

Benefit-cost analysis of options for managing Queensland fruit fly in Victoria

Evaluation Report Series No. 11
April 2010

Benefit–cost analysis of options for managing Queensland fruit fly in Victoria

Evaluation Report Series No. 11

**Arthur Ha, Kristoffer Larson, Sallyann Harvey,
Bill Fisher and Bill Malcolm**

April 2010

Economics and Policy Research Branch

Policy and Strategy Group

Other reports in the Evaluation Report Series are:

- Department of Natural Resources and Environment (2000), 'Beneficiaries and Funders of Research and Development in Agriculture: Science, Technology and Innovation Initiative 1999/2000', *Evaluation Report No. 1*, Melbourne, June.
- Department of Natural Resources and Environment (2000), 'The Value of Prospective Improvements from Research and Development in the Victorian Dairy Industry', *Evaluation Report No. 2*, Melbourne, August.
- Wimalasuriya, R., Grey, D., Fisher, W., Haines, P., and M. Eigenraam (2001), 'The Value of Prospective Improvements from Research and Development in the Victorian Grains Industry', *Evaluation Report No. 3*, Melbourne, December.
- Department of Natural Resources and Environment (2001), 'Beneficiaries and Funders of Research and Development in Agriculture: Science, Technology and Innovation and Naturally Victorian Initiatives 2000/2001', *Evaluation Report No. 4*, Melbourne.
- Wimalasuriya, R., Hamilton, J. and D. Goldsworthy (2002), 'The Value of Prospective Improvements from Research and Development in the Victorian Beef and Lamb Industries', *Evaluation Report Series No. 5*, Melbourne, December.
- Department of Primary Industries (2004), 'Review of Chemical Standards', *Evaluation Report No. 6*, Melbourne, September.
- Department of Primary Industries (2004), 'Review of Animal Welfare', *Evaluation Report No. 7*, Melbourne, December.
- Department of Primary Industries (2005), 'Review of Animal Health', *Evaluation Report No. 8*, Melbourne, May.
- Department of Primary Industries (2005), 'Review of Plant Health', *Evaluation Report No. 9*, Melbourne.
- Department of Primary Industries (2007), 'Auction of marine aquaculture sites in Victoria: A review of concepts and practice', *Evaluation Report No. 10*, Melbourne.

If you would like to receive this information/publication in an accessible format (such as large print or audio), please call the Customer Service Centre on 136 186, TTY 1800 122 969 or email customer.service@dpi.vic.gov.au

Published by the Department of Primary Industries, GPO Box 4440, Melbourne Vic 3001

© The State of Victoria, Department of Primary Industries, Economics & Policy Research Branch, April 2010

This publication is copyright. No part may be reproduced by any process except in accordance with the provisions of the *Copyright Act 1968*.

Authorised by the Victorian Government, 1 Spring Street, Melbourne.

ISSN 1444-2949

ISBN 978-1-74217-700-7 (print)

ISBN 978-1-74217-701-4 (online)

An appropriate citation for this paper is:

Ha, A., Larson, K., Harvey, S., Fisher, W & Malcolm, L. 2010, *Benefit-cost analysis of options for managing Queensland fruit fly in Victoria*, Evaluation Report Series, Department of Primary Industries (Victoria), Melbourne.

Disclaimer

This publication may be of assistance to you but the State of Victoria and its employees do not guarantee that the publication is without flaw of any kind or is wholly appropriate for your particular purposes and therefore disclaims all liability for any error, loss or other consequence which may arise from you relying on any information in this publication.

For more information about DPI, visit the website at www.dpi.vic.gov.au or call the Customer Service Centre on 136 186.

Foreword

The Department of Primary Industries (DPI) Victoria manages Queensland fruit fly through an area-wide management program. It delivers coordinated pest response and surveillance programs across all production and urban areas of the state according to a national code of practice. In response to the high number of fruit fly outbreaks requiring treatment in 2008 and the subsequent disruption to domestic market access for producers, DPI Victoria commissioned Kalang Consultancy Services to undertake a technical review of all Queensland fruit fly operations and management.

Kalang Consultancy Services identified three management options which were: establishment and maintenance of specific Pest Free Areas; re-establishment of state wide area freedom including the Victorian component of the Fruit Fly Exclusion Zone, and; area wide management based on the adoption of a new Code of Practice and phytosanitary principles.

DPI Victoria's Economics and Policy Research Branch has undertaken a benefit–cost analysis of the three management options identified by Kalang Consultancy Services. The objective of this analysis is to inform government and industry about the nature and magnitude of the benefits and costs of these options for managing Queensland fruit fly. This information will also inform cost sharing arrangements to fund any future Queensland fruit fly management program in Victoria.



Dr. Deborah Peterson
Deputy Secretary
Policy and Strategy



Dr. John Skeritt
Deputy Secretary
Agriculture and Fisheries Services



Dr. Hugh Millar
Executive Director
Biosecurity Victoria/
Chief Veterinary Officer

Acknowledgements

The authors thank Patrick Sharkey, Gary Darcy, Dr Andrew Tomkins and Stuart Holland from the department's Plant Standards Branch for the data and advice they provided. Ian Shurvell, Animal Standards Branch (Biosecurity Victoria) prepared the maps used in this report.

The authors also thank Russell Fox (IK Caldwell, Cobram), Mick Stevens (Montague Fresh, Shepparton), and Peter Leach (Senior Entomologist, Primary Industries and Fisheries, Department of Employment, Economic Development and Innovation, Queensland) for advice on data for the pre- and post-harvest chemical costs of fruit fly affected fruit, and Rob Duthie (Kalang Consultancy Services) for advice on trade issues associated with area freedom programs. Neil Barker (BGP International) provided information on the operation of quarantine protocols for importing fresh fruit.

Professor Mark Burgman and Dr Terry Walshe (Australian Centre of Excellence for Risk Analysis, University of Melbourne) advised ways in which to incorporate risk and uncertainty in the analysis. Associate Professor Donald MacLaren (Department of Economics, University of Melbourne) provided advice on the economic framework described in appendix A.

The authors also acknowledge the help of reviewers. Carolyn Tanner (Honorary Senior Lecturer, University of Sydney) reviewed an early draft and the final draft. Comments were also provided by Bob Douglas, Anna Heaney and Chris Chan (from the department's Economics and Policy Research Branch), seminar participants in the department, and Geoff Edwards (from the department's Agriculture and Natural Resources Policy Division). The authors acknowledge the assistance of Rachael Dullahide (The Launch Box) who edited this report.

Contents

Foreword	iii
Acknowledgements	iv
Executive summary	1
Benefit–cost analysis	2
Results	3
1 Introduction	5
1.1 Objectives of this benefit–cost analysis	5
1.2 Structure of the report	5
2 Background	6
2.1 The Queensland fruit fly program and export and interstate markets	6
2.2 Queensland fruit fly	6
2.3 Current Queensland fruit fly program in Victoria	11
3 Estimating the benefits and costs of alternative Queensland fruit fly regimes	13
3.1 Management options for a new Queensland fruit fly program	13
3.2 Previous economic studies	16
3.3 Economic welfare effects of area-wide management programs	17
3.4 The counterfactual case	18
3.5 Method of calculation	18
4 Results and discussion	26
4.1 Summary of results	26
4.2 Testing the sensitivity of results to changes in key variables	27
4.3 Discussion	29
5 References	30
Appendix A: Economic impacts of a Queensland fruit fly management regime	32
Appendix B: Method	36
Appendix C: Primary and secondary benefits and costs of a social and environmental nature	41
Appendix D: Details of results	43
Glossary	49
Acronyms	50

Executive summary

The Queensland fruit fly is regarded as one of the world's worst horticultural pests. It damages host fruit, reducing quality so the fruit is not marketable. It is a native Australian species and has the ability to infest a wide range of host fruit species. Originally found in only tropical and subtropical rainforests in Queensland, it has now established stable populations along the east coast and inland Australia. This extended range has followed the introduction of European cultivated fruits that are suitable hosts.

The major Victorian horticultural industries affected by Queensland fruit fly are stone fruits, grapes, citrus, pome fruit (apples and pears) and tomatoes. Other horticultural industries too are affected, so benefit from Queensland fruit fly management.¹ The Queensland fruit fly is a key reason that Victorian horticulture products have not been granted access to high value markets such as Taiwan and, until May 2009, Japan.

The Department of Primary Industries (DPI) Victoria manages Queensland fruit fly through an area-wide management program. It delivers coordinated pest response and surveillance programs across all production and urban areas of the state according to a national code of practice.² The department's Queensland fruit fly program enables producers and exporters to consign fruit under area freedom certification to gain access to markets. Area-wide pest freedom management programs are recognised under the World Trade Organization's Sanitary and Phytosanitary (SPS) Agreement. International standards for phytosanitary measures—ISPM 26, ISPM 29 and ISPM 30—have been developed as a basis for establishing area-wide management programs for fruit flies (International Plant Protection Convention 2006, 2007 and 2008).

In response to the high number of fruit fly outbreaks requiring treatment in 2008 and the subsequent disruption to domestic market access for producers, DPI Victoria initiated a technical review of all Queensland fruit fly operations and management. This review had the support of peak fruit industry bodies. The review report by Kalang Consultancy Services (2008) identified three management options as potential alternatives to current activities:

- *management option 1: establishment and maintenance of specific pest free areas.* This option effectively deregulates fruit fly management except in pest free areas.
- *management option 2: re-establishment of statewide freedom.* This option involves import controls on host fruits and materials. Pest monitoring, reporting and eradication programs would occur.
- *management option 3: area-wide management through the establishment of pest free areas and areas of low pest prevalence.* This option involves targeting areas of high value production.

This report presents a benefit–cost analysis of these three management options.

¹ Host fruits to Queensland fruit fly are defined by the Interstate Plant Health Regulation Working Group (1996) as abiu, acerola, apple, apricot, avocado, blackberry, Brazil cherry, caimito (star apple), capsicum, carambola (star fruit), cashew apple, casimiroa (white sapote), cherry, cherimoya, chilli, citron, custard apple, date, feijoa, fig, granadilla, grapefruit, gumichama, guava, kiwifruit, kumquat, lemon, lime, loganberry, loquat, mandarin, mango, mulberry, nashi, nectarine, orange, passionfruit, peach, peacharine, pear, pepino, persimmon, plum, plumbcot, prickly pear, pummelo, quince, raspberry, rollinia, santol, sapodilla, soursop, strawberry, sweetsop (sugar apple), tamarillo, tangelo, tomato, wax jambu (rose apple), babaco, banana, black sapote, mangosteen, Tahitian lime, durian, jaitocaba, jackfruit, logan, lychee, pomegranate, rambutan, coffee berry, cucurbits, eggplant, grape, monstera, okra, olive, pineapple, blueberry, breadfruit and cape gooseberry.

² This Code of Practice (COP) provides management guidelines for product disinfestation, pest monitoring, eradication and reporting for Queensland fruit fly. The COP was developed by Interstate Plant Health Regulation Working Group (1996).

Benefit–cost analysis

This analysis examines the benefits and costs to Victoria over 20 years. It thus considers how the program affects the Victorian community rather than just host fruit industries.

In any benefit–cost analysis, a counterfactual (alternative) situation is needed to compare the benefits and costs of the changed situation. The counterfactual used here is the ‘do nothing’ case—that is, no DPI Victoria or collective industry activity to manage Queensland fruit fly. In the ‘do nothing’ case, the areas of the state that are Queensland fruit fly free, including the greater Sunraysia pest free area and the Fruit Fly Exclusion Zone, are assumed to become infested. If all areas become infested, then growers of Queensland fruit fly host fruits are assumed to apply pre-harvest chemicals to control infestations to maintain market access. Post-harvest disinfestation costs are assumed to ensure host fruit produce can be exported to sensitive markets. Essentially, host fruit industries are assumed to respond at the farm level, and no industry-wide actions replace DPI Victoria activities.

In the ‘do nothing’ situation, growers do not have access to sensitive international markets such as the US citrus market. Growers are assumed to have access to sensitive interstate markets providing host fruits are disinfested. The benefits quantified in this benefit–cost analysis are:

- the avoidance of pre-harvest chemical costs
- the avoidance of post-harvest chemical (or disinfestation) costs
- access to the US citrus market.

The quantified costs are:

- disinfestation costs following outbreaks
- the establishment costs of each management option
- the maintenance costs of each option, including eradication.

Area-wide management programs for fruit fly provide growers with benefits that this study has not quantified, such as:

- improved shelf life for fruit because it is not subject to disinfestation treatments
- the increased viability of integrated pest management systems due to less chemical use
- access to interstate markets without incurring pre harvest chemical costs and post harvest chemical (disinfestation) costs.
- improved fruit quality from backyard production due to the absence of Queensland fruit fly.

These benefits apply to all management options. Their omission thus means this benefit–cost analysis underestimates the net benefits of all management options.

This analysis accounts for benefits and costs to growers and the wider community. In the case of environmental impacts, the study relied on scientific advice that Queensland fruit fly does not have any detrimental impact on local insects and ecological systems. Queensland fruit fly also has no human health impact. Box 1 shows the key assumptions of this analysis.

Box 1: Key assumptions underlying the benefit–cost analysis

- Production and export volumes are unchanged from current levels during the period of the analysis.
- Queensland fruit fly management options do not affect the current mix or quantity of horticultural crops grown in Victoria.
- Technology related to Queensland fruit fly management is unchanged from methods used during the period of the analysis.
- The frequency of Queensland fruit fly outbreaks is developed from historical data and assumed to be the same in the future. This assumption is relaxed and tested with sensitivity analysis.
- All trading partners are assumed not to change their Queensland fruit fly management strategies during the period of the analysis.
- All three management options enable access to sensitive markets, and the Queensland fruit fly premium for access to sensitive markets is unchanged during the period of the analysis. This assumption is relaxed and tested with sensitivity analysis.
- Queensland fruit fly management options do not affect domestic market prices.

Results

Two measures are used to report the results for each management option. The net present value (NPV) reports the value of net benefits over the 20 year period, discounted at 5 per cent real. The benefit–cost ratio (BCR) reports the ratio of benefits to costs, discounted at the aforementioned discount rate.

All management options have been ranked from most preferred (in terms of the highest NPV and BCR) to the least preferred. To incorporate risk about estimates and model outputs, the analysis of each option used random estimates of outbreaks of Queensland fruit fly based on probability distributions of outbreaks under each option. The study conducted a large number of runs of 20 years operation of each management option. A simple average of all values for the NPV and the BCR is shown—that is, the mean. The coefficient of variation has been shown for the NPV. It is a measure of the distribution of the probability around the mean. The smaller the coefficient of variation, the more stable is the value for the mean. The higher the coefficient of variation of net benefits for a management option, the higher is the risk associated with that option.

All management options were estimated to generate net benefits. Management option 3 has a higher NPV and a lower coefficient of variation because it has a lower probability of outbreaks of Queensland fruit fly. This option also has the highest BCR, being estimated to generate benefits of \$2.35 for each dollar invested.

Results of benefit–cost analysis at 5 per cent discount rate

	Management option 1	Management option 2	Management option 3
NPV (mean \$ million)	332	353	379
BCR (mean \$)	2.02	2.15	2.35
NPV (coefficient of variation)	0.103	0.091	0.086

Because the benefits of maintaining market access accrue to each management option equally, the results of the benefit–cost analysis are determined primarily by the costs associated with outbreaks of Queensland fruit fly. The fewer annual outbreaks, the lower are the eradication and disinfestation costs. The success of a management option in reducing the frequency of outbreaks is thus critical to the final value of the NPV and the BCR for an option. Of the options considered here, management option 3 is expected to have the lowest number of outbreaks. This outweighs the option's high fixed costs relative to those of the other options.

Management option 3 has the highest BCR under almost all circumstances analysed. The results were tested against the following assumptions:

- an increase in Queensland fruit fly outbreaks in management option 3 (to the same level as in options 1 and 2)
- a halving of US export market access benefits (if, for example, competitiveness declines)
- a total loss of US export market benefits (if, for example, access is lost because doubts arise about the scientific basis of the area freedom program)
- a decrease in Queensland fruit fly outbreaks (if, for example, a hotter and drier climate and a decrease in average annual rainfall leads to reduced Queensland fruit fly populations)
- an increase in chemical and disinfestation costs (if, for example, current chemicals become prohibited and high cost substitutes have to be used).

The results were also tested for changes in several variables simultaneously. Two scenarios were examined:

- the evolution of a 'superfly' due, for example, to temperature increases from climate change, which leads to a doubling of outbreaks and, subsequently, costs of suppression
- the evolution of a 'superfly' due, for example, to temperature increases from climate change that leads to a quadrupling of outbreaks for option 3 and doubling of outbreaks for all other options.

Management option 3 remains the most beneficial under the tests (see above), except in the scenario of a quadrupling of outbreaks for option 3, in which case option 2 has the highest NPV and BCR.

1 Introduction

The Department of Primary Industries (DPI) Victoria manages Queensland fruit fly through an area-wide management program. It delivers coordinated pest response and surveillance programs across all production and urban areas of the state according to a national code of practice. In response to the high number of fruit fly outbreaks requiring treatment in 2008 and the subsequent disruption to domestic market access for producers, DPI Victoria initiated a technical review of all Queensland fruit fly operations and management. The review was completed in November 2008 by Kalang Consultancy Services. DPI Victoria's Economics and Policy Research Branch has undertaken a benefit–cost analysis of the three management options that the review identified.

