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Analysis of the Market for Pollination Services in Australia

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Foreword

Pollination services are the paid use of domestic honeybees to pollinate crops. Australia currently has a very small market for pollination services, with an estimated 200,000 hives being used for paid pollination. Feral honeybees and incidental pollination provided by honey producers supply the remaining needs for pollination of Australian pollination-dependent crops. Australia is one of the last countries in the world free from *Varroa destructor*, a mite that decimates hives. If introduced, *Varroa* is likely to substantially reduce feral honeybee populations and raise the costs of maintaining hives. This report examines the market for pollination services in Australia and how it is expected to evolve over time under three scenarios: business as usual, where there is some growth in demand with expansion of some pollination dependant crops; a *Varroa* incursion that raises supply costs and sparks a massive increase in demand; and this same scenario but where industry is proactive to improve the responsiveness of supply.

The analysis demonstrates that the pollination industry will grow steadily until 2015 under business as usual without really facing major constraints. However, it is unprepared for the impact of *Varroa* on demand, and this would result in short term prices rising by over 200 per cent, with long run prices remaining 147 per cent higher. Estimates of the impact in terms of lost agricultural production vary across industries with declines in output of up to 12.9 per cent in 2011. In 2015 the reduction in output remains significant with some industries still experiencing declines in excess of 5 per cent. The modelling shows that by investing in improving supply side constraints the declines in output can be reduced to an average of 1.7 per cent across the industries considered.

The report provides an assessment of the prices and access to pollination services for the major honeybee pollination dependant industries. This information should inform the development of the business plan for the proposed industry alliance, Pollination Australia, made up of agricultural industries and the honeybee industry.

This report, an addition to RIRDC's diverse range of over 1800 research publications, forms part of our Honeybee R&D program, which aims to improve the productivity and profitability of the Australian beekeeping industry.

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Peter O'Brien
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All errors and omissions remain the responsibility of the authors.

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What the report is about

Pollination services are the paid use of domestic honeybees to pollinate crops. Many Australian crops are completely or partly dependent on pollination by honeybees for their production. Australia currently has a very small market for pollination services, with an estimated 200,000 hives being used for paid pollination. Feral honeybees and incidental pollination provided by honey producers supply the remaining needs for pollination of Australian crops that depend on honeybees. Australia is one of the last countries in the world free from *Varroa destructor*, a mite that annihilates hives and if introduced is likely to substantially reduce feral honeybee populations. Under such circumstances demand for pollination services would rise dramatically as growers in many industries from nuts, fruit and vegetable to pastures would be forced to buy pollination services or face significant losses in production.

This report examines the market for pollination services in Australia and how it is expected to evolve over time under three scenarios. The first is business as usual, where there is some growth in demand with expansion of some pollination dependant crops. Supply of pollination services can expand in the short run as honeybee producers move into paid pollination services, but there is a limit to this expansion unless more producers can be attracted into the industry. Expanding supply beyond the current number of hives available will take time and face constraints arising from lack of trained labour and access to areas of flora needed to keep hives healthy. The second scenario is a *Varroa* incursion which raises the costs of providing pollination services as well as raising demand for these services. It is under this scenario that supply constraints really start to impact on the pollination dependent industries. The third scenario looks at the difference strategies to improve the speed of industry growth can make to the price of pollination services and the volume that will be available. The implications for the production levels of the different pollination dependant crops as well as the adjustments in prices and supply of pollination services are estimated over time for each of the scenarios.

Who is the report targeted at?

The report is aimed at the honeybee and agricultural industries to inform them of the potential opportunities and risks to these industries associated with the changes that could arise in the pollination services market. It forms an input into the discussions on the formation of a Pollination Alliance, currently under development with support from the Industry Partnerships Program.

Background

There have been a number of studies that have looked at the value of pollination services in Australia and the impact on agriculture of loss of those services (such as Gordon and Davis 2000, and more recently Cook et al. 2007). These have focused on estimating the costs to agricultural industries dependent on pollination services of losing, what have been to date largely free, services provided by feral honeybees and incidental pollination from hives used in the production on honey and other bee products. There is a small paid pollination industry, estimated to engage around 200,000 of the 500,000 commercial hives in Australia. In addition an estimated 80,000 to 100,000 hives are used directly in pollination but on a mutually beneficial basis. The paid pollination service industry is concentrated on a few high value crops, notably almonds. Much is undertaken through brokers, who bring together the service providers with the customer and monitor practice and quality. This aims to ensure that the hives are not affected by agricultural practice and the hives supplied have the strength to provide effective pollination services.

Aims/Objectives

The aim of the study is to better inform agricultural industries that are dependant on honeybee pollination services of the impact on the price and availability of these services under different possible futures. This information should help them in developing strategies to ensure they have access to pollination services in the future at reasonable prices. Similarly the study aims to inform the honeybee industry of the opportunities that may emerge through changes in demand for pollination services. It also provides information about the likely impacts of a *Varroa* incursion on the output of certain agricultural industries.

