FRUITION
Horticulture

FRUIT FLY:
LIKELY IMPACT OF AN INCURSION OF FRUIT FLY IN THE BAY OF PLENTY, HAWKES BAY OR NELSON

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1. SUMMARY

This study shows the impact of a small incursion of a pest fruit fly species in one of our horticultural districts would be substantial.

Mediterranean fruit fly, also called medfly and scientifically *Ceratitis capitata* is one of the most destructive pests known. It is considered able to infest most of the temperate and subtropical parts of the world. It has a wide host range, including many types of fruit, vegetable, ornamental and weed species grown in New Zealand. The life cycle is rapid and the breeding prolific. A single infested fruit can be the origin of a new infestation.

Exports of horticultural produce from New Zealand earned $2.3 billion in 2005. Over 90% of fresh fruit and vegetable exports by value are of produce that could host medfly.

A small incursion of medfly was found in Auckland in May 1996 via routine checking of monitoring traps. The Ministry of Agriculture and Forestry (MAF) successfully eradicated the pest. Export markets imposed restrictions on New Zealand produce from the Auckland area which lasted 8-12 months or longer.

This study was prepared to find the likely cost should such an incursion have occurred in a major fruit growing district. It follows on from a similar study in 1998 which modelled the impact of an incursion in the Bay of Plenty.

The market restrictions applied to the Auckland incursion were modelled as if the incursion occurred in one of the three major fruit growing districts of the Bay of Plenty, Hawkes Bay or Nelson. The timing is for the incursion to be found just before harvest. Market restrictions are modelled to occur for 12 months for a 15km radius zone. Fresh fruit fly host produce from this zone is excluded from export markets except Europe and Western Australia, which have medfly and imposed no restrictions in 1996.

The ability to export produce from the incursion zone to European Union markets provides significant mitigation of the impacts, particularly for the major crops of apples and kiwifruit.

Disrupting market plans would cause loss of revenue. Additional costs would occur for insect proofing, packaging changes, transport and adjustments to shipping programmes, for export, domestic and processing crops. Re-assigning produce to packhouses and markets, depending on whether the orchard was inside or beyond the incursion zone, would create significant logistical challenges and stress on top of the usual stresses of harvest.

Table 1 shows the direct revenue losses and extra costs calculated to affect the horticultural sector for an incursion in one of the locations studied. Some of this impact would occur in other districts due to lower prices, pooled returns and managing inventory on a national basis to reduce losses overall.

Table 1: Direct Impact of Regional Incursion on Horticultural Sector (revenue lost plus additional costs, nation-wide, to horticultural sector only**):**

	Location of fruit fly incursion modelled:		
	Bay of Plenty	**Hawke's Bay**	**Nelson**
Horticultural Sector Direct Impact ($ millions)	$71.4	$63.8	$24.4

Losses in the horticultural sector affect other parts of the economy. Revenue losses are magnified by the impact on related sectors. This is offset by other sectors benefiting from the extra spending required to counter an incursion. An economic model calculated the flow-on effects from each incursion modelled to be substantial. The impacts on employment and output (net revenue) are shown in Table 2 for each region and the total New Zealand impact.

Table 2: Regional and National Impact of Incursion Including Flow-on effects:

	Location of fruit fly incursion modelled:		
	Bay of Plenty	**Hawke's Bay**	**Nelson**
Net Within-Region Job Losses (FTE's*)	310	415	75
Net Within-Region Loss ($ millions)	$74.83	$54.78	$10.07
Total NZ Job Losses (FTE's*)	**540**	**690**	**175**
Total NZ Loss ($ millions)	**$109.68**	**$85.98**	**$23.73**

* FTE's = full time equivalent jobs

The Bay of Plenty incursion is modelled to occur in urban Te Puke, in the heart of the major kiwifruit growing area. Kiwifruit is the crop most affected. Premium markets in Asia would be undersupplied with product, thus reducing revenue. Avocados would be affected as their main export market is Australia's eastern states. Other crops would be excluded from their key export markets in the United States and Asia. The Port of Tauranga lies outside the incursion zone so loading of produce from outside the incursion zone could continue at the Port, subject to insect proofing if it travelled through the incursion zone.

The Hawkes Bay incursion is modelled to occur in urban Hastings. The condensed location of horticultural properties around Hastings means about 90% of the area in horticulture in the region would fall within the incursion zone. The most affected sectors are apples and squash. Hawkes Bay provides 56% of New Zealand apple exports. For apples, directing Nelson produce to sensitive markets and Hawkes Bay apples to Europe would minimise losses but leave higher revenue markets significantly undersupplied and revenue lower as a result. Squash grown within the incursion zone would not be available for export to the primary market in Japan. The Port of Napier falls outside the incursion zone so produce from other areas could still be shipped.

The Nelson incursion is modelled to occur in the urban area of Richmond. The horticultural areas are spread out so about 40% would fall in the incursion zone. However, the Port of Nelson would be within the zone which would disrupt shipping. The most affected sector is apples, as Nelson provides 37% of New Zealand's apple exports. The impact would be contained by directing Nelson apples to European markets and using Hawkes Bay fruit to supply markets applying restrictions. The variety and fruit size mix means premium markets would be undersupplied and revenue lowered.

Horticultural growing districts are inter-linked through their common crops, exporters and markets. This inter-linking both provides a good means to reduce losses from an incursion and also spreads some of the impacts to districts not suffering the incursion. A key way to reduce overall losses from an incursion is to send produce from unaffected districts to sensitive markets. Because some fruits, particularly kiwifruit, and often apples, have multi-district pools by product type, lower market revenue affects other growing districts as well.

The analysis in this project has been done at a relatively low point for returns for export produce, due to the relatively high value of the New Zealand dollar against market currencies. Kiwifruit and apple marketers are on record as expecting better New Zealand dollar returns in 2006, so losses from an incursion would be greater than calculated in this analysis.

Losses would greatly escalate if an incursion was less well contained or if more markets applied sanctions to New Zealand host produce. For medfly this could occur if individual European Union markets would not accept produce, particularly the United Kingdom and Germany, both of which are important markets and free of medfly. If an incursion occurred from a species of fruit fly that was less well known internationally, such as Queensland fruit fly, many markets would be lost and losses consequently greater.

A more severe effect from a fruit fly incursion was estimated by calculating the impact of fruit fly host produce being excluded from export for a 15km radius zone and an 80km radius zone. The impacts of all three scenarios for regions are summarised in Table 3.

Table 3: Summary of Estimated Effects of Fruit Fly Incursion

Scale of incursion impacts	Calculated Financial and Employment Impacts	Region of Incursion: Bay of Plenty	Hawkes Bay	Nelson
Base Scenario: "1996-Auckland" impacts: Exports allowed to Europe within 15km radius zone.	Loss of Output ($ millions):			
	- Horticulture sector	$71.4 m	$63.8 m	$24.4 m
	- Flow-on to other sectors	$38.3 m	$22.2 m	-$ 0.7 m
	TOTAL NZ LOSS:	**$109.7 m**	**$86.0 m**	**$23.7 m**
	Jobs at Risk (full time equivalents = FTE):			
	- Horticulture sector	200	352	83
	- Flow-on to other sectors	340	339	92
	TOTAL NZ JOBS:	**540 FTE**	**690 FTE**	**175 FTE**
Worse Impact: 15 km radius no-export zone	Loss of Output ($ millions):			
	- Horticulture sector	$235 m	$202	$133
	- Flow-on to other sectors	$225 m	$183	$134
	TOTAL NZ LOSS:	**$460 m**	**$385**	**$267**
	Jobs at Risk (FTE):			
	- Horticulture sector	970	1960	1185
	- Flow-on to other sectors	1205	1070	760
	TOTAL NZ JOBS:	**2175 FTE**	**3030 FTE**	**1945 FTE**
Much worse impact: 80 km radius no-export zone	Loss of Output ($ millions):			
	- Horticulture sector	$430	$204	$134
	- Flow-on to other sectors	$390	$186	$131
	TOTAL NZ LOSS:	**$820**	**$390**	**$265**
	Jobs at Risk (FTE):			
	- Horticulture sector	1645	1985	1185
	- Flow-on to other sectors	1785	1095	750
	TOTAL NZ JOBS:	**3430 FTE**	**3080 FTE**	**1935 FTE**

None of these scenarios calculate the worst impact of fruit fly in New Zealand, which would be a large scale, multi-region, multi-year incursion severely affecting both export and domestic horticultural crops.

Individual passengers, particularly those travelling by air, are the most likely means of starting an incursion of fruit fly by bringing with them an undeclared infested piece of fruit containing eggs or nearly mature larvae. Passenger clearance is the first line defence against this. The x-ray machines used at international airports are an important tool in detecting undeclared risk material. The rate of just over 30 seizures per 1000 passengers (3%) is concerning, particularly that New Zealanders are the highest single nationality group at 30%. The costs of international travel have increased less relative to the cost of internal New Zealand travel, so pressure from New Zealanders holidaying overseas is likely to continue. More regional airports have proposed becoming international airports. This would increase the number of passenger entry points and their proximity to major horticultural areas. It is therefore important that passenger clearance systems and technologies at any new international airports are at the highest level.

Imports of commercial produce to New Zealand are subject to risk assessment, import health standards, and border inspections. Internationally, such imports are not commonly a source of new fruit fly incursions, however larvae are sometimes found and protocols should then be reviewed.

The trapping programme funded by MAF to monitor for the continued absence of pest fruit flies is very important. The dual outcomes of assuring export markets of New Zealand's continued freedom from the pests and early detection of any pests are both vital.

These costs exclude the cost to MAF to eradicate an incursion which for the 1996 Medfly incursion was calculated to be more than $5 million.

2. INTRODUCTION AND BACKGROUND

Fruit fly species are among the most destructive horticultural pests in the world, affecting a wide range of fruits and vegetables.

Export of horticultural produce from New Zealand earned around $2.3 billion in 2005 (Kerr et al, 2005). The quantity and value of exports has grown considerably since 1980's value of $115 million and now comprises 11% of New Zealands food and fibre export value. New Zealand's freedom from pest fruit flies is a key feature enabling access to export markets for produce. A very high proportion, about 93%, of fresh fruit and vegetable exports are of types that could host fruit fly. The main exceptions are onions and potatoes.

The Ministry of Agriculture and Forestry (MAF) funds a trapping programme that demonstrates New Zealands's continued freedom from fruit flies. One of the species checked for is the Mediterranean fruit fly, scientific name *Ceratitis capitata*, commonly called "medfly". Medfly is one of the worst horticultural pests in the world due to its wide host range, rapid and prolific breeding, tolerance of a range of climates and the normal appearance of produce infested with eggs or nearly full-grown larvae.

In May 1996, a localised breeding population of medfly was found in an Auckland back yard after routine checking of monitoring traps found male medflies.

Such a find is a quarantine issue for New Zealand exports. Countries sensitive to the pest suspended imports of fruit and vegetables that could host medfly from the Auckland area, until they were sure the medfly was eradicated. Eradication was successful with the last pests found within about 3 weeks. Export markets build in a safeguard of additional time for the pest to reproduce before they allow imports to resume. This extended the duration produce from the incursion area was suspended from export to 8-12 months or longer.

The Bay of Plenty Regional Fruitgrowers Committee commissioned a study in 1998 to evaluate the impact of a fruit fly incursion in the Bay of Plenty. The Auckland medfly incursion was used to provide a realistic basis for the study. This study was commissioned by Horticulture New Zealand to calculate the impact of a fruit fly incursion in any of the major fruit growing districts of the Bay of Plenty, Hawkes Bay or Nelson, using similar methodology.

3. METHODOLOGY

In the 1998 study, the importing countries response to the 1996 medfly incursion in Auckland gave a realistic scenario for the study. Market sanctions varied from no restrictions to European markets or Western Australia, to produce being excluded from export markets if it was grown or transported through a specified radius from the incursion location. The duration of restrictions varied with those to the most significant markets lifted within a year of discovery of the incursion.

For the 1998 study, these market sanctions were modelled as if the incursion had occurred in Te Puke in the Bay of Plenty. For this study, the same method is used. The market response to the 1996 Auckland incursion is applied in turn to the Bay of Plenty, Hawkes Bay or Nelson districts. This estimates the impact of an incursion in any one of these major horticultural districts of New Zealand.

This is analysing the quarantine impact, particularly on New Zealand exports, from a small local incursion of one species of fruit fly, not at the costs of controlling a fruit fly should it become an established pest.

The Auckland incursion was in an urban area, not an area growing significant quantities of commercial export horticultural produce. This would be quite different for an incursion as studied in this report where the nearest commercial horticultural properties may be within a few hundred metres of an urban back-yard incursion site. However, because of the success of containment and eradication of the Auckland incursion and the strong ability to identify the source of produce and manage produce inventory, the restrictions applied are not more precautionary.

The methodology used is very close to that for the 1998 report. The data gathered for the study comes from a wide range of published, industry and informal sources. The statistical data is for a range of time periods which have been adjusted to give a representative recent year around 2005/06. Figures have been rounded but may still imply more accuracy than can be claimed. Market restrictions are simplified to a 15km radius incursion zone for counties restricting produce imports due to the incursion. No market restrictions are applied to produce exported to Europe or directly to Western Australia. Market restrictions are applied for 12 months from 1 April in the Bay of Plenty or 1 February in Hawkes Bay or Nelson. Produce grown in the incursion zone that could host fruit fly may not be exported except to Europe or Western Australia. Produce grown outside the incursion zone may be exported as long as it is also packed outside the zone and not transported through the zone unless in insect-proof packaging or transport. Domestic restrictions are more targeted, with produce movement allowed beyond the immediate incursion area after an initial delay, subject to inspection and insect proofing.

Importantly, mitigation of impacts is modelled. Leaving produce unharvested is undesirable as the ripening fruit provides a ready food source for medfly. Thus, to contain the incursion, it is desirable to continue harvesting produce, as long as medfly eggs and larvae are not being distributed with the harvested fruit. The additional trapping and fruit sampling that would be set up by MAF to control an incursion would indicate the geographical spread of the incursion. It is very likely MAF would set up monitoring traps specifically around major processing and packing sites, even some distance from the incursion centre. For this study, it is assumed that outside the 1.5km zone immediately around the incursion site, trapping and inspection results would enable properties to be approved for harvest subject to measures such as insect proofing.

A closed curtain-sided or “Tautliner” truck is acceptable insect-proofing for transport, which helps contain the cost of insect proofing loads. This was acceptable in the 1996 Auckland incursion.

The ability to supply fruit from regions outside the incursion zone to markets applying restrictions provides a significant opportunity to mitigate of the effects of the incursion. This is particularly significant for the major crops of apples and kiwifruit where a sizeable portion of the crop from New Zealand is exported to European markets. There were no market restrictions applied to New Zealand produce by European markets during the 1996 medfly incursion.

Other key assumptions are that production and markets are "back to normal" after the 12 month period, that is, no long term changes in market characteristics or production occur due to an incursion.

The dominating figures are those for apples, kiwifruit and squash, due to the size of these industries in the regions studied and the prevalence of fresh exports to medfly-sensitive markets. Calculations have been made for other crops destined for fresh export, fresh domestic consumption and processing.

Economic analysis of the flow-on effects of the incursion impacts within each region and on the whole New Zealand economy was made by Dr Warren Hughes, Associate Professor of Economics at the Department of Economics, Waikato University, using multi-sector models for each incursion region. John Charles, Science Leader for Applied Entomology in the BioProtection Group at HortResearch looked over some of the entomological content.

The impact of the Mt Roskill medfly incursion was relatively mild. Factors that could increase the impact of a fruit fly incursion are it occurring in a major fruitgrowing area, being a fruit fly species less well known internationally such as the Australian native species Queensland fruit fly, if individual European countries free of medfly applied individual restrictions or if the incursion became more widespread before detection or continued to spread after its detection.

To investigate a more severe impact of a fruit fly incursion in New Zealand, further scenarios were modelled for each region of no exports of fruit fly host produce allowed from a 15km or 80km radius zone around the incursion site for one year. The Australian example of the Papaya fruit fly incursion (see section 9) show these scenarios of a more severe incursion impact are probably still conservative, as that incursion affected the equivalent of nearly 4 times the larger area and control measures were extended over nearly 4 years.

The impact of these scenarios were estimated with a lower level of detail, but they showed a significant increase in impact in all three study regions. The main change from the base scenario is the loss of export markets for apples and kiwifruit which was significantly contained in the "1996-Auckland" scenario by diverting fruit from the incursion zone to European markets not applying restrictions. Some figures are rounded.

This report is self contained, with some relevant material from the 1998 report summarised in the Appendix.

4. GENERAL INCURSION IMPACT

Countries do not have a pre-determined response to any new pest discovered in a country they accept imports from. Generally, restrictions are imposed by a country that does not have the particular pest, but where a country is trying to control or eradicate that pest they may also restrict imports. A country may also be wary that an incursion may be a different strain or species than their existing pest.

Where restrictions occur, they may be applied to a specific distance around the pest, based on mobility of the particular pest, but may also be applied to the whole country or continent, or around natural barriers such as islands or areas with little host vegetation. Medfly is such a significant pest that the response by importing countries is generally precautionary and conservative.

The 1996 response to the Auckland medfly incursion provides a real-life example of the responses to a small incursion of a serious pest in New Zealand. Of course, at the start of an incursion, you don't know it's scale and characteristics, whether the pest can be eradicated or how long eradication might take. The 1996 incursion was found early, rapidly under control in a localised area and then eradicated. The response to the 1996 medfly incursion was relatively mild, due to how contained the incursion was and to acceptance of the integrity of the New Zealand export systems. Despite medfly being a severe pest, it probably also helped that it is a well-known pest internationally so there is greater knowledge and confidence of how to deal with it compared to a more obscure pest.

4.1 What happened in Auckland

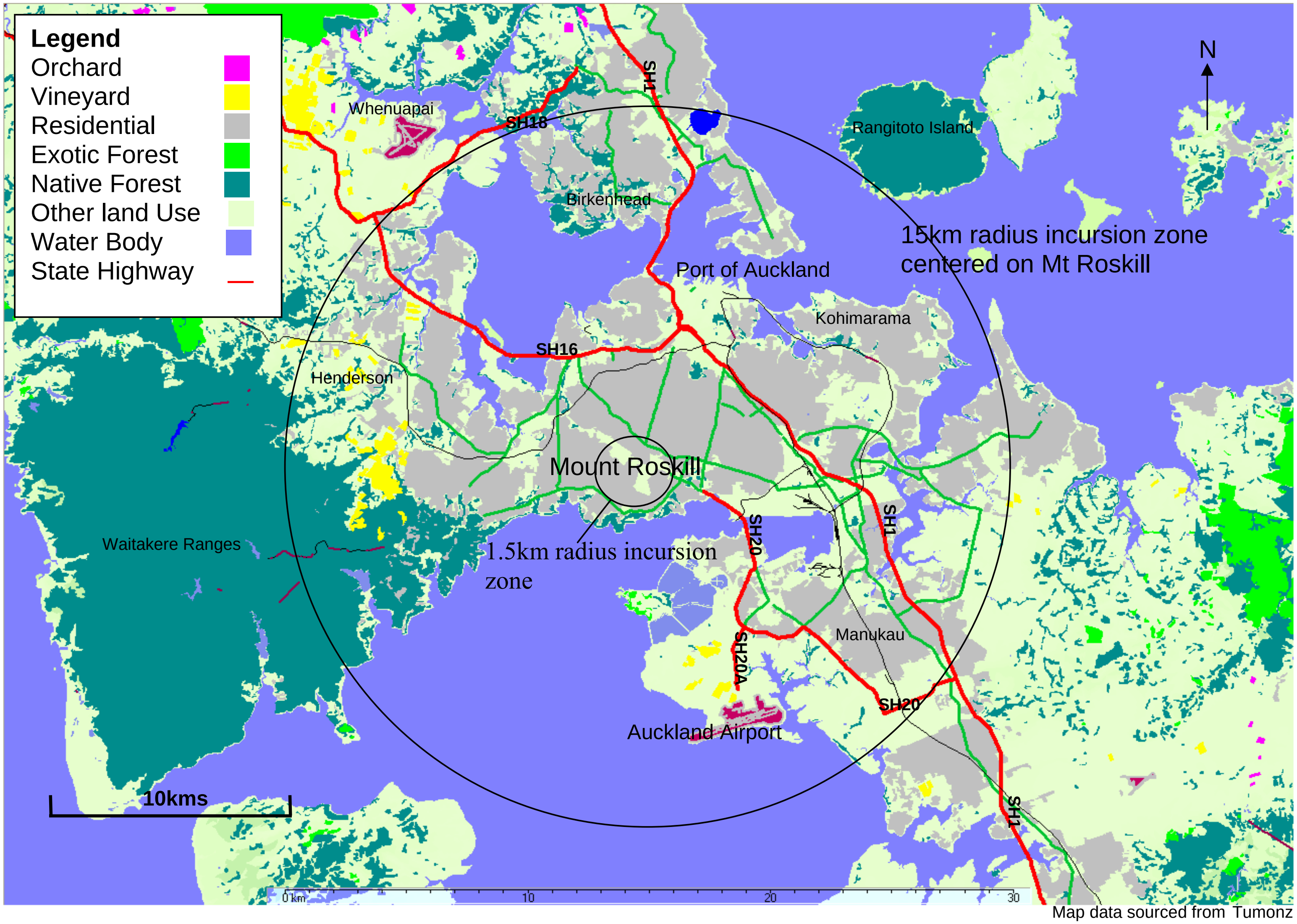
In Auckland in May 1996, 2 male medfly were found during routine checking of a monitoring trap in urban Mount Roskill. Follow-up trapping and monitoring found a localised breeding population. The total population found was 31 male adults, 10 female adults and 12 infested pieces of fruit containing 85 larvae. These were all found within about 3 weeks, all within 200m of the original trap.

