GWRDC PROJECT GWR 08/04

"Assessment of Economic Cost of Endemic Pests & Diseases on the Australian Grape & Wine Industry"

Prepared for : GWRDC

By : Scholefield Robinson Horticultural Services Pty Ltd and EconSearch Pty Ltd

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"Assessment of Economic Cost of Endemic Pests & Diseases on the Australian Grape & Wine Industry" Final Report

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TABLE OF CONTENTS

Glossary vii

Executive Summary viii

1 Introduction 1
1.1 Scope 1
1.2 Project Objectives 1
1.3 Project Team & Management 1

2 Methodology 2
2.1 Inception Meeting 2
2.2 Industry Reference Group 2
2.3 Issues Paper and Survey 2
2.4 Workshop 2
2.5 Initial Estimates 3
2.6 Prioritisation 3
2.7 Design of Economic Model 3
2.8 Operation of Economic Model 3
2.9 Draft Report 3
2.10 Final Report and Distribution 3
2.11 Summary of Methodology 3

3 Project Development & Planning 4
3.1 Introduction 4
3.2 Selection of Climatic Zones 4
3.3 Selection of Pests & Diseases 6
3.4 Types of Data Required 6
3.5 Data Acquisition 6
3.6 Analysis and Synthesis into Model 7

4 Survey, Workshop & Consultation 7
4.1 Data Acquisition 7
4.2 Issues Paper 7
4.3 Survey 7
4.4 Workshop 8
4.5 Description of Priority Pests & Diseases 12
4.6 "Organic" Production Systems 14

5 Economic Modelling 15
5.1 Introduction 15
5.2 Modelling the Economic Impact of Pests & Diseases 15
5.3 Physical & Economic Characteristics of the Australian Winegrape Industry 39
5.4 Estimates of the National Economic Impact of Selected Winegrape Pests & Diseases 41
5.5 Summary & Conclusions 76

6 Findings Related to Investment in RD&E 78
6.1 Introduction 78
6.2 Past GWRDC Funding 78
6.3 Comparison of Economic Impact of Pests & Diseases & GWRDC RD&E Funding 80
6.4 Comments on GWRDC Funding & Industry Needs 83

7 Implications for GWRDC 85
7.1 RD&E for Pests & Diseases: An Overseas Example 85
7.2 Findings from the Present Project 86

LIST OF TABLES

Table 1 : Thresholds for specifying Climatic Zones 5
Table 2 : Wine Zones allocated to Climatic Zones 6
Table 3 : Pests & Diseases Ranked as 'Top 3' & General Nature of Economic Impact 8
Table 4 : Pests & diseases of concern by Climatic Zone 9
Table 5 : Listed pests & diseases not included in 'pests & diseases of concern' 10
Table 6 : Groupings of Priority Pests & Diseases for Economic Modelling 11
Table 7 : Climatic Zones by geographical indications zones & state 17
Table 8 : Selected indicators for representative vineyard-level models 18
Table 9 : Average vineyard size in selected South Australian geographical indications zones, 2008 18
Table 10 : Number of sprays applied per year in each climatic zone 19
Table 11 : Data & assumptions used for modelling the economic impact of Powdery Mildew 24
Table 12 : Data & assumptions used for modelling the economic impact of Botrytis & Other Bunch Rots 24
Table 13 : Data & assumptions used for modelling the economic impact of Downy Mildew 25
Table 14 : Data & assumptions used for modelling the economic impact of Light Brown Apple Moth 25
Table 15 : Data & assumptions used for modelling the economic impact of Garden Weevil 28
Table 16 : Data & assumptions used for modelling the economic impact of Trunk Boring Insects 28
Table 17 : Data & assumptions used for modelling the economic impact of Mealy bugs & Scale 28
Table 18 : Data & assumptions used for modelling the economic impact of Trunk Diseases 36
Table 19 : Data & assumptions used for modelling the economic impact of Roots Rots 36
Table 20 : Data & assumptions used for modelling the economic impact of Viruses & Transmissible Organisms 37
Table 21 : Data & assumptions used for modelling the economic impact of Root-Knot & Other Nematodes 37
Table 22 : Data & assumptions used for modelling the economic impact of Phylloxera 38
Table 23 : Data & assumptions used for modelling the economic impact of Birds 38
Table 24 : Red grapes for winemaking: area & production by climatic zone, 2008 40
Table 25 : White grapes for winemaking: area & production by climatic zone, 2008 40
Table 26 : Total grapes for winemaking: area & production by climatic zone, 2008 40
Table 27 : Average price of grapes for winemaking by climatic zone & variety 41
Table 28 : Average vineyard-level economic impact of Powdery Mildew by climatic zone 42
Table 29 : Average industry-wide economic impact of Powdery Mildew by climatic zone 44
Table 30 : Average vineyard-level economic impact of Botrytis & Other Bunch Rots by climatic zone 45
Table 31 : Average industry-wide economic impact of Botrytis & Other Bunch Rots by climatic zone 46
Table 32 : Average vineyard-level economic impact of Downy Mildew by climatic zone 48
Table 33 : Average industry-wide economic impact of Downy Mildew by climatic zone 49
Table 34 : Average vineyard-level economic impact of Light Brown Apple Moth by climatic zone 50

Table 35 : Average industry-wide economic impact of Light Brown Apple Moth by climatic zone 51

Table 36 : Average vineyard-level economic impact of Garden Weevil by climatic zone 52

Table 37 : Average industry-wide economic impact of Garden Weevil by climatic zone 53

Table 38 : Average vineyard-level economic impact of Trunk Boring Insects by climatic zone 55

Table 39 : Average industry-wide economic impact of Trunk Boring Insects by climatic zone 56

Table 40 : Average vineyard-level economic impact of Mealy bugs & Scale by climatic zone 57

Table 41 : Average industry-wide economic impact of Mealy bugs and Scale by climatic zone 58

Table 42 : Average vineyard-level economic impact of Trunk Diseases by climatic zone.. 59

Table 43 : Average industry-wide economic impact of Trunk Diseases by climatic zone... 60

Table 44 : Average vineyard-level economic impact of Root Rots by climatic zone 61

Table 45 : Average industry-wide economic impact of Root Rots by climatic zone 62

Table 46 : Average vineyard-level economic impact of Viruses & Transmissible Organisms by climatic zone....... 63

Table 47 : Average industry-wide economic impact of Viruses & Transmissible Organisms by climatic zone 64

Table 48 : Average vineyard-level economic impact of Root-Knot & Other Nematodes by climatic zone 66

Table 49 : Average industry-wide economic impact of Root-Knot & Other Nematodes by climatic zone 67

Table 50 : Average vineyard-level economic impact of Phylloxera by climatic zone 68

Table 51 : Average industry-wide economic impact of Phylloxera by climatic zone 69

Table 52 : Average vineyard-level economic impact of birds by climatic zone 71

Table 53 : Average industry-wide economic impact of birds by climatic zone 72

Table 54 : Average industry-wide impact of priority pests & diseases of winegrapes in Australia 73

Table 55 : Confidence intervals for the industry-wide economic impact of selected winegrape pests & diseases in Australia 75

Table 56 : R&D expenditure by GWRDC on pests & diseases between 1993/94 & present..................................... 79

Table 57 : Comparison of pests and diseases in order of Mean Economic Impact ($) and GWRDC funding on these pests and diseases 80

Table 58 : Comparison of ranking of pests and diseases for Mean Economic Impact, Survey and Workshop Priorities and GWRDC funding from 1993 to 2009 81

Table 59 : Specific comments on industry needs related to findings from National Economic Impact of pests & diseases 83

LIST OF FIGURES

Figure 1 : Structure of team and responsibilities.. 2

Figure 2 : Map of Australian Wine Zones.. 5

Figure 3 : Average vineyard-level economic impact of Powdery Mildew by climatic zone [a].................................... 43

Figure 4 : Average industry-wide economic impact of Powdery Mildew by climatic zone [a]..................................... 44

Figure 5 : Average vineyard-level economic impact of Botrytis & Other Bunch Rots by climatic zone [a]................ 45

Figure 6 : Average industry-wide economic impact of Botrytis & Other Bunch Rots by climatic zone [a] 47

Figure 7 : Average vineyard-level economic impact of Downy Mildew by climatic zone [a] 48

Figure 8 : Average industry-wide economic impact of Downy Mildew by climatic zone [a] 49

Figure 9 : Average vineyard-level economic impact of Light Brown Apple Moth by climatic zone[a] 50

Figure 10 : Average industry-wide economic impact of Light Brown Apple Moth by climatic zone [a] 51

Figure 11 : Average vineyard-level economic impact of Garden Weevil by climatic zone[a] 53

Figure 12 : Average industry-wide economic impact of Garden Weevil by climatic zone[a] 54

Figure 13 : Average vineyard-level economic impact of Trunk Boring Insects by climatic zone[a] 55

Figure 14 : Average industry-wide economic impact of Trunk Boring Insects by climatic zone[a] 56

Figure 15 : Average vineyard-level economic impact of Mealy bugs & Scale by climatic zone[a] 58

Figure 16 : Average industry-wide economic impact of Mealy bugs & Scale by climatic zone[a] 59

Figure 17 : Average vineyard-level economic impact of Trunk Diseases by climatic zone[a] 60

Figure 18 : Average industry-wide economic impact of Trunk Diseases by climatic zone[a] 61

Figure 19 : Average vineyard-level economic impact of Root Rots by climatic zone[a] 62

Figure 20 : Average industry-wide economic impact of Root Rots by climatic zone[a] 63

Figure 21 : Average vineyard-level economic impact of Viruses & Transmissible Organisms by climatic zone[a] 64

Figure 22 : Average industry-wide economic impact of Viruses & Transmissible Organisms by climatic zone [a] 65

Figure 23 : Average vineyard-level economic impact of Root-Knot & Other Nematodes by climatic zone [a] 66

Figure 24 : Average industry-wide economic impact of Root-Knot & Other Nematodes by climatic zone [a] 67

Figure 25 : Average vineyard-level economic impact of Phylloxera by climatic zone[a] 69

Figure 26 : Average industry-wide economic impact of Phylloxera by climatic zone[a] 70

Figure 27 : Average vineyard-level economic impact of birds by climatic zone[a] 71

Figure 28 : Average industry-wide economic impact of birds by climatic zone[a] 72

Figure 29 : Average industry-wide economic impact of selected winegrape pests & diseases in Australia[a] 74

Figure 30 : Confidence intervals for the industry-wide economic impact of selected winegrape pests & diseases in Australia[a] 76

Figure 31 : Comparison of Economic Impact and GWRDC Funding 82

Figure 32 : A diagrammatic representation of the relationships between research projects, stakeholder challenges, fundamental research & "blue sky" research 85

LIST OF APPENDICES

Appendix 1 Expression of Interest for Assessment of Economic Cost of Endemic Pests and Diseases on the Australian Grape and Wine Industry

Appendix 2 Issues Paper, Workshop Agenda, Survey Questionnaire and Survey Outcomes Presentation

Appendix 3 Data Collection Template used for Collection of Vineyard Information for the Economic Modelling in Section 5

Appendix 4 Examples of Pest & Disease Programs

Appendix 5 List of References

GLOSSARY

Term/Abbreviation	***Definition***
AWBC	Australian Wine and Brandy Corporation
EPPRD	Emergency Plant Pest Response Deed (agreement between PHA and Commonwealth and State governments)
GFkV	Grapevine Fleck Virus
GI	Geographical Indications
GLRaV	Grapevine Leaf Roll associated Virus
GRSLaV	Grapevine Rootstock Stem Lesion associated Virus
GSR	Growing Season Rainfall
GVA	Grapevine Virus A
GVB	Grapevine Virus B
GWRDC	Grape and Wine Research and Development Corporation
IRG	Industry Reference Group
LBAM	Light Brown Apple Moth
MJT	Mean January Temperature
MOG	Matter Other than Grapes
PHA	Plant Health Australia
PGIBSA	Phylloxera and Grape Industry Board of South Australia
RD&E	Research, Development and Extension
RSPaV	Rupestris Stem Pitting associated Virus
SRHS	Scholefield Robinson Horticultural Services Pty Ltd
WFA	Winemakers Federation of Australia
WGGA	Wine Grape Growers Association
YVD	Young Vine Decline

EXECUTIVE SUMMARY

The Grape and Wine Research and Development Corporation (GWRDC) engaged Scholefield Robinson Horticultural Services Pty Ltd (Scholefield Robinson) and EconSearch Pty Ltd (EconSearch) to estimate the economic impact of the endemic pests and diseases of viticulture in Australia in order to provide current data on their absolute and relative cost to the grape and wine industry. Exotic pests and diseases are not included in this project.

The project objectives formulated by GWRDC were to:

- Collate a list of endemic pests and diseases considered to impact significantly on the productivity of winegrape producers in Australia;
- Collate all available contemporary estimates of the per annum economic impact of these pests and diseases on the profitability of Australian winegrape producers and identify pests including new and emerging pests and diseases for which no estimates of impact are available;
- Develop impact estimates using economic modelling for all significant pests and diseases (selected in consultation with relevant stakeholders) using consistent methodology; and
- Assess qualitatively how research investment on a specified list of pests and diseases might result in the largest return, for example through new prediction models, new control options, improved extension of current control recommendations, or a combination of these.

The project team was made up of Scholefield Robinson consultants with both grape and wine industry experience and pest and disease skills, EconSearch economists with grape and wine industry experience and a panel of industry personnel with "hands on" experience as grape growers, winery viticulturists and chemical company specialists.

This was a project assessing the economic impact over the national industry. The project team divided the industry into climatic zones based on Mean January Temperature (MJT) and Growing Season Rainfall (GSR) as described in Dry and Coombe (2008).

Five climatic zones were selected:

- Hot-wet (MJT >21°C, GSR >300mm);
- Hot-dry (MJT >21°C, GSR <300mm);
- Warm-wet (MJT 19-20.9°C, GSR >300mm);
- Warm-dry (MJT 19-20.9°C, GSR <300mm);
- Cool (MJT <19°C, GSR >300mm).

The Australian wine zones as defined by AWBC as part of their Australian Geographic Indicators (GI) register were allocated to the selected climatic zones (Table ES1). The climatic zones contained wine zones from different states with similar climatic characteristics and pest and disease issues.

Table ES1 : Wine Zones allocated to Climatic Zones

Hot-Wet	Hot-Dry	Warm- Wet	Warm- Dry	Cool
Central Ranges, NSW	Big Rivers, NSW	Northern Slopes, NSW	South West WA	South Coast, NSW
Hunter Valley, NSW	Greater Perth, WA	Central VIC	Fleurieu, SA	Gippsland, VIC
Southern NSW	Central WA	Mt Lofty Ranges, SA	Barossa Valley, SA	Port Phillip, VIC
Northern Rivers, NSW	North West VIC			Western VIC
North East VIC	Lower Murray, SA			Limestone Coast, SA
Queensland	Far North, SA			Tasmania

The wine zones were aggregated into climatic zones to allow more pest and disease data to be collected from a larger vineyard area and to reduce the number of economic analyses required while still allowing for meaningful comparison between regions, pests and diseases.

A long list of pests and diseases was presented to industry for prioritising using an industry survey and workshop. The list was reduced to 13 individual or groups of pests and diseases that formed the basis of the economic impact assessment. These priority pests and diseases are:

Table ES2 : Pests & diseases in industry priority order used in the project

Priority Ranking[(a)]	Pest or Disease Name
1	Powdery Mildew
2	Botrytis and Other Bunch Rots
3	Light Brown Apple Moth
4	Downy Mildew
5	Birds
6	Trunk Diseases
7	Garden Weevil
8	Root-Knot and Other Nematodes
9	Trunk Boring Insects
10	Phylloxera
11	Root Rots
12	Viruses and Transmissible Organisms
13	Mealy bugs and Scale

(a) Based on industry survey and workshop discussions.

Information on pest and disease management programs, incidence and frequency of infestation and yield loss was sourced from attendees at the workshop, survey respondents, contacts with grape growers, winery personnel, chemical supply companies and the Project Industry Reference Group. These data formed the basis to the assumptions used in the economic model for assessing economic impact of pests and diseases.

The methodology used by EconSearch for the economic modelling and analysis is described in detail in Section 5 of this report.

Examples of the data and assumptions applied in the economic model are presented for Powdery Mildew, Light Brown Apple Moth, and Trunk Diseases in Tables ES3, ES4 and ES5 respectively.

Table ES3 : Examples of the data & assumptions applied in the economic model for Powdery Mildew

Climatic Zone	Costs - Preventative Spray Program			Impact on Production	
	Chemical	Application		Annual Frequency	Mean Yield Loss
	$/ha/year	$/ha/applic	Number/year	Probability (%)	Percent
Hot Dry	$78	$50	3.0	25.0%	5.0%
Hot Wet	$86	$60	3.0	33.3%	7.5%
Warm Dry	$73	$60	3.5	50.0%	10.0%
Warm Wet	$86	$80	3.5	50.0%	10.0%
Cool	$104	$60	4.0	50.0%	10.0%

Table ES4 : Examples of the data & assumptions applied in the economic model for Light Brown Apple Moth

	Costs - Preventative Spray Program			Impact on Production	
Climatic Zone	Chemical	Application		Annual Frequency	Mean Yield Loss
	$/ha/year	$/ha/applic	Number/year	Probability	Percent
Hot Dry	$23	$50	0.2	20.0%	3.0%
Hot Wet	$40	$60	0.4	33.3%	3.0%
Warm Dry	$56	$60	0.2	33.3%	3.0%
Warm Wet	$40	$80	0.4	33.3%	3.0%
Cool	$80	$60	0.5	33.3%	3.0%

Table ES5 : Examples of the data & assumptions applied in the economic model for Trunk Diseases

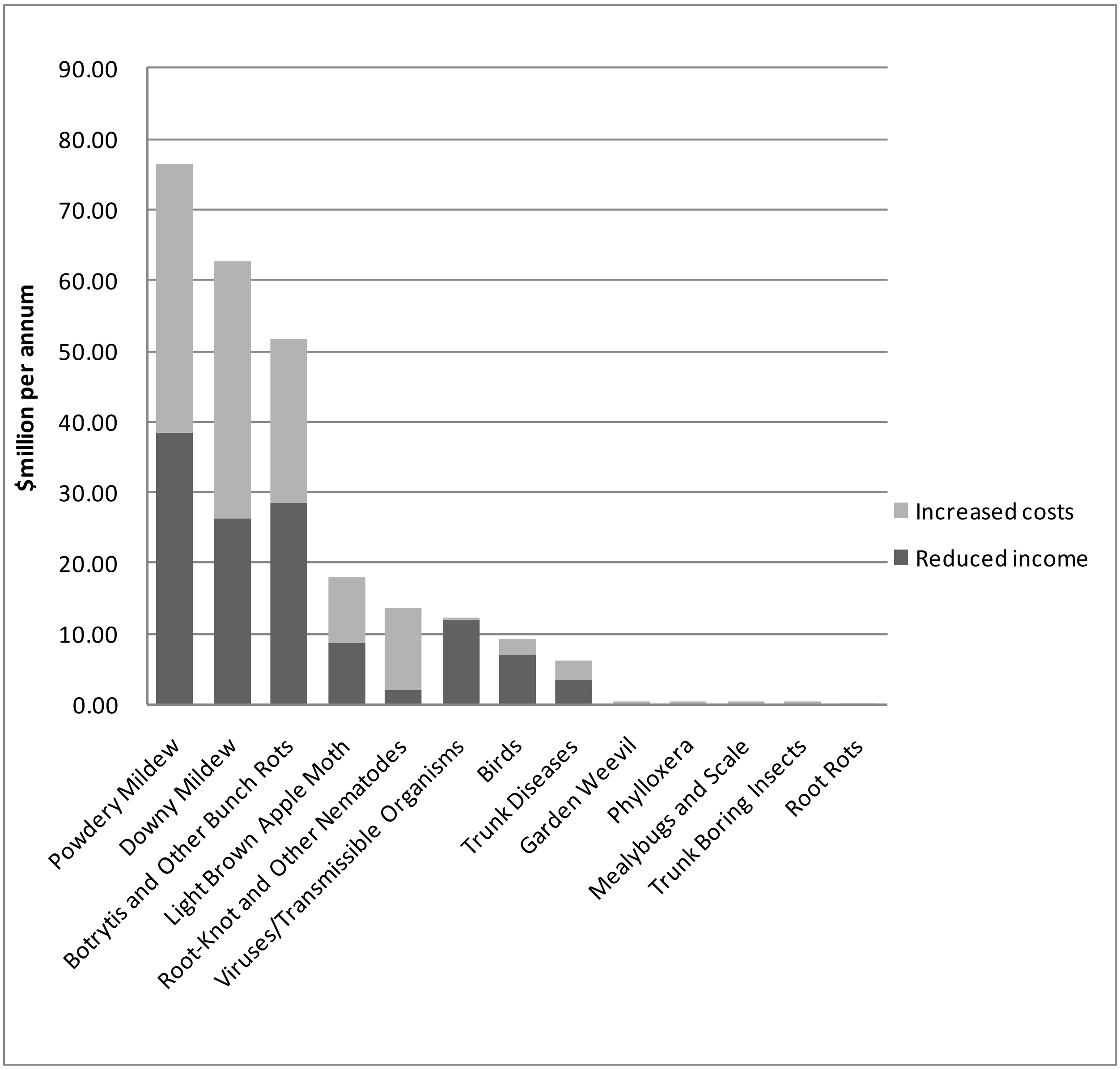
	Costs - Prevention and Control				Impact on Production		
Climatic Zone	Ad-hoc Surgery		Remedial Surgery		Annual Frequency	Incidence	Mean Yield Loss
	$/ha	% area/year	$/ha	% area/year	Probability (%)	% area/year	Percent
Hot Dry	$50	0.0%	$2,800	0.0%	100%	1.0%	0.5%
Hot Wet	$50	1.0%	$2,800	1.0%	100%	5.0%	10.0%
Warm Dry	$50	5.0%	$2,800	1.0%	100%	10.0%	10.0%
Warm Wet	$50	5.0%	$2,800	1.0%	100%	10.0%	10.0%
Cool	$50	5.0%	$2,088	1.0%	100%	10.0%	20.0%

For Powdery Mildew and Light Brown Apple Moth the cost of chemical ($/ha/year), application costs ($/ha/application) and number of applications (apportioned to the pest or disease based on tank mixes used) allow costs to be calculated. The impact on production was calculated using the annual probability of the pest or disease occurring, the regional loss as % of total winegrape area in the region and yield loss.

The assumptions for Trunk Diseases included costs for ad-hoc and remedial surgery, the frequency (annual probability) of the disease occurring, the proportion of area in the zone affected and the yield loss per hectare.

The national economic impact of individual pests and diseases across all climatic zones was calculated and is presented graphically in Figure ES1. The impact is separated into increased costs and reduced income. For further analysis and comparison of these impacts, the pests and diseases were allocated to three groups, Group A High Impact, (Powdery Mildew to Botrytis), Group B Low/Medium Impact, (Light Brown Apple Moth to Trunk Diseases) and Group C Very Low Impact, (Garden Weevil to Root Rots) as shown in Figure ES1.

Figure ES1 : Average industry-wide economic impact of selected winegrape pests & diseases in Australia[a]



a In constant 2009 dollars.
Source: EconSearch analysis.

Table ES6 presents a summary of the National Economic Impact of pests and diseases and GWRDC funding for the priority pests and diseases.

Table ES6 : Comparison of pests and diseases in order of Mean Economic Impact ($) and GWRDC funding on these pests and diseases

Pest or Disease	Grouping Based on Economic Impact	Mean National Economic Impact[a]		GWRDC Funding[b],[c]	
		$m/annum	%	$m	%
Powdery Mildew	Group A *High Impact*	76		3.35	
Downy Mildew		63		1.68	
Botrytis & Other Bunch Rots		52		2.86	
	Sub Total	191	(76%)	7.89	(47.9%)
Light Brown Apple Moth	Group B *Low/ Medium Impact*	18		0.04	
Root-Knot & Other Nematodes		14		0.21	
Viruses/Transmissible Organisms		12		1.67	
Birds		9		0	
Trunk Diseases		6		3.03	
	Sub Total	59	(23.8%)	4.95	(30.1%)
Garden Weevil	Group C *Very Low Impact*	0.3		0.37	
Phylloxera		0.2		2.90	
Mealy bugs and Scale		0.1		0.34	
Trunk Boring Insects		0.02		0.02	
Root Rots		0.01		0	
	Sub Total	0.5	(0.2%)	3.63	(22.0%)
	TOTAL	$251m	(100%)	16.47	(100.0%)

(a) From Table 55, this report (2009 dollars).
(b) Total 1993/94 - present adjusted to 2009 dollars.
(c) Note that GWRDC has also funded R&D for mites and for Phomopsis and Black Spot totalling $0.71 (in 2009 dollars) not included in this table.

The estimated annual economic impact of pests and diseases across the Australian winegrape industry varied between $76m to $52m for Group A, $18m to $6.2m for Group B, and very low <$0.5m for Group C. Across all pests and diseases the total National Economic Impact was $251m per annum. It should be noted that National Economic Impact refers to the estimated annual impact. However, several pests and diseases have a relatively low estimated annual national economic impact but can have relatively high potential national economic impact (eg Phylloxera).

The National Economic Impact was related to the investment by GWRDC in RD&E from 1993/94 to the present. During this period a total of $17.2m was expended on all pest and disease projects with the major allocation to Powdery Mildew ($3.4m), Trunk diseases ($3.0m), Phylloxera ($2.9m), Botrytis and other bunch rots ($2.9m), Downy Mildew ($1.7m) and Viruses/Transmissible diseases ($1.7m).

Table ES7 compares the rankings of the pests and diseases for Mean Economic Impact, Survey and Workshop priorities and GWRDC funding.

Table ES7 : Comparison of ranking of pests and diseases for Mean Economic Impact, Survey and Workshop Priorities and GWRDC funding from 1993 to 2009

		Ranking Base[a]		
Pest or Disease	Grouping Based on Economic Impact	Mean National Economic Impact	Survey & Workshop Priorities	GWRDC Funding
Powdery Mildew	Group A *High Impact*	1	1	1
Downy Mildew		2	4	5
Botrytis & Other Bunch Rots		3	2	4
Light Brown Apple Moth	Group B *Low/ Medium Impact*	4	3	10
Root-Knot & Other Nematodes		5	8	9
Viruses/Transmissible Organisms		6	12	6
Birds		7	5	12 equal
Trunk Diseases		8	6	2
Garden Weevil	Group C *Very Low Impact*	9	7	7
Phylloxera		10	10	3
Mealy bugs and Scale		11	13	8
Trunk Boring Insects		12	9	11
Root Rots		13	11	12 equal

(a) Refer to Table ES6 above for economic impact dollars and GWRDC funding dollars that are the basis for these rankings.

The rankings of the 13 pests and diseases in Table ES7 for their National Economic Impact correlated closely with the ranking from the industry survey and workshop priorities. The main variation was the lower ranking (12th) in the survey and workshop priority for Viruses/Transmissible Organisms compared with a ranking of 6th in the National Economic Impact.

However, the ranking of the National Economic Impact of the 13 priority pests and diseases compared less closely with the ranking of GWRDC expenditure since 1993/94. For example, Light Brown Apple Moth, Root-Knot and other Nematodes and Birds ranked lower for GWRDC funding than their ranking based on National Economic Impact, while Trunk Diseases and Phylloxera received a much higher ranking for level of GWRDC funding than the National Economic Impact indicated.

The difference in these rankings may be related to changing priorities for GWRDC funding extending over the 13 year period to 2009/10 while the National Economic Impact was estimated for the 2009 year. It may also be related to the number of submissions made by RD&E agencies to GWRDC for funding of research on these pests and diseases.

Implications

Pest and disease RD&E funding must have a balance between basic research, applied research and the extension of research findings in a practical way to grape growers. Not all of these RD&E activities have immediate economic impacts for the grape industry but some are still very important for the industry, particularly those which address pests and diseases with high potential economic impact. Examples include:

- Phylloxera is a real and perceived threat to Australian viticulture because only a small proportion of vineyards are grafted on rootstocks that have resistance to phylloxera. Most vineyards are therefore susceptible to phylloxera. Monitoring, vineyard surveillance, grower awareness, and quarantine are all critical to the containment of phylloxera. In addition, technical research capability must be maintained in RD&E agencies to ensure that in the (almost certain) event of future outbreaks of phylloxera, specialists are available to advise on the best course of action.

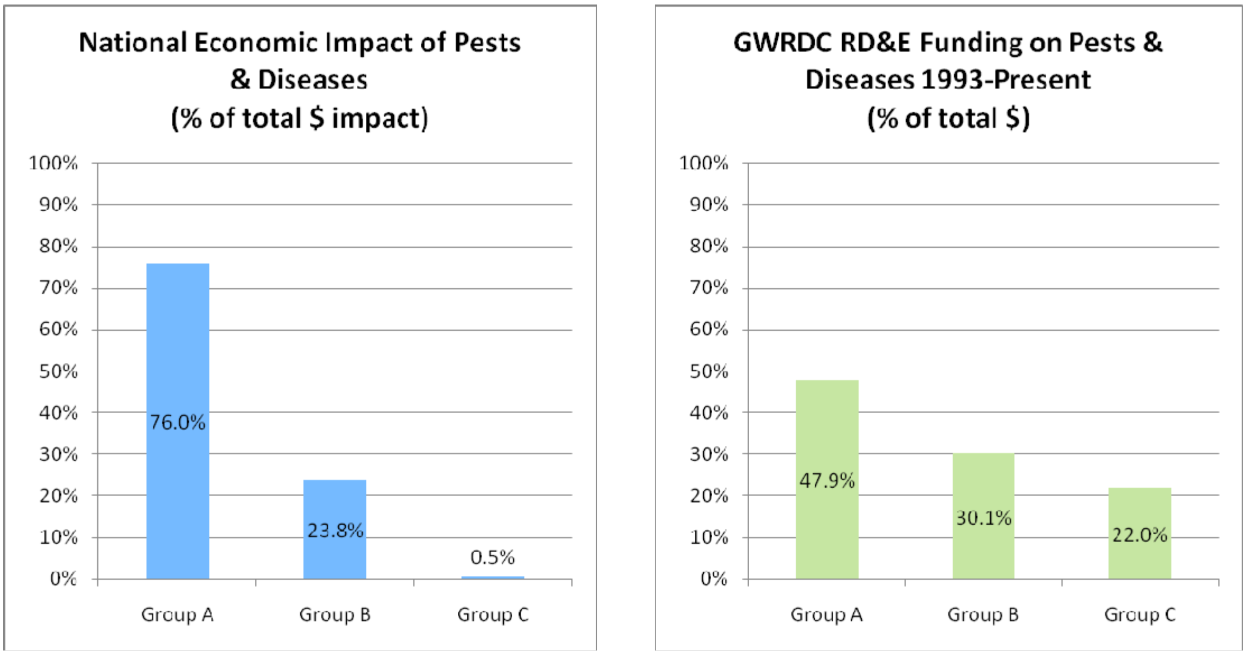
- Grapevine viruses and transmissible diseases have had demonstrated negative impacts on the productivity of vineyards. They are mainly spread in infected planting material. Control is not possible once a vine is infected. Clean planting material is the only way to reduce the economic impact of virus diseases. The technology of testing vines for viruses and the rapid expansion of knowledge of viruses using new scientific methods requires that specialist scientific staff be available and supported. A national capacity in grapevine virus research and testing capacity is necessary.

- Some pests and diseases can be severe but localised in their impact (Garden Weevil in WA, Trunk Borers in the Hunter Valley and Langhorne Creek, Birds, etc). Their national impact is low. RD&E funding is warranted at the local level, and the risk of spread to other regions warrants investment in RD&E to be ahead of future problems, rather than having to catch up if the problem expands.

- "Blue sky" RD&E can generate useful information for understanding pests and diseases, their changing threat profiles and a proportion of investment is warranted in this research.

Figure ES2 presents graphically a comparison of economic impact over Groups A, B & C pests and diseases with GWRDC funding for the same Groups.

Figure ES2 : Comparison of Economic Impact and GWRDC funding



The difficulty for priority setting and investment in RD&E funded by industry levies and matching federal funds is that the immediate issues facing growers demand attention and the scientific capacity of the agencies is only appreciated when a new problem emerges. The need for preparedness is important but inadequately recognised. GWRDC has an industry leadership role in striking a balance between these competing interests for RD&E funding and a legal obligation (as signatories to the EPPRD) to address biosecurity generally by developing Risk Management Strategies.

1 INTRODUCTION

1.1 Scope

The Grape and Wine Research and Development Corporation (GWRDC) engaged Scholefield Robinson Horticultural Services Pty Ltd (Scholefield Robinson) and EconSearch Pty Ltd (EconSearch) to estimate the economic impact of the endemic pests and diseases of viticulture in Australia in order to provide current data on their absolute and relative cost to the grape and wine industry. Exotic pests and diseases are not included in this project.

1.2 Project Objectives

The project objectives formulated by GWRDC are summarised below:

- Collate a list of endemic pests and diseases considered to impact significantly on the productivity of winegrape producers in Australia;
- Collate all available contemporary estimates of the per annum economic impact of these pests and diseases on the profitability of Australian winegrape producers and identify pests including new and emerging pests and diseases for which no estimates of impact are available;
- Develop impact estimates using economic modelling for all significant pests and diseases (selected in consultation with relevant stakeholders) using consistent methodology; and
- Assess qualitatively how research investment on a specified list of pests and diseases might result in the largest return, for example through new prediction models, new control options, improved extension of current control recommendations, or a combination of these.

The results of the Review will be made available to stakeholders of GWRDC, WGGA, WFA, as well as the participating Research Organisations.

1.3 Project Team & Management

The project was established as a joint proposal between Scholefield Robinson and EconSearch with Scholefield Robinson as the contractor to GWRDC. Peter Scholefield of Scholefield Robinson was the Project Leader with Prue McMichael, Adrian Loschiavo and Charles Drew as Consultant Team members. The EconSearch team was Matthew Ferris and Julian Morison.

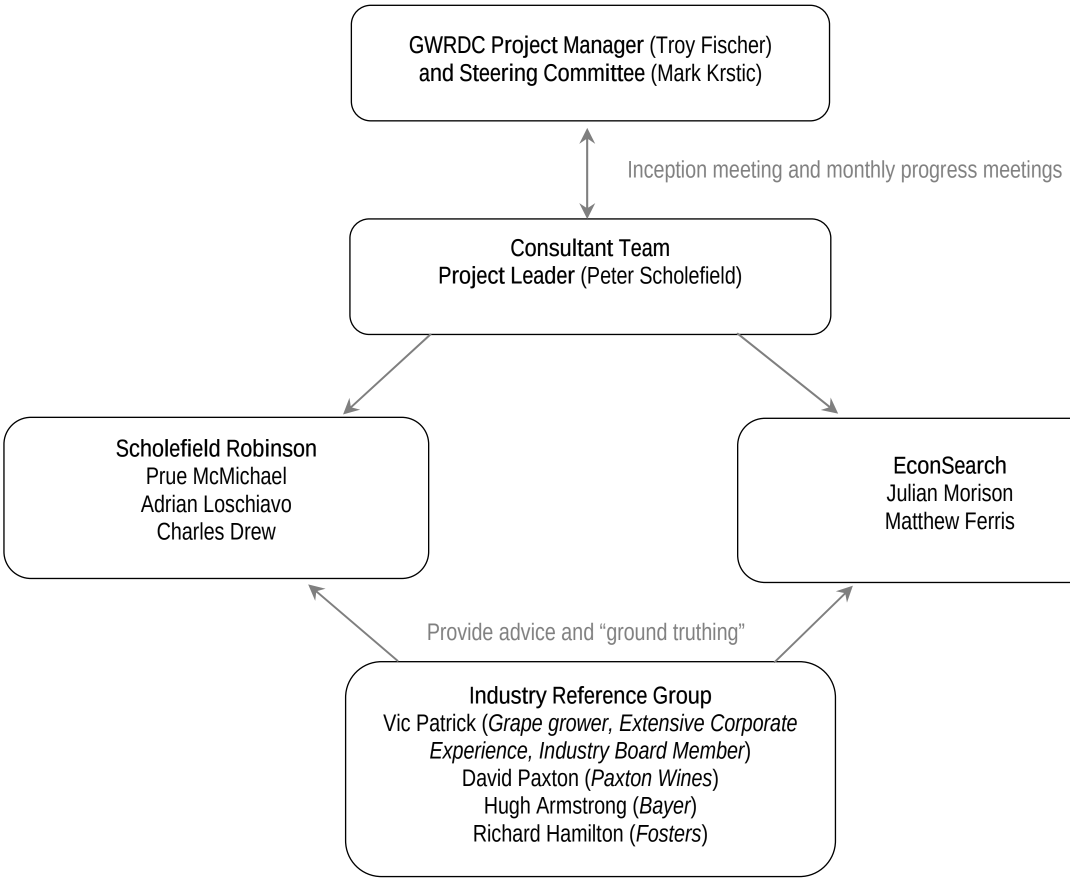
An Industry Reference Group (IRG) provided experienced pest and disease advice and industry knowledge and contacts across Australia. The IRG members were Vic Patrick, David Paxton, Hugh Armstrong and Richard Hamilton.

The GWRDC Project Manager was Troy Fischer and a Steering Committee of Troy Fischer and Mark Krstic that met regularly with the Consultant Team.

All the above participants in the project worked together very effectively.

Figure 1 shows the structure and levels of responsibility within the project.

Figure 1 : Structure of team and responsibilities



2 METHODOLOGY

The methodology uses a series of tasks as described below.

2.1 Inception Meeting

An Inception Meeting with the Project Steering Committee was held to discuss and sign off on the proposed methodology and work plan, to define the economic parameters to be used in the project and to exchange contracts.

2.2 Industry Reference Group

An Industry Reference Group which included experienced members of the grape, wine and chemical industries was selected and established. This group provided practical advice to "ground truth" the assumptions developed for inclusion in the economic model and identified, located and helped procure critical industry data.

2.3 Issues Paper and Survey

An Issues Paper and questionnaire was developed (Appendix 1) for circulation and return by email, and following analysis, to inform the workshop.

2.4 Workshop

An industry workshop was held to ensure that the views of the key scientific and industry specialists working in the pest and disease field have been gleaned for inclusion in the latter stages of the project.

2.5 Initial Estimates

The relative incidence and severity in various production zones of all endemic pests and diseases of winegrapes in Australia including detection and containment techniques were documented. An initial estimate of economic loss due to specific pests and diseases, the types of control used, including costs for application of chemicals, cultural practices, yield loss, etc was prepared

2.6 Prioritisation

Pests and diseases were prioritised based on the initial estimate of their economic impact on grape production. Treatment responses were costed. These responses included conventional chemical (prevention and eradication) and organic systems, monitoring, disease forecasting and IPM strategies and other response methods such as the use of rootstocks, resistant varieties, etc.

2.7 Design of Economic Model

Existing economic models used in the grape industry, horticulture and broader agricultural industries for quantification of pest and disease losses and costs were reviewed to assess their current relevance to this project. The most appropriate economic model to be used in this project was identified. The economic model selected was able to differentiate between large and small scale vineyards and take into account the climatic and other differences between the major production zones in Australia. The model was designed to account for and distinguish between different types of recurrent costs (e.g. variable costs and overheads) and between recurrent and capital costs.

2.8 Operation of Economic Model

Costs and losses associated with each pest were used in the economic model to estimate impacts. The costs and losses used in the model were developed and refined by the workshop participants, the Industry Reference Group and the EconSearch team. Data on RD&E investment on pest projects was obtained from GWRDC and other agencies to relate the estimated impacts to the RD&E investment by GWRDC. Gaps were identified and findings reviewed.

2.9 Draft Report

A Draft Report of overall project findings and recommendations was prepared for GWRDC to allow provision of feedback for incorporation in the final report

2.10 Final Report and Distribution

A Final Report (this report) was prepared and delivered as a formal presentation to GWRDC and industry.

2.11 Summary of Methodology

A diagrammatic representation of the Tasks is shown in Table 1 with activities grouped into the headings of Administration and Project Management, Industry and Research Inputs, Data Gathering and Development of Economic Model, Relation of Findings to RD&E Investment and Report Preparation. Outcomes and Deliverables are also identified in this table.

Table 1 : Project structure & tasks

Tasks	*Activities*	*Outcomes/Deliverables*
	Administration and Project Management	
Task 1	Inception Meeting with Steering Committee. Monthly meetings to monitor progress.	Confirm workplan for Project and timelines. Confirm economic terminology to be used. Sign off on any changes to EOI. Exchange contract.
Task 2	Finalise the role and composition of Industry Reference Group. Hold regular meetings/contact with group.	Establish Reference Group and Terms of Reference. Meetings/contact with Reference Group.
	Industry and Research Inputs	
Task 3	Prepare Issues Paper as basis for workshop with listing of pests and diseases and existing literature on economic losses.	Distribute Issues Paper to workshop participants before workshop.
Task 4	Organise workshop venue, coordinate attendees and speakers, facilitate discussion and outcomes, and prepare report on findings of workshop.	Report with agreed position on priorities from industry and researchers.
	Data Gathering, Development of Economic Model	
Task 5	Further data gathering and gap analysis to develop viticultural inputs to economic model for pests and diseases prioritised at workshop.	Prepare inputs to economic modelling.
Task 6	Finalise economic model incorporating previous studies and new methodology.	Agreed economic model is best available.
Task 7	Develop economic costs of each pest and disease in consistent format to allow comparison.	Data for Draft Report.
	Relate Findings to RD&E Investment	
Task 8	Gather data from GWRDC and other funding agencies on investment in specific pests or diseases to relate to economic costs identified in Task 7. Identify gaps.	Data for Draft Report.
	Prepare Draft and Final Reports	
Task 9	Prepare Draft Report of findings and present to GWRDC program managers for comment.	Draft Report and GWRDC Presentation.
Task 10	Prepare Final Report for presentation to GWRDC (and industry?)	Final Report.

3 PROJECT DEVELOPMENT & PLANNING

3.1 Introduction

This project focussed on estimation of the impact of pests and diseases on the winegrape industry, the formulation of practical and useful findings related to RD&E and identification and discussion of the implications for GWRDC. Because the incidence and impact of winegrape pests and diseases varies with climatic factors, selection and specification of a manageable number of climatic zones was required. The project also required the selection of and grouping of pests and diseases in priority order for analysis and reporting. Estimation of impact also required careful specification of data requirements for input to the modelling process and a mechanism to ensure the data were robust and realistic.

3.2 Selection of Climatic Zones

3.2.1 Introduction

The incidence, impact and management of pests and diseases vary across climatic zones specified according to summer temperatures and rainfall during the growing season. Consequently, for ease of analysis, a small number of climatic zones was proposed.

Parameters for both summer temperatures and rainfall during the growing season were selected by referring to widely accepted viticultural analyses[1] and these resulted in the specification of 5

[1] Dry and Coombe (2008).

climatic zones. Australian Wine Zones as defined by AWBC were then allocated to one of the 5 climatic zones.

3.2.2 Parameters specifying Climatic Zones

The most suitable variable to indicate summer temperature and for which data was available was found to be the mean January temperature (MJT). The most suitable variable to indicate growing season rainfall and for which data was available was found to be rainfall from October to March (GSR). Thresholds were selected for each parameter that allowed realistic and practical differentiation of climatic zones and are shown in Table 1 below.

