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A benefit cost analysis on management strategies for Queensland Fruit Fly: methods and observations

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Abstract

The Queensland Fruit Fly (QFF) — *Bactrocera tryoni* — poses a significant threat to horticultural production in Victoria causing losses of fruit and jeopardising access to interstate and international markets. The Victorian Government implements and largely funds an area freedom program to manage QFF. Concern about the record number of outbreaks in 2007-08 and the escalating costs of maintaining the current management regime, led the Victorian Department of Primary Industries to review the program to identify improved strategies for managing QFF. As part of this work, a benefit cost analysis (BCA) of alternative strategies has been conducted. While the BCA method is well established, in general few studies are publicly available for area freedom programs. In this paper a number of the practical issues encountered in analysing area freedom are detailed, such as estimating welfare effects, how to consider social and environmental costs and benefits and incorporating risk for managing pests. Implications for policy and the design of future programs are discussed. The approach and issues identified in this paper provide insights for other agencies undertaking similar BCAs to inform biosecurity policy.

1 Introduction

The method for undertaking a benefit cost analysis (BCA) is well established, however, many analyses on area freedom biosecurity programs remain unpublished. The purpose of this paper is to discuss the approach taken for the BCA undertaken by Victorian Department of Primary Industries (DPI) on three alternative management strategies for Queensland fruit fly (Ha et al. forthcoming), the findings and some of the issues encountered with the aim of providing insights for other agencies that might undertake or have undertaken similar BCAs.

2 Background

The Queensland fruit fly (QFF) — *Bactrocera tryoni* — is recognised as one of the world's worst horticultural pests. A native Australian species, QFF has the ability to infest a wide range of fruits. In 2006-07, fruit growers in Victoria generated more than $1 billion gross value of product from producing fruits susceptible to QFF. Pome fruit production had the highest annual gross value in 2006-07 at approximately $330 million, followed by grapes (approximately $295 million), stone fruits (approximately $244 million), tomatoes (approximately $82 million) and citrus (approximately $65 million) (ABS 2008). Key production regions of QFF host fruit in Victoria by quantity of production are shown in figure 1.

Female QFF lay eggs in the host fruit, larvae hatch and eventually eat their way out of the fruit, damaging the flesh and promoting rotting from the inside out. Originally found only in tropical and subtropical rainforests in Queensland, stable populations of QFF have established

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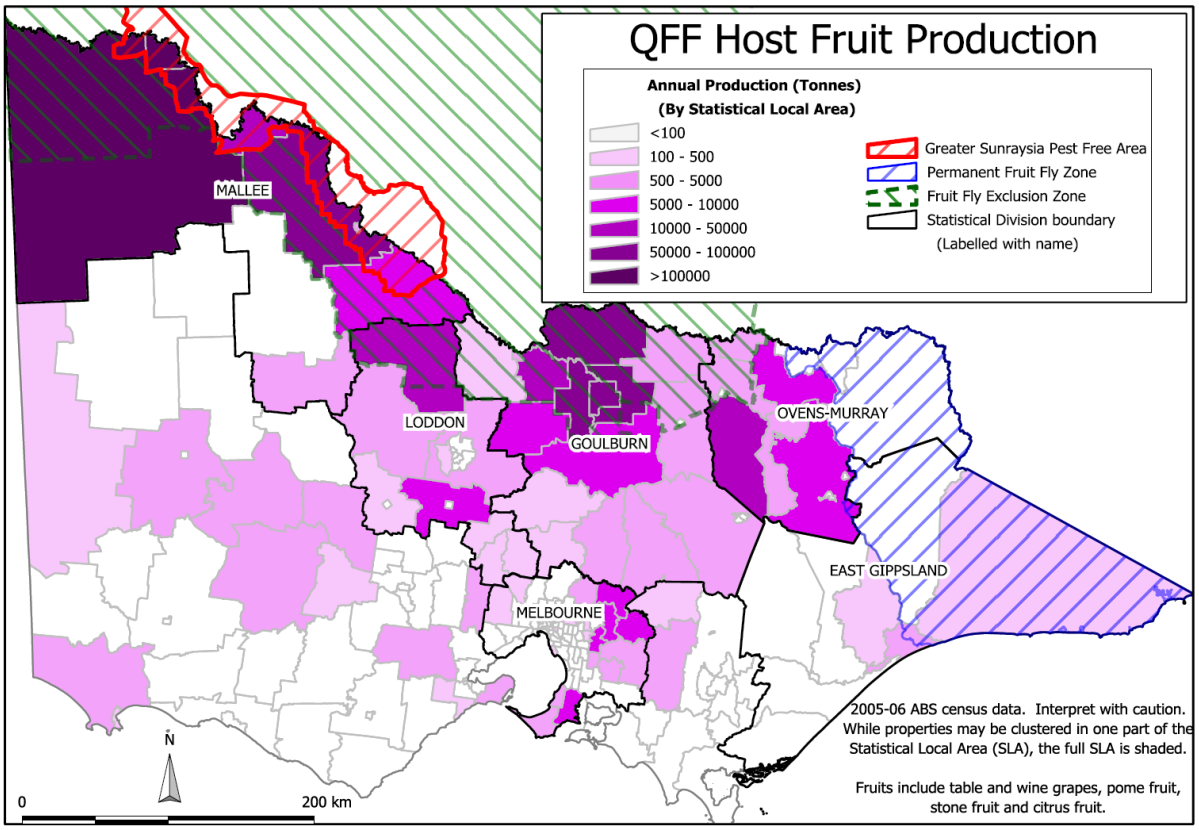
in parts of New South Wales and eastern Victoria following the introduction of European cultivated fruits that are suitable hosts (see permanent fruit fly zone in figure 1). The consequence of QFF outbreaks on Victorian producers has been to temporarily stop market access of host fruit products to QFF sensitive domestic markets such as South Australia and Tasmania, and international markets such as New Zealand and the United States.

Figure 1: QFF host fruit production, 2005-06



Source: Ha et al. (forthcoming)

2.1 Biosecurity management approaches

2.1.1 Area wide management

In Victoria, the DPI manages QFF through an 'area-wide management' program. This includes monitoring and eradication activities in the Fruit Fly Exclusion Zone (FFEZ), the Sunraysia Pest Free Area (PFA) and urban centres along the QFF host fruit supply chain (see figure 1). This is consistent with the definition of area wide management (AWM) as an 'approach that targets pest populations in all areas, including non-commercial urban settings, non-cultivated and wild host areas' (Vreysen et al, 2007: v). AWM is a management tool which addresses issues of scale and coordination to achieve particular outcomes such as area freedom from pests (Devorshak 2008).