Methods used

The research developed a partial equilibrium model of the market for pollination services capturing approximately two thirds of the 200,000 hives used for pollination. This required developing a derived demand for pollination services based on the scale and use of the pollination service dependant industries. A short run and long run supply function for pollination services was estimated based on the maximum capacity of the industry to double the number of hives every three years, and the current costs of supply. The pollination service market is complex with issues arising from the timing of services required and location of the crops and hence how many crops a hive can service, to the value of the crop for honey production. Thus prices for pollination services will vary by the time, location and implicit payment for the nectar and pollen. While the model allows for some of these complexities (value to honey production and transport costs) the information is not available to predict prices and quantity of pollination services at different times and locations. It estimates prices and quantity of pollination services over time under the different scenarios, and identifies which industries will be willing to pay the price and which are likely to miss out on services if demand expands faster than supply. In the short run how much an industry is willing to pay for services depends on its dependence on the honeybee for pollination and whether returns on production will cover variable costs once the cost of pollination services is included. In the longer run, the level of fixed capital invested will be taken into consideration, and unless pollination services are available at a reasonable price, growers may switch to other crops.

Results/Key findings

The first scenario is the business as usual situation where there is modest growth in area of production of pollination dependant industries and little increase in the adoption of paid pollination services. Over the modelling horizon (to 2015) the expansion in demand can be largely met by current honey producers shifting into paid pollination services. This may have some minor impact on honey production, but it was beyond the scope of the study to estimate this change. It is estimated that by 2015 the portion of the pollination market included in the model will grow from 118,000 hives to nearly 220,000 hives. If the pollination industry expands as modelled over time the average price will rise from $60 to $78 per hive. The price varies by crop, with the price for almonds rising from $57 to $76 a hive.

The second scenario is a *Varroa* incursion taking widespread effect in 2010. This pushes up the costs for suppliers by $40 per hive due to the higher labour input required (20 per cent less hives can be managed) and higher costs of chemicals and supplements (estimated to rise by 20 percent). While these cost increases are substantial, the impact on demand is much greater. In 2015 the number of hives supplied is 267,000, a modest increase on the baseline scenario. Despite the relatively small change in the quantity of hives supplied the underlying demand increase and upward pressure on costs for pollination prices sees prices peak at $193 in 2011 and 246,000 hives provided for pollination. This is less than what would be demanded by the agricultural industry to maintain current output and represents lower agricultural production in the industries that cannot access enough pollination services. Some industries, such as almonds and cauliflower seed production, will see output decline by 10 per cent or more.

Over time there will be a response to the price signals by the pollination providers. Existing providers will increase their capacity while new entrants will emerge. By 2015 the price is estimated to have fallen to $149 which is higher than the base case reflecting the higher costs of hive management with *Varroa*. By 2015 the decline in output is estimated to fall to an average of 1.5 per cent across all industries. The value of these losses is somewhat dependent on the alternative options for farmers. Some farmers may opt to employ their current resources such as land and capital in non-pollination dependent ventures while others may choose to leave the agricultural sector altogether. Estimating the value of these losses was beyond the scope of this modelling exercise.

The third scenario looks at the *Varroa* incursion scenario under the situation where supply constraints are being addressed more proactively. This is called the “insurance” scenario. The modelling exercise is not concerned with how the constraints are dealt with but simply assumes they are overcome and the industry is thus able to expand more rapidly. The cause of this does not have to be specified as the focus is on how such actions would change the outcome in the case of a *Varroa* incursion. The model assumes that growers are also proactive and support the growth of the pollination industry by increased adoption of paid services. Speeding up the response of growers and pollination providers changes the estimated price of pollination services in 2011 from $193 to $133, and the volume of services purchased in 2011 from 246,000 to 356,000. With insurance, the decline in output is reduced from 2.5 per cent to 1.7 per cent in 2011.

Implications for relevant stakeholders

The implications of the analysis are quite clear – that there is considerable value for both the agricultural industries and potential pollination service providers in actions to speed up the responsiveness of supply of pollination services. There is also clearly value to agricultural industries dependant on honeybee pollination in improvements in productivity in the pollination service industry as, given that the assumptions of a competitive industry are correct, the benefits will flow to predominantly to the service using industries.

The analysis shows that under a business as usual situation the pollination service providers are able to expand to meet the growing needs of the industry as long as these needs remain modest. That is, as long as there are feral honeybees that provide the services for free. If this situation changes, the current honeybee industry will not be able to adjust in time to keep up with demand. In this, the analysis confirms the motivation for the formation of the Pollination Alliance.

Recommendations

The analysis provides a good first pass at understanding the implications of *Varroa* and other sources of risk to feral honeybee populations on Australia’s agricultural industries. It provides an indication of how prices will move and which industries are likely to suffer the greatest downturn due to lack of access to paid pollination services. More detailed modelling to take into account the timing of pollination needs and locations is required to provide price forecasts for specific crops and regions. Further work in understanding the science behind pollination including detailed analysis of pollination dependence, optimal hive requirements and potential yield effects of optimal pollination will assist in valuing the true losses to agriculture and related industries. However, no model can capture the full complexity of pricing at an individual contract level and the market does this best. This study highlights the high costs of *Varroa* and similar sources of risk, the benefits of managing these risks and the potentially high returns to research and other efforts on how to manage and prepare for what may be inevitable.

1. Introduction

Australia is one of the few countries yet to be affected by *Varroa destructor*, a mite that reduces the lifespan and the vigour of honeybee colonies. Incursions of the mite affecting New Zealand in recent years has provided insight into the impacts on feral honeybee populations and consequences for managed hives. This has significant implications for pollination dependent agricultural industries from almonds to pasture production. The scale of honeybee dependent pollination industries in Australia also appears to be growing, most notably with a major expansion in almonds. At the same time the honeybee industry is facing pressures from an ageing workforce and uncertainty over access to native forests important for hive health. Colony collapse disorder is emerging as a major problem in the United States, and although the cause has yet to be determined, it is clear that *Varroa* and overwork of hives in pollination are contributing factors.