Table 1 : Thresholds for specifying Climatic Zones

Category	Parameter	Unit	Range	Name
Summer Temperature	MJT	^{0}C	>21	Hot
Summer Temperature	MJT	^{0}C	19 to 20.9	Warm
Summer Temperature	MJT	^{0}C	<19	Cool
Rainfall	GSR	mm	<300	Dry
Rainfall	GSR	mm	>300	Wet

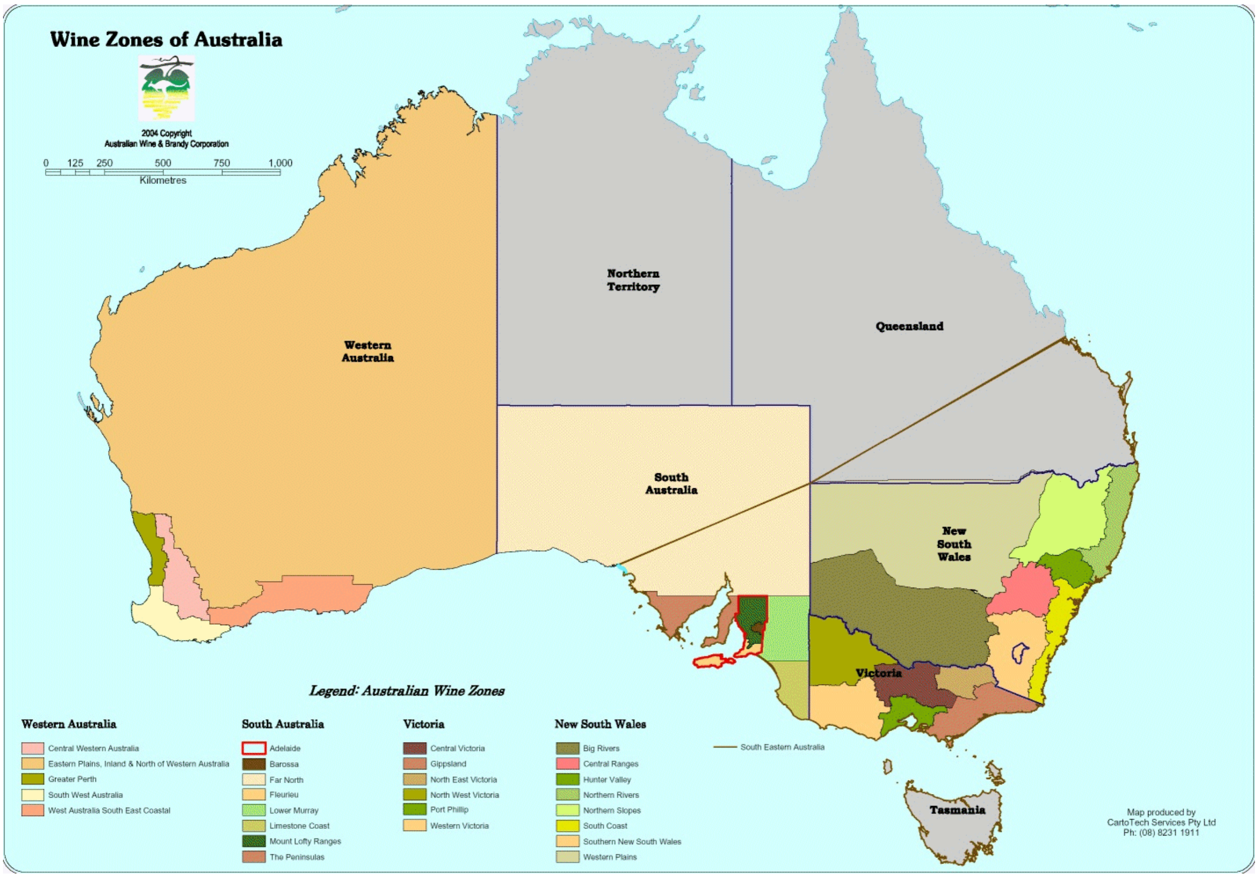
The five climatic zones determined for this project are:

- Hot-wet
- Hot-dry
- Warm-wet
- Warm-dry, and
- Cool

3.2.3 Allocation of Wine Zones to Climatic Zones

The Australian wine zones as defined by the AWBC are shown on the map in Figure 2 below.

Figure 2 : Map of Australian Wine Zones



Source: Australian Wine & Brandy Corporation, 2004

The Australian wine zones included in each Climatic Zone are shown below in Table 2.

Table 2 : Wine Zones allocated to Climatic Zones

Hot-Wet	Hot-Dry	Warm- Wet	Warm- Dry	Cool
Central Ranges, NSW	Big Rivers, NSW	Northern Slopes, NSW	South West WA	South Coast, NSW
Hunter Valley, NSW	Greater Perth, WA	Central VIC	Fleurieu, SA	Gippsland, VIC
Southern NSW	Central WA	Mt Lofty Ranges, SA	Barossa Valley, SA	Port Phillip, VIC
Northern Rivers, NSW	North West VIC			Western VIC
North East VIC	Lower Murray, SA			Limestone Coast, SA
Queensland	Far North, SA			Tasmania

The allocation of most wine zones to Climatic Zones is consistent with the perception of most people familiar with those zones. However, the allocation of some Wine Zones to Climatic zones appears inconsistent. For example, the allocation of Mount Lofty Ranges to the Warm-Wet Climatic Zone may appear questionable. However, reference to the parameters shows that the zone has both a relatively high MJT and GSR greater than 300 mm. Similar concerns may be held for the allocation of North East Victoria to the Hot-Wet Climatic Zone. In this case, North East Victoria includes a wide range of MJT and GSR[2], and a decision regarding allocation had to be made.

3.3 Selection of Pests & Diseases

3.3.1 Introduction

A broad list of pests and diseases of grapes was sourced from Nicholas et. al. (2007), and the project team revised this list for presentation in the survey form sent to workshop participants and other industry members. This list was called “Pests and diseases of concern”.

Using the responses received to the survey and the workshop, the “Pests and diseases of concern” list was reduced to a list of 13 groups of “Priority pests and diseases”.

3.4 Types of Data Required

Estimation of the impact of each pest or disease or group of pests or diseases requires a range of types of data including the operating costs incurred to manage them and estimates of the effects on grape yield, production and price. Assumptions regarding the data also need to be specified.

3.4.1 Effects on Grape Yield, Quality & Price

Estimates were obtained from the survey, the workshop, the Industry Reference Group, and from other targeted consultations

3.4.2 Specification of Assumptions

Assumptions were specified and developed prior to and in the processes of data acquisition and model development. These assumptions are specified in detail in Section 5.

3.5 Data Acquisition

The relative economic significance of winegrape pests and diseases (pests) has been determined through a series of collaborative and interactive activities and analyses, in which industry members, vineyard managers, researchers, viticultural consultants, agricultural economists,

[2] Compare Rutherglen with the King Valley.

corporate wineries and crop protection specialists were active participants. Data acquisition activities included:

- an email questionnaire accompanied by Issues Paper;
- analysis of the survey responses to inform a workshop;
- conduct of an industry workshop;
- further targeted consultation and data gathering;
- review of initial results from the economic model to assess reasonableness of results; and
- identification and remediation of any further data gaps.

The project team and its Industry Reference Group (IRG) planned and implemented the data acquisition activities and associated documentation.

3.6 Analysis and Synthesis into Model

EconSearch conducted this part of the project and it is incorporated as Section 5 of this report.

4 SURVEY, WORKSHOP & CONSULTATION

4.1 Data Acquisition

Prior to the workshop, an Issues Paper and a questionnaire were distributed by email to a wide range of stakeholders including industry members, vineyard managers, researchers, viticultural consultants, agricultural economists, corporate wineries and crop protection specialists (See Appendix 1). Responses to the questionnaire provided an indication of the relative importance of pests and diseases across climatic zones, impact or consequence categories (e.g. yield reduction, production cost increases), and the relative incidence and severity of the pests and diseases. The responses were summarised and formed input to the workshop.

4.2 Issues Paper

The Issues Paper introduced the project team and IRG, described the objectives of the project, summarised the project approach and provided guidelines for completing the on-line survey. It also described the basis of the climatic zone determinations, and the wine zones included in each. As well, it included list of pests considered by the project team have an impact on the productivity of winegrapes in Australia.

The Issues Paper was provided to a wide range of industry members from whom relevant data contributions were sought. It is included in Appendix 1.

The Issues Paper included discussion of pest management before and after planting, and examples of available cultural, biological and chemical strategies for pest management. The criteria for nomination of a listed pest as a ‘pest of concern’ for this project included the:

- lack of available control options;
- costs associated with adequate control; and
- potential yield, production, quality and price losses associated with ineffective control.

4.3 Survey

4.3.1 Description

The survey questionnaire was designed for email distribution and it is attached in Appendix 1. The guidelines for completion were included in the Issues Paper which was circulated with the

questionnaire. At least 50 questionnaires were distributed but it is known that some recipients distributed it further to industry development officers and other personnel who had specific knowledge useful for its completion. Fifty-five completed questionnaires were returned.

The questionnaire had three components:

- Part 1: Contact details and wine zone of respondents;
- Part 2: Responses regarding listed pests and diseases – incidence, development stage, management options; and
- Part 3: Selection of pests and diseases of greatest concern (‘top 3’) - nature of impact and estimated losses/costs.

4.3.2 Responses

Responses were received from each wine zone and therefore data for each ‘climatic zone’ is a collation of that provided by at least three survey respondents. Actual vineyard data received since the survey has provided confirmation that the data is reasonably accurate and representative.

The 19 pests and diseases which were ranked as ‘top 3’ by at least two respondents and the general nature of their economic impact are shown in Table 3 below.

Table 3 : Pests & Diseases Ranked as ‘Top 3’ & General Nature of Economic Impact

Rank #	Name	Number of Responses			
		General Nature of Economic Impact		Additional operating cost	No Control Available
		Reduced yield	Reduced quality		
1	Powdery Mildew	21	31	33	
2	Botrytis Bunch Rot	16	21	21	
3	Downy Mildew	12	9	14	
4	Birds	11	7	9	
5	Eutypa dieback	8	6	5	3
6	Light Brown Apple Moth	5	7	7	
7	Garden Weevil	3	1	3	
8	Bunch Rot (other)	3	4	4	3
9	Root-knot Nematode	4	2	3	
10	Mealy bugs	3	3	3	
11	Insects (trunk boring)	3	0	3	1
12	Phylloxera	3	1	2	
13	Grapevine yellows	3	2	0	2
14	Botryosphaeria	2	2	1	2
15	Root Rot	2	1	2	
16	Other Nematode	2	1	1	1
17	Scale	2	1	2	
18	Leafroll virus	2	0	2	
19	Other virus	2	1	1	

The survey responses reflected the impact of climate and rainfall on winegrape pests and diseases. The pests and diseases of concern for each of the five climatic zones were tabulated and presented to the Workshop participants for validation and comment. The ratings by climatic zone validated by the workshop are included in Table 4 below.

4.4 Workshop

4.4.1 Objectives & Participants

A workshop attended by 30 invited winegrape industry experts, and specialists in pathology, entomology and crop protection, was conducted at the Plant Research Centre, Waite Precinct, Adelaide on August 3, 2009. Workshop participants were provided with feedback and data from the survey.

The objectives of the Workshop were to:

- Explain the project context in greater detail and to encourage participation and information sharing – and ultimately 'ownership' of outputs;
- Validate survey-derived 'pests and diseases of concern' by climatic zones;
- Prioritise pests and diseases by climatic zones; and
- Acquire economic data and identify and record specific factors requiring consideration in economic modelling.

A list of Workshop invitees, the Workshop agenda and the presentation on the survey outcomes are included in Appendix 1.

4.4.2 Program

The Workshop commenced with an introduction to the project and a summary of the survey results. The workshop participants were divided into groups by the climatic zone in which their work has been conducted. Each group was 'facilitated' by a member of the Industry Reference Group and they were asked to review and evaluate the priority list of pests and diseases of concern for that climatic zone. Groups reported to the Workshop and priority lists were agreed.

Workshop participants were subsequently briefed on the basis of economic analysis for pest impact, before being allocated into 'expertise' groups to discuss economic impact components.

4.4.3 Selection of 'Pests & Diseases of Concern'

Workshop participants were presented with the rankings of pests and diseases for each climatic zone derived from the survey responses. The agreed pests and diseases of concern for each climatic zone are shown in Table 4 below.

Table 4 : Pests & diseases of concern by Climatic Zone

Climatic Zone	Disease	Pest
Hot-Dry	Powdery Mildew	Root-knot Nematode
	Downy Mildew	Insects (trunk boring)
	Botrytis Bunch Rot	Light Brown Apple Moth
	Root Rot	Mealy bugs
	Bunch Rot (other)	Other Nematode
	Grapevine Yellows	Scale
Hot-Wet	Botrytis Bunch Rot	Birds
	Downy Mildew	
	Bunch Rot (other)	
	Powdery Mildew	
	Botryosphaeria	
Warm-Wet	Powdery Mildew	Phylloxera
	Botrytis Bunch Rot	Birds
	Eutypa dieback	Light Brown Apple Moth
	Downy Mildew	
Warm-Dry	Powdery Mildew	Garden Weevil
	Botrytis Bunch Rot	Birds
	Downy Mildew	Insects (trunk boring)
		Light Brown Apple Moth
		Other Nematode
		Scale
Cool	Powdery Mildew	Birds
	Botrytis Bunch Rot	Light Brown Apple Moth
	Eutypa dieback	Phylloxera
	Downy Mildew	

Qualifying comments on particular pests were recorded.

Some pests and diseases initially listed in the Issues Paper failed to rank in priority lists (top 3 pests and diseases of concern) in any climatic zone. Although it is known that each may occasionally cause economic losses, it was recognised that such incidences were rare (e.g. grapevine moth, grasshoppers, other moths and grubs) or isolated (e.g. snails as contaminants). Others that failed to register concern were those that were avoided prior to planting (e.g. crown gall) or were 'controlled' before they become visibly established (e.g. early sulphur for powdery mildew controls most mites). These pests and diseases are shown in Table 5 below.

Table 5 : Listed pests & diseases not included in 'pests & diseases of concern'

Pest	Disease
Bud Mite	Black Spot
Bunch Mite	Crown Gall
Other Mites	Petrie Disease
Grasshoppers	Phomopsis
Grapevine Moth	Phytophthora
Other Moth or Grubs	Verticillium Wilt
Snails	Fanleaf Virus

Fanleaf virus, being an exotic disease of winegrapes should not have appeared on the original list despite a potential vector of it (*Xiphinema* sp.) being present in a restricted area of Victoria.

'Young vine decline' (YVD) was raised as a pest of concern not included on the original list. It was decided this was a nursery quality issue particularly on Chardonnay. Hot water treatment before planting remains a viable control, as it does for other pests (phylloxera, nematodes). As with the choice of virus-tested planting material and rootstocks for phylloxera avoidance, hot water treatments are a 'cost' of pest avoidance.

Phomopsis sp. was discussed by both the hot-dry and cool groups respectively, and considered for inclusion on the priority pests for those climatic zones. *Eutypa* sp. and mealy bugs were considered worthy of inclusion in the priority pest list for the warm-dry climatic zone. The members of the hot-wet climatic zone group noted that *Botryosphaeria* sp. needed recognition as both a fruit rot and a trunk/scaffold rot. The warm-wet group raised the importance of garden weevil, rust mite and bunch stem necrosis.

4.4.4 Components of Economic Impact

Prior to the workshop, group members were asked to provide input on economic details relevant to listed pests and diseases. The categories of economic impact data for which data were sought related to severity, incidence, pest-induced changes in production costs and yield, loss attributable to preventative or eradicative treatments etc.

The presentation by EconSearch to the workshop is attached in Appendix 1. Participants were then allocated to groups to discuss the components of economic impact relevant to one of the following groups of pests and diseases:

- Powdery mildew, downy mildew and other foliar diseases;
- Botrytis and other bunch rots;
- Trunk diseases;
- Soil borne diseases and pests; and
- Insect, mite, borer, snail pests.

Each discussion group included one or more industry experts in the relevant group of pests and diseases.

The discussion groups also addressed data categories and issues relevant for economic modelling and estimates of loss. These included:

- the impact of grape demand and supply on investment in pest management;
- varietal susceptibility and tolerances;
- capital investment and depreciation;
- pre-planting control options (e.g. virus-tested rootstocks);
- interactions and predispositions(e.g. light brown apple moth presence has potential to increase losses due to bunch rot);
- tank mixing for multiple pest control;
- implications of the level of management (eg best practice, average, poor);
- confounding factors (eg drought over last 5 years);
- labour components in pest management; and
- post vineyard losses (e.g. downgrades for 'MOG' in wineries; trade restriction for phylloxera).

While the specific economic data captured in this part of the workshop were limited, key resources and other people who could provide valid, first-hand economic data were identified. The modelling considerations and assumptions are discussed in Section 5 "Economic Modelling".

4.4.5 Groupings of Pests

After consideration of the characteristics of each pest and disease and the available economic data, it was decided that the top 19 pests of concern would be clustered into 13 groups of Priority pests and diseases for economic analysis and modelling, as shown in Table 6 below.

Table 6 : Groupings of Priority Pests & Diseases for Economic Modelling

Priority[(a)]	Workshop Ranking	Pest or Disease	Group Name[(b)]
1	*1*	Powdery Mildew	Powdery Mildew
2	*2*	Botrytis Bunch Rot	Botrytis and Other Bunch Rots
	8	Bunch Rot (Other)	
3	*6*	Light Brown Apple Moth	Light Brown Apple Moth
4	*3*	Downy Mildew	Downy Mildew
5	*4*	Birds	Birds
6	*5*	Eutypa dieback	Trunk Diseases
	14	Botryosphaeria	
7	*7*	Garden Weevil	Garden Weevil
8	*9*	Root-knot Nematode	Root-knot and Other Nematodes
	16	Other Nematode	
9	*11*	Insects (Trunk Boring)	Trunk Boring Insects
10	*12*	Phylloxera	Phylloxera
11	*15*	Root Rot	Root Rots
12	*13*	Grapevine yellows	Viruses and Transmissible Organisms
	18	Leafroll virus	
	19	Other virus	
13	*10*	Mealy bugs	Mealy bugs and Scale
	17	Scale	

(a) Industry priority based on survey and workshop discussion and grouping of related pests and diseases.
(b) As used throughout this report.

4.5 Description of Priority Pests & Diseases

Key features of the 13 priority pests and diseases are presented below.

4.5.1 Powdery Mildew

Powdery mildew is caused by the fungus *Erysiphe necator* (*syn. Uncinula necator*), a ubiquitous and persistent fungus that grows on shoots, leaves, bunches. Serious crop losses can occur on unprotected green tissue, particularly on susceptible varieties. Multiple fungicide sprays are needed during the growing season to protect vines. Some wineries will reject loads with >3% affected fruit.

4.5.2 Botrytis & Other Bunch Rots

Botrytis or 'Grey mould', caused by *Botrytis cinerea*, is commonly found in most Australian grape growing areas surviving in infected canes, mummified berries or in plant debris. Botrytis causes the greatest economic loss of the bunch rots however, several other fungi exist which can also cause bunch rots including *Alternaria* spp., *Aspergillus* spp., (black mould), *Botryosphaeira* spp., *Cladosporium* spp., *Colletotrichum* spp. (ripe rot), *Coniella diplodiella* (white rot), *Greeneria uvicola* (bitter rot), *Penicillium* spp., *Phomopsis viticola*, *Rhizopus* spp. and others. Bunch rots cause most damage in warm, wet, humid seasons or where injury sites (mechanical, insects, hail etc) provide entry points for infection. Varietal susceptibility varies depending on skin thickness and bunch architecture. Losses from 'other bunch rots' can vary greatly depending upon geographical location, weather and vineyard practices and fungicides are often used to minimise crop loss.

4.5.3 Downy Mildew

Downy Mildew (*Plasmopara viticola)* can be a major problem when it occurs as it may spread rapidly especially under warm, wet conditions. Full coverage with precisely timed fungicides is essential for control. Protectant and eradicant sprays are registered for control of Downy Mildew. Severe infection around flowering may cause total crop loss in some vineyards, but generally it is found on leaves and berries until they are pea-sized. Monitoring, fungicide sprays and yield reduction are the potential costs associated with this disease.

4.5.4 Light Brown Apple Moth (LBAM)

LBAM (*Epiphyas postvittana*) is a native insect that can be a major problem when it occurs as it may spread rapidly especially under warm, wet conditions. Full coverage with precisely timed insecticides or other treatments is essential for control. Severe infection around flowering may cause total crop loss in some vineyards, but generally it only affects young leaves, especially shoot tips, and berries until they are pea-sized. Late LBAM infestation in bunches can lead to more bunch rots. Monitoring, sprays and yield reduction are the potential costs associated with this pest.

4.5.5 Birds

Damage and yield loss caused by birds occurs in most Australian grape growing zones. Bird species which cause most losses include Cockatoo, Galah and Corella (*Cacatua* spp.), Common blackbird (*Turdus merula*), Common myna (*Acridotheres tristis*), Common starling (*Sturnus vulgaris*), Crows (*Corvus* spp.), Honeyeaters (*Anthochaera* spp.), Lorikeets (*Trichoglossus* spp.), Parrots (*Purpureicephalus spurius* and *Barnardius zonarius*), Ravens (*Strepera* spp.), Rosella (*Platycercus* spp.) and Silvereye (*Zosterops lateralis*).

Birds cause direct yield loss from fruit removal when feeding or indirect loss from peck damage resulting in berry desiccation, infection by bunch rots and possible winery downgrade. Severity

of crop loss varies markedly between vineyards within the same zone and between seasons depending on alternative food sources for the birds.

Bird netting is sometimes used in small vineyards or high value blocks. However it is very expensive and labour intensive to install and roll up. Also, depending on the installation method, netting may be penetrated by smaller birds such as silver eyes.

Disturbance methods include hawk kites, PA systems, scare crows, scare guns, shooting, streamers and various other methods. Disturbance methods are often undertaken with low labour and input costs.

4.5.6 Trunk Diseases

Eutypa dieback (*Eutypa lata*) and Botryosphaeria canker (*Botryosphaeria* spp.) are two important trunk diseases affecting vines in most zones. Spores of the pathogen enter fresh pruning wounds and kill woody tissue resulting in crop loss and vine death. Foliar symptoms are only obvious for Eutypa dieback. *Botryosphaeria* can also cause bunch infection in conducive conditions. Both pathogens produce wedge-shaped dead sections in trunks and cordons when viewed in cross section. Vineyard sanitation, protection of pruning wounds and removal of infected wood are the only forms of treatment. No chemical eradicant treatment is available to treat infected vines.

4.5.7 Garden Weevil

Garden Weevil (*Phlyctinus callosus*) larvae feed on roots of weeds during winter and emerge as adults from the soil around budburst. Adults feed on buds and small shoots of grapevines at night and shelter in plant debris during the day. In high numbers Garden Weevil can cause significant damage to young and mature vines, but usually only in confined areas. In these cases, insecticide is often applied to vine trunks or foliage at night when the weevils are actively feeding.

4.5.8 Root-knot & Other Nematodes

Nematodes are present in most soils. However, Root knot nematode (*Meloidogyne* spp.), Citrus nematode (*Tylenchulus semipenetrans*), Dagger nematode (*Xiphinema index*) and Root-lesion nematode (*Pratylenchus* spp.) are the species that can cause economic losses in grapevines by feeding on roots resulting in decreased vine vigour and yield. Furthermore, infected planting material may fail to establish or grow well. Nematode populations are higher in sandy soils and tolerant rootstocks are often used to avoid losses. Applications of nematicides to the soil are only moderately effective.

4.5.9 Trunk Borers

Fig longicorn (*Acalolepta vastator*) causes the most economic loss in viticulture. However common auger beetle (*Xylopsocus giggicollis*), elephant weevil (*Orthorhinus cylindrirostris*), fruit-tree borer (*Maroga melanostigma*), large auger beetle (*Bostrychopsis jesuita*), vine borer (*Echiomima* spp.) and vine weevil (*Orthorhinus klugi*) can occasionally cause damage. Stressed vines are often more susceptible to trunk boring insects and control is very difficult due to the feeding sites being located within the vine trunk or canes.

4.5.10 Phylloxera

Phylloxera (*Daktulosphaira vitifolii*) infects own-rooted vine roots resulting in decreased yield, vine decline and death. Phylloxera spreads relatively slowly and generally is confined to discreet areas. Substantial efforts are in place to prevent further spread including restriction of fruit and equipment movement. No effective eradicant is available so the use of resistant rootstocks, quarantine and careful hygiene are is the only control measures. Strict quarantine measures are in place to limit the spread of Phylloxera.

4.5.11 Root Rot

Root rot is caused by one or several fungi including Pythium (*Pythium* spp.), Armillaria (*Armillaria* spp.), Fusarium (*Fusarium* spp.), Rhizoctonia root rot (*Rhizoctonia solani*), Esca (*Stereum hirsutum* and *Phellinus igniarius*), Black root rot (*Thielaviopsis basicola*) and White root rot (*Rosellinia necatrix*). Root rot can be an issue in young vines in waterlogged soils but is rarely an issue in mature vines.

4.5.12 Grapevine Virus & Other Transmissible Organisms

Several groups of organisms including grapevine viruses, Rugose wood viruses, phytoplasmas and viroids can infect grapevines. These include the grapevine virus groups, *Closteroviridae* and *Nepoviruses*, Grapevine leafroll associated viruses (GLRaV) (six types: 1, 2, 3, 4, 5 & 9), Grapevine rootstock stem lesion associated virus (GRSLaV) and Grapevine fanleaf virus (GRLV).

Rugose wood viruses are made up of three groups, *Foveaviruses* , *Maculavirus* and *Vitiviruses* which cause Rupestris stem pitting associated virus (RSPaV) strain 1 and 2, Grapevine fleck virus (GFkV) strain A and B, Grapevine virus A (GVA) (associated with Kober stem grooving disease) and Grapevine virus B (GVB) (associated with Corky bark disease).

Grapevine yellows phytoplasma is the most known of the phytoplasmas and yellow speckle the most known of the viroids.

Virus and other transmissible organisms are usually introduced through grafting or the use of infected cuttings. Once present there is no control and symptoms include leaf colour changes, yield losses and general decline. Some viruses can be spread by insects present in Australia. Clean planting material is the only effective management strategy.

4.5.13 Mealy Bugs & Scale

Mealy bugs, *Pseudococcus* spp. are slow moving pests that infrequently cause feeding damage but more importantly excrete honeydew when feeding promoting growth of saprophytic fungi such as sooty mould, potentially resulting in winery downgrade of fruit. Feeding of mealy bugs can also result in transmission of virus between vines.

Scale, *Parthenolecanium persicae*, is a sap sucking insect found throughout Australia that can weaken vines if infestation is severe. When actively feeding, Scale also secretes a sweet, sticky honeydew on bunches and leaves which can promote growth of sooty mould.

Out-breaks of scale and mealy bug are encouraged by over-use of insecticide which reduces predatory insect populations (“beneficials”).

4.6 “Organic” Production Systems

The area of “organic” or “low chemical input” viticulture in its many forms in Australia is relatively small but growing.

Viticultural systems characterised as organic, biodynamic etc aim to use only inputs approved by their respective accreditation/certification agencies for the control of pests, diseases, weeds and to supply nutrients. In some cases these inputs are more expensive than conventional production inputs and the options for pest and disease control are fewer, the management inputs are higher, and the risk of outbreaks of pests, diseases and weeds is greater. Yields may be lower but prices for certified organic grapes can be higher.

Organic grape growing is easier in warm zones with low rainfall where pest and disease pressures are lower than in high rainfall zones.

The control measures of copper for Downy Mildew and sulfur for Powdery Mildew are also approved for organic production so two of the major pests have good existing control options available for organic growers.

The input data obtained from organic vineyards were limited and insufficient to adequately compare organic and conventional production systems for pest and disease control costs and economic impacts.

However, two pest and disease programs from the warm-dry climatic zone contained copper, sulfur, EcoCarb (potassium bicarbonate), oils, and spinosad, an approved product for LBAM control. An average of about 6 sprays was applied at a cost for all sprays of about $300 per hectare. If this total is attributed to the main pests and diseases in this region, the cost is within the range found for conventional vineyards.

5 ECONOMIC MODELLING

5.1 Introduction

This section of the report details the development and application of a consistent method for calculating up-to-date estimates of the economic impact priority pests on the winegrape industry in Australia.

5.2 Modelling the Economic Impact of Pests & Diseases

5.2.1 Definition of Economic Impact

For the purpose of this analysis, e*conomic impact* at the vineyard level was defined as the annual average change in vineyard profit attributable to the income (i.e. production and price) and cost (i.e. operating and capital) effects of the pest or disease, over a period of 15 years[3]. The time dimension of this measure accounts for the frequency of infestation (i.e. the probability of annual infestation) and allows for full consideration of relevant capital and operating costs. *Vineyard profit* was defined as gross income less total operating (i.e. variable and overhead) and capital costs.

To keep the project manageable and the estimation of impacts tractable, the scope of the analysis was limited to the economic consequences at the vineyard level. This means that pest/disease related costs incurred by government and wineries, for example, were not included explicitly in the analysis. Where there are significant economic impacts of the pest/disease that are felt beyond the vineyard gate, some qualitative discussion of the nature and extent of the economic cost is provided.

5.2.2 Measurement of Economic Impact

The purpose of the economic modelling component of the project was to develop and apply a consistent method for calculating up-to-date estimates of the economic impact of a subset of key winegrape pests and diseases in Australia. There were 5 stages in the modelling process, some of which were conducted concurrently.

Stage 1 of the modelling was the identification of a subset of pests and diseases upon which the subsequent data gathering and analysis was focussed as shown in Table 6. The criteria and process by which the priority pests and diseases of winegrapes were identified and selected are described in detail in Sections 2, 3 and 4 of this report.

[3] The vineyard level models were specified with a 5 year development period and 10 year period of steady-state production.

Stage 2 of the modelling was the gathering and compiling of relevant data at the vineyard level. For each pest/disease and climatic zone the following data were obtained:

- Prevention or control option;
- Average income and cost effects over a period of 10 to 15 years;
- Frequency (i.e. the probability of annual infestation); and
- Incidence (i.e. proportion of climatic zone impacted).

A template was developed for gathering the relevant information and a copy is presented in Appendix 1. The relevant data and assumptions by pest/disease and climatic zone are summarised in Section 5.2.4 below. Data sources and the method used to analyse and validate the data are described in detail in Sections 3 and 4 above.

Stage 3 of the modelling was the construction of representative vineyard models. The first step was the development of a base case (i.e. 'without pest/disease') model for each climatic zone. Using the data collected in Stage 2 of the modelling, 'with pest/disease' models were developed by modifying the base case models for the income and cost effects attributable to the pest/disease. The *net impacts* of the pest or disease at the vineyard level (i.e. per hectare) were estimated by comparing the results of the base case and 'with pest/disease' models, whilst holding all other variables constant. Model specification is detailed in Section 5.2.3.

Given that the prevention or control of some winegrape pests/diseases is part of the normal management routine for most vineyards, it is important to acknowledge that the 'base case' models do not necessarily represent normal operating conditions. Nevertheless, the distinction between "with" and "without" infestation is necessary to properly measure the economic impact of the pest/disease.

Another important issue to address is that the prevention or control of one pest/disease can also provide effective prevention or control for one or more other pests or diseases. The attribution of impacts to the relevant pest/disease was dealt with on a case-by-case basis.

The economic impact of winegrape pests and diseases was modelled first at the vineyard level. Through the collection of data on the incidence of each pest or disease (i.e. the proportion of each zone impacted), it was possible to aggregate the vineyard-level data to provide estimates of economic impact on a climatic zone and national basis.

Stage 4 of the modelling was the collection and compilation of relevant data on the winegrape industry for the purpose of this aggregation. These data are detailed in Section 5.3.

Stage 5, the final stage of the modelling process, reports and comments on estimates of the economic impact of the key winegrape industry pests and diseases at the vineyard, zone and national scales (Section 5.4).

5.2.3 Specification of the Base Case Representative Vineyard Models

The building block for the economic modelling was a vineyard-level financial model based on Boon et al. (1999) and similar to that prepared by the consultants for analysis undertaken for the Phylloxera and Grape Industry Board of South Australia (PGIBSA), *The Risk and Economic Impact of Phylloxera in South Australia's Viticultural Zones* (SRHS and EconSearch 2002).

The vineyard level response to winegrape pests and diseases and the magnitude of the impact on vineyard profit is likely to differ according to a range of variables, including:

- climatic zone;
- variety;
- bearing area
- average yield and production; and
- average price received.

Base case representative vineyard models were prepared for five different climatic zones, defined according to 'mean January temperature' and 'growing season rainfall' as described in Section 3.2 above. Definition of the five climatic zones by geographical indications (GI) zone and state and the vineyard area is outlined in Table 7.

Table 7 : Climatic Zones by geographical indications zones & state

Climatic zone	Geographical Indications zone	State	Total area (ha) [a]	Share
Hot-Dry	Big Rivers	NSW	28,144	39.0%
	Western Plains	NSW	314	0.4%
	Lower Murray	South Australia	22,006	30.5%
	Far North	South Australia	154	0.2%
	NW Vic	Victoria	19,864	27.5%
	Greater Perth	Western Australia	1,613	2.2%
	Central WA	Western Australia	130	0.2%
	Eastern Plains, Inland and North of WA	Western Australia	13	0.0%
Total			**72,238**	**100.0%**
Hot-Wet	Central Ranges	NSW	7,212	36.6%
	Southern NSW	NSW	2,021	10.2%
	Northern Rivers	NSW	44	0.2%
	Hunter Valley	NSW	4,520	22.9%
	Queensland	Queensland	2,690	13.6%
	NE Vic	Victoria	3,237	16.4%
Total			**19,724**	**100.0%**
Warm-Dry	Barossa	South Australia	12,438	32.9%
	Fleurieu	South Australia	13,872	36.7%
	SW WA	Western Australia	11,475	30.4%
Total			**37,785**	**100.0%**
Warm-Wet	ACT	ACT	305	2.0%
	Northern Slopes	NSW	282	1.9%
	Mount Lofty Ranges	South Australia	9,542	63.8%
	Central Vic	Victoria	4,824	32.3%
Total			**14,953**	**100.0%**
Cool	South Coast	NSW	251	1.1%
	Limestone Coast	South Australia	14,989	65.5%
	The Peninsulas	South Australia	53	0.2%
	Tasmania	Tasmania	1,507	6.6%
	Western Vic	Victoria	1,623	7.1%
	Port Philip	Victoria	4,265	18.6%
	Gippsland	Victoria	200	0.9%
	WA SE Coastal	Western Australia	12	0.1%
Total			**22,900**	**100.0%**

[a] Bearing and non-bearing area of grapes for winemaking in 2008. Based on ABS (2009) and EconSearch analysis.
Source: SRHS and EconSearch analysis.

To differentiate the effects of winegrape pests and diseases on a varietal basis it was considered sufficient to disaggregate grape varieties into two broad groups, red and white grapes. The proportion of the area of a representative vineyard devoted to red and white winegrape production was based on the split at the national level (see Section 5.3). These proportions are listed by climatic zone in Table 8.

Table 8 : Selected indicators for representative vineyard-level models

Climatic zone	Proportion of area (%) [a]		Average vineyard size (ha) [b]
	Red grapes	White grapes	
Hot-Dry	49%	51%	17.9
Hot-Wet	59%	41%	15.0
Warm-Dry	70%	30%	19.3
Warm-Wet	64%	36%	15.4
Cool	74%	26%	53.8

a Based on estimates of the area of winegrapes by climatic zone in 2008 in Table 24, Table 25 and Table 26.
b See Table 9. An estimate average vineyard size for the hot-wet climatic zone was obtained from Liz Reilly (Vitibit Pty Ltd, pers. comm.).

The base case representative vineyard models were differentiated across climatic zones on the basis of a number of other variables, including the following.

- Average vineyard size (see below).
- Average winegrape yield and price received by variety (data and assumptions detailed in Section 5.3).
- Bearing area and recent plantings by variety (Section 5.3).
- Irrigation rates, proportion of mechanical harvesting and pruning, overhead costs, etc. This information was derived from SRHS and EconSearch (2002) and supplemented with input from the consultants, the Industry Reference Group and other sources[4].

Average vineyard size for all climatic zones except the hot-wet zone was imputed on the basis of the estimated number of growers and vineyard area by selected South Australian GI zones (PGIBSA 2008), as detailed in Table 9. For example, the Lower Murray GI zone was considered to be representative of the hot-dry climatic zone in Australia[5].

Table 9 : Average vineyard size in selected South Australian geographical indications zones, 2008

Climatic zone	GI regions	Number of growers	Area (ha)	Average area (ha)
Hot-Dry	Lower Murray (SA)	1,283	22,926	17.9
Hot-Wet	Hunter Valley[a] (NSW)	301	4,520	15.0
Warm-Dry	Barossa and Fleurieu (SA)	1,494	28,824	19.3
Warm-Wet	Mount Lofty Ranges (SA)	693	10,706	15.4
Cool	Limestone Coast (SA)	298	16,039	53.8

Source: PGIBSA (2008) and EconSearch analysis.
a Area of Hot Wet zone based on estimate from Liz Reilly.

5.2.4 Data & Assumptions Used for the 'With Pest/Disease' Models

As outlined in Section 5.2.2, the 'with pest/disease' models were developed by modifying the base case models for income and cost effects attributable to the pest/disease.

4 Including Liz Reilly (Vitibit Pty Ltd, pers. comm.) for the hot-wet climatic zone.

5 The Lower Murray GI zone accounted for 31 per cent of the vineyard area in the hot-dry climatic zone in 2008. The selected South Australian GI zones accounted for between 64 and 70 per cent of the vineyard area in the warm-dry, warm-wet and cool climatic zones in 2008.

Details of the control programs used in the climatic zones were derived from anonymous spray diaries provided by a number of wineries, attendees at the workshop held in August 2009, survey forms returned by respondents, personal contacts with vineyard managers and contractors, and information from the experienced Industry Reference Group that is part of the project team. In some cases we had to rely on the combined judgement of the project team to develop these assumptions.

Allocation of cost of multi chemical sprays to a range of pests and diseases

The allocation of costs for spray applications to individual pests and diseases proved to be particularly difficult because in most cases multiple chemicals are included in the one tank mix that is applied (eg. Copper and Sulphur) and some chemicals can control more than one pest or disease (eg. Many chemicals are registered for control of both Powdery Mildew and Downy Mildew).

The cost to apply a spray to a hectare of vineyard, including labour, fuel, machinery cost was agreed by the IRG to be $50 to $80 per hectare per application across the climatic zones.

This application cost was apportioned to the pests or diseases controlled by a particular spray as derived from the spray diaries.

For example, if three chemicals were mixed in the spray tank the application would be apportioned to the three pests or diseases aiming to be controlled. Similarly if a specific chemical controlled Downy Mildew and Botrytis the application would be apportioned to these two diseases.

In the Economic Impact tables below, the number entered in the column showing "Number of applications" is the total of the individual spray applications applied for that pest or disease plus where multiple chemicals or multi-action chemicals were in the tank mix, the adjusted proportion of a spray application or applications.

For example, a number of 3 spray applications for Powdery Mildew may have been derived from 6 sprays where the tank mix covered both Powdery Mildew and another pest or disease.

Table 10 shows the average sprays applied per season in the four climatic zones and the portion attributed to specific pests/diseases.

Table 10 : Number of sprays applied per year in each climatic zone

Climatic zone	Avg. No. Sprays Applied Per Season[(a)]	Attributed Application to Specific Pest/Disease[(b)]				
		Powdery Mildew	Downy Mildew	Botrytis & other bunch rots	LBAM	Other
Hot Dry	5.2	3.4	0.9	0.2	0.2	0.5
Hot Wet	7.9	3.4	2.2	1.3	0.4	0.6
Warm Dry	5.4	3.9	0.9	0.4	0.1	0.1
Warm Wet	7.3	4.4	1.3	1.0	0.4	0.2
Cool	7.5	4.4	1.3	1.0	0.4	0.4

(a) Based on spray diaries examined.
(b) Based on our assessment of chemicals included as tank mixes in spray.

Estimation of the economic impact of the priority groups of pests and diseases for the five climatic zones, the pests and diseases were divided according to the type of prevention and control methods required. These were:

- Annual Preventative Spray Programs (Powdery Mildew, Botrytis and Other Bunch Rots, Downy Mildew and Light Brown Apple Moth);
- Eradicant Spray Programs (Downy Mildew[6], Garden Weevil, Trunk Boring Insects, and Mealy bugs and Scale); and
- Other Forms of Prevention and Control (Trunk Diseases, Root Rots, Viruses and Transmissible Organisms, Rootknot and Other Nematodes, Phylloxera and Birds).

The method used to determine the economic impact and the assumptions used for these three groups are described below. The data and assumptions used to estimate these income and costs effects on the groups of priority pests and diseases are summarised in Table 11 to Table 23 below.

In order to account for uncertainty in the results of the analysis, a range of values (i.e. minimum, most likely and maximum) were estimated for key variables. The results of the impact analysis were calculated through the use of Monte Carlo simulations by attaching a triangular probability distribution (described by the minimum, most likely and maximum values) to these variables.

5.2.5 Pests & Diseases Characterised by Annual Preventative Spray Programs

For the priority groups of pests and diseases characterised by annual preventative spray programs, the vineyard-level impacts include the annual costs of a preventative spray program and yield loss attributable to infestation (i.e. the income effect). Each specific pest or disease and its relevant table number is listed below:

- Powdery Mildew (Table 11)
- Botrytis and Other Bunch Rots (Table 12)
- Downy Mildew (Table 13)
- Light Brown Apple Moth (LBAM) (Table 14)

5.2.5.1 Variables

The 'costs associated with a preventative spray program' (TC_{prev}) is a component of the cost effect of the pest/disease and was calculated as:

$$TC_{prev} = C_{prevchem} + (C_{prevapp} * N_{prev})$$

where;

- Cost of chemical ($C_{prevchem}$) – is an estimate of the annual cost per hectare of the chemical(s) used in the prevention of the pest/disease ($/ha/annum). Accounts for chemical type and number of applications.
- Application costs ($C_{prevapp}$) – is an estimate of the cost of contract spraying ($/ha/application). Includes labour, operating costs such as fuel and an annualised capital cost for machinery (i.e. depreciation). This value was used as a proxy for the costs incurred by growers that undertake their own spraying activities.
- Number of applications per annum (N_{prev}) – is an estimate of the number of spray applications per annum specifically attributable to the pest/disease. Accounts for tank mixes that are used in the prevention of two or more pests/diseases.

TC_{prev} represents the total cost effect for Powdery Mildew, Botrytis and Other Bunch Rots and LBAM.

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6 Control of Downy Mildew may require both preventative and eradicant spray programs.

For Downy Mildew, the vineyard level impact also includes the costs of an eradicant spray program where infestation occurs or in response to the threat of infestation[7]. The 'costs associated with an eradicant spray program' (TC_{erad}) is another component of the cost effect for this disease and was calculated as:

$$TC_{erad} = (C_{eradchem} + (C_{eradapp} * N_{erad})) * F_{erad}$$

where;

- Cost of chemical ($C_{eradchem}$) – is an estimate of the annual cost per hectare of the chemical(s) used in the eradication of the pest/disease ($/ha/annum). Accounts for chemical type and number of applications.
- Application costs ($C_{eradapp}$) – is an estimate of the cost of contract spraying ($/ha/application). Includes labour, operating costs such as fuel and an annualised capital cost for machinery (i.e. depreciation). This value was used as a proxy for the costs incurred by growers that undertake their own spraying activities.
- Number of applications per annum (N_{erad}) – is an estimate of the number of spray applications per infestation.
- Frequency of application (F_{erad}) – is an estimate of the annual probability of undertaking an eradicant spray program to treat an actual or threatened infestation of the disease.

For all four of these pests/diseases the 'impact of an infestation on production' (I) is an estimate of the income effect of the pest/disease and was calculated as:

$$I = (F * Y_R) * P$$

where;

- Frequency (F) – is an estimate of the annual probability of a severe infestation of the pest/disease.
- Zonal yield loss (Y_R) – is a measure of the incidence of a severe infestation of the pest/disease across each climatic zone and the consequent yield loss in affected vineyards as a proportion of total potential production in that zone. It accounts for loss of yield and/or the proportion of fruit rejected by wineries.
- Price (P) – is a measure of weighted average zonal grape prices, as specified in Table 27 constant with time. Any impact of severe infestation on price received, such as fruit downgrades, was incorporated into the estimate of yield loss (Y_R).

Note that price effects associated with severe pest/disease infestation have been excluded from the analysis. In most cases they would be expected to be small and, in all cases, would be difficult to estimate. As an example of these measurement difficulties consider the implications for grape prices that would result from a decrease in the supply of grapes for winemaking attributable to pest/disease infestation. In the absence of any offsetting decrease in demand, this decrease in supply would result in a positive impact on the farm-gate price of these grapes.

For all four of these pests/diseases the economic impact (EI) in terms of reduced vineyard profit was calculated as:

$$EI = TC_{prev} + TC_{erad} + I.$$

Note that TC_{erad} is zero for Powdery Mildew, Botrytis and Other Bunch Rots and LBAM.

