Paper to be presented to the 47th Annual Australian Agriculture & Resource Economics Society Conference, Fremantle, 2003

Devising A Method of 'Expected Damage' Estimation for a Polyphagous Invertebrate Pest Exotic to Western Australia

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1. Summary

With increasing efficiency in human and freight transport fuelled by the creation of the global market place, pressure is mounting on quarantine administrators to target their resources strategically. A managed approach to decision-making is therefore becoming an integral part of quarantine management since target species and/or entry pathways must be identified and policed effectively. Using the example of Melon Thrips in Western Australia, this paper presents an economic framework that allows decision-makers to prioritise exotic pests based on the damage and production cost increases they are capable of imposing on affected industries. In doing so it identifies a critical level of expected damage associated with the pest that can then be used as a ceiling for incursion response expenditure.

2. Introduction

As advancement in human transport and freight technology continues to reduce travel time between trading centres and enable increasing volumes of goods to be moved around the globe, *biosecurity* is fast becoming a major concern for signatory nations of the World Trade Organisation (WTO) Agreement[1]. The establishment of new and lucrative trade routes provides a myriad of biological organisms the opportunity to colonise areas of the world previously impossible to reach unaided. The measures available to most trading nations to

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[1] The term "biosecurity" generally applies to any method of non-indigenous pest damage mitigation, be it preventing introductions, detecting incursions and eradicating resultant populations, or managing new species as long-term problems, curtailing their impact and preventing their further spread (Waage *et al*, 2001).

prevent them from doing so are limited in the sense that they must be seen to satisfy the Agreement on Sanitary and Phytosanitary Measures (SPS Agreement). This situation forces WTO Member governments to play a dangerous game balancing the gains from trade on one hand, and the damage potentially caused by invasive organisms on the other. The stakes in this game are high. One wrong decision could lead to a harmful pest outbreak affecting the livelihoods of many agricultural producers, their communities and environment. One right decision could secure a cheaper, wider variety of agricultural produce for all members of society whilst minimising costly retaliatory actions by trading partners in response to excessive quarantine requirements.

In this sort of environment a system of targeting quarantine effort towards those pests, diseases and entry pathways capable of producing the greatest amount of damage to an economy forms an important tool for policy-makers. If advanced warning of pest threats can be provided along with an indication of their potential means of entry and the damage to be expected from them, it may be possible to tailor a quarantine system to minimise losses from exotic pest outbreaks cost-effectively. At the same time, the benefits from trade must be taken into account if quarantine measures are to reflect social preferences with regard to consumption and international trade risk.

With this in mind, this paper puts forward a method of estimating the potential economic losses from an invertebrate plant pest in Western Australia (WA), Melon Thrips (*Thrips palmi*). In recognition of the fact that the notion of ‘zero risk’ is fictitious, it is assumed that the probability the entry and establishment of this pest in susceptible crops is positive both with a concerted quarantine effort and without it. By calculating the difference in the damage to be expected with and without quarantine targeting over a ten year period, the model presented enables a critical level of expected damage to be identified for use in determining an appropriate policy response in the event of an outbreak[2]. If the costs of eradicating an outbreak are believed to exceed this critical level, then other options such as containment or living with the pest should be considered. If the costs of eradication are below the critical level, then a rapid and purposeful campaign should be mounted against the pest without delay to maximise the chances of removal.

3. Background

3.1 Melon Thrips and Western Australian Agriculture

Melon Thrips (*T. palmi*) is a small, polyphagous sucking insect that inhibits host plant development by depriving it of nutrients. It is thought to have originated in Malaysia and western Indonesia, but in the past twenty years *T. palmi* has spread throughout many tropical areas of the world. It is now present in south east Asia, Japan, Papua New Guinea and other Pacific Islands, North America, the Caribbean islands, South America and parts of Europe. The insect is a prolific breeder, and both larvae and adults feed by extracting cell contents from the leaves, stems, flowers and the surface of fruits with mouth parts specifically adapted for sucking (Lewis, 1973).

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[2] Note what is implied here. This model deals with strategic decision-making for *quarantine* resources, as distinct from general biosecurity resources. An ability to screen for foreign organisms in imported agricultural produce will have some bearing on the significance of that organism for quarantine service providers. If SPS measures can not be relied on to reduce the probability of entry and establishment of a pest, then the pest can be said to be of low quarantine significance. But, this is not to say it will not cause a great deal of damage if and when it enters and becomes established in a region. A distinction must therefore be made between pests of a 'quarantine' significance and those of significance to 'post-border surveillance'.

Until recently *T. palmi* was only found in Australia in the Northern Territory and, to a lesser extent, northern Queensland (Young and Zhang, 1998; CABI, 1999). In WA *T. palmi* remains classified as a pest of quarantine significance, and specific quarantine protocols apply to most fruits, vegetables, plants and flowers in addition to those required for other pests (WAQIS, 1999)[3]. However, the label of 'quarantine pest' has recently been called into question following the discovery of *T. palmi* in the Ord River Irrigation Area (ORIA) of the Kimberley region in the north of the State in September 2001. In May 2002 a subsequent discovery was made some 20 kilometres from the previous site, indicating that a permanent population had established, rendering eradication a costly option of doubtful technical feasibility.

