An Economic Evaluation of the Benefits from Import Clearance Activities in Western Australia

By: David Cook, University of Western Australia/Agriculture Western Australia

***Abstract**: Quarantine trade restrictions enforced on agricultural commodities are both a safety measure and a form of subsidy to local producers. With appropriate strategies in place the risk posed to domestic production systems from exotic pests and diseases is reduced. This often means importers of agricultural commodities are effectively taxed, with negative effects on consumer welfare. Hence, analysis of quarantine policy decisions involves a comparison of notional production gains against social welfare loss. Given the large variety of agricultural industries and the virtually endless list of exotic pests deemed as "threatening" to domestic industries, there is a continuum of problems of this type. In some instances the effects of quarantine policies will be felt mainly by producers, while in others it may be consumers, or a blend of the two. In the case of the mango industry in WA, both producers and consumers are affected. A quantitative assessment of the benefits and costs of Agriculture Western Australia's import clearance activities governing mango importation is provided here, demonstrating an appropriate framework for the analysis of these issues following on from James and Anderson (1998). Studies of this nature will be of great importance to policy makers in justifying investments in specific quarantine activities given the recommendations of the Nairne Review and the memorandum of understanding between the states and territories of Australia to abide by these guidelines.*

1. Introduction

The economics of quarantine policy is a complicated issue. Trade restrictions enforced on agricultural commodities are ostensibly a safety measure, protecting domestic production systems from exotic pests and diseases. However, they can also be seen as a form of subsidy for local producers, and a tax on importers, impacting on the welfare of consumers. Hence, analysis of policy decisions involves a comparison of notional production gains against social welfare loss. Bearing this in mind, this analysis provides a quantitative assessment of Agriculture Western Australia's interstate quarantine procedures with regard to mangoes. It does so by estimating the net welfare loss to be expected as a result of restricting competition from eastern states growers, and relating this to the notional benefits which would need to be gained through pest exclusion to justify the import protocols. A lack of information prevents a comprehensive study of the expected benefits from preventing (at least temporarily) pest entry into WA from being presented here. Instead, the approach is taken to identify the likely break even notional damage, or the minimum losses prevented by quarantine restrictions necessary for social benefits to equal total costs. In doing so, it successfully applies the methodology developed by James and Anderson (1998) to an interstate trade setting, which could be combined with pest risk assessments in the future to provide a comprehensive tool for policy analysis.

2. Background

The World Trade Organisation (WTO) Agreement established at Marrakesh on the 15th April 1994 has had some interesting effects with regard to quarantine policy in subsequent years. Following the Uruguay Round of talks, concerns were raise by exporters of agricultural goods that the trend towards free trade may be offset by a movement towards alternative trade barriers such as quarantine restrictions. One category of these alternative barriers, known as *Technical Barriers to Trade* (TBT), relate to rules and standards directed at health, safety and the environment (Bigsby, 1999, p. 1; Hooker and Caswell, 1999, p. 234). Subsequently an agreement on Sanitary (human and animal health) and Phytosanitary (plant health) (SPS) measures was negotiated to ensure that future SPS trade restrictions were based on scientific information (James and Anderson, 1998).

Australia as a principal food exporter is well poised to take advantage of these new developments from a world trade perspective, but what of the interstate trade perspective? In a Memorandum of Understanding between the Commonwealth of Australia and all states and territories (henceforth referred to simply as "the Memorandum") signed on the 21st of December 1995 designed to ensure Australia's compliance with relevant obligations under the SPS agreement, interstate trade restrictions became subject to the same guidelines. Article 11 of the Memorandum stipulates:

> States and Territories shall not apply any relevant sanitary and phytosanitary measures within their jurisdictions which would not conform with the provisions of the SPS Agreement.

The "provisions" referred to are specified in Article 5 of the SPS Agreement, which begins:

> Members shall ensure that their sanitary and phytosanitary measures are based on an assessment, as appropriate to the circumstances, of the risks to human, animal or plant life or health, taking into account risk assessment techniques developed by the relevant international organisations (Photocopy, Jeroen Den Hollander, pers comm, 30/7/99).

So, in the context of interstate trade the contents of relevant *risk analysis* (RA) are paramount in determining if specific trade policies are not only desirable from an importing state or territory's point of view, but also meet international criteria.

The negotiation of SPS agreement was one of several factors which prompted the Hon. Bob Collins, Minister for Primary Industries and Energy, to initiate a review of Australia's quarantine system in December 1995 through an independent committee. In addition, through the course of the 1990s concerns began to surface about the effectiveness of Australia's quarantine control. This coincided with the European Bovine Spongiform Encephalopathy (BSE) outbreak, and the resultant "selective cull" of cattle deemed a contamination risk, and the significant trade disruptions. Several exotic pest incursions in Australia served to heighten public concern over trade safety issues, applying added pressure to the Australian Quarantine and Inspection Service (AQIS) to demonstrate competence in the protection of Australian consumers. Specifically, incidences of Western Flower Thrips, Papaya Fruit Fly, Siam Weed, Chalkbrood, Northern Pacific Starfish and Japanese Encephalitis being imported from abroad received a considerable amount of media attention (Nairn *et al*, 1996, p. 3).

A host of other factors also contributed to the need to formally demonstrate appropriate protection mechanisms were in place, including:

- The voicing of concerns over the processes and science behind AQIS import protocols following their endeavours to finalise import conditions for goods such as fresh Salmon and pork, and cooked chicken meat;

- The increasing use of environmentally-friendly, or "clean and green" approach to food marketing to gain access to certain markets, reflecting consumer concerns over the environment;

- Increased volumes of produce on the world markets, and the greatly enhanced movement of people between international destinations brought about by advances in air and sea travel;

- Scientific advances in the study and identification of plant and animal pests and diseases;

(Nairn *et al*, 1996, pp. 3-4)

The committee appointed to carry out the review was chaired by Emeritus Professor Malcolm Nairn, which presented its findings to the Minister in November 1996 in the form of a report titled *Australian Quarantine: A Shared Responsibility*, widely referred to as the Nairn review. The report put forward 109 recommendations on how Australia's quarantine system could be improved to comply with WTO regulations, concentrating on a range of areas such as environmental awareness, community awareness, RA, consultation in policy-making, surveillance and preparedness.