In Victoria, AWM with respect to QFF currently involves the delivery of coordinated response and surveillance programs across all horticultural production (including the FFEZ) and urban areas of the state according to the QFF National Code of Practice (with the exception of the permanent fruit fly zone in East Gippsland, see figure 1). The FFEZ was established in 1994 through a memorandum of understanding (MOU) between Victoria, New

South Wales and South Australia to keep the Sunraysia (VIC), Riverland (SA) and Riverina (NSW) horticultural production regions free from fruit fly. This MOU was implemented prior to the World Trade Organisation's Sanitary and Phytosanitary (SPS) Agreement which came into affect in 1995. The area freedom provided by the FFEZ 'allowed access to many international markets without the costly need to disinfest produce', including new markets for citrus and stone fruit in the United States, New Zealand and South East Asia (Sutherst et al. 2000: 468; Victoria DPI 2010). The MOU for the FFEZ was not renewed in 2001, however, it continues to be administered on an informal basis through the Tri-State Fruit Fly Committee (TSFFC 2010).[2]

2.1.2 Pest free and low pest prevalence areas

Pest free and low pest prevalence areas for fruit flies are among a number of defined outcomes that may be required importing countries. A pest free area (PFA) is 'an area in which a specific pest does not occur as demonstrated by scientific evidence and in which, where appropriate, this condition is being officially maintained' (IPPC 2006). While an area of low pest prevalence (ALPP) is defined as an area 'in which a specific pest occurs at low levels and which is subject to effective surveillance, control or eradication measures' as accepted by international trading partners (IPPC 2008). The International Plant Protection Convention sets standards relating to such biosecurity measures to ensure that the introduction and spread of pests of plants and plant products is prevented while facilitating trade (World Trade Organisation 2009). The international standards for phytosanitary measures (ISPMs) set out standards for the establishment of PFAs (ISPM 26) and ALPPs for fruit flies (ISPM 30).

Devorshak (2008: 411) notes that the ISPMs contribute to AWM programs in two ways:

1. Trading partners should be prepared to recognise the results of a successful [AWM] program as meeting requirements, for example, of a PFA or an ALPP.
2. These standards provide scientific and technical guidance for the design and operation of key components of [AWM] programs.

Victoria's QFF AWM program aims to prove area freedom from QFF for the Sunraysia region as set out in ISPM 26 to enable export and interstate trade. The FFEZ provides a buffer of protection to the Greater Sunraysia PFA, which is the main source of exports to international markets that are sensitive to fruit fly. Major sensitive destinations for horticulture exports from Victoria such as the United States, Indonesia and New Zealand are amongst 15 countries which recognise this PFA. DPI inspectors routinely verify that consignments of fruit have been treated for QFF (imports as well as exports), as well as accrediting individual businesses under self-verification arrangements or Interstate Certification Assurance (ICA) arrangements, to ensure the PFA is maintained.

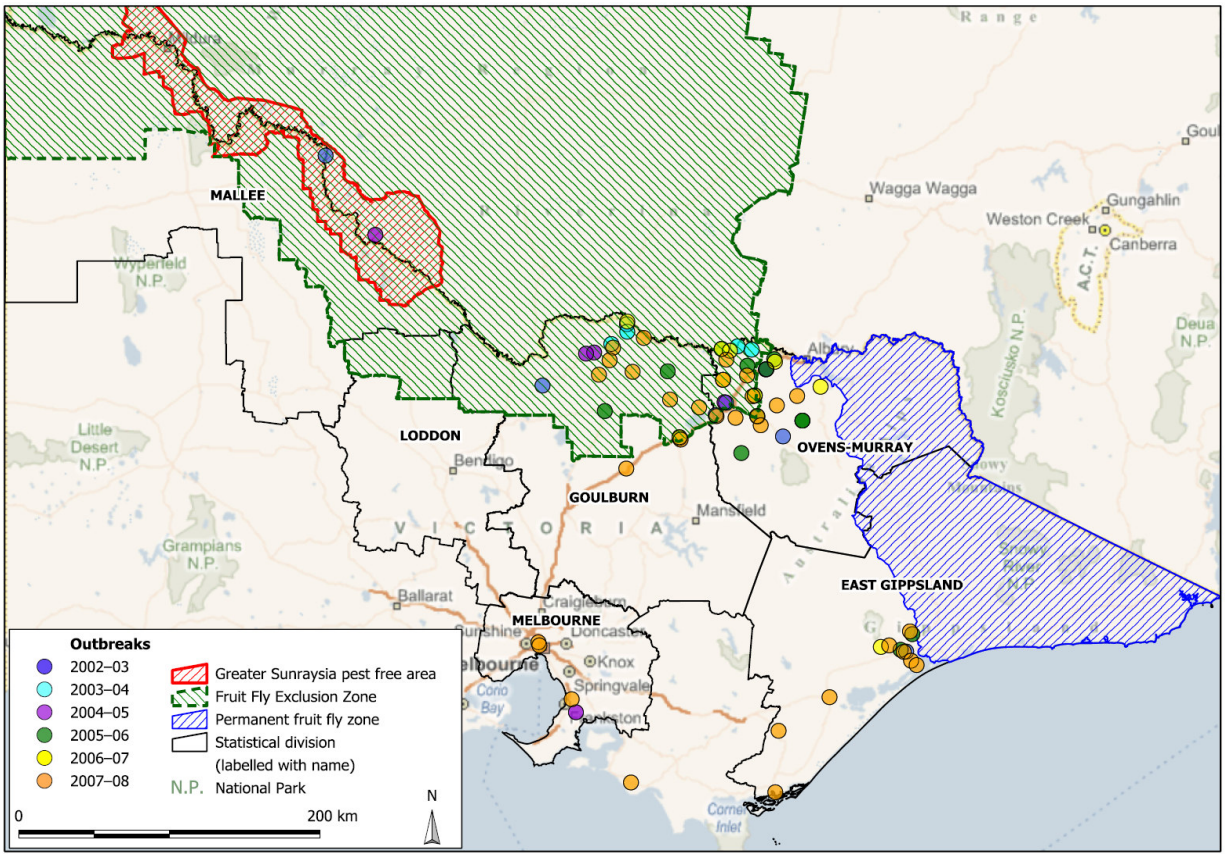
2.2 Increases in outbreaks

In recent times, the number of outbreaks in Victorian horticultural production areas has been increasing (see figure 2). This has been attributed to a number of factors including climate and changes in landuse. Traditionally QFF become less active over winter and are thought to stop breeding, reducing population size. However, recent mild winters in Victoria have allowed populations to persist and remain active for 12 months of the year. When generations of fruit flies overlap, large populations of fruit flies can develop if they are not quickly suppressed (A.