For the purposes of this investigation it is assumed that this outbreak does indeed constitute a permanent population, and can not be eradicated (at least not cost effectively). However, it is further assumed that a mutually government-industry funded containment campaign can successfully restrict the movement of *T. palmi* and prevent it from extending its range beyond the ORIA. The objective here is to establish the *critical* or *break-even* annual value of expected costs required to eradicate any *T. palmi* outbreak outside the ORIA to prevent it from becoming widely established in the State. Using this value, decisions of what course of action to instigate against an outbreak outside the ORIA can be made with minimal delay. If, after an initial survey of the infested area it is believed the pest can be eradicated for less than the critical value, a concentrated eradication campaign should be put in place immediately. If not, an alternative course of action should be considered since eradication is not a reasonable option for an 'economically-rational' decision-making body.

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[3] Other pests for which quarantine protocols have been implemented include Queensland Fruit Fly (*Bactrocera tryoni*), Northern Territory Fruit Fly (*B. aquilonis*), Cucumber Fly (*B. cucumis*), European Red Mite (*Panonychus ulmi*) and Silverleaf Whitefly (*Bemisia tabaci*).

If *T. palmi* were to become widely established in WA beyond the ORIA it is expected to populate most of the State's fruit and vegetable growing areas north of Perth, possibly extending into the south west. Industries affected would include cucurbits, cabbage, Chinese cabbage, lettuce, potato, onion, tomato, citrus, mango, avocado, nurseries and cut flowers. Each of these industries is used to assess the overall impact of *T. palmi* spread on the WA economy. Although the insect is capable of inflicting severe crop damage if its numbers are not adequately controlled, growers of susceptible crops in the Northern Territory and Queensland have successfully managed *T. palmi* using a variety of methods. These range from the use of potassium soap sprays and plastic mulch to weed control, crop rotations and wind breaks (Planck, 2001). So, an increase in the average total cost of production for each crop modelled is expected if the insect becomes established beyond the ORIA in WA.

3.2 The Theoretical Model

The quarantine-significance of *T. palmi* can be determined by measuring the welfare effects of its introduction on WA producers of host crops[4]. For this, a static, partial equilibrium model is appropriate if the following assumptions are made:

i). The domestic market for the good is perfectly competitive;

ii). The domestic price for the product is above the 'landed' price of imported product;

iii). The contribution of WA to the total supply of the good is insufficient to exert influence on the world price, exchange rate or domestic markets for other goods;

iv). Society has a neutral attitude to risk;

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[4] If social welfare optimisation is the primary motivation for policy-makers the impact of the pest on consumer welfare (*consumer surplus*) must also be taken into account. However, in this analysis assume that producer welfare maximisation is the goal, although periodic reference is made to consumer welfare effects.

v). The costs of any quarantine procedures are borne by the exporter and transferred to consumers via the price mechanism (James and Anderson, 1998).

Although *T. palmi* is not host specific, suppose initially only one commodity is affected. If so, figure 1 can be used to illustrate the economic consequences of an incursion where the frame on the left represents the 'on-farm' impact, and frame on the right the aggregated industry impact.

Profit maximising growers in perfectly competitive markets for host plants will choose to produce a level of output corresponding to the point where price (p) equals the Marginal Cost (MC) of production. At this point, the differential between total cost and total revenue is maximised. Assuming the market in which growers operate receives quarantine protection in the form of costly chemical treatments and sampling requirements for imported products, the prevailing domestic market price will be below a closed market equilibrium price, and above a free trade level. If this were the case, a grower facing a price p_q would choose to produce quantity q_0 and earn a profit of ABCp_q. It should be noted that output will be positive so long as the price received by the producer remains above the minimum value of the Average Total Cost (ATC) of production.

If the quarantine protection were to be removed from the market so that produce can move into WA without the need to treat for *T. palmi*, the price faced by domestic growers would be lowered to p_q*. This will be greater than a free-trade price as long as quarantine requirements for other pests remain in place. This being the case, a grower would maximise profits by producing the quantity q_1, where profit is given by the area GHI p_q*.

If all growers in the industry behave in a similar manner, the industry supply schedule produced by the horizontal summation of each producer's output at different prices would resemble the curve S in the right hand frame of figure 1. According to the industry demand

