, 2= slightly affected, 3=moderately affected, 4=seriously affected) if the crops you produce are affected).

Environmental Change	Scale Affected
1. Chemical levels in creeks and rivers	
2. Salt levels in creeks and rivers	
3. Sediment in creeks and rivers	
4. Incidence of chemical spray drift	
5. Incidence of dust drift	
6. Incidence of odour spread	
7. Incidence of noise	
8. Other *(Specify as in Question 3D no. 8)*	

END OF SURVEY

THANKYOU FOR YOUR TIME

The valuable information you have provided will assist horticultural industries to measure and plan for long term sustainable and profitable production.

Please return this survey as soon as possible upon completion and by August 13th, 1999 -

1. FAX: (07) 3832 7298

2. REPLY PAID MAIL *(No Stamp Required)* :

REPLY PAID 76
Macarthur Agribusiness
GPO Box 2452
Brisbane Qld 4001

Appendix 3 Nursery Producers Survey Form

MACARTHUR AGRIBUSINESS

SINCLAIR KNIGHT MERZ

HORTICULTURAL RESEARCH & DEVELOPMENT CORPORATION

Horticultural Productivity & Sustainability Project

Nurseries Survey

This survey is comprised of 4 Sections -

SECTION A -	**Locality and Horticultural Crop Species Grown**
SECTION B -	**Horticulture Crop Specific Information for Largest Crop Product Grown**
SECTION C -	**Labour and Management Information**
SECTION D -	**Environmental Change Information**

The survey is very comprehensive, however it has been designed to minimise the time commitment required to complete it. If you would like to discuss any of the Questions, please contact:

Macarthur Agribusiness
Phone: (07) 3831 7330 Fax: (07) 3832 7298 E-mail: macagri@ozemail.com.au

How to Fill Out the Survey

4. **Complete Section A first.**

- **Question 1. Time Period** ***(THIS IS VERY IMPORTANT)***
  The information you provide will be used in conjunction with data collected in the 1996 / 1997 Financial Year. If you have records for this year please provide information relating to this period in all sections of the survey. If you have records for other years, please indicate this in Question 1.
- The remainder of Section A asks for your contact details, information about the type of horticultural crops you produce and information on the location of the property on which you grow these crops. ***All data you provide in this survey will be supplied to the Horticultural Research and Development Corporation (HRDC), however your name and address will remain confidential.***

5. **Section B.**

- Section B covers production information specific to the ***largest crop product you produce (by volume and WHOLESALE value).***
- All questions from Question 3 to Question 7B should be answered considering only one crop production cycle, even if you grow and harvest the crop more than once a year. ***(THIS IS VERY IMPORTANT)***

6. **Section D.**

- Section D on environmental changes related to horticultural crop production is the last section to complete. This section only needs to be filled in once, irrespective of the number of crops you produce.
- **Question 3A. Your Region** ***(THIS IS VERY IMPORTANT)***
  Please define the regional area outside your property boundary that you consider affects horticultural production on your property, and that may be affected by your horticultural production system. This area should be based on your expert knowledge and observation as a landholder.

We value your commitment to the project. Your responses will provide valuable information that will assist horticultural industries to measure and plan for long term economically and ecologically sustainable production. Thankyou for your contribution.

PLEASE RETURN THIS SURVEY AS SOON AS POSSIBLE, AND BEFORE 6th AUGUST, 1999.

SECTION A - LOCALITY & HORTICULTURAL CROP SPECIES GROWN

1. Time Period *(Please tick the box that relates to the time period for which you will be providing information THROUGHOUT this survey).* ***This is VERY IMPORTANT.***

- ☐ 1996 / 1997 Financial Year
- ☐ 1997 / 1998 Financial Year
- ☐ 1998 / 1999 Financial Year

2. Name of Respondent: _____

3. Organisation (If Any): _____

4. Location: Nearest Town _____

Distance from Nearest Town_____

Direction from Nearest Town_____

5. Postal Address: _____

Postcode: _____

6. Phone: _____ **Mobile:** _____

Fax: _____ **E-mail:** _____

7. What horticultural crop species do you grow, and what is the volume of production, and WHOLESALE value of each ? *(Please calculate volume and wholesale value of each species produced, and then rank according to volume and value of production).*

Example

Crop Name	Seed (Kg)	Seed ($)	Seedlings (No.)	Seedlings ($)	Trees (No.)	Trees ($)	Root Stock (No.).	Root Stock ($)	Rank No.
Asparagus			100,000	$10,000					2
Cucumbers	200	$42,000							1
Tomatoes			100,000	$8,000					3

Nursery A produces cucumber seed, and tomato and asparagus seedlings. 200kg of cucumber seed is produced which has a wholesale value of $42,000. This is the largest crop product produced in terms of both volume and value. Equal numbers of asparagus and tomato seedlings are produced, however asparagus seedlings have a higher selling price at wholesale level, so asparagus is ranked number 2, and tomatoes number 3.

7.

Crop Name	Seed (Kg)	Seed ($)	Seedlings (No.)	Seedlings ($)	Trees (No.)	Trees ($)	Root Stock (No.).	Root Stock ($)	Rank No.
Almonds									
Apples									
Apricots									
Asparagus									
Avocados									
Bananas									
Beans - Broad									
Beans - French/Runner									
Beetroot									
Bitter Melons									
Blackcurrants									
Blueberries									
Broccoli									
Brussel Sprouts									
Cabbages									
Capscium / Chillie									
Carambola									
Carrots									
Cashews									
Cauliflower									
Celery									
Cherries									
Chestnuts									
Chinese Cabbage									
Cucumbers									
Custard Apples									
Garlic									
Gherkin Cucumbers									
Gooseberries									
Grapefruit									
Guava									
Hazelnut / Filberts									
Honeydew Melons									
Jackfruit									
Leeks									
Lemon / Lime									
Lettuce									
Loganberries									
Longans									
Lychees									
Macadamia									
Mandarins									
Mangoes									
Marrows and Squashes									
Nashi									
Nectarines									
Onions - Spring									
Onion - White / Brown									
Oranges									
Parsnips									
Passionfruit									
Pawpaws									
Peacharines									

7. ....Continued

Crop Name	Seed (Kg)	Seed ($)	Seedlings (No.)	Seedlings ($)	Trees (No.)	Trees ($)	Root Stock (No.).	Root Stock ($)	Rank No.
Peaches									
Peanuts									
Pears									
Peas - Green									
Peas - Snow									
Pecans									
Pepinos									
Pineapples									
Pistachios									
Plums and prunes									
Potatoes									
Potatoes - Sweet									
Pumpkin									
Pyrethrum									
Radish									
Rambutan									
Raspberries									
Rockmelons									
Silverbeet									
Strawberries									
Swedes									
Sweet Corn									
Tangelos									
Tomatoes									
Turnips									
Walnuts									
Water Melons									
Zucchini									

SECTION B - HORTICULTURE CROP SPECIFIC INFORMATION FOR LARGEST CROP PRODUCT GROWN

(Ranked No. 1 as identified in Section A)

1. How many crops per year would you grow ?

☐ One ☐ Two ☐ Three ☐ Other *(Please specify)*_____

2. In addition to growing this horticultural crop, are you involved in any of the following activities ?
(Please tick one or more of the following)

☐ Wholesaler ☐ Retailer ☐ Processor
☐ Exporter ☐ Other *(please specify)* _____

For Questions 3 to 7B following please provide your answers for a single crop production cycle only. (THIS IS VERY IMPORTANT)

3. Area of production _____ Ha

4. NO QUESTION

5. NO QUESTION

6. Production Inputs

6A. What Fertilisers, and how much do you apply to this crop ?

	Fertiliser *(please specify product name below)*	**Amount Applied**	
1.	_____	_____	Kilograms
2.	_____	_____	Kilograms
3.	_____	_____	Kilograms
4.	_____	_____	Kilograms
5.	_____	_____	Kilograms
6.	_____	_____	Kilograms

6B. What Insecticides, and how much do you apply to this crop ?

	Insecticide *(please specify product name below)* **Amount Applied**		
1.	_____	_____	Litres
2.	_____	_____	Litres
3.	_____	_____	Litres
4.	_____	_____	Litres
5.	_____	_____	Litres
6.	_____	_____	Litres

6C. What Fungicides, and how much do you apply to this crop ?

	Fungicide *(please specify product name below)*	**Amount Applied**	
1.	_____	_____	Litres
2.	_____	_____	Litres
3.	_____	_____	Litres
4.	_____	_____	Litres

6D. What Herbicides, and how much do you apply to this crop ?

Herbicide *(please specify product name below)*	**Amount Applied**	
1. _____	_____	Litres
2. _____	_____	Litres
3. _____	_____	Litres
4. _____	_____	Litres

7. Irrigation Use

7A. Do you irrigate this crop? ☐ Yes ☐ No

Please complete the following sections (Questions 7B to 7G) only if you answered "Yes" to this Question.

7B. What volume of water do you use to irrigate this crop ? _____ Megalitres

End of Questions relating to one crop production cycle only

7C. What irrigation methods do you use for this crop ? *(Please tick relevant boxes)*

- ☐ Overhead Spray
- ☐ Flood Irrigation
- ☐ Trickle Irrigation
- ☐ Other *(Please specify)* _____

7D. Where is your irrigation water sourced from ?
(Please tick relevant boxes and indicate the percentage acquired from each source)

- ☐ River / Creek _____ %
- ☐ Catchment Dam _____ %
- ☐ Ground Water Supplies _____ %
- ☐ Other *(Please specify* _____

7E. Is the quality of irrigation water adequate for this crop? *(Please tick one box)*

☐ Always ☐ Usually ☐ Sometimes ☐ Rarely ☐ Never

7F. How do you determine timing/volume of irrigation? *(Please tick relevant boxes)*

- ☐ Moisture Probes
- ☐ Leaf Analysis
- ☐ Set Intervals
- ☐ Gut Feel
- ☐ Other *(Please specify* _____

7G. Do you store irrigation water on-site ?

☐ Yes *If Yes,* Capacity _____ML ☐ No

If Yes, from where is this water sourced ? *(Please tick relevant boxes)*

- ☐ Allocation
- ☐ Water (Flood) Harvest
- ☐ Other *(Please specify* _____

SECTION C - LABOUR & MANAGEMENT INFORMATION

1. Labour

1A. How many People do you employ?
(Please average for the year and include Owner/Management and Family)

1. Full Time _____
2. Casual (part-time) _____
3. Seasonal _____

1B. Average age of Employees *(Please indicate number of Employees that fall into each Age Bracket)*

	1. Owner/Manager	2. Other Employees
15 - 19 yrs	_____	_____
20 - 25 yrs	_____	_____
26 - 35 yrs	_____	_____
36 - 55 yrs	_____	_____
55 yrs +	_____	_____

1C. Education and Skills of Employees
(Please indicate number of Employees that fall into each Category)

	1. Owner/Manager	2. Other Employees
Completed to Grade 10 Secondary	_____	_____
Completed Secondary (to Grade 12)	_____	_____
Completed Tertiary Education Study	_____	_____
Completed Other Further Education	_____	_____
Completed other courses/traineeships	_____	_____

2. Management Practices

2A. Do you participate in Resource Management Programs ?

☐ Yes *(Tick one or more in list below)* ☐ No

☐ Landcare ☐ Water Wise on the Farm
☐ Salt Action ☐ Farming for the Future
☐ BushCare ☐ RiverCare
☐ Other *(Please specify)*_____

2B. Does your Industry Organisation recommend Good Management Practices (GMP)?

☐ Yes ☐ No

If Yes, have you adopted and implemented this Industry GMP?