[7] For example, in response to 'Downy Mildew Weather Alerts' from the Bureau of Meteorology.

The assumptions developed by the Project Team and used in the modelling to estimate economic impact for pests and diseases characterised by annual preventative spay programs are set out below.

5.2.5.2 Assumptions - Powdery Mildew

- Powdery Mildew occurs in all climatic zones.
- The chemical costs for control varied between \$73 to \$104 per hectare and between 3 and 4 sprays were applied per season, often mixed with other chemicals. Early season sprays are considered essential for good control.
- The frequency of infestation varied between every year in Hot Dry zones to 1 year in 4 in Hot Dry zones to 1 year in 2 to 3 in other zones.
- Yield loss was 5% in Hot Dry and up to 10% in most other zones.
- McLaren Vale and Margaret River had more Powdery Mildew than other areas in the Warm Dry zone.
- Differences in varietal susceptibility to Powdery Mildew was taken into account in these assumptions.

5.2.5.3 Assumptions - Botrytis & Other Bunch Rots

- Bunch rots caused by Botrytis (grey mould) and other fungi can cause serious yield losses of crop at maturity and downgrading or rejection by the winery. One of the difficult aspects of chemical control is that spray cover of the berries in the centre of the bunch is almost impossible after bunch closure. Therefore, the early application of sprays is essential.
- The chemical costs per hectare varied between \$89 and \$228 per hectare, depending on which chemicals were selected for control. Between 0.3 and 1.6 sprays were applied, most in association with chemicals for other pests and diseases.
- The frequency of yield loss occurring varied from 10% (1 year in 10) for Hot Dry climatic zone to 33% (1 year in 3) in Hot-Wet climatic zone.
- Losses due to Botrytis varied between 3% and 20% between climatic zones.
- Hunter, Mudgee and WA were considered to have more frequent losses and overall white varieties were more susceptible than reds.
- There is an interaction between LBAM damage and botrytis entry to bunches that we have tried to incorporate into our assumptions.

5.2.5.4 Assumptions - Downy Mildew

Downy Mildew is a disease that occurs in most zones when favourable (for the disease) leaf wetness (10mm rain) and temperature conditions (>10ºC) are present.

The disease is controlled by a preventative spray program that maintains cover on expanding shoots and leaves with an option to apply an eradicant spray after a primary infection has occurred when the preventative spray may not provide sufficient protection.

The chemical costs for 1 to 4 preventative sprays varied between \$78 and \$142 per hectare with application costs of between \$50 and \$80 per hectare varying when multiple sprays are applied in the one spray application.

The eradicant sprays are not applied every season and the chemical costs are about \$70 per hectare per spray.

Crop losses occurred due to downy mildew with frequencies of 1 year in 20 (5%) for Hot Dry zones to 1 year in 3 (33%) for Hot Wet zones.

The yield loss varied between 5 and 10% for a disease event across climatic zones.

5.2.5.5 Assumptions - Light Brown Apple Moth (LBAM)

LBAM is a native insect that is found in most grape production zones. The larva of LBAM feeds on shoot tips, inflorescences and bunches. The damage to the inflorescences and bunches causes yield losses due to fewer berries, or extra disease pressure from botrytis due to berry damage allowing entry of the disease.

Monitoring of the development of LBAM in the vineyard is important to allow precise targeting of the early larval stages before damage occurs.

The chemical or BT sprays for up to 1 spray per season are often applied in conjunction with chemicals for other diseases.

Frequency of LBAM damage is between 20% and 30%, resulting in a reasonably low estimated yield loss of 3%.

5.2.5.6 Modelling of Economic Impact for Each Pest & Disease

This section comprises tables showing the data and assumptions used for modelling the economic impact of each of the priority pests and diseases characterised by the requirement for annual preventative sprays.

Table 11 : Data & assumptions used for modelling the economic impact of Powdery Mildew

Climatic zone	Costs associated with a preventative spray program									Impact of an infestation on production					
	Cost of chemical ($/ha/annum)			Application costs ($/ha/applic.)			Number of applications per annum			Frequency (i.e. annual probability)			Regional yield loss		
	Minimum	Most likely	Maximum	Minimum	Most likely	Maximum	Minimum	Most likely	Maximum	Minimum	Most likely	Maximum	Minimum	Most likely	Maximum
Hot-Dry	$25	$78	$150	$30	$50	$90	1.0	3.0	6.0	14.3%	25.0%	50.0%	0.0%	5.0%	10.0%
Hot-Wet	$25	$86	$150	$30	$60	$90	1.0	3.0	6.0	20.0%	33.3%	100.0%	2.0%	7.5%	20.0%
Warm-Dry	$25	$73	$150	$30	$60	$90	1.0	3.5	6.0	25.0%	50.0%	100.0%	2.0%	10.0%	15.0%
Warm-Wet	$25	$86	$150	$30	$80	$90	1.0	3.5	6.0	25.0%	50.0%	100.0%	2.0%	10.0%	15.0%
Cool	$40	$104	$250	$30	$60	$90	1.0	4.0	6.0	25.0%	50.0%	100.0%	2.0%	10.0%	15.0%

Source: Based on SRHS and EconSearch analysis.

Table 12 : Data & assumptions used for modelling the economic impact of Botrytis & Other Bunch Rots

Climatic zone	Costs associated with a preventative spray program									Impact of an infestation on production					
	Cost of chemical ($/ha/annum)			Application costs ($/ha/applic.)			Number of applications per annum			Frequency (i.e. annual probability)			Regional yield loss		
	Minimum	Most likely	Maximum	Minimum	Most likely	Maximum	Minimum	Most likely	Maximum	Minimum	Most likely	Maximum	Minimum	Most likely	Maximum
Hot-Dry	$25	$89	$180	$30	$50	$90	0.1	0.3	1.0	5.0%	10.0%	50.0%	2.0%	3.0%	20.0%
Hot-Wet	$25	$228	$300	$30	$60	$90	0.1	1.0	2.5	25.0%	33.3%	50.0%	5.0%	20.0%	30.0%
Warm-Dry	$25	$113	$300	$30	$60	$90	0.1	0.4	1.0	5.0%	14.3%	50.0%	3.0%	5.0%	20.0%
Warm-Wet	$25	$153	$300	$30	$80	$90	0.1	1.0	2.5	5.0%	20.0%	50.0%	3.0%	5.0%	20.0%
Cool	$25	$183	$300	$30	$60	$90	0.1	1.6	2.5	5.0%	25.0%	50.0%	5.0%	15.0%	30.0%

Source: Based on SRHS and EconSearch analysis.

Table 13 : Data & assumptions used for modelling the economic impact of Downy Mildew

Climatic zone	Costs associated with a preventative spray program								
	Cost of chemical ($/ha/annum)			Application costs ($/ha/applic.)			Number of applications per annum		
	Minimum	Most likely	Maximum	Minimum	Most likely	Maximum	Minimum	Most likely	Maximum
Hot-Dry	$15	$78	$180	$30	$50	$90	0.5	1.0	4.0
Hot-Wet	$30	$142	$240	$30	$60	$90	0.5	4.0	6.0
Warm-Dry	$15	$80	$200	$30	$60	$90	0.5	1.5	4.0
Warm-Wet	$15	$100	$200	$30	$80	$90	0.5	3.0	4.5
Cool	$15	$135	$200	$30	$60	$90	0.5	3.0	4.5

Climatic zone	Costs associated with an eradicant spray program											
	Cost of chemical ($/ha/annum)			Application costs ($/ha/applic.)			Number of applications per annum			Frequency of application		
	Minimum	Most likely	Maximum	Minimum	Most likely	Maximum	Minimum	Most likely	Maximum	Minimum	Most likely	Maximum
Hot-Dry	$25	$70	$240	$30	$50	$90	1.0	1.0	2.0	0.0%	6.7%	10.0%
Hot-Wet	$25	$70	$240	$30	$60	$90	1.0	1.0	2.0	25.0%	66.7%	100.0%
Warm-Dry	$25	$70	$240	$30	$60	$90	1.0	1.0	2.0	5.0%	20.0%	50.0%
Warm-Wet	$25	$70	$240	$30	$80	$90	1.0	1.0	2.0	5.0%	25.0%	50.0%
Cool	$25	$70	$240	$30	$60	$90	1.0	1.0	2.0	5.0%	20.0%	50.0%

Climatic zone	Impact of an infestation on production					
	Frequency (i.e. annual probability)			Regional yield loss		
	Minimum	Most likely	Maximum	Minimum	Most likely	Maximum
Hot-Dry	0.0%	5.0%	10.0%	5.0%	5.0%	50.0%
Hot-Wet	25.0%	33.3%	75.0%	5.0%	10.0%	50.0%
Warm-Dry	5.0%	10.0%	20.0%	5.0%	5.0%	50.0%
Warm-Wet	5.0%	14.3%	20.0%	5.0%	7.0%	50.0%
Cool	5.0%	14.3%	20.0%	5.0%	7.0%	50.0%

Source: Based on SRHS and EconSearch analysis.

Table 14 : Data & assumptions used for modelling the economic impact of Light Brown Apple Moth

Climatic zone	Costs associated with a preventative spray program									Impact of an infestation on production					
	Cost of chemical ($/ha/annum)			Application costs ($/ha/applic.)			Number of applications per annum			Frequency (i.e. annual probability)			Regional yield loss		
	Minimum	Most likely	Maximum	Minimum	Most likely	Maximum	Minimum	Most likely	Maximum	Minimum	Most likely	Maximum	Minimum	Most likely	Maximum
Hot-Dry	$20	$23	$70	$30	$50	$90	0.1	0.2	1.0	10.0%	20.0%	50.0%	0.5%	3.0%	5.0%
Hot-Wet	$20	$40	$70	$30	$60	$90	0.1	0.4	1.0	5.0%	33.0%	50.0%	0.5%	3.0%	5.0%
Warm-Dry	$20	$56	$70	$30	$60	$90	0.1	0.2	1.0	10.0%	33.3%	50.0%	0.5%	3.0%	5.0%
Warm-Wet	$20	$40	$70	$30	$80	$90	0.1	0.4	1.0	10.0%	33.3%	50.0%	0.5%	3.0%	5.0%
Cool	$20	$80	$140	$30	$60	$90	0.1	0.5	1.0	10.0%	33.3%	50.0%	0.5%	3.0%	5.0%

Source: Based on SRHS and EconSearch analysis.

5.2.6 Pests & Diseases Characterised by Eradicant Spray Programs

For the priority groups of pests and diseases characterised by eradicant spray programs, the vineyard-level impacts include the annual costs of an eradicant spray program (i.e. the cost effect) and yield loss attributable to infestation (i.e. the income effect). Each specific pest or disease and its relevant table number is listed below:

- Garden Weevil (Table 15)
- Trunk Boring Insects (Table 16)
- Mealy bugs and Scale (Table 17)

5.2.6.1 Variables

The ‘costs associated with an eradicant spray program’ (TC_{erad}) is an estimate of the cost effect of the pest and was calculated as:

$TC_{erad} = (C_{eradchem} + (C_{eradapp} * N_{erad}))* A_{eradchem}$

where;

- Cost of chemical ($C_{eradchem}$) – is an estimate of the annual cost per hectare of the chemical(s) used in the eradication of the pest ($/ha/annum).
- Application costs ($C_{eradapp}$) – is an estimate of the cost of contract spraying ($/ha/application). Includes labour, operating costs such as fuel and an annualised capital cost for machinery (i.e. depreciation). This value was used as a proxy for the costs incurred by growers that undertake their own spraying activities.
- Number of applications per annum (N_{erad}) – is an estimate of the number of spray applications per annum specifically attributable to the pest.
- Proportion of area treated annually ($A_{eradchem}$) – is an estimate of the area treated annually in affected vineyards as a proportion of total vineyard area in the zone.

The ‘impact of an infestation on production’ (I), an estimate of the income effect of the pest, was calculated as:

$I = (F * A * Y_V) * P$

where;

- Frequency (F) – is an estimate of the annual probability of an infestation of the pest. For some of these pests the ‘most likely’ value was assumed to be 100 per cent (i.e. annual infestation), reflecting their endemic status.
- Incidence (i.e. proportion of area affected) (A) – is a measure of the proportion of the vineyard area of each climatic zone infested by the pest.
- Average vineyard-level yield loss (Y_V) – is a measure of the average yield loss attributable to the pest in infested vineyards as a proportion of total potential production in those vineyards. It accounts for loss of yield and/or the proportion of fruit rejected by wineries.
- Price (P) – is a measure of weighted average zonal grape prices, as specified in Table 27 constant with time. Any impact of infestation on price received, such as fruit downgrades, was incorporated into the estimate of yield loss (Y_V).

For all these pests the economic impact (EI) in terms of reduced vineyard profit was calculated as:

$EI = TC_{erad} + I$.

The assumptions developed by the Project Team and used in the modelling to estimate economic impact for pests and diseases characterised by eradicant spay programs are set out below. Accurate data was difficult to source and the numbers used are best estimates.

5.2.6.2 Assumptions - Garden Weevil

Garden weevils and other related insects feed on buds and young shoots of vines in early spring and can cause severe damage to localised parts of a vineyard.

Control measures include ground baiting around the perimeter of a vineyard, spraying of vine butts with insecticide, physical barriers of cardboard or “tontine” around the trunk, and even the use of free range hens in the vineyard to eat the weevils (reported to be quite effective).

Garden weevil is particularly bad in WA but it and other weevils can cause low levels of damage in other zones.

The presence of garden weevil in other zones is reported to be increasing.

5.2.6.3 Assumptions - Trunk Boring Insects

The larvae of a range of insects can cause extensive damage to localised parts of vineyards resulting in the trunk and cordons of vines being riddled with tunnels, sometimes up to 5-10mm in diameter, where the larva has been feeding on the wood.

Control treatment is very difficult and not all that effective as the grower has to first detect the presence of the insect when it is in the trunk of the vine. Then it is not easy to apply a “soft” chemical to kill the larva.

The incidence of trunk boring insects is low and the yield loss is low over the zone, but individual growers may suffer serious loss to vines in a small part of their vineyard.

5.2.6.4 Assumptions – Mealy bugs & Scale

Mealy bugs and Scales are sucking insects that are sedentary once they become mature. Mealy bugs can be a problem in bunches, while scale are found on shoots and canes.

Control is by spraying with oil to suffocate the insect.

Often the oil may have some insecticide mixed with it but the over-use of insecticide is not recommended as it can also kill beneficial insects that parasitise and keep scale under manageable control.

Infestation of scale and mealy bug are often in pockets rather than across the whole vineyard. In this case, spot spraying or targeted spraying is often all that is needed.

The incidence and yield loss is low.

5.2.6.5 Modelling of Economic Impact for each pest & disease

This section comprises tables showing the data and assumptions used for modelling the economic impact of each of the priority pests and diseases characterised by the requirement for eradicant sprays.

Table 15 : Data & assumptions used for modelling the economic impact of Garden Weevil

Climatic zone	Costs associated with an eradicant spray program												Impact of an infestation on production								
	Cost of chemical ($/ha/annum)			Application costs ($/ha/applic.)			Number of applications per annum			Proportion of area treated annually			Frequency (i.e. annual probability)			Incidence (i.e. proportion of area affected)			Average vineyard-level yield loss		
	Minimum	Most likely	Maximum	Minimum	Most likely	Maximum	Minimum	Most likely	Maximum	Minimum	Most likely	Maximum	Minimum	Most likely	Maximum	Minimum	Most likely	Maximum	Minimum	Most likely	Maximum
Hot-Dry	$3.50	$19.53	$39.00	$30	$50	$90	0.0	0.0	1.0	0.0%	0.0%	1.0%	0.0%	0.0%	2.5%	0.0%	0.5%	1.0%	0.0%	0.5%	5.0%
Hot-Wet	$3.50	$19.53	$39.00	$30	$60	$90	0.0	1.0	2.0	0.0%	0.5%	1.0%	0.0%	10.0%	20.0%	0.0%	0.5%	1.0%	0.0%	0.5%	5.0%
Warm-Dry	$3.50	$19.53	$39.00	$30	$60	$90	0.0	1.0	2.0	0.0%	1.0%	2.0%	50.0%	100.0%	100.0%	1.5%	7.5%	9.0%	0.0%	1.5%	3.0%
Warm-Wet	$3.50	$19.53	$39.00	$30	$80	$90	0.0	1.0	2.0	0.0%	0.5%	1.0%	0.0%	10.0%	20.0%	0.0%	0.5%	1.0%	0.0%	0.5%	5.0%
Cool	$3.50	$19.53	$39.00	$30	$60	$90	0.0	1.0	2.0	0.0%	0.5%	1.0%	0.0%	10.0%	20.0%	0.0%	0.5%	1.0%	0.0%	0.5%	5.0%

Source: Based on SRHS and EconSearch analysis.

Table 16 : Data & assumptions used for modelling the economic impact of Trunk Boring Insects

Climatic zone	Costs associated with an eradicant spray program												Impact of an infestation on production								
	Cost of chemical ($/ha/annum)			Application costs ($/ha/applic.)			Number of applications per annum			Proportion of area treated annually			Frequency (i.e. annual probability)			Incidence (i.e. proportion of area affected)			Average vineyard-level yield loss		
	Minimum	Most likely	Maximum	Minimum	Most likely	Maximum	Minimum	Most likely	Maximum	Minimum	Most likely	Maximum	Minimum	Most likely	Maximum	Minimum	Most likely	Maximum	Minimum	Most likely	Maximum
Hot-Dry	$10.00	$15.00	$30.00	$30	$50	$90	1.0	1.0	2.0	0.0%	0.0%	0.1%	0.0%	0.0%	10.0%	0.0%	0.0%	0.1%	0.0%	1.0%	1.0%
Hot-Wet	$10.00	$15.00	$30.00	$30	$60	$90	1.0	1.0	2.0	0.0%	0.1%	0.1%	1.0%	75.0%	100.0%	0.0%	0.1%	0.2%	0.0%	1.0%	10.0%
Warm-Dry	$10.00	$15.00	$30.00	$30	$60	$90	1.0	1.0	2.0	0.0%	0.1%	0.2%	1.0%	75.0%	100.0%	0.0%	0.1%	0.2%	0.0%	1.0%	10.0%
Warm-Wet	$10.00	$15.00	$30.00	$30	$80	$90	1.0	1.0	2.0	0.0%	0.0%	0.1%	1.0%	20.0%	50.0%	0.0%	0.1%	0.2%	0.0%	1.0%	10.0%
Cool	$10.00	$15.00	$30.00	$30	$60	$90	1.0	1.0	2.0	0.0%	0.0%	0.1%	0.0%	0.0%	10.0%	0.0%	0.0%	0.1%	0.0%	1.0%	1.0%

Source: Based on SRHS and EconSearch analysis.

Table 17 : Data & assumptions used for modelling the economic impact of Mealy bugs & Scale

Climatic zone	Costs associated with an eradicant spray program												Impact of an infestation on production								
	Cost of chemical ($/ha/annum)			Application costs ($/ha/applic.)			Number of applications per annum			Proportion of area treated annually			Frequency (i.e. annual probability)			Incidence (i.e. proportion of area affected)			Average vineyard-level yield loss		
	Minimum	Most likely	Maximum	Minimum	Most likely	Maximum	Minimum	Most likely	Maximum	Minimum	Most likely	Maximum	Minimum	Most likely	Maximum	Minimum	Most likely	Maximum	Minimum	Most likely	Maximum
Hot-Dry	$4.00	$8.00	$12.00	$30	$50	$90	1.0	1.0	2.0	0.0%	0.1%	0.2%	0.0%	100.0%	100.0%	0.5%	1.0%	2.0%	0.0%	0.5%	2.0%
Hot-Wet	$4.00	$8.00	$12.00	$30	$60	$90	1.0	1.0	2.0	0.0%	0.1%	0.2%	0.0%	100.0%	100.0%	0.5%	1.0%	2.0%	0.0%	0.5%	2.0%
Warm-Dry	$4.00	$8.00	$12.00	$30	$60	$90	1.0	1.0	2.0	0.0%	0.1%	0.2%	0.0%	100.0%	100.0%	0.5%	1.0%	2.0%	0.0%	0.5%	2.0%
Warm-Wet	$4.00	$8.00	$12.00	$30	$80	$90	1.0	1.0	2.0	0.0%	0.1%	0.2%	0.0%	100.0%	100.0%	0.5%	1.0%	2.0%	0.0%	0.5%	2.0%
Cool	$4.00	$8.00	$12.00	$30	$60	$90	1.0	1.0	2.0	0.0%	0.1%	0.2%	0.0%	100.0%	100.0%	0.5%	1.0%	2.0%	0.0%	0.5%	2.0%

Source: Based on SRHS and EconSearch analysis.

5.2.7 Pests & Diseases Characterised by Other Forms of Prevention & Control

For the priority groups of pests and diseases characterised by forms of prevention and control other than annual preventative sprays or eradicant sprays, the vineyard-level impact is comprised of a wide range of different methods of prevention and control (i.e. the cost effect), reflecting the specific impact of each pest/disease. As with other pests/diseases, the second component of the impact is yield loss attributable to infestation (i.e. the income effect). Each specific pest or disease and its relevant table number is listed below:

- Trunk Diseases (Table 18);
- Root Rots (Table 19);
- Viruses and Transmissible Organisms (Table 20);
- Root-Knot and Other Nematodes (Table 21);
- Phylloxera (Table 22); and
- Birds (Table 23).

5.2.7.1 Variables – General Explanation

For all of these pest/diseases the ‘impact of an infestation on production’ (I), an estimate of the income effect of the pest/disease, was calculated as:

$I = (F * A * Y_V) * P$

where;

- Frequency (F) – is an estimate of the annual probability of an infestation of the pest/disease. For some of these pests/diseases the ‘most likely’ value was assumed to be 100 per cent (i.e. annual infestation), reflecting their endemic status.
- Incidence (i.e. proportion of area affected) (A) – is a measure of the proportion of the vineyard area of each climatic zone infested by the pest/disease.
- Average vineyard-level yield loss (Y_V) – is a measure of the average yield loss attributable to the pest/disease in infested vineyards as a proportion of total potential production in those vineyards. It accounts for loss of yield and/or the proportion of fruit rejected by wineries.
- Price (P) – is a measure of weighted average zonal grape prices, as specified in Table 27. Set as a constant (i.e. no change from base case models). Any impact of infestation on price received, such as fruit downgrades, was incorporated into the estimate of yield loss (Y_V).

For all of these pests/diseases the economic impact (EI) in terms of reduced vineyard profit was calculated as:

$EI = TC_{prev} + I$

where TC_{prev} was calculated differently for each pest/disease.

Definitions and explanations of the variables used to describe the cost effects and the assumptions used for each pest and disease follows.

5.2.7.2 Variables - Trunk Diseases

The 'costs associated with prevention and control' (TC_{prev}) for Trunk Diseases was calculated as:

$TC_{prev} = (C_{ahsurg} * A_{ahsurg}) + (C_{remsurg} * A_{remsurg})$

where;

- Cost of ad-hoc surgery (C_{ahsurg}) – is an estimate of the cost per hectare of ad-hoc surgery used to control the disease(s) ($/ha).
- Proportion of area treated annually using ad-hoc surgery (A_{ahsurg}) – is an estimate of the area treated annually in affected vineyards as a proportion of total vineyard area in the zone.
- Cost of remedial surgery ($C_{remsurg}$) – is an estimate of the cost per hectare of remedial surgery used to control the disease(s) ($/ha).
- Proportion of area treated annually using remedial surgery ($A_{remsurg}$) – is an estimate of the area treated annually in affected vineyards as a proportion of total vineyard area in the zone.

5.2.7.3 Assumptions - Trunk Diseases

Whilst some vineyards use both methods to control Trunk Diseases, others may use one method only. The assumptions used for the representative vineyard reflect the assumed average response across the zone.

The trunk diseases Eutypa and Botryosphaeria cause sectors of cordons and trunks to die and in extreme cases can kill vines. The fungi enter the vine when spores land on fresh pruning wounds in winter. Spread through the vine is slow but generally inevitable.

Symptoms are usually expressed as distorted shoot growth.

The only method of control is to prune the cordon or trunk to below the downward front of the disease in the wood. New shoots can burst and a new vine structure can be re-trained.

The cost of minor "surgery" on the vine is estimated at $50/hectare while remedial surgery can be up to $2,800/hectare.

Ad hoc surgery - Cutting off symptomatic vine cordons or entire vines - 2 hours/ha at $25/hr (i.e. $2 - $5/vine).

Remedial surgery - Cutting off all vines at the same height. Including cutting vines, cordon wire, removal of vines and wire and two training passes ($1.68/vine).

Wetter zones have more trunk diseases than drier zones because rain releases spores to the atmosphere from fruiting bodies on infected vines.

Yield loss varied between 0.5% in Hot-Dry to 10% to 20% in all other climatic zones.

5.2.7.4 Variables - Root Rots

The 'costs associated with prevention and control' (TC_{prev}) for Root Rots was calculated as:

$TC_{prev} = (C_{targrep} * A_{targrep})$

where;

- Cost of targeted replanting ($C_{targrep}$) – is an estimate of the cost per hectare of targeted replanting used to prevent the disease(s) ($/ha).

- Proportion of area treated annually using targeted replanting ($A_{targrep}$) – is an estimate of the area replanted annually in affected vineyards as a proportion of total vineyard area in the zone.

5.2.7.5 Assumptions - Root Rots

A number of fungi (Phytophthora, Pythium, Fusarium, etc) can damage roots and trunks of vines, particularly when soil conditions are too wet, either as a result of excessive rainfall or over-irrigation.

In young vineyards (Years 1, 2) over-irrigation can cause losses of vines which require replanting.

Some chemical treatments are available, often applied through the dripper system which cost $50 to $150 per hectare.

Older vines can withstand some loss of roots due to fungi in wet conditions without a noticeable effect on growth or yield. However, in some cases where extra stress (heat, water, etc) is applied to the vine, deaths can occur. Losses are generally small.

Mounding of the under-vine bank in areas where waterlogged soils can occur is a good way of improving soil condition and reducing the impact of root rots.

5.2.7.6 Variables - Viruses & Transmissible Organisms

The ‘costs associated with prevention and control’ (TC_{prev}) for Viruses and Transmissible Organisms was calculated as:

$TC_{prev} = (C_{cpm} * A_{cpm})$

where;

- Costs associated with ensuring clean planting material (C_{cpm}) – include costs to growers that may be passed on by nurseries which sell clean or tested planting material, payments to Vine Improvement Societies by those growers who produce their own planting material, virus testing costs for material used in grafting and top-working of vines and virus testing costs incurred by growers before removing affected vines.
- Proportion of new plantings which use clean planting material (A_{cpm}).

5.2.7.7 Assumptions - Viruses & Transmissible Organisms

On average, it was assumed that approximately 5 per cent of the vineyard area in each climatic zone would be replanted annually. This is a long-term estimate that takes into account the recent period of stagnation in new vineyard development in response to fruit oversupply, as well as periods of growth such as that through the 1990s.

In most cases viruses or organisms like phytoplasmas (AGY) mainly are introduced to a vineyard in the planting material. Some viruses have insect vectors but this is not the main method of infestation.

Mother plantings of varieties/clones that are monitored for “trueness-to-type” and freedom of known pathogens (i.e. viruses) are managed by zonal Vine Improvement Societies and “clean” cuttings are available to nurseries to propagate vines.

There is a small extra cost for “clean” cuttings of about 20c more than other cuttings. All other costs for the planting material are the same.

Most growers value the benefits of "clean" planting material but in the big planting years of the wine boom there was not enough material to meet demand and some compromises were made by growers.

Once vines are infected with virus there is no control available other than to plant "clean" material next time.

The yield reduction with virus can be high depending on the virus but we have used a reduction of 5% to 12 % per year.

In addition to the extra cost for "clean" cuttings a cost of $150 per hectare has been included for virus testing of vineyards and vines before topworking.

5.2.7.8 Variables - Root-Knot & Other Nematodes

The 'costs associated with prevention and control' (TC_{prev}) for Root-Knot and Other Nematodes was calculated as:

$TC_{prev} = (C_{nemrsnt} * A_{nemrsnt}) + (C_{chem} * A_{chem})$

where;

- Cost premium for nematode-resistant rootstocks when replanting ($C_{nemrsnt}$) – is an estimate of the cost premium per hectare associated with replanting using nematode-resistant rootstocks rather than own-rooted planting material ($/ha).
- Proportion of area replanted annually with nematode-resistant rootstocks ($A_{nemrsnt}$) – is an estimate of the area replanted annually in affected vineyards as a proportion of total vineyard area in the zone.
- Cost of chemical control of nematodes (C_{chem}) – is an estimate of the cost per hectare of chemical control of the pests. Includes the cost of chemical and application costs ($/ha).
- Proportion of area treated annually using complete replanting (A_{chem}) – is an estimate of the area treated annually in affected vineyards as a proportion of total vineyard area in the zone.

5.2.7.9 Assumptions - Root-Knot & Other Nematodes

Whilst some vineyards use both methods to control Root-Knot and Other Nematodes, others may use one method only. The assumptions used for the representative vineyard reflect the assumed average response across the zone.

Nematodes are either present in the soil resulting from a previous host crop or are introduced to a "clean" site on the roots of the planting material infested in the nursery.

In "clean" soil of a texture that is not conducive to the spread and new infection of vines, the decline in a vineyard due to nematodes is relatively slow. However, high numbers of nematodes in soil can have a greater impact on vine growth.

Control of nematodes is by planting vines grafted to nematode resistant/tolerant rootstocks, or by applying nematicide, (eg Nemacur), through the dripper system.

Cost of chemical control by using Nemacur nematicide ($38.70/L) applied via drippers at 5L/ha = $193/ha or by boom spray at 30L/ha = $1,161/ha

Resistant rootstock is the preferred permanent solution to a nematode problem. The additional costs of resistant rootstocks above that of normal "own rooted" vines is about $5,000/hectare ($4.50 for rootstock vs. $1.50 for own rooted vine).

Sandy soils are more prone to nematode spread and damage than clay soils.

The incidence of nematode infestation varies between zones, mainly due to different soil types in the zones.

The impact of an infestation relates to vineyards with no nematode resistant rootstocks or Nemacur application

A yield loss of 5% is used for the 'most likely' damage caused by nematodes.

The proportion of area replanted annually is 0.5%.

5.2.7.10 Variables - Phylloxera

The 'costs associated with prevention and control' (TC_{prev}) for Phylloxera was calculated as:

$TC_{prev} = (C_{phyrsnt} * A_{phyrsnt})$

where;

- Cost premium for Phylloxera resistant rootstocks when replanting ($C_{phyrsnt}$) – is an estimate of the cost premium per hectare associated with replanting using Phylloxera-resistant rootstocks rather than own-rooted planting material.
- Proportion of area replanted annually with Phylloxera-resistant rootstocks ($A_{phyrsnt}$) – is an estimate of the area replanted annually in affected vineyards as a proportion of total vineyard area in the zone.

The costs to growers of Phylloxera regulation and research, such as those incurred in South Australia through the payment of a levy to the Phylloxera and Grape Industry Board of South Australia, were excluded from the analysis.

5.2.7.11 Assumptions - Phylloxera

Phylloxera is an exotic insect introduced from overseas that is present in some parts of Victoria and NSW where strict quarantine regulations are in force to prevent spread. New outbreaks occasionally occur but the major production zones in the Hot Dry climatic zone are free of Phylloxera.

The only climatic zones with phylloxera present are Hot Wet (NE Victoria only), Warm Wet (Central Victoria) and Cool (Port Phillip–Yarra Valley).

The proportion of these zones infested with phylloxera is small but the risk of spread is high.

The incidence of phylloxera is small and the slow decline is estimated to be about 6% yield loss per year.

The only control of phylloxera is with resistant rootstocks, some the same as those resistant to nematodes.

The extra cost for replanting a vineyard with phylloxera is $5,000/hectare for the rootstocks.

Costs for premature replanting after infestation and the significant costs of vintage hygiene are acknowledged but have not been included.

5.2.7.12 Variables - Birds

The 'costs associated with prevention and control' (TC_{prev}) for birds was calculated as:

$TC_{prev} = (C_{net} * A_{net}) + (C_{disturb} * A_{disturb})$

where;

- Cost of netting (C_{net}) – is an estimate of the cost of contract netting ($/ha). Includes application costs such as labour and fuel and an annualised capital cost for nets (i.e. depreciation). This value was used as a proxy for the costs incurred by growers that undertake their own netting activities.
- Proportion of area netted annually (A_{net}) – is an estimate of the area treated annually in affected vineyards as a proportion of total vineyard area in the zone.
- Cost of bird disturbance methods ($C_{disturb}$) – is an estimate of the cost per hectare of disturbance methods such as gas guns, bird scarers, patrols, etc. used to prevent bird damage.
- Proportion of area which utilises bird disturbance methods ($A_{disturb}$) – is an estimate of the area treated annually in affected vineyards as a proportion of total vineyard area in the zone.

Whilst some vineyards use both methods to control birds others may use one method only. The assumptions used for the representative vineyard reflect the assumed average response across the zone.

5.2.7.13 Assumptions - Birds

Birds are difficult pests to control because they are highly mobile and they become accustomed to regular scaring methods, making these control measures ineffective. Therefore, few options for control are available other than exclusion with netting or moving the birds away from the vineyard. Chemical treatments, like those used for insects and diseases, and shooting are not appropriate.

Several recent reports on the damage caused by birds and how to manage them in horticulture/viticulture have presented information on costs (BRS (2007) and Invasive Animals CRC (2009)).

The assumptions we have used in the economic model are:

- Bird damage varies greatly between vineyards depending on proximity to trees and scrub, dams and water sources, power lines for roosting, etc.
- Netting provides good protection but it is expensive and can cause normal management operations like spraying, harvesting etc to be more difficult.
- The netting on single or multi-rows of vines is installed and rolled up using specialised but simple machinery.
- Initial purchase of netting is $3000 per hectare but over its life span (assumed 5 years) is $600 per hectare per year. Application labour varies between $1000 and $1400 per hectare per year. An average cost of $1,500 per hectare per year has been used.
- Disturbance methods vary with the ingenuity of the grape grower but often include gas guns, electronic noise machines, and people on motorbikes moving the birds along, sometimes with some lead shot above their heads. An average cost of $30 per hectare per year has been used.

- The main species causing damage varies between zones but starlings, silver eyes and parrots are usually on the list.
- Damage is not uniform across the vineyard with yield losses estimated at 2-20% and 5-10% of a zone impacted.
- The term 'netting' refers to 'throw over' netting (single or multiple row) or side netting (clipped over bunch zone) applied annually. This should reduce damage to 0%.
- Permanent 'exclusion' netting has not been considered as it is not often used in viticulture.
- The cost of the netting has been estimated based on 5 years of re-use.
- Birds causing damage/yield loss include: Silvereye, Common starling, Crows, Cockatoos, Parrots, Honeyeaters, Common blackbird and Common myna.

5.2.7.14 Modelling of Economic Impact for each pest & disease

This section comprises tables showing the data and assumptions used for modelling the economic impact of each of the priority pests and diseases characterised by other forms of prevention and control.

Table 18 : Data & assumptions used for modelling the economic impact of Trunk Diseases

Climatic zone	Costs associated with prevention and control												Impact of an infestation on production								
	Cost of ad-hoc surgery ($/ha)			Proportion of area treated annually			Cost of remedial surgery ($/ha)			Proportion of area treated annually			Frequency (i.e. annual probability)			Incidence (i.e. proportion of area affected)			Average vineyard-level yield loss		
	Minimum	Most likely	Maximum	Minimum	Most likely	Maximum	Minimum	Most likely	Maximum	Minimum	Most likely	Maximum	Minimum	Most likely	Maximum	Minimum	Most likely	Maximum	Minimum	Most likely	Maximum
Hot-Dry	$25	$50	$60	0.0%	0.0%	1.0%	$2,000	$2,800	$3,500	0.0%	0.0%	1.0%	0.0%	100.0%	100.0%	0.0%	1.0%	5.0%	0.0%	0.5%	5.0%
Hot-Wet	$25	$50	$60	0.0%	1.0%	2.0%	$2,000	$2,800	$3,500	0.0%	1.0%	2.0%	0.0%	100.0%	100.0%	0.0%	5.0%	10.0%	0.0%	10.0%	15.0%
Warm-Dry	$25	$50	$60	0.0%	5.0%	10.0%	$2,000	$2,800	$3,500	0.0%	1.0%	2.0%	0.0%	100.0%	100.0%	0.0%	10.0%	10.0%	0.0%	10.0%	25.0%
Warm-Wet	$25	$50	$60	0.0%	5.0%	10.0%	$2,000	$2,800	$3,500	0.0%	1.0%	2.0%	0.0%	100.0%	100.0%	0.0%	10.0%	10.0%	0.0%	10.0%	25.0%
Cool	$25	$50	$60	0.0%	5.0%	10.0%	$2,000	$2,800	$3,500	0.0%	1.0%	2.0%	0.0%	100.0%	100.0%	0.0%	10.0%	10.0%	0.0%	20.0%	30.0%

Source: Based on SRHS and EconSearch analysis.

Table 19 : Data & assumptions used for modelling the economic impact of Roots Rots

Climatic zone	Costs associated with prevention and control						Impact of an infestation on production								
	Cost of targeted replanting ($/ha)			Proportion of area replanted annually			Frequency (i.e. annual probability)			Incidence (i.e. proportion of area affected)			Average vineyard-level yield loss		
	Minimum	Most likely	Maximum	Minimum	Most likely	Maximum	Minimum	Most likely	Maximum	Minimum	Most likely	Maximum	Minimum	Most likely	Maximum
Hot-Dry	$20	$50	$100	0.0%	0.1%	0.2%	1.0%	1.0%	25.0%	0.0%	0.0%	0.5%	0.0%	0.0%	0.1%
Hot-Wet	$100	$150	$300	0.0%	0.1%	0.2%	1.0%	10.0%	25.0%	0.0%	0.5%	1.0%	0.0%	0.1%	0.5%
Warm-Dry	$20	$50	$100	0.0%	0.1%	0.2%	1.0%	10.0%	25.0%	0.0%	0.0%	0.5%	0.0%	0.0%	0.1%
Warm-Wet	$100	$150	$300	0.0%	0.1%	0.2%	1.0%	10.0%	25.0%	0.0%	0.5%	1.0%	0.0%	0.1%	0.5%
Cool	$100	$150	$300	0.0%	0.1%	0.2%	1.0%	10.0%	25.0%	0.0%	0.5%	1.0%	0.0%	0.1%	0.5%

Source: Based on SRHS and EconSearch analysis.

Table 20 : Data & assumptions used for modelling the economic impact of Viruses & Transmissible Organisms

Climatic zone	Costs associated with prevention and control						Impact of an infestation on production								
	Cost premium for clean planting material ($/ha)			Proportion of new plantings which use clean planting material			Frequency (i.e. annual probability)			Incidence (i.e. proportion of area affected)			Average vineyard-level yield loss		
	Minimum	Most likely	Maximum	Minimum	Most likely	Maximum	Minimum	Most likely	Maximum	Minimum	Most likely	Maximum	Minimum	Most likely	Maximum
Hot-Dry	$100	$150	$200	10%	50%	75%	0.0%	100.0%	100.0%	0.0%	25.0%	35.0%	1.0%	10.0%	15.0%
Hot-Wet	$100	$150	$200	10%	50%	75%	0.0%	100.0%	100.0%	0.0%	25.0%	35.0%	0.0%	5.0%	10.0%
Warm-Dry	$100	$150	$200	10%	50%	75%	0.0%	100.0%	100.0%	0.0%	25.0%	35.0%	2.0%	12.0%	18.0%
Warm-Wet	$100	$150	$200	10%	50%	75%	0.0%	100.0%	100.0%	0.0%	25.0%	35.0%	0.0%	5.0%	10.0%
Cool	$100	$150	$200	10%	50%	75%	0.0%	100.0%	100.0%	0.0%	25.0%	35.0%	2.0%	12.0%	18.0%

Source: Based on SRHS and EconSearch analysis.

Table 21 : Data & assumptions used for modelling the economic impact of Root-Knot & Other Nematodes

Climatic zone	Costs associated with prevention and control												Impact of an infestation on production								
	Cost premium for nematode resistant rootstocks when replanting ($/ha)			Proportion of area replanted annually			Cost of chemical control of nematodes ($/ha)			Proportion of area treated annually			Frequency (i.e. annual probability)			Incidence (i.e. proportion of area affected)			Average vineyard-level yield loss		
	Minimum	Most likely	Maximum	Minimum	Most likely	Maximum	Minimum	Most likely	Maximum	Minimum	Most likely	Maximum	Minimum	Most likely	Maximum	Minimum	Most likely	Maximum	Minimum	Most likely	Maximum
Hot-Dry	$4,000	$5,000	$6,000	0.1%	0.5%	5.0%	$100	$193	$1,161	0.0%	1.0%	2.0%	0.0%	100.0%	100.0%	0.0%	5.0%	10.0%	5.0%	7.0%	9.0%
Hot-Wet	$4,000	$5,000	$6,000	0.1%	0.5%	2.0%	$100	$193	$1,161	0.0%	1.0%	2.0%	0.0%	100.0%	100.0%	0.0%	2.0%	5.0%	5.0%	7.0%	9.0%
Warm-Dry	$4,000	$5,000	$6,000	0.1%	0.5%	5.0%	$100	$193	$1,161	0.0%	1.0%	2.0%	0.0%	100.0%	100.0%	0.0%	4.0%	10.0%	5.0%	7.0%	9.0%
Warm-Wet	$4,000	$5,000	$6,000	0.1%	0.5%	2.0%	$100	$193	$1,161	0.0%	1.0%	2.0%	0.0%	100.0%	100.0%	0.0%	2.0%	5.0%	5.0%	7.0%	9.0%
Cool	$4,000	$5,000	$6,000	0.1%	0.5%	5.0%	$100	$193	$1,161	0.0%	1.0%	2.0%	0.0%	100.0%	100.0%	0.0%	3.0%	10.0%	5.0%	7.0%	9.0%

Source: Based on SRHS and EconSearch analysis.

Table 22 : Data & assumptions used for modelling the economic impact of Phylloxera

Climatic zone	Costs associated with prevention and control						Impact of an infestation on production								
	Cost premium for Phylloxera resistant rootstocks when replanting ($/ha)			Proportion of area replanted annually			Frequency (i.e. annual probability)			Incidence (i.e. proportion of area affected)			Average vineyard-level yield loss		
	Minimum	Most likely	Maximum	Minimum	Most likely	Maximum	Minimum	Most likely	Maximum	Minimum	Most likely	Maximum	Minimum	Most likely	Maximum
Hot-Dry	$4,000	$5,000	$6,000	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Hot-Wet	$4,000	$5,000	$6,000	0.0%	0.1%	0.1%	0.0%	100.0%	100.0%	0.0%	0.1%	0.1%	2.0%	6.0%	10.0%
Warm-Dry	$4,000	$5,000	$6,000	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Warm-Wet	$4,000	$5,000	$6,000	0.0%	0.1%	0.1%	0.0%	100.0%	100.0%	0.0%	0.1%	0.1%	2.0%	6.0%	10.0%
Cool	$4,000	$5,000	$6,000	0.0%	0.1%	0.1%	0.0%	100.0%	100.0%	0.0%	0.1%	0.1%	2.0%	6.0%	10.0%

Source: Based on SRHS and EconSearch analysis.

Table 23 : Data & assumptions used for modelling the economic impact of Birds

Climatic zone	Costs associated with prevention and control												Impact of an infestation on production								
	Cost of netting ($/ha)			Proportion of area treated annually			Cost of disturbance methods ($/ha)			Proportion of area treated annually			Frequency (i.e. annual probability)			Incidence (i.e. proportion of area affected)			Average vineyard-level yield loss		
	Minimum	Most likely	Maximum	Minimum	Most likely	Maximum	Minimum	Most likely	Maximum	Minimum	Most likely	Maximum	Minimum	Most likely	Maximum	Minimum	Most likely	Maximum	Minimum	Most likely	Maximum
Hot-Dry	$600	$1,500	$2,500	0.0%	0.0%	1.0%	$20	$30	$50	1.0%	5.0%	10.0%	50.0%	75.0%	100.0%	1.0%	5.0%	10.0%	1.0%	2.0%	5.0%
Hot-Wet	$600	$1,500	$2,500	0.0%	0.0%	1.0%	$20	$30	$50	1.0%	5.0%	10.0%	50.0%	75.0%	100.0%	1.0%	5.0%	10.0%	1.0%	10.0%	20.0%
Warm-Dry	$600	$1,500	$2,500	0.0%	2.0%	2.0%	$20	$30	$50	10.0%	20.0%	40.0%	50.0%	75.0%	100.0%	2.0%	10.0%	15.0%	3.0%	20.0%	30.0%
Warm-Wet	$600	$1,500	$2,500	0.0%	3.0%	3.0%	$20	$30	$50	10.0%	20.0%	40.0%	50.0%	75.0%	100.0%	2.0%	10.0%	15.0%	3.0%	20.0%	30.0%
Cool	$600	$1,500	$2,500	0.0%	1.0%	2.0%	$20	$30	$50	10.0%	20.0%	40.0%	50.0%	75.0%	100.0%	2.0%	10.0%	15.0%	3.0%	20.0%	30.0%

Source: Based on SRHS and EconSearch analysis.