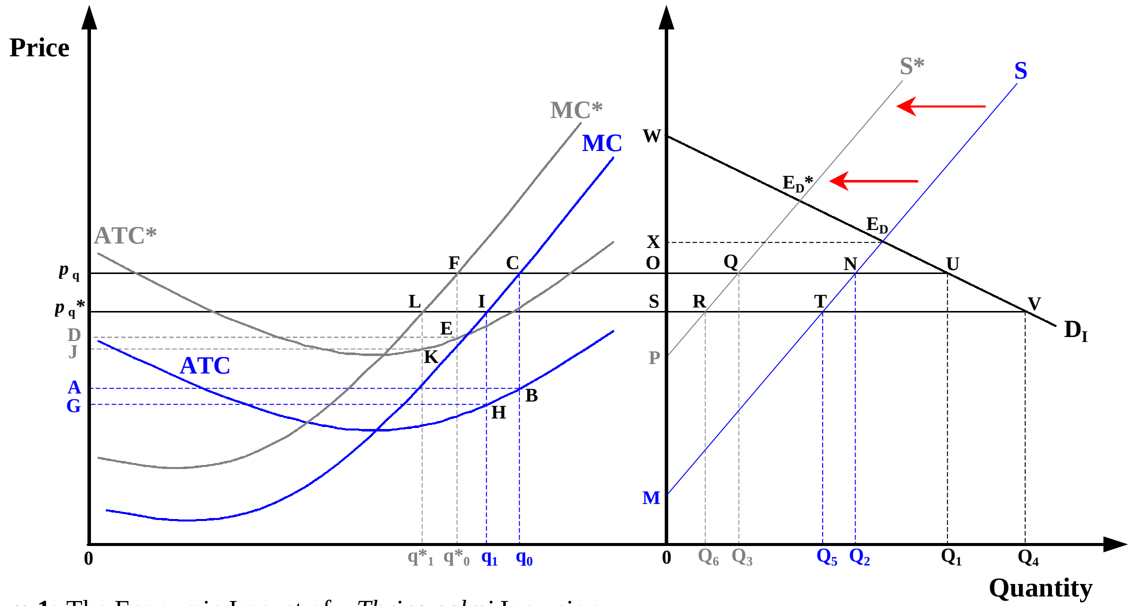

Figure 1: The Economic Impact of a *Thrips palmi* Incursion

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schedule D_I domestic consumers will demand the quantity Q_1 if quarantine restrictions for *T.palmi* are in place. Of this, Q_2 will be supplied by domestic growers, and $Q_1 – Q_2$ by imports. In this situation, producer surplus is given by the area ONM, and consumer surplus by WUO. Under a domestic closed-economy equilibrium scenario (i.e. E_D) producer surplus would be the larger area XE_DM, and consumer surplus the smaller area WE_DX. Hence, the 'traditional' *gains from trade* resulting from quarantine restricted trade is shown as E_DNU.

The gains would be greater if the quarantine regulations concerning *T. palmi* were removed, causing the price to fall from p_q to p_q*. Producer surplus would be reduced to the area STM under the weight of increased volumes of imports (i.e. Q_4 - Q_5), while consumer surplus would increase to the area SVW due to greater volumes of cheaper produce. Therefore, the traditional gains from trade increase to E_DVT.

The removal of quarantine treatments to minimise the risk of importing *T. palmi* increases the likelihood of pest entry and establishment through trade. However, it is important to appreciate that no matter how thorough quarantine treatments, the probability of importing *T. palmi* with food imports from pest-endemic areas will *always* be positive. By making any quantity of imported product available to WA consumers, however small, quarantine authorities are taking a calculated risk that a contaminated batch will not be amongst those imported. Quarantine requirements merely alter the probability that a contaminated unit or group of units will be present. If one is present and the pest is able to escape and enter the WA environment in sufficient numbers and in climatic conditions conducive to its survival, an outbreak *might* occur.

If this series of events were to transpire and *T. palmi* is fortunate enough to find itself in a position to spread to most fruit and vegetable growing areas as predicted, the effect at the farm level will be rising ATC (and MC). Although the pest is capable of causing serious damage if left uncontrolled, producers are able to minimise damage by employing additional pest management measures to those already part of standard management practice[5]. It follows that a greater cost is involved in producing each unit of production after the outbreak than before it. If specific treatments are in place and p_q is the prevailing market price, the increased costs of production would lower grower output from q_0 to q^*_0 where producer surplus is DEFp_q. If the probability of entry and establishment with full quarantine restrictions in place is P_q, then the expected loss of producer surplus at the farm level (ED $(P_q)_F$) associated with imports can be expressed as[6]:

$$\mathrm{ED}\ (P_q)_F = P_q \times (\mathrm{ABC}p_q - \mathrm{DEF}p_q) \qquad (1).$$

Similarly, if the probability of *T. palmi* entry and establishment in the absence of quarantine treatments is P_q^*, the expected loss of producer surplus can be expressed as:

$$\mathrm{ED}\ (P_q^*)_F = P_q^* \times (\mathrm{GHI}p_q^* - \mathrm{JKL}p_q^*) \qquad (2).$$

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[5] See section 4.

[6] Note that the probabilities of *entry* and *establishment* are combined into singular parameters in this discussion. In the empirical investigation of section 5 they are treated separately.