1.1 Objectives of this benefit–cost analysis

The primary objective of this analysis is to inform government and industry about the relative benefits and costs of each management option identified by Kalang Consultancy Services. A secondary objective is to provide information about the nature and magnitude of the benefits and costs of all options for managing Queensland fruit fly. This information will inform cost sharing arrangements to fund any future Queensland fruit fly management program in Victoria.

This analysis may also assist the development of implementation plans for the draft National Fruit Fly Strategy developed by Plant Health Australia. An implementation committee under the auspices of Plant Health Australia is developing projects for industry and government to consider.

1.2 Structure of the report

Chapter 2 contains background information on area freedom programs and international trade, the biology of Queensland fruit fly, the current Queensland fruit fly program and the management options for a new program (as identified by Kalang Consultancy Services). Chapter 3 explains the method used in the benefit–cost analysis. Chapter 4 contains the analysis results and discussion. Appendixes provide more detail on the economic impacts of a Queensland fruit fly management regime, the benefit–cost analysis method, the primary and secondary benefits considered for the analysis, and the analysis results.

2 Background

This chapter explains area freedom programs and export and interstate markets. Also discussed are the biology of Queensland fruit fly, the production of host fruit in Victoria, control methods, the potential effects of climate change on Queensland fruit fly distribution and abundance, Victoria's current Queensland fruit fly management activities and costs, and the three proposed management options for a new program.

2.1 The Queensland fruit fly program and export and interstate markets

The World Trade Organization's Sanitary and Phytosanitary (SPS) Agreement governs the design and implementation of measures for the protection of animal, plant and human health (quarantine). The SPS Agreement thus assists in ensuring these measures do not excessively restrict international trade. World Trade Organization members are, where possible, expected to harmonise their SPS measures by basing the measures on agreed international standards. In the case of plants, the International Plant Protection Convention sets these standards (World Trade Organization 2009). The convention is designed to secure action to prevent the introduction and spread of pests of plants and plant products, and it is governed by the Commission for Phytosanitary Measures. The commission approves international standards for phytosanitary measures (ISPMs) (International Plant Protection Convention 2009).

In the case of area freedom programs, the SPS Agreement states that members shall 'recognise the concepts of pest or disease free areas and areas of low pest or disease prevalence ... and that Exporting Members claiming that areas are pest or disease free ... shall provide the necessary evidence' (World Trade Organization 1995, article 6.2). Disputes relating to animal, plant and human health quarantine arrangements may be resolved through the World Trade Organization's dispute settlement mechanism.

Victoria's Queensland fruit fly program aims to demonstrate area freedom from a pest and thus promote export and interstate trade. The greater Sunraysia fruit fly pest free area is recognised by many Pacific Island countries,³ Sri Lanka, Indonesia, Thailand, New Zealand and the United States. Victoria's exports of the Queensland fruit fly host fruit to these countries in 2006–07 were valued at \$52 million (ABS 2009). The Victorian program is also recognised for the state's trade to Tasmania, Western Australia, South Australia and the New South Wales Fruit Fly Exclusion Zone.

2.2 Queensland fruit fly

The Queensland fruit fly (*Bactrocera tryoni*) is one of the world's worst horticultural pests, and most states and territories (and several international trading partners) regulate the movement of host fruit from affected regions. The fruit fly is a native Australian species and has the ability to infest a wide range of host fruit species. Originally found only in tropical and subtropical rainforests in Queensland, it has established stable populations along the east coast and inland Australia. This extended range has followed the introduction of European cultivated fruits that are suitable hosts.

³ Fiji, French Polynesia, Kingdom of Tonga, Kiribati, Vanuatu and Samoa.

2.2.1 Queensland fruit fly biology

The Queensland fruit fly damages host fruit when a female fly ‘stings’ ripe or over-ripe fruit and lays around six eggs just below the skin (DPI Victoria 2009). Over time, the eggs hatch into larvae and eat their way into the middle of the fruit. This damages the flesh of the fruit and promotes rotting, although the fruit may appear healthy from the outside. The original ‘sting’ may also introduce bacteria that damage the fruit.

Between 10 and 31 days after hatching, the larvae are fully grown and eat their way out of the fruit. Generally, by this time the fruit has fallen and the larvae burrow into the soil. In the soil, the larva become inactive, and they develop into adult fruit flies in around two weeks.

Emerging from the soil, the fruit flies look for a food source. Adult fruit flies eat bacteria from the surface of the host fruit, not the fruit itself. After finding a source of protein and a mate, the female can lay her eggs after five days. Adult female flies can lay several hundred eggs in their lives, and they live for several months. If left uncontrolled, depending on the temperature several generations of fruit flies can overlap creating a large population of fruit flies in an outbreak area (O’Loughlin, G.T, East R. A and Meats A 1984). The growth of Queensland fruit fly populations does not depend on specific commercial host fruits shown in footnote 1.

The flight range of the Queensland fruit fly is not known. Immature adults disperse from their emergence site, and thus move to areas where they are less likely to find a mate. A tri-state technical report noted ‘the paradox with Queensland fruit fly is that it is a good traveller (especially in fruit carried by humans), but a poor coloniser’ (Tri-State Review Team 2001, p. 58).

The range of the Queensland fruit fly is limited by climate and available breeding sites. High heat and/or low humidity limit populations. Irrigation can increase a region’s suitability for the Queensland fruit fly by eliminating the constraint of low humidity and providing uninterrupted access to breeding sites. The Queensland fruit fly becomes less active over winter, when it is thought to stop breeding. Sustained low temperatures can reduce a Queensland fruit fly population; conversely, the recent trend of mild winters in Victoria has allowed populations to persist and remain active all year.

2.2.2 Climate change and the Queensland fruit fly

A study in 2000 estimated the potential effects of climate change on the distribution and abundance of the Queensland fruit fly (Sutherst, Collyer & Yonow 2000). It indicated that the fruit fly, under scenarios of temperature increases ranging from 0.5°C to 2.0°C, would be capable of surviving all year further south in Victoria than ever before, and with an increased number of generations possible in northern parts of the state. The study predicted significantly increased damage to host crops and higher control costs if the range and abundance of the Queensland fruit fly increased in Victoria.

Climate change in southern Australia is predicted to result in decreased average annual rainfall. In contrast to the effects of increased temperature, a decrease in average annual rainfall could reduce the abundance of the Queensland fruit fly. This reduction could occur directly as a result of drier conditions—for example, an adverse effect on pupae survival in the soil beneath infested trees, leading to death—or from the reduced growth and cropping of host plants in backyards in rural towns and seedling fruit trees growing along roadsides or in waste areas. The magnitude of the potential adverse effects of decreased rainfall on the spread of the Queensland fruit fly is difficult to predict.

2.2.3 Queensland fruit fly in Victoria

In 2006–07, fruit growers in Victoria generated more than \$1 billion from producing fruits susceptible to Queensland fruit fly (table 1). Pome fruit production has the highest annual gross value, at more than \$330 million, followed by grapes (almost \$295 million), stone fruits (almost \$244 million), tomatoes (more than \$82 million) and citrus (almost \$65 million).

Table 1: Gross value of production of Queensland fruit fly host fruits in Victoria, 2006–07 (\$ million)

ABS statistical division	Citrus*	Pome fruit	Stone fruit**	Grapes	Tomatoes
Victoria	64.8	330.3	243.9	294.8	82.9
Melbourne	0.9	61.8	10.0	6.4	0.2
Barwon	0.0	0.1	0.1	0.5	4.4
Western District	0.0	0.3	0.0	0.2	0.0
Central Highlands	0.0	6.7	3.0	1.1	0.0
Wimmera	0.0	0.0	0.2	0.6	0.1
Mallee	60.3	0.2	72.1	269.6	0.9
Loddon	0.0	11.0	33.8	1.7	0.5
Goulburn	3.2	231.7	116.6	8.7	75.3
Ovens–Murray	0.0	8.2	7.9	5.8	0.5
East Gippsland	0.3	1.0	0.1	0.1	0.2
Gippsland	0.1	9.2	0.0	0.1	0.8

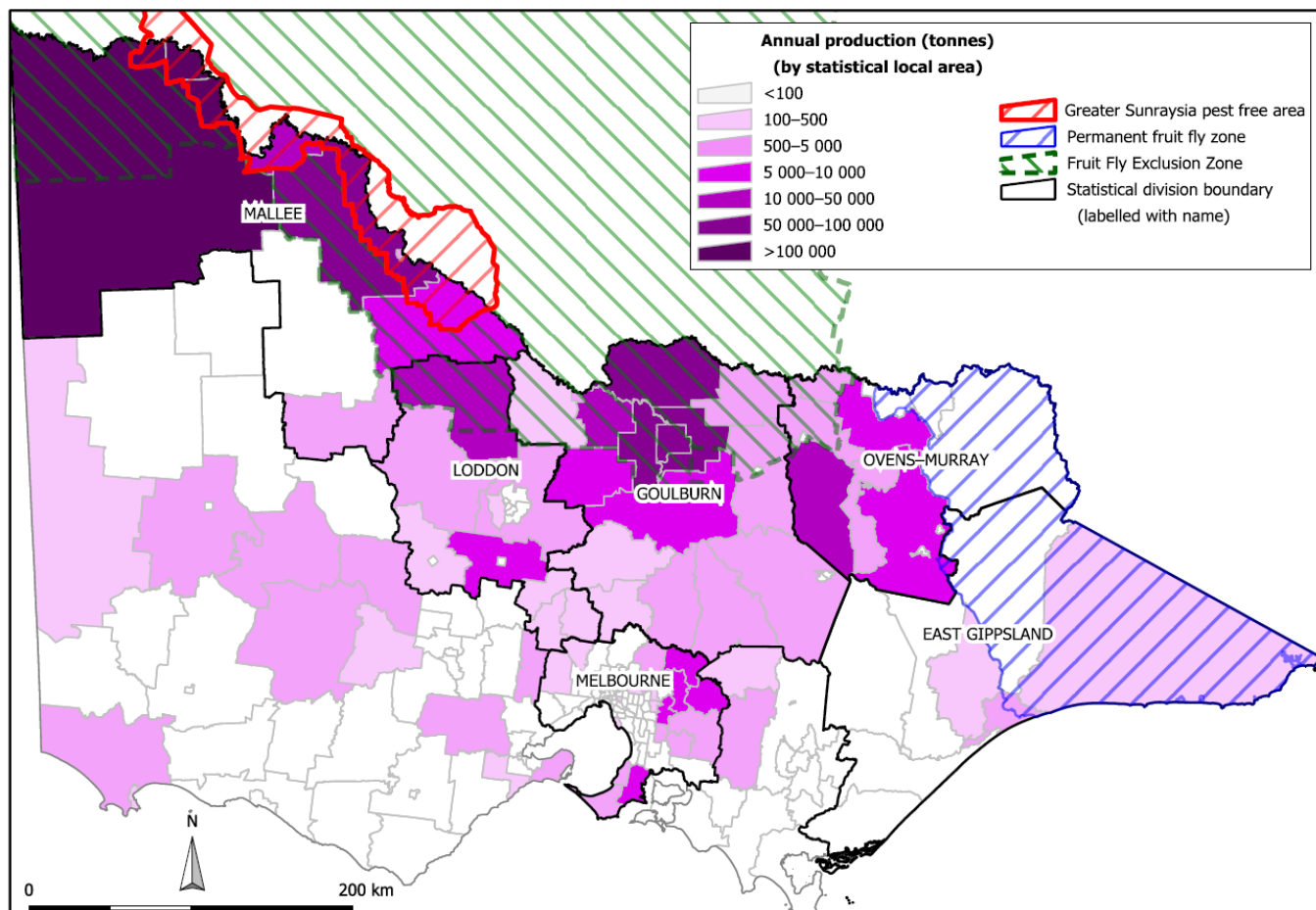
* Includes oranges, mandarins, grapefruit and lemons. ** Includes olives.

Source: ABS (2008b).

Map 1 shows the key production regions of Queensland fruit fly host fruit in Victoria, by quantity of production. Map 2 shows the outbreak history of the Queensland fruit fly from 2002–03 to 2007–08: the majority of outbreaks occurred in the Goulburn and Ovens–Murray regions. Outbreaks occurred in the south of the state in East Gippsland, Gippsland and Melbourne in 2006–07 to 2007–08.

The Queensland fruit fly has the capacity to significantly deplete marketable production. Production losses can be minimal, however, if the fruit fly outbreaks are detected quickly and eradication measures are implemented. Outbreaks in Victoria have temporarily stopped market access of host fruits to Queensland fruit fly sensitive domestic markets such as South Australia, Tasmania and the New South Wales Fruit Fly Exclusion Zone (FFEZ), and to international markets such as Sri Lanka, Indonesia, Thailand, New Zealand and the United States.

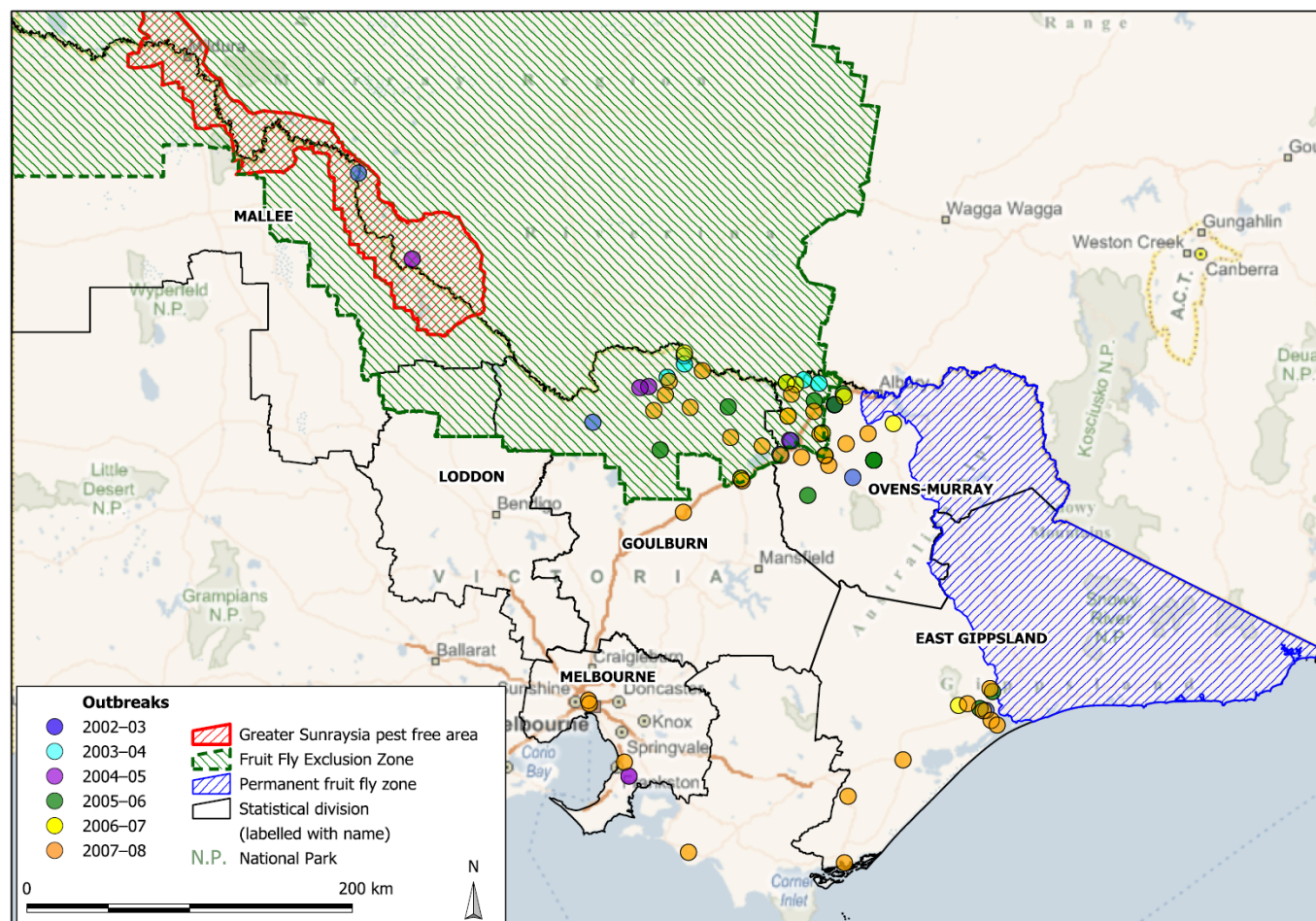
Map 1: Production of Queensland fruit fly host fruit, 2005–06



Note: Interpret with caution: while properties may be clustered in one part of the statistical local area, the full area is shaded. Fruits include table and wine grapes, pome fruit, stone fruit and citrus fruit.

Source: Map generated from 2005–06 ABS census data by Ian Shurvell, Biosecurity Victoria, July 2009.

Map 2: Queensland fruit fly outbreaks, 2002–03 to 2007–08



Source: Map generated by Ian Shurvell, Biosecurity Victoria, July 2009.

2.2.4 Control methods

The Queensland fruit fly is managed in accordance with a nationally agreed code of practice that describes surveillance, control, diagnostic and reporting requirements for fruit fly management in pest free areas. It is monitored in Victoria using more than 2500 permanent traps positioned on a 1 kilometre grid in horticultural production areas and a 400 metre grid in urban centres.