MAF carried out an eradication programme which was successful. They spent about $5 million in additional costs, excluding some of their personnel cost. Incursion zones of radius 15km and 1.5km were set up. This is shown on the Auckland region map attached (Map 1) and included major roads and the airport, but few orchards, vineyards or other commercial horticultural properties. Commercial consignments of fruit travelling through or into the zone required insect proofing and MAF inspection and approval. This was a disruption for growers and produce handlers, requiring short term measures such as changing routes, changing handling buildings, setting up temporary produce centres outside the zone and applying insect proofing to packaging. Urban residents were requested not to take home-grown fruit out of the zone unless it was first cooked or frozen.

Market restrictions excluded produce that might host medfly from an area around the incursion site, particularly to Australia (except Western Australia) the United States (US), Japan and other important Asian export markets. No restrictions were applied to exports to European markets or Western Australia. Most market restrictions were lifted within 12 months. The market restrictions were related to the generation time of medfly, which was extended due to the cool time of the year.

More specific details of the Auckland incursion are contained in Appendix I, a précis of some content from the 1998 report.

Map 1: Auckland Region Showing Incursion Zones, Orchards and Vineyards



4.2 Medfly/Fruit Fly Biology

Medfly originated in Africa (GBIF, 2006) and has long been established in Hawaii, parts of Europe, parts of South America and in Western Australia (Thomas et al, 2005). In the US, there have been infestations in Florida, Texas and California. Medfly was eradicated from Chile in the late 1990's and Chilean produce has since been accepted into more export markets as a result (IAEA, 1997). Some other countries are considering eradication programmes (IAEA, 2000).

Female adult medfly lay their eggs into fruit, piercing the fruit surface with their egg laying apparatus. The site of egg-laying is not visible on the fruit although rots may develop from these sites over time. The eggs hatch into larvae that feed on the fruit flesh, although the fruit may still appear sound. The mature larvae drop from the fruit, burrow into the ground and pupate. The adult fruit flies emerge, and after feeding for a few days are mature, mate and the females lay eggs into host fruit. The medfly adult tends to travel less distance than other fruit fly species before mating. The life cycle is faster in warm conditions but can continue in cooler conditions at a slower rate and adults have been recorded living for 10-12 months in cooler climates. Phenology models are available that predict timing of medfly life stages, based on temperatures in a particular location (UC, 2003). The adult female is prolific, each one laying 300-1,000 eggs during her typical lifespan of 30-90 days (Thomas et al, 2005). Each female lays 8-10 eggs into a fruit and more than one female may lay eggs in each fruit.

Thus, a single infested fruit may be sufficient to start a new infestation of the medfly in a new location. Fruit that contains nearly-mature larvae sufficient to start a breeding population may appear sound from the outside. Once someone opens up the fruit and discovers the mushy flesh and the larvae, the fruit is discarded, often thrown into a backyard corner in disgust. The larvae can then pupate in the soil and emerge as adults, perpetuating the lifecycle. This may occur some distance from where the fruit originated. The success of inter country phytosanitary procedures for commercial produce means that few new incursions occur through commercial produce channels. Most incursions arise from individual people transporting apparently sound fruit that contains eggs or developing larvae.

Fruit means the botanical definition of fruit, that is the part of the plants containing the seeds. Medfly has a wide host range, almost any fleshy fruit is considered capable of being a host to the insect. Thus a wide range of fruit, vegetable, ornamental and weed plants can be hosts to fruit fly. Notable exceptions are asparagus and onions as the product is not the fruit of the plant, and many forestry trees, particularly conifers like Radiata pine, as their fruits (the cones) are not fleshy.

Where medfly is established it causes severe fruit losses and limits markets available to the fruit due to quarantine restrictions by other countries. The pest can destroy 80-100% of fruit where it is not controlled. The main damage is done by the larvae while they develop inside fruit. Growers tend to use a variety of chemical and cultural controls. Cultural controls include harvesting less mature fruit or growing early season varieties. The eggs and larvae are the most difficult life stages to control because they are protected within the fruit. Adults are more vulnerable to chemical controls and control needs to be most vigilant as the fruit ripens. To control adults, insecticides may be sprayed over the whole plant and bait mixed with insecticide is applied to small areas such as tree trunks. To monitor distribution of the pest, a trap with a lure attractive to the male medfly is commonly used.

On a widespread scale, a sterile insect technique (SIT) is used where a large number of sterile male adults are released to mate with the females in the wild population, with the aim of overwhelming the wild population. This technique was used in the strategy to eradicate medfly from Chile in the late 1990's (IAEA, 1997) and is being used to tackle the pest in parts of California (CDFA, 2005).

Other fruit fly species have a similar life cycle. There are differences in their temperature tolerances and host range. Those with a wide host range are of most concern, such as the Queensland fruit fly *Bactrocera tryoni* and the Papaya fruit fly *Bactrocera papayae*. Species found in overseas holiday locations popular to New Zealanders, such as the Pacific Islands and Australia, are also of concern. Behaviour and biology of these pests where they are established can be a guide to their likely activity in a new location, but they may also prove adaptable. For example, high summer temperatures and dryness are thought to contain populations of tropical fruit flies in Australia (HPC, 1991), so the more temperate New Zealand climate may still be suitable.

More detail of the biology and control of medfly and other fruit flies is contained in Appendix II, a précis of this content in the 1998 report.

4.3 Impact on the Processing Sector

The eggs and larvae of fruit flies contained within fruit are killed by cooking or freezing. However, some processors are among the most sensitive sectors to infested produce. This is due to the poor internal quality of infested fruit and to the horror of consumers finding larvae in their canned produce (HPC, 1991). Where the produce is processed finely diced, stewed or juiced there is a higher tolerance to fruit fly.

5. BAY OF PLENTY INCURSION IMPACT

5.1 Bay of Plenty Horticultural Profile

The Bay of Plenty is a major fruit growing district, producing a range of fruits that are fruit fly hosts. The main crops are kiwifruit and avocados grown for export. Citrus, tamarillos, feijoas and passionfruit are also grown in the district, as well as smaller areas of other crops like olives, persimmons and vegetables. The regional map (Map 2) shows the spread of orchards near the coast from Opotiki in the east through to Katikati in the west, with a concentration around Te Puke and the western Bay of Plenty generally.

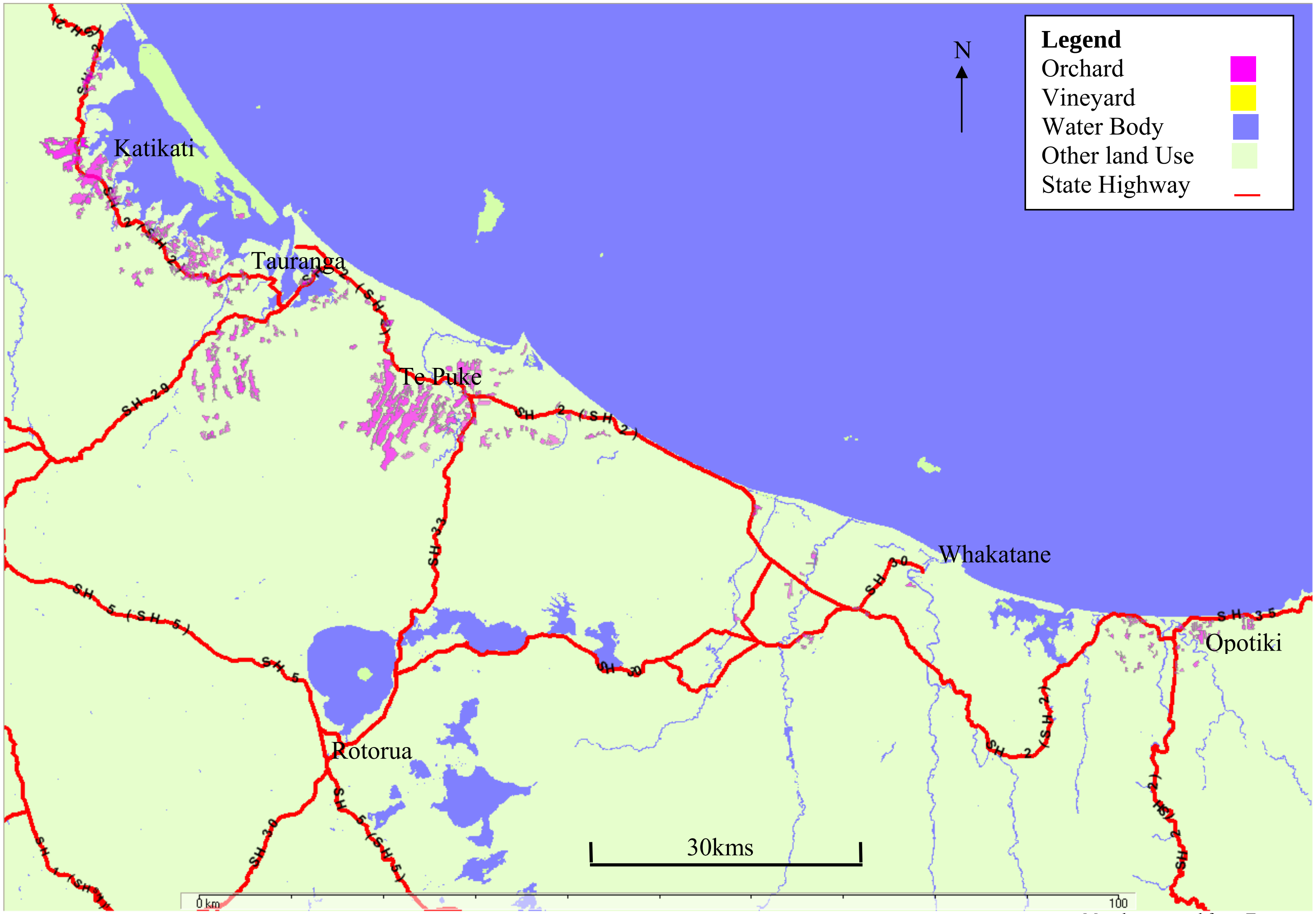
Kiwifruit production consists of the original green kiwifruit as well as organic green kiwifruit and the recently commercialised gold fleshed variety Hort16A, marketed as ZESPRI™ GOLD. The Bay of Plenty is the largest producing area for kiwifruit in New Zealand, producing 80% of the 84.7 million tray crop in 2005 (Zespri, 2006). The area is also the largest avocado district, producing 62% of avocados in 2005/06 (AIC, 2006).

Citrus is grown mainly for the domestic market. Tamarillos and passionfruit are grown for domestic sale and for export, particularly to the US. Feijoas are mostly grown for domestic fresh sale, with some processing and fresh export to the US. Avocados are predominately exported to Australia, especially the eastern states. Those not suitable for export are sold on the domestic market or processed into oil. Kiwifruit is marketed around the world. Kiwifruit not suitable for export are sold on the domestic market, processed or used for stock food.

Packhouses and coolstores are spread through the district, many located among orchards, with some in urban industrial areas.

Export kiwifruit and avocados are shipped from the Port of Tauranga. Other exports are often air freighted via Auckland.

Map 2: Bay of Plenty Region Showing Orchard and Vineyard Locations



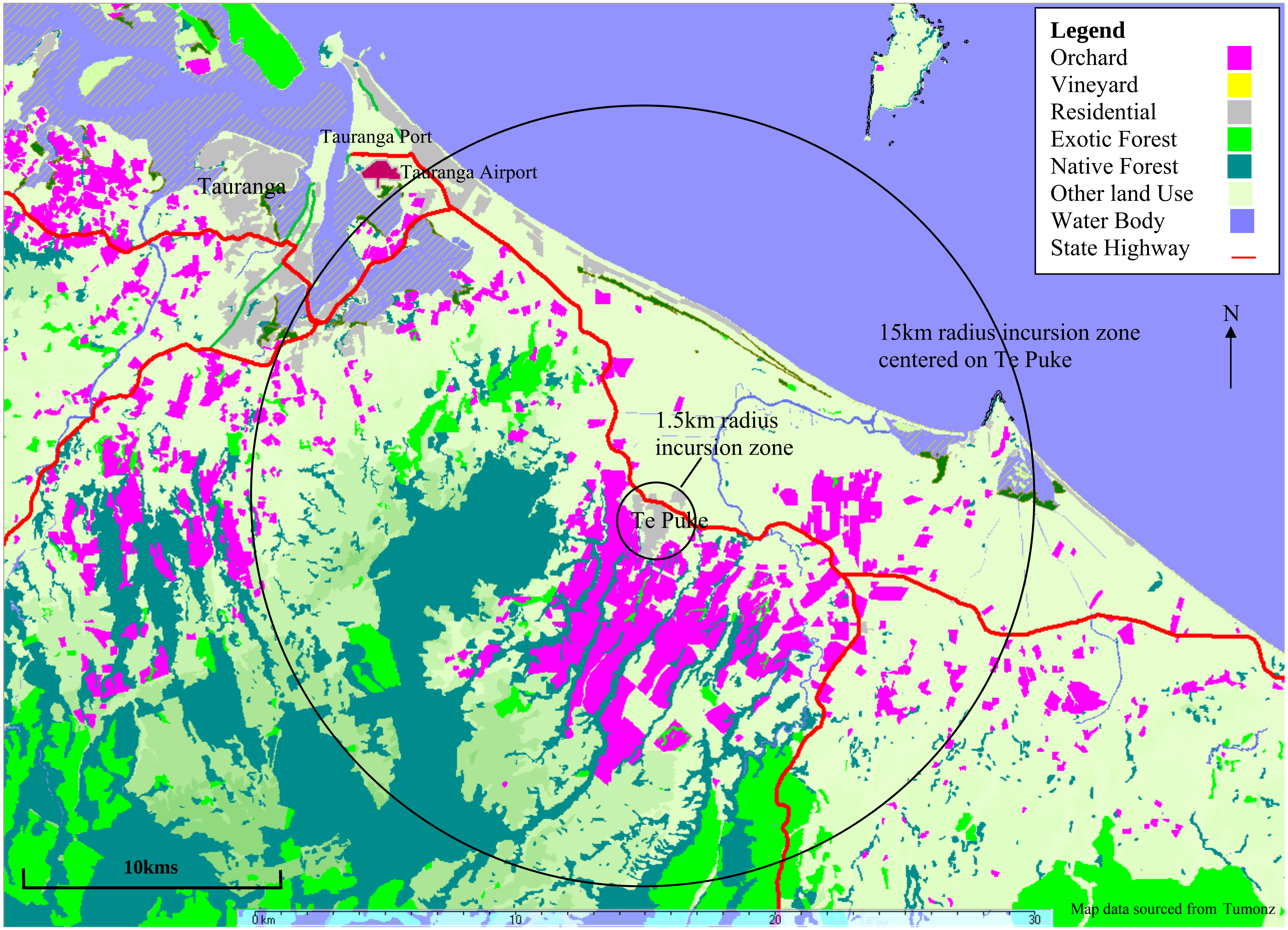
Map data sourced from Tumonz

5.2 Bay of Plenty Incursion Base Scenario

The Bay of Plenty incursion is modelled to occur in Te Puke, a town in the heart of the major kiwifruit growing region. The incursion zone map (Map 3) shows a 15km incursion zone around Te Puke and the location of major roads, the airport and Port. The Port of Tauranga lies outside the incursion zone. The road route over the Tauranga harbour bridge can be used to access the Port without entering the incursion zone.

The incursion is modelled to start in April as the kiwifruit harvest season starts, and for restrictions to be lifted at the end of 12 months. The most substantial medfly host crop in the incursion zone is kiwifruit, although there are areas of other crops, particularly avocados.

Map 3: Bay of Plenty Scenario Showing Incursion Zones



5.3 Mitigation Measures for the Bay of Plenty

The most significant mitigation measure for a medfly incursion in the Bay of Plenty would be to direct kiwifruit from the incursion zone to European markets, and source fruit for other markets from outside the incursion zone. The product traceability for kiwifruit is very good and orchards growing organic and gold kiwifruit all have global positioning system (GPS) co-ordinates on record at Zespri International Ltd, the main marketer for New Zealand kiwifruit.

5.4 Main Impacts

Kiwifruit: Fruit from the incursion zone would not be available for premium markets in Japan and other Asian countries. This would mean these markets were undersupplied with fruit, particularly of the gold type. Prices would be reduced due to lower fruit quality arising from less inventory from which to select premium fruit for these markets. Reallocation of fruit from the incursion zone to available markets would depress prices. Incursion zone fruit would not be able to be exported to the eastern states of Australia, an important market for class II fruit. This would increase reject rates. Crops from orchards in the incursion zone would not qualify for incentives relating to sale in premium markets, as that fruit would be excluded from those markets due to quarantine restrictions.
There would be a significant logistical challenge and cost to re-locate fruit for packing. Fruit grown in the incursion zone would need to be packed in the incursion zone and fruit grown outside the zone also packed outside the zone. This would require a significant re-jig of packing plans including fruit flow plans, packaging types, transport, coolstore location, shipping schedules and so on. This would also cause packing and shipping delays so reduce revenue and increase costs. Insect-proof transport from the orchard to packhouse would require different trucks from the flat-deck ones in common use, so costs would increase. Shipping costs would increase due to late changes to booked schedules. Some of the impact would affect other kiwifruit growing districts as revenue is pooled. Fruit from Hawkes Bay is packed in the Bay of Plenty and some this would need to be re-routed to packhouses outside the incursion zone.

Avocados: Avocados from the incursion zone would not be able to be exported to Australia, so would be diverted to the domestic market or oil production once cleared for harvest. This would depress local market prices. Insect proofing requirements and changes to harvest and packing plans would increase costs.

Other crops: Diversion from export to domestic markets, delays and a requirement for insect proofing would be the main impacts on other crops.

5.5 Losses – Net of Mitigation

Table 4 shows the direct financial impacts calculated for the Bay of Plenty incursion scenario are $71.4 million. Impacts are itemised as reduced revenue and increased costs and whether they occur in the Bay of Plenty or in other districts. About 20% of the impact is calculated to affect districts outside the Bay of Plenty. The main impacts on other districts are via effects on the kiwifruit pool and domestic avocado prices.

Table 4: Bay of Plenty Incursion Direct Financial Impacts on Horticulture ($ millions):

Impacts within the Bay of Plenty:		**Impacts in other NZ Districts:**		**Total Direct Impact:**
Reduced revenue	Increased Costs	Reduced revenue	Increased Costs	Nationwide, revenue losses plus cost increases
$47.54	$10.74	$11.28	$1.88	$71.44

5.6 Economic Model Multiplier Effects

The impacts of a change in the fruit growing sector are increased once the flow-on effects to other sectors of the economy are calculated. Revenue lost to the fruit growing sector causes losses in related sectors. This is partially offset by the impact of increased spending by the fruit growing sector to counter an incursion, which benefits other sectors of the economy. The economic model used for this analysis calculates these effects. Table 5 shows the nationwide loss calculated from the Bay of Plenty incursion scenario is $109.7 million, $74.8 million (68%) of which occurs within the region.

The impact on employment is 540 full time equivalent jobs nationally, 310 (57%) within the region. About 20% of the net impact directly reduces household spending power, shown as Net Household Income. The Value Added estimates the value created within the region by local business units and workers after deducting for materials like fuel imported to the region. The Value Added is 52% of the total impact, reflecting the high proportion of local inputs to the fruit growing sector.