[2] Tri-State Fruit Fly Committee representatives come from host fruit grower industries and the primary industry departments from South Australia, Victoria and New South Wales.

Tompkins, Victorian DPI, pers. comm., 24 November 2008). Demographic changes have seen increased numbers of lifestyle farms in horticultural areas in recent years (Barr 2005). These lifestyle farms may also be facilitating increased outbreaks of QFF in horticultural regions due to different priorities and resource constraints around fruit production and management (see Graziano Ceddia et al. 2008 for discussion of biosecurity risks from hobby farms).

Figure 2: QFF outbreaks 2002-03 to 2007-08



Source: Ha et al. (forthcoming)

The majority of outbreaks from 2002-03 to 2007-08 have occurred in the Goulburn and Ovens-Murray regions, where the permanent fruit fly zone and the fruit fly exclusion zone are closest and two national highways run through. There are also a number of large towns in this region which facilitate the spread of QFF through backyard host fruit production.

The cost of maintaining the QFF management regime for Victoria has been escalating in recent years (see table 1). In 2007-08 there were a high number of outbreaks in Victoria that disrupted both domestic and foreign market access. The cost to the State government was approximately $2.6 million in operational costs and $660 000 for traps, sterile insect technology development and community awareness (Ha et al. forthcoming).

Table 1: Operating and eradication costs of the fruit fly program to Victoria ($'000)

	1997-98*	1998-99*	1999-00*	2007-08
Market access, monitoring and surveillance, and compliance across regions	788	779	873	1,990
Response and eradication	35	80	235	675
TOTAL	**823**	**859**	**1108**	**2665**

Note: only operating costs from 2007-08 which were consistent with estimates for similar operations in the PWC (2001) report were included.

Source: Ha et al. (forthcoming) and PWC (2001).

*Costs are not adjusted for inflation.

In response to these escalating costs, the Victorian DPI initiated a review of all QFF operations and management which was completed in November 2008 by Kalang Consultancy Services Pty Ltd (2008). It presented three alternative options for managing QFF, where the main differences were around the management strategies outside of PFAs and subsequent impact on the risk of an outbreak (see table 2).

Table 2: Comparison of proposed management options for a new QFF program

	Management option one	Management option two	Management option three
PFA in high production areas. [a]	Yes.	Yes.	Yes.
Management strategy outside PFAs.	None – QFF becomes endemic where suitable host fruits and climate permits.	Area freedom across Victoria.	ALPP.
Verification and certification costs.[b]	Only required for fruit going into PFAs.	Required for all fruit coming into Victoria.	Required for all fruit going into PFAs Requirements for rest of Victoria uncertain.
Risk of outbreak relative to current regime	Higher.	Same.	Lower.

Note: a All management options are modelled with PFAs in high production areas in the following regions: Melbourne, Sunraysia, Goulburn-Murray and Loddon: **b** These costs are borne by interstate fruit producers and not considered in the Victorian DPI BCA.

***Source*:** Kalang Consultancy Services Pty Ltd (2008)

Traditionally, the choice of a new QFF management program may have been determined by the risk of outbreak alone (see the final row in table 2). However, limited budgets to implement such programs mean that a wider range of factors need to be considered in deciding where and how to allocate resources to address biosecurity risks. The discipline of economics can be of use, together with science, in informing biosecurity decisions when resources are limited.

3 Economics of biosecurity

The economics of biosecurity has been described as 'the choice of whether, when and how to attempt to manage insects and other pests with scarce capital or labour' (Mumford and Norton 1984: 157). In particular, what distinguishes the economic approach from scientific approach is the consideration of the costs and benefits associated with each of these 'choices' so that scarce resources are allocated to their highest value use and social welfare is maximised. Choices will be influenced by the level at which the decision is being made (farm level, state or national policy level) and the resources available to the decision maker.

Biosecurity choices can be categorised into two broad groups: pre and post incursion management (Beare et al. 2005). Pre-incursion management strategies include: border controls, surveillance and planning (Beare et al. 2005). In the case of QFF, the National Code of Practice determines when an incursion occurs and when post-incursion strategies are triggered. Post-incursion management strategies include activities such as adaptation, containment and eradication (Beare et al. 2005). It is also important to recognise that pre and post incursion strategies are interdependent. For example, high levels of surveillance may increase chances of early detection of an exotic pest as well as reducing containment and eradication costs.

According to economic theory, whether decision makers engage in pre or post border actions and to what extent, should be determined by the level of net benefits generated. BCAs are the most commonly used decision tool to estimate the net benefits of biosecurity management strategies. It allows the assessment of the costs and benefits for a range of alternative management strategies against some base case scenario. In biosecurity this base case is usually a 'do nothing' scenario so that the benefits of avoiding (or reducing the occurrence of) an incursion, and hence costs avoided, are measured (Beare et al. 2005). An economic optimal level of biosecurity will depend on many things including (EPRB 2005):

- detailed understanding of where disease threats originate
- how they are spread
- probabilities of success for pre and post incursion actions
- an understanding of the expected benefits and costs of such actions

On this last point, it is important to consider all benefits and costs, including those which are not captured by a market. Examples include environmental costs to native species from an exotic pest incursion or impacts to integrated pest management (IPM) systems from increased use of chemicals to manage an exotic pest. If the market costs and benefits do not clearly support any biosecurity management strategy compared to a do nothing approach and non market impacts are likely to be significant, it may be necessary to explicitly assess these non market costs and benefits using valuation techniques such as contingent valuation, hedonic pricing, travel cost method or others (Beare et al. 2005). Livingston (2007) and Peterson and Orden (2008) are among recent studies that have assessed pest management regimes and found that the level of protection could be reduced, increasing gains to consumers and overall net benefits without significant impact on the risk of incursion. These results show that it is important for decision makers to consider all benefits and costs of pest management strategies to avoid imposing unnecessary costs, particularly on consumers and governments who in most cases bear the brunt of the costs of biosecurity programs.

4 Method used in Victorian QFF BCA

The method used in the Victorian QFF BCA involved assessing *ex ante* the direct benefits and costs of the three proposed management options (see table 2) against a 'do nothing' counterfactual. The do nothing counterfactual meant that no monitoring, eradication or certification and accreditation programs for QFF would be undertaken by the Victorian Government and growers of QFF host fruits would apply pre and post harvest chemicals to control QFF infestations to maintain domestic and export market access. The benefits quantified in the BCA are avoided chemical costs and market access premiums for the citrus industry. Costs quantified were those associated with establishing pest free areas, monitoring and eradication of QFF outbreaks. Unpriced benefits and costs such as maintaining IPM for producers and backyard growers as a source of infestations were considered but not quantified. Indirect benefits and costs, such as limits on the trade of commodities, were not considered in the Ha et al. (forthcoming) study.