☐ Yes ☐ No

2C. Have you adopted and implemented a Quality Assurance (QA) program ?

☐ Yes *(Please specify Program)* _____

☐ No

2D. Are your farm operations audited?

☐ Yes ☐ No

If Yes, what type of audit is completed? *(Please tick relevant boxes)*

☐ Self ☐ 2nd party *(e.g industry representative)* ☐ 3rd party *(independent)*

2E. Do you actively market your product?

☐ Yes *(Please explain through what avenues)*_____

_____

☐ No

2F. Are you involved in a Marketing Group?

☐ Yes *(Tick one or more in list below)* ☐ No

☐ Product Cooperative ☐ Industry based

☐ Supply Partnership ☐ Local

☐ Processing Orientated ☐ Export Orientated

☐ Other *(Please specify)*_____

2G. Do you have in place a formal Training Program for your Employees?

☐ Yes *(Tick one or more in list below)* ☐ No

☐ Skills based ☐ Workplace Health and Safety

☐ Chemical Handling ☐ Machinery Operation

☐ Quality Assurance ☐ Crop Management - agronomic

☐ Waste Disposal ☐ Financial Management

☐ Other *(Please specify)*_____

3. Information Sources

3A. Where do you source information on horticultural related subjects ? *(Please tick one or more of the following and indicate the percentage of information received from each source nominated)*

☐ Neighbours _____ % ☐ Television _____ %

☐ Local Newspaper _____ % ☐ Radio _____ %

☐ Rural Newspapers _____ % ☐ Extension Officers _____ %

☐ Industry Bodies _____ % ☐ Government Departments _____ %

☐ Industry Publications _____ % ☐ Government Department

☐ Internet _____ % Publications _____ %

☐ Other *(please specify)* _____

SECTION D - ENVIRONMENTAL CHANGE INFORMATION

1. Property Specific Information

1A. What is the soil type on your property? *(Please tick one or more of the following)*

☐ Sand ☐ Sand or loam over clay subsoil ☐ Light clay

☐ Medium/Heavy Clay ☐ Other *(Please specify)*_____

If you know the actual name of the soil type/s please specify _____

1B. What is the topography of your property ?

☐ Flat ☐ Hilly / Steep

☐ Undulating ☐ Other *(Please specify)*_____

1C. Is there evidence of any of the following environmental changes occurring on your property ?
(If no, please tick the "no" box. If yes, please indicate the extent of occurrence by ticking the high, medium or low box. If yes please also tick the relevant box indicating the status of change).

Example

Environmental Change	No	Yes	Status of Change
2. Soil loss	☐ no	☑ high ☐ medium ☐ low	☑ improving ☐ deteriorating ☐ no change

- There is a high degree of soil loss on Farm A, however the rate of soil loss is decreasing through changes to crop production processes.

Environmental Change	No	Yes	Status of Change
10. Soil loss	☐ no	☐ high ☐ medium ☐ low	☐ improving ☐ deteriorating ☐ no change
11. Chemical accumulation in soil	☐ no	☐ high ☐ medium ☐ low	☐ improving ☐ deteriorating ☐ no change
12. Organic matter / soil structure decline	☐ no	☐ high ☐ medium ☐ low	☐ improving ☐ deteriorating ☐ no change
13. Nutrient levels and nutrient availability	☐ no	☐ high ☐ medium ☐ low	☐ improving ☐ deteriorating ☐ no change
14. Soil acidity levels	☐ no	☐ high ☐ medium ☐ low	☐ improving ☐ deteriorating ☐ no change
15. Soil salinity levels	☐ no	☐ high ☐ medium ☐ low	☐ improving ☐ deteriorating ☐ no change
16. Groundwater salinity levels	☐ no	☐ high ☐ medium ☐ low	☐ improving ☐ deteriorating ☐ no change
17. Surface water salinity levels	☐ no	☐ high ☐ medium ☐ low	☐ improving ☐ deteriorating ☐ no change
18. Chemical levels in irrigation water	☐ no	☐ high ☐ medium ☐ low	☐ improving ☐ deteriorating ☐ no change

1C. Continued

Environmental Change	No	Yes	Status of Change
16. Options for storing farm chemicals	☐ no	☐ high ☐ medium ☐ low	☐ improving ☐ deteriorating ☐ no change
17. Options / means for disposing of farm chemicals and chemical containers	☐ no	☐ high ☐ medium ☐ low	☐ improving ☐ deteriorating ☐ no change
18. Options / means for disposing of farm waste (eg. plastic, mulch)	☐ no	☐ high ☐ medium ☐ low	☐ improving ☐ deteriorating ☐ no change
19. Areas of native bushland being removed that would ordinarily assist with pollination functions	☐ no	☐ high ☐ medium ☐ low	☐ improving ☐ deteriorating ☐ no change
20. Areas of riparian (creek) vegetation being removed	☐ no	☐ high ☐ medium ☐ low	☐ improving ☐ deteriorating ☐ no change
21. Other *(Please specify)*		☐ high ☐ medium ☐ low	☐ improving ☐ deteriorating ☐ no change

1D. Are the crops you produce affected by the environmental changes occurring on your property ?
(Please indicate with a number on a 1 to 4 scale (1=not affected, 2= slightly affected, 3=moderately affected, 4=seriously affected) if the crops you produce are affected.

Example

Environmental Change	Scale Affected
2. Soil loss	4

- Soil loss is seriously affecting the yields Cucumbers on Farm A.

Environmental Change	Scale Affected
16. Soil loss	
17. Chemical accumulation in soil	
18. Organic matter / soil structure decline	
19. Nutrient levels and nutrient availability	
20. Soil acidity levels	
21. Soil salinity levels	
22. Groundwater salinity levels	
23. Surface water salinity levels	
24. Chemical levels in irrigation water	
25. Options for storing farm chemicals	
26. Options / means for disposing of farm chemicals & chemical containers	
27. Options / means for disposing of farm waste (eg plastic, mulch)	
28. Areas of native bushland being removed that would ordinarily assist with pollination functions	
29. Areas of riparian (creek) vegetation being removed	
30. Other *(specify same environmental change as in Question 1C no. 15)*	

2. Prevention and Control of Negative Environmental Impact

2A. What prevention or control measures do you adopt to minimise negative impacts on the environment ? *(Please tick the box that corresponds to the control measure you implement).*

2AB. Soil Loss

- ☐ contour banks
- ☐ planned direction of planting
- ☐ other *(please specify)* _____

2AC. Chemical Accumulation in Soil

- ☐ minimise use of chemicals
- ☐ apply chemicals according to specification
- ☐ other *(please specify)* _____

2AD. Organic Matter / Soil Structure Decline

- ☐ green manure cropping
- ☐ crop rotation
- ☐ addition of soil additives
- ☐ other (*please specify)* _____

2AE. Nutrient Levels and Nutrient Availability

- ☐ legume planting
- ☐ addition of fertiliser
- ☐ other (*please specify)* _____

2AF. Soil Acidity Levels

- ☐ reduce fertiliser applications
- ☐ apply lime
- ☐ other *(please specify)* _____

2AG. Soil Salinity Levels

- ☐ implement drainage works
- ☐ salt tolerant crops
- ☐ plant trees in recharge areas as point of catchment response
- ☐ other *(please specify)* _____

2AH. Groundwater Salinity Levels

- ☐ implement drainage works
- ☐ salt tolerant crops
- ☐ plant trees in recharge areas as point of catchment response
- ☐ other *(please specify)* _____

2AI. Surface Water Salinity Levels

- ☐ implement drainage works
- ☐ salt tolerant crops
- ☐ plant trees in recharge areas as point of catchment response
- ☐ other *(please specify)* _____

2AJ. Chemical levels in Irrigation Water

- ☐ property tailwater return/recycling
- ☐ chemical treatment of water
- ☐ other *(please specify)* _____

2AK. Chemical, Salt and Sediment Levels in Regional Creeks and Rivers

- ☐ regional tailwater/recycling systems
- ☐ catchment approaches (wetlands, treed areas)
- ☐ other *(please specify)* _____

2AL. Chemical Spray Drift

- ☐ control timing of applications
- ☐ modify/change spray equipment
- ☐ plant vegetation buffers
- ☐ other *(please specify)* _____

2AM. Dust drift

- ☐ control timing of cultivation
- ☐ reduce number of cultivations
- ☐ modify cultivation equipment
- ☐ plant vegetated buffers
- ☐ other *(please specify)* _____

2AN. Odour spread

- ☐ control timing of cultivation
- ☐ modify/change spray equipment
- ☐ plant vegetated buffers
- ☐ other *(please specify)* _____

2AO. Noise levels

- ☐ control timing of farming operations
- ☐ plant vegetated buffers
- ☐ other *(please specify)* _____

2AP. Native bushland

- ☐ retain remnant vegetation areas
- ☐ maintain a separation distance between crop and bushland area
- ☐ other *(please specify)* _____

2AQ. Riparian (creek) vegetation

- ☐ retain riparian vegetation
- ☐ maintain a separation distance between crop and riparian areas
- ☐ other *(please specify)* _____

2AR. Storing and disposal of farm chemicals and chemical containers

- ☐ establish safe collection areas
- ☐ establish safe disposal methods with authorities
- ☐ other *(please specify)* _____

2AS. Disposal of farm waste (eg plastic mulch)

- ☐ establish safe collection areas
- ☐ establish safe disposal methods with authorities
- ☐ other *(please specify)* _____

2AT. Other *(Please specify)* _____

- ☐ _____
- ☐ _____
- ☐ _____

3. Regional Information

3A. Your Region

(Please define the regional area outside your property boundary that you consider affects horticultural production on your property, and that may be affected by your horticultural production system). ***THIS IS VERY IMPORTANT.***

Regional Area _____ (Kilometres radius from your property boundary)

If you also know the Catchment or River System to which this region belongs, please specify below

Catchment or River System _____

3B. What are the major soil types in your region? *(Please tick one or more of the following)*

☐ Sand ☐ Sand or loam over clay subsoil ☐ Light clay

☐ Medium/Heavy Clay ☐ Other *(Please specify)*_____

If you know the actual name of the soil type/s please specify _____

3C. What is the topography of your region ?

☐ Flat ☐ Hilly / Steep

☐ Undulating ☐ Other *(Please specify)*_____

3D. Is there evidence of any of the following environmental changes occurring in your region ?

(If no, please tick the "no" box. If yes, please indicate the extent of occurrence by ticking the high, medium or low box. If yes please also tick the relevant box indicating the status of change).

Environmental Change	No	Yes	Status of Change
9. Chemical levels in creeks and rivers	☐ no	☐ high ☐ medium ☐ low	☐ improving ☐ deteriorating ☐ no change
10. Salt levels in creeks and rivers	☐ no	☐ high ☐ medium ☐ low	☐ improving ☐ deteriorating ☐ no change
11. Sediment in creeks and rivers	☐ no	☐ high ☐ medium ☐ low	☐ improving ☐ deteriorating ☐ no change
12. Incidence of chemical spray drift	☐ no	☐ high ☐ medium ☐ low	☐ improving ☐ deteriorating ☐ no change
13. Incidence of dust drift	☐ no	☐ high ☐ medium ☐ low	☐ improving ☐ deteriorating ☐ no change
14. Incidence of odour spread	☐ no	☐ high ☐ medium ☐ low	☐ improving ☐ deteriorating ☐ no change
15. Incidence of noise	☐ no	☐ high ☐ medium ☐ low	☐ improving ☐ deteriorating ☐ no change
16. Other *(Please specify)*		☐ high ☐ medium ☐ low	☐ improving ☐ deteriorating ☐ no change

3E. Are the crops you produce affected by the environmental changes occurring in your region ?