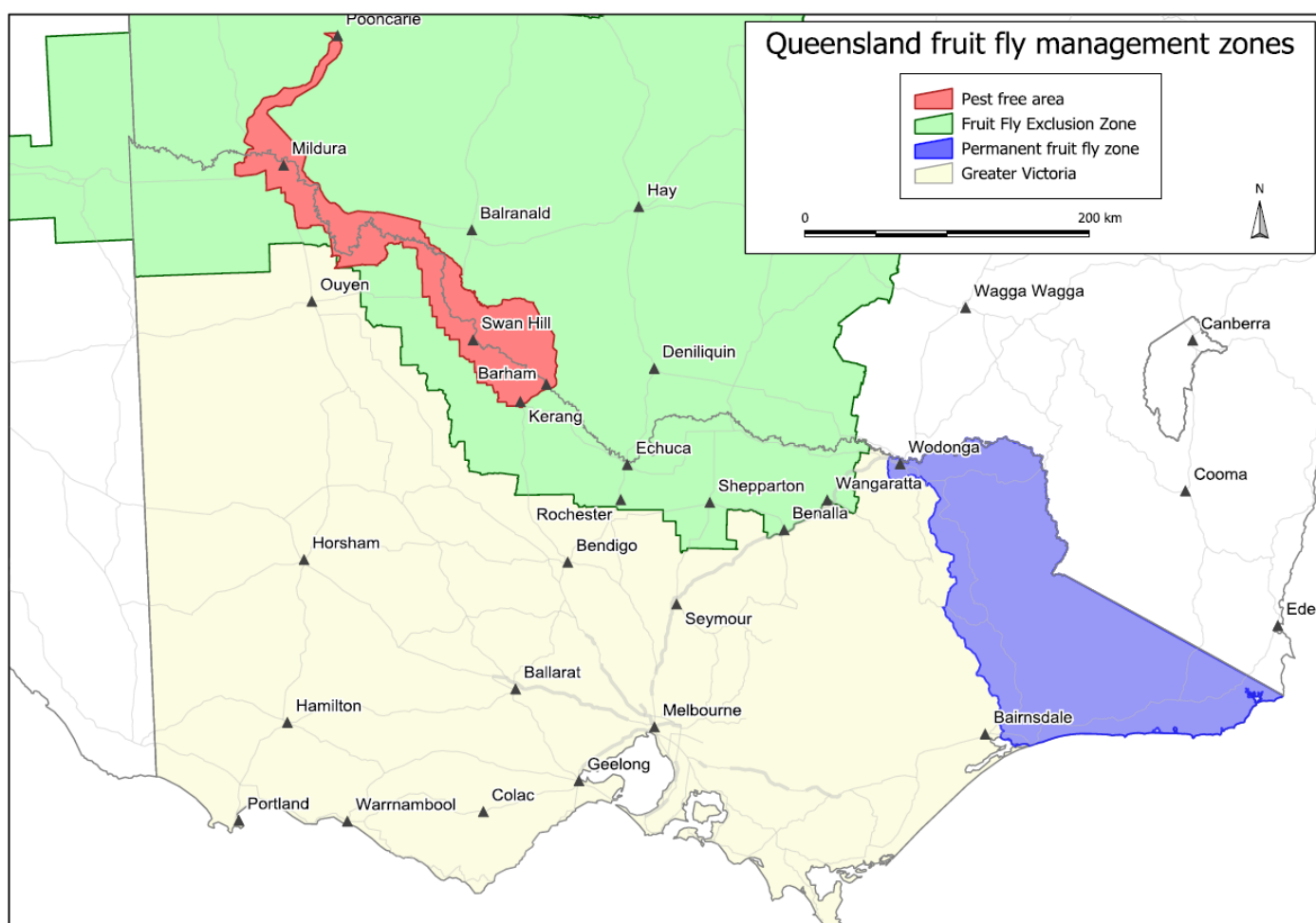
If five or more fruit flies are detected in a single trap within 14 days, a 15 kilometre outbreak suspension zone is declared and area freedom status is lost to local horticultural producers. Once the suspension zone is declared, an eradication program is commenced, which includes chemical control and mating disruption measures. Chemical control measures include the application of attractant baits, cover sprays and ground treatments, while mating disruption includes the use of sterile insect technology (SIT) and the removal of potential egg laying sites (fruit) at the outbreak site. The SIT, which involves introducing large numbers of sterile males, is used to disrupt mating in local wild populations. It is generally used after a Queensland fruit fly population has been reduced to a low level.

2.3 Current Queensland fruit fly program in Victoria

The Queensland fruit fly is gazetted as an exotic species under the Victorian Government's *Plant Health and Plant Products Act 1995*. The current management program provides area freedom for the Queensland fruit fly and the Mediterranean fruit fly, and early warning for exotic fruit flies. The area freedom program aims to facilitate trade to fruit fly sensitive markets.

Since 1994, the governments of Victoria, South Australia and New South Wales have supported a FFEZ, which includes the greater Sunraysia pest free area. Under the Plant Health and Plant Products Act, Victoria is segmented into four management regions: the FFEZ, the greater Sunraysia pest free area, greater Victoria and the Permanent Fruit Fly Zone (an area where fruit fly is not controlled) (map 3).

Map 3: Current area-wide fruit fly program



Source: Map prepared by Ian Shurvell, Biosecurity Victoria, July 2009.

All states and territories recognise the FFEZ—which includes production areas in New South Wales and South Australia—as being area free for both the Mediterranean fruit fly and the Queensland fruit fly. The Permanent fruit fly zone is an endemic area located in East Gippsland where some containment strategies are undertaken to prevent the pest from spreading into fruit production areas.

The program supports access to export and interstate markets. Inspectors routinely verify consignments of fruit (imports as well as exports), as well as accrediting individual businesses under self-verification arrangements or Interstate Certification Assurance arrangements. The greater Sunraysia pest free area is the main source of exports to markets that are sensitive to fruit fly, and it is recognised by 15 countries (including major destinations for horticulture exports from Victoria—the United States, Indonesia and New Zealand).

Costs for the program include head office activities such as policy development and program management, and operational activities such as population monitoring and the eradication of outbreaks. DPI Victoria largely funds these costs (table2).

Table 2: Costs of the current fruit fly program, 2007–08 (\$'000)

Item	DPI Victoria costs	Industry costs
Head office		0
Policy development, including legislation	372	
Program management	269	0
Training, auditing and statewide roles	519	0
Operational		0
Market access, monitoring and surveillance, and compliance across regions	1990	0
Response and eradication	675	0
Fruit fly traps	50	0
Sterile Insect Technology development*	250	
Community awareness	128	0
Greater Sunraysia pest free area	232	200**
Total costs	4485	200
Total costs (Victorian Government and industry)	4685	

* Victoria's share of a national program. ** Excludes funds provided by Horticulture Australia.

Source: Internal estimates, Plant Standards Branch, June 2009.

3 Estimating the benefits and costs of alternative Queensland fruit fly regimes

The objective of a benefit–cost analysis is to quantify the benefits and costs of a project, policy or strategy to assist decision making. This chapter outlines the proposed management options that are analysed (section 3.1). It summarises relevant economic literature (section 3.2), and describes the impact of the management options on producers and consumers (section 3.3). It then details the counterfactual (or alternative) case used to calculate the net benefits and costs of alternative options for managing the Queensland fruit fly (section 3.4). Finally, section 3.5 provides details of the method.

3.1 Management options for a new Queensland fruit fly program

Kalang Consultancy Services (2008) identified three management options for a new Queensland fruit fly area. Table 3 shows the key features of these management options, which are depicted in maps 4, 5 and 6.

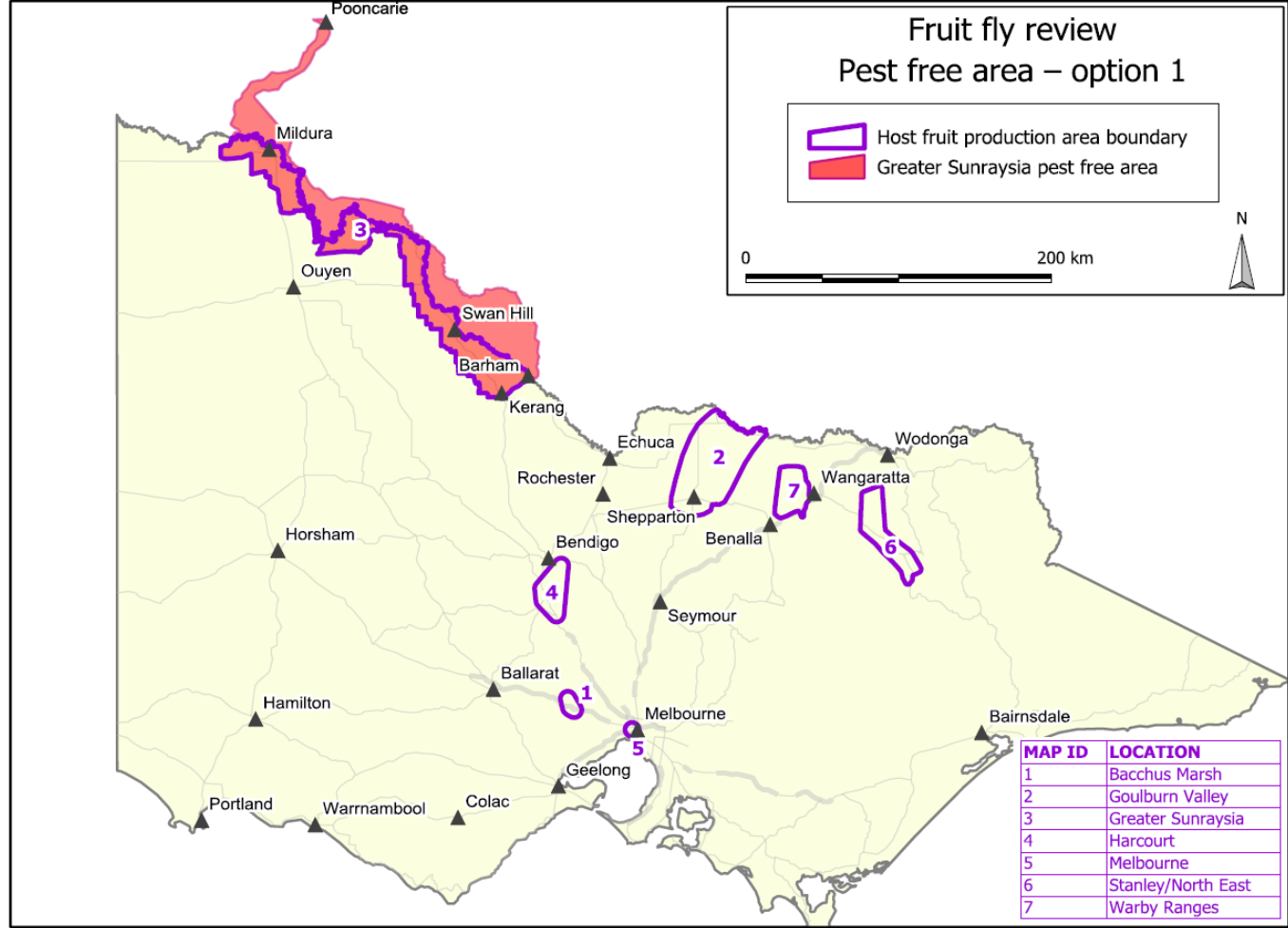
Table 3: Comparison of proposed management options for a new Queensland fruit fly program⁴

	Management option 1	Management option 2	Management option 3
Description	<p>This option effectively deregulates fruit fly management except for pest free areas, and allocates resources to key host fruit production areas.</p> <p>Under this option, there would be no verification and certification costs for fruit imported into Victoria unless the fruit was moved into pest free areas.</p> <p>Endemic Queensland fruit fly populations outside pest free areas increase the risk of outbreaks in pest free areas.</p>	<p>This option involves import controls on host fruits and materials. Pest monitoring, reporting and eradication programs would occur.</p>	<p>This option focuses resources on high production areas by excluding towns and non-production regions from pest free areas.</p> <p>Use of areas of low pest prevalence helps manage Queensland fruit fly populations outside production areas and reduces the risk of outbreaks.</p>
Pest free areas	<p>All management options are modelled with pest free areas in the following regions: Melbourne, Sunraysia, Goulburn–Murray and Loddon.</p> <p>All management options eradicate outbreaks in pest free areas.</p>		
Areas outside pest free areas	No Queensland fruit fly control or eradication for the rest of the state	Statewide area freedom in accordance with the code of practice, including the Victorian component of the FFEZ	Non-pest free areas are managed as areas of low pest prevalence. Population levels are suppressed, but eradication is not required.
Proposed area	See map 4	See map 5	See map 6

Note: All the management options conform to phytosanitary standards established in ISPM 26. Option 3 also conforms to ISPM 30 (International Plant Protection Convention 2006, 2008). The glossary explains the purpose of each ISPM.

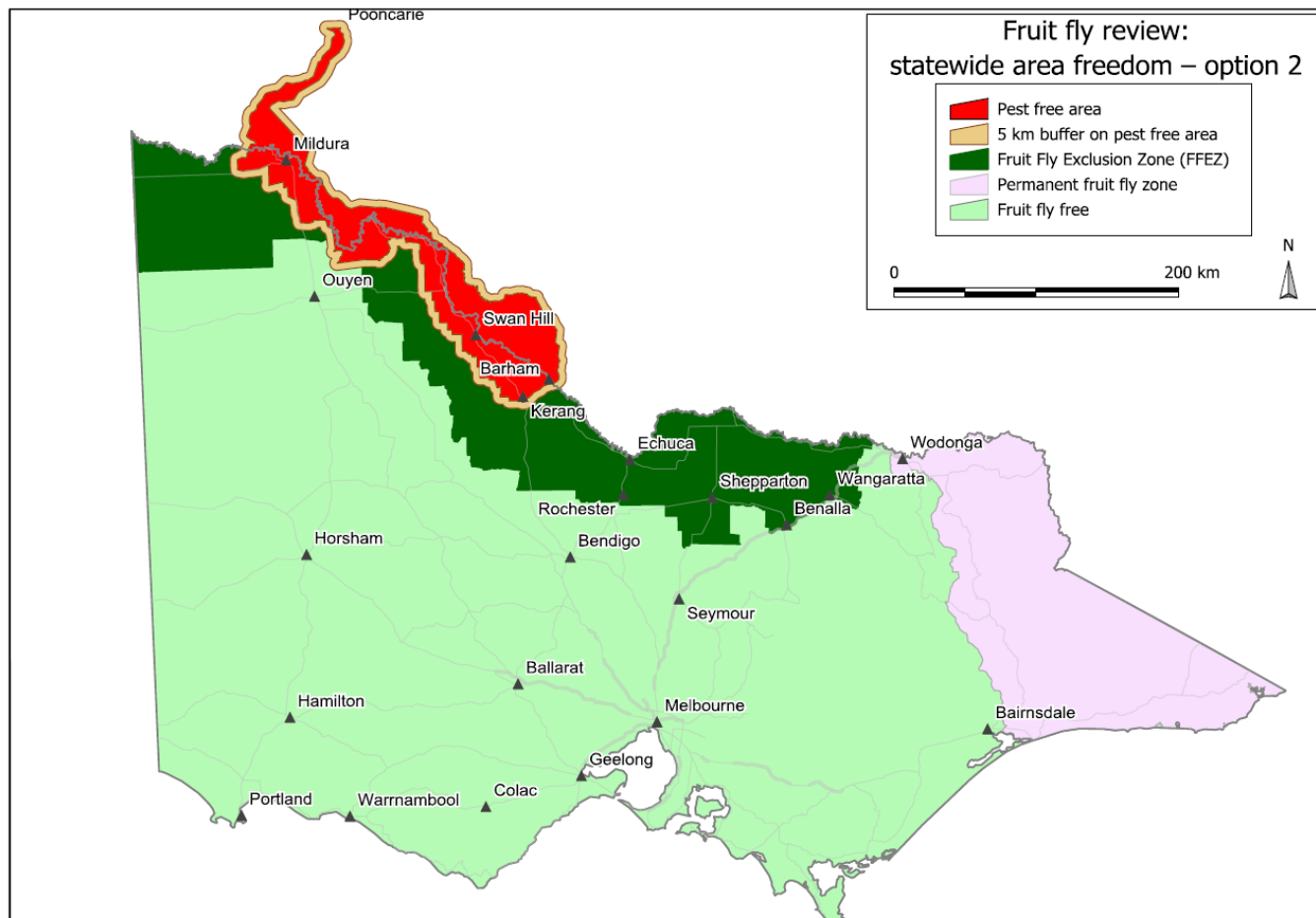
⁴ Based on Kalang Consultancy Services (2008), p. 6.