Table 5: Bay of Plenty Incursion Total Impacts on Regional and New Zealand Economy (including flow-on effects):

	Output/ Revenue ($ millions)	**Employment (Full Time Equivalents = FTE)**	**Net Household Income ($ millions)**	**Value Added/ Gross Regional Product ($ millions)**
Net Loss within the Bay of Plenty Region	$74.83	310 FTE	$14.18	$37.84
Net Loss for all NZ	$109.68	540 FTE	$22.5	$59.14

Employment effects within the fruit growing sector are difficult to be categoric about as there is a high proportion of self employment. Self-employed people lose their income rather than their job as such. Also, labour practices mean shedding staff is not necessarily quick or cost-saving. However, the model indicates the number of positions at risk from the incursion analysis. Further detail of the economic model outputs is in Appendix III, including an explanation of the model and terms used, and detailed figures for each region.

5.7 Worse Impact Scenarios

5.7.1 15km Radius No-export Zone

The main difference for a 15km no-export zone for fruit fly host produce around the Te Puke model incursion site is the loss of export markets for kiwifruit, that in the base scenario could be directed to European markets not applying restrictions to a fruit fly incursion. This greatly increases the lost revenue, as around 40% of the New Zealand kiwifruit crop is produced in a 15km radius zone around Te Puke. Export markets would be undersupplied with fruit with consequently reduced revenue, despite higher prices. Costs would increase due to issues like excess shipping space having to be on-sold at a discount. Domestic and processing markets would be nowhere near able to absorb the volume of fruit potentially available or to provide returns to cover the handling costs, let alone be comparable to export market returns.

The estimated direct impact of this scenario on the horticultural industries is $235 million.

The total impact is $460 million loss of output and 2,175 Full Time Equivalent jobs at risk once the flow on impacts from the economic model are included. Nearly all of the impact would occur in the Bay of Plenty as other regions would have some gain due to higher revenues from undersupplied export markets.

5.7.2 80km Radius No-export Zone

An 80km radius zone around Te Puke would take in all the Bay of Plenty kiwifruit production area except for Opotiki, and would also include kiwifruit produced in Waihi and parts of the Waikato. Around 75% of New Zealand's kiwifruit is produced in this zone. Impacts would be severe, with an estimated $430 million direct impact on the horticultural sector, particularly kiwifruit, through lost income and increased costs. Once the flow-on impact on other sectors of the economy is calculated the financial impact increases to $820 million and nearly 3,500 jobs would be at risk.

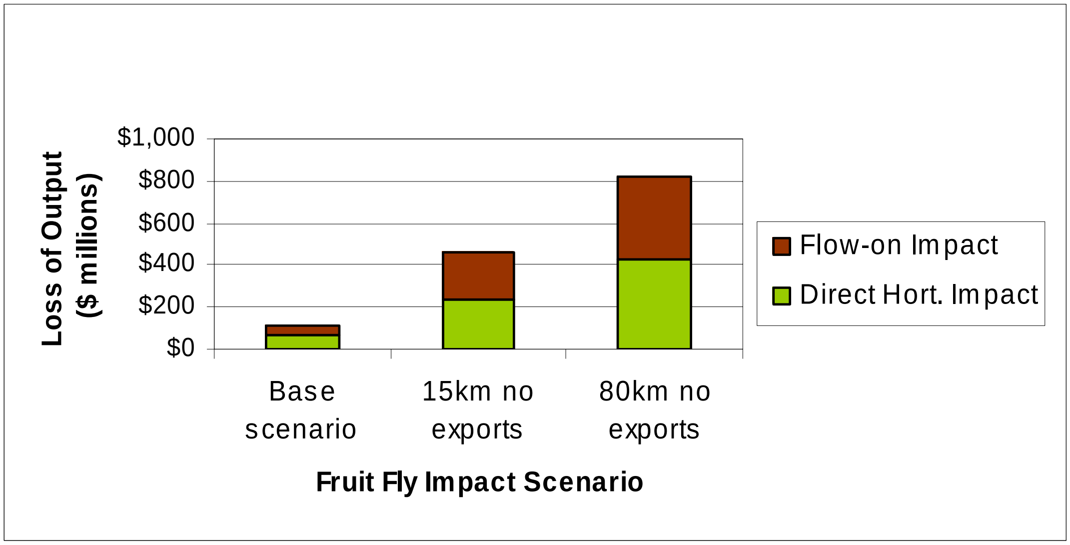
5.7.3 Bay of Plenty Summary

The results of this study for the Bay of Plenty area are summarised in table 6 and graphs 1 and 2 following.

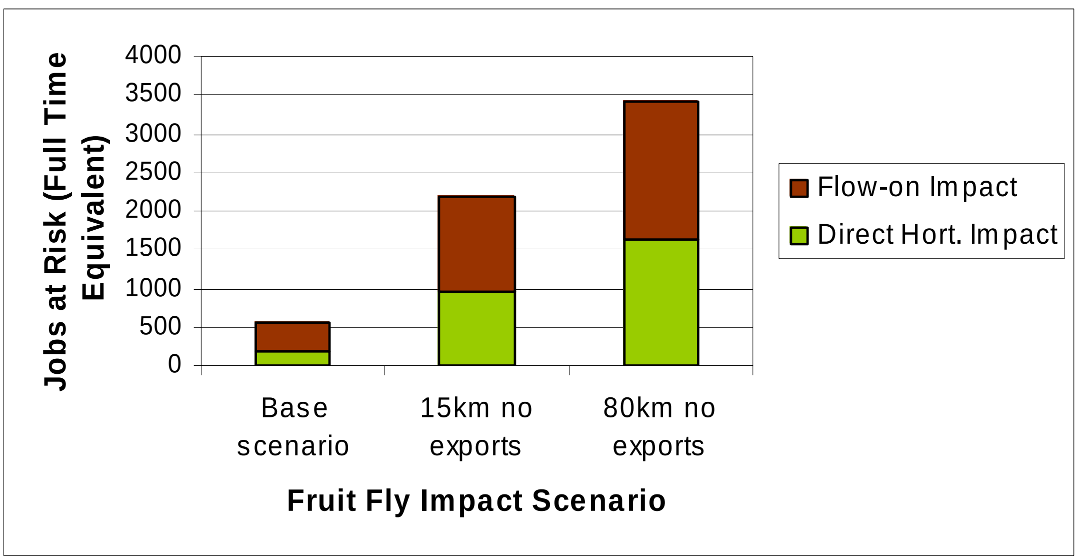
Table 6: Summary of Impacts of Fruit Fly Incursion in the Bay of Plenty Region

Scale of incursion response:	**Direct Impact on Horticultural sector ($ millions)**	**Total Net Impact on Output ($ millions)**	**Total Impact on Employment (FTE jobs)**
Base "1996-Auckland" Scenario	$71.4	$109.7	540 FTE
15 km no-export scenario	$235	$460	2175 FTE
80 km no-export scenario	$430	$820	3430 FTE

Graph 1: Bay of Plenty: Financial Impact of a Fruit Fly Incursion



Graph 2: Bay of Plenty: Employment Impact of a Fruit Fly Incursion



6. HAWKES BAY INCURSION IMPACT

6.1 Hawkes Bay Horticultural Profile

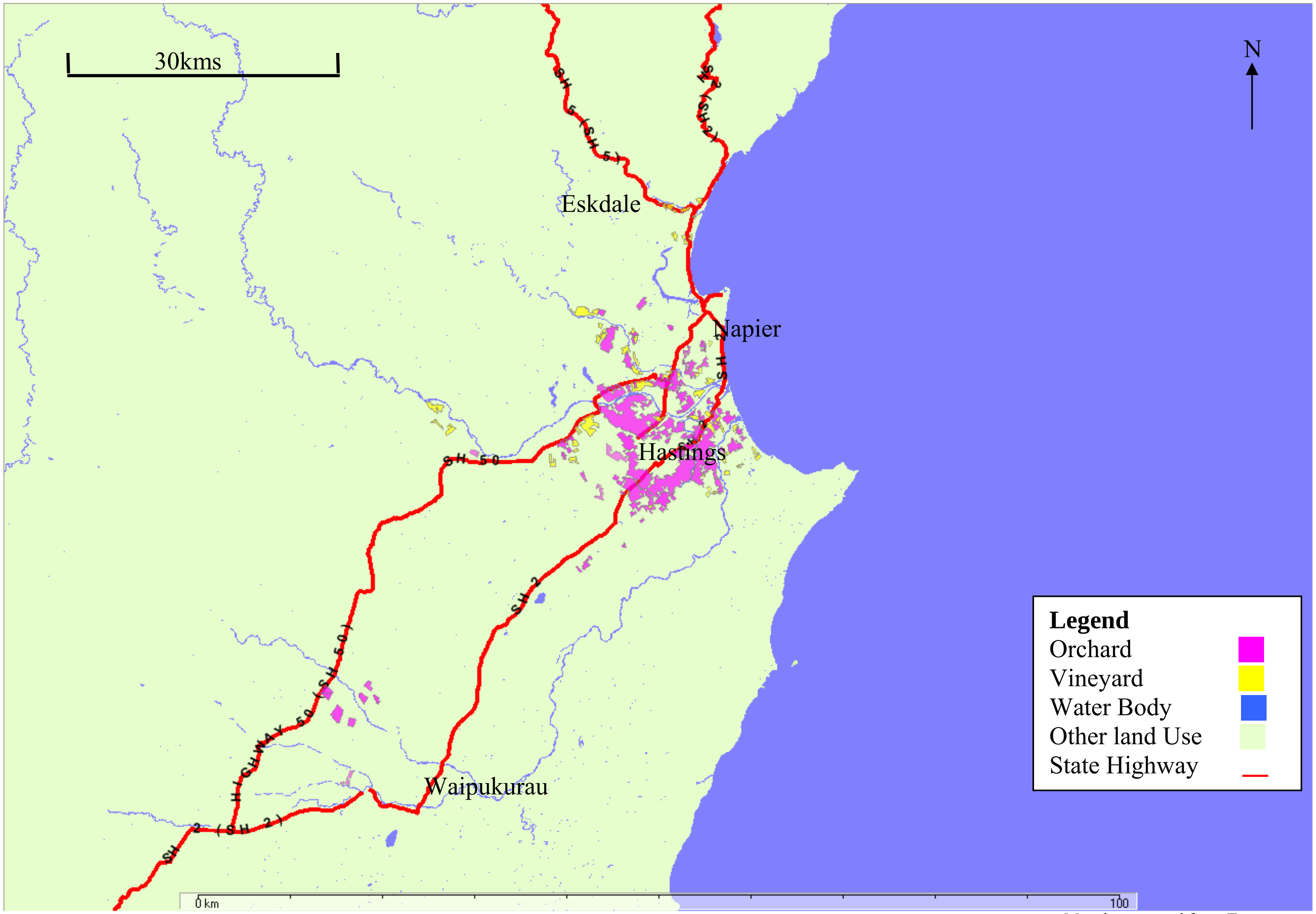
Hawkes Bay is a significant and diverse horticultural district, growing a range of produce that could host medfly. Hawkes Bay is known for apples, grapes, summerfruit and process vegetables but also grows significant areas of squash, olives, kiwifruit and smaller areas of a range of other crops such as berries, fresh vegetables and citrus.

Hawkes Bay is the largest pipfruit growing district with 56% of the export apple crop (MAF, 2006). Apple and squash production is focussed on fresh export, departing through the Port of Napier. Grapes are grown for winemaking. Summerfruit is grown for fresh domestic consumption and processing. Kiwifruit are exported but trucked out of the district to the Bay of Plenty for packing and export. Olives are a young crop in the district being grown for oil production.

The Hawkes Bay area used for horticulture consists of flat and fertile plains, intersected by rivers. Horticultural production is concentrated around the urban areas of Hastings, Havelock North and Flaxmere and between Hastings and Napier. This is shown on the Regional map (Map 4) with the orchard and vineyard areas highlighted. The areas where annual cropping occurs change each season due to crop rotations required to reduce disease pressure. However, a high proportion of the vegetables and other annual crops are grown within the area of dense orchards and vineyards.

Most processing also occurs within a concentrated area. Major apple packhouses are located around Hastings and at Whakatu. Apples are juiced at the ENZA plant in Hastings. The Heinz Watties processing factories are in Hastings. Grapes are processed locally at a number of different wineries or trucked to wineries in other districts.

Map 4: Hawkes Bay Region Showing Orchard and Vineyard Locations



Map data sourced from Tumonz

6.2 Hawkes Bay Incursion Base Scenario

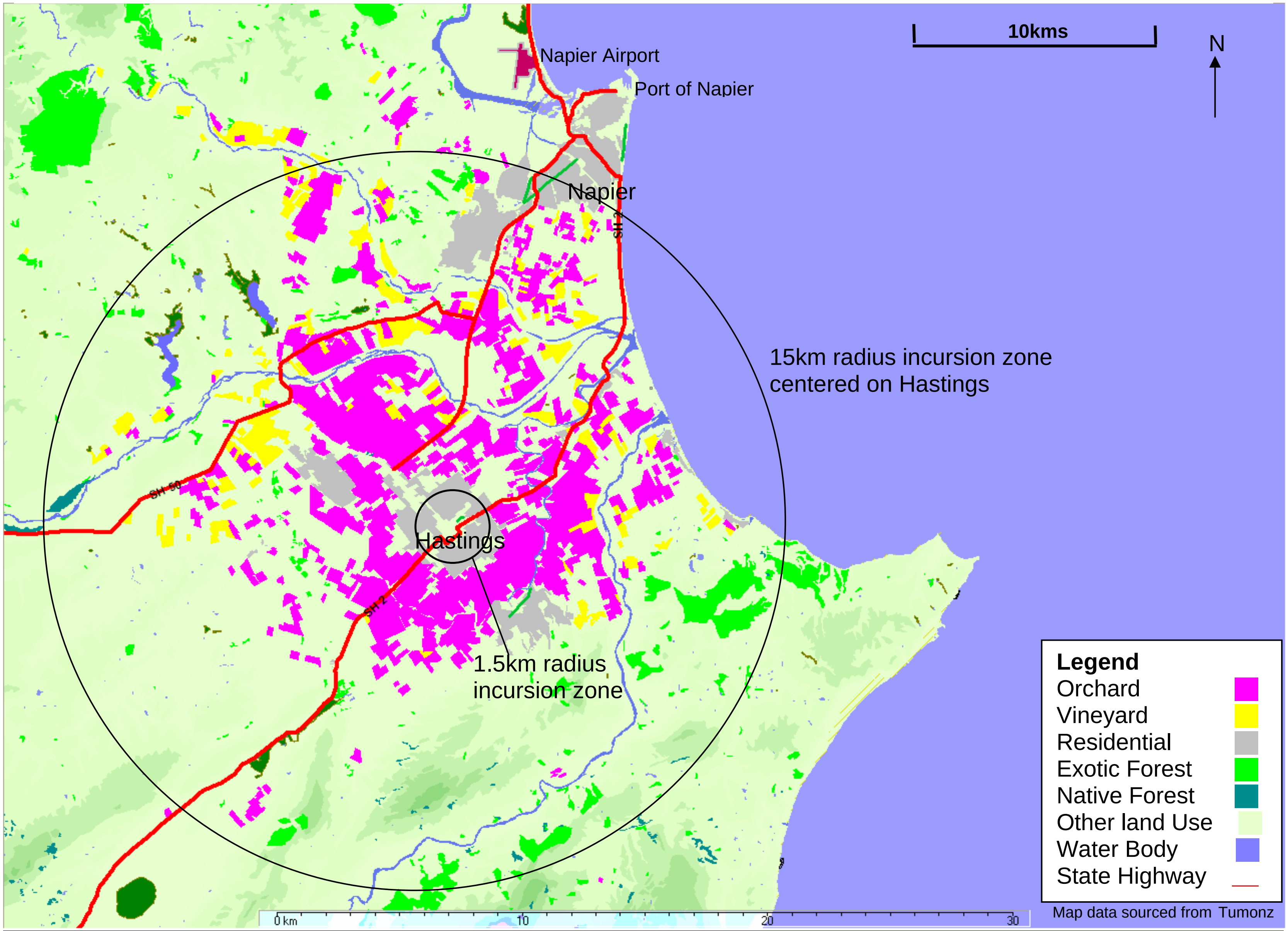
The Hawkes Bay incursion is modelled to centre around Hastings, an urban area in the heart of the fruit growing region. The incursion zone map (Map 5) shows a 15km incursion zone around Hastings and the location of major roads, the airport and Port. The Port of Napier lies outside the incursion zone.

The incursion is modelled to start in February, as the export apple season starts, and for restrictions to be lifted at the end of 12 months.

6.3 Mitigation Measures for Hawkes Bay

The most significant mitigation of the impacts of a medfly incursion in Hawkes Bay would be to direct Hawkes Bay export apples to the European market and use apples from other growing districts, particularly Nelson, to supply medfly-sensitive markets in the US and Asia. The ability to link packed pipfruit to the orchard it originates from is an aid to proving the origins of the fruit to markets.

Map 5: Hawkes Bay Scenario Showing Incursion Zones



6.4 Main Impacts

Apples: The main impact of a medfly incursion in Hawkes Bay would be the undersupply of higher returning apple markets with fruit. Districts outside Hawkes Bay have insufficient volumes to replace the Hawkes Bay product. Once the variety mix and fruit sizes are taken into account there is a shortfall calculated around 40% of volume. Diverting the Hawkes Bay export apples to unrestricted EU markets would increase supply of New Zealand apples to the EU and is calculated to cause a reduction in revenue per TCE from that market. An additional revenue loss to the pool is factored to account for the impact of disruption and delay at the start of the export season.

Increased shipping costs would occur due to late changes to shipping plans. Because most apple exporters operate pools across growing regions, some of the lower revenue and increased costs are calculated to impact growers in other regions because they are impacts on the whole payment pool.

Squash: The other major impact would be on squash grown for fresh export to Japan. Squash grown inside an incursion zone would not be acceptable for the Japanese market. For squash that had already been planted at the time of the incursion this would be a major loss, as returns from the domestic market or processing squash are inferior. If an incursion occurred between growing seasons then squash could be planted outside the incursion zone. This would require re-organising of production plans and paddock leases, but would help to contain losses.

Squash grown outside the incursion zone could only be packed for export inside the zone with insect-proof transport, packhouses and packaging.

Other crops: Other crops grown inside the incursion zone that were approved for harvest after inspection would require insect-proof transport to their processing or packing facility. Those being sold fresh to domestic markets would need insect-proof packaging or transport.

The Port of Napier falls outside the incursion zone so shipping of produce grown outside the incursion zone through the Port could continue. Any of this produce destined for export to markets applying restrictions that passed through the incursion zone would require transport in insect proof packaging or vehicles. Whakatu is inside the incursion zone so movement of produce between the inland Port being developed there (HBRTS, 2004) and the Port at Napier could be restricted.

6.5 Losses – Net of Mitigation

Table 7 shows the direct financial impact calculated for the Hawkes Bay incursion scenario is $63.78 million. This is the total of lost revenue and additional costs bourne directly by the horticultural sector. Most significant is the loss of revenue, particularly from apple and squash exports. About 26% of the impact affects other districts, particularly Nelson and Central Otago through the impact on apples.

Table 7: Hawkes Bay Incursion Direct Financial Impacts on Horticulture ($ millions):

Impacts within Hawkes Bay:		**Impacts in other NZ Districts:**		**Total Direct Impact:**
Reduced revenue	Increased Costs	Reduced revenue	Increased Costs	Nationwide, revenue losses plus cost increases
$ 35.96	$11.34	$12.16	$4.32	$63.78

6.6 Economic Model Multiplier Effects

Losses in the Hawkes Bay horticultural sector affect other parts of the economy, through the flow on effects of reduced revenue and additional spending. The additional spending helps offset the lower revenue as other sectors benefit from the additional spending required to manage an incursion. The economic model used in this analysis calculates these effects. Table 8 shows the nationwide loss from a Hawkes Bay incursion, including these flow-on effects, is $85.98 million, 64% of which occurs within the Hawkes Bay region.

The employment impact is 690 full time equivalent jobs nationally, 415 (60%) within the Hawkes Bay region. Household spending power, measured as Net Household Income, would reduce by $21.44 million. The Value Added component estimates the value created within the region, after deducting materials such as fuel imported to the region. The value added impact is 43% of the impact within Hawkes Bay and 50% of the nation-wide impact, reflecting the high proportion of locally-derived inputs to the horticultural sector.