5.2.8 Costs Excluded from the Analysis

It is important to acknowledge that there are some costs that were excluded from the analysis due to problems of attribution and/or limited data. These costs include the following:

- A number of vineyard cultural or management practices are undertaken primarily for yield/quality management but have positive consequences for the prevention of selected pests and diseases (e.g. hedging, shoot thinning, irrigation management and nutrition management). Another vineyard management practice, weed control, is undertaken primarily for the management of soil moisture/nutrient balance but has positive consequences for the prevention of LBAM infestation. The extent that the cost of these practices can be attributed to pest or disease prevention is not clear.
- There are costs associated with physical infrastructure used for spraying (e.g. chemical storage sheds, water supply) that have also been excluded from the analysis. These costs, which include construction costs and annual repairs and maintenance costs, are difficult to attribute to specific pests/diseases and exhibit a high level of variability across the industry.
- For pests and diseases for which targeted or complete replanting is the primary or only method of prevention and control (i.e. Trunk Diseases, Root Rots, Root-Knot and Other Nematodes and Phylloxera), there is a cost associated with the loss of old vines, many of which produce the highest quality fruit and, in turn, the premium wines for which the industry is renowned.

It is also important to note that the assumptions detailed in Table 11 to Table 23 do not explicitly account for the small proportion of the national vineyard area which is managed using organic practices.

5.3 Physical & Economic Characteristics of the Australian Winegrape Industry

In order to estimate the impact of pests and diseases on the winegrape industry at the zonal (i.e. climatic) and national levels it was necessary to compile some indicators for the industry at these levels of aggregation.

The key indicators for winegrapes by climatic zone and broad variety (i.e. red, white and total) include:

- bearing and non-bearing area;
- production;
- average yield; and
- average price.

Much of the relevant data on area, production and yield are published by the ABS (2009) *2008 Australian Wine and Grape Industry* (and previous issues). However, a number of steps were required to convert the data into a form suitable for use in this analysis.

The base data are published by geographical indications (GI) zone. The first step was the aggregation of these data into the relevant climatic zones.

Estimates of area of grapes published in ABS (2009) are for all uses for grapes (i.e. winemaking, drying and 'table and other'). The area devoted specifically to winegrape production in 2008 was disaggregated from the published data on the basis of ABS estimates of production by zone and use (ABS 2009) and average yields for drying and 'table and other' uses from SRHS (pers. comm.).

Average yields for the period 2004 to 2008 were based on published estimates of grape production for winemaking in ABS (2009 and previous issues) and adjusted estimates of the area devoted to winegrape production, using the method outlined above.

Estimates of the area and production of grapes for winemaking by climatic zone in Australia in 2008 are detailed in Table 24, Table 25 and Table 26 for red, white and total grapes, respectively[8]. Average yields for the period 2004 to 2008 are also provided.

Table 24 : Red grapes for winemaking: area & production by climatic zone, 2008

Climatic Zone	Bearing Area	Non-Bearing Area (ha)		Total Area		Production		Average yield [a]
	ha	Planted Pre-2008	Planted 2008	ha	%	t	%	t/ha
Hot-Dry	34,371	486	320	35,178	35.6%	526,035	53.5%	15.4
Hot-Wet	11,299	140	63	11,502	11.7%	76,289	7.8%	6.5
Warm-Dry	25,287	434	339	26,060	26.4%	192,600	19.6%	7.6
Warm-Wet	9,217	147	99	9,463	9.6%	66,232	6.7%	6.4
Cool	16,121	246	119	16,486	16.7%	122,965	12.5%	7.0
Australia	96,296	1,453	939	98,688	100.0%	984,121	100.0%	10.1

[a] For the period 2004 to 2008.
Source: Based on ABS (2009 and previous issues) and EconSearch analysis.

Table 25 : White grapes for winemaking: area & production by climatic zone, 2008

Climatic Zone	Bearing Area	Non-Bearing Area (ha)		Total Area		Production		Average yield [a]
	ha	Planted Pre-2008	Planted 2008	ha	%	t	%	t/ha
Hot-Dry	35,245	1,239	577	37,061	53.8%	579,992	68.0%	17.9
Hot-Wet	7,903	171	149	8,222	11.9%	63,130	7.4%	7.2
Warm-Dry	11,049	474	203	11,726	17.0%	102,764	12.0%	9.0
Warm-Wet	5,103	241	145	5,490	8.0%	48,347	5.7%	8.0
Cool	5,713	587	113	6,414	9.3%	58,680	6.9%	8.8
Australia	65,013	2,713	1,186	68,912	100.0%	852,913	100.0%	13.4

[a] For the period 2004 to 2008.
Source: Based on ABS (2009 and previous issues) and EconSearch analysis.

Table 26 : Total grapes for winemaking: area & production by climatic zone, 2008

Climatic Zone	Bearing Area	Non-Bearing Area (ha)		Total Area		Production		Average yield [a]
	ha	Planted Pre-2008	Planted 2008	ha	%	t	%	t/ha
Hot-Dry	69,616	1,725	897	72,238	43.1%	1,106,027	60.2%	16.6
Hot-Wet	19,202	311	212	19,724	11.8%	139,419	7.6%	6.8
Warm-Dry	36,336	908	542	37,785	22.5%	295,364	16.1%	8.0
Warm-Wet	14,321	388	244	14,953	8.9%	114,579	6.2%	7.0
Cool	21,834	833	232	22,900	13.7%	181,645	9.9%	7.5
Australia	161,309	4,166	2,126	167,601	100.0%	1,837,034	100.0%	11.4

[a] For the period 2004 to 2008.
Source: Based on ABS (2009 and previous issues) and EconSearch analysis.

Another key indicator for use in the modelling was the average price for winegrapes by climatic zone and broad variety (red, white). An average for the period 2003/04 to 2007/08 in 2008 dollars was calculated as follows.

The 'estimated total value' of winegrapes (nominal) and 'total tonnes crushed' by year and climatic zone were extracted from the Winefacts database published by the Australian Wine and Brandy Corporation (2009) www.wineaustralia.com.

[8] Estimates of the area of grapes for winemaking in 2008, disaggregated by GI zone, (Source: ABS, 2009).

A weighted average nominal price was calculated by zone, variety and year. Real prices were estimated using the All Groups Consumer Price Index from ABS (2008).

The final step was calculation of a weighted average real price by zone and variety for the five years 2003/04 to 2007/08. These data are provided in Table 27.

Table 27 : Average price of grapes for winemaking by climatic zone & variety

Climatic zone	Average price ($/t) [a]	
	Red grapes	White grapes
Hot-Dry	$464	$475
Hot-Wet	$905	$945
Warm-Dry	$1,231	$1,138
Warm-Wet	$1,226	$1,325
Cool	$1,186	$1,261

[a] Average for the period 2003/04 to 2007/08 in 2008 dollars. The base data were derived from the *winefacts* database published by AWBC (2009) www.wineaustralia.com. Real prices were calculated using the All Groups Consumer Price Index from ABS (2008).

It is important to note that recent vineyard-level pest/disease management practices are likely to have been influenced by historically low prices for winegrapes and underlying market oversupply. Much of the data for the analysis is based on recent ‘spray diaries’. Consequently, the absolute and relative levels of the impacts presented in Section 5.4 also reflect the response to these historically low prices.

5.4 Estimates of the National Economic Impact of Selected Winegrape Pests & Diseases

5.4.1 Introduction

Estimates of the economic impact of the 13 groups of priority winegrape industry pests and diseases at the vineyard, zonal and national levels are detailed below. Impacts on vineyard profit have been disaggregated to reflect the relative contribution of income and cost effects. The net impacts of the pest or disease at the vineyard level (i.e. per hectare) were estimated by comparing the base case and ‘with pest/disease’ models, whilst holding all other variables constant.

In order to account for uncertainty in the results of the analysis, the estimates presented below (i.e. the expected impact) represent the mean value from Monte Carlo simulations and were calculated by attaching a triangular probability distribution (described by minimum, most likely and maximum values) to selected variables used in the analysis[9]. The data and assumptions used for the ‘with pest/disease’ models are reported in Section 5.2.4.

The results of the analysis at the vineyard level and nationally by climatic zone are detailed in Section 5.4.2 for the following pests and diseases:

- Powdery Mildew (5.4.2.1)
- Botrytis and Other Bunch Rots (5.4.2.2)
- Downy Mildew (5.4.2.3)
- Light Brown Apple Moth (LBAM) (5.4.2.4)

[9] Using @Risk® software in Microsoft Excel®. Point values were used where no distribution was defined.

- Garden Weevil (5.4.2.5)
- Trunk Boring Insects (5.4.2.6)
- Mealy bugs and Scale (0)
- Trunk Diseases (5.4.2.8)
- Roots Rots (5.4.2.9)
- Viruses and Transmissible Organisms (5.4.2.10)
- Root-Knot and Other Nematodes (0)
- Phylloxera (5.4.2.12)
- Birds (5.4.2.13)

Some comparison of the pests/diseases at the national level is reported in Section 5.4.3.

5.4.2 Results of the Analysis by Pest or Disease and Climatic Zone

5.4.2.1 Powdery Mildew

Estimates of the vineyard-level impact on profit attributable to Powdery Mildew are reported in Table 28 and Figure 3 by climatic zone. These estimates represent an annual average in current (i.e. 2009) dollars, calculated over a period of 15 years. Some of the key points to note from these results include the following.

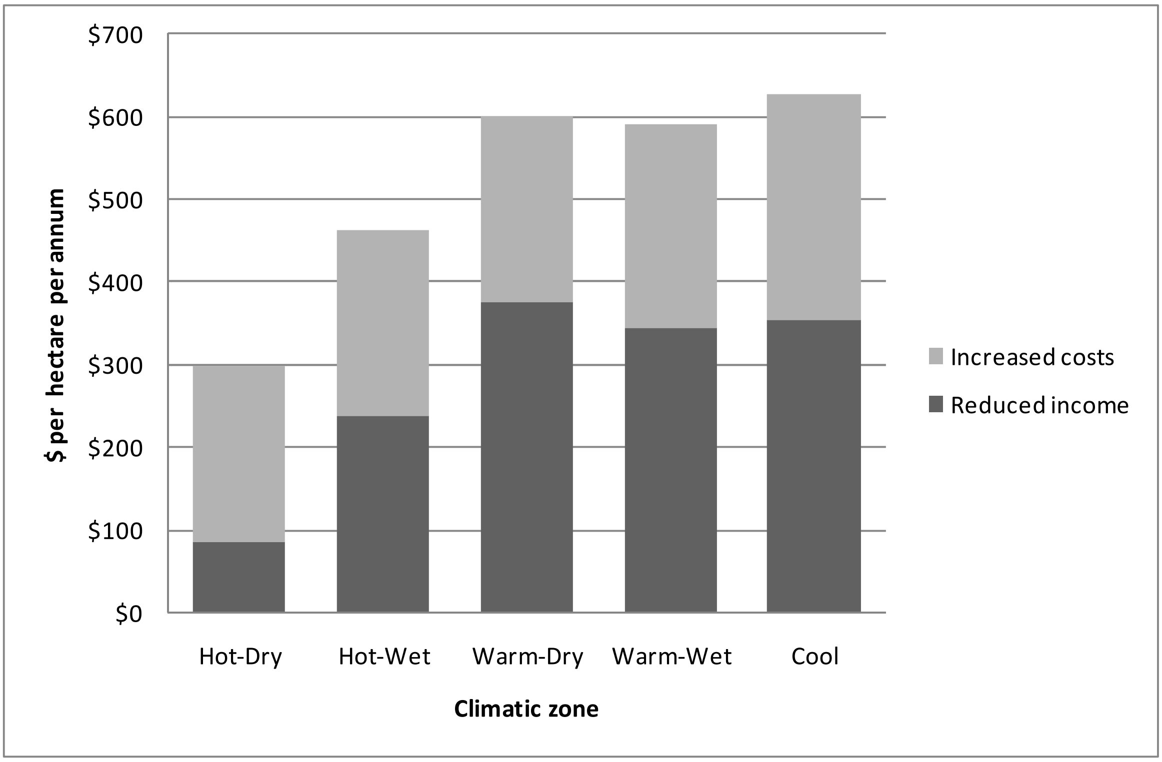
- The average vineyard-level impact of Powdery Mildew in terms of reduced profit is very similar in the warm-dry, warm-wet and cool zones ($599 to $628/ha/annum). The impact in these zones is somewhat higher than that in the hot-wet zone ($462) and significantly higher than that in the hot-dry zone ($298) (Table 28).
- As detailed in Table 11, the vineyard-level impact of Powdery Mildew is comprised of the annual costs of a preventative spray program (i.e. the cost effect) and yield loss attributable to severe infestation (i.e. the income effect). The latter reflects the cost of a failed or inadequate preventative spray program.

Table 28 : Average vineyard-level economic impact of Powdery Mildew by climatic zone

Climatic zone	Average vineyard-level impact [a]				
	Reduced income		Increased costs		Reduced profit
	$/ha/annum	% [b]	$/ha/annum	% [b]	$/ha/annum
Hot-Dry	$86	1.5%	$212	3.1%	$298
Hot-Wet	$239	5.1%	$223	3.1%	$462
Warm-Dry	$375	5.2%	$224	3.7%	$599
Warm-Wet	$344	5.2%	$247	3.5%	$592
Cool	$354	5.2%	$273	5.1%	$628

[a] Over a period of 15 years in constant 2009 dollars.
[b] Percentage difference from base case totals. The prevention and/or control of some winegrape pests/diseases is part of the normal management routine for most vineyards, thus total 'base case' costs do not necessarily represent normal operating conditions.
Source: EconSearch analysis.

Figure 3 : Average vineyard-level economic impact of Powdery Mildew by climatic zone [a]



[a] Estimates are an annual average over a period of 15 years in constant 2009 dollars.
Source: EconSearch analysis.

- In the hot-wet, warm-dry, warm-wet and cool climatic zones, the income effect comprises over 50 per cent of the impact on profit (52 to 63 per cent). In the hot-dry zone the primary contributor to reduced profit at the vineyard level is the cost effect (71 per cent of the total) (Figure 3). This reflects the lower frequency and yield loss associated with severe infestation of Powdery Mildew in this zone.
- Estimates are provided in Table 28 of the relative impact of the income and costs effects, when compared with the base case (i.e. 'without pest/disease') models. Gross income (per ha per annum) with periodic severe infestation of Powdery Mildew is approximately 1.5 per cent less than the base case in the hot-dry zone and approximately 5 per cent less in all other zones. The costs of Powdery Mildew prevention were estimated to add 3.1 to 5.1 per cent to total base case costs. Note, however, that the treatment and/or control of some winegrape pests and diseases is part of the normal management routine for most vineyards, thus total 'base case' costs do not necessarily represent normal operating conditions.

The average industry-wide economic impact of Powdery Mildew by climatic zone was calculated by applying estimates of the area of winegrapes by zone in Australia in 2008 (Section 5.3) to the vineyard-level estimates of economic impact. These national data are presented in Table 29 and Figure 4.

Table 29 : Average industry-wide economic impact of Powdery Mildew by climatic zone

Climatic zone	Average industry-wide impact ($m/annum) [a]		
	Reduced income	Increased costs	Reduced profit
Hot-Dry	6	15	22
Hot-Wet	5	4	9
Warm-Dry	14	8	23
Warm-Wet	5	4	9
Cool	8	6	14
All zones	38	38	76

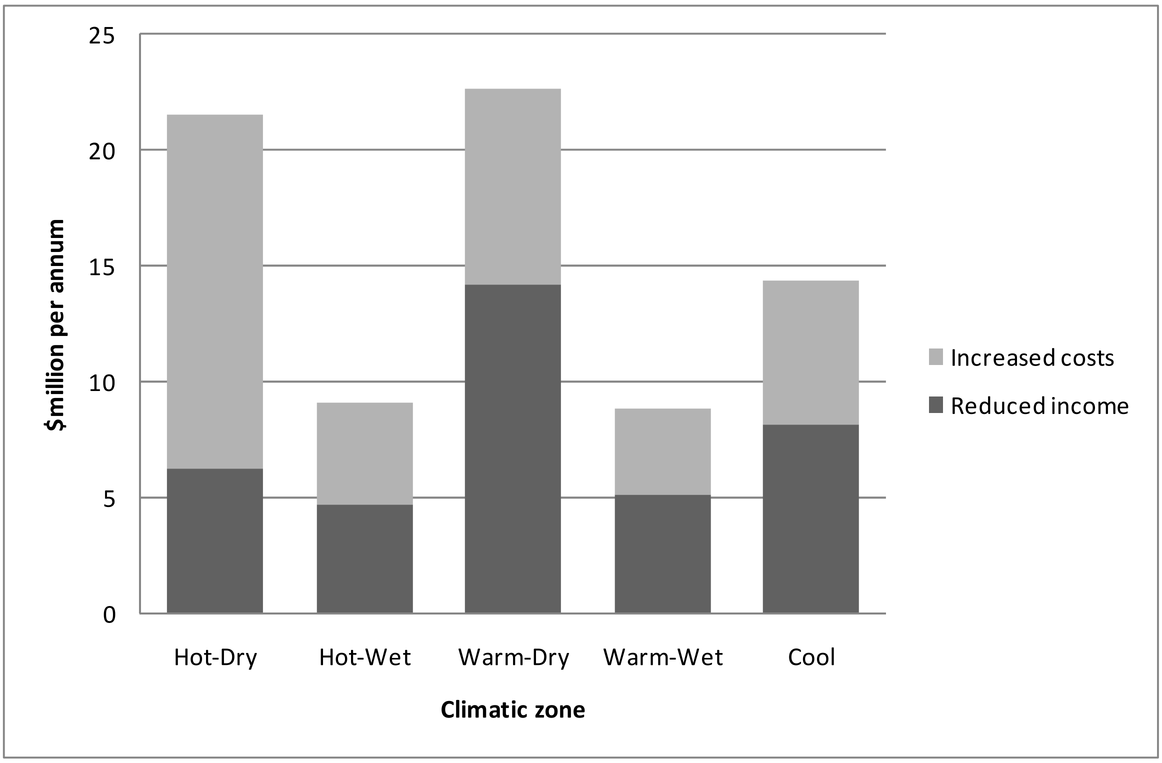
[a] Over a period of 15 years in constant 2009 dollars.
Source: EconSearch analysis.

Some of the key points to note from these results include the following.

The average industry-wide impact of Powdery Mildew in terms of reduced profit is greatest in the warm-dry climatic zone ($23m/annum), a function of the high vineyard-level impact and relatively large vineyard area in this zone. The impact in the hot-dry zone is also high as a consequence of the large vineyard area in this zone.

In aggregate, the income and cost effects contribute equally ($38m/annum each) to the industry-wide reduction in profit attributable to Powdery Mildew ($76m/annum) (Table 29).

Figure 4 : Average industry-wide economic impact of Powdery Mildew by climatic zone [a]



[a] Estimates are an annual average over a period of 15 years in constant 2009 dollars.
Source: EconSearch analysis.

5.4.2.2 Botrytis & Other Bunch Rots

Estimates of the vineyard-level impact on profit attributable to Botrytis and Other Bunch Rots are reported in Table 30 and Figure 5 by climatic zone. Some of the key points to note from these results include the following.

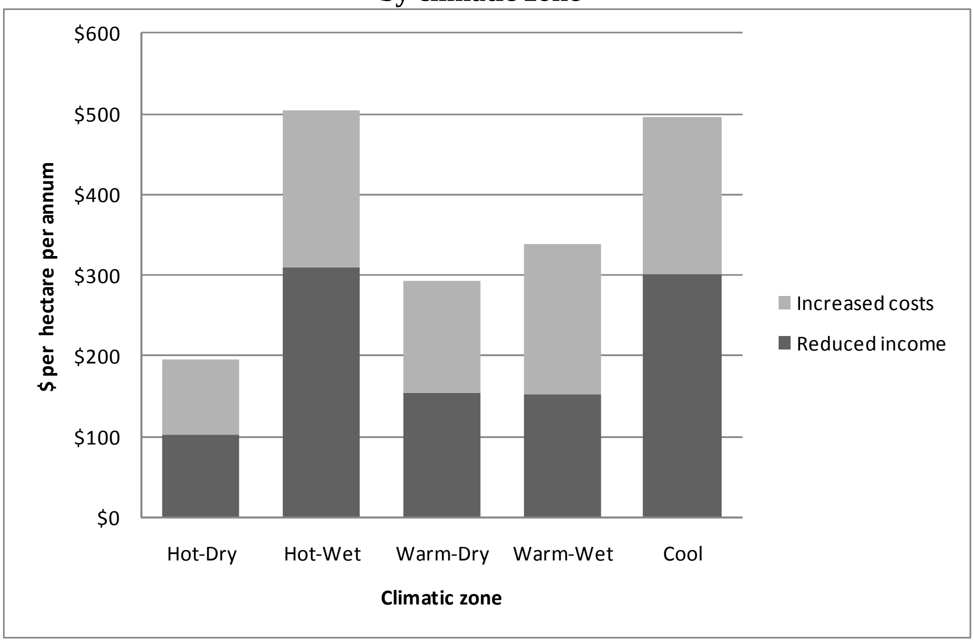
- There is significant variation in the average vineyard-level impact of Botrytis and Other Bunch Rots across zones, with estimates of reduced profit ranging from $196/ha/annum in the hot-dry climatic zone to $505/ha/annum in the hot-wet climatic zone (Table 30).
- The relatively low vineyard-level impact in the hot-dry zone is a function of a lower number of applications for an average preventative spray program and a relatively low frequency and yield loss associated with severe infestation of Botrytis and Other Bunch Rots in this zone (Table 12).
- As detailed in Table 12, the vineyard-level impact of Botrytis and Other Bunch Rots is comprised of the annual costs of a preventative spray program (i.e. the cost effect) and yield loss attributable to severe infestation (i.e. the income effect). The latter reflects the cost of a failed or inadequate preventative spray program.

Table 30 : Average vineyard-level economic impact of Botrytis & Other Bunch Rots by climatic zone

Climatic zone	Average vineyard-level impact [a]				
	Reduced income		Increased costs		Reduced profit
	$/ha/annum	% [b]	$/ha/annum	% [b]	$/ha/annum
Hot-Dry	$103	1.8%	$93	1.4%	$196
Hot-Wet	$309	6.6%	$196	2.7%	$505
Warm-Dry	$155	2.1%	$137	2.2%	$292
Warm-Wet	$153	2.3%	$187	2.6%	$339
Cool	$302	4.5%	$195	3.7%	$496

[a] Over a period of 15 years in constant 2009 dollars.
[b] Percentage difference from base case totals. The prevention and/or control of some winegrape pests/diseases is part of the normal management routine for most vineyards, thus total 'base case' costs do not necessarily represent normal operating conditions.
Source: EconSearch analysis.

Figure 5 : Average vineyard-level economic impact of Botrytis & Other Bunch Rots by climatic zone [a]



[a] Estimates are an annual average over a period of 15 years in constant 2009 dollars.
Source: EconSearch analysis.

- The income effect comprises over 50 per cent of the impact on profit in all zones (52 to 61 per cent of the total effect) except the warm-wet (45 per cent) (Figure 5).
- Estimates are provided in Table 30 of the relative impact of the income and costs effects, when compared with the base case (i.e. ‘without pest/disease’) models. Gross income (per ha per annum) with periodic severe infestation of Botrytis and Other Bunch Rots is approximately 1.8 to 2.3 per cent less than the base case in the hot-dry, warm-dry and warm-wet zones. The average reduction in income in the cool and hot-wet zones is somewhat higher, in relative terms, at approximately 4.5 and 6.6 per cent of ‘base case’ level, respectively. The costs of Botrytis and Other Bunch Rot prevention were estimated to add 1.4 to 3.7 per cent to total base case costs, the former estimate in hot-dry zones.

The average industry-wide economic impact of Botrytis and Other Bunch Rots by climatic zone was calculated by applying estimates of the area of winegrapes by zone in Australia in 2008 (Section 5.3) to the vineyard-level estimates of economic impact. These national data are presented below in Table 31 and Figure 6.

Table 31 : Average industry-wide economic impact of Botrytis & Other Bunch Rots by climatic zone

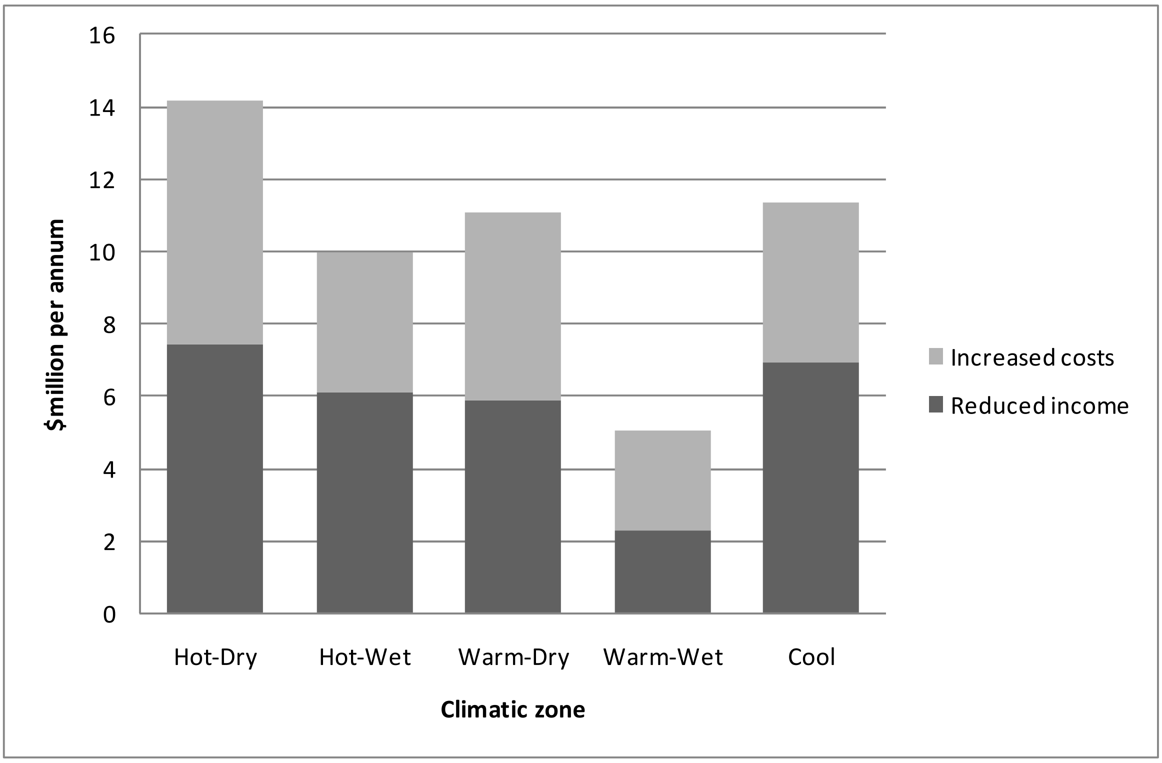
Climatic zone	Average industry-wide impact ($m/annum) [a]		
	Reduced income	Increased costs	Reduced profit
Hot-Dry	7	7	14
Hot-Wet	6	4	10
Warm-Dry	6	5	11
Warm-Wet	2	3	5
Cool	7	4	11
All zones	29	23	52

[a] Over a period of 15 years in constant 2009 dollars.
Source: EconSearch analysis.

Some of the key points to note from these results include the following.

- Despite having a relatively low vineyard-level impact, the average industry-wide impact of Botrytis and Other Bunch Rots in terms of reduced profit is greatest in the hot-dry zone ($14m/annum). The large total impact is due to the large vineyard area in this zone.
- In aggregate, the income effect ($29m/annum) represents approximately 55 per cent of the industry-wide reduction in profit attributable to Botrytis and Other Bunch Rots ($52m/annum) (Table 31).

Figure 6 : Average industry-wide economic impact of Botrytis & Other Bunch Rots by climatic zone [a]



[a] Estimates are an annual average over a period of 15 years in constant 2009 dollars.
Source: EconSearch analysis.

5.4.2.3 Downy Mildew

Estimates of the vineyard-level impact on profit attributable to Downy Mildew are reported in Table 32 and Figure 7 by climatic zone. Some of the key points to note from these results include the following.

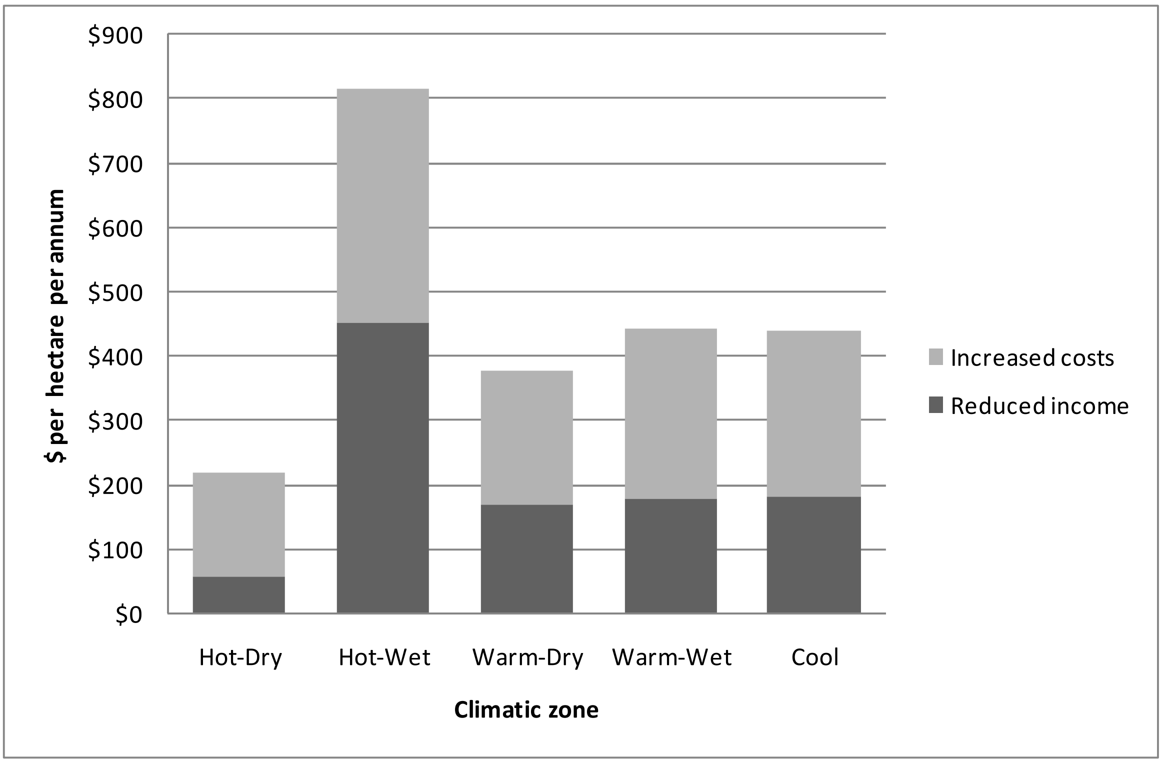
- The average vineyard-level impact of Downy Mildew in terms of reduced profit is very similar in the warm-dry, warm-wet and cool zones ($377 to $439/ha/annum). The impact in these zones is somewhat higher than that in the hot-dry zone ($218) but significantly less than that in hot-wet zone ($814) (Table 32).
- As detailed in Table 13, the vineyard-level impact of Downy Mildew is comprised of the annual costs of a preventative spray program, the costs of an eradicant spray program where infestation occurs or is threatened (in aggregate, the cost effect) and yield loss attributable to severe infestation (i.e. the income effect). The latter reflects the cost of failed or inadequate preventative and eradicant spray programs.
- The relatively high vineyard-level impact in the hot-wet zone is principally a function of the high frequency and yield loss associated with severe infestation of Downy Mildew in this zone (Table 13). The primary contributor to reduced profit at the vineyard level in this zone is, therefore, the income effect (55 per cent of the total) (Figure 7).

Table 32 : Average vineyard-level economic impact of Downy Mildew by climatic zone

Climatic zone	Average vineyard-level impact [a]				
	Reduced income		Increased costs		Reduced profit
	$/ha/annum	% [b]	$/ha/annum	% [b]	$/ha/annum
Hot-Dry	$58	1.0%	$160	2.3%	$218
Hot-Wet	$451	9.6%	$364	5.0%	$814
Warm-Dry	$168	2.3%	$209	3.4%	$377
Warm-Wet	$178	2.7%	$265	3.7%	$443
Cool	$182	2.7%	$257	4.8%	$439

[a] Over a period of 15 years in constant 2009 dollars.
[b] Percentage difference from base case totals. The prevention and/or control of some winegrape pests/diseases is part of the normal management routine for most vineyards, thus total 'base case' costs do not necessarily represent normal operating conditions.
Source: EconSearch analysis.

Figure 7 : Average vineyard-level economic impact of Downy Mildew by climatic zone [a]



[a] Estimates are an annual average over a period of 15 years in constant 2009 dollars.
Source: EconSearch analysis.

- Cost effects comprise a larger proportion (i.e. 55 to 73 per cent) of the reduction in profit in the hot-dry, warm-dry, warm-wet and cool zones (Figure 7).
- Estimates are provided in Table 32 of the relative impact of the income and costs effects, when compared with the base case (i.e. 'without pest/disease') models. Gross income (per ha per annum) with periodic severe infestation of Downy Mildew is approximately 1.0 to 2.7 per cent less than the base case in the hot-dry, warm-dry, warm-wet and cool zones. The average reduction in income in the hot-wet zone is much higher, in relative terms, at approximately 9.6 per cent of 'base case' level. The costs of Downy Mildew prevention and eradication were estimated to add 2.3 to 5.0 per cent to total base case costs.

The average industry-wide economic impact of Downy Mildew by climatic zone was calculated by applying estimates of the area of winegrapes by zone in Australia in 2008 (Section 5.3) to the vineyard-level estimates of economic impact. These national data are presented below in Table 33 and Figure 8.

Table 33 : Average industry-wide economic impact of Downy Mildew by climatic zone

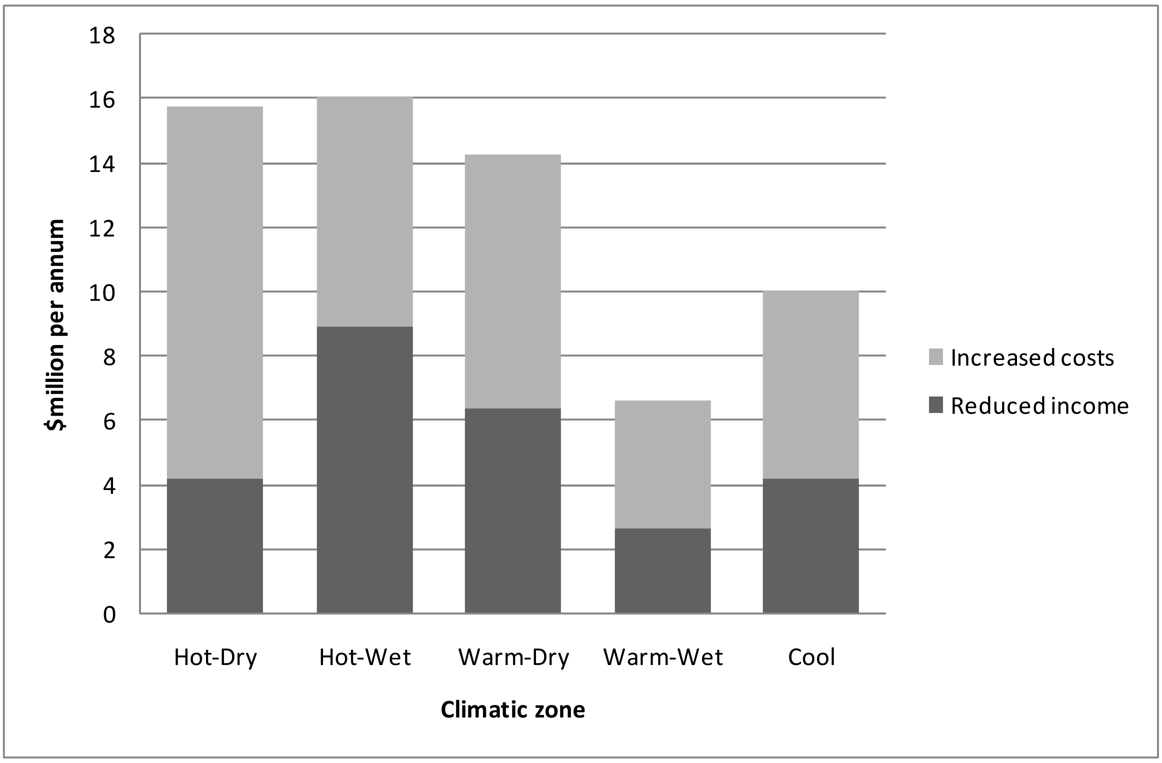
Climatic zone	Average industry-wide impact ($m/annum) [a]		
	Reduced income	Increased costs	Reduced profit
Hot-Dry	4	12	16
Hot-Wet	9	7	16
Warm-Dry	6	8	14
Warm-Wet	3	4	7
Cool	4	6	10
All zones	26	36	63

[a] Over a period of 15 years in constant 2009 dollars.
Source: EconSearch analysis.

Some of the key points to note from these results include the following.

- The average industry-wide impact of Downy Mildew in terms of reduced profit is greatest in the hot-dry and hot-wet zones ($16m/annum), despite the former zone having a relatively low vineyard-level impact when compared with other zones. The impact is also high in the warm-dry zone.
- In aggregate, the cost effect ($36m/annum) represents approximately 58 per cent of the industry-wide reduction in profit attributable to Downy Mildew ($63m/annum) (Table 33).

Figure 8 : Average industry-wide economic impact of Downy Mildew by climatic zone [a]



[a] Estimates are an annual average over a period of 15 years in constant 2009 dollars.
Source: EconSearch analysis.

5.4.2.4 Light Brown Apple Moth

Estimates of the vineyard-level impact on profit attributable to LBAM are reported in Table 34 and Figure 9 by climatic zone. Some of the key points to note from these results include the following.

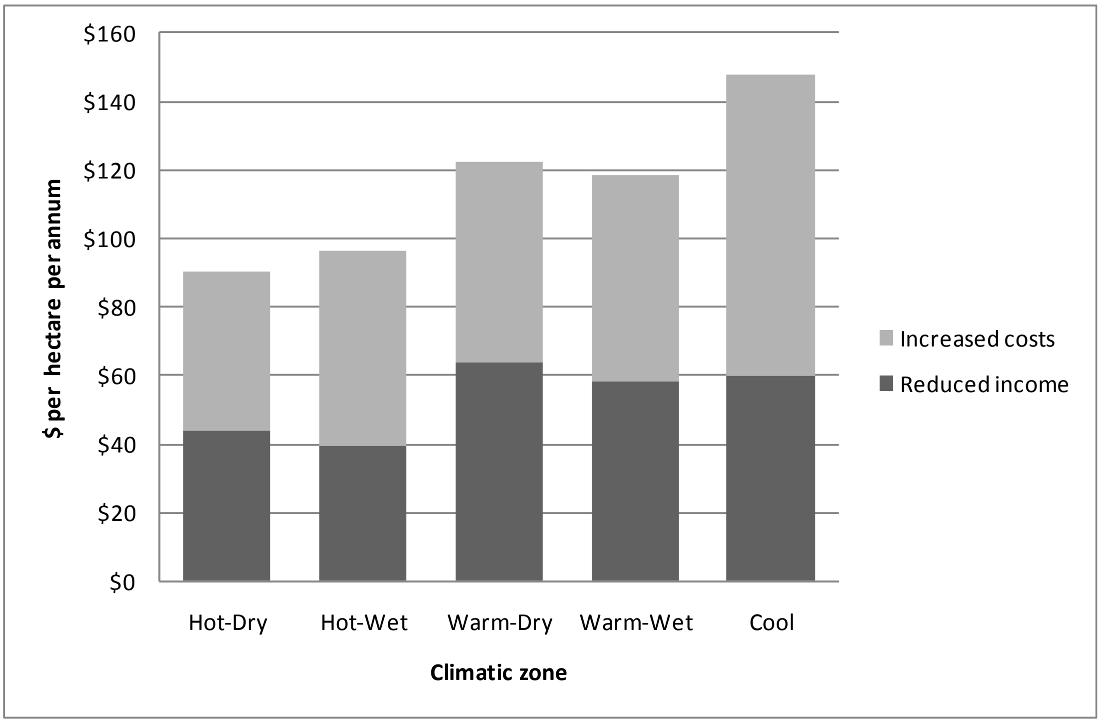
- The average vineyard-level impact of LBAM in terms of reduced profit ranges from $90/ha/annum in the hot-dry zone to $148/ha/annum in the cool zone (Table 34).
- As detailed in Table 14, the vineyard-level impact of LBAM is comprised of the annual costs of a preventative spray program (i.e. the cost effect) and yield loss attributable to severe infestation (i.e. the income effect). The latter reflects the cost of a failed or inadequate preventative spray program.
- Cost effects comprise a higher proportion of the total reduction in profit in all zones (51 to 60 per cent of the total effect) except the warm-dry (48 per cent) (Figure 9).

Table 34 : Average vineyard-level economic impact of Light Brown Apple Moth by climatic zone

Climatic zone	Average vineyard-level impact [a]				
	Reduced income		Increased costs		Reduced profit
	$/ha/annum	% [b]	$/ha/annum	% [b]	$/ha/annum
Hot-Dry	$44	0.8%	$47	0.7%	$90
Hot-Wet	$39	0.8%	$57	0.8%	$97
Warm-Dry	$64	0.9%	$58	1.0%	$122
Warm-Wet	$58	0.9%	$60	0.9%	$119
Cool	$60	0.9%	$88	1.7%	$148

a Over a period of 15 years in constant 2009 dollars.
b Percentage difference from base case totals. The prevention and/or control of some winegrape pests/diseases is part of the normal management routine for most vineyards, thus total 'base case' costs do not necessarily represent normal operating conditions.
Source: EconSearch analysis.

Figure 9 : Average vineyard-level economic impact of Light Brown Apple Moth by climatic zone[a]



a Estimates are an annual average over a period of 15 years in constant 2009 dollars.
Source: EconSearch analysis.

Estimates are provided in Table 34 of the relative impact of the income and costs effects, when compared with the base case (i.e. 'without pest/disease') models. Reductions in gross income (per ha per annum) with periodic severe infestation of LBAM range from approximately 0.8% to 0.9% from the 'base case' level. The costs of LBAM prevention were estimated to add 0.7% to 1.7% to total base case costs.

The average industry-wide economic impact of LBAM by climatic zone was calculated by applying estimates of the area of winegrapes by zone in Australia in 2008 (Section 5.3) to the vineyard-level estimates of economic impact. These national data are presented in Table 35 and Figure 10.