Map 4: Option 1



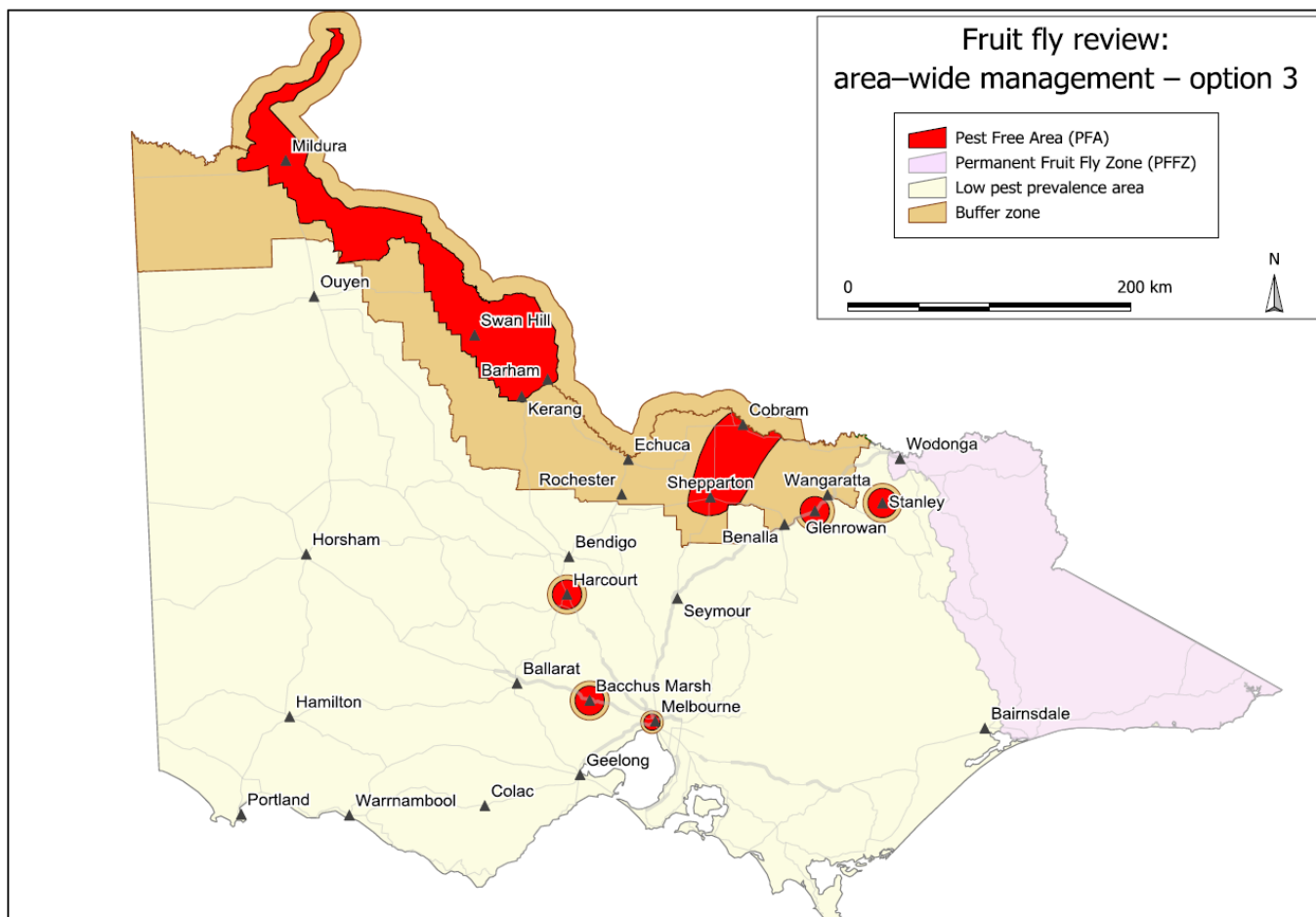
Source: Map prepared by Ian Shurvell, Biosecurity Victoria, July 2009.

Map 5: Option 2



Source: Map prepared by Ian Shurvell, Biosecurity Victoria, July 2009.

Map 6: Option 3



Source: Map prepared by Ian Shurvell, Biosecurity Victoria, July 2009.

3.2 Previous economic studies

Three of the previous economic studies into fruit fly programs in Australia and overseas assess the benefits and costs of an area-wide program, as per the focus of this study. The three studies are by the Horticulture Policy Council (1991), PricewaterhouseCoopers (2001) and Chambers and Franco-Dixon (2007). These studies—and two on the economics of quarantine and animal disease control programs (Hinchey and Fisher 1991; Abdallah, Rodriguez & Heaney 2000)—informed the development of the economic framework used in this report to assess the benefits and costs to the Victorian community of a Queensland fruit fly area-wide program.

The Horticultural Policy Council (1991) reviewed the use of an area freedom program to manage fruit fly threats as part of a wider examination of the impact of fruit flies on Australian horticulture. The report examined the science underlying fruit fly management and included a benefit–cost analysis of the area-wide management program conducted by South Australia, Victoria and New South Wales. It used a partial equilibrium framework to assess the economic impact on producers and consumers from withdrawing a government funded Queensland fruit fly program. Net benefits were in the range \$10.1 million to \$14.5 million per annum.

PricewaterhouseCoopers (2001) estimated the benefits of the area-wide management program conducted and funded by the governments of New South Wales, South Australia and Victoria—that is, the Fruit Fly Exclusion Zone (FFEZ). Map 3 shows the Victorian component of the FFEZ. The study found growers benefited from increased interstate and export market access, and reduced spending on chemical costs. PricewaterhouseCoopers (2001) did not estimate the benefits of increased interstate trade, noting that increased interstate trade involved transfers between consumers and producers. Net benefits were estimated to be \$14.9 million per annum.

Chambers and Franco-Dixon (2007) estimated the economic benefits of an area-wide program to avoid the use of dimethoate, which is a post-harvest chemical used in the Central Burnett district of Queensland. A benefit–cost analysis, incorporating probability analysis, was used to estimate the benefits to producers—namely, avoided chemical costs and the market premiums from interstate trade. Area wide management for Central Burnett producers was assessed as providing net benefits of \$5.2 million per annum.

3.3 Economic welfare effects of area-wide management programs

The impacts of the proposed management options are the effects on producers and consumers in Victoria. Australian fruit is available for domestic consumption during the harvest period. Consumers benefit from free trade in fresh fruit. The majority of host fruits of Queensland fruit fly are imported towards the end of the local harvest period, providing consumers with year round availability of fruit. Table 4 contains import data for fresh fruit.

Table 4: Victorian imports of fresh host fruits of Queensland fruit fly, 2006–07

Host fruit	Imports (\$ million)	Imports as a proportion of Victorian gross value of production (per cent)
Citrus*	9.7	14.9
Pome fruit	0.8	0.2
Stone fruit**	15.7	6.4
Grapes	15.7	5.3

* Includes oranges, mandarins, grapefruit and lemons. ** Includes olives.

Note: Table 1 shows the gross value of production for host fruits of Queensland fruit fly.

Source: ABS (2008b, 2009).

Fruit supplied to the domestic market is of similar quality to that supplied to export markets. Fruit will be exported if this is expected to be more profitable than domestic markets, meets grade standards and can be sold within the storage life of the particular fruit type. All three constraints mean that not all fruit will be exported despite the apparent profitability of export markets. This means that the introduction of a Queensland fruit fly program is not expected to have any influence on consumer prices. The Horticulture Policy Council (1991) also reached this conclusion when considering the removal of the Queensland fruit fly area freedom program.

The introduction of any regime to manage Queensland fruit fly will increase producers' profitability if it reduces their variable costs⁵ of controlling fruit fly. This reduction in variable costs represents a benefit to producers from Queensland fruit fly management. Appendix A contains more information on the approach used to estimate the benefits to producers.

⁵ Including contribution to the cost of area wide management of Queensland fruit fly.

3.4 The counterfactual case

The counterfactual (alternative) case is the baseline against which the net benefits and costs of alternative strategies are compared. It reveals the total benefits and costs, which is recommended by the Food and Agriculture Organization of the United Nations.⁶

The counterfactual case used in this study is for the Victorian Government to ‘do nothing’—that is, the government would cease to monitor Queensland fruit fly populations, eradicate outbreaks and run certification and accreditation programs. The Department of Primary Industries (DPI) Victoria would not carry out Queensland fruit fly related market access activities (such as verification services for host fruit movements into and out of Victoria).

In the ‘do nothing’ situation, the areas of the state that are Queensland fruit fly free (including the greater Sunraysia pest free area and the FFEZ) are assumed to become infested. If all areas became infested, then growers of Queensland fruit fly host fruits are assumed to apply pre-harvest chemicals to control infestations to maintain market access. Post-harvest disinfestation costs are assumed to ensure host fruit produce can be exported to sensitive markets. In summary, host fruit industries are assumed to respond at the farm level, and no industry-wide actions replace current DPI Victoria activities.

The ‘do nothing’ counterfactual would turn Victoria into a non-sensitive market for host fruits. The Queensland fruit fly endemic states (Queensland and New South Wales) could export fruits to Victoria with no controls on movement.

3.5 Method of calculation

Historical information on host fruit production, exports, prices and costs, and DPI Victoria costs in managing fruit fly, is used to calculate the net present value (NPV) and benefit–cost ratio (BCR) for each management option. The benefits and costs of a fruit fly program are explained below.

3.5.1 Time horizon

The benefits and costs of any area freedom program can occur over a long time. In this study, they were analysed over 20 years. Growers contemplating new investment or re-investment would incorporate expected prices and costs (including those from interstate and export market access, and avoided chemical costs) over a lengthy planning period. Twenty years represents a common period for investment in stone and pome fruit, and vineyard development (O. Montecillo, pers. comm., 27 January 2009). For citrus, the period can be up to 25 years.

3.5.2 Benefits and costs

A social benefit–cost analysis considers all benefits and costs. Some benefits are priced and some are unpriced, as depicted in Figure 1. Most benefits and costs are priced in markets and thus are easily quantified and valued. Those not valued in a market are more difficult to quantify.

⁶ The Food and Agriculture Organization of the United Nations recommends estimating total costs and benefits when undertaking cost–benefit studies of pest eradication programs (Secretariat of the International Plant Protection Convention 2007).

Primary benefits	Priced	Unpriced	Primary costs	Priced	Unpriced
Secondary benefits	Priced	Unpriced	Secondary costs	Priced	Unpriced

The following sections explain the primary and secondary benefits and costs considered in this study.

Avoided pre-harvest and post-harvest chemical costs

Calculation of pre-harvest chemical costs

Calculation of post-harvest chemical costs

Access to international markets

⁷ Details required for each export markets can be viewed on the AQIS phyto database (www.aqis.com.au/).

Benefit–cost analysis of options for managing
Queensland fruit fly in Victoria

This analysis focuses on the value of the premium from exports to the US citrus market above prices received in alternative markets that do not require area freedom.⁹ The US citrus market is the only large market that requires area freedom (Table 5). The other large market, Hong Kong, is not sensitive to the pest status of fruit (AQIS 2008). A distinction is made between losing area freedom and suspending area freedom due to an outbreak. The former would occur in the 'do nothing' counterfactual case (section 3.4); the latter would occur if an outbreak occurred under a management strategy with pest free areas. If an outbreak occurred in citrus production regions in Victoria then area freedom would be suspended, but the United States would allow citrus imports from Victoria as long as consignments were treated according to US market access requirements. Alternatively, if those same regions lost area freedom because there was no area management program, as in the do nothing case, then citrus exports to the US would be prohibited and the market would be lost.

Table 5: Major markets for Victorian host fruit exports, 2006–07

Commodity	Victorian production value (\$ million)	Victorian export value (\$ million)	Exports as a proportion of value of production (per cent)	Major markets, as proportion of export value (per cent)			
				United States	Hong Kong	Indonesia	New Zealand
Citrus (dried and fresh)	64.8	60.5	93	28	17	4	7
Pome fruit	330.3	5.6	2	0	2	10	34
Stone fruit	243.9	19.1	8	0	39	1	0
Grapes (dried and fresh)	294.8	94.0	32	0	25	14	3

Sources: ABS (2008b), Global Trade Information Statistics (2009).

The value of this access has two components: a price premium and a quantity component. The price premium is calculated as the price received in a given market less the price received in the next market. The price differential, or premium, represents the market value of a particular quality—in this case, freedom from the Queensland fruit fly. Using the method outlined in appendix B (section B1.1), the estimated real average annual value of access to the US citrus market is around \$9.7 million.

3.5.2.2 Primary benefits (unpriced)

The avoided cost from the loss of integrated pest management systems has not been quantified. These systems allow growers to implement complementary techniques, such as biological methods, to control pests while reducing the use of chemicals. The increased chemical use due to an endemic Queensland fruit fly population would compromise integrated pest management efforts.

The benefits from access to interstate markets without incurring pre harvest chemical costs and post harvest chemical (disinfestation) costs could not be quantified as reliable data could not be obtained.

3.5.2.3 Secondary benefits (unpriced)

Backyard growers of host fruit, particularly those near the Queensland fruit fly program area, receive a benefit from the program because reduced Queensland fruit fly populations mean these growers enjoy more edible fruit but do not pay for Queensland fruit fly control measures. This benefit is difficult to value: some people value the fruit and some people value the gardening experience, and some people value both these attributes. At the time of this analysis, no reliable information was available to place a value on this benefit. Appendix C explains this issue.

⁹ In May 2009, Japan agreed to access for citrus from the greater Sunraysia pest free area. This means citrus picked and packed between June and December will not require treatment for fruit fly. This study has not included the benefits of this access.

3.5.2.4 Primary costs (priced)

The primary costs of a management option include program costs and production costs, both of which depend on outbreak frequency. Program costs include establishing and maintaining a Queensland fruit fly management option—including eradication—and production costs include private disinfestation costs due to outbreaks. This section explains the method for calculating the establishment and maintenance costs of pest free areas, the FFEZ and areas of low pest prevalence, as well as the disinfestation costs from expected outbreaks. Appendix B (section B2) contains details.

Program costs

Establishment costs for Queensland fruit fly management options

Each management option identified by Kalang Consultancy Services (2008) entails establishment costs that would be incurred before the options begin to generate benefits. Management options 1 and 3 require the establishment of pest free areas. Australia has defined these requirements in a code of practice to guide industry and regulators in establishing and maintaining pest free areas (Interstate Plant Health Regulation Working Group 1996). These requirements have guided the estimation of the establishment costs for this benefit–cost analysis.

The establishment costs of a management option are a fixed cost incurred in the first three years of the program implementation. This analysis specifies these costs for each management option. Appendix b (section B2) contains further information.

Maintenance costs

Maintenance costs for both the pest free areas and the FFEZ are associated with activities required to comply with ISPM 26 and/or the code of practice (International Plant Protection Convention 2006). They include fixed and variable costs. Fixed costs include maintenance costs, such as monitoring traps for Queensland fruit fly. Variable costs, such as eradication costs, are incurred as a result of outbreaks and are necessary to retain area freedom.

Victorian DPI staff involved in Queensland fruit fly maintenance also undertake non-Queensland fruit fly activities. These activities include monitoring other types of fruit fly and exotic plant pests and diseases, and advising on interstate quarantine requirements. Staff costs have been reduced by 20 per cent to cover these non-Queensland fruit fly activities

Calculating eradication costs required considering the probability, size and duration of outbreaks, as well as the costs of eradication. Tables 10, 11 and 12 contain data on the expected frequency of outbreaks. Outbreaks are defined by size as small, medium or large. The size of the outbreak refers to how many properties need to be treated in the event of an eradication effort; the more properties treated, the higher are the eradication costs. Eradication costs are based on historical data obtained from DPI Victoria records on previous eradication programs. Table 6 shows the costs of eradicating an outbreak of a given size. Table 7 shows assumptions regarding the eradication costs for each Australian Bureau of Statistics statistical division.

Table 6: Eradication cost, by size of outbreak

Size of outbreak	Cost (\$'000)
Small	61
Medium	131
Large	267

Note: Cost includes \$1775 of administration costs.

Source: Plant Standards Branch, June 2009.

Table 7: Eradication cost, by statistical divisions

Statistical division	Eradication cost
Melbourne	Large
Mallee	Large
Goulburn	Medium
Ovens–Murray	Medium

Source: Plant Standards Branch, June 2009.

Another determinant of eradication cost is the length of the eradication process. Eradication activity is required to occur for at least 12 weeks to ensure domestic area freedom is re-instated. In persistent outbreaks, the domestic area freedom re-instatement period is re-set every time a fly is detected, and eradication activity starts again. Eradication programs are based on weeks. The duration differs across management options, as shown in Table 8.

Table 8: Duration of eradication, by management option and statistical division (weeks)

Statistical division	Option 1	Option 2	Option 3
Melbourne	18	18	12
Mallee	12	12	12
Goulburn	18	18	12
Ovens–Murray	18	18	12

Source: Plant Standards Branch, June 2009.

The same duration of eradication is assumed to apply for all statistical divisions in management options 1 and 2. The eradication duration is assumed to be longer in Melbourne, the Goulburn and the Ovens–Murray statistical divisions for the following reasons. In the Melbourne statistical division, a large number of properties would need to be treated. The Goulburn and Ovens–Murray statistical divisions are close to large Queensland fruit fly populations in Albury Wodonga, and to Queensland fruit fly risk vectors such as the Hume Highway.

Eradication duration is lower in management option 3 for all statistical divisions for two reasons. First, pre-emptive suppression measures are undertaken in adjacent towns, which may be a source of future outbreaks. These will help keep Queensland fruit fly populations low, reducing the likelihood of pest numbers increasing to a level at which they can spread into an adjacent pest free area. Second, because most of the assumed pest free areas do not contain towns or areas of the state that historically have been under high pressure from the Queensland fruit fly, future eradication programs would require the treatment of fewer properties.

Annual suppression costs (table 9) are used in management options 1 and 3 as a preventative measure to keep Queensland fruit fly populations low in areas adjacent to the pest free area. These continuing fixed costs are incurred every year. Suppression activities include the maintenance of surveillance traps, the deployment of Canite blocks, bait spraying and the ground treatment of larvae infestations.