(Please indicate with a number on a 1 to 4 scale (1=not affected, 2= slightly affected, 3=moderately affected, 4=seriously affected) if the crops you produce are affected).

Environmental Change	Scale Affected
9. Chemical levels in creeks and rivers	
10. Salt levels in creeks and rivers	
11. Sediment in creeks and rivers	
12. Incidence of chemical spray drift	
13. Incidence of dust drift	
14. Incidence of odour spread	
15. Incidence of noise	
16. Other *(Specify as in Question 3D no. 8)*	

END OF SURVEY

THANKYOU FOR YOUR TIME

The valuable information you have provided will assist horticultural industries to measure and plan for long term sustainable and profitable production.

Please return this survey as soon as possible upon completion, and before 6th August by -

1. FAX: (07) 3832 7298

2. REPLY PAID MAIL *(No Stamp Required)* :

REPLY PAID 76
Macarthur Agribusiness
GPO Box 2452
Brisbane Qld 4001

Appendix 4 Processor Survey Form

MACARTHUR AGRIBUSINESS

SINCLAIR KNIGHT MERZ

HORTICULTURAL RESEARCH & DEVELOPMENT CORPORATION

Horticultural Productivity & Sustainability Project

Processor Survey

This survey is comprised of 3 Sections -

SECTION A - Locality of Processing Facility

SECTION B - Processing Operations Information

SECTION C - Labour and Management Information

The survey is very comprehensive, however it has been designed to minimise the time commitment required to complete it. If you would like to discuss any of the Questions, please contact:

Macarthur Agribusiness
Phone: (07) 3831 7330 Fax: (07) 3832 7298 E-mail: macagri@ozemail.com.au

Note:

- **Question 1. Time Period**
  The information you provide will be used in conjunction with data collected in the 1996 / 1997 Financial Year. If you have records for this year please provide information relating to this period in all sections of the survey. If you have records for other years, please indicate this in Question 1.
- **Confidentialty**

  All data you provide in this survey will be supplied to the Horticultural Research and Development Corporation (HRDC), however your name and address will remain confidential.

Please return this survey as soon as possible upon completion by -

1. FAX: (07) 3832 7298

2. REPLY PAID MAIL *(No Stamp Required)* :

REPLY PAID 76
Macarthur Agribusiness
GPO Box 2452
Brisbane Qld 4001

We value your commitment to the project. Your responses will provide valuable information that will assist horticultural industries to measure and plan for long term economically and ecologically sustainable production. Thankyou for your contribution.

SECTION A - LOCALITY OF PROCESSING FACILITY

1. Time Period *(Please tick the box that relates to the time period for which you will be providing information THROUGHOUT this survey).* ***This is VERY IMPORTANT.***

- ☐ 1996 / 1997 Financial Year
- ☐ 1997 / 1998 Financial Year
- ☐ 1998 / 1999 Financial Year

2. Name of Respondent: _____

3. Organisation (If Any): _____

4. Location: Nearest Town _____

Distance from Nearest Town_____

Direction from Nearest Town_____

5. Postal Address: _____

Postcode: _____

6. Phone: _____ **Mobile:** _____

Fax: _____ **E-mail:** _____

7. What horticultural commodities do you process ? *(Please rank according to volume processed and indicate percentage of total processed volume. Eg. Largest Commodity: No.=1, %=60, 2nd Largest commodity: No.=2, %=40)*

Crop Name	No.	%	Crop Name	No.	%	Crop Name	No.	%
Almonds			Gherkin Cucumbers			Peas - Green		
Apples			Gooseberries			Peas - Snow		
Apricots			Grapefruit			Pecans		
Asparagus			Guava			Pepinos		
Avocados			Hazelnut / Filberts			Pineapples		
Bananas			Honeydew Melons			Pistachios		
Beans - Broad			Jackfruit			Plums and prunes		
Beans - French/Runner			Leeks			Potatoes		
Beetroot			Lemon / Lime			Potatoes - Sweet		
Bitter Melons			Lettuce			Pumpkin		
Blackcurrants			Loganberries			Pyrethrum		
Blueberries			Longans			Radish		
Broccoli			Lychees			Rambutan		
Brussel Sprouts			Macadamia			Raspberries		
Cabbages			Mandarins			Rockmelons		
Capscium / Chillie			Mangoes			Silverbeet		
Carambola			Marrows and Squashes			Strawberries		
Carrots			Nashi			Swedes		
Cashews			Nectarines			Sweet Corn		
Cauliflower			Onions - Spring			Tangelos		
Celery			Onion - White / Brown			Tomatoes		
Cherries			Oranges			Turnips		
Chestnuts			Parsnips			Walnuts		
Chinese Cabbage			Passionfruit			Water Melons		
Cucumbers			Pawpaws			Zucchini		
Custard Apples			Peacharines					
Garlic			Peaches					
			Peanuts					
			Pears					

SECTION B - PROCESSING OPERATIONS INFORMATION

1. In addition to processing these horticultural products, are you involved in any of the following activities? *(Please tick one or more of the following)*

☐ Wholesaler ☐ Retailer

☐ Exporter ☐ Other *(please specify)* _____

2. Total volume of product processed per year (Tonnes) _____

3. Total value of processed product (Wholesale $ per year) _____

4. Processing and Packaging Products

4A. What processing and packaging products does your operation use? *(e.g. detergents, wooden crates, cardboard cartons, plastic wrap, glass etc.)*

	Products *(please specify type below)*	**Amount Used** *(Please specify Tonnes or Litres)*	
1.	_____	_____	Tonnes or Litres
2.	_____	_____	Tonnes or Litres
3.	_____	_____	Tonnes or Litres
4.	_____	_____	Tonnes or Litres
5.	_____	_____	Tonnes or Litres
6.	_____	_____	Tonnes or Litres

4B. Which of these products are directly recycled for use within the processing facility ?
(Please tick the box that corresponds with the product identified above in Question 4A.)

1. ☐ 2. ☐ 3. ☐ 4. ☐ 5. ☐ 6. ☐

Example

In Question 4A, Processor X specified the following products -

	Products *(please specify below)*	**Amount Used** *(Please specify Tonnes or Litres)*	
1.	Wooden crates	50	Tonnes or Litres
2.	Cardboard cartons	5	Tonnes or Litres

Product 1 (wooden crates) are directly recycled for use in the processing operation, however product 2 (cardboard cartons) are not, so for Question 4B, Processor X has responded as shown below -

4B. Which of these products are directly recycled for use within the processing facility ?
(Please tick the box that corresponds with the product identified above in Question 4A.)

1. ☑ 2. ☐ 3. ☐ 4. ☐ 5. ☐ 6. ☐

4C. How do you dispose of processing and packaging product waste ? *(please tick relevant disposal methods and indicate which product/s disposed of using that method)*

		Product Type/s *(Please specify product as in Question 4A)*					
☐	Send to manufacturing facility	1. ☐	2. ☐	3. ☐	4. ☐	5. ☐	6. ☐
☐	Send to recycling facility	1. ☐	2. ☐	3. ☐	4. ☐	5. ☐	6. ☐
☐	Send to refuse disposal facility	1. ☐	2. ☐	3. ☐	4. ☐	5. ☐	6. ☐
☐	Send to storage facility	1. ☐	2. ☐	3. ☐	4. ☐	5. ☐	6. ☐
☐	Incinerate	1. ☐	2. ☐	3. ☐	4. ☐	5. ☐	6. ☐
☐	Bury on-site	1. ☐	2. ☐	3. ☐	4. ☐	5. ☐	6. ☐
☐	Store on-site	1. ☐	2. ☐	3. ☐	4. ☐	5. ☐	6. ☐
☐	Other *(Please specify)*						
_____		1. ☐	2. ☐	3. ☐	4. ☐	5. ☐	6. ☐
_____		1. ☐	2. ☐	3. ☐	4. ☐	5. ☐	6. ☐

4D. If processing and packaging product waste is stored on-site, how is it stored ?

		Product Type/s *(Please specify product as in Question 4A)*					
☐	Warehouse / sheds	1. ☐	2. ☐	3. ☐	4. ☐	5. ☐	6. ☐
☐	Sealed containers	1. ☐	2. ☐	3. ☐	4. ☐	5. ☐	6. ☐
☐	Ponds	1. ☐	2. ☐	3. ☐	4. ☐	5. ☐	6. ☐
☐	Tanks	1. ☐	2. ☐	3. ☐	4. ☐	5. ☐	6. ☐
☐	Other *(Please specify)*						
_____		1. ☐	2. ☐	3. ☐	4. ☐	5. ☐	6. ☐
_____		1. ☐	2. ☐	3. ☐	4. ☐	5. ☐	6. ☐

5. Biodegradable Processing Waste

5A. What biodegradable waste is produced as a result of your processing operations ? *(e.g. skins, seeds, pressing liquids etc)*

	Waste Products *(please specify below)*	**Amount Produced** *(Please specify Tonnes or Litres)*	
1.	_____	_____	Tonnes or Litres
2.	_____	_____	Tonnes or Litres
3.	_____	_____	Tonnes or Litres
4.	_____	_____	Tonnes or Litres
5.	_____	_____	Tonnes or Litres
6.	_____	_____	Tonnes or Litres

5C. How do you dispose of biodegradable waste ? *(please tick relevant disposal methods and indicate which waste product/s disposed of using that method)*

Waste Product/s *(Please specify product as in Question 5A)*

☐ Recycle as fuel within your processing facility	1. ☐	2. ☐	3. ☐	4. ☐	5. ☐	6. ☐
☐ Send to other manufacturing / processing facility	1. ☐	2. ☐	3. ☐	4. ☐	5. ☐	6. ☐
☐ Send to refuse disposal facility	1. ☐	2. ☐	3. ☐	4. ☐	5. ☐	6. ☐
☐ Send to storage facility	1. ☐	2. ☐	3. ☐	4. ☐	5. ☐	6. ☐
☐ Incinerate	1. ☐	2. ☐	3. ☐	4. ☐	5. ☐	6. ☐
☐ Bury on-site	1. ☐	2. ☐	3. ☐	4. ☐	5. ☐	6. ☐
☐ Store on-site	1. ☐	2. ☐	3. ☐	4. ☐	5. ☐	6. ☐
☐ Other *(Please specify)*						
_____	1. ☐	2. ☐	3. ☐	4. ☐	5. ☐	6. ☐
_____	1. ☐	2. ☐	3. ☐	4. ☐	5. ☐	6. ☐

5D. If biodegradable waste is stored on-site, how is it stored ?

Waste Product/s *(Please specify product as in Question 5A)*

☐ Warehouse / sheds	1. ☐	2. ☐	3. ☐	4. ☐	5. ☐	6. ☐
☐ Sealed containers	1. ☐	2. ☐	3. ☐	4. ☐	5. ☐	6. ☐
☐ Ponds	1. ☐	2. ☐	3. ☐	4. ☐	5. ☐	6. ☐
☐ Tanks	1. ☐	2. ☐	3. ☐	4. ☐	5. ☐	6. ☐
☐ Other *(Please specify)*						
_____	1. ☐	2. ☐	3. ☐	4. ☐	5. ☐	6. ☐
_____	1. ☐	2. ☐	3. ☐	4. ☐	5. ☐	6. ☐

6. Chemical Processing Products and Waste

6A. What chemical products do you use in your processing operation ?