Table 8: Hawkes Bay Incursion Total Impact on Regional and New Zealand Economy (including flow-on effects):

	Output/ Revenue ($ millions)	**Employment (Full Time Equivalents = FTE)**	**Net Household Income ($ millions)**	**Value Added/ Gross Regional Product ($ millions)**
Net Loss within the Hawkes Bay Region	$54.78	415 FTE	$12.70	$23.87
Net Loss for all NZ	$85.98	690 FTE	$21.44	$43.43

Further detail of the outputs of the economic model is in Appendix III, including detailed figures for the Hawkes Bay region and an explanation of the model and terms used.

6.7 Worse Impact Scenarios

6.7.1 15km Radius No-export Zone

The main difference for a 15km no-export zone for fruit fly host produce around the Hastings model incursion site is the loss of export markets, particularly for apples but also for kiwifruit. In the base scenario this produce could be directed to markets in Europe not applying restrictions to a fruit fly incursion. This greatly increases the lost revenue, as around 55% of the New Zealand apple crop is produced in a 15km radius zone around Hastings. Costs would also increase due to issues like excess shipping space having to be on-sold at a discount. Domestic and processing markets would be nowhere near able to absorb the volume of fruit potentially available or to provide returns to cover the handling costs, let alone be comparable to export market returns.

The estimated direct impact of this scenario on the horticultural industries is $202 million.

The multiplier figures from the economic model indicate the total impact, including the flow-on effects on other parts of the economy is $385 million loss of output and 3,030 Full Time Equivalent jobs at risk. Around 15% of the employment impact and 10% of the financial impact would occur in regions other than Hawkes Bay.

6.7.2 80km Radius No-export Zone

For the Hawkes Bay, prohibition of exports of fruit fly host produce from an 80km incursion zone around Hastings has much the same result as for a 15km no-export zone, because export horticultural production is concentrated within the 15km radius zone. The impact is greatly magnified over the "1996-Auckland" base scenario impact due particularly to the lack of export markets for apples that were able to be sent to markets in Europe under the "1996-Auckland" base scenario as those markets did not apply restrictions.

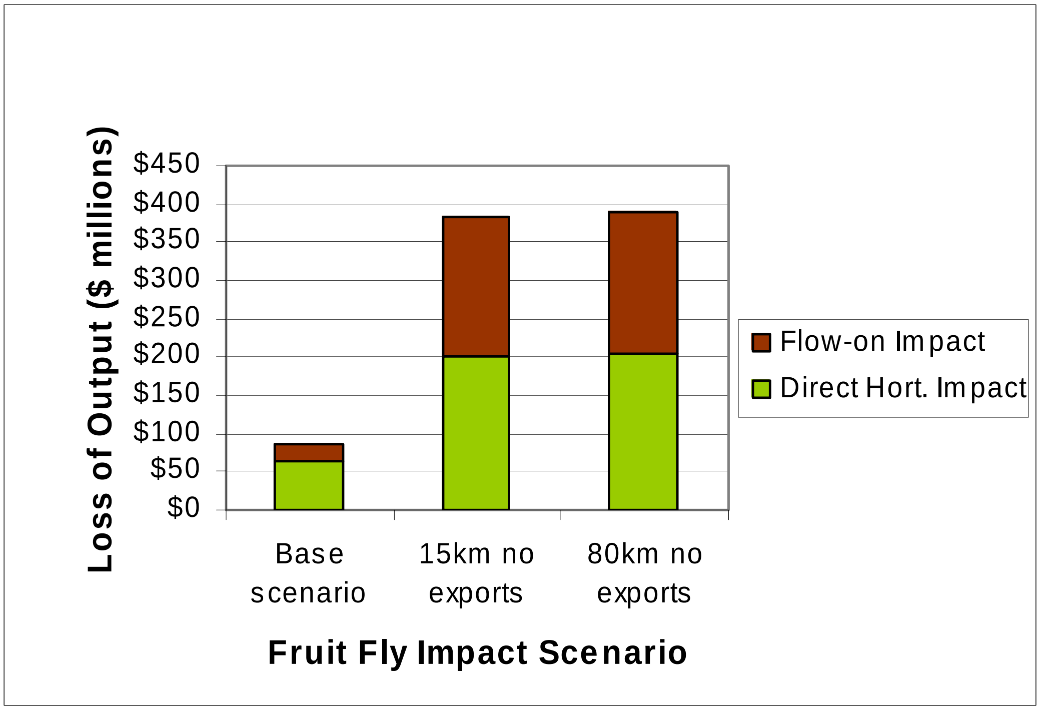
6.7.3 Hawkes Bay Summary

The results of this study for the Hawkes Bay area are summarised in table 9 and graphs 3 and 4 following.

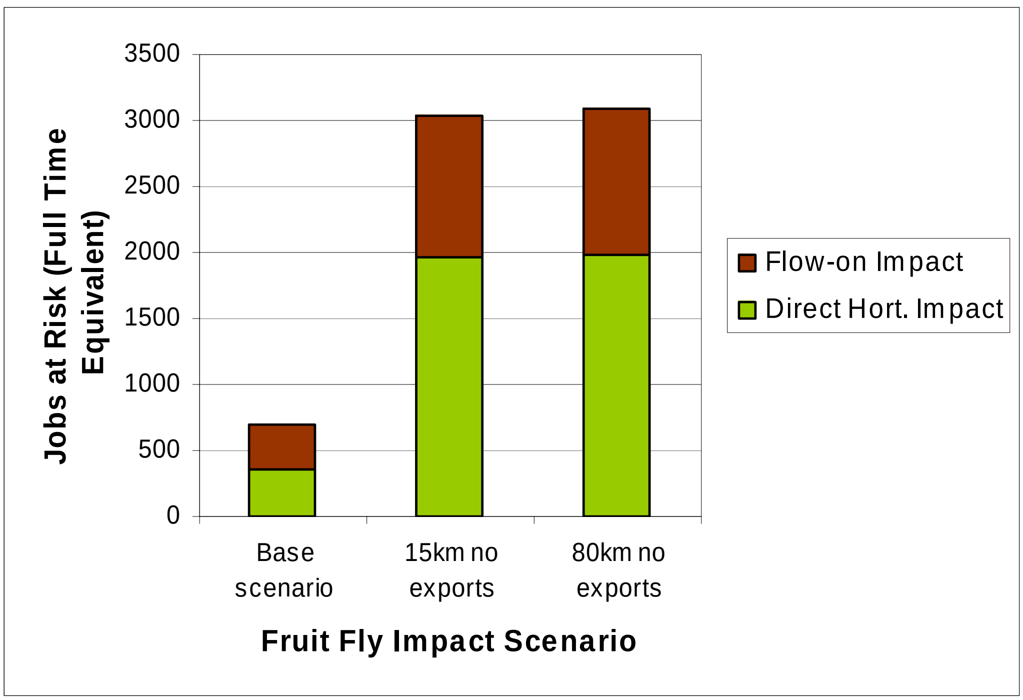
Table 9: Summary of Impacts of Fruit Fly Incursion in the Hawkes Bay Region

Scale of incursion response:	**Direct Impact on horticultural sector ($ millions)**	**Total Impact on Output ($ millions)**	**Total Impact on Employment (FTE jobs)**
Base "1996-Auckland" Scenario	$63.8	$86.0	690 FTE
15 km no-export scenario	$202	$385	3030 FTE
80 km no-export scenario	$204	$390	3080 FTE

Graph 3: Hawkes Bay: Financial Impact of a Fruit Fly Incursion



Graph 4: Hawkes Bay: Employment Impact of a Fruit Fly Incursion



7. NELSON INCURSION IMPACT

7.1 Nelson Horticultural Profile

Nelson is a diverse horticultural district, growing a wide range of produce that could host medfly. Nelson is the second largest apple growing area in New Zealand, producing about 37% of the export crop in 2006 (MAF, 2006). Grapes are grown for local production of wine, with around 3% of New Zealand's 2006 grape tonnage being in Nelson (NZ Wine, 2006). Kiwifruit is grown in the Nelson area for export, with 5% of the 2005 New Zealand export production being from the area (Zespri, 2006).

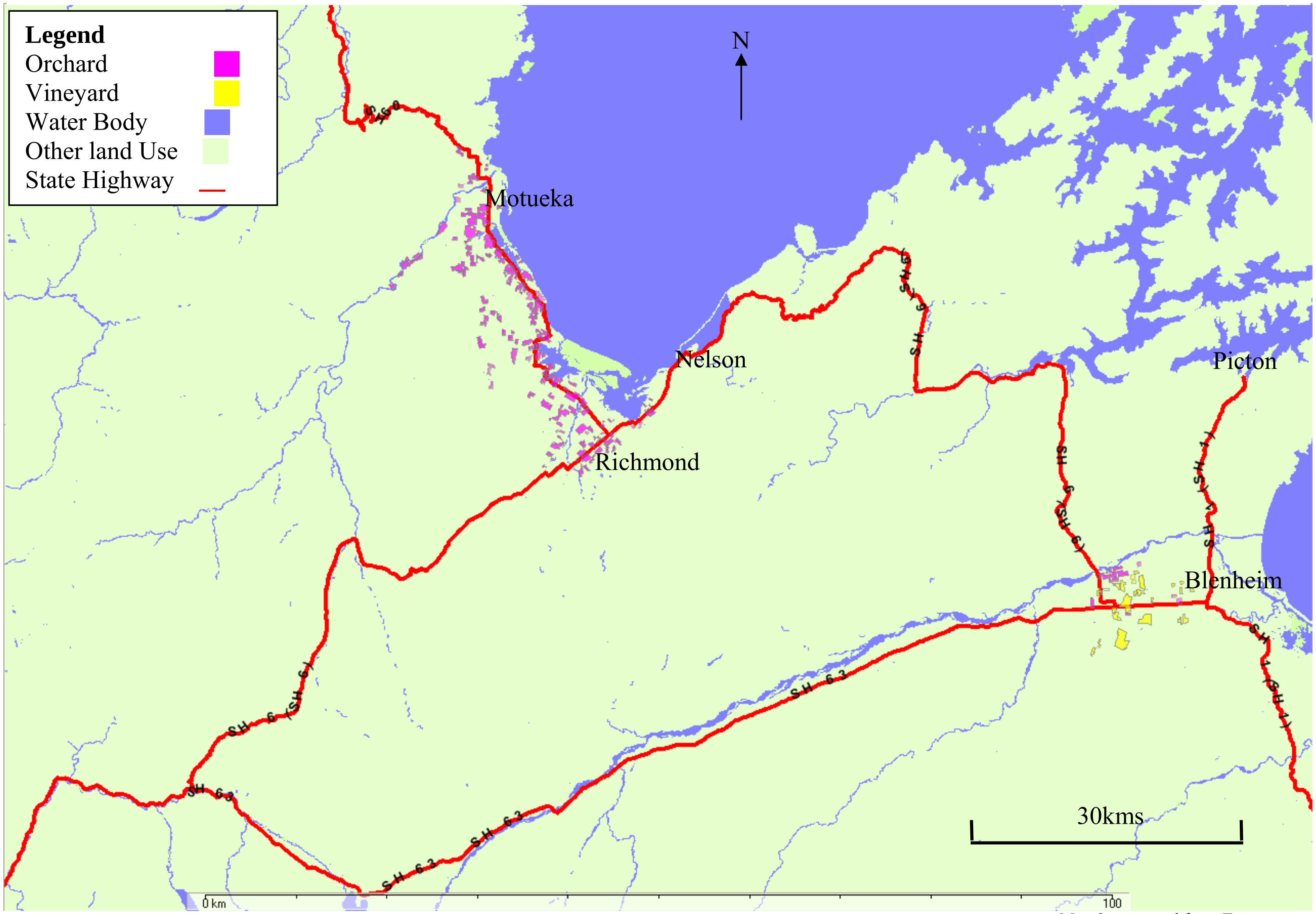
Nelson also produces a small amount of summerfruit, mainly for domestic fresh sale. There are berries, for fresh domestic markets and processed (especially frozen) for export markets. The Nelson region also has small areas of other fruit crops (e.g. citrus, avocados, tamarillos), vegetables, greenhouse vegetables and olives.

Horticultural properties in Nelson are geographically spread around the Waimea Plains, Motueka/Riwaka, Moutere and the coastal area towards Motueka with some over the Takaka Hill in Golden Bay. The Regional map, map 6, shows the distribution of orchards and vineyards and other key features such as roads, the Port and airport. The orchards and vineyards of Marlborough are also shown on the map.

Facilities such as packhouses are spread between those near Nelson/the Waimea Plains and those around Motueka/Riwaka, with a few apples packhouses in the Moutere Hills area. Exported produce mainly departs via the Port of Nelson, close to the city. Some bulk shipments of kiwifruit and apples are made and otherwise most exported horticultural produce is containerised. Coolstores are a mix of those around the region at packing sites and those near the Port. Apples for domestic sale tend to be coolstored locally before distribution. Fresh domestic produce is distributed by truck.

There is an apple processing plant in Nelson which processes most of the apples not suitable for fresh export or domestic sale into juice, slices and purees.

Map 6: Nelson/Marlborough Region Showing Orchard and Vineyard Locations

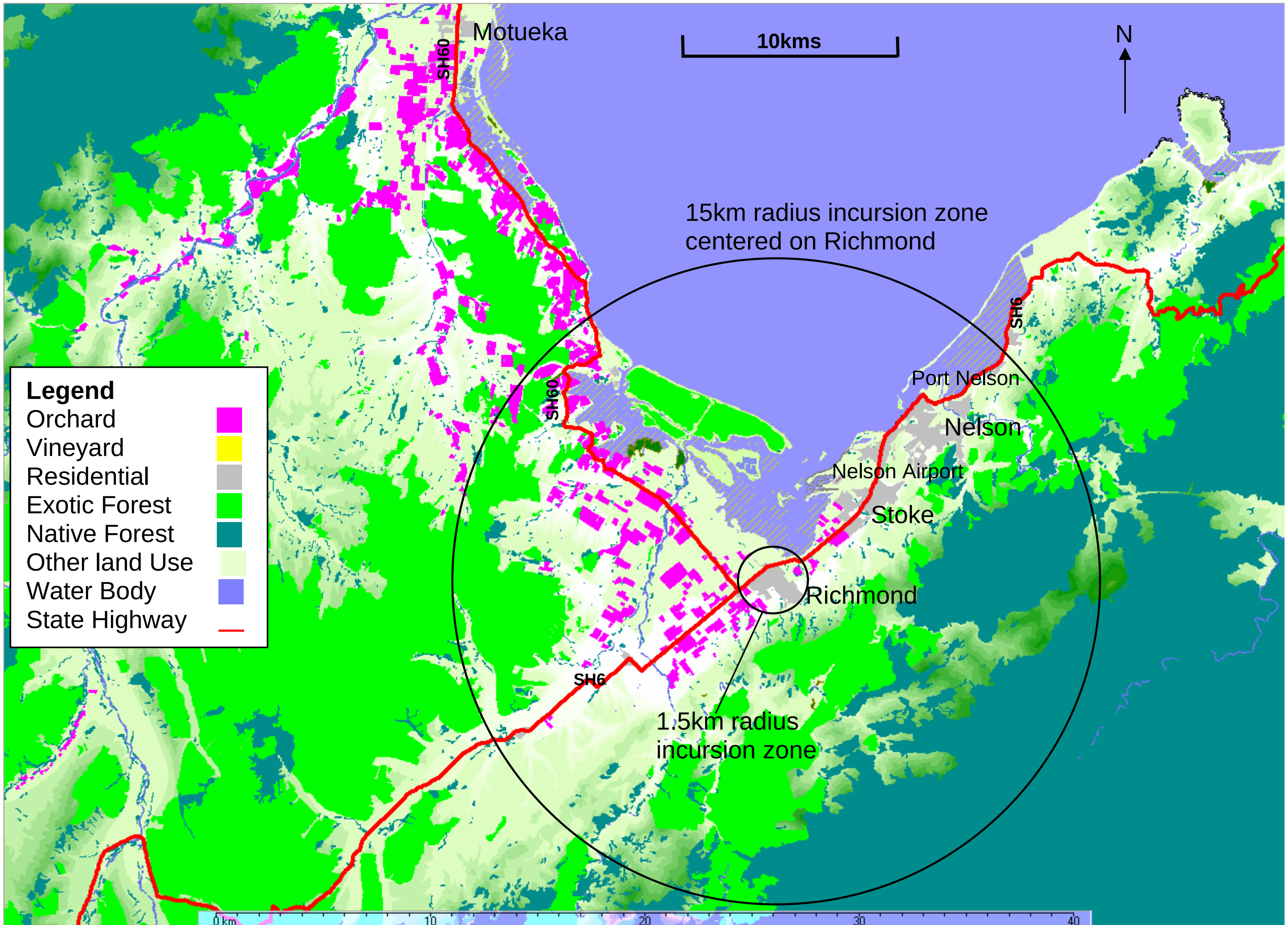


Map data sourced from Tumonz

7.2 Nelson Incursion Base Scenario

The Nelson incursion is modelled to occur in Richmond, an urban area close to Nelson city. The map (Map 7) shows a 15km incursion zone around Richmond, and major roads, the Port, airport and orchards and vineyards.

Map 7: Nelson Scenario Showing Incursion Zones



Map data sourced from Tumonz

7.3 Mitigation Measures for Nelson

The most significant opportunity to mitigate the impact is to manage the New Zealand apple inventory so apples from Nelson are sent to Europe, rather than to markets applying restrictions due to a medfly incursion. Markets applying restrictions could be supplied with product from Hawkes Bay and other regions outside the incursion area such as Central Otago.

Although only around 40% of Nelson orchards fall within the 15km radius incursion zone, the zone includes the Port so produce grown and packed outside the incursion zone could still be excluded from export to sensitive markets via the local Port.

The ability to link packed pipfruit to the orchard it originates from is an aid to proving the origins of the fruit to markets.

7.4 Main Impacts

Apples: The main impact is the undersupply of higher returning apple markets with fruit, due to districts outside Nelson having insufficient volumes of the right varieties and fruit sizes to replace the Nelson product. On total tonnage, these markets could be adequately supplied from other districts but once the variety mix and sizes are taken into account there is a shortfall calculated around 17%. Diverting the Nelson export apples to unrestricted EU markets would increase supply and is calculated to cause a small reduction in revenue per unit from Europe. An additional revenue loss to the pool is factored to account for the impact of disruption and delay at the start of the export season.

Increased shipping costs would occur due to late changes to shipping plans. Transport costs would also increase due to use of insect-proof trucks.

Because most apple exporters operate pools across growing regions, some of the lower revenue and increased costs are calculated to impact growers in other regions.

Kiwifruit: Nelson kiwifruit production comprises 5% of inventory. Directing Nelson fruit to Europe would minimise impacts. Nation-wide inventory is calculated to be sufficient to supply premium medfly-sensitive markets without substantial changes to marketing plans and revenues. Revenue is pooled across product types so the impact is shared with other kiwifruit growing regions. Their fruit being unavailable to premium markets means Nelson growers would not be eligible for a revenue incentive paid for fruit going to premium markets. Nelson fruit would not be able to be exported to Australia, an important market for Class II fruit, so increasing reject rates and reducing revenue. There would be an increase in pool costs, particularly for shipping changes and an increase in handling costs.

Other crops: Other crops would require insect proof transport to their packhouse or processing facility. Those then sold fresh on the domestic market would require distribution in insect proof packaging or transport.

7.5 Losses – Net of Mitigation

Table 10 shows the direct financial impacts calculated for the Nelson incursion total $24.42 million. Revenue lost and costs increased are identified that occur within Nelson and in other districts. About 45% of the impact is calculated to occur in districts outside Nelson due mainly to impacts on apple returns.

Table 10: Nelson Incursion Direct Financial Impacts on Horticulture ($ millions):

Impacts within Nelson:		**Impacts in other NZ Districts:**		**Total Direct Impact:**
Reduced revenue	Increased Costs	Reduced revenue	Increased Costs	Nationwide, revenue losses plus cost increases
$ 8.88	$4.64	$7.56	$3.33	$24.42

7.6 Economic Model Multiplier Effects

Changes in the horticultural sector affect other parts of the local and national economy. Table 11 shows the total losses including these flow-on effects from the Nelson incursion, calculated using the economic model, is $23.73 million. Of this, 42% occurs within the Nelson region. The higher spending required has offset some of the revenue losses. The impact on employment is 175 full time equivalent jobs nationally, 75 being in the Nelson region. About 26% of the loss directly reduces household spending power, shown by the Net Household Income. The Value Added component shows the value created within the region after deducting materials such as fuel and services imported into the region. The Value Added is 50% of the total loss, reflecting the high proportion of local inputs to the horticultural sector.