5 Issues encountered in conducting the QFF BCA

Three publicly available BCAs on QFF management strategies were found to inform the approach taken in the Victorian DPI BCA. A summary of these can be found in table 3.[3] In each of these BCAs the following issues required judgement on the part of the researchers undertaking the study:

- Risk and uncertainty;
- Length of period to consider benefits and costs;
- Welfare impacts to consumers; and
- Costs and benefits quantified and unquantified.

The following section discusses the reasoning behind the Victorian DPI approach used in deciding how to account for these variables in the BCA.

5.1 Incorporating risk

In the Ha et al. (forthcoming) BCA, risk was defined as the probability of an outbreak occurring and probabilistic analysis was undertaken using @Risk software. Uncertainty was characterised by lack of complete information on the probabilities of the size and duration of an outbreak. Two scenarios were defined and analysed to estimate effects of uncertainty of outbreaks around these variables. .

The main risk components to the QFF management plans are:

- The frequency of outbreaks of QFF;
- The duration of outbreaks;
- The spread of outbreaks; and
- The severity of outbreaks, in terms of costs of remedying the situation.

[3] It should be noted that only BCAs that considered QFF are presented here but that the authors acknowledge economic analysis of other pests could provide useful insight.

Table 3 Summary of approach taken by previous QFF BCA

Study and purpose	Treatment of risk	Costs and benefits quantified	Costs and benefits not quantified	Consumer surplus	Producer surplus
Horticultural Policy Council (1991) To estimate benefits and costs of removing an area freedom strategy for QFF in southern Australia.	Two types of infestations considered, normal and heavy.	State and territory government annual costs (monitoring, eradication, inspections, certification, administrative). Direct annual costs to citrus growers (pre and post harvest treatments, baiting, inspection and certification).	Backyard growers. IPM systems. Higher levels of exports and import replacements. Losses from international market access suspension.	No change as imports would fill local demand at world prices.	Loss from increased costs due to chemical use.
Price Waterhouse Coopers (2001) To estimate benefits and costs of the Tri-State Fruit Fly Strategy, identify beneficiaries of the Strategy and recommend an equitable system for contributions.	Not included.	Annualised avoided chemical costs. Annualised market access premiums for citrus, stonefruit, apples, table grapes and melons. Annualised costs of running the tri-state MOU.	Domestic market access. Home garden impacts. Downstream and regional impacts.	Gain from lower prices due to excess supply on domestic market.	Loss from international market access suspension. Loss from lower prices due to excess supply on domestic market from loss of international market access.
Chambers and Franco-Dixon (2007) To estimate benefits and costs of a QFF area freedom strategy in the Central Burnett region considering probabilities of policy changes that would affect market access and chemical use.	State contingent analysis of interstate trade policy (extension of ICA-28 and acceptance of dimethoate). Sensitivity analysis on domestic and export prices, probabilities around ICA and APVMA decisions.	Benefits and costs quantified over 10 year period. Past and future benefits and costs included: premium for domestic markets due to lower transport costs. costs of the Central Burnett area freedom scheme.	Not discussed.	Gain from lower prices due to excess supply on domestic market. Loss due to shortage of supply in interstate markets, increasing price.	Loss from lower prices due to excess supply on domestic market from loss of inter-state market access. Loss from an increase in citrus sent to export markets where price is lower. Losses in export market due to increase in supply from Central Burnett lowering prices further.
Ha et al. (forthcoming) To estimate benefits and costs of three alternative QFF area freedom management strategies.	Probability distributions of an outbreak occurring. Sensitive analysis on market premiums, chemical costs. Changes in frequency of outbreaks and costs considered together.	Benefits and costs quantified over 20 year period benefits and costs included: Avoided chemical costs. Market access premiums for citrus.	Backyard growers. IPM systems.	No change as imports would fill local demand at world prices	Loss from international market access suspension Loss from increased costs due to chemical use

Initially it was thought that frequency of outbreaks, duration of outbreaks (severity and spread) and price risks could be included using probabilistic analysis. In practice, information was only obtainable about the frequency of outbreaks for alternative management regimes. Attempts to incorporate duration, spread and severity of outbreak were hampered by lack of information. Consequently, only the risk of the frequency of QFF outbreaks was included and is the key determinant of eradication and disinfestation costs in the Victorian DPI. It is these costs that differentiated each management option.

Monte Carlo simulation was used to include the probability distribution of an outbreak event. The outputs of the analysis were expressed in terms of distributions, mean and variance, and allowed the management options to be evaluated in terms of risk and return. Central to the risk analysis in the BCA were judgements by the DPI Victoria technical staff about the probability of outbreaks under different management regimes. These estimates were reviewed by the authors with regards to information about actual outbreaks under the current management regime.

Chambers and Franco-Dixon (2007) used a state-contingent approach to incorporate the risk of two particular decisions being made by industry bodies on producers in the Central Burnett region being able to export citrus to interstate and international markets. The first risk is from the Australian Pesticides and Veterinary Medicines Authority (APVMA) banning the use of dimethoate in post harvest treatment of citrus fruits (which currently allows access to the South Australian, West Australian and Tasmanian markets). The second risk is the failure to extend the ICA 28 scheme (pre-harvest bait spraying and post harvest inspection instead of dimethoate dipping post harvest) to the central Burnett region. Payoff matrix probabilities on both the risk variables were constructed for a with and without area freedom in the central Burnett region. Probabilities for a best, middle and worst case were given for the ICA negotiations; and probabilities for no, medium and high impact were given for the outcome of the APVMA decision.

The HPC (1991) BCA addressed uncertainty around the number and size of outbreaks in their study by estimating the costs of QFF infestation with normal and high QFF infestation levels for valencia, navel, lemon, mandarin and grapefruits. The high infestation levels involved a 40 per cent increase in cost per hectare and number of applications for valencia and lemons, a 25 per cent increase in cost per hectare and number of applications for mandarins and a 15 per cent increase in cost per hectare and number of applications for grapefruit. There was no discussion about what constituted a heavy infestation relative to a normal infestation in regards to the number or size of outbreaks in any given year.