The honeybee and pollination dependent industries have recognised these threats and are working together to develop an alliance that will help them to ensure a sustainable future. This process is being supported by the Industry Partnership Program (IPP) and RIRDC. Understanding the prospects for the pollination industry both in the presence and absence of *Varroa*, and the value of a proactive approach to developing pollination services is critical to engaging interest from affected industries.

This study is a first attempt at estimating the size of the pollination industry in Australia under the scenarios of business as usual and in the event of a *Varroa* incursion. It also explores the difference that strategies to support the growth of the pollination industry could make to the pollination dependent industries as well as those supplying the pollination services. The analysis is limited by data availability and simplifies the complex nature of the pollination industry arising from the diverse pollination needs across different crops and geographical regions. Thus it does not provide pricing models in the sense of predicting the prices of pollination services. It does, however, provide information on the welfare gains and losses associated with the different scenarios.

The following chapter looks at the demand for pollination services and the factors that underpin that demand. Chapter 3 presents information on the supply of pollination services, focusing on the cost of supply and how quickly supply can adjust to meet growth in demand under current conditions. Chapter 4 sets out the methodology used for analysing the market for pollination services and sets up the scenarios. Technical details of the modelling are given in an annex. Chapter 5 presents the results of the modelling exercise.

2. Demand for pollination services

The role of honeybees in agriculture

Australia's agricultural industry is worth approximately $30bn (DAFF 2007) annually with $1.8b dependent on honeybee pollination to some degree (CIE 2005). Not all plants are completely dependent on honeybees for pollination however many depend at least in part on the insect. In some instances the plants will still flower but the final fruit, vegetable or seed yields and quality may significantly decline.

Crops dependent on honeybee pollination

Table 2.1 shows dependence on honeybees for pollination for selected crops. Some of these crops such as apples and almonds are 100 per cent dependent, that is, without honeybees yields would decline to zero. Others crops, lemons and limes for instance, are partially dependent on honeybees for pollination. In these crops yields may decline in the absence of honeybees but will not fall to zero. Furthermore fruit or vegetable size, quality, etc. may be adversely impacted and reduce the value of the final product. There is another group of crops that are not dependent on honeybees for growing but are completely dependent during seed production. Without honeybees the production of seed for these crops would not be possible.

2.1 **Honeybee dependence for pollination of selected crops (as percentage of yield)**

Crop	Dependence %	Crop	Dependence %
Tree crops		*Vine crops*	
Almond	100	Blueberry	100
Apple	100	Cucumber	100
Apricot	70	Kiwi	80
Avocado	100	Pumpkin	100
Cherries	90	Rock melon	100
Citrus [a]	30 – 80	Squash	10
Grapefruit	80	Water melon	70
Lemon & Lime	20		
Macadamia	90	*Seed production*	
Mandarin	30	Beans	10
Mango	90	Broccoli	100
Nectarine	60	Brussels sprout	100
Orange	30	Cabbage	100
Papaya	20	Canola	100
Peach	60	Carrot	100
Pear [a]	50 – 100	Cauliflower	100
Plum & Prune	70	Celery	100
		Clover	100
Ground crops		Lucerne	100
Peanut	10	Mustard	100
		Onions	100
Broad acre crops			
Canola	15	Soy	10
Cotton	10	Sunflower [a]	30 - 100

Notes: [a] – depends on variety
Source: Gill (1989), Crop Pollination Association (personal communication 2007).

Most of the honeybee dependent pasture crops depend on honeybees and other pollinators for seed production. Thus as long as farmers can purchase seed they will be able to produce fodder crops such as lucerne and clover. Nevertheless, to the extent to which they rely on self seeding to maintain the pasture they will face higher seed and management costs in the absence of honeybees. Some analyses of the level of honeybee dependence have suggested that honeybee pollination is crucial for dairy production (Cunningham et al. 2002). This analysis does not appear to take into account the fact that grazing enterprises have alternative pastures and as long as seed can be purchased will be able to maintain pastures for fodder and fodder crops. While lack of honeybees would impact on grazing industries this impact is minor compared to honeybee pollination dependant crops. For these reasons the modelling excludes grazing industries.

Oilseeds (canola and cotton seed make up 90 per cent of production, others include soy, sunflower, safflower, peanut, linseed (Australian Oilseeds Federation 2008)) benefit from honeybee pollination. Manning and Boland (2000) report that a natural pollinators in the United States provide pollination for canola but that due largely to the expanse of planting, adding one honeybee hive a hectare can raise yields by 15 per cent. It is not clear the extent to which canola producers in Australia currently use pollination services. With a large share of canola grown in Western Australia, and few honeybee producers located there it suggests that honeybee pollination may be less important in Australia than it is in the United States.

Stocking rates for pollination

The optimal amount of pollination varies from crop to crop. Some crops require many honeybee visits per flower before effective pollination takes place whereas others require very little. There is no clear relationship between the number of hives required and the dependence on honeybees for any given crop. Almonds, apples and avocado for example are all 100 per cent dependent on honeybees for pollination yet the optimal stocking rate varies from 3 to 12.5 hives per hectare. Optimal stocking rates, area planted (in 2007) and pollination timings are shown for selected tree crops in table 2.2. The peak period for pollination in Australia occurs from August to September.