At an industry level, the domestic supply curve will contract (from S to S^* in the right frame of figure 1) in the face of added growing costs and yield reductions. If the industry receives full quarantine protection, domestic producer surplus will decline to the area OUW, representing a loss of MNQP. So, the expected damage to the collective industry from importing *T. palmi*-hosts with full quarantine protection (ED_q (Industry)) can be expressed as:

$$ED_q \text{ (Industry)} = P_q \times MNQP \qquad (3).$$

Similarly, the expected damage to the industry from allowing imports without quarantine treatments (ED_q* (Industry)) can be written as:

$$ED_q^* \text{ (Industry)} = P_q^* \times MTRP \qquad (4).$$

Using equations (1) and (2) at the farm level and (3) and (4) at the industry level a *critical level* of expected damage (ED_{crit}) can be identified which indicates the maximum level of investment appropriate to manage an outbreak of *T. palmi*. This is simply the difference in expected damage with and without the pest-specific quarantine regulations (above which costs outweigh on-farm benefits). So, at the farm level:

$$ED_{crit} = [P_q^* \times (GHI\mathit{p}_q^* - JKL\mathit{p}_q^*)] - [P_q \times (ABC\mathit{p}_q - DEF\mathit{p}_q)] \qquad (5).$$

And, at the industry level:

$$ED_{crit} = (P_q^* \times MTRP) - (P_q \times MNQP) \qquad (6).$$

The value representing ED_{crit} can be used as an important reference point for policy-makers when deciding on an appropriate course of action in response to an outbreak. For instance, should *T.palmi* escape from the ORIA and become established in a certain region, a decision on whether or not to embark on a costly eradication campaign becomes straightforward, at least in terms of the static, partial equilibrium trade model. ED_{crit}

represents the reduction in expected damage by the pest produced by the maintenance of quarantine regulations specific to that pest. If the likely costs of eradicating an outbreak are below this value, the benefits of eradication will outweigh the costs. However, if the costs necessary to eradicate the outbreak exceed ED_{crit} it is more cost-effective to pursue lower cost alternatives such as containment.

Due to a lack of available, sufficiently detailed information concerning the ATC of production under a pest and no-pest scenario, it becomes difficult to use this model in practice. Of primary concern is the inability to estimate the change in domestic producer surplus induced by the removal of quarantine restrictions. To overcome this problem it is necessary to assume that producer surplus both in a full and partial quarantine situation (i.e. without *T. palmi*-specific requirements) remains constant, and to then conduct a sensitivity analysis to discover the likely consequences of this assumption for the model's results[7]. Assuming a constant domestic producer surplus, equation (6) can be re-written as:

$$ED_{crit} = (P_q^* - P_q) \times MNQP \qquad (7).$$

If the assumption of *T-palmi*'s host specificity is now relaxed, the ED_{crit} for all combined host industries can be estimated by summing the ED_{crit} calculated for each industry.

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[7] See section 5.2

4. Estimating the On-Farm Benefits of Pest Freedom

4.1 Modelling Pest Spread

Following the successful establishment of *T. palmi* beyond the ORIA it is expected to spread through susceptible industries utilising both natural and artificial means[8]. Hence, a relevant model of spread must include a random element of sporadic 'satellite' spread as well as spread from an initial infestation. Following the entry and establishment of *T. palmi* on a given area of susceptible crop its spread to neighbouring host crops is assumed to follow a sigmoid function[9]. The total area of susceptible crops infested at any point in time following an 'original' or source outbreak is given by the function:

$$O_i^t = \sum_{i=1}^{n} \frac{a_i^{\min} + a_i^{\max_t}}{a_i^{\min} + e^{(t-1)}} \tag{8}$$

where;

O_i^t = area of crop i infested in time period t following the original outbreak of $T.palmi$;
$a_i^{\min}$ = minimum area of crop i infested (assumed here to be 1 hectare);
$a_i^{\max_t}$ = maximum area of crop i infested in time period t given an annual industry growth rate g,
i.e. $a_i^{\max_t} = a_i^{\max_{t-1}} \times (1+g)$.

As the area involved in an initial infestation increases, so too does the likelihood of a satellite outbreak some distance from the original site. Once *T. palmi* has become established at this new site it is assumed to begin spreading in exactly the same fashion as the original outbreak. The number of new satellites created in each time interval can therefore be

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[8] *T. palmi* is a relatively strong flier, and is easily transported from infested regions to non-infested regions by humans (bearing in mind the insect is extremely small).

[9] It is conceded that this is a simplistic method of determining spread since it does not take account of the geographical composition of an affected industry.

expressed as a function of the total area of range occupied[10]. The model used here follows a logistic law as given by:

$$S_t = \sum_{i=1}^{n} s_i^{\max}\left(1 + \frac{s_i^{\max} - s_i^{\min}}{s_i^{\min}} \cdot e^{-\mu_i \cdot \alpha_i}\right)^{-1} \tag{9}$$

where;

S_t = total number of new satellites created in time period t amongst all susceptible crops;
$s_i^{\max}$ = maximum number of satellites created in crop i (arbitrarily set to 100 in simulations);
$s_i^{\min}$ = minimum number of satellites created in crop i (arbitrarily set to 1 in simulations);
μ_i = intrinsic rate of generation of new foci per hectare in crop i;
α_{i} = area of crop i infested with *T. palmi* in time period t-1;

The variable μ_i is assumed to be constant, and therefore discounts the possibility of different establishment rates caused by outbreak size variations, crop susceptibility, and so forth (Moody and Mack, 1988).