In a clear and concise overview of RA techniques, Nunn (1997) uses a broad RA definition taken directly from the Nairn review which encompasses the key areas of risk assessment, risk management and risk communication. This definition is adopted here, where these key areas are defined as:

- Risk Assessment – process of identifying and estimating risks associated with a policy option and evaluating the likely consequences of taking those risks.
- Risk Management – process of identifying, documenting and implementing measures to reduce these risks and their consequences; and
- Risk Communication – process of interactive exchange of information and views concerning risk between analysts and stakeholders.

(Nunn, 1997, p. 560; Nairn *et al*, 1996, p. 85).

Each of these areas is involved in performing an economic evaluation of cross-border quarantine trade restrictions.

However, there remains some debate over what an optimal economic evaluation of this nature should include, there being surprisingly few examples of formal addressing trade flow and welfare impacts of SPS regulation (Hooker and Caswell, 1999, p. 234). This analysis draws heavily from the techniques used in James and Anderson (1998) in an evaluation of Australia's ban on banana imports. Their study demonstrated that lifting the ban would have the effect of increasing net public welfare by $90-240 million per annum, and that even if the domestic industry were disbanded due to pressure from imported produce the net gains from trade would be in the vicinity of $100 million per annum.

Although several criticisms can be levelled at this approach, it provides a suitable benchmark. For this reason, it is proposed that it be used in a quantitative assessment of the net benefits to several of Agriculture Western Australia's *Interstate Import Clearance* (PAK) activities to facilitate better informed policy decision-making. Rather than take a narrow industry perspective, adopting a broader social perspective in line with recommendations of the Nairn report will ensure the results of economic analyses are more focused on *social* optima.

The large variety of agricultural industries and the virtually endless list of exotic pests deemed as "threatening" to domestic industries means there is a continuum of problems of this type. In some instances the benefits to quarantine policies will be felt mainly by producers, while in others it may be consumers, or a blend of the two. Here, the focus is on one of these problems, the economics of interstate Mango quarantine protocols in WA. This illustrates the analytical techniques to be used in future quantitative analyses of this type, and shows how policy makers stand to benefit from the information they provide.

3. Welfare Loss

The concept of Social Welfare in economics is an ambiguous one. For the purposes of our analysis, let us assume that the term refers to *gains from trade*. Very simply stated, this is the extra consumption benefits achieved through interstate trade. By trading goods, consumers enjoy a wider range of products obtainable at a cheaper price than would otherwise be the case, translating into an improvement in their welfare. This will be explained in diagrammatic form later. By taking welfare effects into account, the scope for this analysis becomes relatively broad. Not only is the concern to quantify the benefits to agricultural industries from preventing exotic disease incursions, but also the effect on consumers as a result of import restrictions. This is in line with the Nairn report's recommendations concerning a broadening of the scope of quarantine to take into consideration national and international obligations (Nairn *et al*, 1996, p. 12).

Consider an exotic insect pest such as Mango Seed Weevil (*Sternochaetus mangiferae*) which is endemic in the eastern states of Australia. The risk of the pest entering WA from the eastern states can be reduced by ensuring imported fruit are subjected to a number of tests before they are permitted across the WA border. But, the reduced risk comes at the cost of the extra testing costs. This will be reflected in higher prices for imported mangoes, causing a welfare loss for consumers. So, while domestic mango/fruit growers receive a notional benefit from the reduced risk of exotic pest incursions, this is offset by a reduction in consumer welfare.

4. Static Analytical Framework

The situation described in section 3 is perhaps best explained using a basic comparative-static partial equilibrium model of interstate trade for a single commodity, as outlined in James and Anderson (1998). In the interests of simplicity, it is prudent to make several assumptions about the system being modelled, which are detailed below:

(1) The domestic market for mangoes is perfectly competitive.

(2) WA is a "price-taker", whereby changes in the domestic market have a negligible impact on the environment for world trade.

(3) Mangoes are a homogenous product, so demand and supply curves are aggregated across the extensively grown Kensington Pride (including Kimberley Research Station (KRS) selection), and late maturing varieties such as Keitt and R2E2.

(4) Society has a neutral attitude to risk.

(5) Potentially imported agricultural pests attack one host exclusively (i.e. mangoes), with no polyphagous tendencies which might affect other industries.

(6) Under quarantine restricted trade, the onus is on importing centres to abide by certified protocols, bearing any necessary costs in order to do so (James and Anderson, 1998, p. 431).

Consider firstly a closed WA economy where no trade in mangoes takes place with the eastern states of Australia[1]. Ignoring the D_R, D_W and S^* initially, assume local suppliers face a downward sloping demand curve (D_F) for their product in the domestic market, and an upward sloping supply curve (S). The intersection of these two curves (at E_d) determines the domestic producer price (P_d) quantity supplied (Q_d) produce at this price. This will subsequently be referred to as the *closed economy* equilibrium.

The standard tool for measuring welfare changes is *Consumer's Surplus* (CS) and *Producer Surplus* (PS). Although only representing an exact measure of welfare change under certain strong assumptions (i.e. quasilinear utility for consumers), they are often used as an approximation in applied work (Varian, 1992, p. 163). In the closed economy situation, CS is the area AE_dP_d, while PS is OE_dP_d. By measuring changes to these areas brought about by quarantine policy changes, an approximate welfare change can be quantified.

Before moving on, it is necessary to introduce marketing margins into the model in order to properly examine these social welfare implications. Most WA mango growers sell their wares on the Perth market through a market agent[2], who in turn sell them to retail outlets, from which they are purchased by consumers. The size of the marketing margins applied at each stage is difficult to verify, as is the manner in which they're applied. Sources close to the market indicate wholesale margins to be in the order of 10-15 per cent (Mercer Mooney; Quality Produce International; Central Fruit Sales; Etherington & Sons, pers comm, 23/11/99), and retail margins around 33 per cent (Woolworths – Fresh Produce, pers comm, 22/11/99; Quality Produce International, pers comm, 23/11/99). Since further details of the idiosyncrasies of fruit marketing are difficult to extract, marketing margins are assumed constant in percentage terms. Consequently, the model infers that (generally) the price paid for mangoes "at the farm gate" is around 12.5 per cent below the wholesale price of fruit, which is in turn is approximately 33 per cent below the retail price.