The state contingent approach was not appropriate to the Victorian DPI BCA because of the recurrent nature of outbreaks under ongoing area freedom strategies. While the states in the Chambers and Franco-Dixon paper were specific to policy decisions by peak bodies over a particular time period which would influence the benefit of introducing area freedom strategies. Outbreaks in the Victorian DPI BCA have the possibility of occurring, or not, every year under each of the management strategies; that is, an outbreak in one year was independent of an outbreak in another year.

The Victorian DPI BCA used a method similar to the HPC (1991) method of high and normal infestation rate to address the uncertainty surrounding the frequency of QFF outbreaks and their severity and the differences in preventing an outbreak from occurring for the three proposed options.[4] The sensitivity of the BCA results to the probability of outbreaks was

[4] Uncertainty here is tied to the trends in climate over the longer term, where a hotter drier climate and lower average rainfall may result in a decrease in QFF populations (Ha et al. forthcoming).

tested by halving the frequency of outbreaks for all options. Scenario analyses were undertaken where more than one assumption was changed at one time to also test the BCA results in the Victorian DPI BCA. Scenario one involved a doubling of both outbreaks and suppression costs for each option, while scenario two quadrupled the frequency of outbreaks for option three and doubled outbreak frequency for the other options (Ha et al. forthcoming).

5.2 Choice of time period for BCA

The studies in table 3 have each used different time periods. Time periods chosen for each study have been driven by the objective or particular question the study was addressing. Chambers and Franco-Dixon (2007) chose a 10 year period in which the likelihood of a policy change in regard to the use dimethoate by the APVMA might occur.[5] PWC (2001) assessed the benefits and costs of the Tri-State QFF Committee continuing to oversee the coordination of the Fruit Fly Exclusion Zone (FFEZ). The benefits and costs were assessed on an annual basis and the authors reasoned that the Tri-State agreement could be 'dismantled rapidly, with little lingering control effect' persisting through to following seasons (PWC 2001: 3).[6] The HPC (1991) BCA also calculated the benefits and costs on a per annum basis, although this was separate to any state coordination programs and included State departments monitoring and eradication costs.

The approach used in the Victorian DPI BCA was to consider that the benefits and costs of ongoing area freedom programs can occur over a long time. A 20 year period was chosen as this is a common time period for new investment or re investment in stone fruit, pome fruit and vineyard development, and it captured the upfront fixed costs of establishing a PFA and the ongoing benefits over the life of an orchard derived from being in a PFA.[7]

5.3 Economic welfare effects of QFF management strategy

The economic welfare effects of the proposed management options can be defined as the sum of consumer surplus (willingness to pay less consumer expenditure) and producer surplus (producer revenue less total variable cost of production) (see figure 4).

Domestic consumer demand and domestic supply for a particular QFF host fruit of a given quality in the absence of any area freedom programs is shown in figure 4 using partial equilibrium representation. It is partial in that in that it only represents demand for and supply of QFF host fruits in the Victorian economy and the immediate impacts of QFF management strategies on consumers and producers. The demand curve D shows where, in the absence of barriers to trade and any area freedom programs, consumers choose to consume quantity Q_d at the world price P_w.[8] Consumer surplus is shown as the shaded triangle CS in figure 4.

In figure 4, long run domestic producer supply without area freedom is shown by the curve S and producers supply Q_0 at the world price P_w. The supply curve can be thought of as the marginal cost of supply for fruit of a given quality. The difference between the revenue received from supplying a given quantity and the marginal cost of producing it, is called producer surplus (triangle PS in figure 4). Notice that Q_0 is greater than domestic consumption Q_d as host fruits are exported at price P_w. Figure 4 shows that even in the absence of area freedom programs Victoria is a net exporter of major QFF host fruits such as

[5] Dimethoate is used as a post harvest chemical treatment for all fruit sent to South Australia, Western Australia and Tasmania.

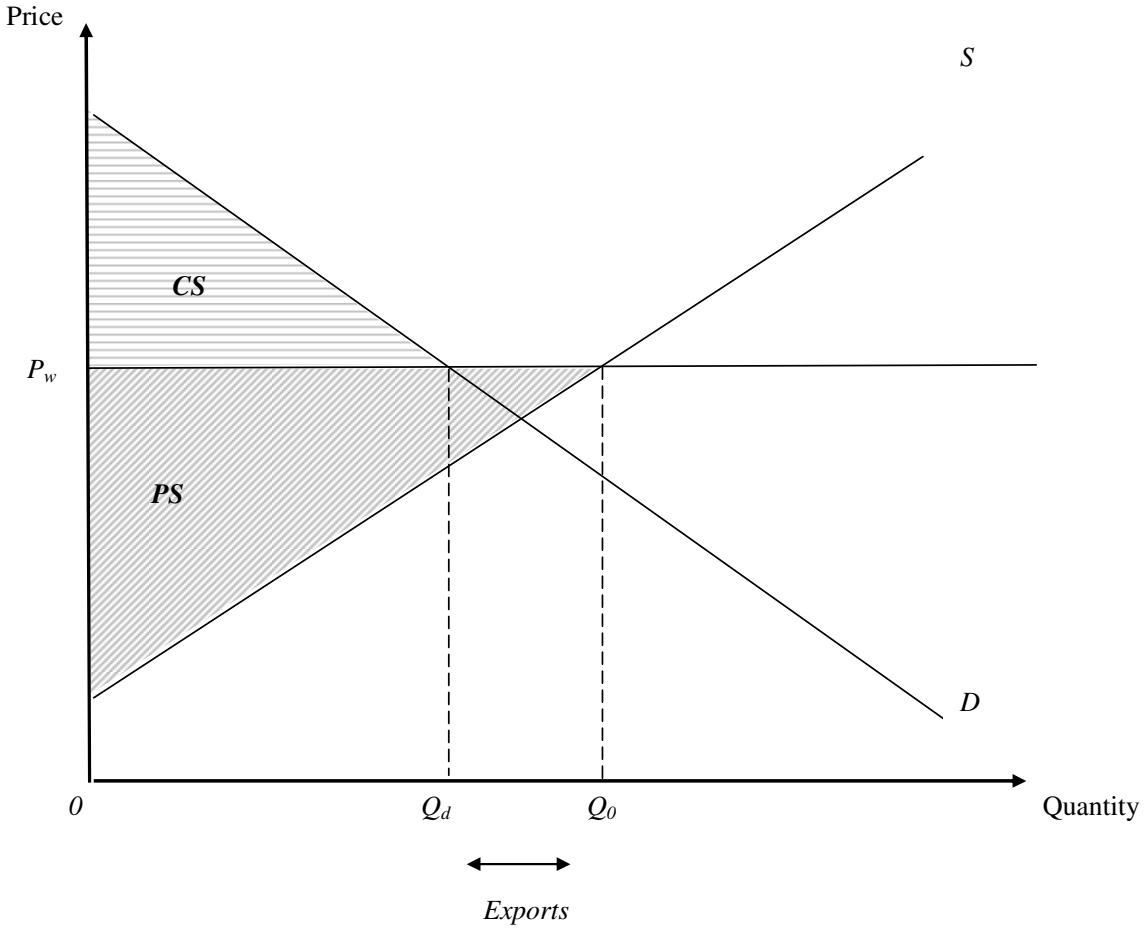
[6] Monitoring and eradication costs that were borne by State Departments were not included.