Potential demand for pollination services

From the information in table 2.2, the total potential demand for pollination services in Australia can be estimated. Over the course of the year over 5 million hives would be used based on the upper limit of the optimal stocking rates. Without detailed information on the timing of pollination needs and geographical location of demand, and hence how many crops one hive could service in a year, the estimates are largely indicative. They do demonstrate that the current level of pollination services used, at around 220 000 hives a year (includes paid pollination services and incidental pollination from beekeepers putting voluntarily placing hives on farmers land), is well short of the potential demand.

The reason Australian demand falls well short of potential is two-fold:

- feral honeybees provide unpaid pollination services in many locations for many crops
- the value added of saturation pollination services may be under appreciated by the agricultural industries.

2.2 **Optimal stocking rates and pollination timings**

Crop	Optimal hives (lower)	Optimal hives (upper)	Area harvested	Pollination timing requirements											
	Per Ha	Per Ha	Ha	J	F	M	A	M	J	J	A	S	O	N	D
Almond	3	5	18500												
Apple	4	12.5	17000												
Apricot	2	5	3100												
Asparagus	5	5	2500												
Avocado	5	8	2400												
Bean (seed)	2.5	2.5	54												
Blueberry	2.5	10	Na												
Broccoli	5	10	6800												
Brussels sprout	5	10	Na												
Cabbage	5	10	Na												
Carrot (seed)	7	8	65												
Cauliflower (seed)	5	10	96												
Celery	7	8	Na												
Cherry	2.5	5	1900												
Clover (seed)	3	5	25												
Cotton lint	1	12	Na												
Cucumber	2.5	7.5	1000												
Grapefruit	1	2	800												
Kiwi	3	8	230												
Lemon & Lime	1	2	1250												
Lettuce (seed)	5	10	58												
Lucerne (seed)	3	5	25												
Lupin	5	8	500000												
Macadamia	5	7.5	17700												
Mandarin	1	2	3700												
Mango	8	15	5000												
Nectarine	3	3	Na												
Onion	12.5	37.5	4500												
Orange	1	2	14500												
Papaya			400												
Peach	2	4	6600												
Pear	2.5	5	3500												
Plum & Prune	2	3	3500												
Pumpkin	2.5	7.5	5800												
Strawberry	1.25	1.25	1300												
Watermelon	3.5	3.5	4000												

Note: Na – not available.
Source: Crop Pollination Association (personal communication 2007), CAPA (1999), Hunt (2000), Department of Agriculture and Food, WA (2007), Future Focus (forthcoming CIE study for Horticulture Australia Limited).

Saturation pollination

Paton (1995) conducted a study of a limited geographic area in South Australia and suggests that there are between 0.001 and 0.77 feral hives per hectare in this region. In the absence of further data this study applies these estimates across the country and notes they are well below the optimal rates set out in table 2.2. It is also acknowledged that this is an average number of bees for the entire country, the actual number will vary from location to location. A large portion of the country will have little or no bee presence while other areas with favourable conditions such as well wooded river banks will have a much higher population density.

Despite this uneven distribution of feral honeybees, some, if not many crops, could benefit from increasing the number of honeybees up to saturation levels. There is research underway funded by RIRDC that is looking at the value to crops of moving to saturation pollination. Unfortunately results from this work are not yet available.

Understanding the demand for paid pollination services

The demand for pollination services is a derived demand – that is it depends on the demand for the industries which purchase these services. As mentioned above, the presence of feral honeybees and other native pollinators (for some crops) has a major influence on demand, as farmers will not pay for a service that they can get for free.

Cost of pollination services as a share of total costs of production

The cost of pollination services ranges from around $60 to 120 per hive in Australia. Recent data from the United States shows prices have risen as high as $160 per hive (personal communication Crop Pollinators Australia). Table 2.3 shows the potential expenditure by industry based on the optimal number of hives and the current area for each crop. It also shows the gross value of production (GVP) for the crops where this information is available. As a share of GVP pollination services range from as little as 0.03 per cent of GVP to as much as 9.7 per cent of GVP. Most are below 4 per cent of GVP, however, if profit margins are slim, these costs could lead to significant changes in production decisions.

Other crops that have some reliance on honeybees for pollination

Oilseeds and pasture production are not included in the model as the stocking rate for honeybee pollination appears to be close to zero for Australian producers. The area of canola is around 1 million hectares a year, while around 35,000 hectares of sunflower is planted and 13,000 hectares of soy (AOF Crop report 2008). Return per hectare varies but a benchmark of around $600 a hectare is a reasonable approximation. If these producers were to seek paid pollination services their demand would dominate the market due to the very large areas of production. However, it is unclear that they would purchase services given the small increase in yield (10 to 15 per cent) provides an additional return that is less than the current price of pollination services. Thus it is difficult to make the economic case that theses industries would be major consumers in the pollination service industry.
Similarly, pasture production for dairy, other grazing industries and fodder crops benefit from the seed production self seeding the pasture. They face additional costs arising from having to replant regularly. Where lucerne and clover are grown in rotation with wheat and other crops this will not impose additional costs as reseeding would be necessary regardless. However, for permanent pastures the impact is more complex and depends on the reliance on self seeding. This cost is likely to be small relative to the cost of purchasing paid pollination services, so it is not expected that these crops would become major purchasers of pollination services.