The demand curves for mangoes at the wholesale and retail levels are shown in Figure 1 as D_W and D_R respectively. For the most part the D_W curve can be ignored since demand at the retail level is of primary concern. Looking once more at the closed economy situation, when the producer price is P_d and the quantity supplied fixed at Q_d, the corresponding retail price is $P^R{}_d$. Therefore, although PS remains constant, CS with marketing margins in place becomes $P^R{}_dJL$.

If the market is now opened up for unrestricted trade with other states, domestic suppliers will be thrown into direct competition with imported product. Instead of dictating terms in the market, WA producers will become price-takers assuming the prevailing state producer price (P_d) exceeds the national producer price (P_n) (CIE, 1988). At P_n domestic suppliers are only willing to supply Q_1, while demand is Q_n. Hence, Q_0-Q_1 is made up by domestic producers and Q_n-Q_1 by

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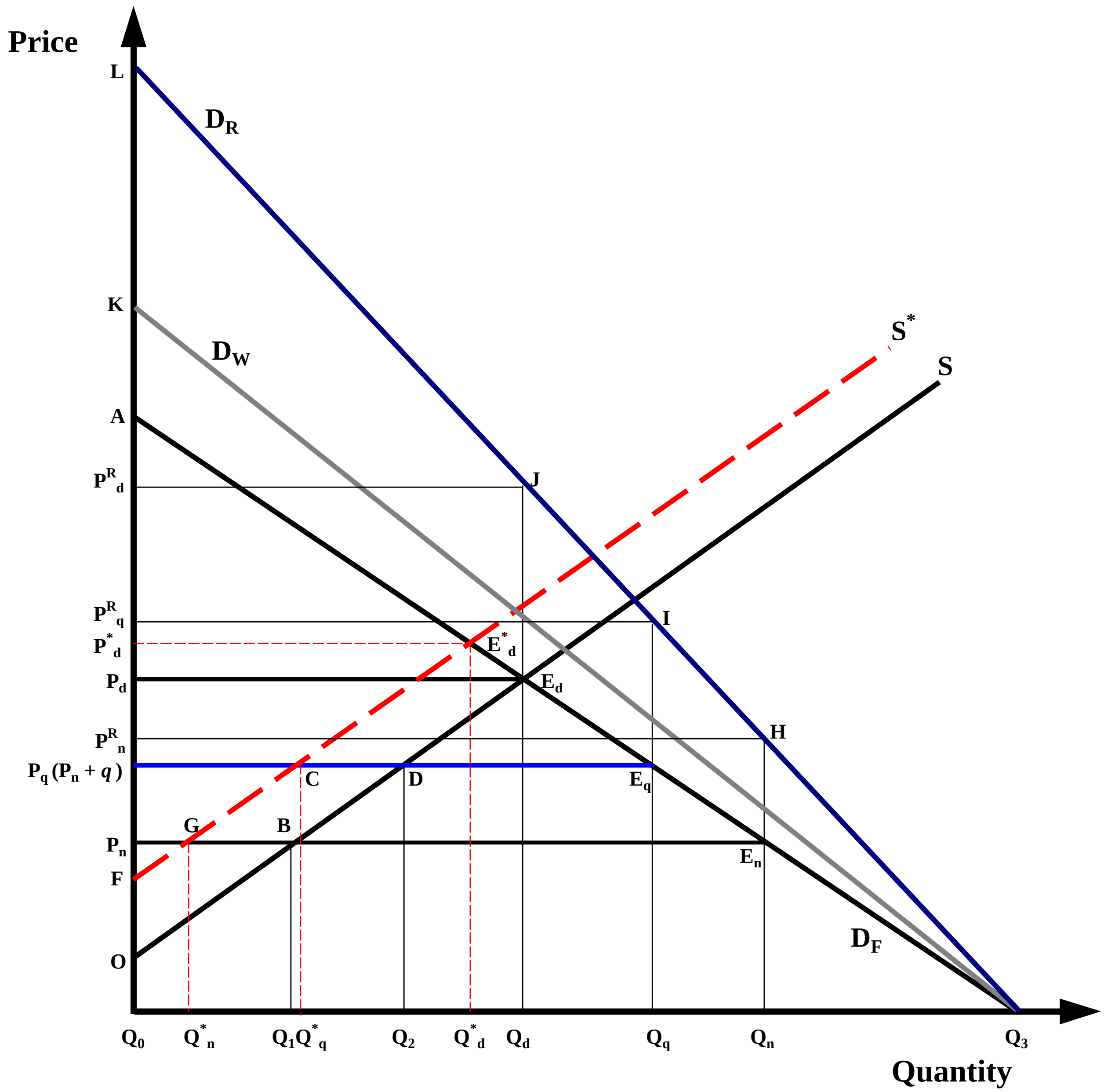
[1] It is characteristic of most mango producing nations to sell the bulk of produce domestically due to difficulties in transporting the fruit over large distances. In fact, although mango ranks forth in terms of total world fruit production (behind banana, citrus and pome fruit), international trade accounts for less that 1 per cent of world production (White, 1997, p. 34). Hence, an open economy situation as presented here is limited to include only trade with other states and territories of Australia, rather than international centres. Since the national price of mangoes does not vary significantly from import prices for several larger trading nations (discussed below) (FAO, 1999), this point is considered trivial.

[2] There are around 23 Perth market agents at the present time (PMA, pers comm, 23/11/99).

imported fruit. As it has been drawn in Figure 1, CS increases by the area $P^R{}_dJHP^R{}_n$ (i.e. from $P^R{}_dJL$ to $P^R{}_nHL$) as the economy is opened up to trade with no quarantine restrictions, and PS

Figure 1: *Interstate Import Clearance & Social Welfare Loss*



decreases by the area $P_nBE_dP_d$ (i.e. from OE_dP_d to OBP_n). With this information it is possible to calculate the net gains to trade by subtracting the loss in PS from the gain in CS. So, in the case of the economy moving from a state of autarchy to one of free-trade net gains can simply be calculated as $P^R{}_dJHP^R{}_n$ - $P_nBE_dP_d$.