[7] For citrus, the period can be up to 25 years.

[8] This assumption was made because Australia is a small producer relative to world production and is unable to influence world prices. It is important to note that this simplification assumes QFF host fruit is of similar quality. In reality quality differences will be reflected in prices.

citrus, table grapes and stone fruit. This is due to a number of non-sensitive export markets accepting fruit that has been treated pre and post harvest for QFF.

Figure 4 Consumer and producer surplus from area wide management QFF strategy



Source: Ha et al. (forthcoming)

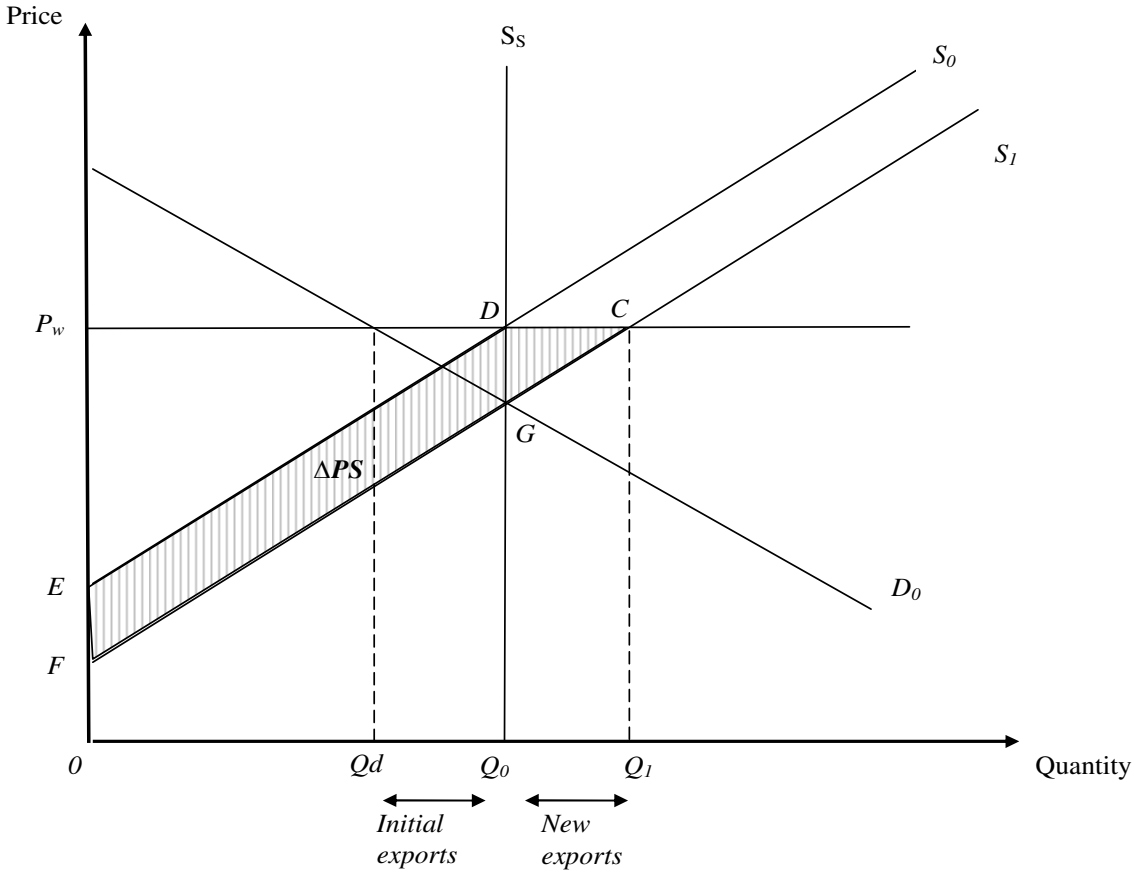
The analysis in Ha et al (forthcoming) estimates the change in economic welfare from a movement to a QFF management program with area freedom compared to the without area freedom management as shown in figure 4. Continuing the partial equilibrium analysis, figure 5 shows the long run supply curve for Victorian QFF host fruit producers moving down from S_0 to S_1. This is due to a decrease in per unit cost from avoided chemical use in QFF control (shown by (E-F) in figure 5). The short run supply curve S_s shows that output will not increase from Q_0 to Q_1, as shown in figure 5 by the long-run supply curve moving downwards, until additional host fruit plants bear fruit. This can take up to seven years and therefore increases in output will not occur for some time.[9] It is assumed the price will remain unchanged (for a given quality of fruit) due to domestic producers being price takers on the world market and domestic producers being able to shift their fruit at relatively low cost to

[9] QFF host fruits will take a number of factors into consideration before increasing their output, including forecast prices, domestic and export consumer demand for QFF host fruits and supply of QFF host fruits in world markets for medium to longer term.

alternative export markets. The increase in producer surplus from lower costs in the presence of area freedom management strategies in the short run is represented by area EFGD and in the long-run by the shaded trapezium, ΔPS in figure 5.

The Victorian DPI BCA was undertaken from the perspective that the existing QFF program is publicly funded. If the government was to completely fund future QFF area freedom management strategies, as it currently does, this would result in a transfer from consumers to producers via the tax system. Consequently consumer surplus would decrease by the amount of the Government contribution to fund the QFF area freedom management strategies and the efficiency costs associated with raising the funds via the tax system (Ha et al. forthcoming). If producers were to completely fund a QFF area freedom management strategy, as in the Central Burnett region QFF BCA, they would be willing to pay up to the value of the increase in producer surplus that such a program generated. As such, producer surplus increasing by less than shown in figure 5 by an amount equal to the cost of the QFF area freedom management strategy implemented.