	Chemical *(please specify product name below)*	**Amount Used** *(Please specify Tonnes or Litres)*	
1.	_____	_____	Tonnes or Litres
2.	_____	_____	Tonnes or Litres
3.	_____	_____	Tonnes or Litres
4.	_____	_____	Tonnes or Litres
5.	_____	_____	Tonnes or Litres
6.	_____	_____	Tonnes or Litres

6B. Do you treat chemical waste on-site (either chemically or physically)?

☐ Yes ☐ No

If Yes, please answer Questions 6C to 6E, if No, please answer questions 6F to 6G.

6C. Which waste products specified above in Question 6A are treated on-site *(Please tick the box that corresponds with the waste product identified in Question 6A.)*

1. ☐ 2. ☐ 3. ☐ 4. ☐ 5. ☐ 6. ☐

6D. How is chemical waste treated on-site disposed of ? *(please tick relevant disposal methods and indicate which waste product/s disposed of using that method)*

Waste Product/s *(Please specify product as in Question 6A)*

☐	Stored on-site	1. ☐	2. ☐	3. ☐	4. ☐	5. ☐	6. ☐
☐	Released into river/stream/ocean	1. ☐	2. ☐	3. ☐	4. ☐	5. ☐	6. ☐
☐	Incinerated	1. ☐	2. ☐	3. ☐	4. ☐	5. ☐	6. ☐
☐	Buried on-site	1. ☐	2. ☐	3. ☐	4. ☐	5. ☐	6. ☐
☐	Other *(Please specify)*						
_____		1. ☐	2. ☐	3. ☐	4. ☐	5. ☐	6. ☐
_____		1. ☐	2. ☐	3. ☐	4. ☐	5. ☐	6. ☐

6E. If treated chemical waste is stored on-site, how is it stored ?

Waste Product/s *(Please specify product as in Question 6A)*

☐	Warehouse / sheds	1. ☐	2. ☐	3. ☐	4. ☐	5. ☐	6. ☐
☐	Sealed containers	1. ☐	2. ☐	3. ☐	4. ☐	5. ☐	6. ☐
☐	Ponds	1. ☐	2. ☐	3. ☐	4. ☐	5. ☐	6. ☐
☐	Tanks	1. ☐	2. ☐	3. ☐	4. ☐	5. ☐	6. ☐
☐	Other *(Please specify)*						
_____		1. ☐	2. ☐	3. ☐	4. ☐	5. ☐	6. ☐
_____		1. ☐	2. ☐	3. ☐	4. ☐	5. ☐	6. ☐

6F. How is untreated chemical waste disposed of ?

Waste Product/s *(Please specify product as in Question 6A)*

☐	Sent to off-site disposal facility	1. ☐	2. ☐	3. ☐	4. ☐	5. ☐	6. ☐
☐	Sent to off-site treatment facility	1. ☐	2. ☐	3. ☐	4. ☐	5. ☐	6. ☐
☐	Sent to off-site storage facility	1. ☐	2. ☐	3. ☐	4. ☐	5. ☐	6. ☐
☐	Stored on-site	1. ☐	2. ☐	3. ☐	4. ☐	5. ☐	6. ☐
☐	Incinerated	1. ☐	2. ☐	3. ☐	4. ☐	5. ☐	6. ☐
☐	Buried on-site	1. ☐	2. ☐	3. ☐	4. ☐	5. ☐	6. ☐
☐	Other *(Please specify)*						
_____		1. ☐	2. ☐	3. ☐	4. ☐	5. ☐	6. ☐
_____		1. ☐	2. ☐	3. ☐	4. ☐	5. ☐	6. ☐

6G. If untreated chemical waste is stored on-site, how is it stored ?

Waste Product/s *(Please specify product as in Question 6A)*

☐	Warehouse / sheds	1. ☐	2. ☐	3. ☐	4. ☐	5. ☐	6. ☐
☐	Sealed containers	1. ☐	2. ☐	3. ☐	4. ☐	5. ☐	6. ☐
☐	Ponds	1. ☐	2. ☐	3. ☐	4. ☐	5. ☐	6. ☐
☐	Tanks	1. ☐	2. ☐	3. ☐	4. ☐	5. ☐	6. ☐
☐	Other *(Please specify)*						
_____		1. ☐	2. ☐	3. ☐	4. ☐	5. ☐	6. ☐
_____		1. ☐	2. ☐	3. ☐	4. ☐	5. ☐	6. ☐

7. Water Use

7A. Do you use water in the processing of these products ? ☐ Yes ☐ No

Please complete the following Questions only if you answered "Yes" to this Question.

7B. What volume of water do you use per annum ? _____ Megalitres

7C. Where is your water sourced from ?
(Please tick relevant boxes and indicate the percentage acquired from each source)

- ☐ River / Creek _____ %
- ☐ On-Site Catchment Dam _____ %
- ☐ Ground Water Supplies _____ %
- ☐ Mains Water Supply _____ %
- ☐ Other *(Please specify* _____

7D. How is waste water disposed of ? *(Please tick relevant boxes)*

- ☐ Directed to on-site treatment facility, then released back to water source once treated
- ☐ Directed to off-site treatment facility, then released back to water source once treated
- ☐ Directed to on-site treatment facility, then recycled in processing plant once treated
- ☐ Directed to off-site treatment facility
- ☐ Released untreated directly back to water source
- ☐ Disposed of through mains sewerage
- ☐ Other *(Please specify)* _____

7E. Is the quality of water adequate for your processing requirements? *(Please tick one box)*

☐ Always ☐ Usually ☐ Sometimes ☐ Rarely ☐ Never

SECTION C - LABOUR & MANAGEMENT INFORMATION

1. Labour

1A. How many People do you employ? *(Please average for the year and include management)*

1. Full Time _____
2. Casual (part-time) _____
3. Seasonal _____

1B. Average age of Employees *(Please indicate number of Employees that fall into each Age Bracket)*

	1. Management	2. Other Employees
15 - 19 yrs	_____	_____
20 - 25 yrs	_____	_____
26 - 35 yrs	_____	_____
36 - 55 yrs	_____	_____
55 yrs +	_____	_____

1C. Education and Skills of Employees
(Please indicate number of Employees that fall into each Category)

	1. Management	2. Other Employees
Completed to Grade 10 Secondary	_____	_____
Completed Secondary (to Grade 12)	_____	_____
Completed Tertiary Education Study	_____	_____
Completed Other Further Education	_____	_____
Completed other courses/traineeships	_____	_____

2. Management Practices

2A. Does your company have, or is your company involved in a Waste Management Program/s?

☐ Yes *(Please specify)* _____

_____

☐ No

2B. Have you adopted and implemented a Quality Assurance (QA) program ?

☐ Yes *(Please specify Program)* _____

☐ No

2C. Are your business operations audited?

☐ Yes ☐ No

If Yes, what type of audit is completed? *(Please tick relevant boxes)*

☐ Self ☐ 2nd party *(e.g industry representative)* ☐ 3rd party *(independent)*

2D. Are you involved in a Marketing Group?

☐ Yes *(Tick one or more in list below)* ☐ No

☐ Product Cooperative ☐ Industry-based

☐ Supply Partnership ☐ Local

☐ Export Orientated

☐ Other *(Please specify)*_____

2E. Do you have in place a formal Training Program for your Employees?

☐ Yes *(Tick one or more in list below)* ☐ No

☐ Skills based ☐ Workplace Health and Safety

☐ Chemical Handling ☐ Machinery Operation

☐ Quality Assurance ☐ Waste Disposal

☐ Other *(Please specify)*_____

3. Information Sources

3A. Where do you source information on horticultural related subjects ? *(Please tick one or more of the following and indicate the percentage of information received from each source nominated)*

☐ Television _____ % ☐ Radio _____ %

☐ Local Newspaper _____ % ☐ Rural Newspapers _____ %

☐ Industry Bodies _____ % ☐ Government Departments _____ %

☐ Industry Publications _____ % ☐ Government Department

☐ Internet _____ % Publications _____ %

☐ Other *(please specify)* _____

END OF SURVEY

THANKYOU FOR YOUR TIME

The valuable information you have provided will assist horticultural industries to measure and plan for long term sustainable and profitable production.

Appendix 5 State Agencies Survey Form

MACARTHUR AGRIBUSINESS

SINCLAIR KNIGHT MERZ

HORTICULTURAL RESEARCH & DEVELOPMENT CORPORATION

ENVIRONMENTAL AUDIT SURVEY 1999

State Agency Survey

This survey is comprised of 2 Sections -

SECTION A - Locality and Regions Administered
SECTION B - Environmental Change Information

The survey is very comprehensive and will require a significant time commitment on your part. You may wish to complete one Section at a time over a period of a few days. We will contact you soon after you receive this survey to assist with any Questions that are unclear. If you would like to discuss any of the Questions, please contact:

Gavin Prentice
Sinclair Knight Merz http://www.skm.com.au
Phone: (07) 4639 8400
Fax: (07) 4639 8490
E-mail: mailto:gprentice@skm.com.au

Survey Information

- The information you provide in this survey will be used in conjunction with data collected by ABARE and ABS in the 1996 / 1997 Financial Year. If you have records for this year please provide information relating to this period in all sections of the survey. If you have records for other years, please indicate this in Question 1.
- Section A requests information relating to your contact details, and horticultural crop production in region(s) you service. ***All data you provide in this survey will be supplied to the Horticultural Research and Development Corporation (HRDC).***
- Section B requests information in relation to environmental changes in the region(s) you service. This section needs to be filled in for each region you offer services, irrespective of the number of crops you work with. Ten (10) *copies of Section B are included so each region in your jurisdiction can be surveyed individually*.

We value your commitment to the Audit process. Your responses will provide valuable information that will assist horticultural industries to measure and plan for long term economically and ecologically sustainable production. Thankyou for your contribution.

SECTION A - LOCALITY & CROPS PRODUCED

1. **Time Period** *(Please tick the box that relates to the time period for which you will be providing information THROUGHOUT this survey)*. ***This is VERY IMPORTANT.***

- ☐ 1996 / 1997 Financial Year
- ☐ 1997 / 1998 Financial Year
- ☐ 1998 / 1999 Financial Year

2. Name of Respondent: _____

3. Organisation: _____

4. Office Location: _____

5. Postal Address: _____

_____

6. Postcode: _____

7. Phone: _____

8. Mobile: _____

9. Fax: _____

10. E-mail: _____

11. Please identify the regions within your state that you are involved with. *(Please rank these regions, with one (1) having the most involvement)*

Region	Rank
1.	
2.	
3.	
4.	
5.	
6.	
7.	
8.	
9.	
10.	