The same is not true for the pasture seed producers, who have a higher reliance on honeybees for setting seed. Lucerne seed makes up the dominant share of the industry with around 10 000 hectares produced in Australia a year. With a total income per hectare of seed of around $3,800 this industry is likely to be willing to pay for pollination services.

2.3 Comparing potential costs of paid pollination services to GVP of crops

Crop	Cost of services		Area harvested	Industry GVP (farm gate)	Cost as a share of GVP
	$ per Ha (lower)	$ per Ha (upper)	Ha	$m	%
Almond	171	285	18500	76.6	2.4
Apple	296*	925*	17000	528.5	2.6
Apricot	148*	370*	3100	28.9	2.5
Asparagus	370*	370*	2500	48.4	1.6
Avocado	370*	592*	2400	90.5	3.2
Bean (seed)	185*	185*	54	6.2	1.0
Blueberry	185*	740*	Na	68.7	Na
Broccoli	600	1200	6800	73.5	Na
Brussels sprout	370*	740*	Na	Na	Na
Cabbage	370*	740*	Na	Na	Na
Carrot (seed)	840	960	65	165.8	3.4
Cauliflower (seed)	500	1000	96	48.8	9.7
Celery	518*	592*	Na	Na	Na
Cherry	185*	370*	1900	67.4	0.04
Clover (seed)	222*	370*	25	21.0	2.2
Cotton lint	74*	888*	Na	Na	Na
Cucumber	185*	555*	1000	Na	1.2
Grapefruit	74*	148*	800	16.5	Na
Kiwi	183	488	230	8.3	1.3
Lemon & Lime	74*	148*	1250	24.7	0.03
Lettuce (seed)	370*	740*	58	1.3	0.02
Lucerne (seed)	222*	370*	25	19.0	2.1
Lupin	370*	592*	500000	Na	2.5
Macadamia	370*	555*	17700	119.4	Na
Mandarin	74*	148*	3700	110.7	Na
Mango	592*	1110*	5000	134.6	Na
Nectarine	222*	222*	Na	90.6	Na
Onion	1250	3750	4500	144.0	Na
Orange	74*	148*	14500	310.0	1.0
Papaya	74+	74+	400	6.9	0.03
Peach	148*	296*	6600	99.2	2.4
Pear	185*	370*	3500	89.2	2.0
Plum & Prune	148*	222*	3500	58.2	2.2
Pumpkin	185*	555*	5800	48.3	2.5
Strawberry	93*	93*	1300	122.3	0.0
Watermelon	214	214	4000	70.0	3.4

Note: Na – not available. * - Little or no data available, an estimated cost per hive is applied for these crops. + - Optimal stocking rate not available, figure shown is cost per hive.
Source: Crop Pollination Association (personal communication 2007), CAPA (1997), Hunt (2000), Department of Agriculture and Food, WA (2007), Future Focus (forthcoming CIE study for Horticulture Australia Limited).

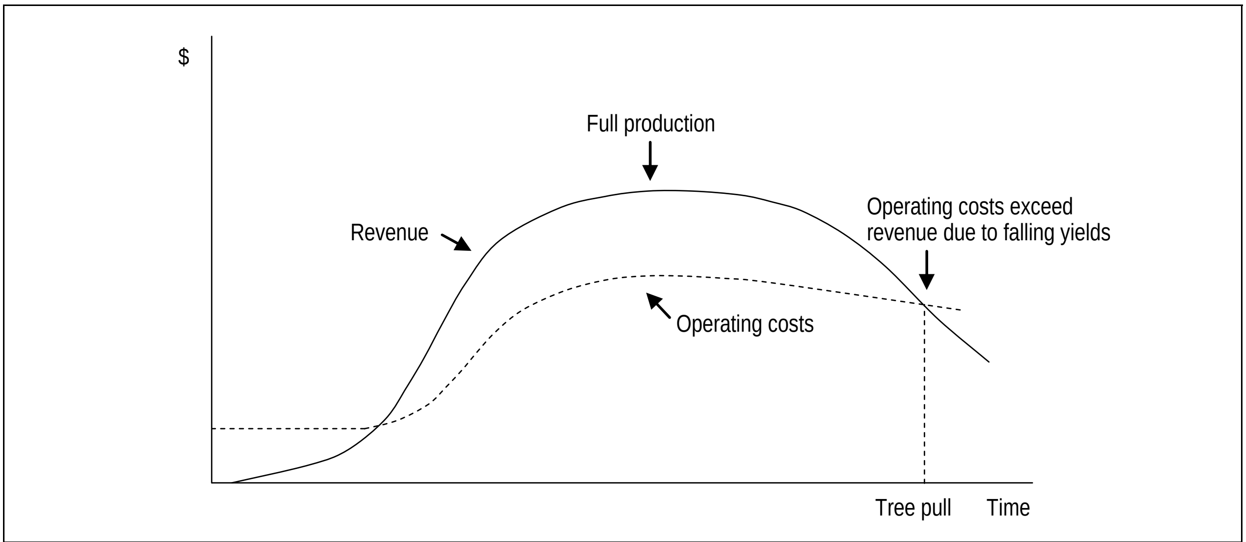
Pollination costs and production decisions