Figure 5 Changes in producer surplus from area wide management QFF strategy



Source: Ha et al. (forthcoming)

5.3.1 Assumptions behind consumer surplus

In the QFF BCA undertaken by Ha et al.(forthcoming), the approach followed that of HPC (1991) in assuming that consumer surplus would not be affected by any changes to QFF management policy. This assumption was made on the grounds that (Ha et al. forthcoming: 32-33):

- Victorian consumers are indifferent to whether QFF host fruit of a given quality is grown domestically or imported;
- Victorian producers and consumers face a world price for QFF host fruit of a given quality. Australia is a small producer relative to world production and is unable to influence world prices through its exports;
- Consumers in Victoria face a situation of (relatively) free trade in QFF host fruits, whereby Victoria exports QFF host fruits after harvest and imports QFF host fruits at other times when domestic supply is not available, ensuring year round availability of fruit to consumers;[10] and
- QFF host fruit supplied by Victorian producers to domestic markets is of similar quality to that supplied to export markets due to common grade standards being used for export and domestic sales.

In the event of an outbreak resulting in lower production levels, Victorian consumers would be able to meet their demand for QFF host fruits through importation at the world price, and consumer surplus would be unchanged. In the event of an outbreak which did not result in production losses but loss of market access to sensitive export markets, it was assumed that producers could shift their produce to less stringent export markets without incurring extra costs (for example Hong Kong). Subsequently, the amount of fruit available domestically would not change significantly, and local prices would not drop relative to the world price.

PWC (2001) and Chambers and Franco-Dixon (2007) took a different approach and assumed that there would be an increase in supply of fruit on domestic markets due to a loss of export markets from QFF outbreaks. They assume that no other export markets could be found in the short term and that local prices would decrease reflecting the increase in QFF host fruit supply, consequently increasing consumer surplus.

5.3.2 Assumptions behind producer surplus

Producer surplus is influenced by assumptions about access to markets, export market premiums and variable production costs. The introduction of a QFF area freedom strategy will increase producer surplus if it reduces their variable costs of controlling fruit fly. Ha et al. (forthcoming) follow the economic analysis shown in HPC (1991) and PWC (2001) and change in producer surplus from the introduction of QFF area freedom was estimated through:

- Producer's unit costs of fruit production falling relative to the 'do nothing' base case with the introduction of QFF management as pre- and post-harvest treatment of fruits are largely avoided. These are assumed to be reductions in variable costs; and
- Increased net prices due to access to QFF sensitive markets with price premiums.

[10] 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 (Ha et al. forthcoming).

Figure 5 shows the movement down of the long run supply curve, reflecting a decrease in per unit cost of fruit fly control. Producer surplus increases because growers are able to produce more fruit at lower costs in the short run. The time required to bring new orchards into production means supply response is inelastic in the short term with little or no change in output expected in the first ten years after a policy change. No estimates of supply elasticity for Victorian QFF host fruits are quoted in the economic literature. The only study that has estimated supply elasticity has been Alston et al. (1980), who estimated the elasticity of orange output for Australia was negligible for up to 10 years and even after 30 years found it was less than 0.18. Consequently the Victorian DPI BCA did not quantify the changes in producer surplus from a possible increase in production. The implications are that the Victorian DPI BCA may under estimate the long term benefits to industry of QFF area wide management strategies.

Figure 5 shows that even with a change of supply costs, the price domestic producers receive remains at the world price as they are price takers on the world market. However, in reality, factors such as quality differences, seasonal availability, different consumer preferences for QFF host fruits between countries may result in price differences in export markets. PWC (2001) noted price premiums available for QFF host fruits in sensitive markets and quantified the market access premium for citrus to the US and stone fruit to Taiwan at 20 per cent margin above domestic prices averaged over 1997-98 to 1999-00 for FFEZ production volumes. However, Ha et al. (forthcoming) took a different approach by estimating the difference between the price premium in the US market for citrus and the price available in the non-sensitive Hong Kong market. Price premiums were only estimated for the citrus market as 93 per cent of the value of Victorian production was exported in 2006-07 compared to 32, two, and eight per cent for grapes, pome fruit, and stone fruit respectively (Ha et al. forthcoming).

Sensitivity testing was undertaken on the frequency of outbreaks and the costs of chemicals required to treat for QFF, pre and post harvest, in the absence of area freedom management. These parameters directly affect the level of chemical costs avoided and the size of the producer surplus estimated. Producer surplus was also tested for sensitivity to the benefits derived by citrus producers by accessing the US market.

5.4 Benefits and costs considered

Benefits and costs that were quantified in the BCAs from Table 3 were:

- Benefits from an export market price premium;
- Benefits from avoided pre-harvest and post-harvest chemical costs due to area freedom; and
- QFF management program costs.

Benefits and costs that were considered but not quantified were:

- Benefits from IPM from not having to use chemicals;
- Backyard growers as a source of external benefits and costs;
- Environmental benefits and costs; and
- Human health benefits and costs.

Other costs not considered in the Ha et al. (forthcoming) BCA included the cumulative benefits of QFF area freedom strategies (reduction of probabilities *over time* from area

freedom management) and secondary benefits to businesses associated with fruit production (which were included in the PWC (2001) report).

6 Preliminary results

Preliminary results from the Ha et al. (forthcoming) BCA on QFF management options provided by Kalang Consultancy Pty Ltd (2008) (see table 2) are in table 4.

Table 4: Mean values of discounted annual benefits and costs of all management options compared to 'do nothing' strategy ($ million)

		Management option one	Management option two	Management option three
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
TOTAL BENEFITS		33.2	33.3	33.3
Annual production costs	disinfestation following outbreaks (mean)	13.9	12.3	11.7
Program costs:	establishment (for first 3 years)	1.1	0.1	1.2
Annual program maintenance costs:	Eradication (mean)	0.6	1.9	0.4
	Fixed (incl. Suppression)	2.0	1.5	2.0
TOTAL COSTS#		17.6	15.8	14.3
Benefit Cost Ratio*		2.02:1	2.15:1	2.35:1

Notes: * BCR values reported here and in the report are the mean BCR values for all of the runs of the model, not the BCR as calculated from the mean values of the benefits and costs. # 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.

Source: (Ha et al., forthcoming)

As can be seen in table 4, management option three has the highest benefit cost ratio. All three management options derive the same level of benefits from the presence of a QFF area freedom strategy allowing access to sensitive export markets. However, it is the differing probabilities of an outbreak associated with each management option, and the subsequent flow on effects for production and eradication costs which account for the BCR differences.

The BCRs estimated in table 4 for Victorian DPI QFF management options are similar to findings by Chambers and Franco-Dixon (2007) for the Central Burnett QFF area freedom strategy at 2.27:1 and that of the PWC (2001) for the tri-state QFF strategy which had a BCR of 2.5:1, despite the scope of these studies being significantly different to the Victorian DPI BCA.