12. Which of the following horticultural crops are you involved with? *(Please rank crops according to Volume of Production and indicate percentage of time. (Eg. Largest Crop: No.=1, %=60, 2nd Largest Crop: No.=2, %=40)*

Crop Name	No.	%	Crop Name	No.	%	Crop Name	No.	%
Almonds			Gherkin Cucumbers			Peas - Green		
Apples			Gooseberries			Peas - Green - Seed		
Apricots			Grapefruit			Peas - Snow		
Asparagus			Guava			Pecans		
Avocados			Hazelnut / Filberts			Pepinos		
Bananas			Honeydew Melons			Pineapples		
Beans - Broad			Jackfruit			Pistachios		
Beans - French/Runner			Leeks			Plums and prunes		
Beans - French/Runner-Seed			Lemon / Lime			Potatoes - Autumn/Spring		
Beetroot			Lettuce			Potatoes - Seed		
Bitter Melons			Loganberries			Potatoes - Sweet		
Blackcurrants			Longans			Pumpkin		
Blueberries			Lychees			Pumpkin - Seed		
Broccoli			Macadamia			Pyrethrum		
Brussel Sprouts			Mandarins			Radish		
Cabbages			Mangoes			Radish - Seed		
Capsicum / Chilli			Marrows and Squashes			Rambutan		
Carambola			Nashi			Raspberries		
Carrots			Nectarines			Rockmelons		
Carrots - Seed			Nurseries			Silverbeet		
Cashews			Onions – Spring			Strawberries		
Cauliflower			Onion - White / Brown			Swedes		
Cauliflower - Seed			Onions – Seed			Sweet Corn		
Celery			Oranges			Tangelos		
Cherries			Parsnips			Tomatoes		
Chestnuts			Passionfruit			Turnips		
Chinese Cabbage			Pawpaws			Walnuts		
Chinese Cabbage - Seed			Peacharines			Water Melons		
Cucumbers			Peaches			Zucchini		
Custard Apples			Peanuts					
Garlic			Pears					

<u>THIS SURVEY IS CONFINED TO THESE CROPS ONLY.</u>

13. What part of the production chain in the horticultural industry are you involved with? *(Please tick one or more of the following)*

A ☐ Growers

B ☐ Processors

C ☐ Retailers

D ☐ Wholesalers

E ☐ Exporters

F ☐ Other_____

Of These, Which sector are you most Involved with? _____

_____

14. How much time in your work year do you spend on activities relating to the service of the horticultural industry?

☐ 100% ☐ 75% ☐ 50% ☐ 0%

15. What type(s) of written advice does your department give? *(Please note: Issue specific management questions are asked in later questions)*

☐ Land Management

☐ Water Use

☐ Native Vegetation Management

☐ Waste Management

☐ Air/ Noise/ Odour Control

☐ Chemical Use

☐ Nutrient Management

☐ Other (please specify) _____

_____

16. What document(s) are used to form the basis of this advice on a <u>crop</u> specific basis? *(see Q17 for regional specific documents)*

Some examples of management issues include:

- Financial
- Environmental
- Production

Crop	Management Issue	Document Title
eg. Pineapple		
1)		
2)		
3)		
4)		
5)		
6)		
7)		
8)		
9)		
10)		

17. What document(s) are used to form the basis of this advice on a region specific basis?

Region	Management Issue	Document Title
eg. Pineapple		
1)		
2)		
3)		
4)		
5)		
6)		
7)		
8)		
9)		
10)		

18. Does your department recommend a good management practice (GMP) program to growers? *(If yes, please answer Q19 and Q20, if no please go to Q21)*

☐ Yes ☐ No

19. What document(s) are used to form the basis of this advice on a crop basis?

Crops	GMP Manual Title
1)	
2)	
3)	
4)	
5)	
6)	
7)	
8)	
9)	
10)	

20. What document(s) are used to form the basis of this advice on a regional basis?

Region	GMP Manual Title
1)	
2)	
3)	
4)	
5)	
6)	
7)	
8)	
9)	
10)	

21. Does your department keep records on the level of adoption of GMP in horticulture? *(If yes, please answer Q22 and Q23, if no please go to Q24)*

☐ Yes ☐ No

22. Please indicate the percentage adoption rate of good management practice (GMP) in horticulture achieved on a region basis?

Region where either perennial or annual crop types are grown	Adoption Percentage 100%	> 80%	> 50%	< 50%	0%	Area (ha)
☐ Perennial						
_____	☐	☐	☐	☐	☐	_____
_____	☐	☐	☐	☐	☐	_____
_____	☐	☐	☐	☐	☐	_____
_____	☐	☐	☐	☐	☐	_____
_____	☐	☐	☐	☐	☐	_____
_____	☐	☐	☐	☐	☐	_____
_____	☐	☐	☐	☐	☐	_____
☐ Annual						
_____	☐	☐	☐	☐	☐	_____
_____	☐	☐	☐	☐	☐	_____
_____	☐	☐	☐	☐	☐	_____
_____	☐	☐	☐	☐	☐	_____
_____	☐	☐	☐	☐	☐	_____
_____	☐	☐	☐	☐	☐	_____
_____	☐	☐	☐	☐	☐	_____

23. Please indicate the percentage adoption rate of good management practice (GMP) achieved on a crop basis?

Crops of perennial or annual type grown under GMP	Adoption Percentage 100%	> 80%	> 50%	< 50%	0%	Area (Ha)
☐ Perennial						
1) _____	☐	☐	☐	☐	☐	_____
2) _____	☐	☐	☐	☐	☐	_____
3) _____	☐	☐	☐	☐	☐	_____
4) _____	☐	☐	☐	☐	☐	_____
5) _____	☐	☐	☐	☐	☐	_____
6) _____	☐	☐	☐	☐	☐	_____
7) _____	☐	☐	☐	☐	☐	_____
☐ Annual						
1) _____	☐	☐	☐	☐	☐	_____
2) _____	☐	☐	☐	☐	☐	_____
3) _____	☐	☐	☐	☐	☐	_____
4) _____	☐	☐	☐	☐	☐	_____
5) _____	☐	☐	☐	☐	☐	_____
6) _____	☐	☐	☐	☐	☐	_____
7) _____	☐	☐	☐	☐	☐	_____

24. Does your department provide advice on any of the following wider horticultural industry issues? *(Please consider on-site and off-site advice)*

Industry Issue	Advice Document(s) Used	What level?				
		National	Regional	State	Industry	Other
1. Acid Sulphate Soils						
2. COAG Water Reform						
3. Urban Encroachment						
4. Restrictions due to protected plants and/or animals						
5. Market opportunities for product grown under environmental management						

25. Do you know if industry has developed a GMP?

☐ Yes

☐ No

SECTION B - Regional Analysis

Note: Please complete Section B (this section) for each region as determined from question 11. Extra copies of this section may be photocopied for additional regions.

26. Your Region

(Please define the regional area you consider encompasses this general horticultural production area, and that may be affected by a single horticultural production system).

THIS IS VERY IMPORTANT.

REGION: _____

Regional Area _____ (ha)

If you also know the Catchment or River System to which this region belongs, please specify below

Catchment or River System _____

27. Do you have any gross margin data available? If yes, please fill in the Gross Margin in Question 28.

☐ Yes ☐ No

28. Gross Margin

There are two sections to the Gross Margin. Section 1 describes machinery costs and Section 2 all other costs associated with production, harvesting, packing and marketing. Please fill in the tables for each Section following the examples shown below -

Example

Section 1

Variable Cost Type	Number of Hours	Cost per hour	Number of Passes
Machinery Costs			
1. Discing	5	$11.40	2

- The cropping area was disc ploughed twice (2 passes). These operations took a total of 5 hours and cost $11.40 per hour.

Section 2

Variable Cost Type	Unit of Application *(description)*	Number of Applications *(number of times*	Application Rate / ha *(amount applied*	Cost / Unit *(total cost of application per*
PRODUCTION COSTS				
Fertiliser				
1. CK88	Kilograms	1	350	$0.52
Labour				
2. Casual Labour	Hours	NA	20	$12.00
Packing and Handling				
2. Packing material				
- Cartons	Number of Cartons	NA	2000	$1.32
Road Freight				
Destination 1: Brisbane	Number of Carton/Bin/Tray/Box	NA	2000	$1.20

- CK88 fertiliser was applied once at a rate of 350 Kg per hectare and cost $0.52 per Kilogram.
- 20 hours of Casual Labour per hectare was hired as part of crop production. The employees were paid at a rate of $12.00 pr hr.
- 2000 Cartons per hectare were purchased. Cartons cost $1.32 each.
- 2000 Cartons per hectare were trucked to Brisbane by road. This freight cost $1.20 per Carton.

Section 1

Variable Cost Type	Number of Hours	Cost per hour	Number of Passes
Machinery Costs *(please specify other costs if necessary in the available spaces below)*			
1. Discing			
2. Ripping			
3. Slashing			
4. Mulch Removal			
5. Planting			
6. Bed and Mulch			
7. Tape Laying			
8. Rotary Hoe			
9. Tractor Chemical Spray Application			
10.Aerial Spray Application			
11.Tractor Fertiliser Application			
12.Aerial Fertiliser Application			
13.			
14.			
15.			
16.			

Section 2

Variable Cost Type	Unit of Application	Number of Applications	Application Rate / ha	Cost / Unit
PRODUCTION COSTS				
Fertiliser *(please specify type below)*				
1.	Kilograms			
2.	Kilograms			
3.	Kilograms			
4.	Kilograms			
5.	Kilograms			
6.	Kilograms			
7.	Kilograms			
Insecticide *(please specify type below)*				
1.	Litres			
2.	Litres			
3.	Litres			
4.	Litres			
Herbicide *(please specify type below)*				
1.	Litres			
2.	Litres			
3.	Litres			
4.	Litres			
Fungicide *(please specify type below)*				
1.	Litres			
2.	Litres			
3.	Litres			
4.	Litres			
Irrigation *(please specify other costs if necessary in the available spaces below)*				
1. Layflat (4")	Metres			
2. Trickle Tape	Metres			
3. Irrigation Water	Megalitres			
4. Pumping	Hours			
5.				
6.				
Mulch				
1. Plastic Mulch	Metres			

Variable Cost Type	Unit of Application	Number of Applications	Application Rate / ha	Cost / Unit
2. Organic Mulch	Kilograms			
Plants and Seed				
1. Speedlings	Number of Plants			
2. Seed	Kilograms			
3. Plants	Number of Plants			
Labour *(please specify other costs if necessary in the available spaces below)*				
1. Bug Checking	Hours			
2. Casual Labour	Hours	NA		
3.				
4.				
5.				
Consulting *(please specify other costs if necessary in the available spaces below)*				
1. Soil analysis	Number of Tests			
2. Plant and Leaf analysis	Number of Tests			
3.				
HARVEST AND PACKING COSTS				
Harvesting *(please specify other costs if necessary in the available spaces below)*				
1. Picking	Hours	NA		
2. Machinery	Hours			
3. Cartage on Farm	Hours	NA		
4.				
5.				
Packing and Handling *(please specify other costs if necessary in the available spaces below)*				
1. Packing	Hours	NA		
2. Packaging material				
- Cartons	Number of Cartons	NA		
- Bins	Number of Bins	NA		
- Trays	Number of Trays	NA		
- Boxes	Number of Boxes	NA		
3. Pre-cooling	Applications		NA	
4.				
5.				
6.				
7.				
MARKETING COSTS				
Road Freight *(please specify the destination)*				
Destination 1:	Number of Carton/Bin/Tray/Box	NA		
Destination 2:	Number of Carton/Bin/Tray/Box	NA		
Destination 3:	Number of Carton/Bin/Tray/Box	NA		
Levies	Number of Carton/Bin/Tray/Box	NA		
Sales/ Commission	Number of Carton/Bin/Tray/Box	NA		

29. What are the major soil types in this region? *(Please tick one or more of the following)*

- ☐ Sand
- ☐ Sand or loam over clay subsoil
- ☐ Light clay
- ☐ Medium/Heavy Clay
- ☐ Other *(Please specify)*_____

If you know the actual name of the soil type/s please specify _____

30. What is the topography of this region?

- ☐ Flat
- ☐ Hilly / Steep
- ☐ Undulating
- ☐ Other (Please specify)_____

31. Is there evidence of any of the following environmental changes occurring in this region?

(If no, please tick the "no" box. If yes, please indicate the degree to which this change is occurring by ticking the high, medium or low box. If yes please also tick the relevant box indicating the status of change).