Table 9: Suppression cost, by statistical division

Statistical division	Suppression cost (\$'000)
Melbourne	10
Mallee	30
Loddon	30
Goulburn	330
Ovens–Murray	340

Source: Plant Standards Branch, June 2009.

Production costs

Disinfestation costs due to outbreaks

While one of the main benefits of a Queensland fruit fly program is avoided disinfestation costs for producers, outbreaks will still occur and will necessitate private disinfestation of fruit. The costs of disinfesting fruit due to outbreaks will depend on the frequency of outbreaks, the quantity of fruit disinfested and the cost of the disinfestation technique. Appendix B (section B2.3) explains the calculation of these costs.

Frequency of outbreaks

The frequency of Queensland fruit fly outbreaks is a key determinant of total eradication and disinfestation costs. This section explains the estimates of frequency developed for each management option.

Management option 1 is similar to the counterfactual case. Areas other than designated pest free areas will become endemic, leading to an increased likelihood of outbreaks in the pest free areas. There are no Victorian data that indicate how this increased likelihood will affect outbreak frequency.

Data from pest free areas in the New South Wales portion of the FFEZ was used as a proxy to estimate the increase in outbreak frequency for management option 1 (because the Queensland fruit fly is endemic in New South Wales outside the FFEZ). Outbreak data in nearby regions were compared, and outbreaks were found to have occurred twice as often, on average, than in similar areas in Victoria.

Towns that have a history of Queensland fruit fly outbreaks would be excised from proposed pest free areas for management option 1. The outbreak frequency estimates for option 3 are thus relevant for option 1 (table 10). They were increased by a factor of two to reflect the increase due to pest pressure estimated from the New South Wales data.

Table 10: Outbreak frequency data, by statistical division—option 1

Statistical division	2004	2005	2006	2007	2008
Melbourne	0	0	0	0	0
Mallee	0	2	0	0	0
Loddon	0	0	0	0	0
Goulburn	4	4	2	0	2
Ovens–Murray	0	0	0	0	2

Source: Plant Standards Branch, June 2009.

Probability distributions were fitted to historical data from 2004–08 to estimate the probability of outbreaks under management option 2 (because option 2 is similar to the current area-wide management strategy and would be likely to result in similar outbreaks). Table 11 suggests an increase in outbreak frequency since 2004 in some areas, due to milder winters and an inability to complete eradication in endemic areas of the state under high fruit fly pressure, particularly in the Ovens–Murray statistical division (G Darcy, pers. comm., 9 June 2009).

Table 11: Outbreak frequency data, by statistical division—option 2

Statistical division	2004	2005	2006	2007	2008
Melbourne	0	1	0	0	3
Mallee	0	1	0	0	0
Loddon	0	0	0	0	0
Goulburn	2	2	2	0	6
Ovens–Murray	3	0	9	5	9

Source: Plant Standards Branch, June 2009.

The probability of outbreaks under management option 3 (table 12) was estimated from the information on historical outbreaks. The design of pest free areas under option 3 would not include towns with significant previous Queensland fruit fly activity, because they are recognised as a major source of Queensland fruit fly infestation; removing these towns from pest free areas would result in a lower number of outbreaks.¹⁰ The resulting outbreaks were used to construct probability distributions of outbreaks under option 3.

Table 12: Outbreak frequency data, by statistical division—option 3

Statistical division	2004	2005	2006	2007	2008
Melbourne	0	1	0	0	3
Mallee	0	1	0	0	0
Loddon	0	0	0	0	0
Goulburn	2	2	1	0	1
Ovens–Murray	0	0	0	0	1

Source: Plant Standards Branch, June 2009.

A computer software program called @Risk was used to incorporate the frequency of outbreaks in the benefit–cost analysis.¹¹ This program enables a model to be run using random numbers chosen from probability distributions for key risk variables. The results, such as the NPV and BCR, are presented as probability distributions. Management options are compared in terms of both the mean and variance of estimated NPVs and BCRs.

3.5.2.5 Secondary costs (unpriced)

Secondary costs could be external effects of the Queensland fruit fly on the natural environment, effects on human health, and costs arising from backyard activities.

One issue is whether Queensland fruit fly management has possible environmental benefits. The Queensland fruit fly is a native fruit fly of northern Australia. Originally found only in tropical and subtropical rainforests of Queensland, it has extended south over time with the introduction of European cultivated fruits that are suitable hosts. Controlling the Queensland fruit fly would have no environmental benefits, however, because the pest has no adverse effect on other local insects and ecological systems (A Tomkins, pers. comm., 20 February 2009). Appendix C contains further information on this issue.

A further issue is whether control of the Queensland fruit fly through an area-wide program would provide human health benefits. Enquiries revealed, however, that the Queensland fruit fly has no effect on human health.

Backyard growers of fruit can be a source of infestation of fruit fly, in which case they could impose a cost on commercial producers. This issue is complex and was not included in this study. Appendix C contains more detail.

¹⁰ Suppression costs will increase, however, because additional activity will be undertaken to ensure towns do not become a source of infestation.

¹¹ @Risk was developed by the Palisade Corporation (www.palisade.com).

3.5.3 Discount rate

The discounting of the value of future streams of benefits and costs incorporated the opportunity cost of funds. The analysis used a social discount rate to calculate the NPV and the BCR. It used this rate because the existing management program is organised and largely funded by the Victorian Government. The social discount rate of 5 per cent real is based on the Treasury Corporation Victoria's 10 year bond rate.¹² The sensitivity of the results was tested using real discount rates of 8 and 10 per cent per year.

3.5.4 Risk

Risk and uncertainty are distinguished in this analysis. *Risk* is defined as the probability of an event; *uncertainty* is characterised by lack of information on the probabilities of different impacts.

The analysis tested the sensitivity of results to changes in the values of key components. Monte Carlo analysis¹³ of the probability of outbreaks incorporated risk into the estimation of the three options' costs and benefits. The risk of Queensland fruit fly outbreaks is the main determinant of:

- eradication costs
- the cost of disinfecting fruit in response to an outbreak.

Outbreaks are expressed as *probability distributions* of outbreaks, not single values, and the resulting NPV and BCR estimates are expressed as distributions. Having the output of the analysis expressed in terms of distributions allows the management options to be evaluated in terms of risk and return. The expected value of a management option can be estimated, as well as the variation around the mean. This information assists decision makers to choose options according to preferences for risk and return.

3.5.5 Net present value and benefit–cost ratio

The benefits and costs of each management option are expressed in two ways. First, the NPV calculation was used to quantify the discounted net benefits of each option over the 20 year period. The NPV was calculated by adding all the benefits and subtracting all costs for each year. The annual net benefits were discounted at the Victorian Department of Treasury and Finance's social discount rate of 5 per cent and summed over a 20 year period to yield the NPV for the respective option. Appendix B (section B3) details the formula used to compute the NPV for each option.

The BCR is the second way of expressing the benefits and costs of each management option. It is the ratio of discounted benefits over discounted costs, and was computed (in 2009 dollar values) for the three options. Appendix B (section B3) details the formula used to compute the BCR for each option.

Both the NPV and BCR were calculated because they provide different information. The NPV is an estimate of the *absolute* magnitude of the present value of net benefits resulting from the use of resources. The BCR is a *relative* measure of net benefits. It measures the relative difference between benefits and costs—the greater the BCR, the greater is the net return per dollar of capital invested (Commonwealth of Australia 2006). The NPV was used to rank projects, and the BCR was used to comment on the efficiency of resource use under each management option.

¹² This rate was agreed in discussion with officials in the Department of Treasury and Finance.

¹³ Monte Carlo analysis refers to a method of research that relies on multiple runs of a model using random estimates based on probability distributions. It allows the user to incorporate uncertainty around estimates and model outputs.

4 Results and discussion

This chapter explains the estimated annual benefits and costs of each management option, and reports the results of the discounted cash flow analysis.

4.1 Summary of results

Table 13 shows the differences across the three management options derive from differences in costs.

Table 13: Mean values of discounted annual benefits and costs of all management options (\$ million)

	Management option 1	Management option 2	Management option 3
Annual benefits			
Market access	6.3	6.3	6.3
Avoided pre-harvest chemical costs	1.3	1.4	1.4
Avoided post-harvest disinfestation costs	25.6	25.6	25.6
<i>Total benefits</i>	33.2	33.3	33.3
Annual costs			
Production costs: disinfestation costs following outbreaks (mean)	13.9	12.3	11.7
Program costs: establishment costs (for first three years)	1.1	0.1	1.2
Program costs: maintenance costs			
Eradication costs (mean)	0.6	1.9	0.4
Fixed costs (including suppression costs)	2.0	1.5	2.0
<i>Total costs</i>	16.6	15.7	14.4

Note: Annual costs include establishment costs for the first three years. Total costs are not the sum of the annual costs listed for each management option. This is because they are discounted over the 20 year period.

Table 14 reports the mean results of the discounted cash flow analysis, and variance. Management option 3 has the highest NPV. The mean (or average) net present value (NPV) of management option 3 is estimated to be more than \$379 million over the 20 year period. Similarly, the benefit–cost ratio (BCR) is larger for option 3 than for the other management options: 2.35 compared with 2.02 and 2.15 for options 1 and 2 respectively. Option 3 has the lowest variance of all NPVs and BCRs.

Management option 3 generates a higher NPV mostly because the probability of outbreaks is lower. This translates into savings from disinfestation and eradication costs of more than \$2–3 million per year, relative to options 1 and 2. These savings in annual recurring costs offset the higher establishment and suppression costs.

Another difference is that the coefficient of variation¹⁴ is lower for management option 3 than for the other options: 0.086 compared with more than 0.09. The NPV for option 3 is thus less variable than it is for the other options—that is, there is less uncertainty about this estimate than there is about the other two.

The risk profile of the management options can be considered in terms of the likely value ranges for each option. This is shown by the 90 per cent upper and lower estimates of the NPV and BCR. Option 3 has a 90 per cent probability of being between \$324 million and \$431 million. The equivalent 90 per cent upper and lower ranges for options 1 and 2 are less than for option 3.

The following sections present tests of the robustness of this result.

Table 14: Results of benefit–cost analysis over 20 years, at 5 per cent discount rate

	Management option 1	Management option 2	Management option 3
NPV (mean \$ million)	332.5	353.5	379.5
90% lower bound	275.0	298.8	323.9
90% upper bound	386.9	405.0	431.3
NPV coefficient of variation	0.103	0.091	0.086
BCR (mean \$)	2.02	2.15	2.35
90% lower bound	1.71	1.81	1.95
90% upper bound	2.39	2.54	2.83

4.2 Testing the sensitivity of results to changes in key variables

The results indicate that management option 3 generates the highest economic value because it has lower annual eradication and disinfestation costs as a result of lower frequency of outbreaks. This conclusion holds over the range of possible outcomes for each management option.

4.2.1 Sensitivity to changes in one key variable

The analysis investigated the impact on the results of a change in one assumption, as follows:

1. sensitivity analysis 1: a discount rate of 8 per cent real
2. sensitivity analysis 2: a discount rate of 10 per cent real
3. sensitivity analysis 3: halving of the benefits from US citrus market access
4. sensitivity analysis 4: no benefits from the US citrus market
5. sensitivity analysis 5: halving of the frequency of Queensland fruit fly outbreaks
6. sensitivity analysis 6: doubling of chemical and disinfestation treatment costs.

¹⁴ The coefficient of variation is a measurement of the dispersion of a probability distribution, so it suggests how a dataset varies around its mean. It is a dimensionless measurement, so it can be compared directly across datasets.

Table 15 summarises the results of these analyses, with details provided in appendix D. Management option 3 remains the preferred option even when key variables are changed.

Table 15: Results of sensitivity analyses

	Management option 1	Management option 2	Management option 3
Sensitivity analysis 1 (8 per cent real discount rate)	NPV: \$269 million BCR: 2.02	NPV: \$286 million BCR: 2.15	Highest NPV: \$307 million BCR: 2.35
Sensitivity analysis 2 (10 per cent real discount rate)	NPV: \$237 million BCR: 2.02	NPV: \$253 million BCR: 2.15	Highest NPV: \$271 million BCR: 2.35
Sensitivity analysis 3 (halving of benefits from US citrus market access)	NPV: \$272 million BCR: 1.83	NPV: \$289 million BCR: 1.95	Highest NPV: \$316 million BCR: 2.13
Sensitivity analysis 4 (no US citrus market access benefits)	NPV: \$205 million BCR: 1.64	NPV: \$226 million BCR: 1.74	Highest NPV: \$252 million BCR: 1.90
Sensitivity analysis 5 (halving of frequency of Queensland fruit fly outbreaks)	NPV: \$378 million BCR: 2.35	NPV: \$473 million BCR: 3.55	Highest NPV: \$508 million BCR: 4.37
Sensitivity analysis 6 (doubling of chemical and disinfestation costs)	NPV: \$585 million BCR: 2.01	NPV: \$636 million BCR: 2.20	Highest NPV: \$672 million BCR: 2.36

4.2.2 Possible scenarios

This section examines some scenarios that may occur. Scenarios differ from sensitivity analyses by having more than one assumption changed at a time. Two scenarios are simulated here:

1. scenario 1: a 'superfly' causes a doubling of outbreak frequency and suppression costs
2. scenario 2: a 'superfly' causes a quadrupling of outbreaks for management option 3 and a doubling of outbreaks under the other options.

The findings from the scenarios (table 16) complement those from the sensitivity analyses.

Table 16: Results of scenario analyses

	Management option 1	Management option 2	Management option 3
Scenario 1 (doubling of outbreaks per year for all management options)	NPV: \$237 million BCR: 1.56	NPV: \$302 million BCR: 1.85	Highest NPV: \$314 million BCR: 1.91
Scenario 2 (quadrupling of outbreaks for option 3, while doubling of outbreaks for other options)	NPV: \$247 million BCR: 1.60	Highest NPV: \$302 million BCR: 1.85	NPV: \$248 million BCR: 1.60

Management option 3 has the highest NPV up to the point at which the number of outbreaks results in high eradication costs in high value statistical divisions. This was found in scenario 2.

4.3 Discussion

The results of the analysis derive from costs rather than benefits. The benefits are constant across all management options because they would not exist without a Queensland fruit fly area-wide management program.

The management option with the lowest cost is the option that will have the highest NPV and BCR. While option 3 has the highest fixed costs in all but scenario 2, it is expected to have the lowest number of outbreaks. The fewer outbreaks, the lower are the eradication and disinfestation costs. As a result, total costs are lower. A key implication from this benefit–cost analysis is that a management option's success in reducing Queensland fruit fly outbreak frequency critically determines the final NPV and BCR.

While all proposed management options result in net benefits, management option 3 has the highest NPV and BCR. Additionally, it generally has less risk of generating returns that are lower than those of the other management options. A range of tests confirmed the robustness of these results.

More overseas markets may recognise Queensland fruit fly area-wide programs over time. Currently, free trade agreements and Sanitary and Phytosanitary Agreement issues are under discussion with many countries. Regardless of possible changes in access to markets, the management options examined in this analysis reduce the costs of Queensland fruit fly management, and improve the competitiveness of producers.

5 References

- Abdallah, A, Rodriguez, G and Heaney, A 2000, 'The economic value of animal disease control measures in Australia', *Animal health in Australia—securing our future*, Canberra.
- ABS (Australian Bureau of Statistics) 2001, *International merchandise trade, Australia: concepts, sources and methods*, Canberra.
- ABS 2002, *Australian social trends*, cat. no. 4102.0, Canberra.
- ABS 2008a, *Australian social trends*, cat. no. 4102.0, Canberra.
- ABS 2008b, *Agricultural commodities: small area data, Australia, 2006-07*, cat. no. 7125.0, Canberra.
- ABS 2009, *International trade*, Unpublished data, cat. no. 5368.0, Canberra.
- AQIS (Australian Quarantine and Inspection Service) 2008, *Phyto database: international phytosanitary standards*, Canberra.
- Chambers, S and Franco-Dixon, MA 2007, *Benefit–cost analysis of area wide management (AWM) of fruit flies in the Cental Burnett District of Queensland*, Queensland Department of Primary Industries and Fisheries, Brisbane.
- Commonwealth of Australia 2006, *Handbook of cost–benefit analysis*, Canberra.
- Commonwealth of Australia 2008, *Architecture of Australia's tax and transfer system*, Canberra.
- Department of Agriculture, Fisheries and Forestry (Commonwealth of Australia) 2009, *Sanitary and phytosanitary measures*, Canberra.
- Department of Primary Industries (Victoria) 2009, *Queensland fruit fly*, Melbourne.
- Duyck, PF, David, P and Quilici, S 2004, 'A review of relationships between interspecific competition and invasions in fruit flies (*Diptera Tephritidae*)', *Ecological Entomology*, vol. 29, pp. 511–20.
- Edwards, GW and Freebairn, JW 1982, 'The social benefits from an increase in productivity in part of an industry', *Review of Marketing and Agricultural Economics*, vol. 50, pp. 193–210.
- Global Trade Information Statistics 2009, Unpublished data collected for the Victorian Department of Primary Industries, Melbourne.
- Hall, T 2007, *Where have all the gardens gone? An investigation into the disappearance of backyards in the newer Australian suburb*, Griffith University Urban Research Program, Brisbane.
- Hinchey, MD and Fisher, BS 1991, *A cost benefit analysis of quarantine*, Technical Paper Series, ABARE, Canberra.
- Horticultural Policy Council 1991, *The impact of fruit flies on Australian horticulture*, HPC Industry Report no. 3, Report to the Hon. John Kerin, Minister for Primary Industries and Energy, Canberra.
- International Plant Protection Convention 2006, *ISPM 26 Establishment of pest free areas for fruit flies (Tephritidae)*.