With no restrictions on trade the probability of exotic pest incursions is maximised, with Q_n-Q_1 imports entering the state free of screening mechanisms. Suppose now that a quarantine restriction on this imported produce is introduced in an effort to decrease the likelihood of incursions. As outlined in the previous section, the cost to eastern states producers of complying with the specified protocols, *q*, is passed on the consumers in the form of higher prices. Hence, with the quarantine restriction in place the market faces the producer price P_q and retail price P^R_q. At this price, consumers will remain better off than under the closed economy scenario, but will be worse off than under a free trade regime. Their CS is now $P^R_q IL$, an increase of $P^R_d JIP^R_q$ relative to autarchy. The opposite is true of producers, being worse off than under autarchy and better off than under free trade. The PS is now ODP_q, a decrease of $P_q DE_d P_d$ relative to the no trade situation. Therefore, the net gains of quarantine restricted trade as opposed to a closed economy can be calculated by $P^R_d JIP^R_q - P_q DE_d P_d$.

Using this framework, the impact of quarantine restrictions on consumer and producer surplus can clearly be seen. Consider what happens when there is an incursion of an exotic pest such as MSW, which is highly host-specific. Once it has been detected, certain measures will be taken to manage the spread of the pest in line with its biological characteristics, the presence of nationally co-ordinated management strategies, the size and structure of the affected market, and so forth. For now, assume the impact of these management strategies is to raise the domestic cost of production. This will of course shift the supply function to the left from S to S^* as domestic supply contracts under the added costs from the newly introduced pest, so in the absence of any demand shocks domestic supply will contract while the volume of imported product increases. Although it is conceivable that consumers may switch to rival goods if the pest or disease has a negative impact on "product image", the model ignores this possibility (recalling assumption (3) above). Under the quarantine restricted price P_q domestic supply will be $Q_0-Q^*_q$, and imports $Q_q-Q^*_q$. Domestic CS will remain constant at $P^R_q IL$, and PS will contract to FCP_q. Therefore, the net loss to the WA economy of importing the pest becomes ODCF.

An estimate of the potential economic benefits and costs of adopting any one strategy (either a free trade policy or quarantine restricted trade) can now be calculated by comparing the net gains from trade with the potential loss to the domestic PS should a pest enter. For instance, the potential net benefits to a free trade policy (PB_{ft}) relative to a closed economy situation are given by:

$$PB_{ft} = (P^R_d JHP^R_n - P_n BE_d P_d) - (p \times OBGF) \tag{1}$$

where;

p = probability of pest entry under free trade
$P^R_n HJP^R_d - P_n BE_d P_d$ = net gains from trade under a free trade regime
OBGF = potential loss of PS under free trade

With unrestricted trade, p is expected to be relatively high when compared to a restricted environment assuming quarantine only affects the probability of a disease outbreak, and has no impact on the severity. The potential net benefits to a quarantine restricted trade policy (PB_{qt}) with respect to a closed economy situation can be calculated as:

$$PB_{qt} = (P^R_d JIP^R_q - P_q DE_d P_d) - (p^* \times ODCF) \tag{2}$$

where;

p^* = probability of pest entry under quarantine protocols trade (i.e. $p^* < p$)
$P^R_d JIP^R_q - P_q DE_d P_d$ = net gains from trade under a quarantine policy
ODCF = potential losses to PS brought about by a pest incursion.

If the losses expected to be suffered under a free trade regime are sufficiently low when compared to those under a quarantine policy, then it would be very difficult to justify this protection. On the other hand, if the pests which could potentially enter WA through imported mangoes are capable of inflicting very severe damage, it may be that free trade is not worth the risk. By simply subtracting (2) from (1), an expression can be derived which will indicate the potential benefit of quarantine policies relative to free trade ($PB_{qt/ft}$):

$$PB_{qt/ft} = [(P^R{}_d JIP^R{}_q - P_q DE_d P_d) - (p^* \times ODCF)] - [(P^R{}_d JHP^R{}_n - P_n BE_d P_d) - (p \times OBGF)] \qquad (3)$$

Of course, estimating ($p^* \times$ ODCF) and ($p \times$ OBGF), the expected losses to PS from expected pest incursions under quarantine and free trade respectively, would involve a high amount of subjectivity. An alternative is to calculate $(P^R{}_d JIP^R{}_q - P_q DE_d P_d) - (P^R{}_d JHP^R{}_n - P_n BE_d P_d)$, the total net welfare loss to society resulting from choosing quarantine restrictions over free trade, and assume the policy will break even (i.e. total net gain = total notional PS loss), as shown in (4):

$$(P^R{}_d JIP^R{}_q - P_q DE_d P_d) - (P^R{}_d JHP^R{}_n - P_n BE_d P_d) = (p^* \times ODCF) - (p \times OBGF) \qquad (4)$$

or

$$(P_n BDP_q - P^R{}_q IHP^R{}_n) = (p^* \times ODCF) - (p \times OBGF) \qquad (5)$$

By doing so, it is possible to estimate the minimum value of the right hand side of equation (4) necessary for the policy to be justified on economic grounds. By comparing the figure on the right to an estimate of total PS in WA at the moment, the expected damage to the domestic mango industry which are avoided by trade restrictions can be put into perspective.

Problems

A great deal more work is needed in this area before a more comprehensive study can be completed, particularly in relation to estimating the values p and p^*. Knowing more about these probabilities would be very useful in terms of policy assessment, but at present they are largely unknown. In passing, the comment can be made that it is doubtful given geographic characteristics that WA's main mango producing areas (see below) will be at great risk from imported produce through the Perth market. However, in the absence of quantitative data this can only be regarded as a value judgement.

Although this methodology has been proven to be readily applicable in quantitative evaluations, there are several shortcomings which are important to note. These can be summarised as follows:

- PS losses are calculated on the assumption of zero opportunity cost. Once profits are lost, they are lost permanently since no assumptions are made concerning alternative, or "next best" land uses. This implies all land, labour and capital resources displaced from the industry concerned through pressure from imported goods could not be employed elsewhere in the economy. This is a very significant assumption, particularly in a dynamic sense, since it ignores any form of adaptive behaviour. As a result, producer losses may be overstated (Sinner,1999, p. 15). There may well be considerable socioeconomic factors to consider in any resource re-allocation, which would be difficult to "sell" politically since they tend to be more visible than the indivisible loss of welfare to consumers in general.