The high proportion of increased costs from an incursion in Nelson relative to lost revenue contains the net national loss. In other words, other sectors benefit from the extra spending by the horticulture sector by more than they suffer from reduced horticulture sector revenue.

Table11: Nelson Incursion Total Impact on Regional and New Zealand Economy (including flow-on effects):

	Output/ Revenue ($ millions)	**Employment (Full Time Equivalents = FTE)**	**Net Household Income ($ millions)**	**Value Added/ Gross Regional Product ($ millions)**
Net Loss within the Nelson Region	$10.07	75 FTE	$2.69	$4.53
Net Loss for all NZ	$23.73	175 FTE	$6.28	$11.94

Further detail of the outputs of the economic model is in Appendix III, including detailed figures for the Nelson region and an explanation of the model and terms used.

7.7 Worse Impact Scenarios

7.7.1 15km Radius No-export Zone

The main difference for a 15km no-export zone around the Nelson model incursion site is the loss of export markets for fruit fly host produce, particularly apples and kiwifruit. In the base scenario this produce could be directed to markets in Europe not applying restrictions to a fruit fly incursion. This greatly increases the lost revenue, as around 35% of the New

Zealand apple crop and 5% of the kiwifruit crop is produced in the Nelson region. Because the Port of Nelson falls within the incursion zone exports from the whole region are calculated to be affected. Costs would also increase due to issues like excess shipping space having to be on-sold at a discount. Domestic and processing markets would be nowhere near able to absorb the volume of fruit potentially available or to provide returns to cover the handling costs let alone be comparable to export market returns.

The estimated direct impact of this scenario on the horticultural industries is $133 million.

The multiplier figures from the economic model indicate the total impact, including the flow-on effects on other parts of the economy is $267 million loss of output and 1,945 Full Time Equivalent jobs at risk. Around 10% of the financial and employment impacts would occur in regions outside Nelson.

7.7.2 80km Radius No-export Zone

For Nelson, prohibition of exports of fruit fly host produce from an 80km incursion zone around Richmond has much the same result as for a 15km no-export zone, as export produce was already calculated to be affected due to the Port of Nelson being inside the 15km radius incursion zone. The 80km zone would cause additional costs to be incurred for more domestic market produce suppliers. Otherwise, the impact is much the same as the impact of a 15km radius no-export zone.

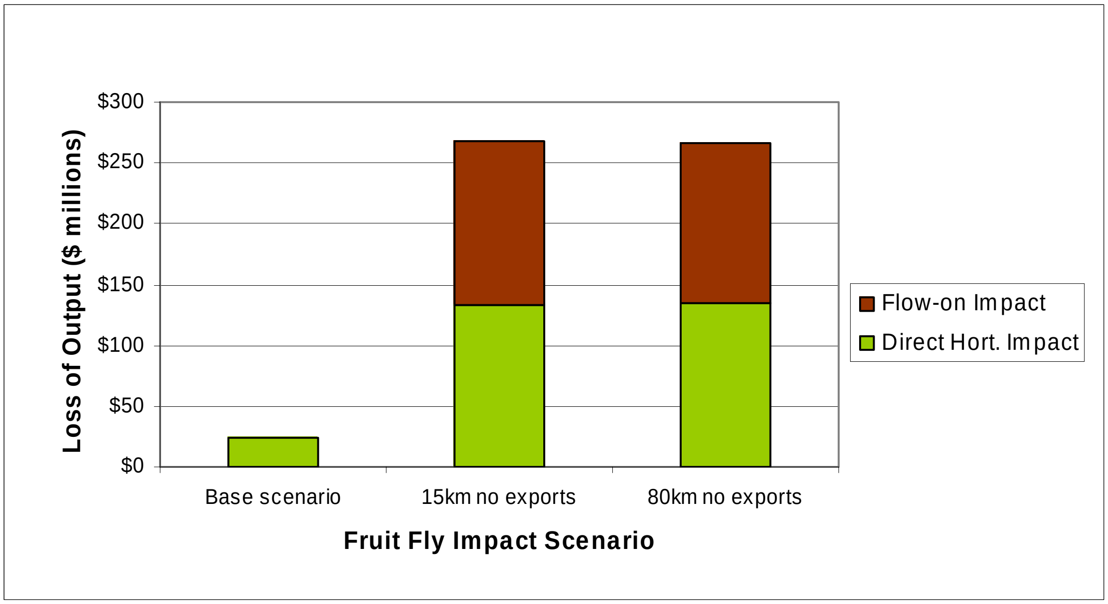
7.7.3 Nelson Summary

The results of this study for the Nelson area are summarised in table 12 and graphs 5 and 6 following.

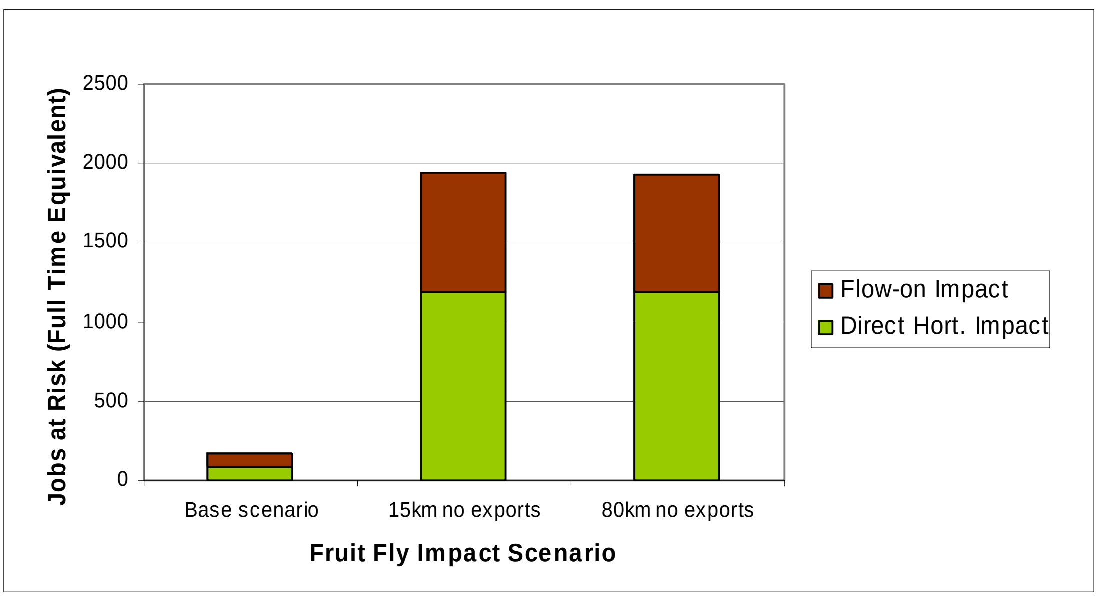
Table 12: Summary of Impacts of Fruit Fly Incursion in the Nelson Region

Scale of incursion response:	Direct Impact on horticultural sector ($ millions)	Net Impact on NZ Output ($ millions)	Net Impact on NZ Employment (FTE jobs)
Base "1996-Auckland" Scenario	$24.4	$23.7	175 FTE
15 km no-export scenario	$133	$267	1945 FTE
80 km no-export scenario	$134	$265	1935 FTE

Graph 5: Nelson: Financial Impact of a Fruit Fly Incursion



Graph 6: Nelson: Employment Impact of a Fruit Fly Incursion



8. OVERVIEW OF REGIONAL IMPACTS

Horticultural districts are inter-linked. This occurs through the crops grown, markets, the exporters and other service providers used. In this analysis, a key way to reduce overall losses is to manage inventory so produce from unaffected districts is sent to markets applying restrictions due to the pest incursion.

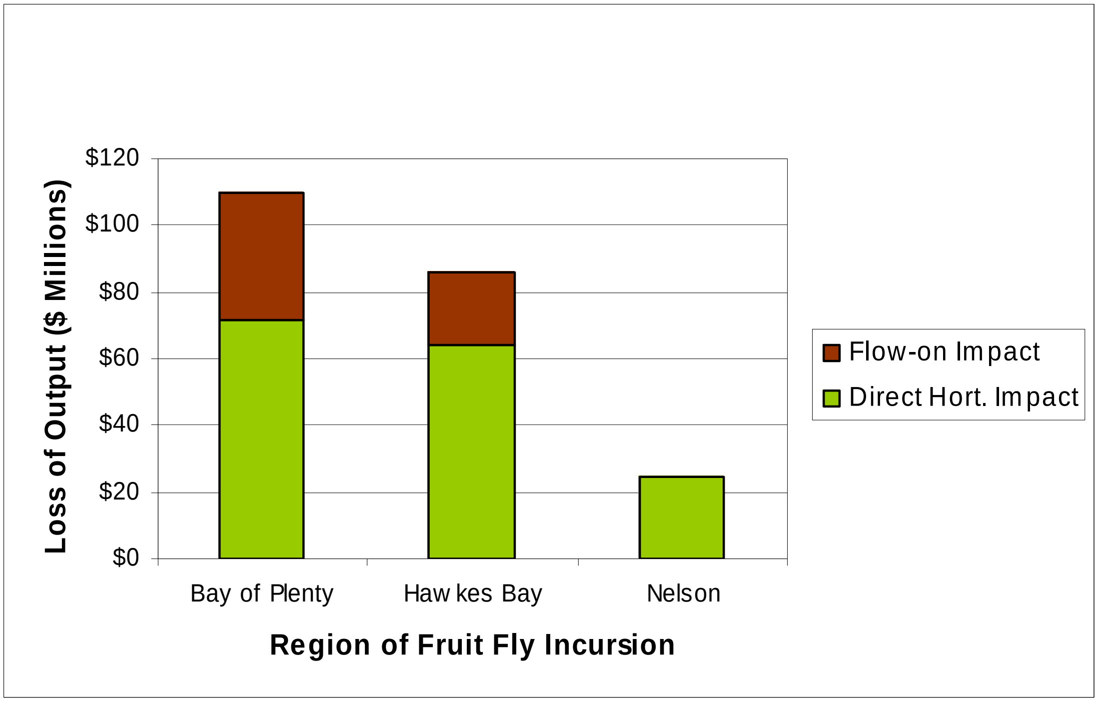
Grower returns for some produce are pooled. This applies particularly to exports of kiwifruit, often to apples and avocados and also to some other crops. A pool may be for a portion of a season, for a whole season, a variety or a product type (like organically grown produce). Having such pools is an aid to managing an incursion as there would be a good ability to manage the product inventory to minimise overall impacts. Pooled returns spread returns across districts, so growers in districts outside an incursion would be affected through their payment pools. This would be in addition to impacts on produce markets following an incursion, such as depressed local market prices due to higher volumes, which would be caused by produce ineligible for export being diverted to the domestic market.

Hawkes Bay has the most geographically concentrated horticultural production base, as was shown in the regional map in Map 4. Nelson and the Bay of Plenty horticultural properties are spread over a greater area, so less of their regional production base is affected by a 15km radius incursion zone.

8.1 Base Scenario – "1996 – Auckland" Incursion in other Regions

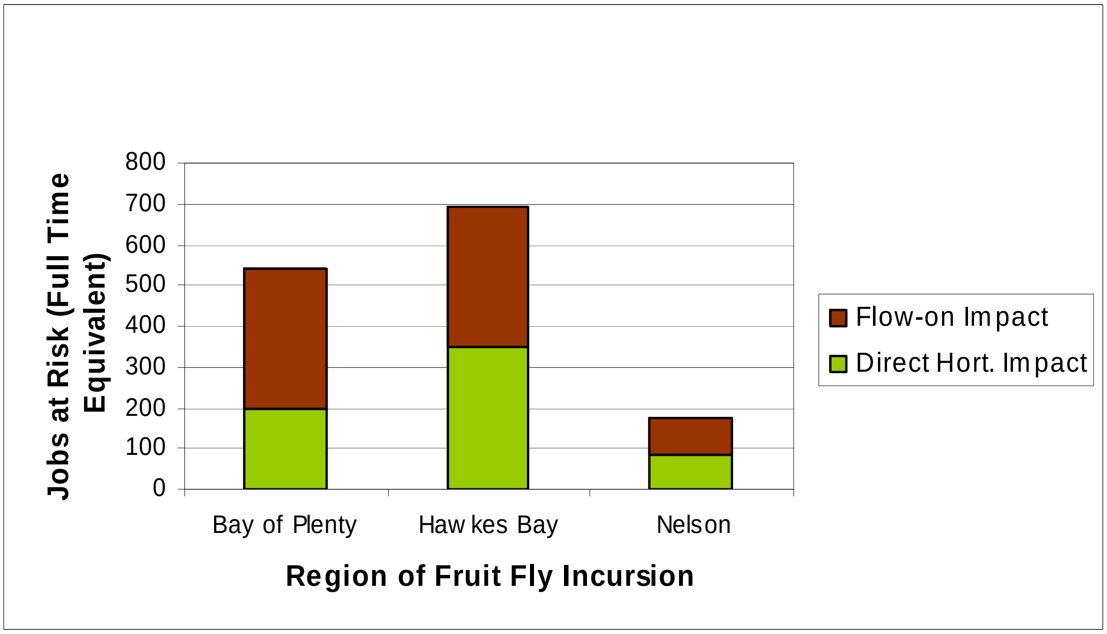
The graph following (Graph 7) indicates the financial impact of a fruit fly incursion, the nature of the 1996-Auckland medfly incursion, in the Bay of Plenty, Hawkes Bay or Nelson. In all three regions, horticulture bears the brunt of impacts. There are considerable flow-on impacts on other parts of the local and national economy in the Bay of Plenty and Hawkes Bay. In Nelson, flow-on gains from additional spending offset flow-on losses. Graph 7 shows the greatest financial impact from this type of incursion would occur in the Bay of Plenty and Graph 8 shows the greatest employment impact would occur in Hawkes Bay.

Graph 7: Financial Impact of "1996-Auckland" Medfly Incursion in Study Regions



The employment impact of the incursion modelled is greatest in the Hawkes Bay, as shown in the following graph (Graph 8). Hawkes Bay has the largest number of jobs at risk in the horticultural sector and in other sectors.

Graph 8: Employment Impact of "1996-Auckland" Medfly Incursion in Study Regions



8.2 Summary of the Three Scenarios Studied in the Three Regions

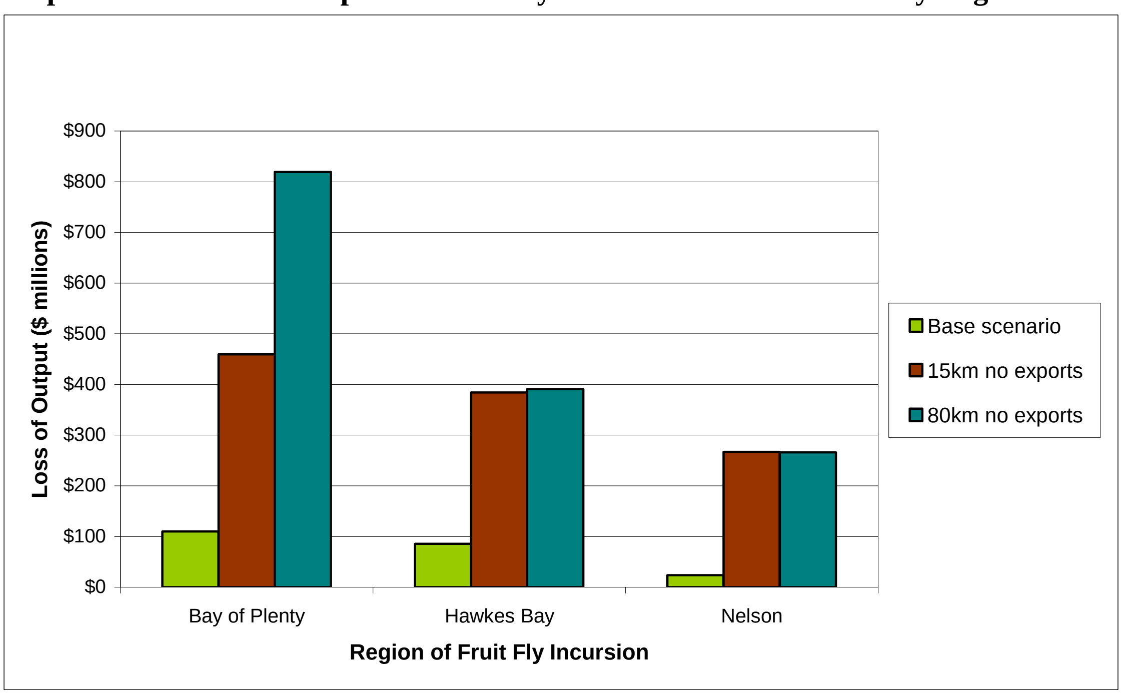
Financial Impact – Net Nationwide Loss of Output

Graph 9 shows the total net financial loss to New Zealand from a fruit fly incursion for the 3 impact scenarios studies. The greatest loss would be in the Bay of Plenty, followed by Hawkes Bay and then Nelson. This is due to the size of the kiwifruit industry and its concentration in the Bay of Plenty. Losses in each of the major apple growing districts of Hawkes Bay and Nelson are contained in the base scenario by managing the apple inventory nation-wide.

For an incursion preventing exports of fruit fly host material from a 15km radius zone around the incursion site the impact is greatly increased for all three study regions.

For both Hawkes Bay and Nelson the impact of an 80km radius no-export zone is not much different from the impact of a 15km radius no-export zone, but for different reasons. In Hawkes Bay, the horticultural activity affected by fruit fly is largely concentrated within 15km of the Hastings incursion site modelled. Thus, the additional horticultural production affected by a larger incursion zone is not substantial. In Nelson the horticultural production is more spread around the district. However, the incursion site modelled at Richmond is within 15km of the Port of Nelson used for exports from the region. Thus, the 15km radius no-export zone in effect prevents most exports from the larger area because the local Port is not available for export produce and more distant Ports are impractical to rapidly access.
In the Bay of Plenty, the impact is progressively larger as the size of the incursion zone increases. This is because the main export Port at Tauranga is outside the 15km radius incursion zone and the area in horticultural production is spread across the coastal Bay of Plenty area.

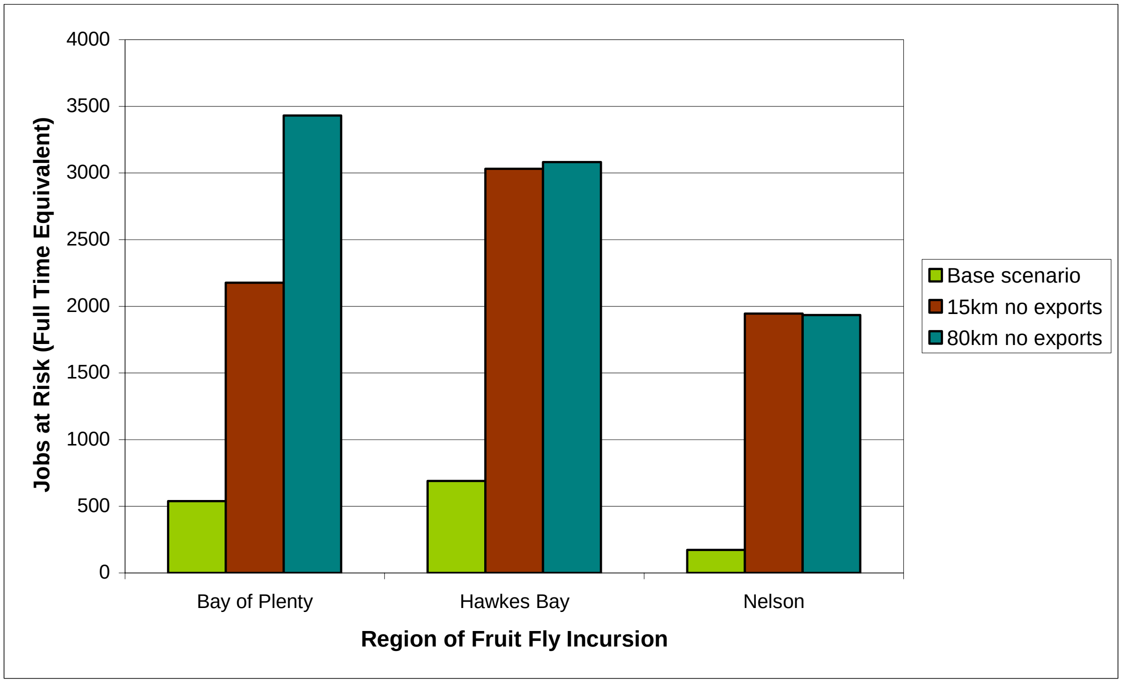
Graph 9: Financial Impact of Fruit Fly Incursion Scenarios in Study Regions



Employment Impact

The following graph (Graph 10) shows the employment impact from the three fruit fly impact scenarios in each of the three study regions. The impact on jobs is greatest in Hawkes Bay for the base "1996-Auckland" scenario and for the 15km no-export zone. The employment effects are greatest in the Bay of Plenty for the 80km radius no-export zone.