Where the share of pollination services in total costs is small a rise in the price of pollination services, or having to pay for them at all, will not affect the production decisions by farmers. If this is the case then under a scenario of loss of feral honeybee pollinators, the demand for pollination services can be calculated based on the projected area of production for each crop. Unfortunately the analysis is not as simple. For some crops the costs would significantly erode the profit margin unless they can be passed onto the consumer. Farmers make decisions about what to grow based on expected demand for the crops and expected cost. Even a small increase in the cost of production of one crop relative to another can see farmers change their production decision, in this case to crops that do not require honeybee pollination. Apart from the size of the cost, factors influencing this decision are the:

- level of capital invested in the crop that is specific to the crop - thus tree crops are less likely to switch than annual crops
- impact of the additional cost on the profit margin, and the value of the assets in alternative uses – for example, for farmers facing water restrictions, even a small added cost may make selling their water allocation rather than crop production more financially viable
- impact on the price of the crop of a reduction in supply, and how increases in costs can be passed through to consumers – this depends on the availability of substitutes and import restrictions
- access to paid pollination services – if farmers are unable to access services as needed and hence face several years without pollination services, the relative returns to switching crops to non-pollination dependent crops, or non-agricultural uses of the land and water assets rises.

Chart 2.4 shows a stylised cost and revenue curves for a tree crop enterprise and how the decision to stop production is influenced by a rise in costs. It excludes the fixed costs of establishment as these are 'sunk' once the trees have been planted and ongoing production decisions depend on operating costs relative to revenue. The costs associated with keeping a tree alive are incurred each year the plant is maintained regardless of whether it is producing or not. In this diagram these costs are assumed to be constant whereas in reality they may vary over time (more fertiliser may be required for young plants which makes the costs higher in early years and so forth). When the tree begins to produce we introduce harvesting costs which makes the costs more variable over time. These costs are combined to give a cost curve which varies over time as shown in chart 2.4 (the dashed line).

2.4 **Cost and revenue curves for a tree crop – impact of a rise in costs**

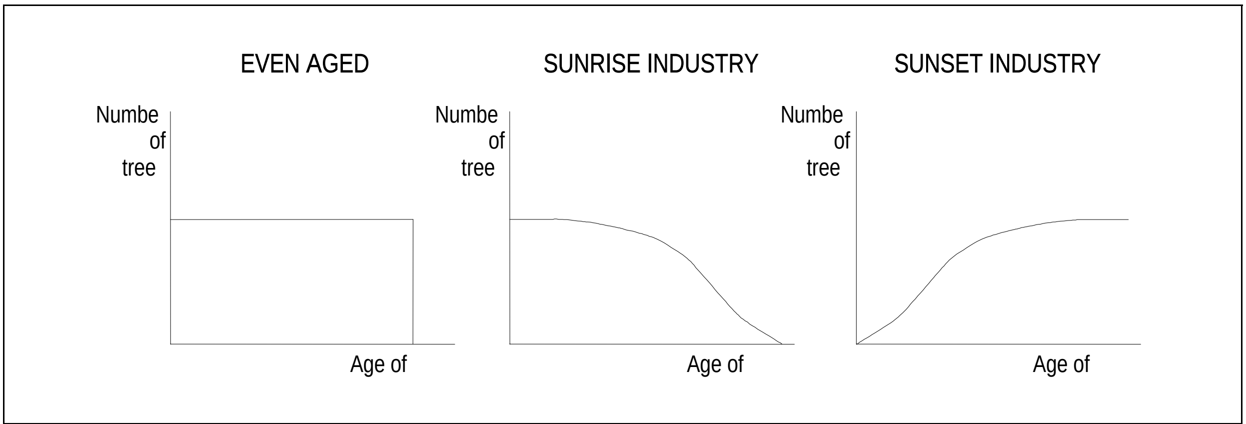


Source: CIE.

The revenue from the enterprise also varies over time. In the early years the tree tends to produce very little and revenues are small. Over time production increases and revenue rises accordingly. As time progresses the tree will reach peak production after which point its output, and revenue, declines.
The profit (loss) at any point in time is calculated as the surplus (deficit) of revenue over (under) costs. If, over the life of the tree, revenue exceeds costs then a net profit will be obtained. Conversely, a loss will be incurred should costs exceed revenue. Revenue is shown as the solid line in chart 2.4.
The point in time when operating costs begin to exceed revenue marks the end of the useful life of the tree. In chart 2.4 this is referred to as 'tree pull'. After this time the farmer must make a decision to replant the same crop, change to another crop or move away from the industry altogether.
This demonstrates the importance that the age profile of the pollination dependent industries trees has on the switch point, and hence on the likely demand for pollination services over time.

For farmers contemplating major investments in perennial pollination dependent crops the availability of pollination services as well as their price will be important considerations. Thus the total demand for pollination services also depends on the age profile of the plantings for perennial crops. Chart 2.5 shows different age profiles labelled as even aged, sunrise and sunset. Sunrise industries have a large number of plantings that are relatively young while industries whose plantings tend to be older are referred to as sunset industries. An even aged industry has a uniform distribution of plantings over time. Such an industry would see some farmers who have planted more recently be more inclined to purchase pollination services to ensure they maximise the useful life of their plantings. Others, whose plants are nearing the end of their useful life, may choose to pull their trees early and forego the last few years of revenue.