4.2 Probabilities of Entry and Establishment Outside the ORIA

The probabilities of entry and establishment under a comprehensive and laps quarantine regime are estimated using the semi-quantitative risk categorisation methodology outlined in AFFA (2001), presented in table 1.

Table 1: Semi-Quantifiable Risk Categorisation Methodology

Likelihood	Descriptive Definition	Probability Range
High	Very likely to occur	0.7 - 1.0
Moderate	Occurs with even probability	0.3 - 0.7
Low	Unlikely to occur	0.05 - 0.3
Very Low	Very unlikely to occur	0.001 - 0.05
Extremely Low	Extremely unlikely to occur	0.000001 - 0.001
Negligible	Almost certainly will not occur	0 - 0.000001

AFFA (2001)

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[10] This method of incorporating satellite spread into the spread of an exotic species is not new, having been first presented in Moody and Mack (1988) in the context of invasive weeds. The model used here is very similar.

The probabilities of pest entry and establishment are considered separately. The presence of quarantine protocols only affects the probability of *T. palmi* entering WA on contaminated fruit, or by other means. Given the pest is small and capable of surviving on many plant species the likelihood of entry with appropriate measures in place is considered to be *Very Low*. As table 1 indicates, this means a probability of entry of between 0.001 and 0.05, which can be specified as a uniform distribution for modelling purposes. Since the pest is established in neighbouring Northern Territory, the likelihood of it entering in the absence of appropriate quarantine measures is assumed to be *High*. Again, this is specified as a uniform distribution with a minimum value of 0.7 and a maximum of 1.0.[11]

Once *T. palmi* has entered WA its polyphagous characteristics are assumed to allow it to become established with relative ease. But, the sheer size of WA (relative to the area of suitable cultivated crops) is expected to restrict colonisation potential. Hence, establishment capabilities after introduction are assumed to be *Moderate*. The probability of establishment is therefore represented by a uniform distribution with a minimum value of 0.3 and a maximum of 0.7.

4.3 Average Total Cost Increments – Producer Surplus Lost

The losses to individual growers resulting from *T. palmi* becoming established in WA can be expected to comprise of the following:

<u>Management Costs</u> – Production cost increases are to be expected to result from the need for additional chemical and oil sprays several times per season. Assume insecticides used are methidathion (around \$10/L applied at 75-125ml/ha) or imidacloprid (around

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[11] Ideally, economic analyses of exotic pest threats are accompanied by comprehensive risk analyses estimating probabilities of entry and establishment amongst host crops. It is acknowledged that the choice of risk category here is purely subjective judgement. Sensitivity of results to these parameters are explored in section 5.

$300/L applied at 25ml/ha), both of which are registered for thrips control in selected crops in WA (DAWA, 2001). Given that *T. palmi* has shown resistance to most chemical insecticides (many of which actually promote its abundance by destroying natural predators), alternative approaches may be required for effective control (CPC, 1999). One such approach might involve the use of potassium soap (e.g. *NATRASOAP*, around $130/20L applied at 1L/ha), which acts by suffocating insects rather than poisoning them (Young and Zhang 1998; Young and Zhang, 2000). Assume additional sprays are necessary between 1 and 3 times per year, which can be modelled using a uniform distribution with a minimum value of 1 and a maximum value of 3. In addition, vehicle, equipment and labour costs of $35/ha per application are assumed[12].

<u>Loss of Marketable Product</u> - Despite incorporating a spraying program into normal management practise, a small yield loss to *T. palmi* is still to be expected. A pert distribution with a minimum value of 0 per cent, a mean of 2.5 per cent and a maximum of 5 per cent per year was used to represent yield losses in the calculations to follow.

4.4 Export Market Losses

It is conceivable that both interstate and international export losses may result from *T. palmi* becoming widely established in WA.

<u>Interstate Trade</u> - Volume statistics on interstate are currently unavailable. However, as a rough guide approximately 75 per cent of melon sales from the ORIA are transported east. The main quarantine protocols of concern are those of South Australia (SA) and Tasmania. (Chris Robinson - DAWA, pers comm, 09/05/2002).

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[12] ie. Labour = $15/hr, tractor and spray rig costs (i.e. fuel, oil, maintenance) = $20/hr, time per hectare sprayed = 1hr/ha.

International Trade - Collectively the host commodities modelled earn over $22 million international export revenue annually, some of which may be threatened by the presence of *T. palmi* requiring additional quarantine treatments. However, the pest is present in many prominent destinations for WA produce, such as Hong Kong, Singapore, Malaysia and Brunei (AGWEST Trade and Development, 2001). This makes the imposition of bans on WA exports due to a perceived threat of *T. palmi* unlikely, and indeed illegal under the terms and conditions of the WTO Agreement. Currently around 10 per cent of melons from the ORIA are exported internationally, but the extent to which prices are affected by WA's *T. palmi*-status is unclear (Chris Robinson - DAWA, pers comm, 09/05/2002). A variable estimate is assumed using a uniform distribution with a minimum value of 5 per cent and a maximum value of 15 per cent.