Graph 10: Employment Impact of Fruit Fly Incursion Scenarios in Study Regions



9. INCURSION REPONSE AND DISINFESTATION PROCEDURES – SOME LITERATURE FINDINGS

Market responses to pest incursions are not standardised or pre-determined. In this section, some incursion responses, market access protocols and disinfestation procedures are discussed.

The immediate response to reports of a new pest is typically to suspend import of products that may bring the pest with them. This may be confined to a local area as is modelled in this report or be extended to the entire source region or country.

As more information about the pest incursion is developed, an initial emergency response may be scaled down. For example, Australia initially applied sanctions to an 80km radius zone around the 1996-Auckland medfly incursion but reduced the radius to 15km as the localised nature of the incursion became apparent.

An example of an emergency response is the United States (US) response to a medfly incursion in parts of neighbouring Mexico in 2004. The US required all Mexican produce that could host medfly being commercially exported to the US to have a phytosanitary certificate and declaration that it did not originate from and "was not packed in or transported through" the incursion area (Challis, 2004). Produce personally brought into the US from Mexico was being confiscated at the border and extra resources were assigned to doing this and testing then destroying the confiscated produce (Cross, 2004). The US has also recently extended their internal quarantine area for dealing with medfly in California on an emergency basis (Shea, 2006). Produce movement is restricted and treatments are required within the specified quarantine areas to help combat the medfly (Shea, 2006; Uwanawich, 2006).
As found in the previous study, the impact of the 1996 medfly incursion in Auckland's Mount Roskill area was well contained. An incursion that was detected at a later stage would have a more substantial impact. One example of a larger incursion is the Australian incursion of Papaya Fruit fly which was detected in 1995 in north Queensland. An eradication programme began within 10 days of the pest being detected in October 1995, and the last pest was detected in July 1997 (Cantrell et al, 2002). Provisional eradication was declared in August 1998 and the eradication programme was formally closed in June 1999, nearly 4 years after the pest was detected. The peak area over which the eradication programme operated was 78,000 km^2 (DPI, 2005), which is the equivalent area of a circle of radius approximately 157km. The Interstate Certification Assurance programme to allow movement of host produce from Queensland to other states began operating on 19 July 1996, 9 months after the pest was detected. Domestic produce movement did occur before the Interstate Certification Assurance scheme began operating, although there were some restrictions and the cost of access was increased by treatments required to control Papaya fruit fly.

The Government cost to eradicate the Papaya fruit fly in Queensland was $A 34 million over the 4 years of the eradication programme. It was a huge programme, with nearly 64,000 fruit samples collected, 3 million lure/insecticide blocks used and more than 3 million vehicles stopped at roadblocks.

Factors that contained the impact of the incursion were (DPI, 2005):

- Growers were already managing their crops to deal with other species of fruit fly so needed to adjust rather than introduce fruit fly control programmes
- There was a long research history into fruit fly including local scientists with international expertise in the group of pests
- Once the incursion was detected, control action was quickly taken to determine the extent of the incursion, control movement of fruit from the incursion area and to eradicate the pests.
- The incursion was found at the start of the key breeding season in October.

Later analysis indicated that the pest may have been around for over a year before it was first detected. It was detected after a grower observed his pawpaw were being attacked by fruit fly at an earlier stage of fruit maturity than was usual, who followed up to identify why this was occurring.

Where a country wants to export produce that may bring with it pests not wanted in the importing country, a market access protocol may be developed. This is a long term process, not always successful and usually taking a minimum of several years or into decades.

A multi-pronged 'systems approach' is typically used to develop these market access protocols. Where there is medfly (or another pest) present in a country, exporting may still occur, with procedures worked out to contain the likelihood of the pest spreading with the host produce exports. Mediterranean fruit fly commands strict procedures. For example, the level of security the US Department of Agriculture (USDA) targets in their medfly protocols is very high, requiring a likely survival rate of less than 0.0032% of pests (Shea, 2004).
An article discussing the then-proposed resumption of trade in avocados between Mexico and the United States outlined the systems approach being designed to reduce the likelihood of pests arriving in the avocados due to be imported to the US (Strollo, 1997). The systems approach had 9 components:

1. Host resistance (how likely the crop is to be infested with the particular pest)
2. Field surveys for the pests in the vicinity of the orchards growing for export
3. Trapping and field baiting of pests
4. Field sanitation e.g. removing windfall fruit that may host pests.
5. Post harvest safeguards, such as covering bins of picked fruit and pest-screens on packhouse entrances.
6. Seasonal supply – so that the produce is only shipped during times of year when any pests would be unlikely to survive and reproduce.
7. Packhouse fruit inspection, including destructive sampling.
8. Inspection at the Port of arrival.
9. Limiting distribution in the importing country to areas unlikely to provide suitable conditions for the pest to survive and reproduce.

Each component specified for a protocol brings with it a requirement to document or verify operation of the protocols. Mexican avocados are now sold to the US after decades of being excluded due to pest issues, including fruit fly species.

Where a protocol is established, it may later be extended to other source countries or types of produce. For example, one strategy in the US to prevent medfly larvae arrival in imported tomatoes from specified Central American countries has been to allow importation only of green tomatoes as they are not ripe and therefore not as attractive to medfly. It is proposed to extend imports to ripening pink and red tomatoes using additional measures to exclude medfly (Shea, 2006a). The proposed requirement for the riper tomatoes includes fruit being grown in a proven medfly-free area then packed into insect–proof packaging. Requirements for tomatoes grown in an area known to harbour medfly are more stringent. They must be grown in an insect screened greenhouse, with monitoring traps for medfly in and around the greenhouse and be packed promptly in an insect-screened packhouse into insect proof packaging. Specific details include how often the monitoring traps must be cleared, notification of any medfly found in the traps, documentation and verification of the procedures adopted. Regular involvement of the exporting country's National Plant Protection Organisation is required. These measures are designed to exclude medfly from the produce being shipped.

Such "exclusion" measures may be augmented by treating produce to kill any eggs or larvae in it. For example, medfly and Queensland fruit fly are each established in various parts of Australia. Citrus exported to India from Australia must be inspected and shown to be free from the pests. In addition, the fruit must either be from an area free of the pests or have undergone disinfestation via cold treatment or fumigation in Australia before export (AQIS, 2001). The pre-shipment treatments are specified. The cold regime against medfly is given for three temperatures, with the options being:

Temperature:	Duration:
0 °C or below	10 days
0.55 °C or below	11 days
1.1 °C or below	12 days

For cold treatment against the Queensland fruit fly, the time specified is 3-6 days longer. The US used the same medfly cold temperature treatment on imported citrus until 2002. The regime was revised following findings of live medfly larvae in cold-treated Clementine mandarins imported from Spain in 2001 (Fernandez, 2002). There was no evidence that the cold treatment regime had not been accurately applied. The US Department of Agriculture commissioned a literature review of cold treatment against medfly (Fernandez, 2002). The expert panel conducting the review recommended increasing the duration of cold treatment by 2 days (APHIS, 2002). Their recommendation was largely accepted but durations shorter than 14 days were removed from the treatment options adopted by the USDA. In addition to the cold treatment, US inspectors now cut open a sample of the fruit upon arrival in the US (Shea, 2004). The revised options for cold treatment against medfly adopted by the USDA in October 2002 are:

Temperature:	Duration:
1.1 °C or below	14 days
1.6 °C or below	16 days
2.2 °C or below	18 days

The review panel considered that cold treatments may fail when medfly larvae numbers were high, but was not able to specify what that level of larval infestation was. They also recommended the cold treatment be tested for effectiveness for different citrus varieties and different wild strains of medfly.

Variation in effectiveness of treatment between different varieties of a particular fruit does occur. In Australia, research on a heat treatment against Medfly and Queensland fruit fly for the mango variety 'Kensington' led to exports of that mango variety to Japan being allowed (Corcoran et al, 2002). Further research was done to validate the treatment for other varieties of mango and it was proven effective for 4 further varieties of mango (Corcoran et al, 2002). There were differences in effectiveness between varieties, but the treatment level determined for the 'Kensington' variety was also effective in the further 4 varieties.

Identification of the genetic strain of medfly causing a particular incursion is possible, which could help to validate an existing disinfestation technique for use in response to a particular incursion. Use of sophisticated analysis has helped to identify likely sources of pests found in New Zealand (Stewart, 2006). For example, during the painted apple moth eradication programme in New Zealand, genetic analysis was able to indicate whether moths found were new arrivals or from breeding locally. Also, molecular analysis can now indicate where larvae developed by comparing their composition to water and vegetation at locations where the pest is known to occur. This is helping to identify likely means that the pest came to New Zealand.

These techniques provide some ability to reassure markets about treatment regimes by indicating the genetic strain of a fruit fly, and therefore whether established treatment regimes may be validly applied.
The cold storage treatments against medfly described above for citrus are also used for other crops. The USDA lists countries and crops they allow to use the cold treatment regime against medfly above (Fernandez, 2002). The crops listed that are grown commercially in New Zealand are apples, pears, citrus, summerfruit, kiwi[fruit], grapes and persimmons. The USDA allows the cold treatment to be applied during shipping, provided specified steps are taken to protect the integrity of the temperature monitoring regime. The USDA also use the cold treatments for produce from their state of Hawaii, where medfly is long established, and for produce from quarantined areas in mainland USA which are subject to an incursion of medfly.

For less known crops such as feijoas, passionfruit and tamarillos exported from New Zealand, it is unlikely disinfestation regimes will be developed overseas. For more perishable crops like berries, the short product life works against developing disinfestation procedures. For some tropical crops, heat treatment methods have been developed (Corcoran et al, 2002; Laidlaw, 2001) but the temperatures are too high for the sub-tropical and temperate crops exported from New Zealand.

The temperature regimes detailed above fit well with the usual storage temperatures and shipping times to market for the major New Zealand export crops of apples and green kiwifruit. Both products are usually cooled below the lower end of the temperatures specified and shipping duration is usually longer than the minimum times specified. For Hort16A gold-fleshed kiwifruit, the storage temperature is sometimes higher than is required for medfly cold treatment.

10. DISCUSSION

The horticultural sector has undergone significant growth, with fresh fruit the largest sector among the $2.3 billion exports in 2005 (Kerr et al, 2005). The total value of New Zealand's horticultural industry is estimated at $4.8 billion annually. Much of this is produce that would be affected by fruit fly.

Individual passengers, particularly those travelling by air, are the most likely means of starting a new incursion of fruit fly by bringing with them an undeclared piece of fruit that appears sound but contains fruit fly eggs or nearly mature larvae.

Passenger clearance is the first line of defence against pest fruit fly species being brought into New Zealand by individual travellers. The x-ray technology introduced since 1996 has been a good aid to detecting undeclared risk goods such as fruit brought in by airline passengers. Compulsory screening of all international passenger luggage was introduced in 2001 (Stewart, 2006a). The increase in use of detector dog teams has also been a positive step. In 2005, around 3% of airline passengers had undeclared risk material (Newsroom, 2006) and over 28 tonnes of fresh fruit and vegetables were seized (Stewart, 2006b). The worst group by nationality was New Zealanders at around 30% of offences (SONZAF, 2005). The second highest group of offenders for undeclared risk goods was Chinese nationals (Newsroom, 2006). This may reflect a high number of students among this group. MAF's Biosecurity Monitoring Group estimates 75 – 90% of the biosecurity risk goods arriving at Auckland, Wellington and Christchurch airports are being detected (Stewart, 2006b).

The amount of overseas travel is increasing. A recent article on tourism highlighted a 26% increase in New Zealanders travelling overseas in the 2 years from 2004 to 2005, with 1.86 million trips overseas recorded in 2005 (Cropp, 2006). Overseas travel has increased in cost relatively less than the cost of domestic travel, which has encouraged more overseas holidays by New Zealanders. Most popular travel destinations were Australia, then Fiji, the Pacific Islands, the USA and United Kingdom (Cropp, 2006). Australia has a range of pest fruit fly species, including medfly primarily in Western Australia and Queensland fruit fly, mainly in some eastern states. Some Pacific Islands have pest fruit fly species. Hawaii in the USA has medfly, although most of mainland USA does not have serious fruit fly pests.

The high proportion of seizures overall and the high proportion of New Zealanders offending may reflect the relatively casual status of overseas travel in the age of the discount airline. Many New Zealanders have close relatives living overseas, especially in Australia, which increases the number of trips overseas for family reasons.

More regional airports have proposed becoming international airports. This would increase the number of passenger entry points and their proximity to major horticultural areas. It is important that any additional international airports have passenger clearance systems at the highest level to reduce the chance of undeclared risk material escaping detection.

Commercial produce imports to New Zealand are subject to risk assessment, import health standards and border inspections. Internationally, imports under a system structured like that are seldom a source of new fruit fly infestations. However, larvae of fruit fly was found in New Zealand in 2006 in commercially imported produce from Australia (Orchardist, 2006) and in California in 2001 as discussed in section 9.

MAF funds a fruit fly surveillance programme with traps baited with attractant lure and an insecticide placed in 3,500 key areas (Stewart, 2006c). These target particular fruit fly species, including medfly and Queensland fruit fly. This trapping network is vital to prove New Zealand's continued freedom from pest fruit flies. It is also vital to detect early any fruit flies that could form a breeding population. The trapping network revealed the medfly incursion in Auckland in 1996. It was discovered early enough to be able to contain the impacts to a limited geographical area and to quickly eradicate the pest. However, this report shows that even a small incursion like occurred in Auckland would cause substantial losses in a major horticultural area.

The trapping programme was described in the 1998 report as costing MAF around $1 million annually. That figure still appears to be fairly current, with the programme also described in the review of New Zealand's Biosecurity Surveillance Systems (Pearson, 2002) as costing approximately $1 million annually. That review concluded that the fruit fly programme provides a core infrastructure capability and "appears to be well documented and robust." The review expressed concern that the programme cost "consumes a significant proportion of MAF's plant biosecurity budget, leaving other areas under-resourced." Biosecurity New Zealand notes that adult medfly are unlikely to be found during an incursion except in lure traps (BNZ, 2006). Therefore, should an incursion occur, it will only be noticed through the monitoring trap network or a very observant neighbour noticing unusual larvae in fruit from their backyard trees. Without the monitoring trap network, an incursion is likely to be well established before it is detected. Monitoring traps are an important on-going activity in other countries. A monitoring trap network is operating in the Pacific Islands (SPC, 2004). Countries that have medfly spend considerable government funds to contain or attempt to eradicate the pest. For example, the programme to eradicate medfly from Chile cost around $US 50 million (IAEA, 1997) and the exclusion programme in Southern California in the US was budgeted to cost $US 15 million annually in 1996 (CDFA, 2005). The Californian programme was for an area of 2,155 square miles. That is the equivalent of 5,580 square kilometres, the area in a circle of radius 42 kilometres. The cost to MAF to eradicate medfly in Auckland in 1996 was estimated at $5 million, which did not include all personnel time. This cost would be higher in a major horticultural area or for a larger or more prolonged incursion.

This analysis shows the dominant issue from an incursion would be the loss of export markets for New Zealand produce. Similarly, a study of California in 1999 found that if medfly became established, the main impact would be the predicted loss of around 60% of Californian exports, based on embargoes by countries sensitive to medfly, particularly in Asia (Siebert, 1999). In addition, growers were predicted to incur an additional 3-6.5% in production costs for medfly control.

11. ABBREVIATIONS

EU	European Union
FOB	Free on Board
FTE	Full Time Equivalent
MAF	The New Zealand Ministry of Agriculture and Forestry
Medfly	Mediterranean fruit fly, scientific name *Ceratitis capitata.*
SIT	Sterile Insect Technique

TCE	Tray Carton Equivalent, the standard unit of volume for apples of 18.5kg, based on the original "bushel" unit.
Tray	The standard unit of volume for kiwifruit exported from New Zealand, equivalent to 3.5 kg and based on the original single layer tray unit.
US	USA: United States of America.

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Any errors or omissions in the report remain the responsibility of the author.

13. REFERENCES

AIC, 2006: *Annual Report Statistics 2005/06* Avocado Industry Council

Anon. 2006: *MAF launches regional pest management website.* Biosecurity New Zealand Issue 68, June 2006

Anon. 2006: *Better Border Biosecurity: helping defend New Zealand's border against foreign pests.* Biosecurity New Zealand Issue 68, June 2006

APHIS, 2002: *Evaluation of cold storage treatment against Mediterranean Fruit Fly, Ceratitis capitata* (Wiedemann) (Diptera:Tephritidae) United States Department of Agriculture, Animal and Plant Health Inspection Service, May 2, 2002.

AQIS, 2001: *Phyto – Restriction Detail India*. Australian Quarantine and Inspection Service. (last updated 30 January 2006) http://www.aqis.gov.au/phyto/asp/ex_restriction.asp

Armstrong, Dr Karen. 2006: *Trans-Tasman collaboration for Better Border Biosecurity: Distance diagnostics the goal* Biosecurity New Zealand Issue 68, June 2006

Biosecurity New Zealand, 2002: Data Sheet for *Ceratitis capitata*

Biosecurity New Zealand, 2006: Mediterranean fruit fly http://biosecurity.govt.nz/pest-and-disease-response/pest-and-diseases-watchlist/mediterranean-fruit-fly

Cantrell, Bryan; Chadwick, Blair; Cahill, Anna. 2002: *Fruit Fly Fighters*. CSIRO Publications, extract via http://www.publish.csiro.au/pid/3063.htm

CDFA, 2005: *Background of Mediterranean Fruit Fly Exclusion Program.* California Department of Food and Agriculture http://www.cdfa.ca.gov/phpps/pdep/prpinfo/pg1.html

Challis, S. 2004: *Battling the Mediterranean Fruit Fly – CBP is Winning* Customs and Border Protection Today December 2004

Corcoran, R.J.; Peterson, P.M.; Heslin, L.M.; Eelkema, M.; Jen, E.V. 2002: *Study of the Response to Heat of Queensland Fruit Fly in Mangoes Allows Additional Varieties to be Exported to Japan.* Acta Horticulturae 575 (ISHS) 575:673-679 (Abstract) http://www.actahort.org/books/575/575_79.htm

Cropp, Amanda. 2006: *Not so close to home.* Listener 24 June 2006

Cross, E. 2004: *Mediterranean Fruit Flies Attempt to Sneak In – Again* Customs and Border Protection Today October/November 2004

Dekker, Laurel. Messing, Dr. Russell. Undated. *Introduction to Managing Fruit Flies in Hawaii.* HITAR Brief No. 114 http://www.exteno.hawaii.edu/kbase/reports/fruit_pest.htm

DPI: Queensland Department of Primary Industries, February 2005: *Winning the War against the Papaya Fruit Fly.* http://www2.dpi.qld.gov.au/health/4639.html

Fernandez, Peter. 2002: *Cold treatment of fruits.* Federal Register October 15, 2002 Vol: 67 No: 199 United States Department of Agriculture, Animal and Plant Health Inspection Service http://ceris.purdue.edu/fr_archive/0210/15/0000.html

Gereben, A.; Woolford, I. 2003: *The Macroeconomic Impacts of a Foot-and-Mouth Disease Outbreak.* Feb 2003 Reserve Bank of New Zealand

GBIF, 2006: *Biodiversity Data Portal Species: Ceratitis capitata (Wiedmann, 1824)* Global Biodiversity Information Facility
http://www.asia.gbif.net/portal/ecat_browser.jsp?taxonKey=220051&countryKey=0.htm

HBRTS, 2004: *Hawke's Bay Regional Traffic Study*
http://www.hastingsdc.govt.nz/strategic/transport/strategy.htm

HPC, 1991: *The Impact of Fruit Flies on Australian Horticulture.* Horticultural Policy Council (Aust) Industry Report No 3 1991

IAEA, 1997: *Defeating the Medfly.* International Atomic Energy Agency Technical Cooperation – Building Development Partnerships brochure.
http://www.iaea.org/Publications/Booklet/UndpBook/undp.html

IAEA, 2000: *Consultants Group Meeting on Rational Supply of Sterile Flies for Medfly SIT in the Mediterranean Basin.* International Atomic Energy Agency Summary of Meeting in Vienna, Austria, August 2000 D4-00CT07603

Journal of the American Medical Association 1999 *Surveillance for Acute Pesticide-Related Illness During the Medfly Eradication Program.* 15 December 1999 Vol. 282 No.23
http://www.safe2use.com/ca-ipm/0099-12-17a.htm
http://jama.ama-assn.org/cgi/search?fulltext=Medfly

Kerr, J.P.; Hewett, E.W.; Aitken, A.G. 2005: *Fresh Facts New Zealand Horticulture* 2005 HortResearch Publication

Kiwifruit New Zealand 2004: *Kiwifruit Sector a Major Contributor to the Economic Vitality of the Bay of Plenty.* November/December 2004

Laidlaw, Wm. G. 2001: *Quarantine Heat Treatments of Fruit.*
http://www.ucalgary.ca/~laidlaw/quarantine/quarantine.html

Lincoln University Financial Budget Manual 2006

MAF, 2005: *Horticulture Monitoring Report* Ministry of Agriculture and Forestry
http://www.maf.govt.nz/mafnet/rural-nz/statistics-and-forecasts/farm-monitoring/2005/horticulture.htm

MAF, 2005: *North Monitoring Report July 2005* Ministry of Agriculture and Forestry

MAF, 2006: *Pipfruit Monitoring Report April 2006* Ministry of Agriculture and Forestry

Newsroom, 2006: *Kiwis, Chinese Worst for Biosecurity Breaches* in Fruitnews, Te Puke Fruitgrowers Association Inc newsletter, June 2006.