Management option three was the most preferred option even when key variables such as the discount rate, outbreak frequencies, pre and post harvest treatment costs and export market price premium to the United States are subject to sensitivity analysis. Despite having the highest fixed costs due to establishing PFAs and ALPP, management option three was the preferred choice except in scenario two when it was adjusted to have more frequent outbreaks

compared to the other options (see end of section 5.1 for a description of scenario one and two).

7 The question of funding biosecurity programs

The counterfactual of a 'do nothing' has the advantage of enabling estimates to be made of the total benefits of each alternative management strategy. It also highlights the distribution of the benefits and costs, with the main economic beneficiaries of implementing an area freedom strategy for QFF in Victoria being producers exporting to sensitive markets (also identified in PWC (2001)). This has implications for the way the preferred option on management should be funded.

Of the past BCAs on QFF management strategies discussed in this paper, all examined a move away from existing funding arrangements based almost entirely on State and Commonwealth government funding to a cost sharing approach. The PWC (2001) study considered the beneficiary pays principle as instructed by the terms of reference for their BCA, and recommended funding for the tri-state board to be divided as 30 to 50 per cent to come from Government, 70 to 50 per cent from beneficiaries with the ratio between exporters and growers 3:1, and the state governments to continue funding roles as defined under legislation. The HPC (1991) study identified that most of the net gain to society of an area-free management strategy comes from reduced on-farm costs, with the net savings only estimated for the citrus industry. In terms of funding, they state in theory the beneficiaries should pay, the beneficiaries being the growers of host fruits and vegetables. So, HPC (1991) suggested it would be 'reasonable' that these groups contribute funding to such a program. As HPC (1991) also identified backyard growers receiving benefits from area freedom (they avoid the use of chemicals for home grown fruit), they suggest that the government also contribute funding. In contrast Chambers and Franco-Dixon (2007) note in their BCA that ongoing funding for the area freedom of QFF in the Central Burnett region in Queensland was being met entirely by the producers in the region.

The PWC (2001) BCA noted problems with using the beneficiary pays principle, including that the beneficiaries may change over time and the practical and legal constraints to collecting funds for a QFF management strategy from growers. These problems were also noted by the HPC (1991). However, neither of these issues seemed to have been insurmountable for the Central Burnett region in implementing an area freedom strategy for QFF. This may be because the growers in the region are locked out of export markets due to the presence of QFF and the benefits from meeting area freedom requirements for desirable export markets exceed the costs by more than double.

As discussed in section 5.3, how the funding of a QFF area freedom management strategy is shared between government and producers will affect the distribution of economic welfare such a strategy ultimately generates.

8 Concluding comments

Escalating costs of the current Victorian QFF management strategy resulted in the Victorian DPI undertaking a major review of their current program and a BCA of three alternative management options. In undertaking a BCA on area freedom biosecurity strategies, there are a number of issues which researchers need to make decisions about, including the duration of the analysis, how to incorporate risk and uncertainty, how to estimate welfare effects, and how to consider social and environmental costs and benefits. Decisions made on these questions for three publicly available BCAs on area freedom programs for QFF were considered in relation to the Victorian DPI BCA in this paper.

On the above decision variables, there were differences on the treatment of welfare effects, time periods analysed and approaches to risk and uncertainty. The main difference in the treatment of welfare effects was with Chambers and Franco-Dixon (2007) and PWC (2001) who estimated an increase in consumer surplus from lower domestic prices of fruit when sensitive markets were lost due to area freedom strategies not being pursued. The Ha et al. (forthcoming) BCA assumed that QFF host fruit producers would still be able to access non-sensitive export markets without area freedom management strategies.

In all studies, different time periods were used to calculate the net present value of the stream of future benefits and costs. This was because the strategies being analysed were different or influences on the strategies being successful were different. The Victorian DPI BCA analysed future strategies for a much longer time period relative to the other studies.

All studies took different approaches to incorporating risk, both in the way risk was addressed and the variables for which risk was considered. Each approach was determined in part by the data which were available, and also by the judgements about the main risk factors of each strategy under consideration. The study by PWC (2001) did not include any formal risk analysis, while HPC (1991) looked at two levels of outbreak intensity. Chambers and Franco-Dixon (2007) used state contingent analysis to look at different probabilities related post harvest chemical use and ICA scenarios. In comparison, the Victorian DPI BCA estimated an outbreak probability distribution for each management option to account for risk as well as undertaking sensitivity analysis around key variables. In two scenarios the effects of uncertainty surrounding possible changes in the QFF persistence were examined.

In all studies, the costs and benefits to producers and governments of implementing an area freedom strategy were measured. Certain costs and benefits, such as the benefits from retaining integrated pest management regimes and the external benefits to backyard growers of fruit from AWM were not quantified in any of the studies but were recognised as providing additional benefits on top the net economic benefits derived by AWM strategies. While this approach simplifies the BCA without ignoring these non-market benefits and costs, the issue of how large these benefits and costs might be is still important when considering funding options for the chosen strategy.

In making use of the information generated by the BCA on the three management options for QFF, Victoria DPI faces the task of considering how to fund a new strategy. Previous QFF BCAs all suggest that the beneficiaries of such strategies should contribute to their costs; however, this has generally not been pursued in the past. Difficulties associated with the collection of funds from identified beneficiaries have been noted as a reason for not pursuing such a policy. However, this situation is no different to the organisation and funding of rural research, where funds are collected through a levy from producers. The design of funding mechanisms and collection of funds from producers for biosecurity programs continues to be a relevant policy issue and will ultimately determine the net economic welfare derived from a QFF area freedom management strategy for Victoria.

In conclusion, lessons learnt from this review of QFF area freedom BCAs include:

- By undertaking a BCA, the costs and benefits and their distribution are clarified and can be different to prior expectations, such as in the Ha et al. (forthcoming) DPI BCA the main source of benefits was from avoided post harvest disinfestation costs rather than market access premiums as was the case in the PWC (2001) study;
- Assumptions about the QFF host fruit markets are critical and should be tested using sensitivity analysis;

- Risk and uncertainty should be explicitly incorporated where possible to account for a range of possible outcomes that might occur in reality, such as price movements and outbreak occurrence; and
- That the funding of such programs has implications for overall distribution of economic welfare generated.

Whilst the method and many of the main issues in conducting a BCA of biosecurity policy options are common, the detail matters. Every policy question is unique and presents unique issues and problems of theory and data to resolve. Importantly, having confronted the issues and questions, the approach and reasoning used to resolve these should be documented in clear detail to provide guidance for subsequent BCA analysts of similar policy options.

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