4.5 Size and Growth of Affected Industries in Susceptible Areas

Data indicating the gross value of WA industries susceptible to *T. palmi* was sourced from the ABS (1998), and supplemented by Cirillo (2001). Relevant figures are contained in table 2.

Table 2: Gross Value of Production (GVP) of WA Industries Potentially Affected by General Spread of *T. palmi*

	GVP (5 Year Average, 1998-2002)		
Crop	**WA (Excluding Ord River Irrigation Area)**	**Ord River Irrigation Area**	**WA (Total)**
Cucumbers	$ 1,705,900	$ 25,500	$ 1,731,400
Capsicum & Chilli	$ 3,729,300	$ 9,500	$ 3,738,800
Pumpkin	$ 3,065,900	$ 5,238,000	$ 8,303,900
Zucchini	$ 490,800	$ 98,100	$ 588,900
Rock Melon	$ 1,662,200	$ 10,464,200	$ 12,126,400
Water Melon	$ 1,986,200	$ 4,035,800	$ 6,022,000
Nurseries	$ 34,408,300	$ 428,700	$ 34,837,000
Cut Flowers	$ 27,869,700	$ 19,000	$ 27,888,700
Beans	$ 1,698,100	$ 192,200	$ 1,890,300
Cabbage	$ 2,188,200	$ 4,600	$ 2,192,800
Chinese Cabbage	$ 3,040,400	$ 1,000	$ 3,041,400
Lettuce	$ 7,464,300	$ 6,300	$ 7,470,600
Onion	$ 8,701,900	$ 24,100	$ 8,726,000
Potato	$ 35,366,900	$ 3,800	$ 35,370,700
Tomato	$ 8,462,400	$ 19,600	$ 8,482,000
Orange	$ 2,109,400	$ 100	$ 2,109,500
Lemon and Lime	$ 706,500	$ 1,200	$ 707,700
Mandarin	$ 1,759,600	$ -	$ 1,759,600
Mango	$ 2,094,700	$ 1,884,300	$ 3,979,000
Avocado	$ 2,910,700	$ 400	$ 2,911,100
TOTAL	**$ 151,421,291**	**$ 22,456,509**	**$ 173,877,800**

5. Results and Sensitivity Analysis

The *@Risk* computer software package (*Palisade Corporation*) was used to simulate the possible impact of *T. palmi* over a 10 year period. Ten thousand iterations of the model were performed using the Latin Hypercube sampling technique to extract values from each variable specified as a distribution. Due to the uncertainty surrounding several model parameters it is prudent to run an extensive sensitivity analysis to establish how significantly results change in response to changes in these parameters. This is particularly useful in that it highlights those variables exerting the greatest influence over the expected benefits of exclusion over time.

5.1 Estimated Annual Benefits to Host Industries from Containment in the ORIA

Results of an economic assessment of *T. palmi* isolation to the ORIA indicate that the net present value of the on-farm benefits of excluding the insect from the remainder of WA are between -$0.8 million and $1.7 million per annum. Gross benefits estimated for each industry appear in table 3. This reveals that the cut flower industry will be the highest beneficiary of *T. palmi* exclusion (mean of $110,500 per year over ten years), followed by the Chinese cabbage industry ($53,800 per year), the potato industry ($53,600), the nursery industry ($51,100 per year), the lettuce industry ($40,700) and the onion industry ($35,100 per year).

When industry benefits are represented as a proportion of their Gross Value of Production (GVP) the results are quite different. As figure 2 graphically demonstrates, when benefits are expressed in these terms the Chinese cabbage industry (0.8 per cent of industry GVP) appears to be the largest beneficiary followed by the rockmelon (0.3 per cent), lettuce (0.2 per cent), onion (0.2 per cent) and cut flower (0.2 per cent) industries. However, it must be pointed out that these results should not be interpreted in terms of ‘capacity to absorb costs’ since GVP contains no information on production costs.

Table 3: Results

Industry	**Annual Industry Benefits of Exclusion Over a 10 Year Period**		
	Minimum	**Mean**	**Maximum**
Capsicums & Chilies	-$ 67,900	$ 6,400	$ 74,000
Cucumbers	-$ 27,900	$ 3,100	$ 41,500
Melons - Rock	-$ 100,100	$ 12,800	$ 135,500
Melons - Water	-$ 39,500	$ 4,500	$ 48,300
Beans (French & Runner)	-$ 27,900	$ 2,900	$ 32,100
Cabbages	-$ 56,800	$ 7,800	$ 75,000
Pumpkins	-$ 54,700	$ 6,400	$ 59,000
Oranges	-$ 41,800	$ 5,900	$ 51,500
Lemons and Limes	-$ 20,900	$ 2,300	$ 25,200
Mandarins	-$ 42,400	$ 4,900	$ 50,200
Zucchini	-$ 11,500	$ 1,100	$ 12,600
Tomatoes	-$ 139,600	$ 16,100	$ 179,500
Mangoes	-$ 54,200	$ 6,200	$ 72,800
Cut Flowers	-$ 663,500	$ 110,500	$ 833,100
Nurseries	-$ 344,900	$ 51,100	$ 465,200
Lettuces	-$ 206,600	$ 40,700	$ 280,000
Potatoes	-$ 268,000	$ 53,600	$ 404,200
Onions	-$ 109,500	$ 35,100	$ 188,900
Avocados	-$ 53,000	$ 5,400	$ 79,600
Chinese Cabbage	-$ 304,500	$ 53,800	$ 337,200
TOTAL	**-$ 831,000**	**$ 430,500**	**$1,656,400**