NZ Winegrowers, 2006: *2006 Vintage Survey results.*

Orchardist, 2006: *Find of Fruit Fly Eggs Alarms HortNZ.* The Orchardist Magazine, October 2006

Pearson, 2002: *An Independent Review of New Zealand's Biosecurity Surveillance Systems* report for Biosecurity New Zealand http://www.biosecurity.govt.nz/pests-diseases/surveillance-review/plants.htm

Siebert, Jerry. 1999: *Update on the Economic Impact of Mediterranean Fruit Fly on California Agriculture.* Subtropical Fruit News 1999 Vol: 7 No: 1

SONZA, 2005: *Situation and Outlook for New Zealand Agriculture and Forestry – Situation and Outlook for Horticulture.* Ministry of Agriculture and Forestry http://www.maf.govt.nz/mafnet/rural-nz/statistics-and-forecasts/sonzaf/2005/08horticulture.htm

SPC: Secretariat of the Pacific Community, December 2004: *Trapping Network in the Pacific Islands.* http://www.spc.int/pacifly/Success_stories/quarantine_surveillance_2.htm

Stewart, Phil (editor), 2006: *Four tools for use in biosecurity incursion responses.* Biosecurity Issue 68, June 2006, Biosecurity New Zealand

Stewart, Phil (editor), 2006a: *Fruit Fly Surveillance Provides Essential Early Warning.* Biosecurity Issue 70, September 2006, Biosecurity New Zealand

Stewart, Phil (editor), 2006a: *Flight of the Photon.* Biosecurity magazine, Issue 69, August 2006, Biosecurity New Zealand

Stewart, Phil (editor), 2006b: *Monitoring Biosecurity Pathways.* Biosecurity Magazine, Issue 69, August 2006, Biosecurity New Zealand

Stewart, Phil (editor), 2006c: *Fruit Fly Surveillance provides Essential Early Warning.* Biosecurity Magazine, Issue 70, September 2006, Biosecurity New Zealand

Strollo, Mike. 1997: *Mexico-U.S. Avocado Trade Dispute* TED Case Studies No: 413 http://www.american.edu/TED/avocado.htm

Shea, Kevin. 2004: *Cold Treatment of Fruits.* Federal Register February 2004 Vol: 69 No: 21 United States Department of Agriculture, Animal and Plant Health Inspection Service http://ceris.purdue.edu/napis/pests/ffmd/freg/fr040402-med.txt

Shea, Kevin. 2006: *Mediterranean Fruit Fly; Add Portions of Los Angeles, San Bernardino, and Santa Clara Counties, CA, to the List of Quarantined Areas* Federal Register February 13 2006 Vol: 71 No: 29 United States Department of Agriculture, Animal and Plant Health Inspection Service http://ceris.purdue.edu/napis/pests/ffmd/freg/fr060213-med-ca.txt

Shea, Kevin. 2006a: *Importation of Tomatoes from certain central American Countries*. Federal Register February 2006 Vol: 71 No: 24 United States Department of Agriculture, Animal and Plant Health Inspection Service
http://ceris.purdue.edu/napis/pests/ffmd/freg/fr060206-tomato.txt

Thomas, M.C. Heppner, J.B. Woodruff, H.V. Weems, H.V. Steck, G.J. and Fasulo, T.R. 2005: *Featured Creatures: Mediterranean fruit fly*. University of Florida.
http://creatures.ifas.ufl.edu/fruit/Mediterranean_fruit_fly.html

Tumonz, Source for mapping data: Vision Software, Tumonz Version 2 ©2001/2

UC, 2003: *Phenology Model Database: Mediterranean Fruit Fly*. IPM Online, University of California http://www.ipm.ucdavis.edu/PHENOLOGY/ma-med_fruit_fly.html

Underwood, R. 1998: *Fruit Fly: A Study of Likely Effects of a Fruit Fly Incursion in the Bay of Plenty Region.* Report for the Bay of Plenty Regional Fruitgrowers Committee

Uwanawich, Y. 2006: *Medfly Infests Pomona's Fruit.* The Poly Post, California State Polytechnic University, Pomona http://www.thepolypost.com/story/php?story=2948

White, I.M., Elson-Harris, M.M. 1992: *Fruit Flies of Economic Significance: Their Identification and Bionomics* (Summary in "Fact Sheet for Fruit Flies" July 1993)
http://ceris.purdue.edu/napis/pests/misc/fff.txt

Zespri, 2006: *Kiwiflier* May 29 2006 Issue No: 248 Zespri Group Ltd

Zespri, 2006: *Annual Report 2005-06* Zespri Group Ltd

Photos of medfly available digitally for non-profit purposes from:
http://www.Forestryimages.org

MAF Media Releases: **http://www.maf.govt.nz**

29 November 2002	*MAF to test Fruit Fly Response Capability*
9 September 2005	*Port of Napier First to Achieve 'Place of First Arrival' Standard*
11 October 2005	*Painted Apple Moth Catch another Immigrant*

From MAF's Internet Site: **http://www.maf.govt.nz**

Mediterranean Fruit Fly MAFnet

APPENDIX I

WHAT HAPPENED IN AUCKLAND IN 1996

MOUNT ROSKILL MEDITERRANEAN FRUIT FLY INCURSION 1996

An incursion of Mediterranean fruit fly was discovered in May 1996 as a result of routine monitoring of traps in the urban Auckland suburb of Mount Roskill. A control programme was enacted. The total finding was 41 adults, (31 males and 10 females) plus 85 larvae over a period of about three weeks, all within an A zone of 200 metres radius from the original trap site. No medfly have been found in the area since then and the pest was successfully eradicated.

The following section provides more detail of the 1996 incursion, and is abridged from the 1998 report:

On 2 May 1996, two male Mediterranean fruit flies were captured in a trap that is part of the monitoring trap network. This generated a structured response from MAF, the agency operating the monitoring trap network. The response included more intensive trapping in the area including setting traps that would attract and detect female fruit flies.

Female fruit flies were found on the 5th May and larvae on the 6th May showing that a breeding population was established and that the fruit fly finding constituted an incursion. MAF established an A zone of 200m radius around the initial find, a B zone of 1.5km radius and a C zone of 15km radius. Movement of fruit between in these zones was restricted, particularly in the weeks following discovery of the medfly population. Fruit sampling to detect larvae occurred and bait and insecticides were applied to control the adult flies. More adults were found until 15th May, and larvae until 23rd May. Most of the larvae was in feijoa fruit and some in tangelos. The table below summarises the fruit fly findings during the incursion.

Medfly Findings in Auckland 1996:

Date	2 May 1996	5 May 1996	6 May 1996	7 May 1996	8 May 1996	9-15th May	16-20th May 1996	21-23rd May 1996	Total
No. male	2	8	12	4	1	4	-	-	31
No. female	-	6	1	2	-	1	-	-	10
Adults: Total Number found	2	14	13	6	1	5	-	-	41
Adults: Cumulative total found	2	16	29	35	36	41	41	41	41
Larvae Found	-	-	10		5	10	40	20	85
Larvae: Cumulative total found	0	0	10		15	25	65	85	85

MAF carried out a control programme, spending about $5 million in extra costs. This figure does not include much of MAF's personnel time spent on control activities.
Export markets applied market access restrictions to medfly host produce from New Zealand as a response to the incursion. The responses from major markets are summarised in the following table.

Market Restrictions to Mount Roskill Medfly Incursion:

Market	Radius applied for restrictions	Date Restrictions Lifted	Duration of restrictions (lifecycle)	Duration of restrictions (months)
United States	7.2km (4.5 miles)	2 April 1997	3 generations	~10 + ½ months
Korea	15km	23 April 1997	3 generations	~11+½months
Japan	15km	14 April 1997	3 generations	~11 months
Australia (except Western Australia)	80km, reduced to 15 km on 5 June 1996	22 January 1997	1 generation plus 28 days	8+½months
Western Australia	No restrictions	No restrictions	No restrictions	No restrictions
China	North Island	BOP kiwifruit exempted within 1 year, other restrictions remained		Final restrictions lifted more than 2 years after initial incursion
Europe	No restrictions	No restrictions	No restrictions	No restrictions
NZ Domestic	A zone: 200m radius B zone: 1.5km radius C zone:15km radius	~23 Jan 1997 (With Australia)	1 generation plus 28 days	~8+½months

Source: Underwood, 1998

Responses ranged from the mildest response of no restrictions from Europe (where medfly is established in a number of countries) to severe restrictions from China which excluded fruit from the whole of the North Island for a period of time, then accepted kiwifruit exports from the Bay of Plenty before totally lifting the restrictions more than 2 years after the initial outbreak.

A typical market response was to restrict market access to host material produced in or passing through a 15km radius zone around the find. Fruit from within this zone was not acceptable for markets applying restrictions. In addition, fruit passing through this 15km zone required insect proofing and documentation to be acceptable for markets sensitive to medfly. Being in an urban area there was very little commercial fruit grown in the 15km zone. A commercial greenhouse producer growing for the domestic market was able to continue selling product following MAF inspection. An export strawberry grower in the area was not able to export their strawberries to Japan but was able to supply domestic markets.

The requirement for insect proofing fruit transiting the 15km zone had the most significant effect on commercial growers. The zone included access routes to the airport, Ports of Auckland and major road transport routes. The insect proofing also required additional MAF inspections and sealing of loads as part of the programme to assure markets. The costs outside MAF's control fell where they lay. For example, the cost of providing insect proof wrapping and additional MAF inspections or transport diversion was met by the owner of the produce at the time. Apart from these measurable costs, there were costs that are more difficult to measure, for example, it is difficult to quantify the loss of product quality following insect proofing or due to delays relating to the market restrictions.

The type of activities reported by people affected by the incursion include:

- Having to submit details of produce origin and transport routes to MAF for approval before despatching produce. This affected local market distributors. As time passed, they had only to fax MAF details of loads, rather than to wait for MAF approval. The main effects were delays of a few hours and longer working days. Distributors spoken with estimated about six weeks duration for these restrictions.

- Being unable to use usual warehousing and distribution centres without incurring insect proofing costs. This meant having to use temporary facilities outside the affected zone.

- Having to re-route produce to avoid passing through the 15km C zone area to save the cost of insect proofing. This applied to road freight and also to sea freight, especially where sufficient time was available to alter shipping plans without significant financial penalty. This affected export produce for longer.

- Having produce grown for export to a sensitive market redirected to the local market.

- Having to install plastic strip screens on coolstore doors. These were not previously used and have since been removed.

- Having to prepare export loads in areas not normally used for them. An example was preparing export loads in insect-screened coolstores rather than in warehouse space. The work in doing this took longer.

- Having to insect-mesh individual boxes of fruit fly host fruit. Doing individual boxes had an advantage over wrapping whole pallets as if the insect-proofing was damaged, only individual boxes were affected rather than a whole pallet. Also, for air freighting, the individual boxes were stacked in the airfreight container.

- Insect proofing produce containers was done using a domestic continuous curtain material with the style name of "Jodi', made by Manukau Knitting Mills in Auckland. This material has a very small mesh size, sufficient to exclude medfly adults, and is relatively inexpensive when compared to quarantine-grade insect meshes used for greenhouses. This style of netting is still made in 2006.

The costs of growers and exporters dealing with the control measures were less where there was a significant lead time before crop harvest. This time lapse allowed planning and negotiation with export markets. For example, the method of insect proofing used for squash took some effort and time to develop as different insect meshes and glues were trialled. Video footage was used to communicate the process to Japanese officials which helped get their approval for the techniques used.
After the incursion, analysis of genetic make-up of the medfly from the Auckland incursion with that from other countries indicated it is highly likely that the original source of the incursion was Hawaii (Dr Ruth Frampton, Pers. Comm. in 1998)

APPENDIX II

FRUIT FLY BIOLOGY AND CONTROL

This section is largely a précis of content in the 1996 report, with some update of more recent information and expansion to consider the Hawkes Bay and Nelson regions.

MEDITERRANEAN FRUIT FLY

Mediterranean fruit fly has a broad host range of 100–200 plants (SONZA, 1996). Many are commercial fruit and vegetable species grown in New Zealand, as shown in the table below. Where it is not controlled, medfly spoils 80-100% of the fruit on host plants (HPC, 1991). The medfly species has a strong breeding potential. It is good at finding hosts, has a wide range of hosts, the female fly lays many eggs and there are few natural predators or parasites to control the pest.

One infested fruit is enough to start a new medfly population or outbreak. One of the key means of transferring fruit fly to a new site is through human transport of infested fruit. A fruit can contain nearly mature larvae and still appear sound. About ten larvae per fruit is common so a single fruit can contain male and female larvae. When the fruit is discovered to be full of larvae it is likely to be thrown away, often into a back yard compost area. This is a good environment for a new population to develop. Urban back yards are especially inviting to medfly because they tend to contain unsprayed trees with windfall and ripening fruit which helps perpetuate the pest life cycle.

Medfly is not highly mobile when compared to other pest species of fruit fly. This lack of mobility has two effects. It is more difficult to detect because it is more likely to have established a breeding population before travelling far enough to encounter a monitoring trap. This is a negative feature of the low mobility. Secondly however, the low mobility aids control of medfly as any population that does establish is more likely to be in a limited geographical area.

The most attractive stage of a host plant is when the fruit is ripening. The most attractive fruits are soft fleshy fruits. The following table shows that harvest of medfly host crops occurs year round in New Zealand.

Main Harvest Periods for Major Crops grown in NZ that are Medfly Hosts:

Crop	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Avocados	√	√								√	√	√
Berryfruit	√										√	√
Capsicums	√	√	√	√	√	√	√	√	√	√	√	√
Other Citrus					√	√	√	√	√	√	√	
Feijoa			√	√	√							
Grapes			√	√								
Kiwifruit				√	√	√						
Mandarins					√	√	√	√				
Olives				√	√	√						
Passionfruit	√	√	√	√	√	√						
Persimmons				√	√	√						
Pipfruit	√	√	√	√								
Squash	√	√	√	√								√
Summerfruit	√	√	√									√
Tamarillos					√	√	√	√	√			
Tomatoes	√	√	√	√	√	√	√	√	√	√	√	√

A fruit being a known host of a fruit fly species is sufficient to generate market access restrictions to sensitive markets following an incursion, even if the fruit is not a preferred host for the pest. For example, kiwifruit is not a preferred host of medfly (Carey, 1992), probably because it is harvested mature but not ripe. However, an incursion of medfly in a kiwifruit growing area will result in market access restrictions for kiwifruit because it is a known medfly host, despite it not being a preferred host. The recently commercialised Hort16A gold-fleshed variety of kiwifruit marketed as ZESPRI™ GOLD may be more attractive as a fruit fly host as it is smoother skinned and is often softer at harvest.

The life cycle of Mediterranean fruit fly is typical of pest fruit fly species:

- Fertilised eggs are laid into ripening fruit by the female adult fly.
- These eggs hatch into larvae which feed inside the fruit.
- When the larvae mature, they drop to the ground, then pupate in the soil and emerge as adults.
- The adults then feed, mate and the life cycle is perpetuated. The life cycle is temperature dependant and thus faster in summer taking around 30 days, than in winter when it may take 100 days.
- Adult medfly typically live for one to three months. However, in cooler climates adults have been recorded living for ten to twelve months.
- Each female adult lays eggs throughout its life usually laying 300-1,000 eggs in total in batches of three to fourteen.
- Different female adults may lay eggs in the same piece of fruit.

Control

The absence of fruit flies is very significant for New Zealand and has allowed New Zealand grown produce to be exported to a wide range of markets around the world. Freedom from fruit fly is a cornerstone of access for our fruit products to sensitive markets, and is a point of comparative advantage with respect to other countries where fruit fly is established. For New Zealand, the difficulty during an incursion would be providing sufficient assurance to markets that no fruit fly was being distributed in exported fruit. The time frame to develop and negotiate suitable treatments for a wide range of crops could leave a considerable quantity of fruit subject to severe market restrictions. These market restrictions could last, as they did in the May 1996 Auckland incursion, long after the last pest was found, as shown in the table in Appendix I.

Control of an incursion of fruit fly is two pronged. Firstly, because of the risk of the pest spreading via movement of infected fruit, there is a need to contain its potential spread by restricting fruit movements near an incursion. Secondly, there is a need to control or eradicate the pest through treatment because of the significant damage it could cause if it became established. These treatments generally include trapping, (using traps that attract both male and female adults rather than the monitoring traps which attract only males), protein bait and insecticide sprays and collection and destruction of fruit that may be infested with larvae. In an incursion where monitoring is an important adjunct to eradication, fruit may be incubated and cut open to establish if they contain larvae, before being destroyed.

Colder soil temperatures below about 10°C may break the medfly life cycle by stopping development of the pupae in the soil. The depth the soil temperature is important is around 2.5cm (UC, 2003). The standard depth for soil temperature measurement in New Zealand is 10 cm. There are a small number of sites where temperature is being recorded at 5cm depth

(NIWA, 2006). Medfly is considered more likely to survive cooler temperatures than other pest fruit fly species (HPC, 1991).

In countries or areas where fruit flies are established, control of fruit fly comprises an important part of the routine chemical pest control programme on the crop. Such pre-harvest chemical strategies may be sufficient to restrict the loss of marketable fruit to fruit flies but is generally not sufficient to gain access to sensitive markets. As significant exporters of fruit, New Zealand needs to provide confidence to markets that the risk of their being exposed to pest sourced from any incursion in New Zealand is negligible. Because of this need, control strategies need to be conservative.

Disinfestation is one means of providing market assurance that the likelihood of fruit fly in a shipment of fruit is acceptably small. However, disinfestation procedures tend to be established for each species of fruit fly, by each export market, for each crop. More detail of disinfestation for particular crops is contained in section 9 of this report.

Processing fruit by freezing or cooking is sufficient to kill fruit fly eggs and larvae. However, commercial processing options are limited within New Zealand and are generally low value and often low volume market outlets.

Control Where Established

The intention clearly is that the present trap monitoring programme provides sufficiently early warning to prevent the establishment of any pest fruit fly. However should medfly become established a number of techniques are available to provide control and eradication. Those techniques include trapping and baits and insecticides as described above.

It is often assumed that routine chemical pest control is sufficient to prevent fruit fly becoming established on commercially grown crops. The increasing trend to non chemical pest controls and low residue fruit by allowing long intervals between the last spray and harvest date make this assumption inappropriate. The period close to harvest when fruit is ripening which is most attractive to fruit fly is also the time when sprays are avoided to produce low residue fruit. For example, New Zealand kiwifruit crops are seldom sprayed with a broad spectrum insecticide that would kill fruit fly from mid January until harvest over three months later.

Adult fruit flies may be killed by broad spectrum "knockdown" insecticides in common use on fruit crops to control other pests. However, these sprays do not kill eggs and larvae which are protected inside the fruit, or pupating larvae in the soil, so the fruit fly life cycle can continue. Larvae and eggs within the fruit can be killed by systemic insecticide sprays that penetrate the fruit. These may be applied as a cover spray over the whole plant, in which case they also kill any adults that come into contact with the spray. The interval between the last spray and harvest can be a problem, as new eggs can be laid during this period that will survive and hatch. Also, fruit may deteriorate from bacteria that enters via the tiny wound created when fruit fly eggs are laid, even when the eggs subsequently die due to insecticide.