Table 35 : Average industry-wide economic impact of Light Brown Apple Moth by climatic zone

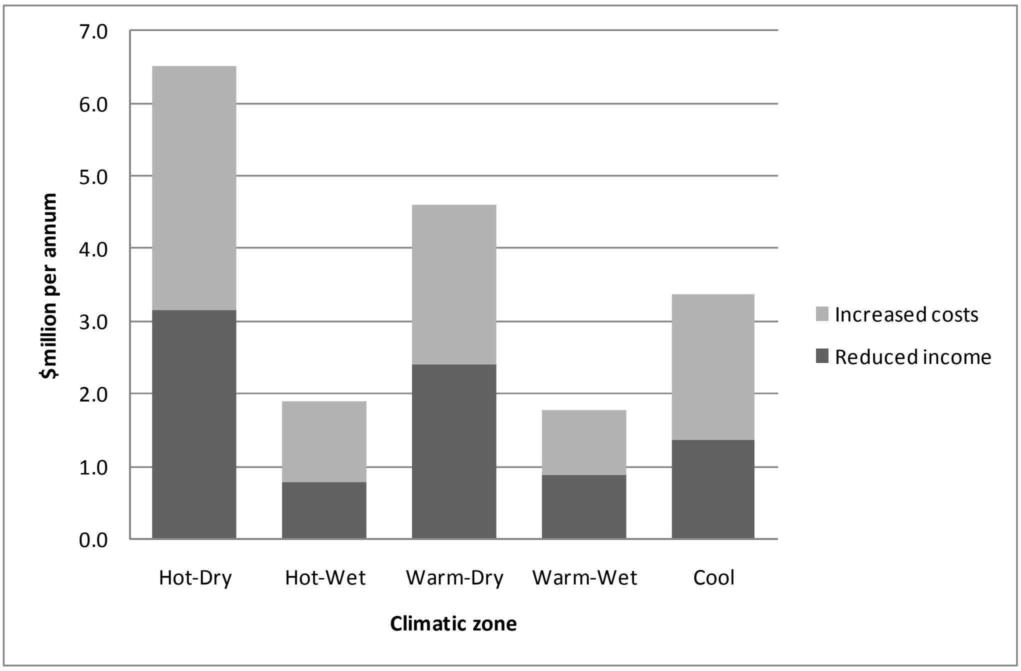
Climatic zone	Average industry-wide impact ($m/annum) [a]		
	Reduced income	Increased costs	Reduced profit
Hot-Dry	3.2	3.4	6.5
Hot-Wet	0.8	1.1	1.9
Warm-Dry	2.4	2.2	4.6
Warm-Wet	0.9	0.9	1.8
Cool	1.4	2.0	3.4
All zones	8.6	9.6	18.2

[a] Over a period of 15 years in constant 2009 dollars.
Source: EconSearch analysis.

Some of the key points to note from these results include the following.

- The average industry-wide impact of LBAM in terms of reduced profit is greatest in the hot-dry zone ($6.5m/annum), despite having a relatively low vineyard-level impact when compared with other zones.
- In aggregate, the cost effect ($9.6m/annum) represents approximately 53 per cent of the industry-wide reduction in profit attributable to LBAM ($18.2m/annum) (Table 34).

Figure 10 : Average industry-wide economic impact of Light Brown Apple Moth by climatic zone [a]



[a] Estimates are an annual average over a period of 15 years in constant 2009 dollars.
Source: EconSearch analysis.

5.4.2.5 Garden Weevil

Estimates of the vineyard-level impact on profit attributable to Garden Weevil are reported in Table 36 and Figure 11 by climatic zone. Some of the key points to note from these results include the following.

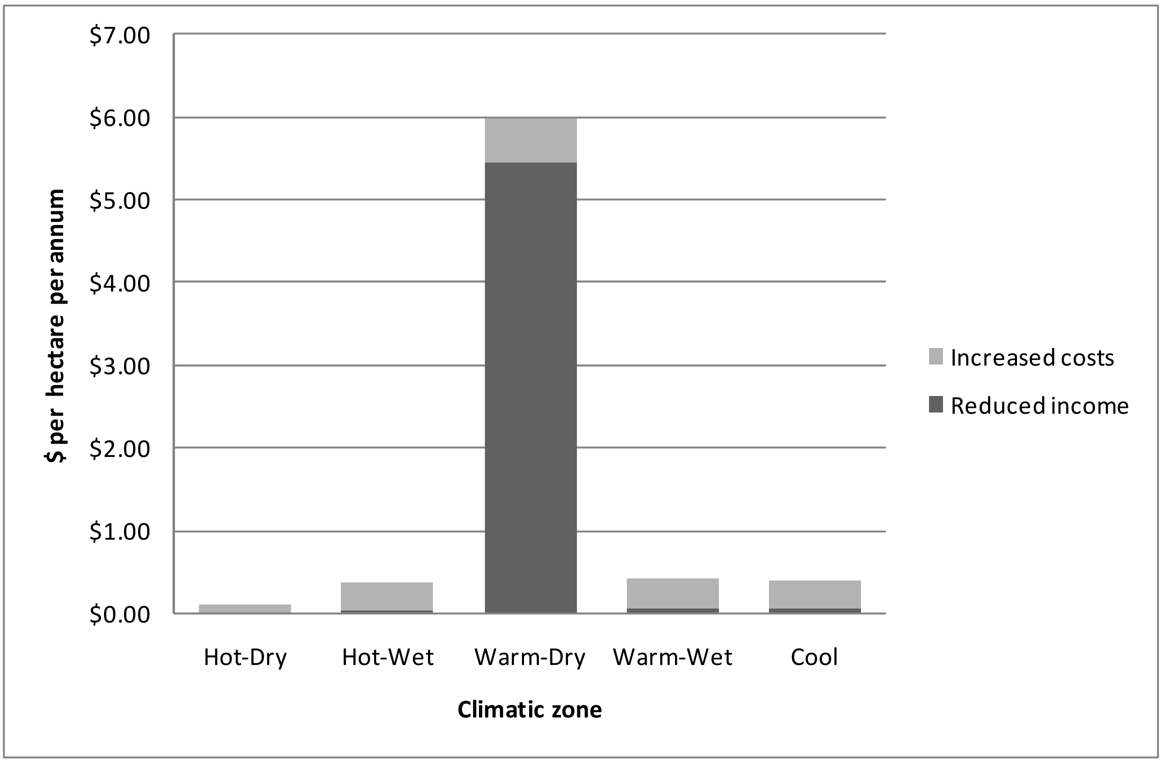
- Garden Weevil has a very low impact even in the Warm Dry climatic zone.
- The average vineyard-level impact of Garden Weevil in terms of reduced profit is very similar in the hot-wet, warm-wet and cool zones ($0.36 to $0.41/ha/annum). The impact in these zones is somewhat higher than that in the hot-dry zone ($0.11) but significantly less than that in warm-dry zone ($5.98) (Table 36).
- As detailed in Table 15 the vineyard-level impact of Garden Weevil is comprised of the annual costs of an eradicant spray program (i.e. the cost effect) and yield loss attributable to infestation (i.e. the income effect). The latter refers to damage in untreated vineyards and may also reflect the cost of failed or inadequate eradicant spray programs.
- The relatively high vineyard-level impact in the warm-dry zone is principally a function of the higher frequency, incidence and yield loss associated with infestation of Garden Weevil in this zone. The primary contributor to reduced profit at the vineyard level in this zone is, therefore, the income effect (91 per cent of the total) (Figure 11).

Table 36 : Average vineyard-level economic impact of Garden Weevil by climatic zone

Climatic zone	Average vineyard-level impact [a]				
	Reduced income		Increased costs		Reduced profit
	$/ha/annum	% [b]	$/ha/annum	% [b]	$/ha/annum
Hot-Dry	$0.00	0.000%	$0.11	0.002%	$0.11
Hot-Wet	$0.04	0.001%	$0.32	0.004%	$0.36
Warm-Dry	$5.44	0.075%	$0.53	0.009%	$5.98
Warm-Wet	$0.06	0.001%	$0.35	0.005%	$0.41
Cool	$0.06	0.001%	$0.33	0.006%	$0.39

a Over a period of 15 years in constant 2009 dollars.
b Percentage difference from base case totals. The prevention and/or control of some winegrape pests/diseases is part of the normal management routine for most vineyards, thus total 'base case' costs do not necessarily represent normal operating conditions.
Source: EconSearch analysis.

Figure 11 : Average vineyard-level economic impact of Garden Weevil by climatic zone[a]



a Estimates are an annual average over a period of 15 years in constant 2009 dollars.
Source: EconSearch analysis.

- Cost effects comprise a larger proportion (i.e. 85 to 96 per cent) of the reduction in profit in the hot-dry, hot-wet, warm-wet and cool zones (Figure 11).
- Estimates are provided in Table 36 of the relative impact of the income and costs effects, when compared with the base case (i.e. 'without pest/disease') models. Whilst the average vineyard-level impact of Garden Weevil across all zones is very low, this average masks the fact that the impact on individual vineyards or pockets of vines within a vineyard may be much higher.

The average industry-wide economic impact of Garden Weevil by climatic zone was calculated by applying estimates of the area of winegrapes by zone in Australia in 2008 (Section 5.3) to the vineyard-level estimates of economic impact. These national data are presented in Table 37 and Figure 12.

Table 37 : Average industry-wide economic impact of Garden Weevil by climatic zone

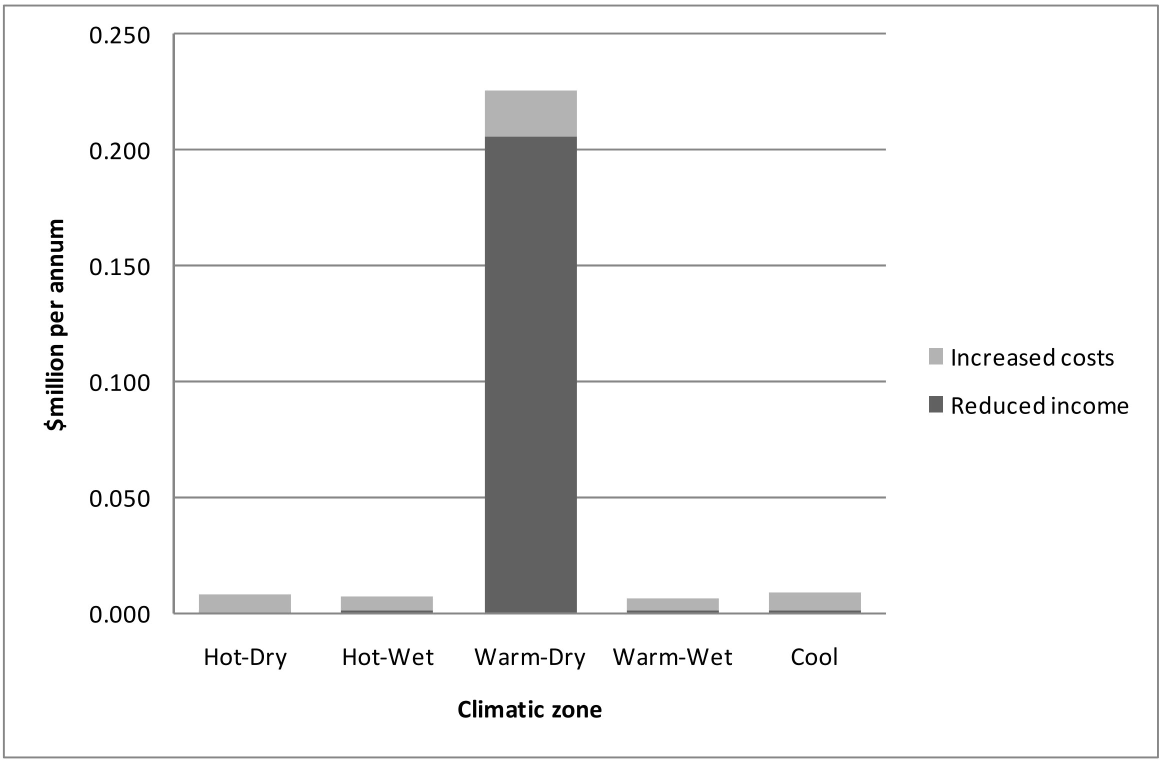
Climatic zone	Average industry-wide impact ($m/annum) [a]		
	Reduced income	Increased costs	Reduced profit
Hot-Dry	0.000	0.008	0.008
Hot-Wet	0.001	0.006	0.007
Warm-Dry	0.206	0.020	0.226
Warm-Wet	0.001	0.005	0.006
Cool	0.001	0.008	0.009
All zones	0.209	0.047	0.256

a Over a period of 15 years in constant 2009 dollars.
Source: EconSearch analysis.

Some of the key points to note from these results include the following:

- The average industry-wide impact of Garden Weevil in terms of reduced profit is greatest in the warm-dry zone ($0.226m/annum), reflecting the high vineyard-level impact when compared with other zones.
- In aggregate, the income effect ($0.209m/annum) represents approximately 82 per cent of the industry-wide reduction in profit attributable to Garden Weevil ($0.256m/annum) (Table 37).

Figure 12 : Average industry-wide economic impact of Garden Weevil by climatic zone[a]



[a] Estimates are an annual average over a period of 15 years in constant 2009 dollars.
Source: EconSearch analysis.

5.4.2.6 Trunk Boring Insects

Estimates of the vineyard-level impact on profit attributable to Trunk Boring Insects are reported in Table 38 and Figure 13 by climatic zone. Some of the key points to note from these results include the following.

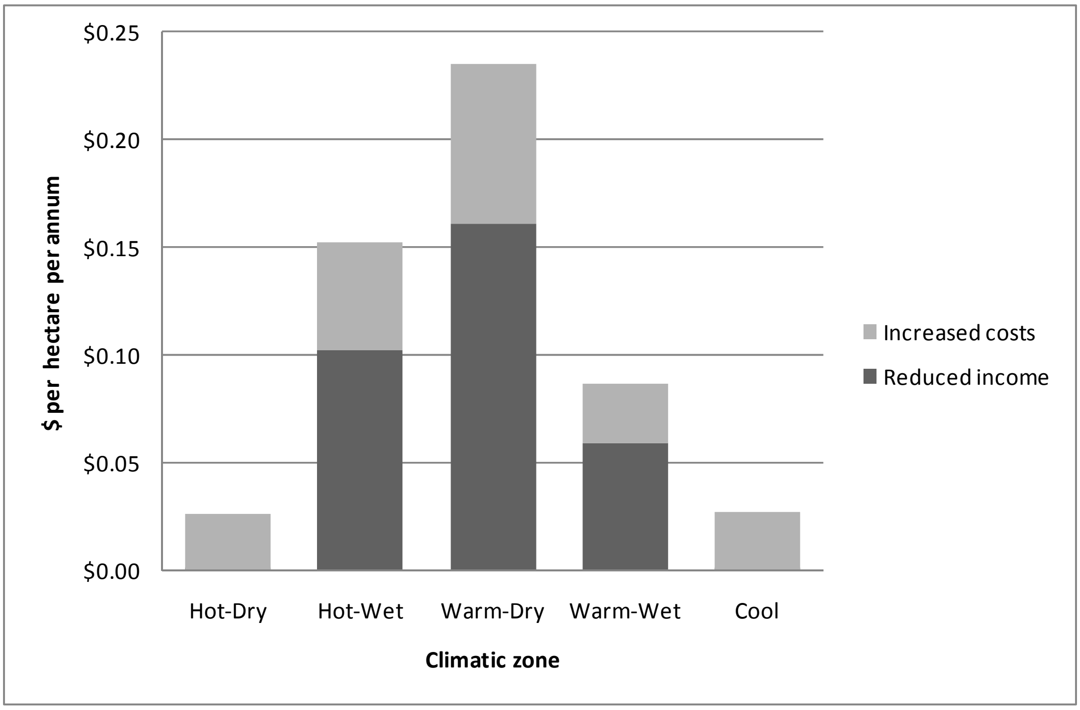
- The impact of trunk boring insects is low.
- The average vineyard-level impact of Trunk Boring Insects in terms of reduced profit ranges from $0.026/ha/annum in the hot-dry zone to $0.235/ha/annum in the warm-dry zone (Table 38).
- As detailed in Table 16, the vineyard-level impact of Trunk Boring Insects is comprised of the annual costs of an eradicant spray program (i.e. the cost effect) and yield loss attributable to infestation (i.e. the income effect). The latter refers to damage in untreated vineyards and may also reflect the cost of failed or inadequate eradicant spray programs.
- The relatively high vineyard-level impact in the hot-wet and warm-dry zones is principally a function of the higher frequency and yield loss associated with infestation of Trunk Boring Insects in these zones (Table 16). The primary contributor to reduced profit at the vineyard level in these zones is, therefore, the income effect (67 to 68 per cent of the total) (Table 38).

Table 38 : Average vineyard-level economic impact of Trunk Boring Insects by climatic zone

Climatic zone	Average vineyard-level impact [a]				
	Reduced income		Increased costs		Reduced profit
	$/ha/annum	% [b]	$/ha/annum	% [b]	$/ha/annum
Hot-Dry	$0.000	0.000%	$0.026	0.000%	$0.026
Hot-Wet	$0.102	0.002%	$0.050	0.001%	$0.152
Warm-Dry	$0.161	0.002%	$0.075	0.001%	$0.235
Warm-Wet	$0.059	0.001%	$0.027	0.000%	$0.086
Cool	$0.001	0.000%	$0.027	0.001%	$0.027

a Over a period of 15 years in constant 2009 dollars.
b Percentage difference from base case totals. The prevention and/or control of some winegrape pests/diseases is part of the normal management routine for most vineyards, thus total 'base case' costs do not necessarily represent normal operating conditions.
Source: EconSearch analysis.

Figure 13 : Average vineyard-level economic impact of Trunk Boring Insects by climatic zone[a]



a Estimates are an annual average over a period of 15 years in constant 2009 dollars.
Source: EconSearch analysis.

- Cost effects comprise a larger proportion (i.e. 98 per cent) of the reduction in profit in the hot-dry and cool zones (Figure 13).
- Estimates are provided in Table 38 of the relative impact of the income and costs effects, when compared with the base case (i.e. 'without pest/disease') models. Whilst the average vineyard-level impact of Trunk Boring Insects across all zones is very low, this average masks the fact that the impact on individual vineyards or pockets of vines within a vineyard may be much higher.

The average industry-wide economic impact of Trunk Boring Insects by climatic zone was calculated by applying estimates of the area of winegrapes by zone in Australia in 2008 (Section 5.3) to the vineyard-level estimates of economic impact. These national data are presented in Table 39 and Figure 14.

Table 39 : Average industry-wide economic impact of Trunk Boring Insects by climatic zone

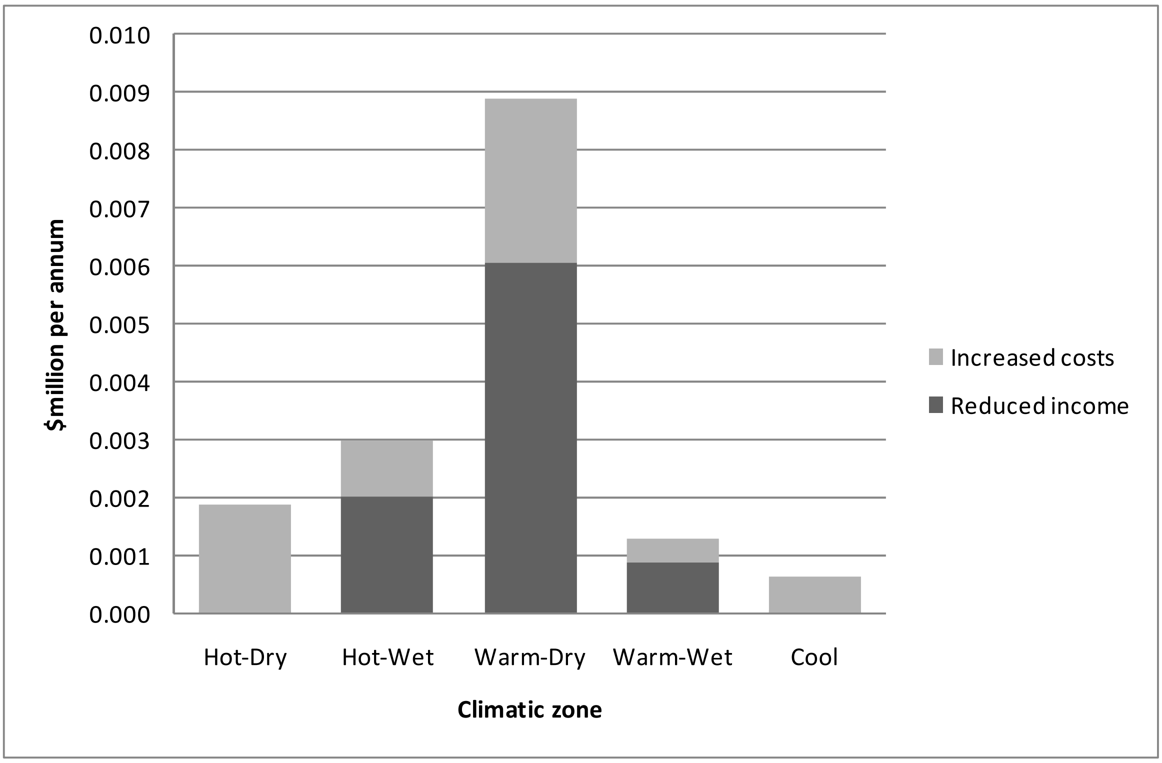
Climatic zone	Average industry-wide impact ($m/annum) [a]		
	Reduced income	Increased costs	Reduced profit
Hot-Dry	0.000	0.002	0.002
Hot-Wet	0.002	0.001	0.003
Warm-Dry	0.006	0.003	0.009
Warm-Wet	0.001	0.000	0.001
Cool	0.000	0.001	0.001
All zones	0.009	0.007	0.016

[a] Over a period of 15 years in constant 2009 dollars.
Source: EconSearch analysis.

Some of the key points to note from these results include the following.

- The average industry-wide impact of Trunk Boring Insects in terms of reduced profit is greatest in the warm-dry zone ($0.009m/annum), reflecting the high vineyard-level impact when compared with other zones.
- In aggregate, the income effect ($0.009m/annum) represents approximately 57 per cent of the industry-wide reduction in profit attributable to Trunk Boring Insects ($0.016m/annum) (Table 39).

Figure 14 : Average industry-wide economic impact of Trunk Boring Insects by climatic zone[a]



[a] Estimates are an annual average over a period of 15 years in constant 2009 dollars.
Source: EconSearch analysis.

5.4.2.7 Mealy bugs & Scale

Estimates of the vineyard-level impact on profit attributable to Mealy bugs and Scale are reported in Table 40 and Figure 15 by climatic zone. Some of the key points to note from these results include the following.

- The average vineyard-level impact of Mealy bugs and Scale in terms of reduced profit is quite similar in all zones ($0.36 to $0.53/ha/annum) (Table 40).
- As detailed in Table 17, the vineyard-level impact of Mealy bugs and Scale is comprised of the annual costs of an eradicant spray program (i.e. the cost effect) and yield loss attributable to infestation (i.e. the income effect). The latter refers to damage in untreated vineyards and may also reflect the cost of failed or inadequate eradicant spray programs.
- Income effects comprise a larger proportion of the reduction in profit in all zones (i.e. 83 to 90 per cent) (Figure 15).
- Estimates are provided in Table 40 of the relative impact of the income and costs effects, when compared with the base case (i.e. 'without pest/disease') models. Whilst the average vineyard-level impact of Mealy bugs and Scale across all zones is very low, this average masks the fact that the impact on individual vineyards or pockets of vines within a vineyard may be much higher.

Table 40 : Average vineyard-level economic impact of Mealy bugs & Scale by climatic zone

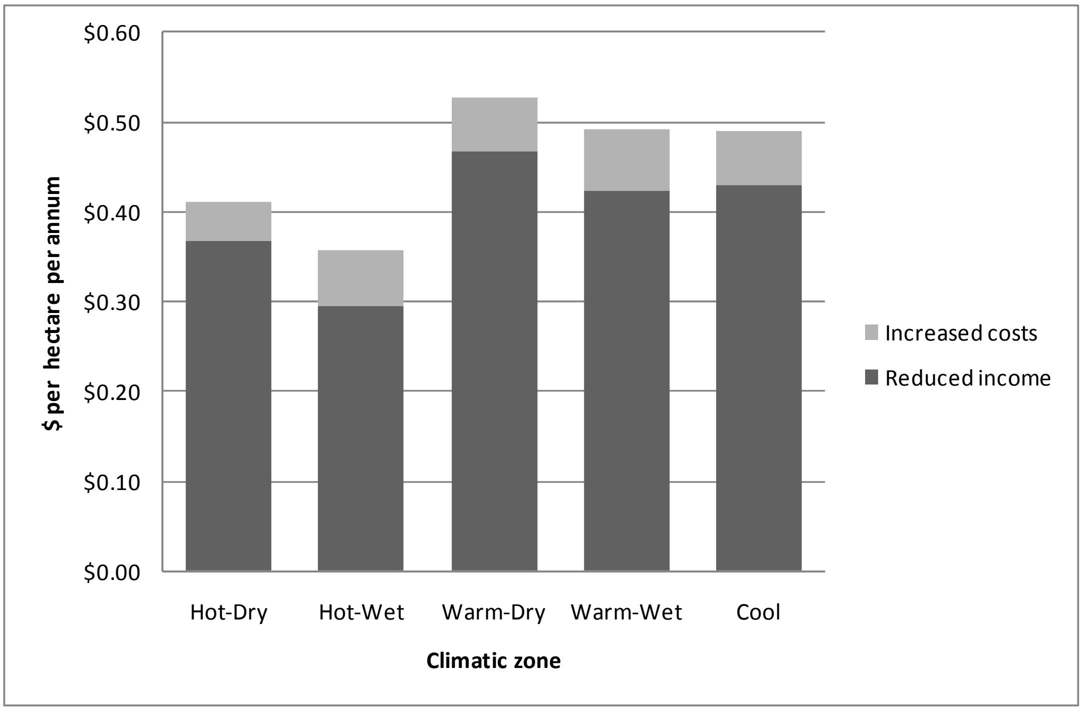
Climatic zone	Average vineyard-level impact [a]				
	Reduced income		Increased costs		Reduced profit
	$/ha/annum	% [b]	$/ha/annum	% [b]	$/ha/annum
Hot-Dry	$0.37	0.006%	$0.04	0.001%	$0.41
Hot-Wet	$0.30	0.006%	$0.06	0.001%	$0.36
Warm-Dry	$0.47	0.006%	$0.06	0.001%	$0.53
Warm-Wet	$0.42	0.006%	$0.07	0.001%	$0.49
Cool	$0.43	0.006%	$0.06	0.001%	$0.49

[a] Over a period of 15 years in constant 2009 dollars.

[b] Percentage difference from base case totals. The prevention and/or control of some winegrape pests/diseases is part of the normal management routine for most vineyards, thus total 'base case' costs do not necessarily represent normal operating conditions.

Source: EconSearch analysis.

Figure 15 : Average vineyard-level economic impact of Mealy bugs & Scale by climatic zone[a]



[a] Estimates are an annual average over a period of 15 years in constant 2009 dollars.
Source: EconSearch analysis.

The average industry-wide economic impact of Mealy bugs and Scale by climatic zone was calculated by applying estimates of the area of winegrapes by zone in Australia in 2008 (Section 5.3) to the vineyard-level estimates of economic impact. These national data are presented in Table 41 and Figure 16.

Table 41 : Average industry-wide economic impact of Mealy bugs and Scale by climatic zone

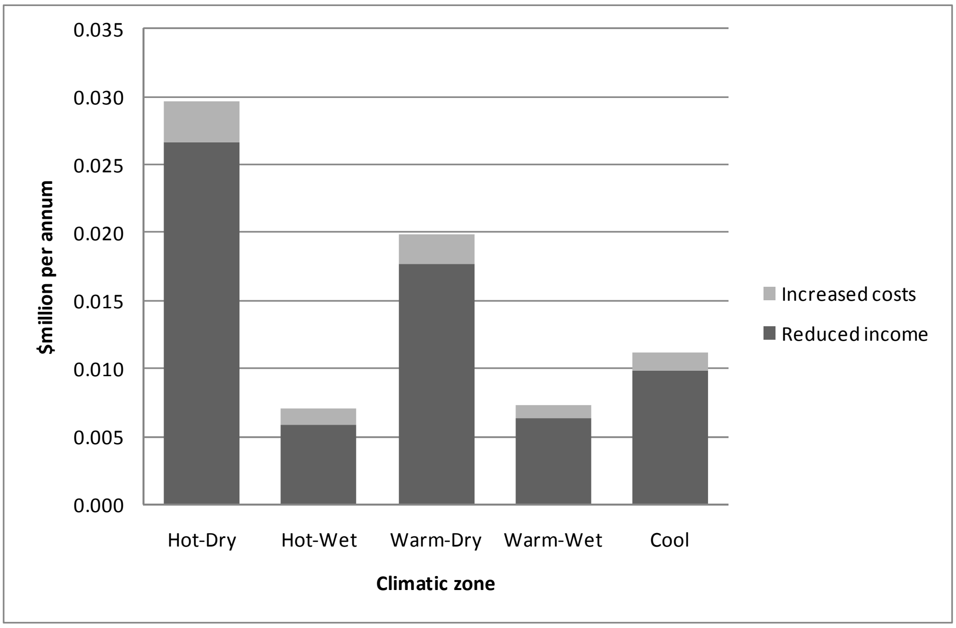
Climatic zone	Average industry-wide impact ($m/annum) [a]		
	Reduced income	Increased costs	Reduced profit
Hot-Dry	0.027	0.003	0.030
Hot-Wet	0.006	0.001	0.007
Warm-Dry	0.018	0.002	0.020
Warm-Wet	0.006	0.001	0.007
Cool	0.010	0.001	0.011
All zones	0.066	0.009	0.075

[a] Over a period of 15 years in constant 2009 dollars.
Source: EconSearch analysis.

Some of the key points to note from these results include the following.

- The average industry-wide impact of Mealy bugs and Scale in terms of reduced profit is greatest in the hot-dry and warm-dry zones, reflecting the large vineyard area when compared with other zones.
- In aggregate, the income effect ($0.066m/annum) represents approximately 88 per cent of the industry-wide reduction in profit attributable to Mealy bugs and Scale ($0.075m/annum) (Table 41).

Figure 16 : Average industry-wide economic impact of Mealy bugs & Scale by climatic zone[a]



[a] Estimates are an annual average over a period of 15 years in constant 2009 dollars.
Source: EconSearch analysis.

5.4.2.8 Trunk Diseases

Estimates of the vineyard-level impact on profit attributable to Trunk Diseases are reported in Table 42 and Figure 17 by climatic zone. Some of the key points to note from these results include the following.

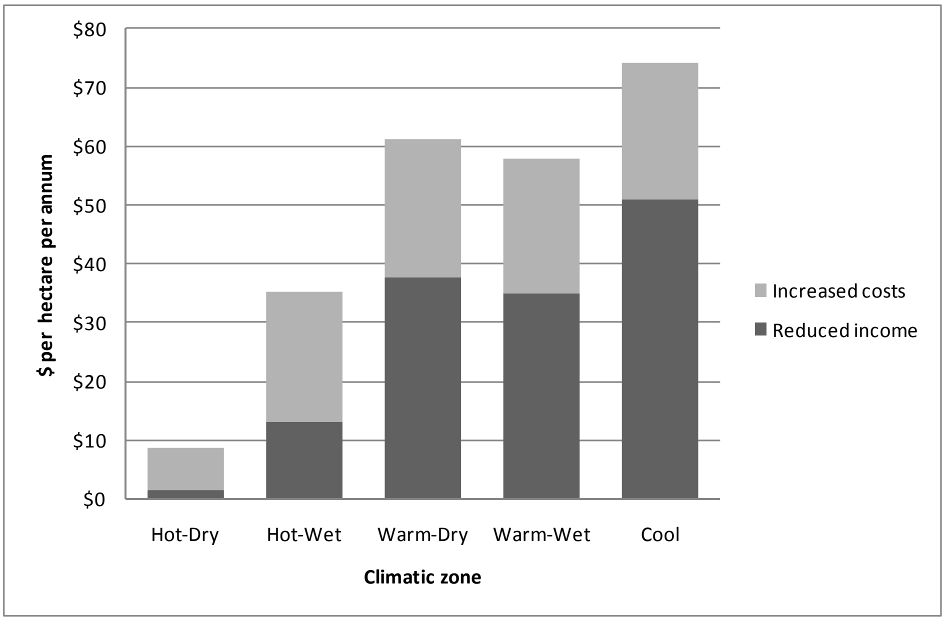
- The average vineyard-level impact of Trunk Diseases in terms of reduced profit is similar in the warm-dry, warm-wet and cool zones ($58 to $74/ha/annum). The impact in these zones is somewhat higher than that in the hot-wet zone ($35) and all are significantly higher than that in hot-dry zone ($9) (Table 42).
- As detailed in Table 18, the vineyard-level impact of Trunk Diseases is comprised of the costs of ad-hoc and remedial surgery (in aggregate, the cost effect) and yield loss attributable to infestation (i.e. the income effect).
- The relatively high vineyard-level impact in the warm-dry, warm-wet and cool zones is principally a function of the high incidence and yield loss associated with infestation of Trunk Diseases in these zones (Table 18). The primary contributor to reduced profit at the vineyard level in these zones is, therefore, the income effect (60 to 69 per cent of the total) (Figure 17).

Table 42 : Average vineyard-level economic impact of Trunk Diseases by climatic zone

Climatic zone	Average vineyard-level impact [a]				
	Reduced income		Increased costs		Reduced profit
	$/ha/annum	% [b]	$/ha/annum	% [b]	$/ha/annum
Hot-Dry	$1.39	0.02%	$7.40	0.11%	$8.79
Hot-Wet	$13.04	0.28%	$22.03	0.30%	$35.07
Warm-Dry	$37.62	0.52%	$23.48	0.38%	$61.10
Warm-Wet	$35.01	0.53%	$22.95	0.32%	$57.96
Cool	$50.89	0.75%	$23.16	0.44%	$74.05

[a] Over a period of 15 years in constant 2009 dollars.
[b] Percentage difference from base case totals. The prevention and/or control of some winegrape pests/diseases is part of the normal management routine for most vineyards, thus total 'base case' costs do not necessarily represent normal operating conditions.
Source: EconSearch analysis.

Figure 17 : Average vineyard-level economic impact of Trunk Diseases by climatic zone[a]



a Estimates are an annual average over a period of 15 years in constant 2009 dollars.
Source: EconSearch analysis.

- Cost effects comprise a larger proportion of the reduction in profit in the hot-wet and hot-dry zones (i.e. 63 and 84 per cent, respectively) (Figure 17).
- Estimates are provided in Table 42 of the relative impact of the income and costs effects, when compared with the base case (i.e. 'without pest/disease') models. Gross income (per ha per annum) with periodic infestation of Trunk Diseases is approximately 0.28 to 0.75 per cent less than the base case in the hot-wet, warm-dry, warm-wet and cool zones. The average reduction in income in the hot-dry zone is much lower, in relative terms, at approximately 0.02 per cent of 'base case' level. The costs of Trunk Disease surgery were estimated to add 0.11 to 0.44 per cent to total base case costs.

The average industry-wide economic impact of Trunk Diseases by climatic zone was calculated by applying estimates of the area of winegrapes by zone in Australia in 2008 (Section 5.3) to the vineyard-level estimates of economic impact. These national data are presented in Table 43 and Figure 18.

Table 43 : Average industry-wide economic impact of Trunk Diseases by climatic zone

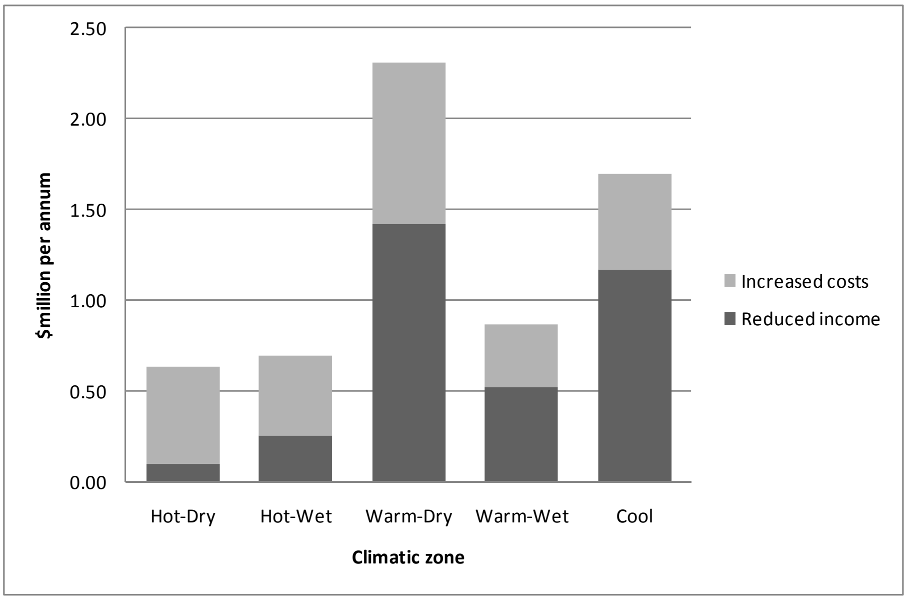
Climatic zone	Average industry-wide impact ($m/annum) [a]		
	Reduced income	Increased costs	Reduced profit
Hot-Dry	0.10	0.53	0.63
Hot-Wet	0.26	0.43	0.69
Warm-Dry	1.42	0.89	2.31
Warm-Wet	0.52	0.34	0.87
Cool	1.17	0.53	1.70
All zones	3.47	2.73	6.20

a Over a period of 15 years in constant 2009 dollars.
Source: EconSearch analysis.

Some of the key points to note from these results include the following.

- The average industry-wide impact of Trunk Diseases in terms of reduced profit is greatest in the warm-dry zone ($2.31m/annum), reflecting the high vineyard-level impact and relatively large vineyard area in this zone.
- In aggregate, the income effect ($3.47m/annum) represents approximately 56 per cent of the industry-wide reduction in profit attributable to Trunk Diseases ($6.20m/annum) (Table 43).

Figure 18 : Average industry-wide economic impact of Trunk Diseases by climatic zone[a]



[a] Estimates are an annual average over a period of 15 years in constant 2009 dollars.
Source: EconSearch analysis.

5.4.2.9 Root Rots

Estimates of the vineyard-level impact on profit attributable to Root Rots are reported in Table 44 and Figure 19 by climatic zone. Some of the key points to note from these results include the following.

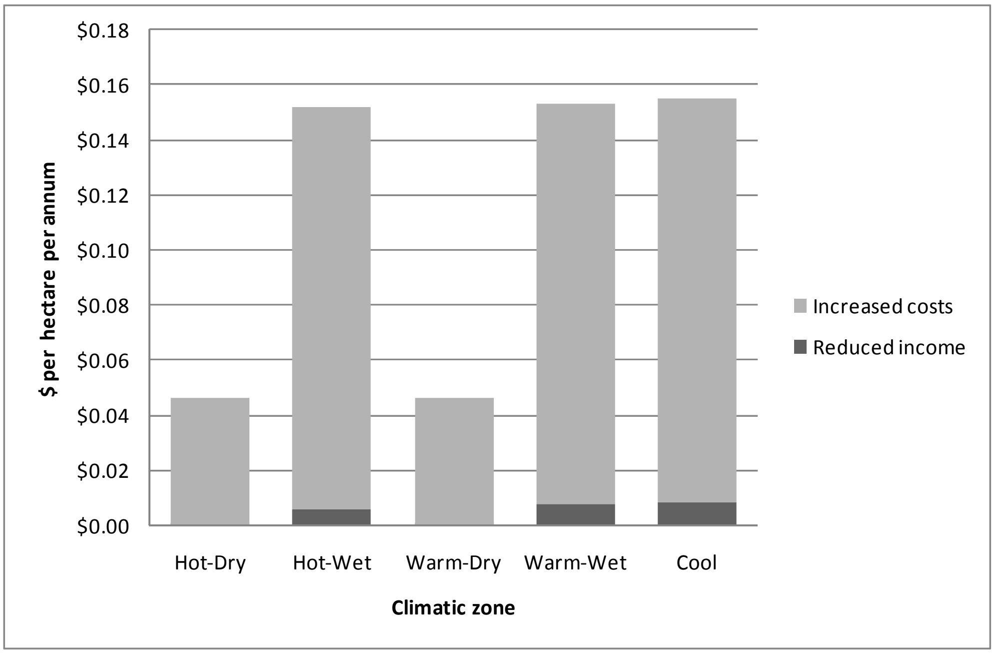
- The average vineyard-level impact of Root Rots in terms of reduced profit is low in all zones ($0.05 to $0.16/ha/annum) (Table 44).
- As detailed in Table 19, the vineyard-level impact of Root Rots is comprised of the cost of targeted replanting (i.e. the cost effect) and yield loss attributable to infestation (i.e. the income effect).
- Cost effects comprise a larger proportion of the reduction in profit in all zones (i.e. 95 to 99 per cent) (Figure 19).
- Estimates are provided in Table 44 of the relative impact of the income and costs effects, when compared with the base case (i.e. 'without pest/disease') models. Whilst the average vineyard-level impact of Root Rots across all zones is very low, this average masks the fact that the impact on individual vineyards or pockets of vines within a vineyard may be much higher.

Table 44 : Average vineyard-level economic impact of Root Rots by climatic zone

Climatic zone	Average vineyard-level impact [a]				
	Reduced income		Increased costs		Reduced profit
	$/ha/annum	% [b]	$/ha/annum	% [b]	$/ha/annum
Hot-Dry	$0.00	0.000%	$0.05	0.001%	$0.05
Hot-Wet	$0.01	0.000%	$0.15	0.002%	$0.15
Warm-Dry	$0.00	0.000%	$0.05	0.001%	$0.05
Warm-Wet	$0.01	0.000%	$0.15	0.002%	$0.15
Cool	$0.01	0.000%	$0.15	0.003%	$0.16

[a] Over a period of 15 years in constant 2009 dollars.
[b] Percentage difference from base case totals. The prevention and/or control of some winegrape pests/diseases is part of the normal management routine for most vineyards, thus total 'base case' costs do not necessarily represent normal operating conditions.
Source: EconSearch analysis.

Figure 19 : Average vineyard-level economic impact of Root Rots by climatic zone[a]



a Estimates are an annual average over a period of 15 years in constant 2009 dollars.
Source: EconSearch analysis.

The average industry-wide economic impact of Root Rots by climatic zone was calculated by applying estimates of the area of winegrapes by zone in Australia in 2008 (Section 5.3) to the vineyard-level estimates of economic impact. These national data are presented in Table 45 and Figure 20.

Table 45 : Average industry-wide economic impact of Root Rots by climatic zone

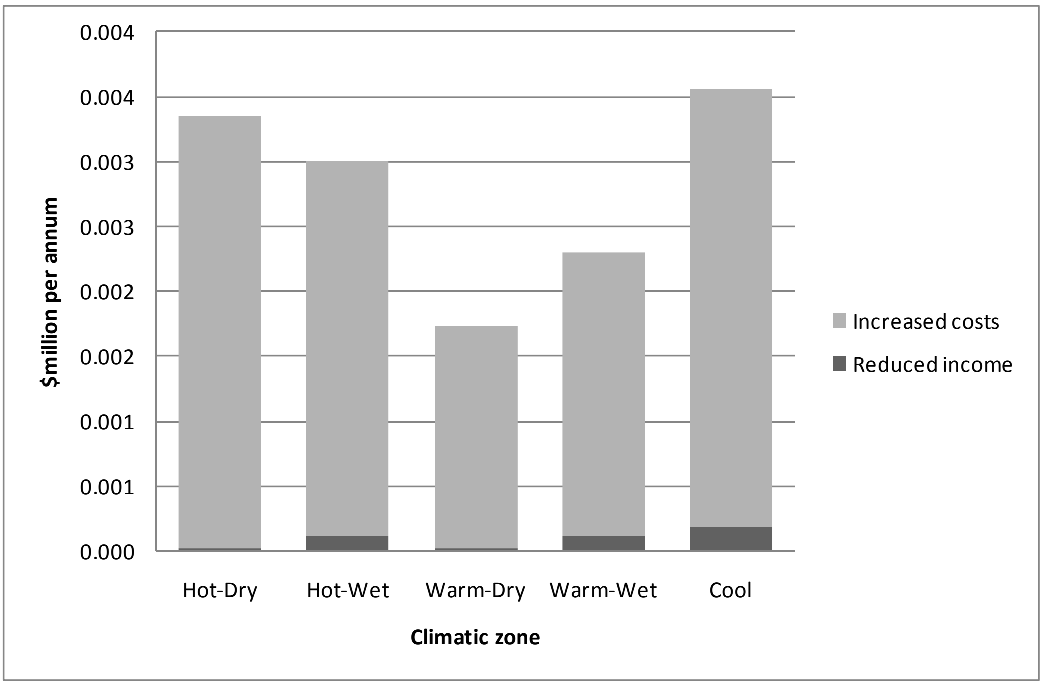
Climatic zone	Average industry-wide impact ($m/annum) [a]		
	Reduced income	Increased costs	Reduced profit
Hot-Dry	0.000	0.003	0.003
Hot-Wet	0.000	0.003	0.003
Warm-Dry	0.000	0.002	0.002
Warm-Wet	0.000	0.002	0.002
Cool	0.000	0.003	0.004
All zones	0.000	0.013	0.014

a Over a period of 15 years in constant 2009 dollars.
Source: EconSearch analysis.