- International Plant Protection Convention 2007, ISPM 29 Recognition of pest free areas and areas of low pest prevalence.
- International Plant Protection Convention 2008, ISPM 30 Establishment of areas of low pest prevalence for fruit flies (*Tephritidae*).
- International Plant Protection Convention 2009, International phytosanitary portal, <https://www.ippc.int/>.
- Interstate Plant Health Regulation Working Group 1996, 'Code of practice for management of Queensland fruit fly', in Standing Committee on Agriculture and Resource Management (ed.), Melbourne.
- Kalang Consultancy Services 2008, *Review of fruit fly management in Victoria and options for future management*, Independent review produced for the Department of Primary Industries (Victoria), Melbourne.
- O'Loughlin, G.T, East R. A. and Meats A. 'Survival, Development Rates and Generation Times of Queensland Fruit Fly, *Dacus tryoni*, in marginally Favourable Climate: Experiments in Victoria' *Australian Journal of Zoology* 32, 353-61
- PricewaterhouseCoopers 2001, *Benefit cost analysis of the tristate fruit fly strategy*, Report for the Department of Agriculture, Fisheries and Forestry (Commonwealth of Australia), Canberra.
- Secretariat of the International Plant Protection Convention 2007, International standards for phytosanitary measures 1–29, Food and Agriculture Organization of the United Nations, Rome.
- Sutherst, RW, Collyer, BS and Yonow, T 2000, 'The vulnerability of Australian horticulture to the Queensland fruit fly, *Batrocera (Dacus) tryoni*, under climate change', *Australian Journal of Agricultural Research*, vol. 51, pp. 467–680.
- Tri-State Review Team 2001, *Technical review of the tri-state strategy for Queensland fruit fly*, Report to the Standing Committee on Agriculture and Resource Management, Melbourne.
- van Velsen, RJ 1987, 'Review of fruit fly campaigns', Department of Agriculture (South Australia). Cited in Horticulture Policy Council (1991).
- Vera, MT, Rodrigues, R, Segura, DF, Cladera, JL and Sutherst, RW 2002, 'Potential geographical distribution of the Mediterranean fruit fly, *Ceratitis capitata* (*Diptera Tephritidae*), with emphasis on Argentina and Australia', *Environmental Entomology*, vol. 31, pp. 1009–22.
- World Trade Organization 1995, Agreement on the application of sanitary and phytosanitary measures, Geneva.
- World Trade Organization 2009, Standards and safety, Understanding the WTO: the agreements, Geneva.

Appendix A

Economic impacts of a Queensland fruit fly management regime

This appendix explains the economic impact of a Queensland fruit fly management regime on consumers and producers.

A1 Producer surplus and consumer surplus

Figure A1 shows domestic consumer demand for a particular Queensland fruit fly host fruit as the curve D . A key assumption is that this fruit is a homogenous product irrespective of its source, domestic or imported. Under this assumption, domestic consumers are indifferent about where the fruit is produced, and their demand for the fruit can be represented by one demand curve. Consumers choose to consume quantity Q_d at the price P_w . In the absence of barriers to trade, this price is given by the world price, P_w .¹⁵ The demand curve D measures the consumer's marginal willingness to pay for a given quantity of consumption. The difference between the consumer's willingness to pay for fruit and the necessary expenditure is called the consumer surplus (shown as the shaded triangle CS).

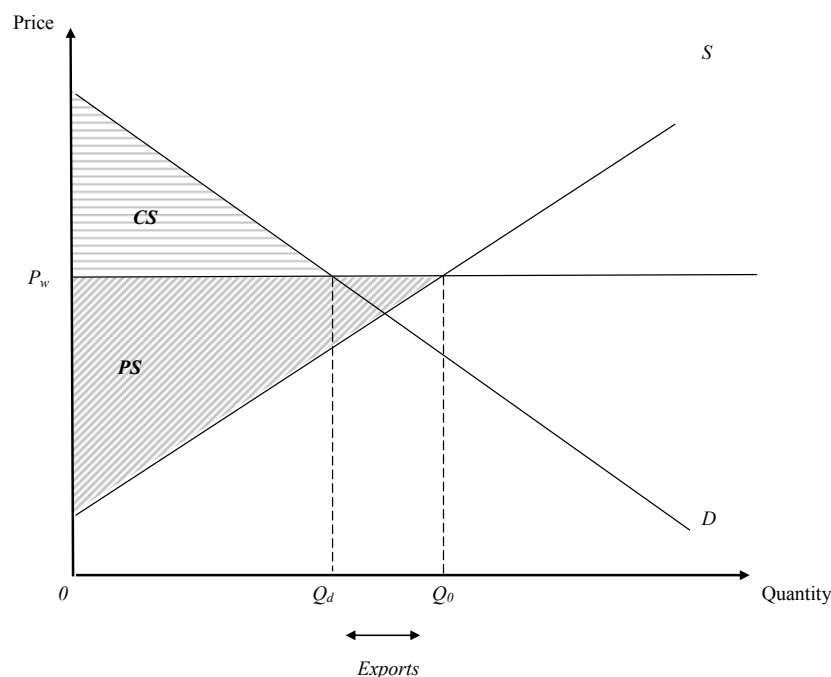
Figure A1 shows domestic producer supply as the curve S , and producers supply Q_o at the world price P_w . The supply curve can be thought of as the marginal cost of supply. The producer surplus (triangle PS) is the difference between the revenue received from supplying that quantity and the marginal cost of producing it. Notice that Q_o is greater than domestic consumption Q_d when host fruits are exported. Australia is a net exporter of major host fruits such as citrus, table grapes and stone fruit.

The net social benefit is the sum of the consumer surplus (willingness to pay less consumer expenditure) and producer surplus (producer revenue less total variable cost of production) from providing a defined quantity of a good or service.

The aim of this benefit–cost analysis is to estimate the *change* to net social benefit from the use of resources in Victoria. Analysing the net social benefit that may result from alternative management regimes for Queensland fruit fly means estimating the change in consumer surplus and producer surplus associated with the alternative management regimes.

¹⁵ This assumption was made because Australia is a small producer relative to world production and is unable to influence world prices.

Figure A1: Consumer surplus and producer surplus without a Queensland fruit fly program



The state of Victoria is the boundary of this benefit–cost analysis. Consumers in Victoria face a situation of (relatively) free trade in Queensland fruit fly host fruits. As a result, this study assumes the Queensland fruit fly management options considered would not lead to higher consumer prices and loss of consumer surplus, for the following reasons. Victoria exports host fruits after harvest and imports host fruits at other times when domestic supply is not available, ensuring year round availability of fruit to consumers.¹⁶ In the case of citrus, fruit supplied to export markets is of the same quality as that supplied to domestic markets.¹⁷ The study thus assumes the Queensland fruit fly management options assessed here would have no impact on domestic prices.¹⁸

While the consumer surplus is unaffected by a Queensland fruit fly area-wide program¹⁹, the producer surplus of host fruit growers in Victoria is directly affected because area-wide measures affect producers' variable costs of production. The management options investigated here will increase producer surplus²⁰ by:

1. increasing the net prices received from having access to the US market
2. reducing the variable costs that producers have to incur to gain and retain access to some markets.

¹⁶ Navel oranges, for example, are harvested from late April to December, after which time the fruit is not suitable for sale. Californian navel oranges are imported from late December through to April, when domestic (Victorian) production is not available. A similar situation occurs with other Queensland fruit fly host fruits.

¹⁷ Common grade standards are used for export and domestic sale.

¹⁸ This conclusion was reached in an earlier study by the Horticulture Policy Council (1991). It means consumer welfare would be unchanged because domestic prices are unchanged.

¹⁹ This analysis is being undertaken before consideration of the financing of a Queensland fruit fly area wide program. If consumers contribute to the cost, then consumer surplus would be reduced by the amount of the contribution to the program, plus the efficiency costs of raising funds. At a system level, the efficiency costs of taxation in Australia have been estimated to be around 6 per cent of GDP. See Freebairn, J 1998, 'Efficiency issues' in *The Tax Reform Debate*, ed P Abelson, Allen and Unwin, Sydney. Cited in Commonwealth of Australia (2008).

²⁰ This analysis is being undertaken before consideration of the financing of a Queensland fruit fly area-wide program. If producers contribute to the cost, then the cost would need to be deducted from the estimated producer surplus.

A2 Estimating changes in the producer surplus

Changes in producer surplus associated with alternative management options are an important component to rank the alternatives. Change in producer surplus is estimated in the following manner:

- Producer's unit costs of fruit production fall with the introduction of Queensland fruit fly management as pre- and post-harvest treatment of fruits are largely avoided. These are assumed to be reductions in variable costs.
- Increased net prices due to sales in Queensland fruit fly sensitive markets.

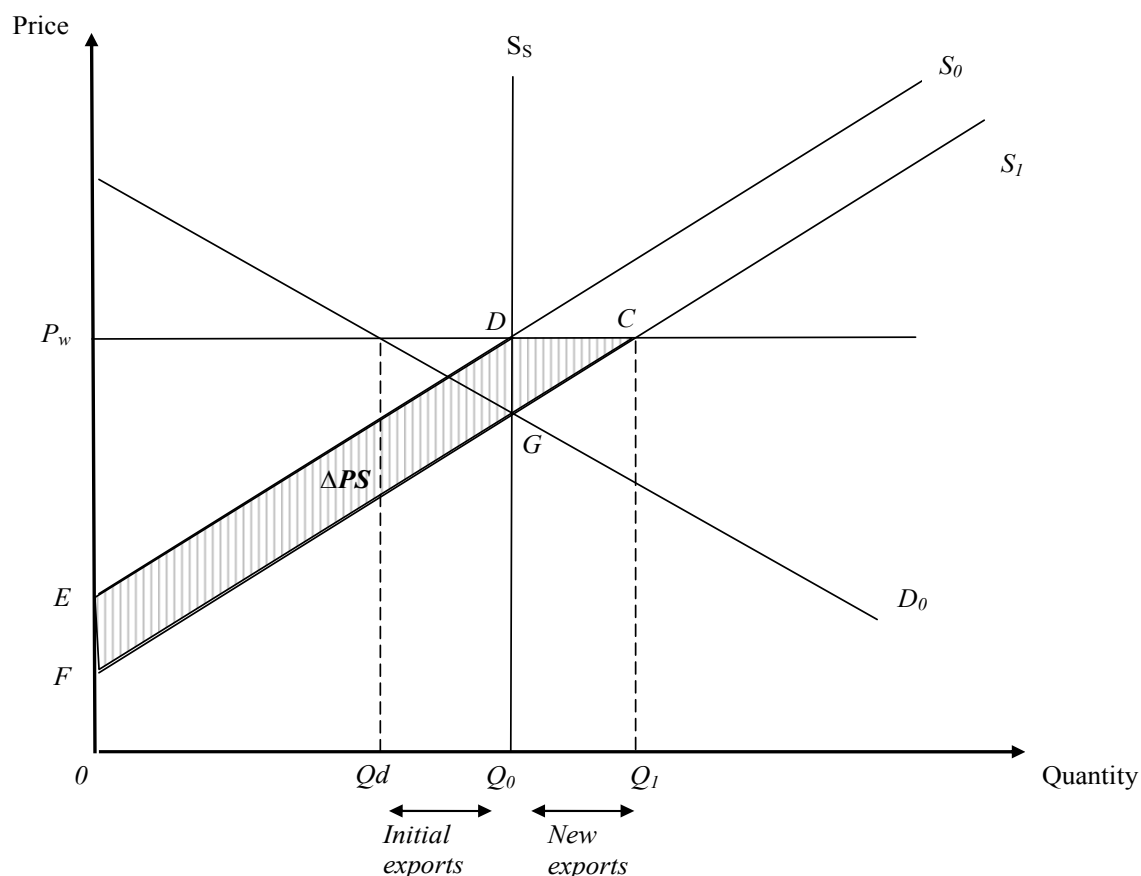
Figure A2 depicts the change in the producer surplus from an area-wide management program. The increase in net receipts (that is, the market premium) is not shown.

Figure A2 closely follows the economic analysis of the Horticulture Policy Council (1991), which assessed the impact of withdrawing the Queensland fruit fly program in south east Australia.²¹ It shows the demand curve for host fruits as D , the short run supply curve as S_s , and the long run supply curve as S_0 . The equilibrium price and quantity with trade are shown as P_w and Q_0 respectively. Q_0 is the quantity supplied from domestic sources at price P_w before the introduction of an area-wide program, and Q_d is the quantity consumed domestically.

The analysis in this report describes a movement from no area-wide program of fruit fly management to a program of control. The long run supply curve would move down and to the right, reflecting a decrease in the per unit cost of fruit fly control ($E-F$), and production would increase to Q_1 . The quantity exported by producers would increase by (Q_1-Q_0) . The price would remain unchanged because domestic producers are price takers on the world market. The increase in producer surplus is represented by the shaded trapezium ΔPS . It is the area $EDCF$. The producer surplus increases because growers can produce more fruit at lower costs. For simplicity, this diagram does not depict the change in the producer surplus due to the premium obtained in Queensland fruit fly sensitive markets.

²¹ The analytical framework is based on Edwards and Freebairn (1982).

Figure A2: Impact of area-wide management program on production of Queensland fruit fly host fruit



The time period for this analysis is 20 years. The economic literature contains no estimates of supply elasticity for other Queensland fruit fly host fruits,²² so it is not possible to measure the area DCG in Figure A2. The implication is that this study underestimates the long term benefits to industry of an area-wide management program.

²² Previous economic studies on Queensland fruit fly do not estimate supply elasticity, so do not measure the producer surplus. See PricewaterhouseCoopers (2001) and Chambers and Franco-Dixon (2007). Other studies that involve horticulture industries (such as irrigation modelling) also do not estimate supply elasticity. ABARE confirmed there is no supply estimate for Australian horticulture (J Hogan, pers. comm., 5 May 2009). The only study that estimated supply elasticity estimated the short and long run supply elasticity of the Australian orange industry to price movements and other variables (Alston et al. cited in Horticultural Policy Council 1991).

Appendix B

Method

This benefit–cost analysis used historical information on host fruit production, exports, prices, production costs and Department of Primary Industries (DPI) Victoria management costs to calculate the net present value (NPV) and benefit–cost ratio (BCR) for each Queensland fruit fly management option. Information about the use of pre-harvest chemicals and avoided post-harvest treatments was developed from discussions with Plant Standards Branch (DPI Victoria) staff, industry contacts and outside experts.

This appendix details the mathematical formulas used to calculate benefits and costs, and the NPV and BCR.

B1 Primary benefits

B1.1 Avoided chemical costs

The total avoided chemical costs (AC_t) is the sum of the avoided cost of pre- and post-harvest chemical costs for the year t as summarised in equation (1)

$$AC_t = PreHC_t + PostHC_t \quad (1)$$

where, $PreHC_t$ is the avoided cost of pre-harvest chemicals for year t ; and $PostHC_t$ is the avoided cost of post-harvest chemical costs for year t . The method for calculating pre- and post-harvest chemical costs is explained as follows.²³

B1.1.1 Pre-harvest chemical costs

Pre-harvest chemicals are applied to host fruit plants as the fruit ripens and becomes vulnerable to Queensland fruit fly infestation. This analysis includes the direct business cost of purchasing chemicals and the labour cost of applying the chemicals.

Pre-harvest chemical costs depend on the application rate and the production area of host fruits in Victoria. The application rate may depend on the type and planting density of host fruit plants, and would influence the per hectare chemical costs. Using data on these components, the benefit of avoided pre-harvest chemical costs under management option i are calculated using equation (2):

$$PreHC_{SD} = \sum_{k=1}^4 (Area_{k,SD} \times C_k) \quad (2)$$

where $PreHC_{SD}$ is the avoided pre-harvest chemical cost in Australian Bureau of Statistics statistical divisions, $Area_{k,SD}$ is the production area for fruit k in the statistical division, and C_k is the pre-harvest control cost of chemicals at a rate applicable to fruit k (including the labour cost of application).

Total annual avoided pre-harvest control cost ($PreHC_t$) for each management option is the summation of equation (3) across statistical divisions:

$$PreHC_t = \sum_{SD=1}^6 PreHC_{SD} \quad (3)$$

²³ In the description of pre- and post-harvest chemical costs, the t subscript has been suppressed to simplify notation. The calculations for each of these costs can be interpreted as being for annual avoided costs.

DPI staff advised that stone fruit and tomatoes are the only host fruits that require pre-harvest treatment to avoid Queensland fruit fly damage. Plant Standards Branch staff provided pre-harvest control data for stone fruit and tomatoes. These data were checked with industry (R Fox, pers. comm., 18 June 2009). Costs per kilogram and per business were used to estimate the avoided costs of pre-harvest chemicals for stone fruit production at \$0.01 per kilogram.

B1.1.2 Post-harvest chemical costs

Post-harvest chemical costs (or disinfestation costs) are incurred when fruit is treated for Queensland fruit fly larvae to prevent the transport of the Queensland fruit fly to export markets. Under an area freedom situation, these costs are not incurred unless an outbreak has occurred.