Environmental Change	No	Yes	Status of Change
1. Soil loss	☐ no	☐ high ☐ medium ☐ low	☐ improving ☐ deteriorating ☐ no change
2. Chemical accumulation in soil	☐ no	☐ high ☐ medium ☐ low	☐ improving ☐ deteriorating ☐ no change
3. Salt accumulation in soil	☐ no	☐ high ☐ medium ☐ low	☐ improving ☐ deteriorating ☐ no change
4. Organic matter / soil structure decline	☐ no	☐ high ☐ medium ☐ low	☐ improving ☐ deteriorating ☐ no change
5. Nutrient levels and nutrient availability	☐ no	☐ high ☐ medium ☐ low	☐ improving ☐ deteriorating ☐ no change
6. Soil acidity levels	☐ no	☐ high ☐ medium ☐ low	☐ improving ☐ deteriorating ☐ no change
7. Soil salinity levels	☐ no	☐ high ☐ medium ☐ low	☐ improving ☐ deteriorating ☐ no change
8. Groundwater salinity levels	☐ no	☐ high ☐ medium ☐ low	☐ improving ☐ deteriorating ☐ no change
9. Surface water salinity levels	☐ no	☐ high ☐ medium ☐ low	☐ improving ☐ deteriorating ☐ no change
10. Chemical levels in irrigation water	☐ no	☐ high ☐ medium ☐ low	☐ improving ☐ deteriorating ☐ no change
11. Options for storing farm chemicals	☐ no	☐ high ☐ medium ☐ low	☐ improving ☐ deteriorating ☐ no change

Environmental Change	No	Yes	Status of Change
12. Options / means for disposing of farm chemicals and chemical containers	☐ no	☐ high ☐ medium ☐ low	☐ improving ☐ deteriorating ☐ no change
13. Options / means for disposing of farm waste (eg. plastic, mulch)	☐ no	☐ high ☐ medium ☐ low	☐ improving ☐ deteriorating ☐ no change
14. Areas of native bushland being removed that would ordinarily assist with pollination functions	☐ no	☐ high ☐ medium ☐ low	☐ improving ☐ deteriorating ☐ no change
15. Areas of riparian (creek) vegetation being removed	☐ no	☐ high ☐ medium ☐ low	☐ improving ☐ deteriorating ☐ no change
16. Other *(Please specify)*		☐ high ☐ medium ☐ low	☐ improving ☐ deteriorating ☐ no change

32. What category of horticultural crop you administer is affected by the environmental changes occurring in this region ?

(Please indicate with a number on a 1 to 4 scale (1=not affected, 2= slightly affected, 3=moderately affected, 4=seriously affected) which crop category is affected. If the environmental change is not an issue for any crop you produce, please tick the Not An Issue box).

Example

Environmental Change	Crop Category		Not an Issue
	Perennial	Annual	
1. Soil loss	2	4	

Soil loss is affecting the yields of both Pecans and Cucumbers on Farm A, however the reduction to Cucumber crop yield has been seriously affected whilst the reduction to Pecan crop yield has only been slightly affected.

Environmental Change	Crop Category		Not an Issue
	Perennial	Annual	
1. Soil loss			
2. Chemical accumulation in soil			
3. Salt accumulation in soil			
4. Organic matter / soil structure decline			
5. Nutrient levels and nutrient availability			
6. Soil acidity levels			
7. Soil salinity levels			
8. Groundwater salinity levels			
9. Surface water salinity levels			
10. Chemical levels in irrigation water			
11. Options for storing farm chemicals			
12. Options / means for disposing of farm chemicals & chemical containers			
13. Options / means for disposing of farm waste (eg plastic, mulch)			
14. Areas of native bushland being removed that would ordinarily assist with pollination functions			

15. Areas of riparian (creek) vegetation being removed			
16. Other *(specify same environmental change as in Question 1C no. 16)*			

33. What prevention or control measures do you adopt to minimise negative impacts on the environment *?* *(Please tick the box that corresponds to the control measure you implement for each relevant crop category)*.

33A. Soil Loss

Crop Category	Prevention and Control Measures
☐ Perennial	☐ contour banks ☐ planned direction of planting ☐ alternative strategies *(Please specify below)* (a) …… (b) …… (c) ……
☐ Annual	☐ contour banks ☐ planned direction of planting ☐ alternative strategies *(Please specify below)* (a) …… (b) …… (c) ……

33B. Chemical Accumulation in Soil

Crop Category	Prevention and Control measures
☐ Perennial	☐ minimise use of chemicals ☐ apply chemicals according to specification ☐ alternative strategies *(Please specify below)* (a) …… (b) …… (c) ……
☐ Annual	☐ minimise use of chemicals ☐ apply chemicals according to specification ☐ alternative strategies *(Please specify below)* (a) …… (b) …… (c) ……

33C. Organic Matter / Soil Structure Decline

Crop Category	Prevention and Control measures
☐ Perennial	☐ green manure cropping ☐ crop rotation ☐ addition of soil additives ☐ alternative strategies *(Please specify below)* (a) …… (b) …… (c) ……
☐ Annual	☐ green manure cropping ☐ crop rotation ☐ addition of soil additives ☐ alternative strategies *(Please specify below)* (a) …… (b) …… (c) ……

33D. Nutrient Levels and Nutrient Availability

Crop Category	Prevention and Control measures
☐ Perennial	☐ legume planting ☐ addition of fertiliser ☐ alternative strategies *(Please specify below)* (a) …… (b) …… (c) ……
☐ Annual	☐ paddock spelling ☐ legume planting ☐ addition of fertiliser ☐ alternative strategies *(Please specify below)* (a) …… (b) …… (c) ……

33E. Soil Acidity Levels

Crop Category	Prevention and Control measures
☐ Perennial	☐ reduce fertiliser applications ☐ apply lime ☐ alternative strategies *(Please specify below)* (a) …… (b) …… (c) ……
☐ Annual	☐ reduce fertiliser applications ☐ apply lime ☐ alternative strategies *(Please specify below)* (a) …… (b) …… (c) ……

33F. Soil Salinity Levels

Crop Category	Prevention and Control measures
☐ Perennial	☐ implement drainage works ☐ salt tolerant crops ☐ plant trees in recharge areas as point of catchment response ☐ alternative strategies *(Please specify below)* (a) …… (b) …… (c) ……
☐ Annual	☐ implement drainage works ☐ salt tolerant crops ☐ plant trees in recharge areas as point of catchment response ☐ alternative strategies *(Please specify below)* (a) …… (b) …… (c) ……

33G. Groundwater Salinity Levels

Crop Category	Prevention and Control measures
☐ Perennial	☐ implement drainage works ☐ salt tolerant crops ☐ plant trees in recharge areas as point of catchment response ☐ alternative strategies *(Please specify below)* (a) …… (b) …… (c) ……
☐ Annual	☐ implement drainage works ☐ salt tolerant crops ☐ plant trees in recharge areas as point of catchment response ☐ alternative strategies *(Please specify below)* (a) …… (b) …… (c) ……

33H. Surface Water Salinity Levels

Crop Category	Prevention and Control measures
☐ Perennial	☐ implement drainage works ☐ salt tolerant crops ☐ plant trees in recharge areas as point of catchment response ☐ alternative strategies *(Please specify below)* (a) …… (b) …… (c) ……
☐ Annual	☐ implement drainage works ☐ salt tolerant crops ☐ plant trees in recharge areas as point of catchment response ☐ alternative strategies *(Please specify below)* (a) …… (b) …… (c) ……

33I. Chemical levels in Irrigation Water

Crop Category	Prevention and Control measures
☐ Perennial	☐ property tailwater return/recycling ☐ chemical treatment of water ☐ alternative strategies *(Please specify below)* (a) …… (b) …… (c) ……
☐ Annual	☐ property tailwater return/recycling ☐ chemical treatment of water ☐ alternative strategies *(Please specify below)* (a) …… (b) …… (c) ……

33J. Chemical, Salt and Sediment Levels in Regional Creeks and Rivers

Crop Category	Prevention and Control measures
☐ Perennial	☐ regional tailwater/recycling systems ☐ catchment approaches (wetlands, treed areas) ☐ alternative strategies *(Please specify below)* (a) …… (b) …… (c) ……
☐ Annual	☐ regional tailwater/recycling systems ☐ catchment approaches (wetlands, treed areas) ☐ alternative strategies *(Please specify below)* (a) …… (b) …… (c) ……

33K. Chemical Spray Drift

Crop Category	Prevention and Control measures
☐ Perennial	☐ control timing of applications ☐ modify/change spray equipment ☐ plant vegetation buffers ☐ alternative strategies *(Please specify below)* (a) …… (b) …… (c) ……
☐ Annual	☐ control timing of applications ☐ modify/change spray equipment ☐ plant vegetation buffers ☐ alternative strategies *(Please specify below)* (a) …… (b) …… (c) ……

33L. Dust drift

Crop Category	Prevention and Control measures
☐ Perennial	☐ control timing of cultivation ☐ reduce number of cultivations ☐ modify cultivation equipment ☐ plant vegetated buffers ☐ alternative strategies *(Please specify below)* (a) …… (b) …… (c) ……
☐ Annual	☐ control timing of cultivation ☐ reduce number of cultivations ☐ modify cultivation equipment ☐ plant vegetated buffers ☐ alternative strategies *(Please specify below)* (a) …… (b) …… (c) ……

33M. Odour spread

Crop Category	Prevention and Control measures
☐ Perennial	☐ control timing of cultivation ☐ modify/change spray equipment ☐ plant vegetated buffers ☐ alternative strategies *(Please specify below)* (a) …… (b) …… (c) ……
☐ Annual	☐ control timing of cultivation ☐ modify/change spray equipment ☐ plant vegetated buffers ☐ alternative strategies *(Please specify below)* (a) …… (b) …… (c) ……

33N. Noise levels

Crop Category	Prevention and Control measures
☐ Perennial	☐ control timing of farming operations ☐ plant vegetated buffers ☐ alternative strategies *(Please specify below)* (a) …… (b) …… (c) ……
☐ Annual	☐ control timing of farming operations ☐ plant vegetated buffers ☐ alternative strategies *(Please specify below)* (a) …… (b) …… (c) ……

33O. Native bushland

Crop Category	Prevention and Control measures
☐ Perennial	☐ retain remnant vegetation areas ☐ maintain a separation distance between crop and bushland area ☐ alternative strategies *(Please specify below)* (a) …… (b) …… (c) ……
☐ Annual	☐ retain remnant vegetation areas ☐ maintain a separation distance between crop and bushland area ☐ alternative strategies *(Please specify below)* (a) …… (b) …… (c) ……

33P. Riparian (creek) vegetation

Crop Category	Prevention and Control measures
☐ Perennial	☐ retain riparian vegetation ☐ maintain a separation distance between crop and riparian areas ☐ alternative strategies *(Please specify below)* (a) …… (b) …… (c) ……
☐ Annual	☐ retain riparian vegetation ☐ maintain a separation distance between crop and riparian areas ☐ alternative strategies *(Please specify below)* (a) …… (b) …… (c) ……

33Q. Storing and disposal of farm chemicals and chemical containers

Crop Category	Prevention and Control measures
☐ Perennial	☐ establish safe collection areas ☐ establish safe disposal methods with authorities ☐ alternative strategies *(Please specify below)* (a) …… (b) …… (c) ……
☐ Annual	☐ establish safe collection areas ☐ establish safe disposal methods with authorities ☐ alternative strategies *(Please specify below)* (a) …… (b) …… (c) ……

33R. Disposal of farm waste (eg plastic mulch)