Some of the key points to note from these results include the following.

- The average industry-wide impact of Root Rots in terms of reduced profit is low across all zones, reflecting the low vineyard-level impact.
- In aggregate, the income effect ($0.013m/annum) represents approximately 97 per cent of the industry-wide reduction in profit attributable to Root Rots ($0.014m/annum) (Table 45).

Figure 20 : Average industry-wide economic impact of Root Rots by climatic zone[a]



a Estimates are an annual average over a period of 15 years in constant 2009 dollars.
Source: EconSearch analysis.

5.4.2.10 Viruses & Transmissible Organisms

Estimates of the vineyard-level impact on profit attributable to Viruses and Transmissible Organisms are reported in Table 46 and Figure 21 by climatic zone. Some of the key points to note from these results include the following.

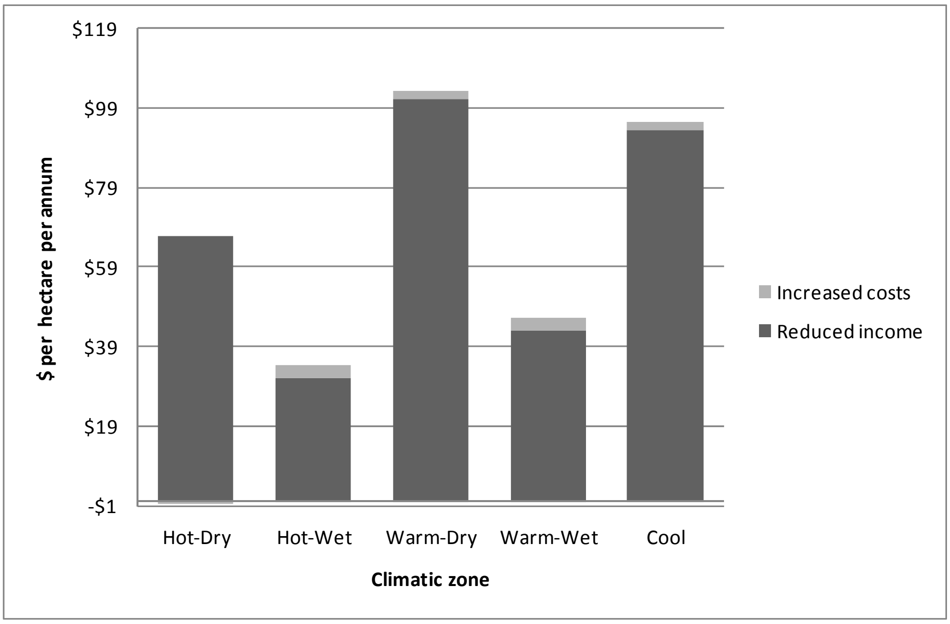
- The average vineyard-level impact of Viruses and Transmissible Organisms in terms of reduced profit ranges from $34/ha/annum in the hot wet zone to $103/ha/annum in the warm-dry zone (Table 46).
- As detailed in Table 20, the vineyard-level impact of Viruses and Transmissible Organisms is comprised of the costs associated with ensuring clean planting material used in new plantings (i.e. the cost effect) and yield loss attributable to infestation (i.e. the income effect).
- Income effects comprise a larger proportion of the reduction in profit in all zones (90 to 99 per cent) (Figure 21).

Table 46 : Average vineyard-level economic impact of Viruses & Transmissible Organisms by climatic zone

Climatic zone	Average vineyard-level impact [a]				
	Reduced income		Increased costs		Reduced profit
	$/ha/annum	% [b]	$/ha/annum	% [b]	$/ha/annum
Hot-Dry	$66.92	1.15%	-$0.18	0.00%	$66.73
Hot-Wet	$31.00	0.66%	$3.35	0.05%	$34.35
Warm-Dry	$101.15	1.40%	$2.04	0.03%	$103.20
Warm-Wet	$42.95	0.65%	$3.32	0.05%	$46.27
Cool	$93.46	1.38%	$2.19	0.04%	$95.65

a Over a period of 15 years in constant 2009 dollars.
b Percentage difference from base case totals. The prevention and/or control of some winegrape pests/diseases is part of the normal management routine for most vineyards, thus total 'base case' costs do not necessarily represent normal operating conditions.
Source: EconSearch analysis.

Figure 21 : Average vineyard-level economic impact of Viruses & Transmissible Organisms by climatic zone[a]



[a] Estimates are an annual average over a period of 15 years in constant 2009 dollars.
Source: EconSearch analysis.

- Estimates are provided in Table 46 of the relative impact of the income and costs effects, when compared with the base case (i.e. 'without pest/disease') models. Gross income (per ha per annum) with infestation of Viruses and Transmissible Organisms is approximately 0.7 to 1.4 per cent less than the base case in all zones. In most zones the costs associated with preventing Viruses and Transmissible Organisms were estimated to add approximately 0.03 to 0.05 per cent to total base case costs.
- In the hot-dry zone the cost of production with the disease(s) is less than the 'base case' cost of production (i.e. negative value in increased costs in Table 46 and Table 47). In other words, the reduced harvest and transport costs attributable to yield loss are greater than the annualised costs associated with ensuring clean planting material for new plantings.

The average industry-wide economic impact of Viruses and Transmissible Organisms by climatic zone was calculated by applying estimates of the area of winegrapes by zone in Australia in 2008 (Section 5.3) to the vineyard-level estimates of economic impact. These national data are presented in Table 47 and Figure 22.

Table 47 : Average industry-wide economic impact of Viruses & Transmissible Organisms by climatic zone

Climatic zone	Average industry-wide impact ($m/annum) [a]		
	Reduced income	Increased costs	Reduced profit
Hot-Dry	4.83	-0.01	4.82
Hot-Wet	0.61	0.07	0.68
Warm-Dry	3.82	0.08	3.90
Warm-Wet	0.64	0.05	0.69
Cool	2.14	0.05	2.19
All zones	12.05	0.23	12.28

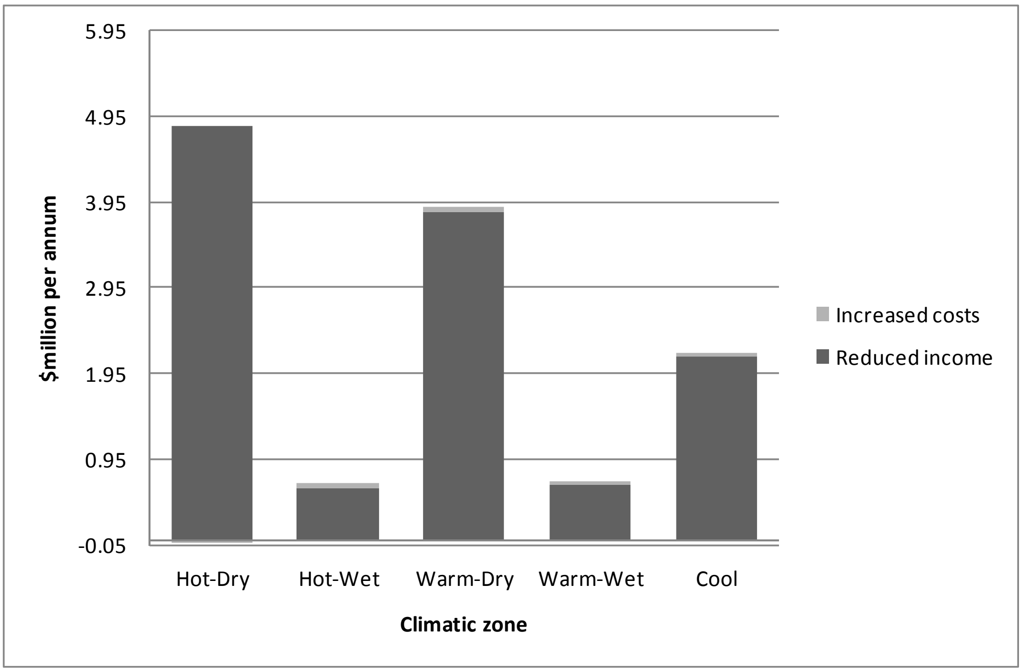
[a] Over a period of 15 years in constant 2009 dollars.
Source: EconSearch analysis.

Some of the key points to note from these results include the following.

- The average industry-wide impact of Viruses and Transmissible Organisms in terms of reduced profit is greatest in the hot-dry zone ($4.8m/annum), reflecting the large vineyard area in this zone.

- In aggregate, the income effect ($12.1m/annum) represents approximately 98 per cent of the industry-wide reduction in profit attributable to Viruses and Transmissible Organisms ($12.3m/annum) (Table 47).

Figure 22 : Average industry-wide economic impact of Viruses & Transmissible Organisms by climatic zone [a]



a Estimates are an annual average over a period of 15 years in constant 2009 dollars.
Source: EconSearch analysis.

5.4.2.11 Root-Knot & Other Nematodes

Estimates of the vineyard-level impact on profit attributable to Root-Knot and Other Nematodes are reported in Table 48 and Figure 23 by climatic zone. Some of the key points to note from these results include the following.

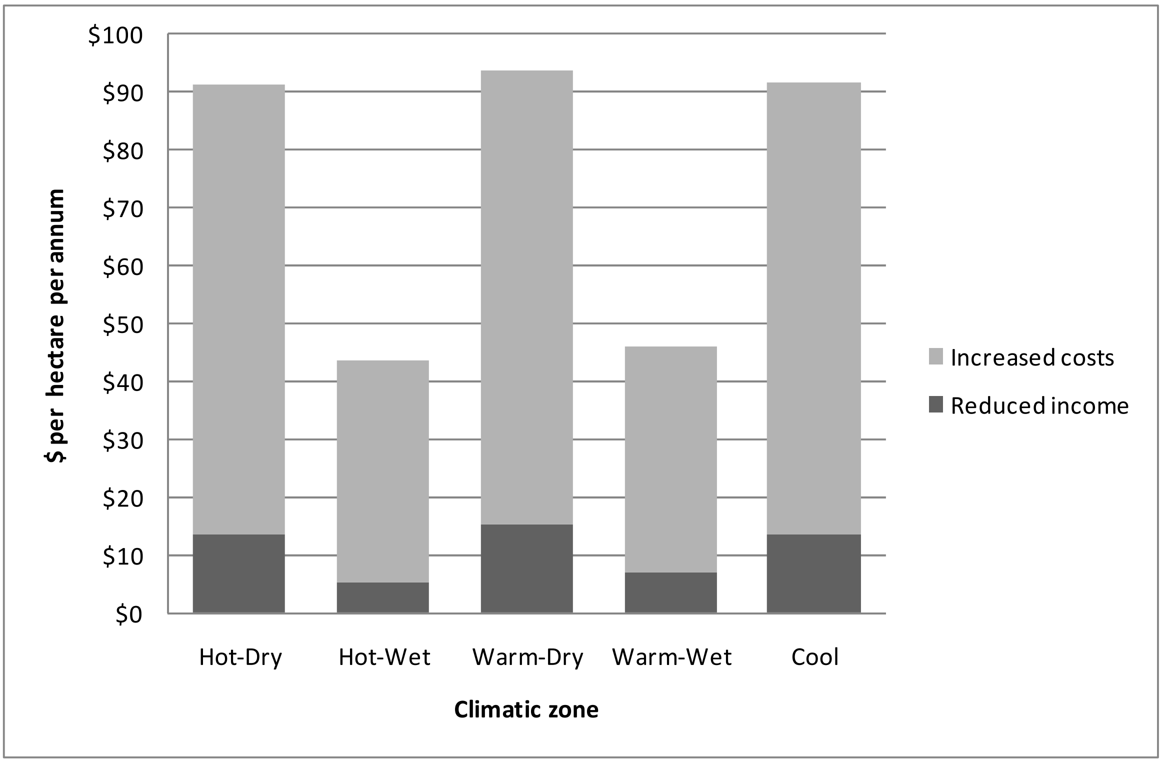
- The average vineyard-level impact of Root-Knot and Other Nematodes in terms of reduced profit is very similar in the hot-dry, warm-dry and cool zones ($91 to $94/ha/annum). The impact in these zones is somewhat higher than that in the hot-wet and warm-wet zones ($43 to $46) (Table 48).
- As detailed in Table 21, the vineyard-level impact of Root-Knot and Other Nematodes is comprised of the cost premium associated with replanting using nematode-resistant rootstocks rather than own-rooted planting material, the cost of chemical control of the pests (in aggregate, the cost effect) and yield loss attributable to infestation (i.e. the income effect).
- The relatively high vineyard-level impact in the hot-dry, warm-dry and cool zones is a function of the higher incidence of infestation of Root-Knot and Other Nematodes and higher proportion of area replanted to nematode-resistant rootstocks annually in these zones (Table 21).
- Cost effects comprise a larger proportion of the reduction in profit in all zones (83 to 88 per cent) (Figure 23).

Table 48 : Average vineyard-level economic impact of Root-Knot & Other Nematodes by climatic zone

Climatic zone	Average vineyard-level impact [a]				
	Reduced income		Increased costs		Reduced profit
	$/ha/annum	% [b]	$/ha/annum	% [b]	$/ha/annum
Hot-Dry	$13	0.23%	$78	1.14%	$91
Hot-Wet	$5	0.11%	$38	0.53%	$43
Warm-Dry	$15	0.21%	$78	1.28%	$94
Warm-Wet	$7	0.11%	$39	0.55%	$46
Cool	$14	0.20%	$78	1.47%	$92

[a] Over a period of 15 years in constant 2009 dollars.
[b] Percentage difference from base case totals. The prevention and/or control of some winegrape pests/diseases is part of the normal management routine for most vineyards, thus total 'base case' costs do not necessarily represent normal operating conditions.
Source: EconSearch analysis.

Figure 23 : Average vineyard-level economic impact of Root-Knot & Other Nematodes by climatic zone [a]



[a] Estimates are an annual average over a period of 15 years in constant 2009 dollars.
Source: EconSearch analysis.

- Estimates are provided in Table 48 of the relative impact of the income and costs effects, when compared with the base case (i.e. 'without pest/disease') models. Gross income (per ha per annum) with infestation of Root-Knot and Other Nematodes is approximately 0.11 to 0.23 per cent less than the base case in all zones. The costs of Root-Knot and Other Nematodes prevention were estimated to add 0.5 to 1.5 per cent to total base case costs.

The average industry-wide economic impact of Root-Knot and Other Nematodes by climatic zone was calculated by applying estimates of the area of winegrapes by zone in Australia in 2008 (Section 5.3) to the vineyard-level estimates of economic impact. These national data are presented in Table 49 and Figure 24.

Table 49 : Average industry-wide economic impact of Root-Knot & Other Nematodes by climatic zone

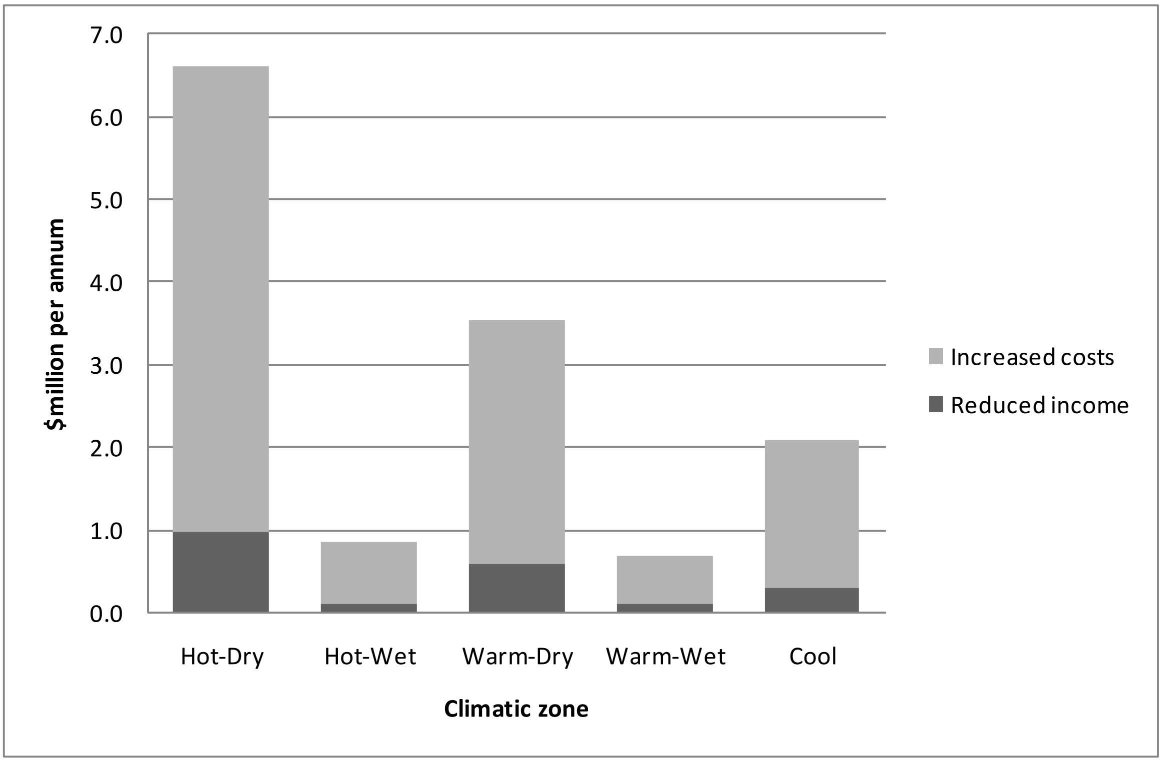
Climatic zone	Average industry-wide impact ($m/annum) [a]		
	Reduced income	Increased costs	Reduced profit
Hot-Dry	1.0	5.6	6.6
Hot-Wet	0.1	0.8	0.9
Warm-Dry	0.6	3.0	3.5
Warm-Wet	0.1	0.6	0.7
Cool	0.3	1.8	2.1
All zones	2.1	11.7	13.8

[a] Over a period of 15 years in constant 2009 dollars.
Source: EconSearch analysis.

Some of the key points to note from these results include the following.

- The average industry-wide impact of Root-Knot and Other Nematodes in terms of reduced profit is greatest in the hot-dry zone ($6.6m/annum), reflecting the large vineyard area in this zone.
- In aggregate, the cost effect ($11.7m/annum) represents approximately 85 per cent of the industry-wide reduction in profit attributable to Root-Knot and Other Nematodes ($13.8m/annum) (Table 49).

Figure 24 : Average industry-wide economic impact of Root-Knot & Other Nematodes by climatic zone [a]



[a] Estimates are an annual average over a period of 15 years in constant 2009 dollars.
Source: EconSearch analysis.

5.4.2.12 Phylloxera

Estimates of the vineyard-level impact on profit attributable to Phylloxera are reported in Table 50 and Figure 25 by climatic zone. Some of the key points to note from these results include the following.

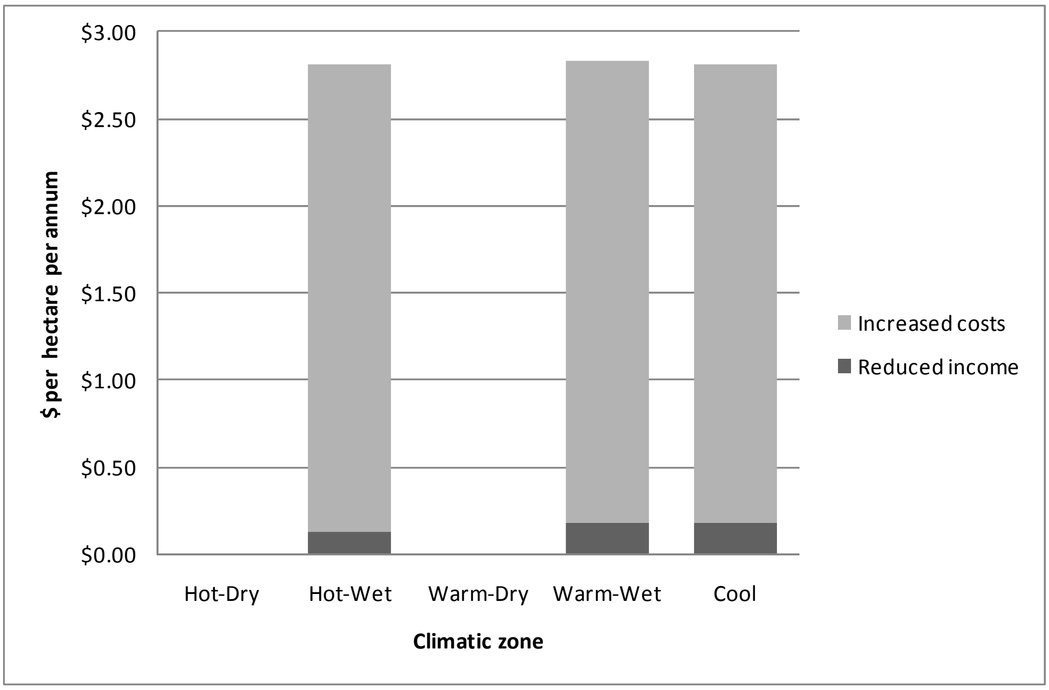
- The average vineyard-level impact of Phylloxera in terms of reduced profit is very similar in zones which have a declared Phylloxera Infestation Zone (i.e. the hot-wet, warm-wet and cool zones) ($2.81 to $2.83/ha/annum). Those zones without a PIZ (i.e. the hot-dry and warm-dry zones) were assumed to incur no reduction in vineyard-level profit that can be directly attributed to Phylloxera infestation or prevention (Table 50).
- The costs to growers of Phylloxera regulation and research, such as those incurred in South Australia through the payment of a levy to the Phylloxera and Grape Industry Board of South Australia, were excluded from the analysis.
- As detailed in Table 22, the vineyard-level impact of Phylloxera is comprised of the cost premium associated with replanting using Phylloxera-resistant rootstocks rather than own-rooted planting material (i.e. the cost effect) and yield loss attributable to infestation (i.e. the income effect).
- Cost effects comprise the majority of the reduction in profit in zones with a PIZ (i.e. 94 to 96 per cent) (Figure 25).
- Estimates are provided in Table 50 of the relative impact of the income and costs effects, when compared with the base case (i.e. 'without pest/disease') models. Whilst the average vineyard-level impact of Phylloxera in zones with a PIZ is very low, this average masks the fact that the impact on individual vineyards or pockets of vines within a vineyard may be much higher.
- It is important to note that an infested vineyard in a PIZ without processing facilities is particularly disadvantaged and will incur costs over and above those detailed above.

Table 50 : Average vineyard-level economic impact of Phylloxera by climatic zone

Climatic zone	Average vineyard-level impact [a]				
	Reduced income		Increased costs		Reduced profit
	$/ha/annum	% [b]	$/ha/annum	% [b]	$/ha/annum
Hot-Dry	$0.00	0.000%	$0.00	0.000%	$0.00
Hot-Wet	$0.13	0.003%	$2.69	0.037%	$2.81
Warm-Dry	$0.00	0.000%	$0.00	0.000%	$0.00
Warm-Wet	$0.18	0.003%	$2.65	0.038%	$2.83
Cool	$0.18	0.003%	$2.64	0.050%	$2.81

[a] Over a period of 15 years in constant 2009 dollars.
[b] Percentage difference from base case totals. The prevention and/or control of some winegrape pests/diseases is part of the normal management routine for most vineyards, thus total 'base case' costs do not necessarily represent normal operating conditions.
Source: EconSearch analysis.

Figure 25 : Average vineyard-level economic impact of Phylloxera by climatic zone[a]



a Estimates are an annual average over a period of 15 years in constant 2009 dollars.
Source: EconSearch analysis.

The average industry-wide economic impact of Phylloxera by climatic zone was calculated by applying estimates of the area of winegrapes by zone in Australia in 2008 (Section 5.3) to the vineyard-level estimates of economic impact. These national data are presented in Table 51 and Figure 26.

Table 51 : Average industry-wide economic impact of Phylloxera by climatic zone

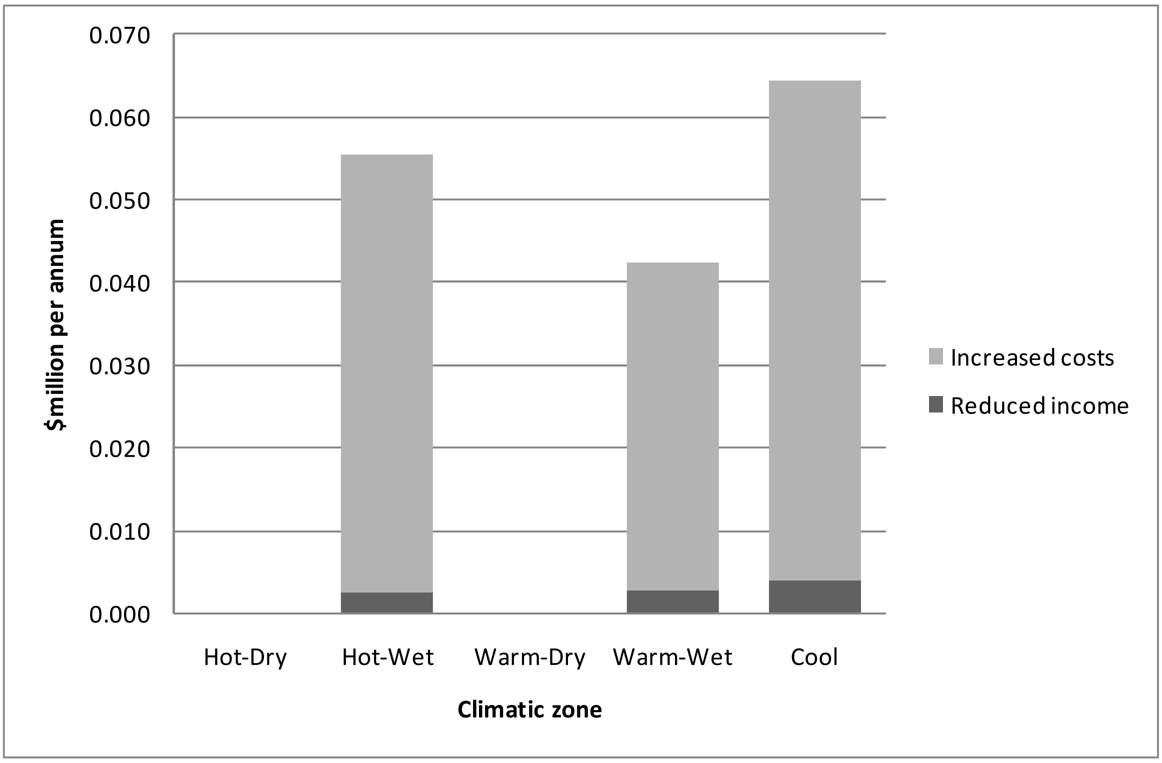
Climatic zone	Average industry-wide impact ($m/annum) [a]		
	Reduced income	Increased costs	Reduced profit
Hot-Dry	0.000	0.000	0.000
Hot-Wet	0.002	0.053	0.055
Warm-Dry	0.000	0.000	0.000
Warm-Wet	0.003	0.040	0.042
Cool	0.004	0.060	0.064
All zones	0.009	0.153	0.162

a Over a period of 15 years in constant 2009 dollars.
Source: EconSearch analysis.

Some of the key points to note from these results include the following.

- The average industry-wide impact of Phylloxera in terms of reduced profit is greatest in the cool zone ($0.064m/annum), although there is little difference in the impact between those zones with a declared PIZ.
- In aggregate, the cost effect ($0.153m/annum) represents approximately 94 per cent of the industry-wide reduction in profit attributable to Phylloxera ($0.162m/annum) (Table 51).

Figure 26 : Average industry-wide economic impact of Phylloxera by climatic zone[a]



[a] Estimates are an annual average over a period of 15 years in constant 2009 dollars.
Source: EconSearch analysis.

5.4.2.13 Birds

Estimates of the vineyard-level impact on profit attributable to bird damage are reported in Table 52 and Figure 27 by climatic zone. Some of the key points to note from these results include the following.

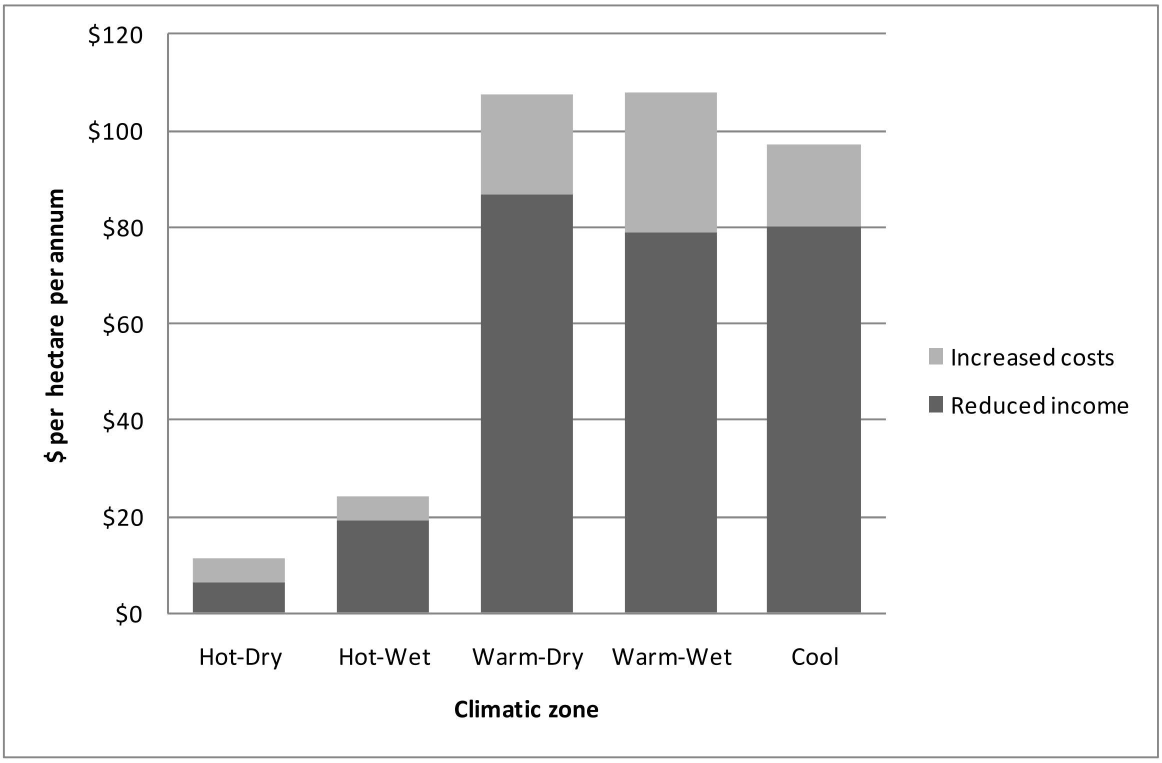
- The average vineyard-level impact of birds in terms of reduced profit is very similar in the warm-dry, warm-wet and cool zones ($97 to $108/ha/annum). The impact in these zones is significantly higher than that in the hot-dry and hot-wet zones ($11 and $24/ha/annum, respectively) (Table 52).
- As detailed in Table 23, the vineyard-level impact of birds is comprised of the annual costs of netting and disturbance methods (i.e. the cost effect) and yield loss attributable to bird damage (i.e. the income effect).
- The relatively high vineyard-level impact in the warm-dry, warm-wet and cool zones is a function of the larger area ‘treated’ annually and higher incidence and yield loss associated with bird damage in these zones (Table 23).
- Income effects comprise a larger proportion of the reduction in profit in all zones (55 to 83 per cent) (Figure 27).

Table 52 : Average vineyard-level economic impact of birds by climatic zone

Climatic zone	Average vineyard-level impact [a]				
	Reduced income		Increased costs		Reduced profit
	$/ha/annum	% [b]	$/ha/annum	% [b]	$/ha/annum
Hot-Dry	$6	0.11%	$5	0.07%	$11
Hot-Wet	$19	0.41%	$5	0.07%	$24
Warm-Dry	$87	1.20%	$21	0.34%	$108
Warm-Wet	$79	1.19%	$29	0.41%	$108
Cool	$80	1.19%	$17	0.32%	$97

[a] Over a period of 15 years in constant 2009 dollars.
[b] Percentage difference from base case totals. The prevention and/or control of some winegrape pests/diseases is part of the normal management routine for most vineyards, thus total 'base case' costs do not necessarily represent normal operating conditions.
Source: EconSearch analysis.

Figure 27 : Average vineyard-level economic impact of birds by climatic zone[a]



[a] Estimates are an annual average over a period of 15 years in constant 2009 dollars.
Source: EconSearch analysis.

- Estimates are provided in Table 52 of the relative impact of the income and costs effects, when compared with the base case (i.e. 'without pest/disease') models. Gross income (per ha per annum) with periodic bird damage is approximately 1.2 per cent less than the base case in the warm-dry, warm-wet and cool zones. The average reduction in income in the hot-dry and hot-wet zones is somewhat lower, in relative terms, at approximately 0.1 and 0.4 per cent of 'base case' level, respectively. The costs of preventing bird damage were estimated to add 0.07 to 0.41 per cent to total base case costs.

The average industry-wide economic impact of birds by climatic zone was calculated by applying estimates of the area of winegrapes by zone in Australia in 2008 (Section 5.3) to the vineyard-level estimates of economic impact. These national data are presented in Table 53 and Figure 28.

Table 53 : Average industry-wide economic impact of birds by climatic zone

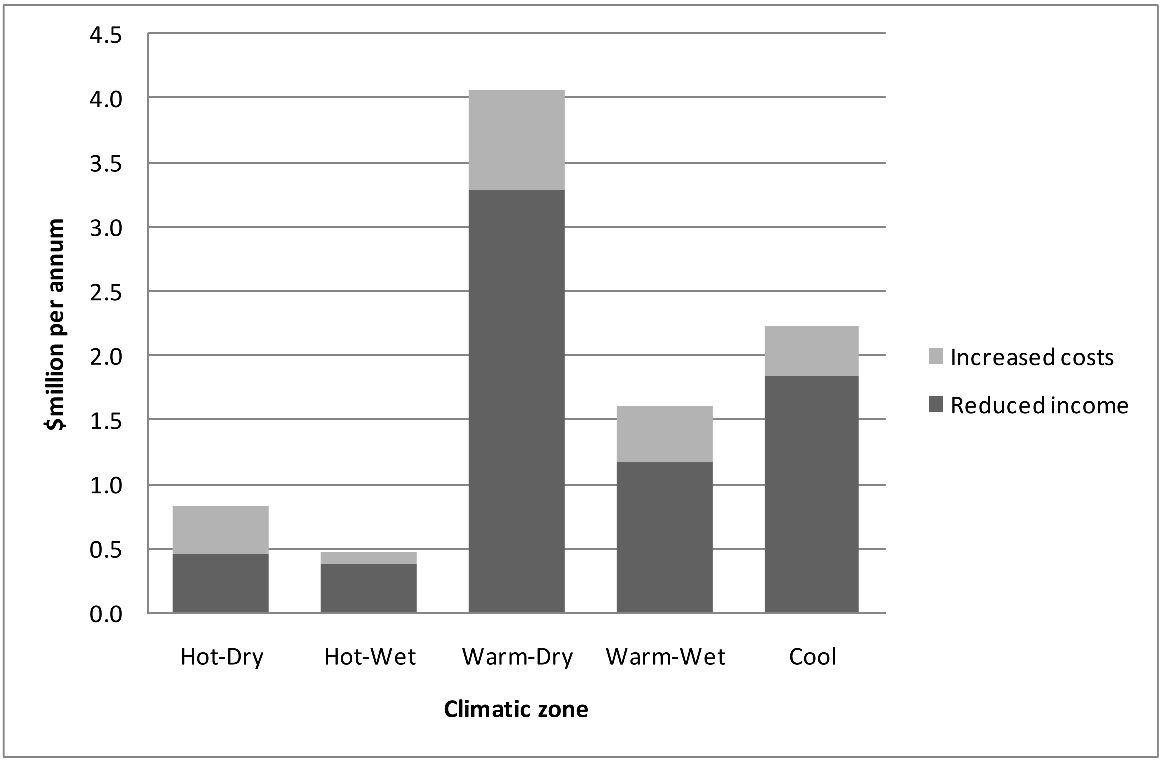
Climatic zone	Average industry-wide impact ($m/annum) [a]		
	Reduced income	Increased costs	Reduced profit
Hot-Dry	0.5	0.4	0.8
Hot-Wet	0.4	0.1	0.5
Warm-Dry	3.3	0.8	4.1
Warm-Wet	1.2	0.4	1.6
Cool	1.8	0.4	2.2
All zones	7.1	2.1	9.2

[a] Over a period of 15 years in constant 2009 dollars.
Source: EconSearch analysis.

Some of the key points to note from these results include the following.

- The average industry-wide impact of birds in terms of reduced profit is greatest in the warm-dry zone ($4.1m/annum), reflecting the relatively high vineyard-level impact and large vineyard area when compared with the warm-wet and cool zones.
- In aggregate, the income effect ($7.1/annum) represents approximately 78 per cent of the industry-wide reduction in profit attributable to birds ($9.2m/annum) (Table 53).

Figure 28 : Average industry-wide economic impact of birds by climatic zone[a]



[a] Estimates are an annual average over a period of 15 years in constant 2009 dollars.
Source: EconSearch analysis.

5.4.3 Comparison of Impact Estimates at the National Level

Estimates of the industry-wide impact of the 13 groups of priority winegrape pests and diseases in Australia are summarised in Table 54 and Figure 29. For these selected pest and diseases, the following conclusions can be drawn.

- The pest or disease with the highest estimated economic impact (i.e. reduced profit) on the wine and grape industry in Australia is Powdery Mildew. The annual costs of prevention and infestation were estimated to be approximately $76 million (in current dollars). Income and cost effects contribute equally to the industry-wide reduction in profit attributable to Powdery Mildew.
- The annual costs of prevention of and infestation by Downy Mildew were estimated to be almost $63 million. Approximately 58 per cent of this impact is attributable to cost effects and the balance to income effects associated with infestation.
- The annual impact of Botrytis and Other Bunch Rots is slightly less than that for Powdery and Downy Mildew ($52 million), with the income effect the major contributor to reduced profit (55 per cent).

Table 54 : Average industry-wide impact of priority pests & diseases of winegrapes in Australia

Pest or disease	Industry-wide impact ($m/annum) [a]		
	Reduced income	Increased costs	Reduced profit
Powdery Mildew	38.36	38.13	76.48
Downy Mildew	26.26	36.45	62.71
Botrytis and Other Bunch Rots	28.58	23.05	51.62
Light Brown Apple Moth	8.58	9.61	18.20
Root-Knot and Other Nematodes	2.08	11.71	13.79
Viruses/Transmissible Organisms	12.05	0.23	12.28
Birds	7.14	2.06	9.20
Trunk Diseases	3.47	2.73	6.20
Garden Weevil	0.21	0.05	0.26
Phylloxera	0.01	0.15	0.16
Mealybugs and Scale	0.07	0.01	0.08
Trunk Boring Insects	0.01	0.01	0.02
Root Rots	0.00	0.01	0.01

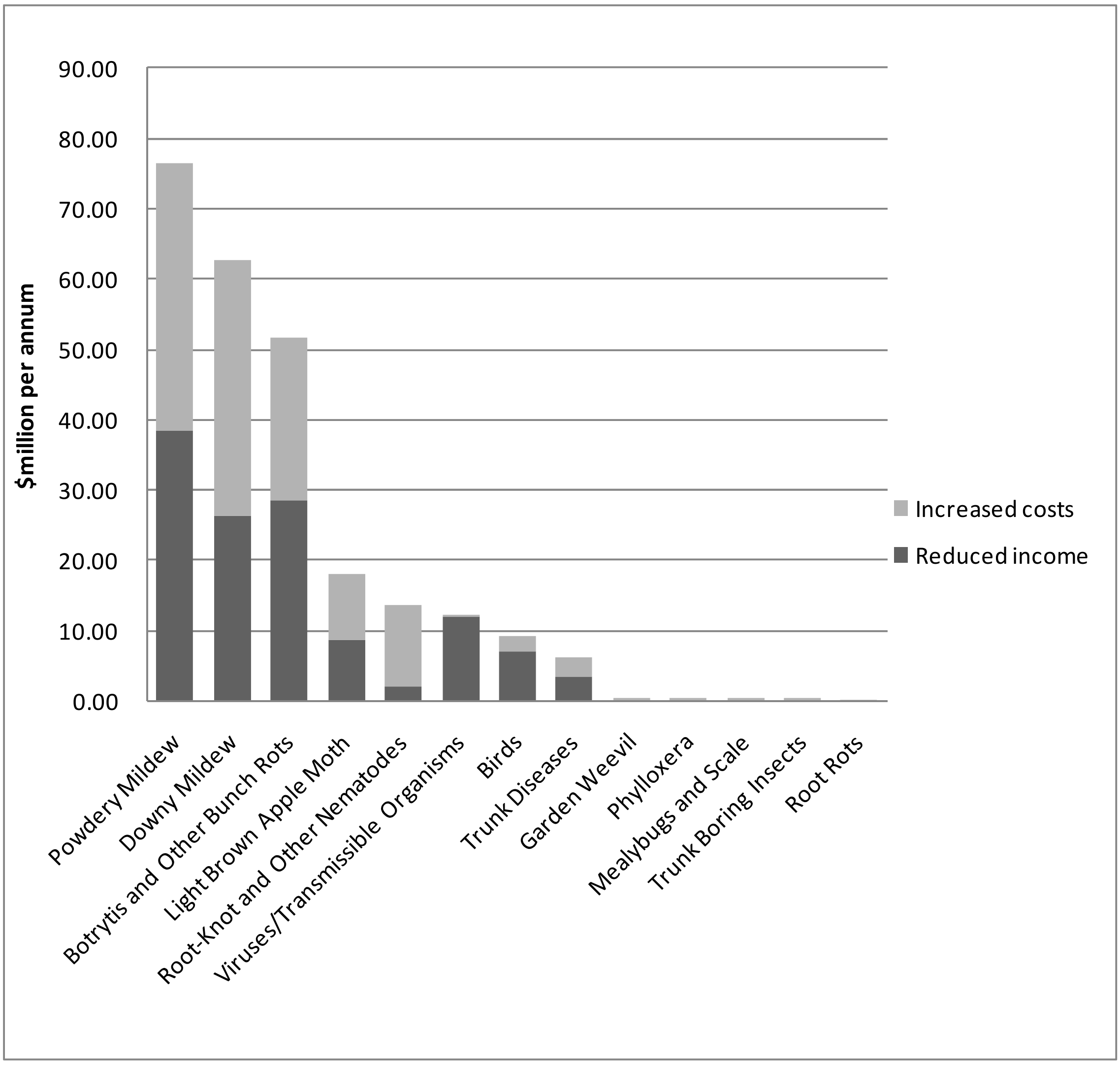
[a] In constant 2009 dollars.
Source: EconSearch analysis.

- The top three winegrape pests and diseases in Australia account for approximately 76 per cent of the total industry-wide economic impact of the 13 key winegrape pests/diseases included in this analysis.
- LBAM, Root-Knot/Other Nematodes and Viruses/Transmissible Organisms are the next biggest contributors to reduced profit across the industry with impacts of approximately $18m, $14m and $12m per annum, respectively.
- Birds and Trunk Diseases are also significant contributors to industry-wide profit reduction with impacts of approximately $9m and $6m per annum, respectively.

- There are a number of winegrape pests and diseases for which the estimated annual industry-wide impact is very low in relative terms. These include Phylloxera, which is currently restricted to a few PIZ, and Garden Weevil Mealy bugs/Scale, Trunk Boring Insects and Roots Rots. Whilst the geographic spread of the latter pests/diseases is greater than that for Phylloxera, the average vineyard-level impact is small.