- The analysis is industry specific, and does not allow for cross-industry impact analysis. While some pests attack one host exclusively, others are highly polyphagous, attacking a variety different hosts in different ways, depending on the idiosyncrasies of the attacker.

- Concise information on marketing margins, particularly at the retail level, is extremely hard to come by. There is therefore a level of uncertainty surrounding the position of the retail demand curve (D_F), which may have significant implications for the model's accuracy.

To address these problems is to add a great deal of complexity to the analysis. Hence, no alternative method is proposed here, but subsequent work may wish to at least attempt incorporating these issues into the general framework.

5. Dynamic Model

The framework described in section 4 represents a static approach to quarantine policy analysis, assuming the impact of the pest(s) is industry specific (i.e. assumption 5) and persists for one time period. The likelihood of pests affecting production in subsequent time periods is not altered by their presence in previous time periods. However, it is possible to identify two cases where this would not be valid:

1. Where the effects of a pest carry over from one time period to the next (i.e. the outbreak is not/can not be contained in the first time period, as is the case for a large portion of agricultural pests with multiple spread vectors).
2. Where industries operate under dynamic production processes, such as those of a variety of horticultural enterprises like orchard fruit growing and viticulture, where inputs purchased in one time period yield benefits over a number of future time periods. Hence, a pest outbreak affecting inputs in one time period will tend to have carry-over effects in subsequent time periods, so the industry is effectively in a pest-affected state over that time regardless of whether it was eradicated in the first time period.

In both these cases, the probability of a pest-affected industry state occurring in any time period is partly determined by the pest status of the industry in previous time periods.

This poses a major problem for analysts attempting to model the impact of a particular pest, or pests, over time in that the data requirements to tract their effects are huge. In most cases it is necessary to use deterministic models where spread and impact under different management strategies over time are known with certainty (Hinchy and Fisher, 1991, p. 34).

6. The Mango Industry and Western Australia in Brief

World Production

The mango (*Mangifera indica*) has been described as the "most extensively grown of all fruits" (Alexander, 1987, p. 5). It is believed to have evolved in the tropical rainforests of south and south east Asia (Kaur *et al.*, 1980), and is now grown every country throughout the tropical areas of the world in both hemispheres. Mango plants can live over 100 years, and can stand over 30 meters high at maturity. There are now thousands of known mango varieties available throughout the world, of which 277 are listed in the 1999 Commonwealth Plant Quarantine active list. The names of some of these apply to the same variety, so the real number of species is likely to somewhat less.

Commercial Mango growing enterprises predominate in tropical lowland areas roughly 23° 26′ north and south of the equator. Approximately 60 per cent of the world's mango supply comes from India, which has a 6,000 year history of growing the fruit (Alexander, 1987, p. 5). There it remains an important cultural and religious symbol. Other major growing areas are found on the Indian subcontinent, south east Asia, and central and South America. With advances in cultivation techniques, a limited amount of production also takes place in subtropical areas such as in Israel and Spain.

In 1993, world mango production was estimated to be in excess of 17.7 million tonnes (Litz, 1997, p.12). This represented an increase of some 30% since the early 1980's (Alexander, 1987, p. 5). However, despite this increase and the huge global production, mangoes remain insignificant in world trade when compared with other fruit varieties such as bananas, apples, and citrus fruit.

Australian Production

In Australia, mangoes are grown throughout the northern tropical and subtropical regions where they are picked from late September to early April (Liz, 1997, p. 204; White, 1997, p. 3). National production accounts for around 2 per cent of the recorded world output of mangoes, producing just over 27,000 tonnes in 1995/96 (ABS, 1997). With a history of broad acre agriculture, it is not surprising that the national mango industry has never been prominent, but it continues to grow in size and stature. In the early 1970's, production (of 1-2,000 tonnes at that stage) was marketed mainly from Sydney and Brisbane, but by the mid-1980's mangoes were available from all major Australian markets (Alexander, 1985, p. 5). The major producing states are Queensland, New South Wales, and of course Western Australia.

Western Australian Production

The WA mango industry has been expanding significantly over the past ten years. In 1995/96 it accounted for around 5% of national output, producing a total of 1,257.69 tonnes (ABS, 1997). This made it the third largest producer behind Queensland (85%) and the Northern Territory (NT) (9%) (White, 1997, p. 3). Production is centred around two main regions, Carnarvon (890 tonnes, 1995/96) and Kununurra (550 tonnes). The former's production peeks from late December to February, while the latter is one of the earliest producers in Australia, peeking during October and November. Other growing centres include Broome (52.4 tonnes), Gingin (22 tonnes) and Derby (2.2 tonnes) (ABS, 1997). This dispersion of producers across the state causes a lengthy picking time, and a continuous supply to the Perth Market from October through to April (White, 1997, p. 8).

Generally, WA is free from serious mango pests and diseases, although isolated occurences of Black spot and anthracnose are detected from time to time, as are several common fungal diseases. The only insect pest of significance to mangoes which is endemic in the north of the state is Mediterranean Fruit Fly (*Ceratitis capitara*), although this pest has been eradicated in some areas (e.g. Broome, 1998).

7. Import Protocols for Mangoes

Despite the mango tree being a hardy species, several pests pose a significant threat to their well being. WA is generally free of many major pests which occur in other states, and as such quarantine plays a vital role for the domestic industry (Strickland, 1992, p. 108). These invertebrate pests such as Queensland Fruit Fly (*Bactrocera tryoni*), Mango Seed Weevil (*Sternochaetus mangiferae*), Mango Pulp Weevil (*Sternochaetus frigidus*), Northern Teritory Fruit Fly (*Bactrocera aquilonis*), European Red Mite (*Panonynchus ulmi*), Melon Thrips (*Thrips palmi*), Spiraling Whitefly (*Aleurodicus dispersus*), Mango Leaf Hopper (*Idioscopes niveosparsus* and *Idioscopes clypealis*), and diseases such as Mango Scab. These pests have the potential to inflict serious damage to mango crops in WA if not detected and treated early, and/or to add significantly to the marginal costs of production if they were to become endemic in WA.