2.5 **Age profile of plantations**



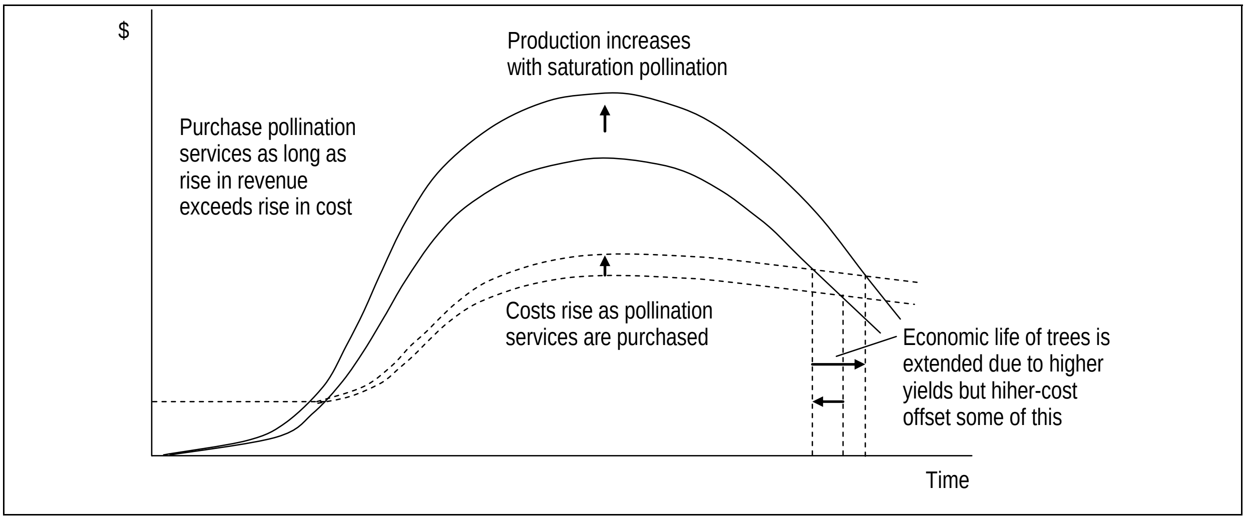
Source: CIE.

Returns to the purchase of pollination services

Even without a *Varroa* incursion there may be benefits in some industries to purchasing pollination services. Paying for pollination services will shift the cost curve of a farmer upwards but this is justified if it increases productivity and hence revenue more than cost. If the revenue increase outweighs the cost increase then the farmer will see a net benefit from purchasing pollination services.

In some instances the increase in productivity may extend the useful life of the tree. Chart 2.6 shows a case where paid pollination increases costs for the farmer. Initially this reduces the useful life of the tree but given the increase in productivity this reduction may be offset and even reversed. The net result of pollination may therefore be an increase in useful life and profits.

2.6 **Pollination benefits**



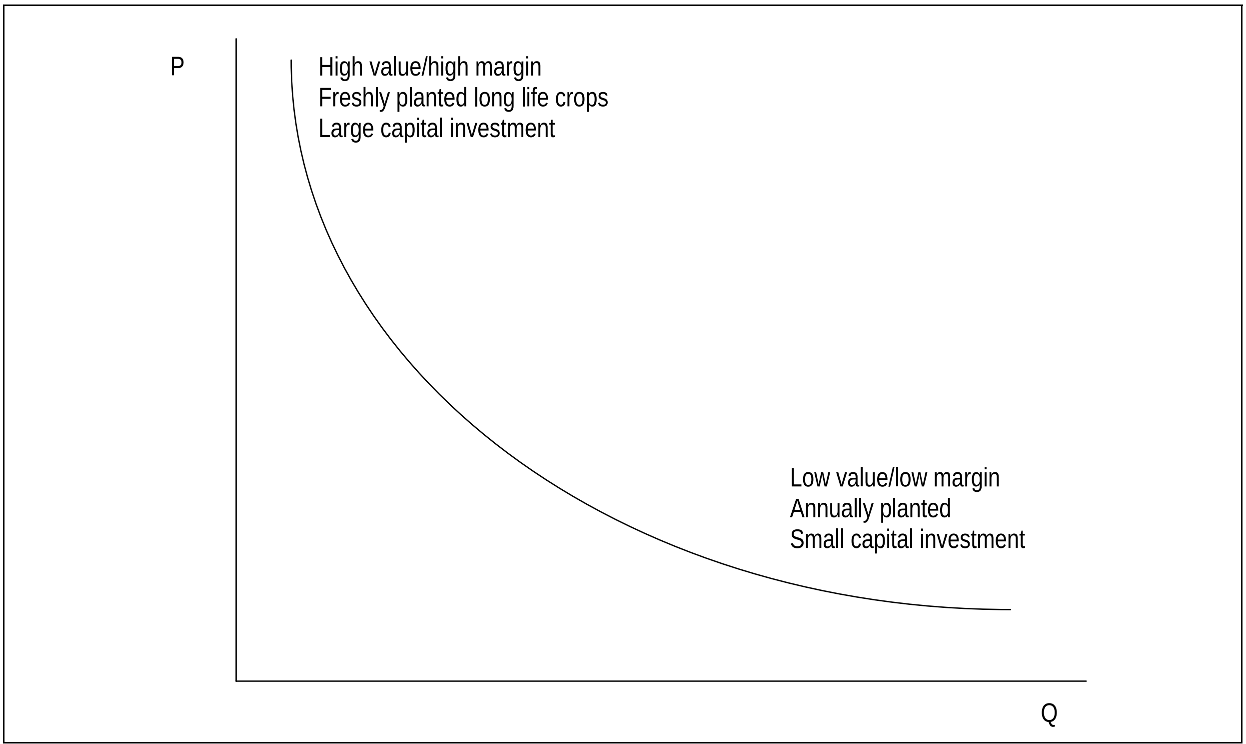
Source: CIE.