The estimates shown in the last 5 priority pests and diseases in Table 54 may provide a false impression of their importance as they may have extremely significant but very localised impact. The modelling process which was rigorously followed, may have resulted in an underestimate of their importance and possibly their potential impact.

Figure 29 : Average industry-wide economic impact of selected winegrape pests & diseases in Australia[a]



[a] In constant 2009 dollars.
Source: EconSearch analysis.

In order to account for uncertainty in the results of the analysis, a range of values (i.e. minimum, most likely and maximum) have been estimated for key variables, as defined in Section 5.2.4. The estimates of industry-wide impact reported in Table 54 and Figure 29 are the mean values from Monte Carlo simulations calculated by attaching a triangular probability distribution to

these variables. It is also possible to calculate a 90 per cent confidence interval[10] for these and other outputs from the modelling. Confidence intervals for the industry-wide economic impacts of the key pests/diseases are provided in Table 55 and Figure 30.

These data can be interpreted as follows, using as an example, Powdery Mildew. The reduced vineyard profit attributable to Powdery Mildew industry-wide and across all climatic zones was estimated to have a mean value of $76m per annum (Table 54 and Table 55), with a 90 per cent probability that this value will be in the range from $54m to $103m per annum (Table 55 and Figure 30).

Table 55 : Confidence intervals for the industry-wide economic impact of selected winegrape pests & diseases in Australia

Pest or disease	Reduced profit ($m/annum) [a]		
	5% confidence point	Mean	95% confidence point
Powdery Mildew	54.00	76.48	102.98
Downy Mildew	43.26	62.71	86.50
Botrytis and Other Bunch Rots	34.33	51.62	72.95
Light Brown Apple Moth	12.97	18.20	23.77
Root-Knot and Other Nematodes	6.48	13.79	22.18
Viruses/Transmissible Organisms	4.62	12.28	22.35
Birds	5.29	9.20	13.76
Trunk Diseases	3.06	6.20	10.01
Garden Weevil	0.13	0.26	0.43
Phylloxera	0.09	0.16	0.23
Mealybugs and Scale	0.03	0.08	0.14
Trunk Boring Insects	0.01	0.02	0.03
Root Rots	0.01	0.01	0.02

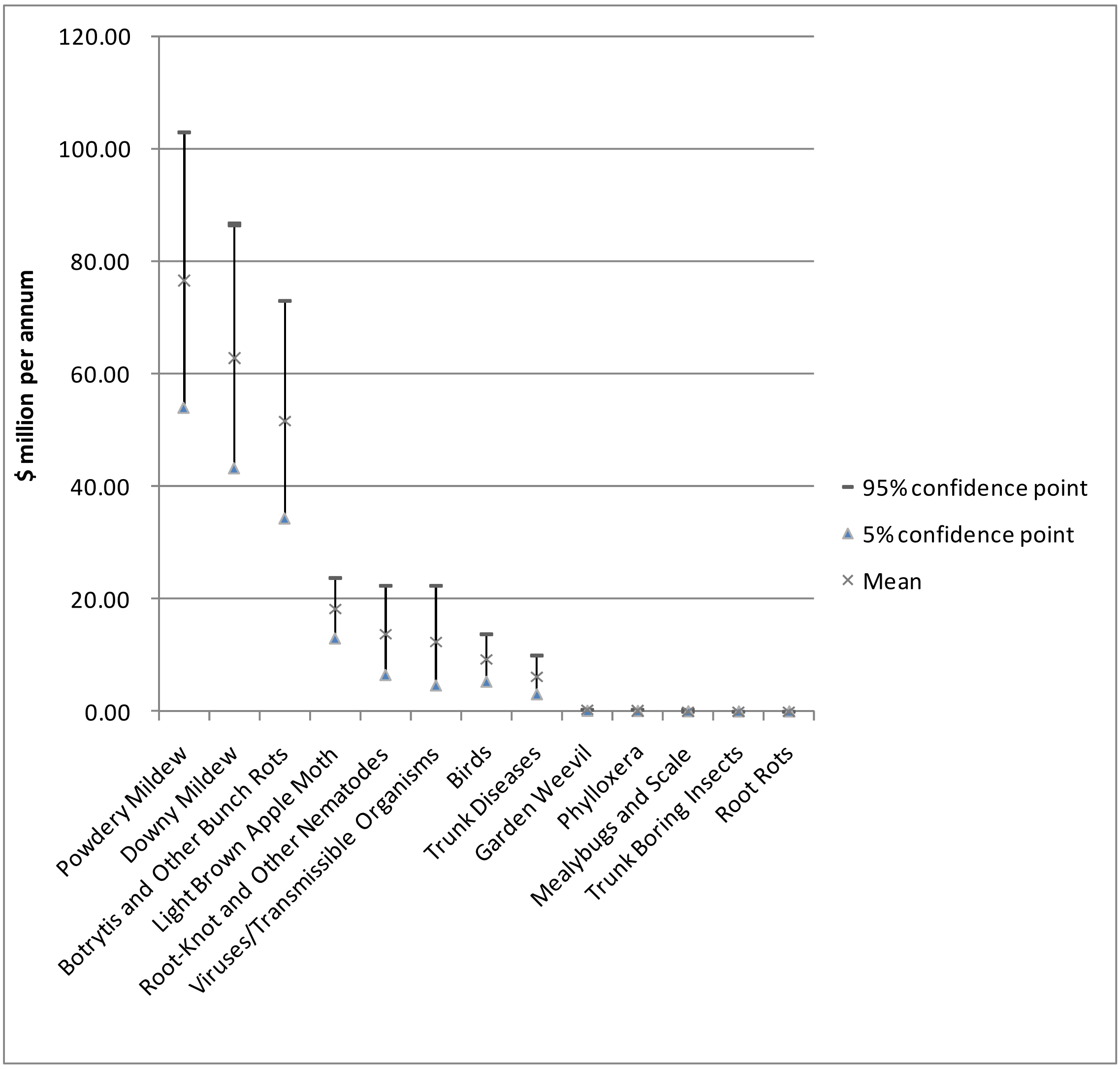
[a] All values in 2009 dollars.
Source: EconSearch analysis.

The following conclusions can be drawn from these confidence intervals.

- As the 90 per cent confidence intervals for Downy Mildew and Botrytis and Other Bunch Rots overlap that for Powdery Mildew, it is probable, in some years, that the pest/disease with the highest estimated economic impact on the wine and grape industry in Australia would be Downy Mildew or Botrytis and Other Bunch Rots, rather than Powdery Mildew (Figure 30).
- A similar conclusion can be drawn for the next group of pests and diseases (i.e. LBAM, Root Knot/Other Nematodes, Viruses/Transmissible Organisms, Birds and Trunk Diseases), in which overlaps are apparent in the 90 per cent confidence intervals. Note also that the level of uncertainty in estimates of industry-wide impact for Viruses/Transmissible Organisms, as indicated by the size of the 90 per cent confidence interval, is much greater than that for Root Knot/Other Nematodes and LBAM, for example.

[10] A confidence interval of 90% is the range between the 5% and 95% confidence points.

Figure 30 : Confidence intervals for the industry-wide economic impact of selected winegrape pests & diseases in Australia[a]



[a] All values in 2009 dollars.
Source: EconSearch analysis.

5.5 Summary & Conclusions

5.5.1 Introduction

This section of the report details the development and application of a consistent method for estimating the economic impact of 13 key winegrape pests and diseases in Australia. Data constraints and finite research resources prevented the consultants from calculating reliable estimates of the economic impact of all winegrape pests and diseases.

The scope of the analysis was limited to the economic impact of pests/diseases at the vineyard level. The costs incurred by winemakers, government, consumers, etc. have not been quantified. For the purpose of this analysis, e*conomic impact* at the vineyard level was defined as the annual average change in vineyard profit attributable to the income (i.e. yield and price) and cost (i.e. operating and capital) effects of the pest or disease, over a period of 15 years. The time dimension of this measure accounts for the frequency of infestation (i.e. the probability of annual infestation) and allows for full consideration of relevant capital and operating costs. *Vineyard profit* was defined as gross income less total operating (i.e. variable and overhead) and capital costs.

5.5.2 Costs

The major pest and disease related costs included chemical and application costs of preventative and eradicant spray programs (including labour, fuel and depreciation), as well as the costs of undertaking a range of other preventative and treatment measures. The frequency of infestation, the incidence of the pest/disease and implications for winegrape yield at a vineyard level were the primary components of the income effect.

It is important to acknowledge that there are several costs that were excluded from the analysis due to problems of attribution and limited data (e.g. costs associated with physical infrastructure used for spraying). For pests and diseases for which targeted or complete replanting is the primary or only method of prevention and control (i.e. Trunk Diseases, Root Rots, Root-Knot and Other Nematodes and Phylloxera), there is an unquantified cost associated with the loss of old vines, many of which produce the highest quality fruit and, in turn, the premium wines for which the industry is renowned.

Given that much of the information used in this analysis is based on recent vineyard-level pest/disease management practices and that these practices are likely to have been influenced by historically low prices for winegrapes and underlying market oversupply, the absolute and relative levels of the impacts presented in this report also reflect the response to these historically low prices.

5.5.3 Top Three Pests

Based on the assumptions and data presented in the report, the top three winegrape pests and diseases in Australia, in terms of industry-wide economic impacts are:

- Powdery Mildew ($76m/annum in 2009 dollars);
- Downy Mildew ($63m); and
- Botrytis and Other Bunch Rots ($52m).

These three diseases account for approximately 76 per cent of the industry-wide economic impact of the 13 pests/diseases included in the analysis. By accounting for uncertainty in the results of the analysis it was demonstrated that the ranking of these top three diseases may vary from year-to-year.

For a number of pests/diseases (e.g. Garden Weevil, Phylloxera and Roots Rots), the low vineyard-level and industry-wide impact masks the fact that the impact on subsets of vineyards, individual vineyards or pockets of vines within a vineyard may be much higher.

5.5.4 Implications for RD&E Investment Priorities

In conclusion, the results of this analysis are a necessary but not sufficient basis for exhaustively identifying research priorities for winegrape pest and diseases. Other factors to consider include:

- downstream impacts on winemakers, government, consumers, etc.;
- the adequacy of extension activities for existing pest/disease research and development findings and technology;
- the cost of research and development to address the economic impacts highlighted; and
- the net returns to investment in other, non-pest/disease related research and development.

6 FINDINGS RELATED TO INVESTMENT IN RD&E

6.1 Introduction

The major purposes of this section of the report are:

- to determine the economic cost of endemic grapevine pests and diseases to the Australian grape and wine industry;
- to relate these costs to past RD&E expenditure by GWRDC; and
- to identify any gaps or anomalies in the RD&E funding by GWRDC and the economic impact of a pest or disease on the national industry.

GWRDC is a significant provider of pest and disease RD&E funds to the wine industry but other funding is also provided by RD&E agencies, (State and Federal agencies), universities, companies, industry bodies, input supply houses, and individual growers.

6.2 Past GWRDC Funding

Details of the funding of RD&E by GWRDC for specific pest and disease projects from 1993/94 to 2009/10 were provided and are presented in Table 56 with some comments by the Project Team.

The 13 highest priority pests and diseases in Table 56 are ranked based on their National Economic Impact, together with five other pests and diseases funded but not included in our priority list. These are Crown Gall, Fruit Fly, Mites, Phomopsis/Black Spot and Termites/Borers. The annual GWRDC funding has been adjusted to 2009 dollars to allow a better comparison with the National Economic Impact.

The total funding (in 2009 dollars) by GWRDC from 1993 to the present was $17.2m with major support for Powdery Mildew ($3.4m), Trunk diseases ($3.0m), Phylloxera ($2.9m), Botrytis and other bunch rots ($2.9m), Downy Mildew ($1.7m) and Viruses/Transmissible diseases ($1.7m). All the pests and diseases that received major support are included in the list of 13 priority pests and diseases.

As shown in Table 56, two priority pests and diseases (Birds and Root Diseases) received no funding over this period, while Fruit Fly ($0.02m), Mites ($0.25m) and Phomopsis/Black Spot ($0.46m) were not on the current priority list but received funding.

Grapes have only recently been listed as a fruit fly host and as such have benefitted indirectly from the investments of the States and Commonwealth quarantine and the National Fruit Fly Strategy (NFFS). The fact that mites and Phomopsis did not rank highly in this project is likely due to their sporadic and localised impact and the known management options. This may in fact reflect on prior GWRDC investment, as well as the availability of products registered for their control.

Table 56 : R&D expenditure by GWRDC on pests & diseases between 1993/94 & present

Pest or Disease[(a)]	No. of Projects	1993/94	1998/99	1999/00	2000/01	2001/02	2002/03	2003/04	2004/05	2005/06	2006/07	2007/08	2008/09	2009/10	2010/11	2011/12	Total (nominal)	Total (real 2009 dollars)	Comments[(b)]
1 Powdery Mildew	22	$28,067		$110,789	$82,058	$90,471	$225,146	$439,649	$583,664	$505,334	$563,166	$15,000	$232,029	$128,331			$3,003,704	$3,348,161	Good funding since 1999/00
2 Downy Mildew	15				$16,440	$58,763	$81,078	$197,340	$254,928	$132,319	$450,729		$232,029	$123,331			$1,546,957	$1,677,696	Regular funding since 2000/01
3 Botrytis and other Bunch Rots	24			$54,743	$58,255	$116,148	$277,947	$268,388	$92,098	$111,691	$432,742	$470,427	$434,638	$207,358	$128,996		$2,653,431	$2,857,052	Good funding since 1999/00
4 Light Brown Apple Moth	3					$13,869	$13,475	$7,741									$35,085	$41,754	No significant funding
5 Root knot and other Nematodes	3			$42,365	$50,931	$45,043	$25,355										$163,694	$205,813	No funding since 2002/03
6 Grape vine yellows[(c)]	3				$108,694	$140,750	$36,226	$33,665	$34,575								$353,910	$429,457	No funding since 2004/05
6 Virus[(c)]	8			$37,580	$185,607	$200,264	$107,315	$40,563	$38,057	$101,888	$103,706	$132,880	$137,979	$3,900			$1,089,739	$1,242,311	Regular funding until 2009/10
7 Birds	0																$0	$0	No funding
8 Trunk diseases (Eutypa, Bot canker)	20			$122,692	$158,781	$219,400	$195,438	$245,334	$297,656	$345,052	$235,697	$284,114	$293,542	$221,685	$128,996		$2,748,387	$3,034,428	Regular funding since 1999/00
9 Weevils/ beetles/ cutworms/ grasshoppers[(d)]	11						$9,850		$69,200	$113,650	$53,500	$98,000					$344,200	$368,483	Funding 2004/05 to 2007/08
10 Phylloxera	20			$180,662	$151,683	$230,861	$243,874	$309,290	$362,619	$250,487	$122,400	$128,273	$209,091	$163,393	$169,307	$60,000	$2,581,940	$2,896,886	Significant annual funding since 1999/2000
11 Mealy bug[(e)]	4						$14,600		$13,550	$70,629	$3,500	$30,000	$32,032				$164,311	$174,986	Sporadic funding
11 Scale[(e)]	4								$11,934	$20,945	$92,721	$14,430	$20,000				$160,030	$169,189	Major funding in 2006/07
12 Trunk boring insects	1						$4,133	$13,025									$17,158	$19,805	Minor funding
13 Root rots	0																$0	$0	No funding
Crown Gall	0																$0	$0	No funding
Fruit Fly	1												$18,500				$18,500	$18,500	Minor funding
Mites	6									$44,851	$91,042	$93,604	$5,000				$234,497	$245,299	Funding 2005/06 to 2008/09
Phomopsis/Black spot	3		$66,482	$144,983	$64,443	$69,551							$2,860	$4,140			$352,459	$458,486	No significant funding since 2001/02
Termites	0																$0	$0	No funding
																	$15,468,002	$17,188,305	

(a) Ranking, 1-13, based on National Economic Impact.
(b) Comments from Project Team.
(c) Grapevine yellows and viruses combined as "Viruses and transmissible organisms" in report.
(d) This group of insects named "Garden weevil" in report.
(e) Mealy bug and scale combined in report.

6.3 Comparison of Economic Impact of Pests & Diseases & GWRDC RD&E Funding

6.3.1 Comparisons

Table 57 presents the National Economic Impact of the 13 priority pests and diseases on the national grape and wine industry compared with the GWRDC funding of the priority pests and diseases taken from Table 56. For this comparison the 13 priority pests and diseases were placed in one of 3 groups, A (High Impact), B (Low/Medium Impact) and C (Very Low Impact) as shown in Table 57.

Table 57 : Comparison of pests and diseases in order of Mean Economic Impact ($) and GWRDC funding on these pests and diseases

Pest or Disease	Grouping Based on Economic Impact	Mean National Economic Impact[a]		GWRDC Funding[b],[c]	
		$m/annum	%	$m	%
Powdery Mildew	Group A *High Impact*	76		3.35	
Downy Mildew		63		1.68	
Botrytis & Other Bunch Rots		52		2.86	
	Sub Total	191	(76%)	7.89	(47.9%)
Light Brown Apple Moth	Group B *Low/ Medium Impact*	18		0.04	
Root-Knot & Other Nematodes		14		0.21	
Viruses/Transmissible Organisms		12		1.67	
Birds		9		0	
Trunk Diseases		6		3.03	
	Sub Total	59	(23.8%)	4.95	(30.1%)
Garden Weevil	Group C *Very Low Impact*	0.3		0.37	
Phylloxera		0.2		2.90	
Mealy bugs and Scale		0.1		0.34	
Trunk Boring Insects		0.02		0.02	
Root Rots		0.01		0	
	Sub Total	0.5	(0.2%)	3.63	(22.0%)
	TOTAL	$251m	(100%)	16.47	(100.0%)

(a) From Table 55, this report (2009 dollars).
(b) Total 1993/94 - present adjusted to 2009 dollars.
(c) Note that GWRDC has also funded R&D for mites and for Phomopsis and Black Spot totalling $0.71 (in $2009) not included in this table.

Mean National Economic Impact, industry priority for pests and diseases based on the industry survey and workshop and the level of GWRDC funding between 1993/94 and 2009/10 were ranked for the 13 pests and diseases to allow a comparison to made between these three different indicators of the importance of pests and diseases to the Australian grape and wine industry. Table 58 presents the rankings that form the basis of the discussion that follows in Sections 6.3.2 and 6.3.3 below.

Table 58 : Comparison of ranking of pests and diseases for Mean Economic Impact, Survey and Workshop Priorities and GWRDC funding from 1993 to 2009

		Ranking Base[(a)]		
Pest or Disease	Grouping Based on Economic Impact	Mean National Economic Impact	Survey & Workshop Priorities	GWRDC Funding
Powdery Mildew	Group A *High Impact*	1	1	1
Downy Mildew		2	4	5
Botrytis & Other Bunch Rots		3	2	4
Light Brown Apple Moth	Group B *Low/ Medium Impact*	4	3	10
Root-Knot & Other Nematodes		5	8	9
Viruses/Transmissible Organisms		6	12	6
Birds		7	5	12 equal
Trunk Diseases		8	6	2
Garden Weevil	Group C *Very Low Impact*	9	7	7
Phylloxera		10	10	3
Mealy bugs and Scale		11	13	8
Trunk Boring Insects		12	9	11
Root Rots		13	11	12 equal

(a) Refer to Table 57 above for economic impact dollars and GWRDC funding dollars that are the basis for these rankings.

6.3.2 Economic Impact - Discussion

In Table 57 the pests and diseases in Group A (ranked 1, 2 and 3 in terms of mean National Economic Impact) account for an estimated 76% of the total National Economic Impact. The pests and diseases in Group B are ranked from 4 to 8 and account for an estimated 23.8% of the National Economic Impact while the pests and diseases in Group C account for only 0.2% of the National Economic Impact.

The very large difference between Group A (High Impact) and Group C (Very Low Impact) in National Economic Impact per year can be explained by their epidemiology, the distribution of susceptible vines in the climatic zones and the methodology used to calculate the mean National Economic Impact in Section 5 of this report.

- The Group A (High Impact) pests and diseases (Powdery Mildew, Downy Mildew and Botrytis and Other Bunch Rots) are found in most climatic zones of Australia and they have a frequency (annual probability of infestation) varying between 5% and 50% with yield losses of 3% to 20%.
- However, the Group C (Very Low Impact) pests and diseases (Garden Weevil, Phylloxera, Mealybug and Scale, Trunk Boring Insects and Root Rots) have only localised sporadic impact. As well, the proportion of the vineyard area affected in the zones where they occurred is low and the yield loss across the zone accordingly is also very low. The very localised nature of the Group C pests and diseases like Phylloxera, Garden Weevil and Trunk Boring Insects did not lead to significant National Economic Impact. Although vineyards with infestation of these pests and diseases can suffer very high individual losses, when the impact is averaged over the climatic zones and the much larger national industry, the National Economic Impact of this group of pests and diseases is very low.
- Mean National Economic Impact in this report does not include potential economic impact, only estimated annual economic impact. For example, Phylloxera has been estimated to have a relatively low annual economic impact across the whole Australian industry but it is

widely accepted to have a very large potential economic impact and this is a major reason for it being ranked number 3 in GWRDC funding.

The mean annual National Economic Impact of grapevine pests and diseases is not the only factor to consider when determining investment in RD&E. For some, the possible high but localised impact is an important factor to consider.

6.3.3 Comparison of Rankings - Discussion

The rankings of the 13 pests and diseases in Table 58 for their National Economic Impact correlated closely with the ranking from the industry survey and workshop priorities. The main variation was the lower ranking (12^{th}) in the survey and workshop priority for Viruses/Transmissible Organisms compared with a ranking of 6^{th} in the National Economic Impact.

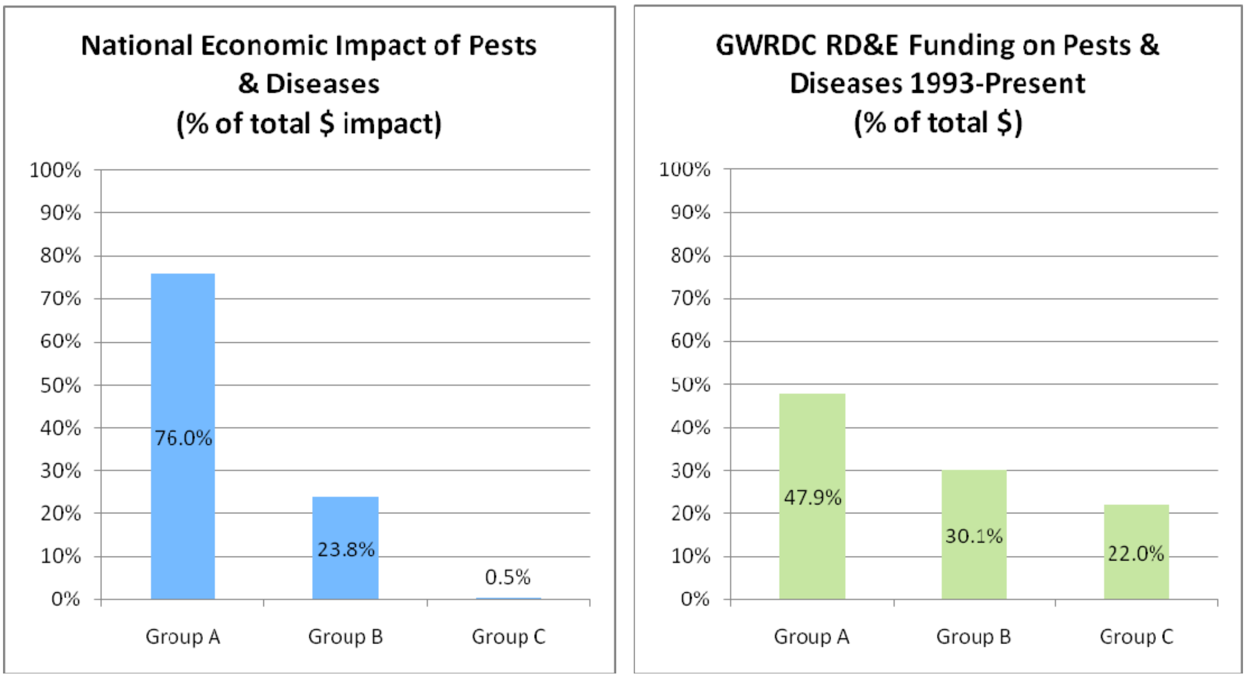
However, the ranking of the National Economic Impact of the 13 priority pests and diseases compared less closely with the ranking of GWRDC expenditure since 1993/94. For example, Light Brown Apple Moth, Root-Knot and other Nematodes and Birds ranked lower for GWRDC funding than their ranking based on National Economic Impact, while Trunk Diseases and Phylloxera received a much higher ranking for level of GWRDC funding than the National Economic Impact indicated.

The difference in these rankings may be related to changing priorities for GWRDC funding extending over the 13 year period to 2009/10 while the National Economic Impact was estimated for the 2009 year. It may also be related to the number of submissions made by RD&E agencies to GWRDC for funding of research on these pests and diseases.

Although the National Economic Impacts of Phylloxera and Trunk Diseases were low in Table 57, the potential impact and permanent consequences of infestations by these pests and diseases on the industry are great and the level of funding by GWRDC is justified.

Figure 31 shows graphically the differences in percentages of National Economic Impact and GWRDC pest and disease funding since 1993/94 for Groups A, B and C pests and diseases.

Figure 31 : Comparison of Economic Impact and GWRDC Funding



6.4 Comments on GWRDC Funding & Industry Needs

In relating the findings of the National Economic Impact of pests and diseases to investment in RD&E, the project team and the Industry Reference Group prepared the comments in Table 59. This table has also been used in the development of Section 7, Implications for GWRDC, to follow.

Table 59 : Specific comments on industry needs related to findings from National Economic Impact of pests & diseases

Pest or Disease	Ranking Based on National Economic Impact		IRG Comments							Project Team Comments on whether R&D Inputs Need to be Modified
			Available Knowledge	Commercially Managed	Adoption of BMP	RD&E Capacity	Potential Impact of Basic R&D	Potential Impact of Applied RD&E	Highly Localised Impact	
Powdery Mildew	Group A *High Impact*	1	High	High	Med/High	High	Medium	High	No	• The interest of the agrochemical companies is high because of the size of the market to control these diseases. • Much R&D already done. • Extension programs needed to get messages to grape growers. • Perhaps need for R&D on resistance.
Downy Mildew		2	Med/High	High	Medium	Medium	Medium	Medium	No	
Botrytis and Other Bunch Rots		3	Medium	Low/Med	Medium	Medium	Medium	High	No	
Light Brown Apple Moth	Group B *Low/ Medium Impact*	4	Med/High	Med/High	Med/High	Med/High	Low	Medium	No	• Monitoring and better understanding of IPM control. Systems approaches.
Root-Knot and Other Nematodes		5	Medium	Medium	Medium	Low/Med	Medium		No	• Urgent need for increased resource capability for nematodes in agencies.
Viruses/Transmissible Organisms		6	Medium	Med/High	Medium	Low/Med	Medium	High	No	• Urgent need for increased resource capability for viruses in agencies.
Birds		7	Low	Low/Med	Med/High	Low/Med	Medium	Medium	Partly	• Localised in some regions where serious, otherwise problem manageable.
Trunk Diseases		8	Medium	Low/Med	Medium	Low/Med	Medium	High	No	• Need for Australia-wide awareness program in vineyards planted in the 1990s.
Garden Weevil	Group C *Very Low Impact*	9	Low/Med	Low/Med	Medium	Medium	Medium	High	Yes	• Problem localised to WA but seems to be spreading to other regions.
Phylloxera		10	High	Med/High	Medium	Medium	Low	Medium	Yes	• Special case can be made for phylloxera because of large impact if spread of the pest occurs across industry. • Current losses across industry small but very significant for individuals. • Need for quarantine and resource capability in agencies (PIRSA, PGIBSA, DPI Vic, NSW DPI).
Mealy bugs and Scale		11	Medium	Medium	Low/Med	Medium		Low	No	• Extension program on IPM and use of chemicals.
Trunk Boring Insects		12	Low	Medium	Medium	Medium	Medium	High	Yes	• Localised but serious problem when occurs. • Do we understand reasons why infestations occur?
Root Rots		13	Medium	Medium	Medium	Medium			No	• Serious in wet years and young vineyards with over-watering. • Can't see under ground so not as noticeable.

Some general points from the above comments are:

- **Group A**
  - *Powdery Mildew*: Most of the R&D will be carried out by the chemical companies. The grower needs are still related to application technology with some extension work necessary.
  - *Downy Mildew*: Similar comments to Powdery Mildew above. Timing is critical for effective control. Monitoring of weather and infection periods is critical. Cropwatch is a good model.
  - *Botrytis*: R&D on new product development by chemical companies. Extension work is needed on timing and spraying applications. Development of resistance to chemicals is a constant issue.

- **Group B**
  - Some of these pests and diseases have cross industry relevance (birds, nematodes, LBAM, virus) so collaborative R&D work between industries would be useful and capacity building of agencies should be more achievable.
  - *LBAM*: Some market access issues with crops other than winegrapes.
  - *Nematodes*: Rootstock research and nematode research and identification capacity must be maintained in agencies.
  - *Viruses*: Testing and identification capacity needs to be maintained.
  - *Birds*: Cross industry problem.
  - *Trunk Diseases*: Prevention easier than cure but plantings of the last 15 years are just showing problems.
- **Group C**
  - *Garden Weevil, Trunk Borers*: Localised problems but need for solutions at local level.
  - *Phylloxera*: Agency capacity must be maintained.

The substantial RD&E funding by GWRDC on the Group A diseases has greatly increased the knowledge and understanding of Powdery Mildew, Downy Mildew and Botrytis and Other Bunch Rots. The effective extension of the existing R&D findings to industry for the control of these diseases may provide additional economic benefits to industry by reducing the number of spray applications, or making them more effective by the use of better spray application technology.

There is still a need for continued research on these diseases to ensure that new chemical and other control measures are evaluated and assessed but with pests that have been well researched for many years, the returns on new R&D investment can often diminish as the knowledge base increases.

The Project Team believes that there are still substantial industry gains to be made by the use of pest and disease warning systems (eg. CropWatch example), vineyard monitoring of the early stages of pest and disease development and the better understanding of spray application technology. The three key components of good pest and disease control are:

- Selection and use of the most effective chemical;
- The best timing for control.
- The most efficient application technology that covers the vine and does not waste chemical.

If any one of these components is inadequate, the risk of damage, economic loss, and extra production costs increase greatly.

Given the dwindling commitment of agencies to maintain "in-house" expertise or provide extension support, the industry has a greater need for self sufficiency. Perhaps a review of the specialist services and expertise available to the grape and wine industry would highlight the gaps (as the citrus industry has done) and provide a targeted plan to ensure specialist expertise and services are maintained.

7 IMPLICATIONS FOR GWRDC

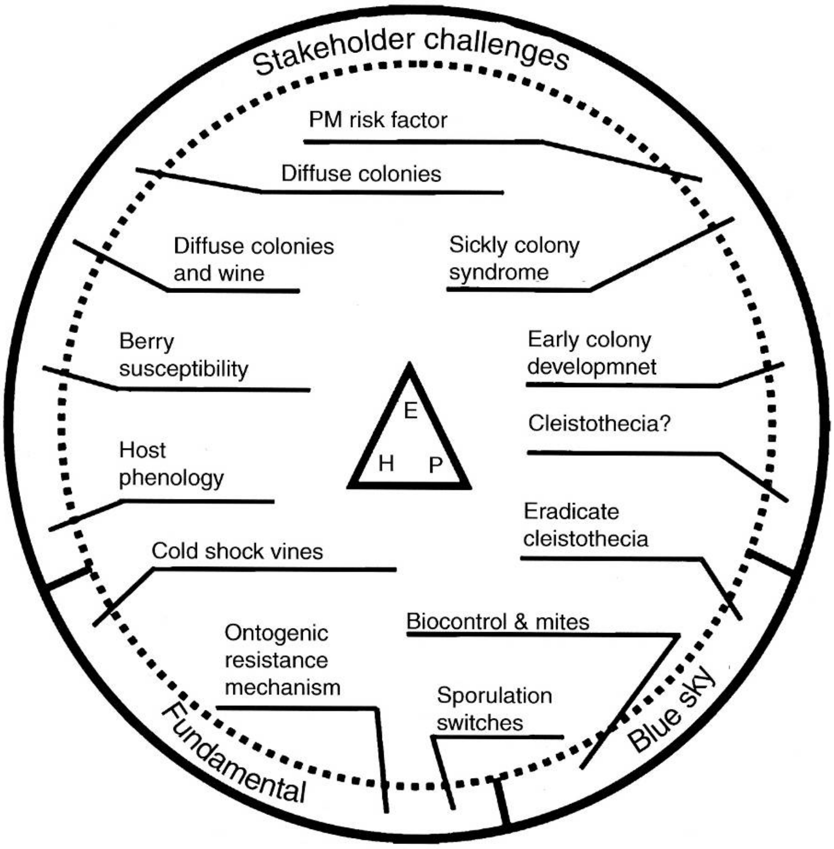
7.1 RD&E for Pests & Diseases: An Overseas Example

A recent paper by Seem and Gadoury (2010) presents an interesting discussion on the transfer of research results to growers using Powdery Mildew research in the NE production regions of the USA as an example. The authors use the term “translation” rather than extension, outreach or technology transfer because they perceive the process as converting “science speak” to something more understandable to grape growers.

Figure 32, reproduced from the Seem and Gadoury paper, shows the research projects carried out in the NE USA over 30 years related to one or more of the stakeholder (grower) challenges, the fundamental (basic) research and the “blue sky” research.

Figure 32 : A diagrammatic representation of the relationships between research projects, stakeholder challenges, fundamental research & “blue sky” research

(Source: Seem & Gadoury, 2010)



Some of the lessons learned from their research over 30 years on Powdery Mildew apply equally to the broader pest and disease issues identified in this report. These include the following:

- Understand that growers and field specialists are a rich source of practical knowledge;
- Be observant, look at the big picture but keep an eye open for a chance observation or odd result you may encounter;
- Know the grapevine and how other pests and diseases affect the vine;
- Collaborate with scientists and industry to strengthen research programs; and
- Train the next generation of researchers in the technology of research and the translation of research results to growers.

These lessons apply to the Australian industry as well as that in USA. An enthusiastic and clever research community that has an understanding of the needs of grape growers and can “translate” their research to meaningful solutions for growers’ pest and disease problems will ensure that the Australian winegrape industry is well supported technically with GWRDC and other funding support.

7.2 Findings from the Present Project

7.2.1 Summary

The analysis of the economic impact of pests and diseases on the Australian winegrape industry (Section 5) provided a ranking of impact that closely matched the industry ranking determined by a grower survey and industry workshop (Table 57).

The ranking of the GWRDC investment in RD&E on pests and diseases from 1993/94 to the present did not match the economic impact ranking as well as did the current industry ranking.

This does not reflect on the past funding decisions of GWRDC as the industry priorities would have changed over the 16 year period of GWRDC investment. In addition, there is a need for GWRDC to not just invest in current issues facing the winegrape industry but to support some “blue sky” research as well as research on strategic management of pests and diseases like Phylloxera that would have catastrophic consequences if they were not contained by vigilant quarantine, grower awareness and technical capability programs.

7.2.2 Implications

Pest and disease RD&E funding must have a balance between basic research, applied research and the extension of research findings in a practical way to grape growers. Not all of these RD&E activities have immediate economic impacts for the grape industry but some are still very important for the industry, particularly those which address pests and diseases with high potential economic impact. Examples include:

- Phylloxera is a critical risk to Australian viticulture because only a small proportion of vineyards are grafted on rootstocks that have resistance to phylloxera. Most vineyards are therefore susceptible to Phylloxera. Monitoring, vineyard surveillance, grower awareness, and quarantine are all critical to the management of phylloxera. In addition, technical research capability must be maintained in RD&E agencies to ensure that in the (almost certain) event of future outbreaks of phylloxera, specialists are available to advise on the best course of action for the industry (see Case Study, page 87).

- Grapevine viruses and transmissible diseases can affect the productivity of vineyards. They are mainly spread by planting vines produced with cuttings taken from already infected vines. Control is not possible once a vine is infected. Clean planting material is the only way to reduce the economic impact of virus diseases. The technology of the testing of vines for viruses and the rapid expansion of knowledge of viruses using new scientific methods requires that specialist scientific staff are available in Australia to maintain a national capacity in grapevine viruses research and testing capacity.

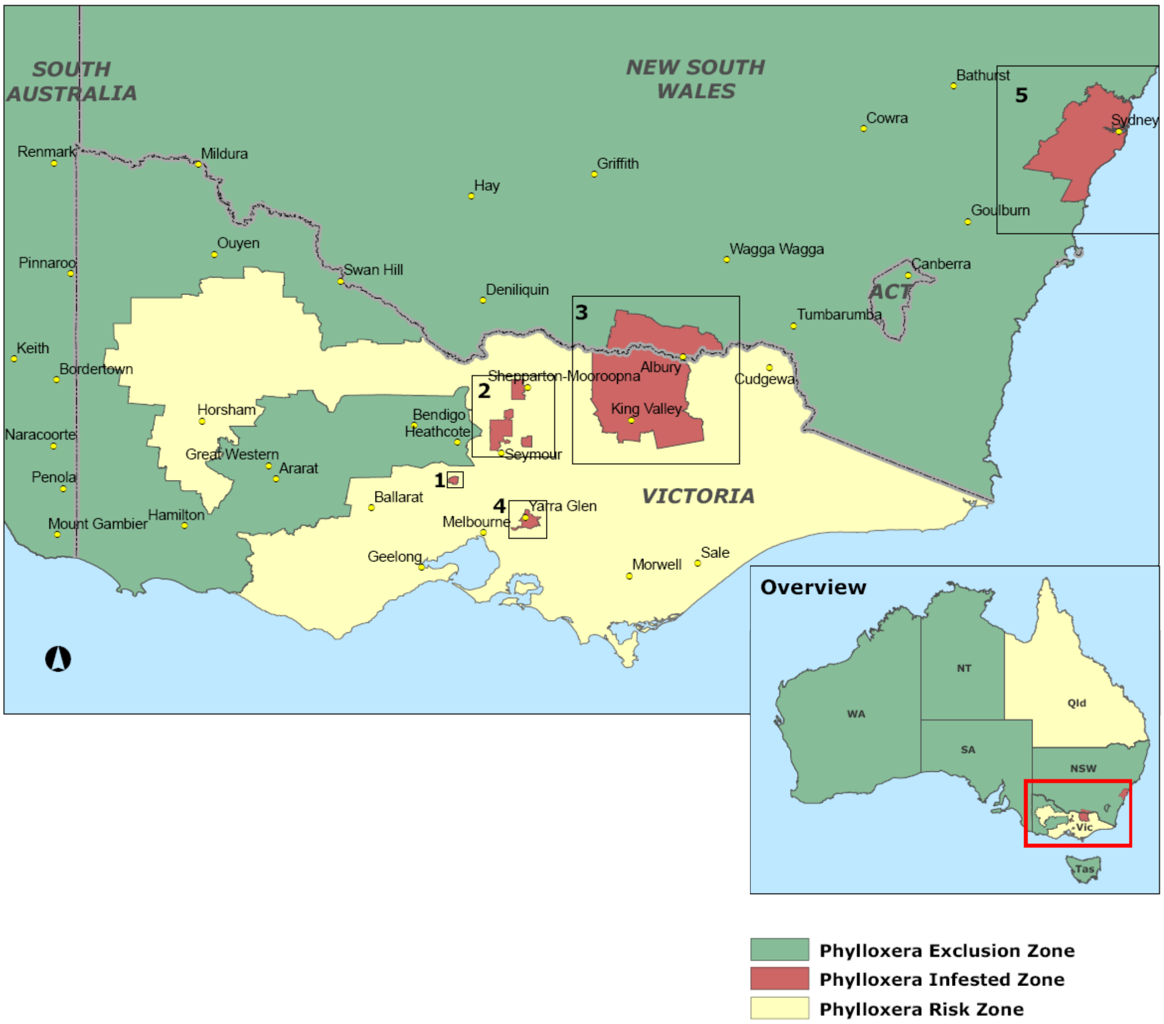
PHYLLOXERA HISTORY AND RD&E INVESTMENT – CASE STUDY

RD&E expenditure by GWRDC since 1993 on Phylloxera has been $2.9m, comparable with that on Powdery Mildew ($3.35m), Trunk Diseases ($3.0m), Botrytis ($2.9m). In this report Phylloxera ranked 10th in National Economic Impact and this warranted comment on the significance of Phylloxera in the Australian industry.

History

- Phylloxera is a native of North America and was introduced to Europe and most other grape growing regions in the mid 1800s where it spread in vineyards of *Vitis vinifera* which have no resistance to Phylloxera.
- In 1877 Phylloxera was detected in Australia in Victoria and near Sydney and it decimated the Victorian wine industry in the 1880s.
- Vineyards in regions where Phylloxera is present must be planted on resistant rootstocks. The Rutherglen (NE Victoria), Corowa (NSW) areas have lived with Phylloxera for many years by the use of rootstocks and quarantine/vineyard hygiene.
- South Australia imposed a total quarantine ban on grapevine material in the late 1800s and other regions had similar restrictions.
- With the expansion of grape growing across Australia and the increased movement of grapes for crushing, vineyard machinery, workers and winery personnel between vineyards in different regions the risk of Phylloxera spread has increased and in Victoria new outbreaks outside the quarantine zones have occurred in the King Valley, Seymour/Shepparton, Yarra Valley, Whitebridge and very recently Mansfield. Clearly the threat of Phylloxera spread elsewhere in Australia is real and as it can take several years for symptoms of infestation on vines to become evident, Phylloxera can be well established before it is known to be present.
- The Australian grape and wine industry needs to be ever vigilant and RD&E agencies, industry groups like the Phylloxera and Grape Industry Board SA and quarantine agencies all have important roles in monitoring, managing, conducting research, maintaining research capacity, and reviewing grower awareness campaigns.
- The map of Phylloxera Management Zones below shows the relatively small area affected by Phylloxera and its concentration mainly in the grape growing zones of northern Victoria and southern NSW.
- The low National Economic Impact in Section 5 of this report and the low priority based on this impact (Table 57) should not lead to complacency about Phylloxera and the need for vigilance.
- The industry cost when resistance of the main rootstock used in California for Phylloxera collapsed and large areas of vineyard need to be replanted on more resistant rootstocks is a lesson that Australia needs to heed.
- Therefore the level of funding for Phylloxera by GWRDC, other government agencies and industry is still necessary for the Australian grape and wine industry to be supported by resources with the expertise and capacity to respond to further outbreaks of Phylloxera.

Map of Phylloxera management zones of Australia (Source: PGIBSA)



- Some pests and diseases can be severe but localised in their impact (Garden Weevil in WA, Trunk Borers in the Hunter Valley and Langhorne Creek, Birds, etc) but the national impact is low. Some RD&E funding is warranted at the local level but the risk of spread to other regions warrants investment in RD&E to be ahead of future problems, rather than having to catch up if the problem expands.
- "Blue sky" RD&E can generate useful information for understanding pests and diseases and a proportion of investment is warranted in this research.

The difficulty in priority setting and investment decisions in RD&E when funded by industry levies and matching federal funds, is that the immediate issues facing growers demand attention and the scientific capacity of the agencies is often only appreciated when a new problem emerges. The need for preparedness (capacity, capability and regulatory framework) to cope with new problems by agencies, industry and GWRDC is important but inadequately recognised. Clearly, GWRDC has an industry leadership role in striking a balance between these competing interests for RD&E funding.

SCHOLEFIELD ROBINSON
HORTICULTURAL SERVICES PTY LTD

23rd March 2010

PB SCHOLEFIELD
Principal Consultant/Director
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Appendix 1

Expression of Interest for Assessment of Economic Cost of Endemic Pests and Diseases on the Australian Grape and Wine Industry

Australian Government
Grape and Wine Research and Development Corporation

EXPRESSIONS OF INTEREST SOUGHT:

ASSESSMENT OF ECONOMIC COST OF ENDEMIC PESTS AND DISEASES ON THE AUSTRALIAN GRAPE AND WINE INDUSTRY

Background

The Grape and Wine Research and Development Corporation (GWRDC) intend to commission a project to assess the economic impact of endemic pests and diseases on the Australian Grape and Wine industry. The purpose of this document is to outline the scope of the project for parties interested in conducting this work.