The benefit of avoiding post-harvest chemical costs depends on production volume and the cost of disinfestation. The calculation of avoided post-harvest chemical costs is expressed as:

$$PostHC_t = \sum_{SD=1}^6 \sum_{k=1}^4 (Q_{k,SD} \times C_k) \quad (4)$$

where $PostHC_i$ is the expected total avoided post-harvest chemical cost under management option i for year t ; $Q_{k,SD}$ is the production volume of fruit k in a given statistical division, and C_k is the post-harvest disinfestation costs for treating fruit k .

C_k is assumed to be the lowest cost allowable chemical for a particular fruit. In nearly all cases, the only allowable chemical cost for disinfestation is cold treatment (AQIS 2008). While cold treatment is not appropriate for all host fruits, especially stone fruit, it is used to estimate the avoided cost of disinfesting pome fruit, citrus, grapes and stone fruit because it is widely accepted as a disinfestation technique, and it is generally less expensive than alternative treatments.

The cost data were obtained from the Plant Standards Branch of DPI Victoria, and checked with industry (M Stevens, pers. comm., 19 June 2009). The cost of cold storage disinfestation was estimated at \$0.05 per kilogram of fruit.

B1.2 Premium for exports to US citrus market

Access to the US citrus market was valued in the following way. First, Hong Kong was chosen as the alternative market because it is a large non-sensitive competitive market. To establish the difference in premium between the United States and Hong Kong, the real²⁴ Australian dollar free-on-board (fob) prices received from these countries were compared. The fob price is defined as the export market price less the cost of getting the fruit to export markets, such as sea/air transport costs and the cost of customs inspection at the destination (ABS 2001). The fob price is the price received by exporters, who may or may not be producers. Thus the premium calculated here may not be fully received by producers. The price premium for the US citrus market is defined as the fob price of US citrus less the fob price of Hong Kong citrus.

²⁴ The nominal fob prices are deflated using the consumer price index of tradable goods—that is, mobile goods that are traded internationally—in 2006-07 Australian dollars as reported by the Reserve Bank of Australia.

Real US and Hong Kong fob prices from 1999–2007 were averaged to remove the effects of exchange rate fluctuations and the volatility of other factors affecting the price differentials. The difference between these average prices gave the average per kilogram US price premium. Only the most recent year's quantity of exports to the United States was used as a proxy for export volumes. This discussion is summarised mathematically in equation:

$$MA_t = \left[\frac{\sum_{t=1999-2000}^{2006-07} P_{US,t}}{9} - \frac{\sum_{t=1999-2000}^{2006-07} P_{HK,t}}{9} \right] X_{US,2006-07} \quad (5)$$

where MA is the total price premium of the US citrus market, $P_{US,t}$ is the fob price per kilogram of citrus in the US market at year t , P_{HK} is the fob price per kilogram of citrus in the Hong Kong market at year t , and $X_{US,2006-07}$ is the export volume to the US citrus market for 2006–07 in kilograms. Table B1 details the prices and quantities used to calculate the value of the premium.

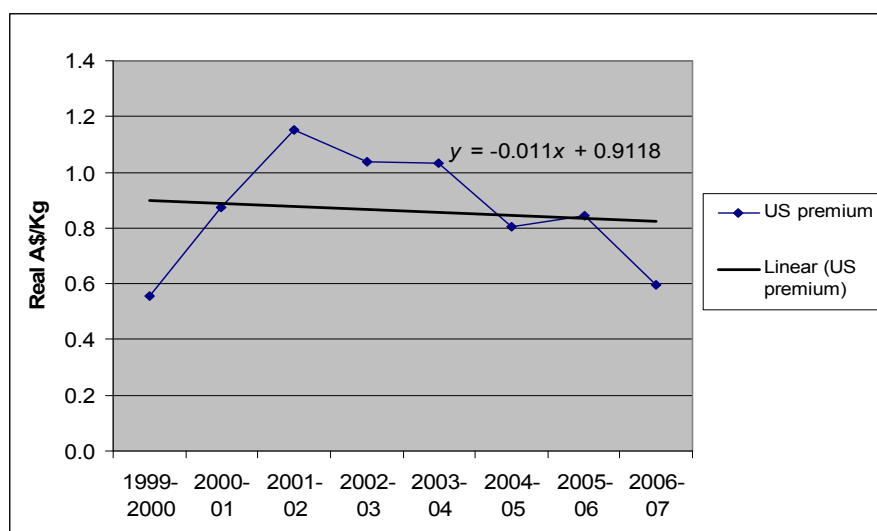
Table B1: Calculation of annual value of the US premium

Real price points (\$/kg)								
	1999–2000	2000–01	2001–02	2002–03	2003–04	2004–05	2005–06	2006–07
US prices	1.269	1.663	2.142	1.912	1.940	1.694	1.593	1.529
HK prices	0.708	0.777	0.975	0.863	0.896	0.878	0.740	0.927
Average US price (\$/kg)			1.718	Average HK price (\$/kg)			0.845	
Premium from US market (\$/kg)			0.872	US quantity 2008 (kg)			11 142 115	
Annual value of US premium (\$)				9 704 627				

Source: Global Trade Information Statistics (2009).

The PricewaterhouseCoopers (2001) report on the tri-state agreement noted that premiums for the US citrus market were decreasing to 2001. But using the estimation method presented here, it is difficult to establish any trend because of the variability in both US and Hong Kong prices. For simplicity, this study assumes the premium is constant during the 20 year time horizon of the analysis.

Figure B1: US citrus premium trend



Source: Global Trade Information Statistics (2009).

B2 Primary costs

B2.1 Establishment costs

Establishment costs are annual fixed costs that differ across the three management options and apply only for the first three years of each program. Establishment costs for each statistical division are shown in table 13 in chapter 4. Establishment costs (EC) can be expressed as:

$$EC = \begin{cases} EC_{SD} & \text{for } 1 \leq t \leq 3 \\ 0 & \text{for } t > 3 \end{cases} \quad (6)$$

B2.2 Maintenance costs

Maintenance costs (MC) are a function of fixed annual costs and variable costs due to outbreaks. They can be expressed as:

$$MC_t = FC_t + VC_t \quad (7)$$

Fixed annual costs (FC) include annual fixed maintenance and suppression costs. Variable costs (VC) are eradication costs due to outbreaks and can be expressed as:

$$VC_t = \sum_{SD=1}^6 \delta_{SD} \times S_{SD} \times D_{SD} \quad (8)$$

where for each SD , δ_{SD} is the number of outbreaks, S_{SD} is the size of the outbreak, and D_{SD} is the duration of the outbreak. Section 3.5.2 outlines assumptions about outbreak size and duration for each statistical division.

B2.3 Disinfestation costs in response to outbreaks

When an outbreak occurs, Victorian horticulture producers are required to disinfest their fruits to maintain market access. This study assumes all fruit in a statistical division with an outbreak will be disinfested, as expressed annually in equation 9 for each management option i for each region:

$$DC_t = \sum_{SD=1}^6 \sum_{k=1}^4 \gamma_{i,SD,t} \times Q_{k,SD} \times C_k \quad (9)$$

where $Q_{k,SD}$ is the quantity of fruit k produced in region SD , C_k is the cost of cold treatment, and γ is an indicator variable that is 1 or 0 depending on whether there were any outbreaks in the region in that year. The study uses the cost of cold treatment because most export markets will accept only fruits that are cold treated.

B2.4 Probability of outbreak

Each of the variable costs depends on the likelihood of outbreaks under each management option. This likelihood is integrated into the following cost equations with δ , which indicates the number of outbreaks in a statistical division in a given year. For the Monte Carlo simulation of the costs and benefits of each management option, @Risk chooses δ as an integer based on the probability of outbreak. The probability of an outbreak was derived from the outbreak frequencies outlined in section 3.5.

B3 Net present value and benefit–cost ratio

The benefits and costs of each management option are expressed in two ways. First, the NPV calculation is as described in equation 10:

$$NPV_{i,r} = \sum_{t=1}^{20} \frac{(MA_t + AC_t - EC_t - MC_t - DC_t)}{(1+r)^t} \quad (10)$$

where $NPV_{i,r}$ is the net present value summed over the 20 year time horizon (beginning in 2009–10 and ending in 2029–30) of management option i ($i = 1, 2, 3$) at discount rate r ; t is the year subscript, MA_t is the market access benefit for year t , AC_t is the avoided chemical and disinfection cost for year t , DC_t is the administration cost for year t , EC_t is the establishment cost for year t , and MC_t is the maintenance cost for year t .

The NPV of each management option is expressed in terms of the value of the net benefits over the 20 years—for example, $NPV_{1,5\%} = \$10$ million can be interpreted to mean that management option 1 generates \$10 million of net benefits calculated at a real discount rate of 5 per cent, compared with the 'do nothing' case and other alternative uses of the resources.

The second way in which to express the benefits and costs of each management option is the use of the BCR as shown in equation 11:

$$BCR_{i,r} = \frac{\sum_{t=1}^{20} PV(MA_t + AC_t)}{\sum_{t=1}^{20} PV(EC_t + MC_t + DC_t)} \quad (11)$$

where $BCR_{i,r}$ is the BCR for management option i at the discount rate r , and $PV(.)$ is the present value of benefits (in the numerator) and of costs (in the denominator).

The BCR for each management option is expressed in relation to costs—for example, $BCR_{1,5\%} = 2.04$ can be interpreted to mean that management option 1 produces a present value benefit of \$2.04 for each dollar invested, at a real discount rate of 5 per cent over the 20 years, compared with the 'do nothing' case.

In both the NPV and BCR, and the following calculations, costs and benefits are in 2008–09 dollars.

The study uses both NPV and BCR calculations because they provide different information. The NPV is an estimate of the *absolute* magnitude of the present value of net benefits resulting from the use of resources, whereas the BCR is a *relative* measure of net benefits (Commonwealth of Australia 2006). The NPV is used to rank projects; the BCR provides information on the efficiency of resource use under each management option. That is, the BCR measures the relative difference between benefits and costs—the greater the BCR, the greater is the net return per dollar of capital invested.

Appendix C

Primary and secondary benefits and costs of a social and environmental nature

A benefit–cost analysis must consider all benefits and costs, even if some cannot be quantified. Primary and secondary benefits and costs may be of an economic, environmental or social nature. Those concerned with the production and consumption of goods and services exchanged in markets are easily quantifiable. Other benefits and costs, such as those of an environmental nature, are often not captured in a market, so are difficult to quantify.

C1 Secondary benefits and costs from backyard growers

Backyard growers of fruit enjoy an *external benefit* of any government or industry Queensland fruit fly management strategy to protect production regions from outbreaks.²⁵ The benefit is accrued because someone else controls the Queensland fruit fly, allowing backyard growers to grow and consume fruit without using chemicals to control Queensland fruit fly infestations that would otherwise occur. Conversely, backyard growers in production regions can pose an *external cost* to commercial growers if they do not take appropriate control measures because they can become a source of infestation.

A 1987 review of fruit fly eradication in Adelaide estimated benefits to backyard growers from Queensland fruit fly management (van Velsen 1987). The review estimated that the annual value of backyard fruit production in Adelaide was over \$22 million, and that the absence of a fruit fly eradication program would result in a loss of \$18 million in backyard fruit production (van Velsen 1987). Estimates of the value of backyard growers were not used in the derivation of the net benefit of Queensland fruit fly management programs conducted by the Horticultural Policy Council (1991, p. 94), because a robust analysis would require the involvement of many disciplines as well as an economic evaluation, and would take considerable time. The Horticultural Policy Council (1991) report referred, however, to the van Velsen (1987) estimates in arguing there are significant benefits to backyard growers. PricewaterhouseCoopers (2001, p. 99) was more cautious, although acknowledging that a Queensland fruit fly program would ascribe significant benefits to backyard growers. Referring to the figure of \$22 million, it highlighted the following:

- Some home owners will not ascribe much value to the fruit.
- Tree counts for all of Adelaide were based on observations in an older suburb of Adelaide where fruit trees are very common.
- Community resistance to a state eradication program indicates some households may be less than willing to retain the benefits of backyard fruit.

A growing trend in new housing developments is for smaller plots and dwellings that take up a greater proportion of the plot, leaving less room for gardens, including fruit trees (ABS 2008a; Hall 2007). There is also a growing trend of renovations to existing dwellings in older suburbs, which also reduces the area of a plot for cultivation (ABS 2002). Using fruit tree numbers gained from an older suburb (as in van Velsen 1987) and extrapolating across the entire city is likely to significantly overestimate the number of fruit trees and, therefore, the benefits of backyard production. The PricewaterhouseCoopers (2001) report highlighted this concern. The 2008–09 eradication undertaken in the inner Melbourne suburb of Ascot Vale covered 2571 dwellings averaging 2.9 trees per house—30 per cent less than the average measured in an inner suburb of Adelaide 20 years ago and reported in van Velsen (1987).

²⁵ Backyard growers are defined here as growers of fruit for personal use, not commercial producers.

In conclusion, while secondary or external benefits to backyard growers from Queensland fruit fly management by the government and industry can be demonstrated, the method previously used to estimate these costs must be treated with caution. Given the methodological issues associated with valuing backyard fruit production, this analysis does not include quantitative estimates of external benefits to backyard growers. The benefits are considered qualitatively, in addition to the benefits that can be quantified.

C2 Secondary benefits and costs from environmental impacts

Although the Queensland fruit fly is an Australian fruit fly species, it is endemic to the east coast of Queensland. For this reason, its spread to Victoria in the absence of any management programs may have environmental consequences for local Victorian insects and their ecosystems.

Displacement is generally observed between closely related species of insects in an invasion scenario whereby an exotic species displaces a native species or another exotic species through interspecific competition (Duyck, David & Quilici 2004). In particular, interspecific competition is a 'reduction in individual fecundity, survival, or growth as a result of exploitation of resources or by interference with individuals of another species' (Duyck, David & Quilici 2004, p. 512)

A review conducted by Duyck, David & Quilici (2004) found, where fruit fly species have been introduced in areas already occupied by a fruit fly, that interspecific competition has resulted in the decreased number and niche shift of the pre-established species. An example in Australia is the displacement of the Mediterranean fruit fly by the Queensland fruit fly around the Sydney area (Duyck, David & Quilici 2004; Vera et al. 2002).

The advice from scientific staff in DPI Victoria is that the Queensland fruit fly does not have any detrimental impact on other (non-fruit fly) local insects and ecological systems (A Tomkins, pers. comm., 20 February 2009).

Appendix D

Details of results

This appendix discusses the results presented in chapter 4.

D1 Benefit–cost analysis of management option 1 (pest free area only)

The main annual benefits from management option 1 are the avoided post-harvest treatment costs of almost \$26 million per year, and market access benefits of around \$6 million per year (chapter 4, table 13). Key costs are the disinfestation costs in response to outbreaks (over \$13 million per year) and fixed maintenance costs (around \$2 million per year) in pest free areas. Option 1 also incurs the establishment costs of new pest free areas in Melbourne, Loddon, Goulburn and Ovens–Murray statistical divisions (over \$1.1 million in the first three years of the analysis).

The frequency of Queensland fruit fly outbreaks determines the mean estimates of disinfestation costs and eradication costs. Table D1 contains the outbreak frequency estimated to occur under management option 1: Goulburn is expected to experience two outbreaks per year on average; Melbourne is expected to experience one outbreak per year on average; and the Ovens–Murray and Mallee statistical divisions are expected to experience outbreaks but less than one per year.²⁶ As a result, most of the eradication costs of nearly \$1 million per year are generated in the Goulburn statistical division.

Table D1: Estimated mean annual outbreak frequency under management option 1

Statistical division	Outbreak frequency
Melbourne	1
Mallee	0*
Loddon	0
Goulburn	2
Ovens–Murray	0*

* Predicted frequency is less than 1 but there is a positive (but small) probability of outbreak.

Source: Plant Standards Branch, June 2009.

Management option 1 is estimated to generate positive net economic benefits for Victoria (chapter 4, table 14). Over the 20 years of analysis, option 1 is calculated to generate a mean net benefit of over \$333 million, at a 5 per cent real discount rate. The mean of the benefit–cost ratio (BCR) is 2.02, which means option 1 generates \$2.02 for each dollar invested.

²⁶ Negative bin distribution was fitted to the Goulburn data, uniform risk distribution to the Ovens–Murray data, geometric distribution to Melbourne data, and binomial distribution to the Mallee data. Melbourne outbreaks were slightly altered from the outbreak frequency to account for the increased outbreak potential due to endemic Queensland fruit fly outside the pest free area.