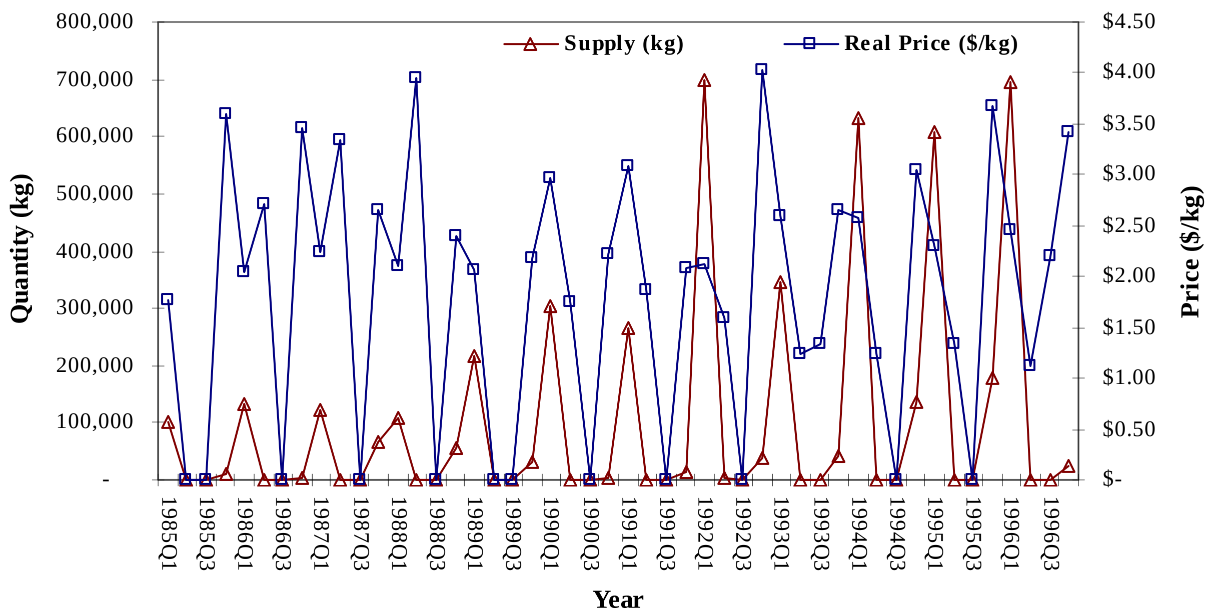
Prior to 1994, importation from the largest eastern states rival was prohibited (Hawkins, 1994). The Northern Territory since it houses exotic pests like MSW and Northern Territory Fruit Fly, and Queensland due to the presence of Q-fly. However, in 1994 a new set of protocols was introduced to permit imports from the former under certain circumstances. Queensland imports remain prohibited.

The criteria are notoriously strict, with preventative measures taken to prevent the entry of all the pests mentioned above. All costs are born by the growers seeking to export product into WA, the most significant of which are made up of post harvest sprays for fruit fly, and sampling costs for Mango Seed Weevil (MSW). Detection of MSW requires the fruit to be dissected and inspected for evidence of larvae in the seed, as the name would suggest, rendering it un-saleable. A property wishing to export must undergo sampling for two years prior to the first consignment being permitted across the border to demonstrate property freedom. This involves up to 4,000 fruit being inspected at the commencement of each season. If approval is given by the Western Australian Quarantine and Inspection Service (WAQIS) and export takes place, a market sample of 600 fruit will be taken either prior to or immediately upon arrival. Maintenance of property freedom is accepted on the basis of there being no MSW infestation within 50km of the property, and no detection occurs in annual fruit sampling or consignment sampling (WAQIS, 1999; Manbulloo Mangoes Australia, pers comm, 26/8/99).

8. Data Specification

A major concern for any economic assessment of mango quarantine protocols is the variability of time-series price and quantity data for the WA market. Quarterly data from 1985 Q1 to 1996 Q2 from the Perth Marketing Authority (PMA) was used to estimate the pre and post quarantine quantity demanded and price. However, the highly seasonal nature of mango supply makes this a challenge, as Figure 2 graphically illustrates. The nominal price of mangoes was converted to real price using quarterly inflation data.

Figure 2: *Mango Price and Quantity Data for the Perth Market, 1985-1996*



Aggregating this kind of information is fraught with danger, and the best bet estimates of key variables in the model should be viewed with this in mind.

9. Results and Sensitivities

The information outlined above was placed into a simple spreadsheet model which calculates the net gains from trade in both a free trade and post quarantine setting, in line with the methodology outlined earlier. To clarify, the objective is to estimate the value of total notional PS loss saved by the quarantine protocol for mangoes (as a result of preventing pest incursions) required exactly offset the total net welfare loss resulting from inflating prices above a free trade level. In the absence of information on the aggregated probability of pest incursions under quarantine versus free trade regimes, these notional PS losses have been grouped together. Although this is regrettable in many ways, the results will still provide a good indication of the necessary cost effectiveness of interstate quarantine protocols if they are to be justified on economic grounds.

Results of a “best bet” approximation are detailed in Table 1 with references to Figure 1 in brackets, below which are listed the key assumptions used in the estimation.

Table 1: *Key Assumptions*

	Free Trade	Post Quarantine
Change in Producer Surplus	**-$130,300** ($P_nBE_dP_d$)	**-$95,760** ($P_qDE_dP_d$)
Change in Consumer Surplus	**$206,640** ($P^R_dJHP^R_n$)	**$149,850** ($P^R_dJIP^R_q$)
Net Gains to Trade	**$76,340** ($P^R_dJHP^R_n - P_nBE_dP_d$)	**$54,090** ($P^R_dJIP^R_q - P_qDE_dP_d$)
Total Net Welfare Loss	**$22,250** ($P_nBDP_q - P^R_qIHP^R_n$)	

where; Demand Elasticity = **-2.30**
Supply Elasticity = **0.60**
Closed Economy Equilibrium Price (P_d) = **$1.95/kg**
Closed Economy Equilibrium Quantity (Q_d) = **630,000/kg**
Price Under Free Trade (P_n) = **$1.75/kg**
Post Quarantine Price (P_q) = **$1.80/kg**

Here, the post-quarantine price (P_q) was calculated (in real terms) as a three year average in the period following 1994 when imports from the eastern states were no longer prohibited due to the threat of MSW using PMA data. The closed economy domestic equilibrium price (P_d), quantity demanded (Q_d) and post-quarantine quantity demanded (Q_q) were derived in a similar manner using pre-1994 data.