Chemical pest control methods available to organic growers, an increasing sector, would not control fruit fly species sufficiently.

A further method of control is the Sterile Insect Technique (SIT). With this method, sterile male fruit flies are released and swamp the fertile wild population. These sterile flies are released in large numbers, and mate with the wild flies, although being sterile, no offspring result. The wild, fertile flies are overwhelmed by the sheer numbers of sterile flies and the breeding population dies out. Repeated releases of the sterile flies are required throughout the breeding season. The US has used the sterile insect technique to help combat medfly. It is a huge and expensive programme, described in some detail on the California Department of Agriculture and Food website (CDFA, 2005). The sterile male medflies are released daily by air. The flies for the programme are imported immature as pupae, mostly from specialised laboratories in Hawaii where medfly has been established since the early 1900's. The sterile males are also dyed so they can be identified when caught in monitoring traps. A sterile insect technique programme was used in New Zealand to help combat the Painted Apple Moth (Stewart, 2006) which has since been declared eradicated. This was on a much smaller scale than the programme in California and that used to rid Chile of medfly in the late 1990's.

Growth Models

Growth models are used to estimate the life cycle development of medfly and guide application of control measures. The models use temperatures to predict generation time. One example is available for growers at the website referenced by UC (2003). It is recommended growers validate the models in their own conditions. In the US, some control measures are specified in terms of the Growing Degree Days (a temperature index) elapsed (Shea, 2006).

OTHER FRUIT FLY SPECIES

The equable New Zealand climate is a key attribute favouring pest establishment, as well as the lack of natural population controls via predators and parasites. For some exotic pests, biological control is able to be developed by examining pest ecology in their countries of origin. However, as fruit flies typically have few predators this is not a likely option. The significance of the trade issues surrounding fruit flies mean there would be very significant effects well before additional disinfestation methods could be developed or biological controls developed.

The medfly life cycle is typical of a pest fruit fly species with species differing in host range and preferred climatic conditions. Those species with a wide host range and tolerance of cooler climate are of most concern as pests in New Zealand.

Australia has many native fruit flies, but only six of the approximately 80 species still found in the rain forest have become significant pests of cultivated horticultural produce. Within Australia, the most significant species is the Queensland fruit fly, *Bactrocera tryoni*, which is very destructive and has a wide host range of temperate and tropical fruits. The Queensland fruit fly is native to Australia and inhabits much of the eastern side of Australia. It is considered to have the potential to inhabit most of the tropical and sub tropical areas of the world (HPC, 1991).

Of concern to New Zealand is that high summer temperatures and summer dryness are a significant limitation to population development of tropical fruit flies within Australia. New Zealands cooler summers and frequent rainfall mean our environment may be favourable for species such as Queensland fruit fly. Cool winter temperatures are a limitation on the increase in fruit fly populations. However, the adult stages of species may survive winters without breeding and resume breeding in the spring and summer (HPC, 1991; Citograph, 1992).

It is also possible that an established population may over time become better adapted to a new environment. The potentially rapid population increase of fruit flies may hasten this adaptation.

Population dynamics and interactions between fruit fly species are also important. Although fruit fly species tend to have few predators or parasites, competing for a similar ecological niche may influence the relative pest status of different species in one environment. For example, in the eastern states of Australia, the Queensland fruit fly is the dominant species and may be suppressing pest activity of other fruit fly species (HPC, 1991). Thus species that appear to be less significant pests in their natural environment when competing with other fruit fly species, may behave quite differently should they start a new population in an area without competing species.

There is also concern about interbreeding of different species of fly giving rise to progeny with different environmental tolerances and host preferences. The rapid population increases typical of fruit flies make the risk of this happening more significant. Within Australia, interbreeding is thought to have happened with some species. Other species have mated and produced fertile progeny in the laboratory but in the wild have sufficiently different mating times that interbreeding does not occur. In different climatic conditions such as in other countries, this could be more likely to occur in the wild. Thus the population dynamics and pest characteristics of fruit fly species are liable to change in different climatic environments and in light of different interactions between species.

New Zealand also has favourable conditions to spread of a fruit fly population such as prevalence of unsprayed urban host plants, backyard and commercial produce providing year round host material. There is increasing use of a wide range of host plants as urban amenity plants, for example olives and coffee. Declining commercial insecticide use must increase the chance of fruit fly becoming established in commercial crops. This decline in insecticide use is not at all confined to growers undertaking organic production.

Other countries with fruit fly species considered a risk to New Zealand include tourist destinations, the country of origin of tourists and the countries of origin of imported produce such as Australia, Hawaii and the Pacific Islands. Australia has mainly native species of fruit fly. This poses a special risk to New Zealand as a near neighbour and significant trading partner for produce between the two countries. Given that the Australian native species of fruit flies are not found outside Australia, there are few markets that would not be "sensitive" to their presence in New Zealand. Thus, restrictions could be expected by nearly all of New Zealand's export markets for a significant duration if a breeding population of an Australian native species of fruit fly was found here. The factors affecting this would be the time of year, host range and "virulence" of the species found, and the location of the find. Market restrictions would also apply for New Zealand produce destined for Australia, even for a fruit fly species native to Australia. This is because species of fruit flies have a limited distribution within Australia, and Australia applies domestic market access restrictions to help prevent their spread. Australia is very aware of the cost and impact of fruit fly incursions. Their eradication programme dealing with the Papaya fruit fly in Northern Queensland was discussed in Section 9.

APPENDIX III

ECONOMIC IMPACTS OF FRUIT FLY INCURSIONS

NATIONAL & REGIONAL IMPACTS

FOR

BAY OF PLENTY REGIONAL COUNCIL

HAWKES BAY REGIONAL COUNCIL

NELSON CITY COUNCIL & TASMAN DISTRICT COUNCIL

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INTRODUCTION

The direct impacts of fruit fly incursions involve first the reductions in revenue for the affected crops (apples, pears, kiwifruit, other fruit and vegetables) and secondly the extra expenditure incurred in containing the incursion. The first involves the affected region in losses through reduced crop revenue and other losses in sectors that now face reduced demands for the services such as road freight, cool stores, packing etc. However, while increased expenditure to contain the incursion involves growers in further losses, sectors receiving this expenditure gain extra revenue which in turn benefits the local workforce and the business units that employ them. The national and regional impacts therefore comprise both losses and gains, although the crop revenue losses will far outweigh any gains engendered by the extra activity to contain the incursion.

To evaluate these losses and gains, 112-sector economic models of the Bay of Plenty Regional Council, Hawkes Bay Regional Council, Nelson City Council plus Tasman District Council and the NZ economy were constructed for the year ending December 2005. Accordingly, the resulting estimates of losses and gains can be considered as if they occurred during calendar year 2005. Resulting impacts are expressed both in total and as percentage impacts for the regional and national totals for Output or Revenue, Net Household Income, Employment in Full-time Equivalents (FTEs) and Gross Domestic Product or GDP (NZ) or Gross Regional Product or GRP for the three regions. Note that GRP is the regional equivalent of GDP.

METHODOLOGY

The direct impacts for each region are detailed in the report in sections 5 - 7. The main crops involved are apples, kiwifruit, avocados and squash. For our 112-sector economic models, these crops are included in the italicised model sectors as follows: *Apples & Pears*, *Kiwifruit*, *Other Fruit* and *Other Horticulture*. Note that a direct crop loss due to the fruit fly will have flow-on impacts for sectors servicing the growing sectors. For example, a significant loss in the *Kiwifruit* sector for a region has flow-on losses for the *Road Freight*, *Other Business Services* (packing), *Water & Rail Services* and other sectors. The regional and NZ models estimate these flow-on impacts and when these are added to the initial direct impact the total impact on the economy can be derived.

Four economic impacts are modelled as follows:

- Total revenue, output or sales in dollars.
- Net household income after tax, superannuation and other saving in dollars.
- Value added or gross regional (domestic) product or GRP or GDP in dollars.
- Employment in full-time equivalent persons or FTEs.

Although total revenue, output or sales best measures the dollar value of total economic activity in a region, it can be inflated by the value of large imports of products or services (e.g. sophisticated legal or financial services) into a region like the BOP from say Auckland or Wellington. While such sales figures measure total transaction value, the value added measure quantifies the economic value in dollars created within a region or country by local business units and their employees after allowing for any necessary imports of raw materials (e.g. diesel for most NZ regions) and other goods and services from outside the region or country. This is the measure of the addition to GRP for regions such as BOP, Hawkes Bay and Nelson/Tasman and also to NZ's GDP, and best reflects the true gain to the economy of interest.

Net household income is the best measure of available household purchasing power. Strong growth or impact for this measure in a region signals improved prospects for the *Wholesale* and *Retail Trade* sectors, *Ancillary Construction* (e.g. house additions or renovations) and similar sectors.

A wealthy region or country may show acceptable outcomes for the three dollar measures above but may lack the industrial capacity to support good job growth in the region. Employment is therefore an important attribute of regional prosperity and this means economic development within the region is required to expand opportunities for a regional workforce. Such employment is measured in full-time equivalents or FTEs since about 24% of regional workforces are currently part-time employees. For example, an important capital intensive facility such as the Port of Napier may itself need only a moderate workforce for efficient operation. However, through a port's linkages to other sectors, it can ensure profitability in those sectors and facilitate growth in employment in those sectors such as *Other Fruit Growing* which includes grape growing for the Hawkes Bay region.

BAY OF PLENTY & NZ IMPACTS

The table headed "Fruitfly Analysis July 2006 – Bay of Plenty Incursion" summarises the regional and national impact of a fruit fly incursion in the BOP.

The table shows total direct revenue losses for kiwifruit and avocados (*Other Fruit*) at $51.78 m. Associated with this total Revenue loss is a Net Household Income loss of $10.81 m, an Employment loss of 200 FTEs and a Value Added or GRP loss of $26.68 m. From our 112-sector economic model of the BOP regional economy, the flow-on losses from other sectors such as *Road Freight* etc means the total BOP region losses for Revenue, Income, Employment and Value Added are respectively $99.32 m, $19.01 m, 476 FTEs and $48.7 m. The respective regional multipliers for each of the four impact measures are shown just above the Rest of NZ impacts.

Offsetting the above losses associated with the reduced crop outputs are the extra costs incurred regionally to contain the fruit fly incursion. These costs have been spread evenly over three sectors closely associated with incursion containment. *Agricultural Services* (spraying, clean-up etc), *Road Freight* (substitute fruit etc shipped from unaffected growing areas), and *Water & Rail Services*. Extra costs total $10.74 m within the region but another $1.88 m of extra cost for BOP growers is incurred in the Rest of NZ and adds to the direct national impact accounted for in the lower part of the table. After allowing for direct and flow-on extra regional costs, regional gains from this extra expenditure total $24.49 m, $4.83 m, 307 FTEs and $37.84 m for the respective impacts. The net regional BOP loss is the difference between regional losses and gains so that total Revenue loss from the incursion is estimated at $74.83 m with a GRP loss of $37.84 m. Note that the Value Added net loss at just over 50% of the Revenue loss is relatively a high proportion and results from the relatively indigenous nature of fruit growing and processing for the regional economies involved with this fruit fly analysis. That is, apart from fuel and other essential imports into the region, most goods and services associated with fruit production are supplied by the well-developed infrastructure of the regional economies developed over many years in support of fruit growing and processing. Finally, percentage impacts on the BOP regional economy are estimated at around or just under one half of one percent of annual regional aggregates.

The revenue and expenditure losses and gains outside the BOP regional economy are summarised towards the bottom of the table and lead to the total impacts for all NZ. So out of the total net Revenue or Output loss for NZ of $110 m, an estimated $75 m or 68% of this loss is realized in the BOP regional economy.

HAWKES BAY & NZ IMPACTS

The table headed "Fruitfly Analysis July 2006 – Hawkes Bay Incursion" shows the regional and national impact of a fruit fly incursion in the Hawkes Bay.

The affected crops for the Hawkes Bay region are apples, kiwifruit and squash (*Other Horticulture*). The analysis for this incursion contained in the table above is the same as for the BOP table and need not be repeated here. Overall we can note that the regional percentage impacts for a Hawkes Bay incursion are slightly higher than for the BOP incursion. This reflects the fact that the BOP economy with a GRP of $8.3 b is about 46% larger than Hawkes Bay at $5.7 billion. Accordingly, a similar sized incursion in both economies will almost certainly have a larger percentage impact on the smaller economy. Nationally, however, the BOP incursion has a generally greater impact (Employment is the exception) possibly reflecting the fact that around 80% of NZ's kiwifruit crop is grown in the BOP with economies of scale minimising the employment impact.

NELSON/TASMAN & NZ IMPACTS

The table headed "Fruitfly Analysis July 2006 – Nelson Incursion" shows the regional and national impact of a fruit fly incursion in the Nelson City plus Tasman District Council regional economy.

The analysis for Nelson/Tasman is similar to that of the previous regions. This incursion has the smallest impact of the three regions analysed with only one quarter of the national impact attributable to incursions in the other two regions. Regionally, the percentage impacts at about one fifth of one percent for Nelson/Tasman are less than half of the regional impacts for the other two regions.

FRUITFLY ANALYSIS JULY 2006 - BAY OF PLENTY INCURSION

BAY OF PLENTY & NZ IMPACTS

	ECONOMIC MEASURES			
	Output/ Revenue	**Net Household Income**	**Employment**	**Value Added/GRP***
	$ millions	**$ millions**	**Full-time Equivalents**	**$ millions**
BAY OF PLENTY REVENUE:				
Direct Sector Losses:				
Kiwifruit	44.11			
Other Fruit	3.43			
Total Direct Revenue Losses	47.54	10.81	200	26.68
Flow-on losses to other sectors	51.78	8.20	276	22.02
Total Revenue Loss BOP	**99.32**	**19.01**	**476**	**48.70**
BAY OF PLENTY COSTS:				
Direct Sector Increased Costs:				
Agricultural Services	3.58			
Road Freight	3.58			
Water & Rail Services	3.58			
Total Direct Expenditure Gains	10.74	2.52	96	5.05
Flow-on expenditure gains to other sectors in BOP	13.75	2.31	73	5.81
Total BOP Expenditure Gains	**24.49**	**4.83**	**169**	**10.86**
NET BOP REGIONAL LOSS	**74.83**	**14.18**	**307**	**37.84**
BOP Regional Totals	12,876.40	3,293.50	100,108	8,294.40
BOP Percent Impacts	0.58%	0.43%	0.31%	0.46%
BOP Regional Revenue Multiplier	2.09	1.76	2.38	1.83
BOP Regional Cost Multiplier	2.28	1.92	1.76	2.15
REST OF NZ IMPACTS:				
Revenue Loss for Rest of NZ	42.09	10.16	290	25.69
Total Revenue Loss for all NZ	**141.41**	**29.17**	**766**	**74.39**
Expenditure Gain for Rest of NZ	7.24	1.84	58	4.39
Total Expend. Gain for all NZ	**31.73**	**6.67**	**227**	**15.25**
NET LOSS FOR ALL NZ	**109.68**	**22.5**	**539**	**59.14**
NZ Totals	204,266.9	61,030.6	1,802,087	154,118.5
NZ Percent Impacts	0.054%	0.037%	0.030%	0.038%
NZ Revenue Multiplier	2.33	2.06	2.73	2.14
NZ Cost Multiplier	2.51	2.25	2.01	2.57

*GRP = Gross Regional Product the regional equivalent of national Gross Domestic Product or GDP.
Total Revenue loss & Expenditure gain for Rest of NZ include both direct & flow-on impacts.
Regional equivalents show direct & flow-on separately.

<u>FRUITFLY ANALYSIS JULY 2006 - HAWKES BAY INCURSION</u>

HAWKES BAY & NZ IMPACTS

	ECONOMIC MEASURES			
	Output/ Revenue	**Net Household income**	**Employment**	**Value Added/GRP***
	$ millions	**$ millions**	**Full-time Equivalents**	**$ millions**
HAWKES BAY REVENUE:				
Direct Sector Losses:				
Apples & Pears	24.68			
Kiwifruit	0.098			
Other Horticulture (Squash)	11.18			
Total Direct Revenue Losses	35.96	10.78	352	16.94
Flow-on losses to other sectors	42.51	6.35	223	16.73
Total Revenue Loss H Bay	**78.47**	**17.13**	**575**	**33.67**
HAWKES BAY COSTS:				
Direct Sector Increased Costs:				
Agricultural Services	3.78			
Road Freight	3.78			
Water & Rail Services	3.78			
Total Direct Expenditure Gains	11.34	2.50	96	5.00
Flow-on expenditure gains to other sectors in Hawkes Bay	12.35	1.93	63	4.80
Total H Bay Expenditure Gains	**23.69**	**4.43**	**159**	**9.80**
NET H BAY REGIONAL LOSS	**54.78**	**12.70**	**416**	**23.87**
Hawkes Bay Regional Totals	9,407.5	2,248.0	70,861	5,666.4
Hawkes Bay Percent Impacts	0.58%	0.56%	0.59%	0.42%
H B Regional Revenue Multiplier	2.18	1.59	1.63	1.99
H B Regional Cost Multiplier	2.09	1.77	1.66	1.96
REST OF NZ IMPACTS:				
Revenue Loss for Rest of NZ	46.89	12.58	398	28.68
Total Revenue Loss for all NZ	**125.36**	**29.71**	**973**	**62.35**
Expenditure Gain for Rest of NZ	15.69	3.84	123	9.12
Total Expend. Gain for all NZ	**39.38**	**8.27**	**282**	**18.92**
NET LOSS FOR ALL NZ	**85.98**	**21.44**	**691**	**43.43**
NZ Totals	204,266.9	61,030.6	1,802,087	154,118.5
NZ Percent Impacts	0.042%	0.035%	0.038%	0.028%
NZ Revenue Multiplier	2.61	1.95	1.92	2.57
NZ Cost Multiplier	2.51	2.25	2.01	2.57

*GRP = Gross Regional Product the regional equivalent of national Gross Domestic Product or GDP.

Total Revenue loss & Expenditure gain for Rest of NZ include both direct & flow-on impacts.

Regional equivalents show direct & flow-on separately.

FRUITFLY ANALYSIS JULY 2006 - NELSON + TASMAN INCURSION

NELSON + TASMAN & NZ IMPACTS

	ECONOMIC MEASURES			
	Output/ Revenue	**Net Household income**	**Employment**	**Value Added/GRP***
	$ millions	**$ millions**	**Full-time Equivalents**	**$ millions**
NELSON + TASMAN REVENUE:				
Direct Sector Losses:				
Apples & Pears	8.19			
Kiwifruit	0.68			
Other Fruit	0.01			
Total Direct Revenue Losses	8.88	2.89	82	4.36
Flow-on losses to other sectors	10.95	1.66	59	4.25
Total Revenue Loss N & T	**19.83**	**4.55**	**141**	**8.61**
NELSON + TASMAN COSTS:				
Direct Sector Increased Costs:				
Agricultural Services	1.55			
Road Freight	1.55			
Water & Rail Services	1.54			
Total Direct Expenditure Gains	4.64	1.05	40	2.10
Flow-on expenditure gains to other sectors in Nelson & Tas	5.12	0.81	26	1.98
Total N + T Expenditure Gains	**9.76**	**1.86**	**66**	**4.08**
NET N + T REGIONAL LOSS	**10.07**	**2.69**	**75**	**4.53**
Nelson & Tasman Regional Totals	5,629.5	1,346.8	41,436	3,306.7
Nelson + Tasman % Impacts	0.18%	0.20%	0.18%	0.14%
N + T Regional Revenue Multiplier	2.23	1.57	1.72	1.97
N + T Regional Cost Multiplier	2.10	1.77	1.65	1.94
REST OF NZ IMPACTS				
Revenue Loss for Rest of NZ	23.94	5.94	176	12.96
Total Revenue Loss for all NZ	**43.77**	**10.49**	**317**	**21.57**
Expenditure Gain for Rest of NZ	10.28	2.35	77	5.55
Total Expend. Gain for all NZ	**20.04**	**4.21**	**143**	**9.63**
NET LOSS FOR ALL NZ	**23.73**	**6.28**	**174**	**11.94**
NZ Totals	204,266.9	61,030.6	1,802,087	154,118.5
NZ Percent Impacts	0.012%	0.010%	0.010%	0.008%
NZ Revenue Multiplier	2.66	1.96	2.09	2.67
NZ Cost Multiplier	2.51	2.25	2.01	2.57

*GRP = Gross Regional Product the regional equivalent of national Gross Domestic Product or GDP.
Total Revenue loss & Expenditure gain for Rest of NZ include both direct & flow-on impacts.
Regional equivalents show direct & flow-on separately.