Figure D1: Distribution of the NPV for management option 1, at 5 per cent real discount rate

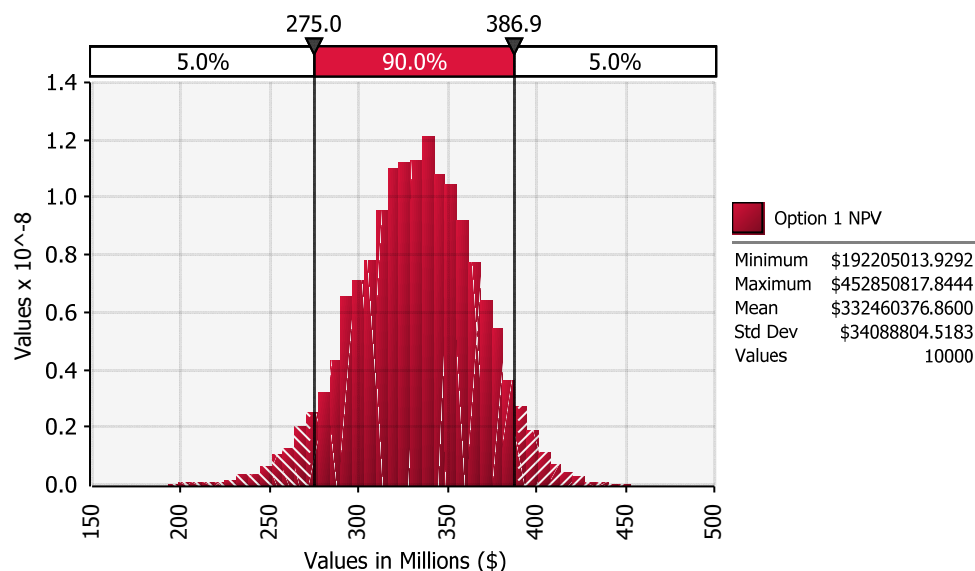
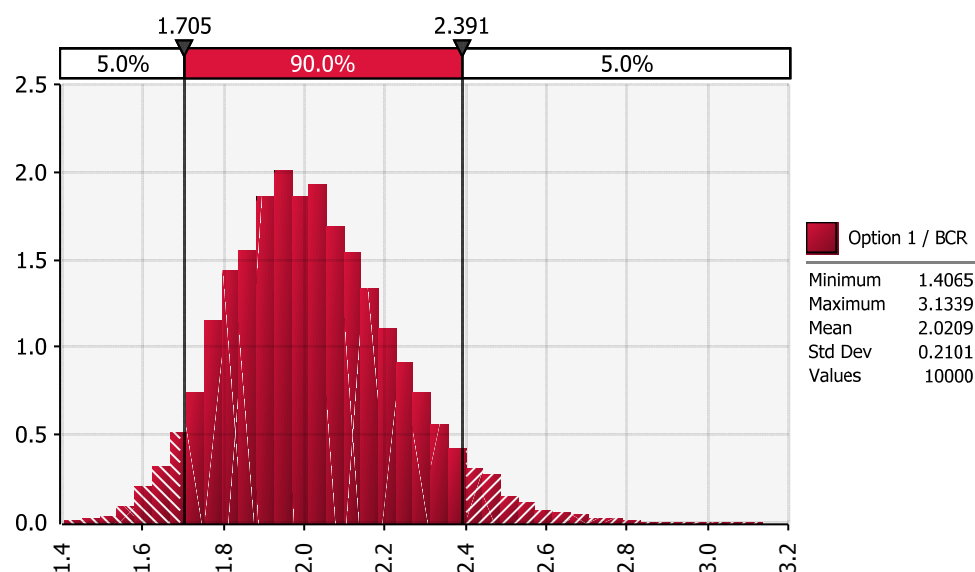


Figure D2: Distribution of the BCR for management option 1, at 5 per cent real discount rate



In terms of risk, Figure D1 shows the distribution of option 1's NPV based on 10 000 iterations. The NPV range for option 1 has an estimated 90 per cent probability of being \$275–387 million. That is, this option is estimated to generate net benefits under all likely outcomes.

Figure D2 shows the BCR distribution for option 1, with a 90 per cent probability of being 1.7–2.4. Given the frequency distribution, outbreaks are unlikely to become frequent enough to render option 1 uneconomic.

D2 Benefit–cost analysis of management option 2 (tri-state Fruit Fly Exclusion Zone)

The main benefits from management option 2 are avoided post-harvest treatment costs of nearly \$26 million per year, and market access benefits of around \$6 million per year (chapter 4, table 13). The main cost of option 2 is from the disinfestation cost due to outbreaks, at over \$12 million per year. Eradication costs also depend on outbreak frequency and are above \$1.9 million. Fixed maintenance costs are also about \$1.5 million and do not include suppression costs, so they are lower than the fixed maintenance costs under options 1 and 3.

Disinfestation and eradication costs are determined by probability of outbreak. Table D2 shows the probability of outbreak under option 2.

Table D2: Estimated mean annual outbreak frequency under management option 2

Statistical division	Outbreak frequency
Melbourne	1
Mallee	0*
Loddon	0
Goulburn	2
Ovens–Murray	5

* Predicted frequency is less than 1 but there is a positive (but small) probability of outbreak.

Source: Plant Standards Branch, June 2009.

Management option 2 is estimated to have a positive mean NPV of over \$353 million at a 5 per cent discount rate over the 20 years of analysis (chapter 4, table 14). The mean BCR for this option is estimated to be 2.15.

The NPV range is estimated to have a 90 per cent probability of being \$299–405 million (figure D3). The BCR range is estimated to have a 90 per cent probability of being 1.81–2.54 (figure D4). This suggests option 2 is likely to generate over \$2 of benefits for every \$1 spent.

Figure D3: Distribution of the NPV for management option 2, at 5 per cent real discount rate

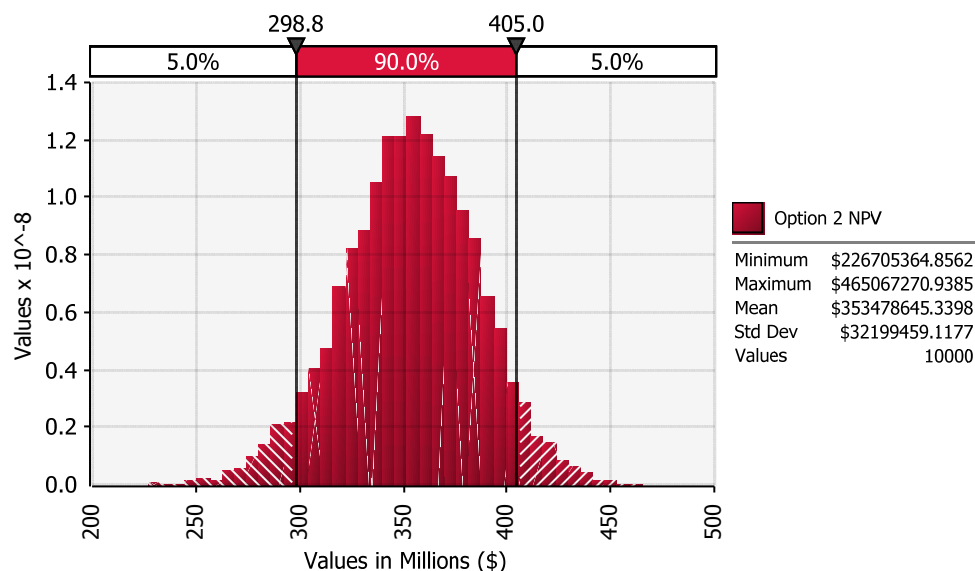
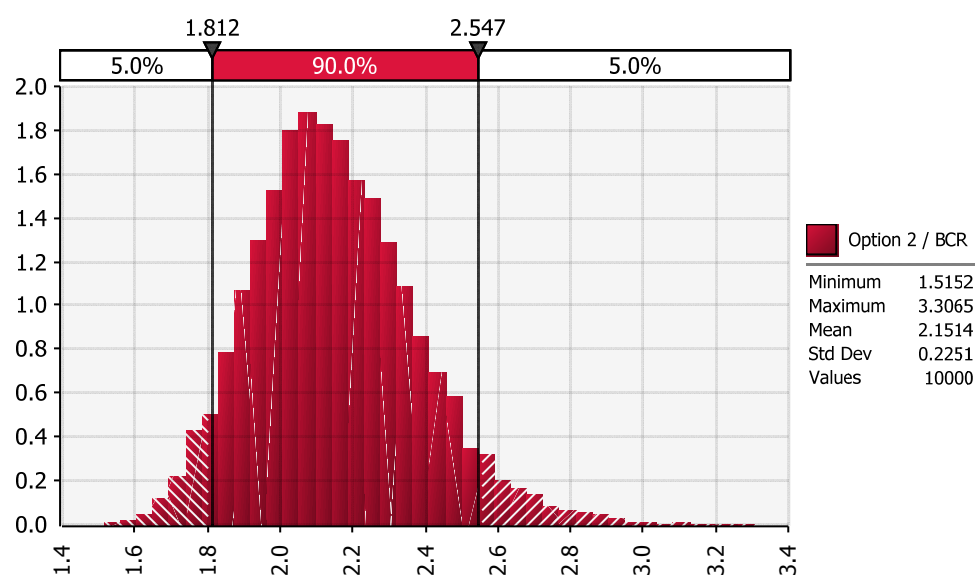


Figure D4: Distribution of the BCR for management option 2, at 5 per cent real discount rate



D3 Benefit–cost analysis of management option 3 (pest free areas and areas of low pest prevalence)

Management option 3 has a similar benefits profile to that of options 1 and 2—that is, benefits mostly derive from avoided post-harvest chemical (or disinfestation) costs and market access benefits (chapter 4, table 13). The costs of option 3 are derived from disinfestations costs (over \$11 million per year), fixed maintenance costs (almost \$2 million per year) and establishment costs for new pest free areas (over \$1 million per year).

The disinfestation costs are slightly lower than for management options 1 and 2 because option 3 has a lower probability of outbreak in the Goulburn and Ovens–Murray statistical divisions (table D3)—a result of preventative suppression measures being implemented in towns near pest free areas to restrict Queensland fruit fly population growth. Given the Goulburn host fruit production is nearly 20 times that of Ovens–Murray (Table D4), the disinfestation costs for option 3 are mostly from the costs of treating Goulburn host fruits. As a result, total disinfestation costs are only slightly lower under management option 3, even though there is an overall significantly lower risk of Queensland fruit fly outbreak.

Table D3: Estimated mean annual outbreak frequency under management option 3

Statistical division	Number of outbreaks
Melbourne	1
Mallee	0*
Loddon	0
Goulburn	1
Ovens–Murray	0*

* Predicted frequency is less than 1 but there is a positive (but small) probability of outbreak.

Source: Plant Standards Branch, June 2009.

Table D4: Gross value of production in Goulburn and Ovens–Murray statistical divisions, 2006–07 (\$ million)

Host fruit	Goulburn	Ovens–Murray
Citrus	3.2	0
Pome fruit	231.7	8.2
Stone fruit	116.6	7.9
Grapes	8.7	5.8
Tomatoes	75.3	0.5
Total	435.5	22.4

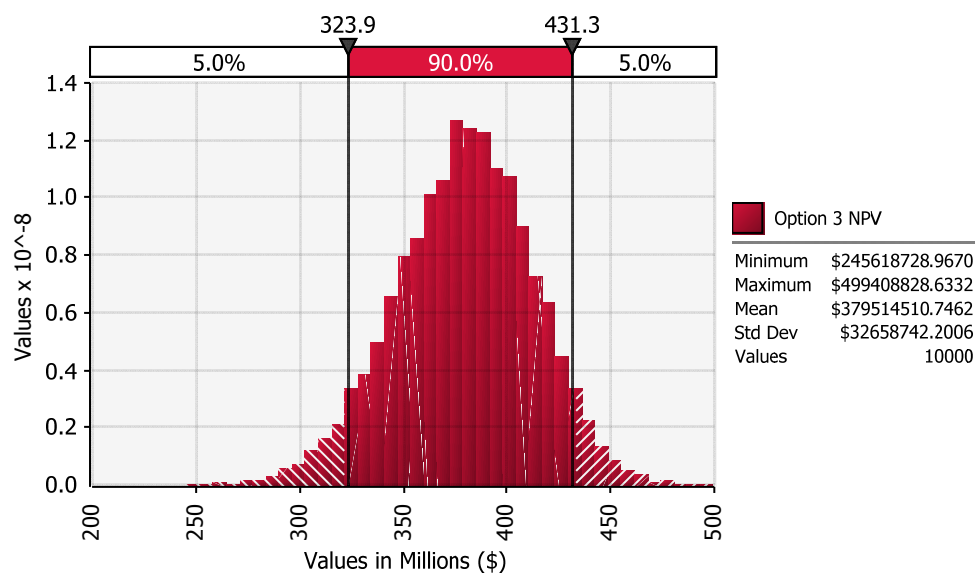
Source: ABS (2008b).

Eradication costs are also determined by the probability of outbreak (table D3). As a result of the lower probability of outbreak, management option 3 is estimated to involve substantially lower eradication costs than those under the other options, at over \$400 000 per year.

The mean of the NPV for option 3 is estimated to be nearly \$380 million at a 5 per cent discount rate over the 20 year period of analysis (chapter 4, table 14). The mean of the BCR for this option is calculated to be 2.35.

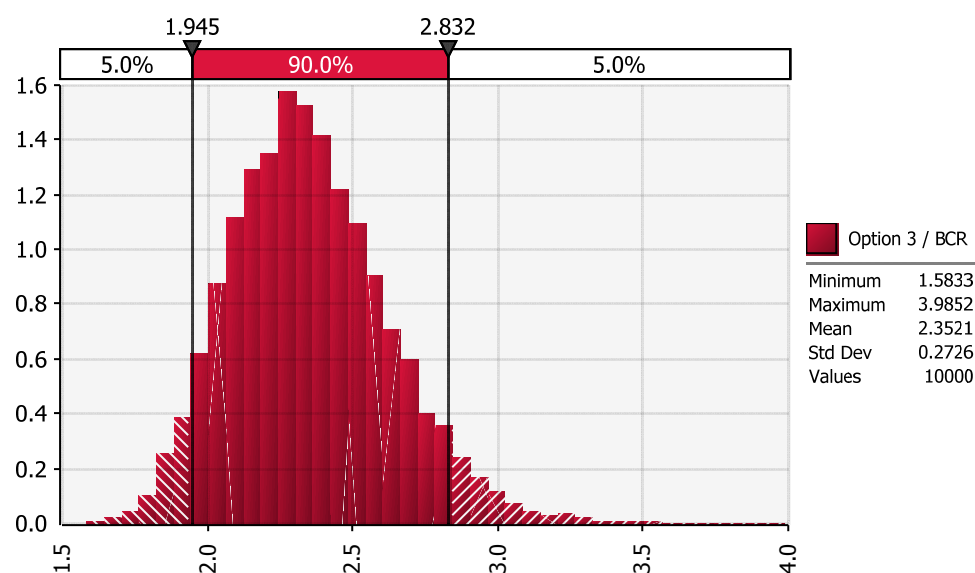
The range of the NPV for option 3 is estimated to have a 90 per cent probability of being \$324-431 million (figure D5).

Figure D5: Distribution of the NPV for management option 3, at 5 per cent real discount rate



Option 3 is estimated to have a 90 per cent probability of generating a BCR of 1.95-2.83 (figure D6). This suggests option 3 is likely to generate \$2-3 for every \$1 invested over the 20 year investment period.

Figure D6: Distribution of the BCR for management option 3, at 5 per cent real discount rate



Glossary

area of low pest prevalence (ALPP)	<p>“An identified geographic area managed in accordance with the requirements of ISPM 30 (<i>Establishment of areas of low pest prevalence for fruit flies (Tephritidae)</i>) in which a fruit fly pest occurs at low levels and which is subject to effective surveillance, control or eradication ...”</p> <p>(Kalang Consultancy Services 2008, p. 7)</p>
International Standard for Phytosanitary Measures (ISPM)	<p>Internationally agreed standards established by the International Plant Protection Convention to give effect to the Sanitary and Phytosanitary Agreement</p>
ISPM 22	<p>“This standard describes the requirements and procedures for the establishment of areas of low pest prevalence (ALPP) for regulated pests in an area and, to facilitate export, for pests regulated by an importing country only. This includes the identification, verification, maintenance and use of those ALPPs.”</p> <p>(ISPM 22, p. 265)</p>
ISPM 26	<p>“This standard provides guidelines for the establishment of pest free areas for fruit flies (<i>Tephritidae</i>) of economic importance, and for the maintenance of their pest free status.”</p> <p>(ISPM 26, p. 5)</p>
ISPM 30	<p>“This standard provides guidelines for the establishment of areas of low pest prevalence for fruit flies (FF–ALPPs) by a national plant protection organisation (NPPO). Such areas may be utilised as official pest risk measures alone, or as part of a systems approach, to facilitate trade of fruit fly host products, or to minimise the spread of regulated fruit flies within an area.”</p> <p>(ISPM 30, p. 5)</p>
pest free area (PFA)	<p>“A geographic area managed in accordance with the requirements of ISPM-26 (<i>Establishment of pest free areas for fruit flies (Tephritidae)</i>) and technical standard operating procedures consistent with the requirements of the current code of practice for Queensland fruit fly management. PFA status requires that the fruit fly status of a region must be kept below out break levels.”</p> <p>(Kalang Consultancy Services 2008, p. 7)</p>
Sanitary and Phytosanitary (SPS) Agreement	<p>“... provides a framework of rules to guide World Trade Organisation member countries in the development, adoption and enforcement of sanitary (human and animal health) and phytosanitary (plant health) measures.”</p> <p>(Department of Agriculture, Fisheries and Forestry (Commonwealth of Australia) 2009)</p>

Acronyms

ABS	Australian Bureau of Statistics
BCR	benefit–cost ratio
DPI	Department of Primary Industries Victoria
FFEZ	Fruit Fly Exclusion Zone
fob	free on board
ISPM	International Standard for Phytosanitary Measures
NPV	net present value
SD	statistical division
SIT	sterile insect technology
SPS	sanitary and phytosanitary