The free-trade equilibrium price (P_n) was assumed to approximate the marginal cost of mango production for eastern states rival growers. If there were no restrictions to trade, these producers would be inclined to take advantage of the WA market and increase supply to the point where all profits are diminished, and price equals marginal cost. White (1997) calculated the marginal cost of production and transport to local markets for producers in Carnarvon, Kununurra, Katherine in the Northern Territory, and Mareeba in Queensland. By substituting transport costs to Perth for local transport costs (i.e. Brisbane-Perth = $410/tonne; Sydney-Perth = $380/tonne (Harris Transport, pers comm, 4/10/99)) for eastern states producers, the lowest marginal cost was found to be in Queensland at around $1.75/kg.

Therefore, using this information as input into the spreadsheet model, results indicate that the potential loss to PS avoided by maintaining quarantine protocols must be in the order of $22,250 for the policy to break even. As the curves are defined here, domestic PS in a quarantine restricted trade situation (i.e. post-1994) is approximately $757,600. Therefore, in order for the policy to break even, the expected value of PS saved by excluding mango pests must constitute around 2.9% of the current total value of the industry. To put this another way, the probability of the industry being completely destroyed by imported pests must be in the order of 2.7% per year. This is surprisingly high, particularly when the geographic constraints to pest spread in WA are taken into account.

In light of the subjective nature of many assumptions used to derive this result, it is prudent to run an extensive sensitivity analysis to indicate the areas most likely to cause bias. Each of the key input variables was tested, and a summary of the results appears in Table 2.

Table 2: *Sensitivity Analysis*

Variable (Best Bet Value)	Value	Relative Change in Value from "Best Bet" Scenario	Net Gain Under Free Trade	Net Gain Under Quarantine Restricted Trade	Net Welfare Loss Due to Quarantine	Relative Change in Net Welfare Loss from "Best Bet" Scenario ($22,250)
Elasticity of Demand (-2.30)	-1.00	-56.52%	$72,300	$51,850	**$20,455**	-8.08%
	-3.04	32.17%	$78,640	$55,365	**$23,280**	4.61%
Elasticity of Supply (0.60)	0.30	-50.00%	$72,610	$52,020	**$20,595**	-7.45%
	1.00	66.67%	$81,315	$56,845	**$24,470**	9.96%
Closed Economy Price ($/kg) (Farm: $1.95)	$1.90	-2.56%	$56,015	$35,395	**$20,620**	-7.34%
	$2.00	2.56%	$101,880	$77,805	**$24,075**	8.18%
Free-Trade Price ($/kg) (Farm: $1.75)	$1.70	-2.86%	$100,500	$54,090	**$46,410**	108.55%
	$1.79	2.29%	$58,385	$54,090	**$4,300**	-80.68%
Post-Quarantine Price ($/kg) (Farm: $1.80)	$1.76	-2.22%	$76,340	$71,740	**$4,600**	-79.33%
	$1.85	2.78%	$76,340	$33,735	**$42,605**	91.45%
Wholesale Marketing Margin (12.50%)	10.00%	-20.00%	$96,605	$73,800	**$22,805**	2.48%
	15.00%	20.00%	$55,134	$33,670	**$21,465**	-3.55%
Retail Marketing Margin (33.33%)	25.00%	-25.00%	$63,425	$44,720	**$18,705**	-15.95%
	50.00%	50.00%	$102,170	$72,820	**$29,355**	31.91%

There are many interesting aspects of table 2, each of which warrant a brief comment. Firstly, the net welfare loss does not appear to be overly sensitive to changes in the elasticity of demand. The relationship is positive, as might be expected, but the sensitivity is very low since changes in P_d lead to less than proportional changes in net welfare loss of the same sign.

As previously stated, the sensitivity of net welfare loss to the elasticity of supply is not expected to be high, so it is not surprising that this is exactly what the table shows. Very large changes in the supply elasticity produce only minor changes in the same direction. This partly justifies the lack of a formal derivation of this value in this analysis.

The situation is somewhat different for the price under autarky, P_d. Changes in this value lead to slightly more than proportional changes in net welfare loss of the same sign, so the results could be said to be relatively sensitive to P_d. However, the areas of highest sensitivity are associated with the free trade price, P_n, and post-quarantine price, P_q. The former displays a negative relationship with the net welfare loss, and the latter a positive relationship. Relatively small changes in these values have a large impact on the net welfare loss, which is easily explained by returning once more to Figure 1. The sensitivities alter the distance between P_n and P_q, thus affecting the size of the areas $P^R{}_q IHP^R{}_n$ (the opportunity cost of maintaining quarantine protocols) and $P_n BDP_q$ (the gain in PS). It follows that raising the value of P_n diminishes the loss in CS and gain in PS, whilst the opposite effect is had by increasing P_q. So, the extreme sensitivities are to be expected in terms of Figure 1.

With various areas in need of further research, it is difficult to pass judgement on the current interstate quarantine protocols for mangoes based on these results. Perhaps the most obvious requirement is an investigation of the probabilities of pest entry and spread under the different trade environments, and quantifying the added production costs which would be incurred should a pest or pests of mangoes enter WA as a result of imports from the eastern states. However, an appropriate methodology has been demonstrated, and with further refinement will enable a more concise evaluation to be performed.

Nevertheless, for the moment assume (hypothetically) that the probability of pest entry and establishment is 100 per cent under free trade (p = 1.0) and 0 per cent under quarantine restricted trade (i.e. p^* = 0.0). If it is decided to abort the quarantine protocols and permit trade in interstate mangoes, using the data presented in this analysis the PS which would be lost would be in the order of $757,600 while the net welfare gain to society through trade would be around $22,250. Obviously this is an impossible scenario. However, given the geographic obstacles limiting potential pest spread vectors p will be significantly lower than 100 per cent, say 2 per cent for the sake of argument. If this were the case, expected PS losses under free trade would be around $15,150. So, a rational, risk averse society may be prepared to wager this loss against a more significant increase in CS if this information is accurate.

Again, it must be reiterated that the extreme volatility of prices over time and the high sensitivity of results to changes in post quarantine and free trade prices make it difficult to pass a final judgement on the mango quarantine issue.