Crop Category	Prevention and Control measures
☐ Perennial	☐ establish safe collection areas ☐ establish safe disposal methods with authorities ☐ alternative strategies *(Please specify below)* (a) …… (b) …… (c) ……..
☐ Annual	☐ establish safe collection areas ☐ establish safe disposal methods with authorities ☐ alternative strategies *(Please specify below)* (a) …… (b) …… (c) ……

33S. Other *(Please specify)* _____

Crop Category	Prevention and Control measures
☐ Perennial	(a) …… (b) …… (c) ……
☐ Annual	(a) …… (b) …… (c) ……

34. Are farm operations in the region audited?

☐ Yes ☐ No

35. If yes, what type of farm operations audit is completed in your region?

☐ Self
(eg landholder records audit results)

☐ 2nd party
(eg industry REPRESENTATIVE)

☐ 3rd party
(eg completely independent party)

☐ None

36. Where do you supply information on horticultural subjects and other related agricultural subjects?

(Please tick one or more of the following and indicate the percentage of information received from each source nominated)

- ☐ Meetings _____ %
- ☐ Industry papers _____ %
- ☐ Industry newsletters _____ %
- ☐ Internet _____ %
- ☐ Rural Newspapers _____ %
- ☐ Radio _____ %
- ☐ Television _____ %
- ☐ Government publications _____ %
- ☐ Field days/ workshops _____ %
- ☐ Other *(please specify)* _____

37. Do you conduct formal training programs for landholders in your region(s)?

☐ Yes ☐ No

38. Please specify training programs offered, if any.

Industry/ Crop	Region	Training Program Details

END OF SURVEY - THANKYOU FOR YOUR TIME

Appendix 6 Environmental Legislation Affecting Horticulture

Federal

Title	Year
Aerial Spraying Control Act	1994
Agricultural and Veterinary Chemicals Act	1996
Agricultural Practices Disputes Act	1962
Agriculture Act	1993
Agriculture and Related Resources Act	1992
Australian Animal Health Council (Live-stock Industries) Funding Act	1991
Biological Control Act	1992
Catchment and Land Protection Act	1992
Clean Waters Act	1975
Controlled Substances (Pesticides) Act	1987
Crown Lands Act	1993
Endangered Species Protection Act	1992
Environment Protection (Impact of Proposals Act)	1974
Income Tax Assessment Act	1936
Murray-Darling Basin Act	1993
National Residue Survey Administration Act	1992
National Road Transport Commission Act	1991
Native Title Act	1993
Natural Resource Management (Financial Assistance) Act	1992
Primary Industries and Energy Research and Development Act	1989
Quarantine Act	1908
Australian Horticultural Corporation Act	1987
Dried Sultana Production Underwriting Act	1993
Urban and Regional Development (Financial Assistance) Act	1977

New South Wales

Title	Year
Biological Control Act	1985
Catchment Management Act	1989
Clean Air Act	1961
Clean Waters Act	1970
Coastal Protection Act	1979
Conservation Agricultural Tenancies Act	1990
Dangerous Goods Act	1975
Endangered Fauna (Interim Protection) Act	1991
Environmental Offences and Penalties Act	1989
Environmental Planning and Assessment Act	1979
Environmental Protection Act	
Environmental Restoration and Rehabilitation Trust Act	1990
Environmentally Hazardous Chemicals Act	1985
Farm Water Supplies Act	1985
Fertilisers Act	1985
Land and Environment Court Act	1979
Local Government Act	1993
Murray-Darling Basin Act	1992
New South Wales - Queensland Border Rivers Act	1947
Noise Control Act	1975
Noxious Weeds Act	1993
Pesticides Act	1978
Plant Diseases Act	1924
Pollution Control Act	1975
Prickly Pear Act	1987
Protection of the Environment Administration Act	1991
Public Health Act	1991
Rivers and Foreshores Improvement Act	1948
Rural Adjustment Scheme Agreement Act	1993
Rural Lands Protection Act	1989
Soil Conservation Act	1938
Waste Disposal Act	1970
Water Act	1912
Water Administration Act	1986
Water Board Act	1987
Western Lands Act	1901
Horticultural Policy Council Act	1997
Bush Fires Act	1949

Northern Territory

Title	Year
Planning Act	1993
Environmental Assessment Act	1982
Water Act	1992
Waste Management and Pollution Control Act	1998
Territory Parks and Wildlife Conservation Act	
Aboriginal Lands Act	1978
Northern Territory Fisheries Act	1988

Queensland

Title	Year
Agricultural Chemicals Distribution Control Act	1966
Agricultural Standards Act	1952
Carriage of Dangerous Goods by Road Act	1984
Chemical Usage (Agricultural and Veterinary) Control Act	1988
Clean Air Act	1963
Clean Waters Act	1971
Conservation Biological Control Act	1987
Contaminated Land Act	1991
Environmental Protection Act	1994
Irrigation Act	1994
Irrigation Areas (Land Settlement) Act	1962
Land Act	1994
Local Government (Planning and Environment) Act	1990
Local Government Act	1993
Mixed Use Development Act	1993
Native Plants Protection Act	1930
Native Title (Queensland) Act	1993
Nature Conservation Act	1992
Noise Abatement Act	1978
Pollution of Waters by Oil Act	1973
River Improvement Trust Act	1940
Rural Lands Protection Act	1985
Soil Conservation Act	1986
Water Resources Act	1989
Horticultural Research and Development Corporation Act	1994
Horticulture, Stock and Nurseries Act	

South Australia

Title	Year
Agricultural Chemicals Act	1955
Animal and Plant Control (Agricultural Protection and other Purposes) Act	1986
Catchment Water Management Act	1995
Biological Control Act	1986
Controlled Substances Act	1984
Country Fires Act	1989
Crown Lands Act	1929
Dangerous Substances Act	1979
Environment Protection Act	1993
Groundwater (Border Agreement) Act	1985
Land Acquisition Act	1969
Land Administration Act	1929
Local Government Act	1934
Murray-Darling Basin Act	1993
National Parks and Wildlife Act	1972
Native Vegetation Act	1991
Natural Resources Management (Financial Assistance) Act	1997
Noxious Insects Act	1934
Pesticides Act	1962
Pollution of Waters by Oil and Noxious Substances Act	1987
Public and Environmental Health Act	1987
Soil Conservation and Land Care Act	1989
Water Conservation Act	1936
Water Resources Act	1990
Wilderness Protection Act	1992
Fruit and Plant Protection Act	1992

Tasmania

Title	Year
Biological Control Act	1986
Conservation National Parks and Wildlife Act	1970
Dangerous Goods Act	1976
Public Health Act	1962
Environment Protection Act	1973
Farm Water Development Act	1985
Fertilisers Act	1993
Groundwater Act	1985
Land Use Planning and Approvals Act	1993
Lands Acquisition Act	1993
Local Government Act	1993
Noxious Insects and Molluscs Act	1951
Noxious Weeds Act	1964
Pesticides Act	1968
Plant Diseases Act	1930
Poisons Act	1971
Pollution of Waters by Oil and Noxious Substances Act	1987
Resource Management and Planning Appeal Tribunal Act	1993
Rural Adjustment Act	1990
Water Act	1957
Water Resources Investigation Act	1937

Victoria

Title	Year
Agricultural and Veterinary Chemicals Act	1992
Biological Control Act	1986
Catchment and Land Protection Act	1994
Conservation, Forests and Lands Act	1987
Dangerous Goods Act	1985
Drugs, Poisons and Controlled Substances Act	1981
Environment Protection (Air Pollution Control) Act	1982
Environment Protection (Clean Air) Act	1981
Environment Protection (Ozone Layer) Act	1989
Environment Protection (Waste Disposals) Act	1985
Environment Protection Act	1970
Environmental Effects Act	1978
Flora and Fauna Guarantee Act	1988
Groundwater (Border Agreement) Act	1985
Groundwater Act	1964
Land Conservation (Vehicle Control) Act	1970
Land Conservation Act	1970
Local Government Acts	1989
Murray-Darling Basin Act	1993
Occupational Health and Safety Act	1985
Planning and Environment Act	1987
Planning Appeals Act	1980
Pollution of Waters by Oil and Noxious Substances Act	1986
Protection of Environment Act	1998
Rural Adjustment Act	1994
Rural Lands Protection Act	1994
Soil and Land Conservation Act	1958
Soil Conservation and Land Utilization Act	1958

Title	Year
Vegetation and Vine Diseases Act	1958
Vermin and Noxious Weeds Act	1958
Water (Rural Water Corporation) Act	1992
Water Act	1989
Wildlife Act	1975
Victorian Conservation Trust Act	
Reference Areas Act	1978

Western Australia

Title	Year
Agricultural Produce (Chemical Residues) Act	1983
Agriculture Act	1988
Agriculture and Related Resources Protection Act	1976
Agriculture Protection Board Act	1950
Biological Control Act	1986
Conservation and Land Management Act	1984
Environmental Protection Act	1986
Fertilisers Act	1977
Land (Titles and Traditional Usage) Act	1993
Land Drainage Act	1925
Local Government Act	1960
Occupational Health, Safety and Welfare Act	1984
Plant Diseases Act	1914
Poisons Act	1964
Pollution Aerial Spraying Control Act	1966
Pollution of Waters by Oil and Noxious Substances Act	1987
Regional Development Commission Act	1993
Reserves and Land Revestment Act	1991
Rights in Water and Irrigation Act	1914
Soil and Land Conservation Act	1945
Soil Conservation and Landcare Act	1988
Town Planning and Development Act	1928
Water Authority Act	1984
Water Resources Act	1997
Waterways Conservation Act	1976
Western Australian Land Authority Act	1992
Wildlife Conservation Act	1950
Bush Fires Act	1954

Appendix 7 Gross Margins

Crop Name	Notes	Year	Region	Source	Gross Margin ($/ha)
Beans	French & Runner	1997	North Qld	QDPI	3,991.89
Beans	Green	1997	North Qld	QDPI	2,205.00
Beans	Green	1998/99	TAS high rainfall	Tas DPIF	1,305.00
Beans	Broad	1998/99	TAS high rainfall	Tas DPIF	291.00
Beetroot	Sliced / processed	1997	North Qld	QDPI	5,301.00
Brocolli		1996	NSW	NSW Agriculture	1,839.80
Brocolli		1997	north	QDPI	1,036.00
Brocolli		1998/99	TAS high rainfall	Tas DPIF	2,151.00
Brussel Sprouts		1998/99	TAS high rainfall	Tas DPIF	5,613.00
Cabbage		1996	NSW	NSW Agriculture	953.81
Capsicum		1996	NSW	NSW Agriculture	1,113.58
Capsicum		1999	Katherine NT, 1999	NT Govt Ag Note	14,237.87
Capsicum		1997	central Qld	QDPI	903.85
Capsicum		1996	south east Qld	QHI	9,423.78
Carrots	Processing	1996	NSW	NSW Agriculture	3,147.18
Carrots	Fresh	1996	NSW	NSW Agriculture	2,317.18
Carrots	Baby	1998/99	TAS high rainfall	Tas DPIF	5,043.00
Carrots		1998/99	TAS high rainfall	Tas DPIF	3,839.00
Cauliflower		1996	NSW	NSW Agriculture	505.10
Cauliflower		1998/99	TAS high rainfall	Tas DPIF	3,125.00
Cucumbers	Lebanese	1996	Sydney, NSW	L Davis & L James, "Economic Analysis", 1996	6,411.80
Cucumbers		1996	NSW	NSW Agriculture	114.85
Cucumbers		1997	central Qld	QDPI	7,528.32
Eggplant		1996	NSW	NSW Agriculture	(1.93)
Garlic		1996	NSW	NSW Agriculture	6,496.85
Lettuce		1996	NSW	NSW Agriculture	2,706.67
Lettuce		1997	North Qld	QDPI	11,628.00
Melons - Rock	Early	1996	NSW	NSW Agriculture	2,840.06
Melons - Rock	Late	1996	NSW	NSW Agriculture	1,518.02
Melons - Rock		1997	Katherine NT	NT Govt Ag Note	5,482.12
Melons - Rock		1997	central Qld	QDPI	3,100.40
Melons - Water		1996	NSW	NSW Agriculture	1,702.25
Melons - Water		1997	Katherine NT	NT Govt Ag Note	1,883.52
Melons - Water		1997	central Qld	QDPI	918.52
Onions	packer-grower	1996	NSW	NSW Agriculture	4,493.10
Onions	grower only	1996	NSW	NSW Agriculture	1,273.10
Onions	white	1997	North Qld	QDPI	1,977.00
Onions		1998/99	TAS high rainfall	Tas DPIF	2,616.00
Parsnips		1996	NSW	NSW Agriculture	1,908.99