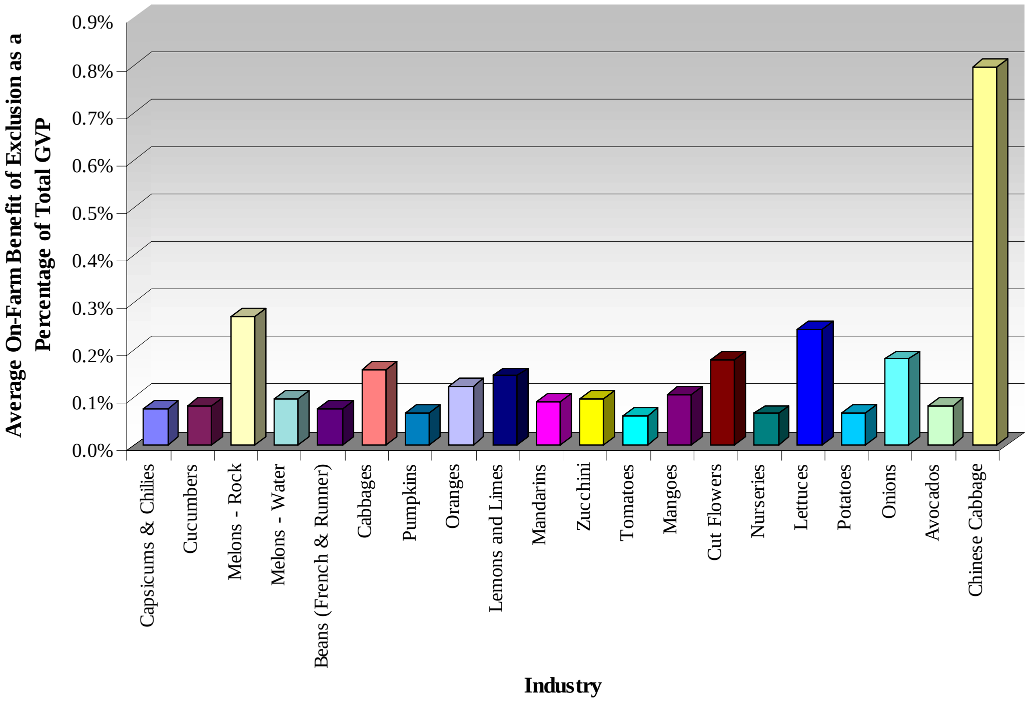

Figure 2: Annual Industry Benefit from *Thrips palmi* Containment (Over 10-Years) as a Percentage of GVP.

5.2 Sensitivity Analysis

The sensitivity of ED_{crit} to each key variable is shown in table 4. Here, the percentage change in the variable concerned is indicated along with the resultant change (Δ%) in total benefits. The extent of shading in the table is directly proportional to the degree of variable sensitivity.

Table 4: Sensitivity of ED_{crit} to changes in Key Assumptions

Assumption **(Most Likely Value)**	**Value Tested**	**Δ%**	**Expected Average Annual On-Farm Cost to Affected Industries**	**Δ%**
Probability of *Entry* With Exclusion Policy (Very Low)	Extremely Low	- 98.0%[*]	\$450,300	+ 4.6%
	Low	+ 586.0%[*]	\$361,300	- 16.1%
Probability of *Entry* Without Exclusion Policy (High)	Moderate	- 41.2%[*]	\$249,200	- 42.1%
	Low	+ 79.4%[*]	\$100,600	+ 76.6%
Probability of *Establishment* (Moderate)	Low	- 65.0%[*]	\$159,600	- 62.9%
	High	+ 70.0%[*]	\$720,200	+ 67.3%
Discount Rate (7.00%)	3.5%	- 50.0%	\$532,100	+ 23.6%
	10.5%	+ 50.0%	\$351,100	- 18.4%
Satellite Infestation Parameter, μ (1.0×10^{-3})	1.0×10^{-4}	- 90.0%	\$423,700	- 1.6%
	1.0×10^{-2}	+ 900.0%	\$479,400	+ 11.4%
Average Total Cost Increment (Excl. Yield Loss) (\$90/ha/yr - 2 sprays, ie. distribution mid point)	\$45/ha/yr - 1 spray	- 50.0%	\$423,300	- 1.7%
	\$135/ha/yr – 3 sprays	+ 50.0%	\$436,000	+ 1.3%
Percentage of Yield Loss Despite Control Effort (2.5% - distribution mean)	0.0%	- 100.0%[*]	\$269,500	- 37.4%
	5.0%	+ 100.0%[*]	\$688,500	+ 59.9%
Proportion of Host Industries Potentially Affected (≈ 75%[**])	50.0%	- 25.0%	\$367,600	- 14.6%
	100.0%	+ 25.0%	\$485,600	+ 12.8%
Export Revenue Losses Attributable to Loss of Pest-Freedom Status (10% - distribution mid point)	5.0%	- 50.0%[*]	\$384,700	- 10.6%
	15.0%	+ 50.0%[*]	\$543,900	+ 26.3%
Change in Producer Surplus Induced by Removal of Quarantine Restrictions (0%)	- 20.0%	na	\$433,800	+ 0.8%
	- 50.0%	na	\$436,800	+ 1.5%