Proposed Scope of Project

The purpose of the project is to estimate the costs of the major endemic pest and diseases of viticulture in Australia in order to provide current data on the absolute and relative costs of the major diseases to the grape and wine industry.

The objectives of the project are outlined below:

1. Collation of a list of endemic diseases considered to significantly impact on the productivity of wine grape producers in Australia.
2. Collation of all available contemporary estimates of the per annum economic impact of these diseases on the profitability of Australian wine grape producers. This should include costs associated with reduced productivity, disease prevention and treatment of clinical cases. Where no previous estimates are available this should be identified. Some of these deficiencies will be for new emerging diseases, for which it is difficult to quantify probable losses, and this should be highlighted.
3. Assessment of these previous estimates to determine which are still valid and which are no longer current and require re-estimation. The limitations of any estimates considered still valid should also be highlighted. Consideration should also be given to the need to remodel estimates for all diseases using consistent methodology.
4. Development of new per annum economic estimates for a subset of diseases where previous estimates are no longer considered valid, or where previous estimates are not available. Diseases to be remodelled are those where economic impacts are likely to be greatest. These will be selected in consultation with relevant stakeholders. If possible, the modelling should indicate where profitability losses are occurring (e.g. through production losses, treatment costs).
5. A qualitative assessment of how research investment on a specified list of pests and diseases might result in largest return, for example through new prediction models, new control options, improved extension of current control recommendations, or a combination of these.
6. The results of the Review will be made available to stakeholders of GWRDC, WGGA, WFA, as well as the participating Research Organisations.

Tasks to be performed:

The successful applicant(s) will be expected to:

- Work with GWRDC staff with respect to project outputs, participation, methodology and outputs.
- Set up a workshop that will engage the key scientific and industry representatives actively working on the pests and diseases considered for this study with a view to obtaining the latest economic estimates and any other information required for the analysis. This will include at least the following tasks:
  - Identifying appropriate industry participants
  - Organising the attendance of participants at the workshop
  - Facilitating the workshop
  - Documenting the outcomes of the workshop
- In the reporting phase, the consultant(s) will provide a draft report and give a presentation to staff at the GWRDC including progress and providing recommendations.
- After the GWRDC has received the initial report, the consultant(s) will then incorporate relevant comments into the final report.
- It is envisaged that the final report will be submitted to the GWRDC by the end of October 2009.

Due Date for Expressions of Interest

Expressions of interest marked ‘Confidential’ to be submitted by 17 April 2009 to:

Troy Fischer
R&D Program Manger
Grape and Wine Research and Development Corporation
PO Box 221
Goodwood SA 5034

- Project Team to be appointed based on experience, quality of the proposed project and ability to deliver the project within the suggested timeframe.
- Budget for the project has not been disclosed, however, value for money is one of the factors assessed based during the EOI process.
- Timeline for the project is commencement 1 May 2009 and for completion by 31 October 2009.

All enquiries to:

Troy Fischer
R&D Program Manager
08 8273 0500
Email: troy@gwrdc.com.au

Appendix 2

Issues Paper, Workshop Agenda, Survey Questionnaire and Survey Outcomes Presentation

ISSUES PAPER

Basis for Workshop Discussions

3rd August 2009

Assessment of Economic Costs of Pests and Diseases

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1 INTRODUCTION & BACKGROUND

1.1 Proposed Scope of Project

The purpose of the project is to identify the most costly pests and diseases of wine grape production. The Workshop is designed to acquire current cost estimates from a range of sources and wine zones in Australia, for management of the major endemic pest and diseases of viticulture in Australia.

The objectives of the project are outlined below:

1. Collation of a list of endemic diseases considered to significantly affect the productivity of wine grape producers in Australia.

2. Collation of all available contemporary estimates of the per annum economic impact of these pests and diseases on the profitability of Australian wine grape producers. This should include costs associated with reduced productivity, disease prevention and treatment of clinical cases. Where no previous estimates are available this should be identified. Some highlighted deficiencies will be for new emerging diseases, for which it is difficult to quantify probable losses.

3. Assessment of previous estimates to determine which are still valid and which are no longer current and require re-estimation. The limitations of estimates considered still valid should be highlighted. Consideration should also be given to the need to remodel estimates for all pests and diseases using consistent methodology.

4. Development of new per annum economic estimates for a subset of pests and diseases where previous estimates are no longer considered valid, or where previous estimates are not available. Pests and diseases to be remodelled are those where economic impacts are likely to be greatest. These will be selected in consultation with relevant stakeholders. If possible, the modelling should indicate where profitability losses are occurring (eg: through production losses, treatment costs, etc).

5. A qualitative assessment of what type (eg. research, development, extension) of future investments are needed and which are likely (on a specified list of pests and diseases) to result in largest returns (eg: new prediction models, new control options, improved extension of current control recommendations, or a combination of these).

6. The results of the Review will be made available to stakeholders of GWRDC, WGGA, WFA, as well as the participating research provider organisations.

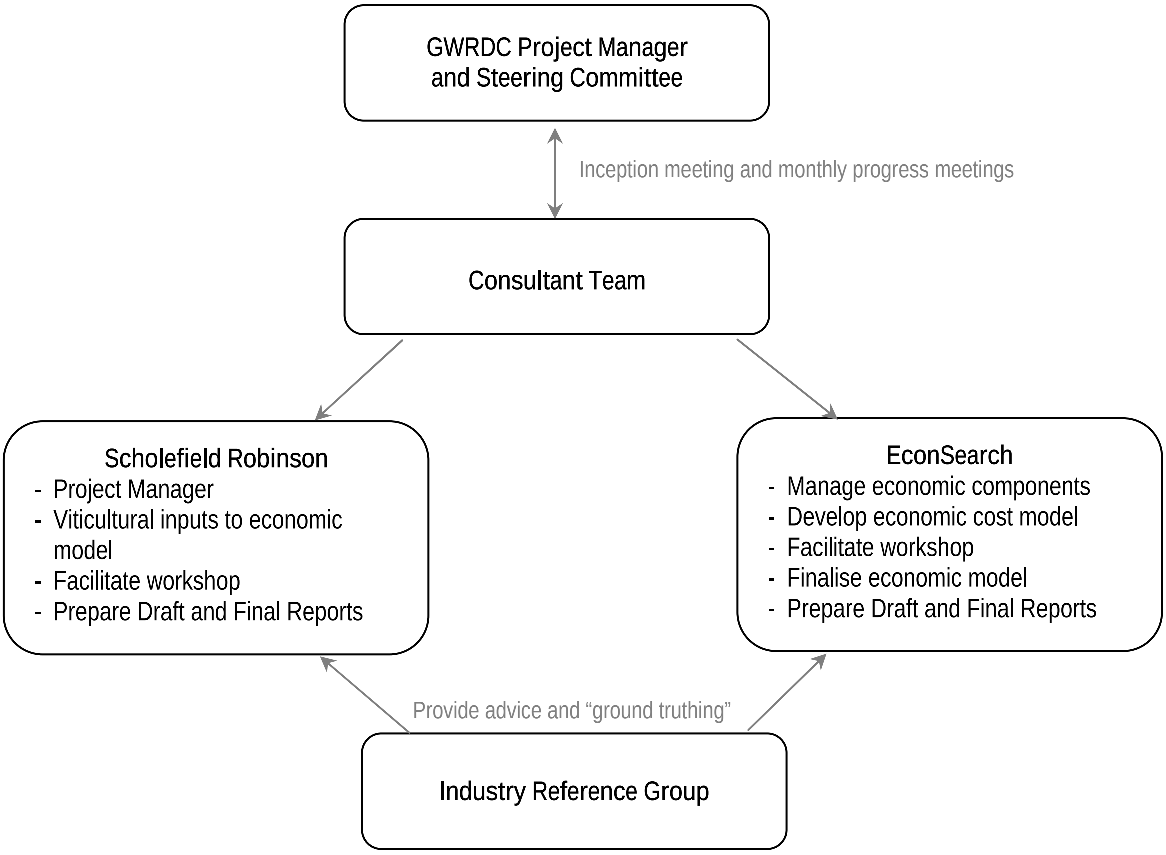
1.2 Project Team

The Project Team is made up of Scholefield Robinson and EconSearch consultants with an Industry Reference Group providing industry inputs.

Scholefield Robinson	EconSearch	Industry Reference Group
Peter Scholefield	Julian Morison	Richard Hamilton (Fosters)
Prue McMichael	Matt Ferris	Vic Patrick (Grapegrower)
Charles Drew		Hugh Armstrong (Bayer CropScience)
Adrian Loschiavo		David Paxton (Grapegrower/Consultant)

Figure 1 shows the interactions between the GWRDC Steering Committee, the Consultant Team and the Industry Reference Group.

Figure 1 : Structure of team and responsibilities



2 DIVIDING THE AUSTRALIAN WINE INDUSTRY INTO MANAGEABLE ZONES FOR PEST & DISEASE ASSESSMENT

For consistency in describing the wine areas for use in this project the Australian Wine Zones described by the Australian Wine and Brandy Corporation will be used (Table 1 and Figure 2). These zones are further divided into Regions and Sub-Regions but we ask you to use the wine zone names only when providing input and answering the survey.

Figure 2 shows the location of the wine zones and Table 1 presents the ABS 2008 winegrape production for these wine zones to provide an indication of their industry significance.

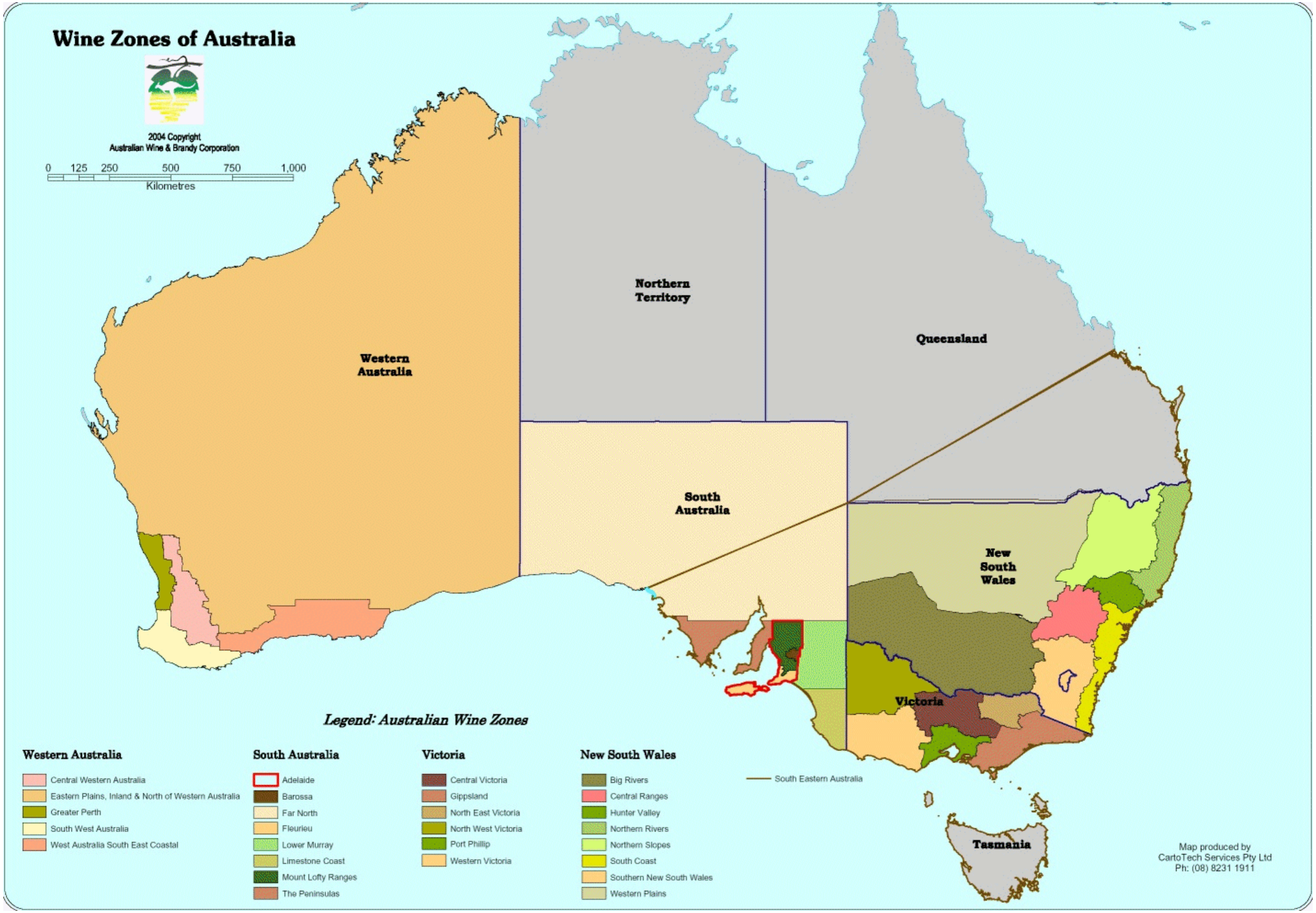
Big Rivers (NSW), North West Victoria (Vic) and Lower Murray (SA) collectively made up almost 60% of the Australian winegrape production in 2008.

Table 1 : 2008 Vintage Winegrape Production for Australian Wine Zones

Wine Zone	Winegrape Production (t) 2008
NSW	
Big Rivers	422,324
Western Plains	3,425
Central Ranges	63,603
Southern NSW	15,406
South Coast	1,468
Northern Slopes	1,398
Northern Rivers	213
Hunter Valley	28,152
Total	535,989 (29.1%)
VICTORIA	
North West Victoria	286,547
North East Victoria	28,738
Central Victoria	41,881
Western Victoria	6,095
Port Phillip	30,454
Gippsland	837
Total	394,552 (21.5%)
SOUTH AUSTRALIA	
Mt Lofty Ranges	70,175
Barossa	89,309
Fleurieu	133,372
Limestone Coast	131,643
Lower Murray	383,437
The Peninsulas	316
Far North	861
Total	809,113 (44.1%)
WESTERN AUSTRALIA	
Greater Perth	9,061
Central WA	341
Southwest Australia	72,682
WA SE Coastal	82
Eastern Plains Inland & North of WA	30
Total	82196 (4.5%)
TASMANIA	
Total	10,749 (0.6%)
QUEENSLAND	
Total	3,307 (0.2%)
AUSTRALIA	
Total	1,835,906

Source: ABS Publication 1329.0

Figure 2 : Map of Wine Zones of Australia



The production zones have been climatically ranked using Mean January Temperature (MJT), an index well correlated with degree days (Smart and Dry 1988) and rainfall from October to March. Rainfall during the growing season can influence the incidence of some pests, leaf and bunch diseases (Table 2).

MJT across the zones ranges from a high of 26.8°C for the NSW Western Plains zone to 16.7°C for the Tasmania zone. For simplicity we have combined the MJT of zones into groups of;

MJT >23ºC (Hot)

MJT 21ºC to 23ºC (Warm), and

MJT <21ºC (Cool)

Wine zones have been further characterised by their respective rainfall. "Wet" zones are those with >300 mm rainfall and "Dry" zones have <300 mm rainfall during the growing season (October – March). Rainfall information is also presented in Table 2.

Table 2 : Australian Wine Zones Climatically Ranked

Wine Zone	State	Mean January Temperature (MJT) Range (°C) [a]		Growing Season (Oct-Mar) Rainfall (GSR) (mm) [b]	
MJT >23°C (based on max of range)	HOT				
Western Plains	NSW	N/A	26.8 [c]	251 [d]	N/A
Central WA	WA	21.9 [c]	25.8 [c]	88 [d]	125 [d]
Eastern Plains, inland and north of WA	WA	N/A	25.8 [c]	105 [d]	N/A
Greater Perth	WA	23.7	24.5	123	129
Big Rivers	NSW	23.4	23.9	133	192
Hunter Valley	NSW	23.7	23.7	436	436
North West Vic.	VIC	23.4	23.6	133	153
Southern NSW	NSW	20.1	23.6	298	425
Queensland	QLD	21.5	23.5	488	542
Central Ranges	NSW	19.6	23.5	317	468
Northern Rivers	NSW	23.4	23.4	721	721
North East Vic.	VIC	20.4	23.3	262	375
Lower Murray	SA	23.2	23.2	113	113
Far North	SA	23.1	23.1	160	160
MJT 21 - 23°C	WARM				
Northern Slopes	NSW	22.8	22.8	525	525
South West WA	WA	19.3	22.8	168	240
Mt Lofty Ranges	SA	18.7	22.4	155	329
Central Vic.	VIC	19.2	21.6	224	358
Fleurieu	SA	19.4	21.4	164	204
Barossa Valley	SA	19.3	21.2	163	183
MJT <21°C	COOL				
WA South East coastal	WA	N/A	20.9 [c]	180 [d]	N/A
The Peninsulas	SA	N/A	20.7 [c]	107 [d]	N/A
South Coast	NSW	19.4	20.9	498	639

Wine Zone	State	Mean January Temperature (MJT) Range (°C) [(a)]		Growing Season (Oct-Mar) Rainfall (GSR) (mm) [(b)]	
Western Vic.	VIC	17.7	20.8	216	285
Limestone Coast	SA	18.3	20.3	167	188
Port Phillip	VIC	18.5	19.8	248	375
Gippsland	VIC	19	19	361	361
Tasmania	TAS	16.7	17.7	290	372

KEY

Dry <300mm GSR

Wet >300mm GSR

(a) MJT range from Dry, P & Maschmedt, DJ, *et al.* (2004) *The grapegrowing regions of Australia* in 'Viticulture Volume 1 : Resources' (eds Coombe & Dry), Winetitles, Adelaide, pp 17-55. The lowest and highest MJT value from each wine zone is presented as the MJT range.

(b) GSR range is sourced from Dry & Coombe (2004).

(c) MJT figures included are for a single BOM station in these zones (range not available from Dry & Coombe (2004)).

(d) GSR figures included are for a single BOM station in these zones (range not available from Dry & Coombe (2004)).

3 STRATEGIES FOR MANAGING PESTS & DISEASES

A wide range of strategies are available to grapegrowers to manage pests and diseases in vineyards. They range from "avoidance" (eg: planting virus-tested vines, grafting on rootstocks), to "control" (eg: regular spraying with fungicides or insecticides). IPM methods combine cultural, biological and chemical strategies where natural predators are encouraged and control treatments are only applied when necessary in a way that does not interfere with natural predators.

Examples are presented in Table 3 and these will be a useful guide for the survey questionnaire (attached). In some cases, no pest and disease control options are available.

Table 3 : Examples of Pest and Disease Management Strategies

Pre-plant	Post-plant
Cultural Methods	
• Plant certified vines with virus-tested status.	• Monitor P&D in vineyard and understand life cycles.
• Hot water treatment of vines to minimise risk of nematode introduction.	• Manage canopy with shoot thinning or trimming to increase air flow.
• Install a trellis system that allows good air flow through vine canopy to reduce disease development.	• Irrigation and nitrogen management to reduce excessive vigour in canopy.
• Use varieties with more resistance to P&D in high risk areas (eg: powdery mildew – some varieties much worse than others).	• Control weeds undervine to reduce humidity.
Biological Methods	
• Apply organic matter and incorporate before planting to increase soil fertility and biological activity.	• Manage vegetation on vineyard floor to provide habitat for beneficial insects (selection of species, mow alternate rows, etc).
• Plant bio-fumigant cover crop (brassica, etc) for suppression of soil pathogens.	• Apply organic compost, mulch to enhance soil biological activity and fertility.
• Avoid soil cultivation or disturbance unless absolutely necessary.	• Those using organic/bio-dynamic systems will add acceptable biological products to soils and vines.

<table>
<tr><th>Pre-plant</th><th>Post-plant</th></tr>
<tr><td colspan="2">Chemical Methods</td></tr>
<tr><td>Fumigation prior to planting to destroy P&D (nematode, soil pathogens).
However fumigation usually non-selective and destroys “good” as well as “bad” organisms.</td><td>Regular application of approved chemicals to vines for control of P&D (eg: powdery mildew, botrytis etc).
Avoid spray drift.
Soil treatments for P&D can be applied using injection into drip irrigation system (difficult to treat all of rootzone).</td></tr>
<tr><td colspan="2">Sometimes Control Not Possible</td></tr>
<tr><td colspan="2">With some P&D, if they are found in a vineyard it is too late to control them other than by replanting
If viruses, crown gall, etc are found they cannot be eliminated other than by replanting.
Eutypa dieback or other trunk diseases cannot be eliminated when well established but if found in early stages, the vine can be cut back to remove infected parts of cordon or trunk.
A phylloxera infestation of a vineyard cannot be treated in any way other than replanting the vineyard with phylloxera resistant/tolerant rootstocks.
A way to minimise the impact of these “non-treatable” pests and diseases is to manage the vines with irrigation and nutrition programs to ensure stress is minimised.</td></tr>
</table>

4 GENERAL COMMENTS

We need your comments on your experiences and observations on the incidence of pests and diseases within your vineyard or wine zone.

Attached is a survey questionnaire that we ask you to complete and email back to us by **27th July 2009** so we can collate prior to the workshop on 3rd August, 2009. We prefer to receive the survey questionnaire electronically but if you are unable to do this, please return by fax or post. Detailed instructions on how to complete the survey questionnaire are included in the attached Excel file.

The survey questionnaire is divided into three parts:

1. Contact Information (Name, contact details and the wine zone that your comments apply to).

2. Pest and disease infestation and management (we need your opinion on the way all pests and diseases affect your vineyard and how you manage them).

3. Impact on vineyard income and costs (Indicate the three main pests and diseases that cause you greatest concern or economic impact on your vineyard or wine zone. If possible, provide us with an estimate of any yield losses, quality reduction, increases in operating expenses or additional capital required for treatment for each selected pests or disease).

The information on the impact and costs is required to provide meaningful inputs to the economic model.

You are also encouraged to bring any pest and disease control costs along to the workshop.

5 DEADLINES

Please return the survey questionnaire to Adrian Loschiavo:

By Email srhs@srhs.com.au

Or Fax: (08) 8373 2442

Or Mail Scholefield Robinson Horticultural Services Pty Ltd
PO Box 650
FULLARTON SA 5063

By 27th July 2009

Thanks for your interest and cooperation.

SCHOLEFIELD ROBINSON
HORTICULTURAL SERVICES PTY LTD

PB SCHOLEFIELD
Principal Consultant/Director
F:\SRHSDATA\Clients\GWRDC\P&D 0509\Issues Paper\Rpbs160709IssuesPaper.doc

Appendices

Appendix 1 Survey Questionnaire

GWRDC Project "Assessment of Economic Cost of Endemic Pests and Diseases on the Australian Grape and Wine Industry"

survey form instructions

PLEASE COMPLETE ALL 3 PARTS OF THIS SURVEY BY MONDAY 27th of JULY 2009 AND EMAIL TO:
srhs@srhs.com.au

If you are unable to email this form please return a hard copy to:

Adrian Loschiavo
Scholefield Robinson Horticultural Services Pty Ltd
PO Box 650, FULLARTON SA 5063

Or Fax: (08) 8373 2488

This form is designed for use in Microsoft Excel 2003 or 2007. If you have an earlier version of Excel some of the features of this survey may be unavailable.
For more help on completing this survey please phone Adrian Loschiavo on (08) 8373 2488

This survey is brief and should only take 10 minutes to complete

Part 1 : Type your contact information into the relevant boxes. Select the 'wine zone' from the drop down list that your information relates to, ie. your vineyard location or the wine zone you work in most frequently.

Part 2 : For each pest and disease listed, indicate the relevance to your vineyard or your recent experiences with the pest or disease. If the pest or disease is of concern, indicate how the pest or disease is managed.

Part 3 : Select the three pest or diseases that cause YOU most concern or greatest economic loss in your wine zone. For your selected three, indicate how they cause economic loss or additional costs. If possible, detail the loss &/or costs (approximates are still useful) caused by the pest or disease.

Each part of the survey is on a separate worksheet.
CLICK ON PART 1, PART 2 & PART 3 BUTTONS BELOW TO START COMPLETING THIS SURVEY

Go to PART 1 | Go to PART 2 | Go to PART 3

Go to PART 2 | Go to PART 3 | Instructions

contact information

First Name		Surname			
Company Name					
Postal Address					
Suburb		State		Postcode	
Phone		Fax			
Email					

Which zone does your information refer to? (select from drop-down list below)

For more information on Wine Zones, refer to Figure 2 : Map of Wine Zones of Australia on page 4 of the Issues Paper.

Please complete PART 1, PART 2 and PART 3 of this survey form by following the link below. Each part of the form is on a separate worksheet.

NEXT

Click Here to go to PART 2

PART 2 : infestation & management

Click on the radio buttons or tick boxes to make your selections

Pest or Disease Name	What is the frequency of the problem?					Stage at which vineyard is affected		How is the pest or disease managed?			
	Never	Seasonal (new infection each season) eg Powdery Mildew		Ongoing Presence (within plant or soil) eg virus							
		Every Year	Sporadic	Can't Eradicate	Can Eradicate	Development 0- 3 Years	Mature > 3Years	Cultural Examples	Biological Examples	Chemical Examples	No Action Examples

Click on a button below to select one option for each pest and disesase

Click to select one option

Click to select one or more options

1. DISEASES

1.1 FUNGUS

Pest or Disease Name	Never	Every Year	Sporadic	Can't Eradicate	Can Eradicate	Development 0- 3 Years	Mature > 3Years	Cultural	Biological	Chemical	No Action
Botrysphaeria											
Black spot (anthracnose)											
Bunch rot (other)											
Eutypa dieback											
Petrie disease (Pch + Pal)											
Phomopis											
Phytophthora root rot											
Root rot (other)											
Verticillium Wilt											
Botrytis bunch rot											
Downy mildew											
Powdery mildew											

1.2 BACTERIA

Pest or Disease Name	Never	Every Year	Sporadic	Can't Eradicate	Can Eradicate	Development 0- 3 Years	Mature > 3Years	Cultural	Biological	Chemical	No Action
Crown Gall											

1.3 TRANSMISSIBLE/VIRUS

Pest or Disease Name	Never	Every Year	Sporadic	Can't Eradicate	Can Eradicate	Development 0- 3 Years	Mature > 3Years	Cultural	Biological	Chemical	No Action
Fanleaf virus											
Grapevine yellows											
Leafroll virus											
Other virus											

2. PESTS

2.1 INSECT PESTS

Garden weevil	○	○	○	○	○	○	○	☐	☐	☐	☐
Grapevine moth	○	○	○	○	○	○	○	☐	☐	☐	☐
Grasshoppers	○	○	○	○	○	○	○	☐	☐	☐	☐
Insects (trunk boring)	○	○	○	○	○	○	○	☐	☐	☐	☐
Lightbrown apple moth	○	○	○	○	○	○	○	☐	☐	☐	☐
Mealybugs	○	○	○	○	○	○	○	☐	☐	☐	☐
Other moth or grubs	○	○	○	○	○	○	○	☐	☐	☐	☐
Phylloxera	○	○	○	○	○	○	○	☐	☐	☐	☐
Scale	○	○	○	○	○	○	○	☐	☐	☐	☐

2.2 MITES

Other mites	○	○	○	○	○	○	○	☐	☐	☐	☐
Bud mite	○	○	○	○	○	○	○	☐	☐	☐	☐
Bunch mite	○	○	○	○	○	○	○	☐	☐	☐	☐

2.3 NEMATODE

Other nematode	○	○	○	○	○	○	○	☐	☐	☐	☐
Root-knot nematode	○	○	○	○	○	○	○	☐	☐	☐	☐

2.4 OTHER PESTS

Birds	○	○	○	○	○	○	○	☐	☐	☐	☐
Snails	○	○	○	○	○	○	○	☐	☐	☐	☐

PART 3 : impact on vineyard income, costs & profitability

Which are your top 3 pests or diseases of concern or that cause you greatest economic loss/cost?

Pest or Disease Name	Reduced yield	Reduced quality	Additional operating cost (eg labour for spraying)	Additional capital cost (eg. rootstocks, heat treated planting material)	No treatment available
Click on the drop down lists below to select your top 3 pests or diseases of concern	*Click on the tick boxes to select any of thsese options*				
1	☐	☐	☐	☐	☐
2	☐	☐	☐	☐	☐
3	☐	☐	☐	☐	☐

For the same 3 pests or diseases you selected above, comment below on how the pest or disease impacts on vineyard income or costs.

Pest or Disease Name	Reduced yield (T/ha)	Price penalty due to reduced quality ($/T)	Additional operating cost	Additional capital cost	No treatment available
Click on the drop down lists below to select the same 3 pests or diseases as above	*Type your comments into the boxes below*				
eg. Powdery Mildew	*eg. 1t/ha*	*eg. Winery penalty $100/t*	*eg. 7 sprays per season @ $/application*	*eg. Extra machineray & overhead expenses*	
Pest or Disease 1					
Pest or Disease 2					
Pest or Disease 3					

"Assessment of Economic Cost of Endemic Pests and Diseases on the Australian Grape and Wine Industry"

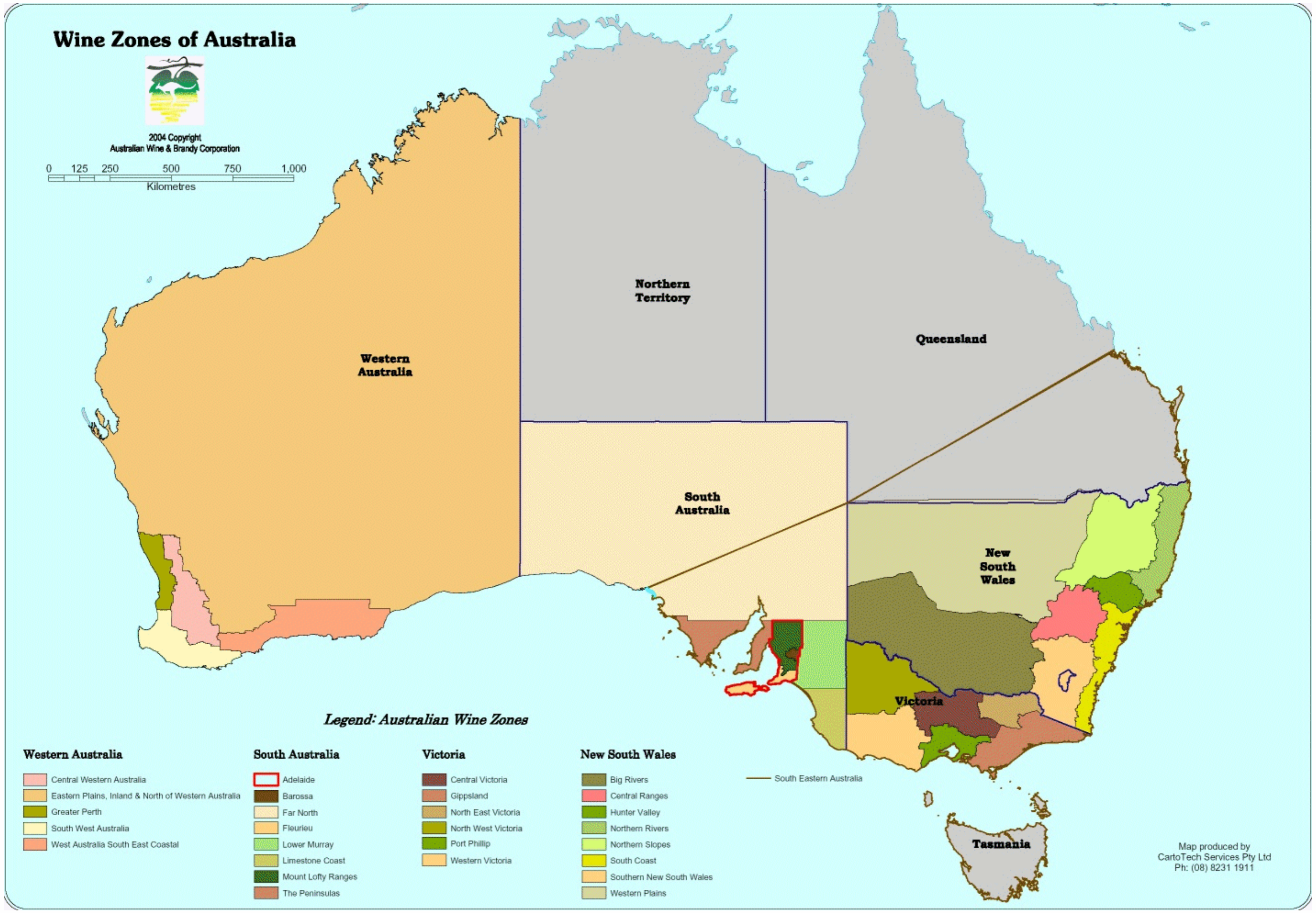
Survey outcomes

Presented by Adrian Loschiavo
Consultant

Presentation Overview

- Climatic zones
- Pest and disease list
- Survey results

Wine Zones of Australia



Basis of ‘Climatic Zones’

Mean January temperature (°C)

- MJT is well correlated with degree days (Smart and Dry, 1980)
- Allocation based on maximum of MJT range
- Divided into three temperature ranges
  – MJT > 23°C = Hot
  – MJT 21 - 23°C = Warm
  – MJT < 21°C = Cool

Growing season rainfall (mm)

- GSR from October to March
- Divided into two rainfall ranges
  – <300 mm = Dry
  – >300 mm = Wet

Climatic Zones

	MJT >23ºC (Hot)	MJT 21 - 23ºC (Warm)	MJT <21ºC (Cool)
Wet >300 mm	Central Ranges, NSW	Northern Slopes, NSW	South Coast, NSW
Wet >300 mm	Hunter Valley, NSW	Central VIC	Gippsland, VIC
Wet >300 mm	Southern NSW	Mt Lofty Ranges, SA	Port Phillip, VIC
Wet >300 mm	Northern Rivers, NSW		Western VIC
Wet >300 mm	North East VIC		Limestone Coast, SA
Wet >300 mm	Queensland		Tasmania
Dry <300 mm	Big Rivers, NSW	South West WA	
Dry <300 mm	Greater Perth, WA	Fleurieu, SA	
Dry <300 mm	Central WA	Barossa Valley, SA	
Dry <300 mm	North West VIC		
Dry <300 mm	Lower Murray, SA		
Dry <300 mm	Far North, SA		

Survey Pest List

Insects	Mites	Nematode	Other
Garden weevil	Bud mite	Other nematode	Birds
Grapevine moth	Bunch mite	Root-knot nematode	Snails
Grasshoppers	Other mites		
Insects (trunk boring)			
Light Brown Apple Moth			
Mealybugs			
Other moth or grubs			
Phylloxera			
Scale			

Survey Disease List

Fungus	Virus	Bacteria
Black spot (anthracnose)	Fanleaf virus	Crown Gall
Botrysphaeria	Grapevine yellows	
Botrytis bunch rot	Leafroll virus	
Bunch rot (other)	Other virus	
Downy mildew		
Eutypa dieback		
Petrie disease (Pch + Pal)		
Phomopis		
Phytophthora root rot		
Powdery mildew		
Root rot (other)		
Verticillium Wilt		

Format of Survey

- 50 surveys returned

Survey - Part Two

- Frequency of problem
- Stage that vineyard is affected
- Management techniques

Survey - Part Three

- Identification of ‘Top 3’ pests or disease
- Indicated why pest or disease is a concern
- Estimates of associated costs &/or losses

'Top 3' Pest and Disease - Ranking

#	Pest or Disease	Responses
1	Powdery Mildew	34
2	Botrytis Bunch Rot	21
3	Downy Mildew	15
4	Birds	12
5	Eutypa dieback	8
6	Light Brown Apple Moth	7
7	Garden Weevil	4
8	Bunch Rot (other)	4
9	Root-knot Nematode	4
10	Mealybugs	3
11	Insects (trunk boring)	3
12	Phylloxera	3
13	Grapevine yellows	3
14	Botryosphaeria	2
15	Root Rot	2
16	Other Nematode	2
17	Scale	2
18	Leafroll virus	2
19	Other virus	2

‘Top 3’ Pest and Disease - Losses and Costs

#	Pest or Disease	Responses	Reduced yield	Reduced quality	Additional operating cost
1	Powdery Mildew	34	21	31	33
2	Botrytis Bunch Rot	21	16	21	21
3	Downy Mildew	15	12	9	14
4	Birds	12	11	7	9
5	Eutypa dieback	8	8	6	5
6	Light Brown Apple Moth	7	5	7	7
7	Garden Weevil	4	3	1	3
8	Bunch Rot (other)	4	3	4	4
9	Root-knot Nematode	4	4	2	3
10	Mealybugs	3	3	3	3

‘Top 3’ Pest and Disease - Losses and Costs

#	Pest or Disease	Responses	Reduced yield	Reduced quality	Additional operating cost
11	Insects (trunk boring)	3	3	0	3
12	Phylloxera	3	3	1	2
13	Grapevine yellows	3	3	2	0
14	Botryosphaeria	2	2	2	1
15	Root Rot	2	2	1	2
16	Other Nematode	2	2	1	1
17	Scale	2	2	1	2
18	Leafroll virus	2	2	0	2
19	Other virus	2	2	1	1

‘Top 3’ Pest and Disease - No Treatment Available

#	Pest or Disease	Responses	No treatment available
5	Eutypa dieback	8	3
8	Bunch Rot (other)	4	3
11	Insects (trunk boring)	3	1
13	Grapevine yellows	3	2
14	Botryosphaeria	2	2
15	Root Rot	2	2
15	Other Nematode	2	1

'Top 3' Pest and Disease - Not Rated (<2)

Pest	Disease
Bud Mite	Black Spot
Bunch Mite	Crown Gall
Other Mites	Petrie Disease
Grasshoppers	Phomopsis
Grapevine Moth	Phytophthora
Other moth or grubs	Verticillium Wilt
Snails	Fanleaf Virus

Pest and Disease Rating by Climatic Zone

- **Hot and Dry** climatic zone
- 12 responses

Disease	%	Pest	%
Powdery Mildew	28%	Root-knot Nematode	11%
Downy Mildew	17%	Insects (trunk boring)	6%
Botrytis Bunch Rot	11%	Light Brown Apple Moth	6%
Root Rot	6%	Mealybugs	3%
Bunch Rot (other)	3%	Other Nematode	3%
Grapevine Yellows	3%	Scale	3%

Pest and Disease Rating by Climatic Zone

- **Hot and Wet** climatic zone
- 5 responses

Disease	%	Pest	%
Botrytis Bunch Rot	20%	Birds	7%
Downy Mildew	20%		
Bunch Rot (other)	20%		
Powdery Mildew	20%		
Botryosphaeria	13%		

Pest and Disease Rating by Climatic Zone

- **Warm and Wet** climatic zone
- 4 responses

Disease	%	Pest	%
Powdery Mildew	25%	Phylloxera	17%
Botrytis Bunch Rot	17%	Birds	8%
Eutypa dieback	17%	Light Brown Apple Moth	8%
Downy Mildew	8%		

Pest and Disease Rating by Climatic Zone

- **Warm and Dry** climatic zone
- 8 responses

Disease	%	Pest	%
Powdery Mildew	29%	Garden Weevil	19%
Botrytis Bunch Rot	14%	Birds	14%
Downy Mildew	5%	Insects (trunk boring)	5%
		Light Brown Apple Moth	5%
		Other Nematode	5%
		Scale	5%

Pest and Disease Rating by Climatic Zone

- **Cool** climatic zone
- 15 responses

Disease	%	**Pest**	%
Powdery Mildew	28%	Birds	16%
Botrytis Bunch Rot	21%	Light Brown Apple Moth	7%
Eutypa dieback	14%	Phylloxera	2%
Downy Mildew	9%		

What now???

- Review and validate information on climatic zone

- Break into your representative ‘climatic zone’
- **Hot wet** = Hugh Armstrong
- **Hot dry** = Charlie Drew
- **Warm wet** = Vic Patrick
- **Warm dry** = Richard Hamilton
- **Cool** = Adrian Loschiavo

Appendix 3

Data Collection Template used for Collection of Vineyard Information for the Economic Modelling in Section 5

General Information		Comments
Pest or Disease Name	Downy Mildew	
Region (Hot-Dry, Hot-Wet, Warm-Dry, Warm-Wet or Cool)		
Frequency (probability of annual infestation)		
Incidence (proportion of region impacted)		
Treatment or Control Option		

Impact on vineyard income [1] **(<u>without</u> treatment or control)**	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Reduced yield (t/ha or %) - by major variety										
Price penalty ($/t or %) - by major variety										

Impact on vineyard costs [1] **(<u>with</u> treatment or control)**	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Additional operating costs ($/ha or %) [2]	$/ha	$/ha	$/ha	$/ha	$/ha	$/ha	$/ha	$/ha	$/ha	$/ha
Additional capital costs ($/ha or %) [3]	$/ha	$/ha	$/ha	$/ha	$/ha	$/ha	$/ha	$/ha	$/ha	$/ha

1 - Impacts can be expressed as % change or $/ha, $/t. Need a range of values (low, most likely, high)
2 - labour, chemicals, fuel, monitoring costs, machinery maintenance etc.
3 - e.g. rootstocks for vineyard establishment, specialised equipment.

Appendix 4

Examples of Pest & Disease Programs

Example Spray Program from Warm Dry Climatic Zone

Timing	Point of Run Off (L/ha)	Target	Product	Group	Rate/100L	Rate/ha	
Shoots 10cm	500	Powdery Mildew	Sulfur	Y	0.6	3	kg/ha
		Downy Mildew	Kocide Opti	Y	0.115	0.575	kg/ha
Shoots 20-25cm	700	Powdery Mildew	Topas	C	0.0125	0.0875	L/ha
		Downy Mildew, Black Spot	Dithane Rainshield	Y	0.2	1.4	kg/ha
Shoots 40+cm	900	Powdery Mildew	Prosper	E	0.06	0.54	L/ha
		Downy Mildew, Black Spot	Captan	Y	0.125	1.125	kg/ha
Pre-Flowering	1100	Powdery Mildew	Flint	K	0.015	0.165	kg/ha
		Downy Mildew					
Flowering 80%	1200	Powdery Mildew	Flint	K		0.18	kg/ha
		Downy Mildew					
		Botrytis	Teldor	J	0.1	1.2	L/ha
Berries Pea Sized	1300	Powdery Mildew	Sulfur	M	0.02	0.26	L/ha
		Downy Mildew	Dithane Rainshield	Y	0.2	2.6	kg/ha
Pre-Bunch Closure	1200	Powdery Mildew	Mycloss Xtra	C	0.016	0.192	L/ha
		Downy Mildew	Captan	Y	0.125	1.5	kg/ha
Veraison	1200	Powdery Mildew	Sulfur	Y	0.3	3.6	kg/ha

Example Organic Spray Program from Warm Dry Climatic Zone

Timing	Point of Run Off (L/ha)	Target	Product	Group	Rate/100L	Rate/ha	
Shoots 10cm	500	Powdery Mildew	Sulfur	Y	0.6	3	kg/ha
		Downy Mildew, Black Spot	Kocide Opti	Y	0.115	0.575	kg/ha
Shoots 20-25cm	700	Powdery Mildew	Eco Carb	Y	0.4	2.8	kg/ha
		Downy Mildew, Black Spot	Kocide Opti	Y	0.115	0.805	kg/ha
Shoots 40+cm	900	Powdery Mildew	Sulfur	Y	0.4	3.6	kg/ha
		Downy Mildew, Black Spot	Kocide Opti	Y	0.115	1.035	kg/ha
Pre-Flowering	1000	Powdery Mildew	Eco Carb	Y	0.4	4	kg/ha
Flowering 80%	1000	Powdery Mildew	Eco Carb	Y	0.4	4	kg/ha
Berries Pea Sized	1000	Powdery Mildew	Sulfur	Y	0.3	3	kg/ha
		Downy Mildew, Black Spot	Kocide Opti	Y	0.115	1.15	kg/ha
Pre-Bunch Closure	1000	Powdery Mildew	Sulphur	Y	0.3	3	kg/ha
		Downy Mildew	Kocide Opti	Y	0.115	1.15	kg/ha
Veraison	1000	Powdery Mildew	Sulfur	Y	0.3	3	kg/ha

Appendix 5

List of References

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