Crop Name	Notes	Year	Region	Source	Gross Margin ($/ha)
Peas	Processing	1998/99	TAS high rainfall	Tas DPIF	1,224.00
Peas	Green - irrigated	1997/98	TAS low rainfall	Tas DPIF	914.00
Peas	Field - dryland	1997/98	TAS low rainfall	Tas DPIF	82.00
Potato - sweet		1991	NT (the Top End)	NT Govt Ag Note	6,355.79
Potatoes	Spring/Summer - Processing	1996	NSW	NSW Agriculture	3,552.84
Potatoes	Autumn/Winter	1996	NSW	NSW Agriculture	989.44
Potatoes		1997	central Qld	QDPI	2,747.03
Potatoes	white	1997	North Qld	QDPI	1,637.00
Potatoes	Processing, Russet Burbank	1998/99	TAS high rainfall	Tas DPIF	5,759.00
Potatoes	Processing, Kennebec	1998/99	TAS high rainfall	Tas DPIF	4,601.00
Potatoes	Processing - Russet Burbank	1997/98	TAS high rainfall	Tas DPIF	5,814.00
Potatoes - seed	Kennebec	1998/99	TAS high rainfall	Tas DPIF	5,923.00
Potatoes - seed	Russet Burbank	1998/99	TAS high rainfall	Tas DPIF	5,721.00
Pumpkins	Butternut	1996	NSW	NSW Agriculture	1,281.84
Pumpkins		1996	NSW	NSW Agriculture	898.71
Pumpkins	Butternut	1997	Katherine NT	NT Govt Ag Note	4,500.95
Pumpkins	Jap/Qld Blue	1995	Katherine NT	NT Technical Bulletin 237	1,499.96
Pumpkins		1997	central Qld	QDPI	2,791.79
Pumpkins	Jarrahdale	1997	North Qld	QDPI	541.00
Squash	Button	1997	Katherine NT	NT Govt Ag Note	4,536.23
Squash	Kabocha	1998/99	TAS high rainfall	Tas DPIF	1,586.00
Swedes		1996	NSW	NSW Agriculture	1,260.06
Sweet Corn	Processing	1996	NSW	NSW Agriculture	716.46
Sweet Corn	irrigated	1997	North Qld	QDPI	1,272.00
Sweet Corn		1997	central Qld	QDPI	245.61
Tomatoes	Processing	1996	NSW	NSW Agriculture	2,520.23
Tomatoes	Fresh	1996	NSW	NSW Agriculture	3,063.87
Tomatoes		1997	central Qld	QDPI	3,960.37
Tomatoes	trellised	1997	North Qld	QDPI	7,328.00
Tomatoes	trellised	1996	south east Qld	QHI	11,872.02
Zucchini		1996	NSW	NSW Agriculture	3,132.63
Zucchini		1995	Katherine NT	NT Technical Bulletin 237	2,563.93
Zucchini		1997	central Qld	QDPI	1,640.53

Crop Name	Notes	Year	Region	Source	Gross Margin ($/ha)
Apples	lateral bearing	1991	Batlow, NSW	NSW Agriculture	23,112.00
Apples	intensive	1991	Batlow, NSW	NSW Agriculture	22,900.00
Apples	spur bearing	1991	Batlow, NSW	NSW Agriculture	20,134.00
Asparagus	mature	1997	Qld		10,336.47
Asparagus	year 4	1996	NSW	NSW Agriculture	13,010.25
Asparagus	year 3	1996	NSW	NSW Agriculture	8,573.25
Asparagus	year 4 on	1997	Katherine NT	NT Govt Ag Note	5,233.83
Asparagus	year 3	1997	Katherine NT	NT Govt Ag Note	2,756.33
Asparagus	year 2	1997	Katherine NT	NT Govt Ag Note	278.83
Asparagus	year 6	1998	Qld	QDPI	9,176.07
Asparagus	year 5	1998	Qld	QDPI	6,792.37
Asparagus	year 4	1998	Qld	QDPI	2,702.94
Asparagus	year 3	1998	Qld	QDPI	(111.53)
Asparagus	year 2	1998	Qld	QDPI	(990.59)
Asparagus	year 1	1998	Qld	QDPI	(7,835.38)
Avocadoes		1997	Mareeba Dimbula Irrigation Area - Qld	QDPI	12,663.46
Bananas	top 20% of growers	1997/98	North Qld	ABGC - Aust Banana Growers' Council	12,786.00
Bananas	average grower	1997/98	Ord	ABGC - Aust Banana Growers' Council	6,304.00
Bananas	top 20% of growers	1997/98	Southern Aust	ABGC - Aust Banana Growers' Council	4,688.00
Bananas	average grower	1997/98	north Qld	ABGC - Aust Banana Growers' Council	2,187.00
Bananas	average grower	1997/98	Southern Aust	ABGC - Aust Banana Growers' Council	358.00
Bananas	top 20% of growers	1996/97	North Qld	ABGC - Aust Banana Growers' Council	25,971.00
Bananas	average grower	1996/97	Ord	ABGC - Aust Banana Growers' Council	17,244.00
Bananas	average grower	1996/97	North Qld	ABGC - Aust Banana Growers' Council	12,737.00
Bananas	top 20% of growers	1996/97	Southern Aust	ABGC - Aust Banana Growers' Council	11,653.00
Bananas	average grower	1996/97	Southern Aust	ABGC - Aust Banana Growers' Council	2,047.00
Bananas	average grower	1995/96	Ord	ABGC - Aust Banana Growers' Council	13,540.00

Crop Name	Notes	Year	Region	Source	Gross Margin ($/ha)
Bananas	top 20% of growers	1995/96	North Qld	ABGC - Aust Banana Growers' Council	10,043.00
Bananas	top 20% of growers	1995/96	Southern Aust	ABGC - Aust Banana Growers' Council	6,522.00
Bananas	average grower	1995/96	north Qld	ABGC - Aust Banana Growers' Council	3,845.00
Bananas	average grower	1995/96	Southern Aust	ABGC - Aust Banana Growers' Council	(1,043.00)
Bananas	Lady Finger	1996	NSW	BGF Bulletin "R&D Matters" Jan 1996, p.20	1,504.20
Bananas	Cavendish	1996	NSW	BGF Bulletin Jan 1996, p.20	(1,901.00)
Bananas	ratoon crop	1991	Katherine NT	NT Govt Ag Note	10,363.00
Bananas	plant crop	1991	Katherine NT	NT Govt Ag Note	(6,027.00)
Bananas	ratoon crop	1997	tropical north Qld	Phil Ross (QHI) - Agrilink	4,620.54
Bananas	plant crop	1997	tropical north Qld	QHI - Agrilink	(1,382.69)
Cherries	irrigated - Lenswood	1997	NSW	NSW Agriculture	19,227.20
Cherries	irrigated - vase trained	1997	NSW	NSW Agriculture	16,603.60
Lemons	double density planting	1997	central coast NSW	NSW Agriculture	6,041.50
Lemons	Standard density planting	1997	central coast NSW	NSW Agriculture	3,359.70
Lychees		1997	Mareeba Dimbula Irrigation Area - Qld	QDPI	26,286.38
Mandarins	Clementine	1997	Riverina	NSW Agriculture	8,211.84
Mandarins	Imperial	1997	Sunraysia	NSW Agriculture	3,246.73
Mandarins		1997	North Qld	QDPI	29,175.73
Mangoes		1997	Dry Tropics	QDPI	11,026.41
Nectarine	Palmette Hedgerow - Mayglo	1998	Gosford, NSW	NSW Agriculture	35,326.52
Nectarine	open vase - Springbright	1998	Gosford, NSW	NSW Agriculture	14,277.04
Nectarine	Palmette Hedgerow - Flavour Top	1998	Orange, NSW	NSW Agriculture	12,186.11
Oranges	early Navel	1997	Riverina	NSW Agriculture	8,203.39
Oranges	late Navel	1997	Sunraysia	NSW Agriculture	6,024.21
Oranges	late Navel	1997	Riverina	NSW Agriculture	3,964.64
Oranges	Washington navel	1997	Sunraysia	NSW Agriculture	3,884.13
Oranges	Washington navel	1997	Riverina	NSW Agriculture	2,581.49
Oranges	Valencia	1997	Riverina	NSW Agriculture	1,739.29
Oranges	Valencia	1997	Sunraysia	NSW Agriculture	1,333.03
Oranges	Washington navel	1997	central coast NSW	NSW Agriculture	1,278.53

Crop Name	Notes	Year	Region	Source	Gross Margin ($/ha)
Oranges	Valencia	1997	central coast NSW	NSW Agriculture	236.51
Passionfruit		1998	northern NSW	AgriLink - prepared by John Dirou	5,881.00
Peach	Palmette hedgerow - J H Hale	1998	Orange, NSW	NSW Agriculture	18,956.69
Peach	Palmette Hedgerow - Rich lady	1998	Gosford, NSW	NSW Agriculture	4,054.27
Peaches		1997	north Qld irrigation	QDPI	27,027.63
Peaches & Nectarines	low to medium chill - Palmette Hedgerow	1998	Windsor, NSW	NSW Agriculture	14,699.29
Peaches & Nectarines	low chill - Palmette Hedgerow, Alstonville	1998	Alstonville, NSW	NSW Agriculture	14,496.61
Peaches & Nectarines	low chill - open vase	1998	Alstonville, NSW	NSW Agriculture	13,046.61
Peaches & Nectarines	low to medium chill -open vase	1998	Windsor, NSW	NSW Agriculture	11,875.24
Peaches & Nectarines	high chill - Palmette Hedgerow	1998	Tumut, NSW	NSW Agriculture	11,602.31
Peaches & Nectarines	low to medium chill -open vase	1998	Camden, NSW	NSW Agriculture	10,744.92
Peaches & Nectarines	High chill - open vase trained	1998	Tumut, NSW	NSW Agriculture	10,654.98
Peaches & Nectarines	High chill - open vase trained	1998	Young, NSW	NSW Agriculture	1,950.17
Pineapples	plant crop	1991	Darwin, NT	NT Govt Ag Note	23,272.00
Pineapples	ratoon crop	1991	Darwin, NT	NT Govt Ag Note	17,752.00
Plum	Palmette hedgerow - President	1998	Orange, NSW	NSW Agriculture	18,722.98
Plum	Palmette Hedgerow - Donsworth	1998	Gosford, NSW	NSW Agriculture	8,511.20
Plum	Open vase - Japanese	1998	Young, NSW	NSW Agriculture	2,659.07
Strawberries		1999	Sydney Basin	NSW Agriculture	14,522.76