[*] Indicates mid point or mean of distribution used to calculate Δ%.

[**] Represents mean across all regions. Actual areas used were taken from ABS (1998).

6. Discussion

The findings of section 5 give an indication of the potential benefits a general system of pest assessment can deliver to those empowered with quarantine policy formulation. The methodology demonstrated here provides quarantine policy-makers with a high level of information concerning the repercussions of their decisions. Perhaps the two most critical pieces of information concern the strategic importance of the pest to the State economy, and maximum amount of resources that should be expended to combat an outbreak of the pest concerned.

The techniques used to calculate ED_{crit} are directly applicable to every exotic pest species. If assessments could be completed for each species of concern to primary stakeholders it would be possible to compare and rank each pest according to the economic benefits of excluding them from the State. Each pest's individual ED_{crit} provides an indication of the ability to use quarantine as a front-line method of preventing it from entering and becoming established amongst suitable hosts in WA. Hence, those with a highest ED_{crit} value are of highest strategic significance to policy-makers, and vice versa. If quarantine resources are targeted towards those species of strategic significance then the State could be said to be fully embracing the concept of 'managed risk'. Pest risks are assessed, quantified, and resources targeted to those areas where it is believed the highest economic benefits (in terms of damage or cost increments averted) can be produced.

In addition to indicating economic importance, eliciting values of ED_{crit} specific to pest species also identifies a critical level of expected damage to be used as a point of reference in the event of an outbreak. For instance, in the case of *T. palmi* results indicate that the critical level of expected damage associated with the pest is in the order of $430,500 per annum. If an incursion outside the ORIA were to occur this represents the maximum amount of resources that can be spent annually to combat the pest before the costs of counter measures outweigh the benefits of exclusion.

When an outbreak is detected it is vital that surveys be conducted to determine the full extent of the outbreak. This information can then be used to estimate an annual cost of eradicating the outbreak (C_e) and the probability that eradication can be completed successfully over time (P_e). These estimates can then be compared to the value of ED_{crit} corresponding to the pest to determine the appropriate course of action to take in response to the incursion. If $P_e \times C_e < ED_{crit}$, then an eradication campaign should be embarked upon without delay to maximise the chances of success. On the other hand, if $P_e \times C_e > ED_{crit}$ an alternative strategy should be sought in which it is accepted the objective is ‘damage minimisation’ as opposed to eradication.

It is conceded that such a rigid interpretation of economic modelling results poses a problem as far as non-market goods are concerned. Invariably decisions of this nature require supplementary information where pest species pose additional threats to native biodiversity, and/or whose introduction could force members of rural communities to seek employment in other economic sectors. Moreover, the ‘visibility’ of these types of effects has the potential to create political imperatives that take precedence over all other information. This makes for an interesting state of affairs with politicians, environmental scientists, sociologists and economists all having input into the decision-making process. Quarantine analysis therefore represents a unique opportunity for interdisciplinary co-operation to deliver socially desirable outcomes.

7. Conclusions

The model presented in this analysis is capable of providing quarantine decision-makers with a high level of information concerning the repercussions of their decisions. Not only does it disclose the level of damage to be expected by a pest, thereby indicating its strategic importance, but it also identifies a critical level of expected damage to be used as a point of reference in the event of an outbreak. When applied to the case of *T. palmi* in WA results indicate that the critical level of expected damage associated with the pest is in the order of $430,500 per annum. Hence, if an incursion outside the ORIA were to occur this represents the maximum expenditure limit of an eradication campaign before the costs begin to outweigh the benefits of exclusion.

If decisions on the course of action to be embarked upon in response to an outbreak can be made swiftly the probability of successfully eradicating outbreaks greatly improves. If widely employed to analyse the potential impact of large numbers of pests, it is possible that the model presented in this paper could form the basis of a system of quarantine prioritisation. While this is technically feasible, it is important to recognise supplementary information in the analytical process. Non-price information can and should exert an influence over decision-makers, so some system of including qualitative information is necessary. Nevertheless, the economic model of pest impact presented here may serve as an important building block on which future research effort can be devoted. If an effective system of pest prioritisation and response determination is forthcoming it has the potential to greatly improve WA’s efficiency and accountability with regard to quarantine policy and administration.

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