10. Conclusion

The economics of quarantine policy is indeed an involved area of applied research. This study has attempted to apply the model developed by James and Anderson (1998), designed to evaluate trade restrictions enforced on agricultural commodities as a means of agricultural pest protection, to an interstate trade issue. WA places significant requirements on mangoes imported from the eastern states of Australia, principally the Northern Territory, but to date there have been no economic assessments made as to their impact on consumer welfare. The estimates derived here have been calculated by estimating the net welfare loss associated with restricting interstate competition. That is, the difference between the loss in CS resulting from quarantine restricted trade (relative to free trade) and the gain in PS. For the policy to have a zero welfare impact, the results indicate that the potential losses to domestic producer surplus avoided through quarantine protocols must be in the order of $22,250. Considering the presumably low probability of pest entry and establishment and the estimated $757,600 domestic PS, it is difficult to speculate just how “close to the mark” present protocols are. This is not aided by the variability of quantity and price information. Nevertheless, the application of the model to interstate problems provides an insight into the key variables determining policy outcomes, which when combined with pest risk analyses could provide a comprehensive framework for decision-makers.

BIBLIOGRAPHY

ABS (1997) *Agstats*, Australian Bureau of Statistics, Canberra.

ABS (1999a) *Retail Trade Australia*, Cat. No. 1501, Australian Bureau of Statistics, Canberra.

ABS (1999b) *Consumer Price Index*, Cat. No. 6401.0, Australian Bureau of Statistics, Canberra

Alexander, D. (1987) *The Mango in Australia*, Commonwealth Scientific and Industrial Research Organisation (CSIRO), Melbourne.

Australian Quarantine and Inspection Service (1995) *Import Risk Analysis - Disease Risks Associated with the Importation of Uncooked, Wild, Ocean-Caught Pacific Salmon Product from the USA and Canada*, Draft Report, Department of Primary Industries and Energy, Canberra.

Bigsby, H. (1999) *Quantifying Phytosanitary Barriers to Trade*, Paper Presented at 43rd Annual AARES Conference Pre-Conference Workshop, Christchurch, New Zealand, 19th January 1999.

QDPI (1991) *Mango Pests and Disorders*, Queensland Department of Primary Industries, Brisbane.

Fraser, R. (1999) *An Economic Risk Assessment of the Impact on Producers of Removing Quarantine Restrictions*, Unpublished Article.

Hawkins, A. F. (1994) *A Hedgerow Mango Plantation in Carnarvon*, Information Sheet No. 10/94, Agriculture Western Australia, Carnarvon.

Hinchy, M. D. and **Fisher, B. S.** (1991) *A Cost-Benefit Analysis of Quarantine*, Australian Bureau of Agricultural and Resource Economics Technical Paper 91.3, Australian Government Publishing Service, Canberra.

Hooker, N. H. and **Caswell, J. A.** (1999) "A Framework for Evaluating Non-Tariff Barriers to Trade Related to Sanitary and Phytosanitary Regulation", *Journal of Agricultural Economics*, Vol. 50, No. 2, pp. 234-246.

Horticultural Policy Council (1991) *The Impact of Fruit Flies on Australian Horticulture*, Industry Report No. 3, Primary Industries and Energy, Canberra.

James, S. and **Anderson, K.** (1998) "On the Need for More Economic Assessment of Quarantine Policies", *Australian Journal of Agricultural and Resource Economics*, Vol. 42, No. 4, pp. 425-444.

Kane, J. (1989) *"Mango Mythunderstandings": An Alternative Strategic Mission for Reaching the Demand Potential of Mangoes on the Australian Domestic Market*, Queensland Department of Primary Industries, Brisbane.

Litz, R. E. (ed.) (1997) *The Mango: Botany, Production and Uses*, Centre for Agriculture and Biosciences (CAB) International, Cambridge.

Mather, D. (ed.) (1992) *Proceedings of a Mango Seminar*, Agriculture Western Australia, South Perth..

Milham, N. and **Davenport, S.** (1999) *Plant and Animal Health Regulation: Some Competition Policy Issues*, Paper Presented at 43rd Annual AARES Conference Pre-Conference Workshop, Christchurch, New Zealand, 20th-22nd January 1999.

Nairn, M. E., **Allen, P. G.**, **Inglis, A. R.** and **Tanner, C.** (1997) *Australian Quarantine - A Shared Responsibility*, Department of Primary Industries and Energy, Canberra.

Nunn, M. (1997) "Quarantine Risk Analysis", *Australian Journal of Agricultural and Resource Economics*, Vol. 41, No. 4, pp. 559-578.

PMA (1998a) *Fruit Throughput Statistics for 1984/85-1997/98*, Perth Marketing Authority, Canningvale.

PMA (1998b) *Monthly Price Summaries for 1984/85-1997/98*, Perth Marketing Authority, Canningvale.

Sinner, J. (1999) *Cost-Benefit Analysis and the SPS Agreement*, Paper Presented at Workshop on Border Securuty and Risk Analysis, Lincoln, New Zealand, 19th January

Standing Committee on Uniform Legislation and Intergovernmental Agreements (1996) *Competition Policy - Consideration of the Implementation of a National Competition Policy*, State Law Publisher, Perth.

Strickland, G. (1992) "Mango Pest Management", In: *Proceedings of a Mango Seminar*, ed. D. Mather, Agriculture Western Australia, South Perth., pp. 108-115.

Tanner, C. (1997) "Principles of Australian Quarantine", *Australian Journal of Agricultural and Resource Economics*, Vol. 41, No. 4, pp. 541-558.

Tanner, C. and **Nunn, M.** (1998) "Australian Quarantine Post the Nairn Review", *Australian Journal of Agricultural and Resource Economics*, Vol. 42, No. 4, pp. 545-558.

Toohill, B. (1992) "Update on the Australian and Kimberley Industries", In: *Proceedings of a Mango Seminar*, ed. D. Mather, Agriculture Western Australia, South Perth., pp. 2-18.

Varian, H. R. (1992) *Microeconomic Analysis*, 3rd Edition, W. W. Norton and Company, New York.

WAQIS (1999) *Interstate Quarantine WA: Operations Manual*, Western Australian Quarantine and Inspection Service 'Control Copy', Agriculture Western Australia, South Perth.

White, K. (1997) *The Mango Industry in Western Australia: A Situation Analysis*, Agriculture Western Australia, South Perth.