Demand across the different industries

Willingness to pay for pollination services varies across industries with some willing to pay a very high price to access services and others a much lower price. This is represented in chart 2.7.
The difference in willingness to pay (but not what they have to pay) is due to the:

- dependence of production on the honeybee as a pollinator (see table 2.1)
- capacity to switch to other crops is pollination services are temporarily unavailable – this is related to the level of fixed capital investment – most notable for tree crops, but also potentially for specialist machinery including processing plant and equipment. As discussed above, the age of the capital stock and the extent to which it is fully depreciated will affect this decision
- capacity to pass on cost increases to consumers. This depends on how responsive consumers are to changes in price. This is captured by the elasticity of demand, given in table 2.8 for the main crops under consideration. These elasticities are based on the current level of import restrictions. Removal of restrictions on imports may see some crops face a more elastic demand as consumer can access imports of the crops, however, this will also depend on seasonal factors. The estimates used in the business as usual scenario in the model assume that the import restrictions are unchanged.

2.7 **Demand for pollination services by crop type**



Source: CIE.

2.8 Elasticity of demand for pollination dependent crops

Crop	Demand elasticity	Crop	Demand elasticity
Almond	1.24	Kiwi	0.36
Apple	0.78	Lemon & Lime	1.41
Apricot	1.15	Lupins	0.88
Asparagus	1.21	Macadamia	3.69
Avocado	0.82	Mandarin	1.41
Beans	0.88	Mango	0.36
Blueberry	0.36	Nectarine	1.15
Broccoli	0.67	Onions	0.22
Brussels sprout	0.67	Orange	1.41
Cabbage	0.67	Papaya	0.36
Carrot	0.46	Peach	1.15
Cauliflower	1.02	Pear	0.36
Celery	0.67	Plum & prune	1.15
Cherries	0.36	Pumpkin	1.02
Cotton	1.00	Strawberry	2.26
Cucumber	1.02	Watermelon	0.36
Grapefruit	1.41		

Source: Future Focus (forthcoming CIE study for Horticulture Australia Limited)

3. Supply of pollination services

The Australian honeybee industry

In 2005 there were approximately 9600 registered beekeepers with around 500 000 hives in Australia. NSW and Queensland are home to about one third of the country's apiarists each while Victoria, Western Australia, South Australian and Tasmania account for 15, 10, 8 and 3 per cent respectively (CIE 2005). The industry currently has a gross value of production of around $65 million consisting mainly of honey, beeswax, queen bees and packaged bees, pollen and propolis. Paid pollination services also contribute to this amount although at $3.5 million in 2006 (RIRDC 2007) this value is still relatively small.

The pollination services industry

The Australian honeybee industry can be broken into two broad categories – honey producers and pollination service providers. Honey producers include those beekeepers that keep bees purely for the purposes of producing honey. As an indirect consequence of their activities these beekeepers will supply incidental pollination to crops in the areas where the hives are located but this is not the primary intention of the beekeeper. Pollination providers, on the other hand, set out to provide pollination services and honey production is a bonus on top of any income derived from pollination services. Approximately 1 per cent of hives in Australia are kept for pollination only. Some honey producers also provide paid pollination services, while others provide unpaid services reflecting mutual benefits from the arrangement.

Brokers play an important role in sourcing beekeepers for agricultural industries. They provide the link between those who have services to sell and those who wish to buy them thereby reducing the search costs to both parties. They may also provide quality assurance services assisting in ensuring the crops are managed in a way that maintains hive health, and that the hives provided are providing the services required.

The Australian pollination services industry is very small, in part due to the presence of feral honeybees. Agriculture also benefits from the relatively large number of amateur beekeepers whose bees add to the free pollinator population. In other countries the presence of pests and diseases has reduced the feral honeybee populations and also reduced the involvement of amateurs. As a consequence most other countries have large pollination service industries.

Pollination service industries in New Zealand and the United States

The industry in New Zealand provides pollination services to over 45 000 hectares of horticultural land and more than 10 million hectares of pastoral land (National Beekeepers Association of New Zealand 2008). Following the recent arrival of *Varroa* the crops grown on this land, especially clover, has become more reliant on paid services to sustain production.

The mite first entered the North Island and despite considerable effort it has since entered the South Island illustrating the difficulties associated with containing the pest. Once it had established itself the mite caused considerable damage all but wiping out the local feral populations of bees. In addition the number of managed hives on the North Island of New Zealand has declined from over 135 000 in 2000 to approximately 115 000 in 2004 (Goodwin 2005) with similar consequences expected for the South Island. The presence of the mite has also caused beekeeping costs to rise in the order of $40 - $50 per hive, costs which are largely reflected in increases to the price of pollination services.

The effect of price increases and reduced availability of hives sees horticulture and pastoral growers faced with rising costs for an increasingly scarce resource. With few alternatives (Lloyd, 1985) New Zealand growers have little option but to buy higher cost pollination services or risk lower yields and declines in quality.

The United States also has a growing pollination industry. The National Honey Board (2007) estimates there are approximately 1600 commercial beekeepers (beekeepers that have 300 or more colonies) with nearly 1.5 million hives that are used for honey production and pollination services. Like New Zealand, the United States faces challenges related to *Varroa* and other pests and diseases which present issues to growers of pollination dependent crops.

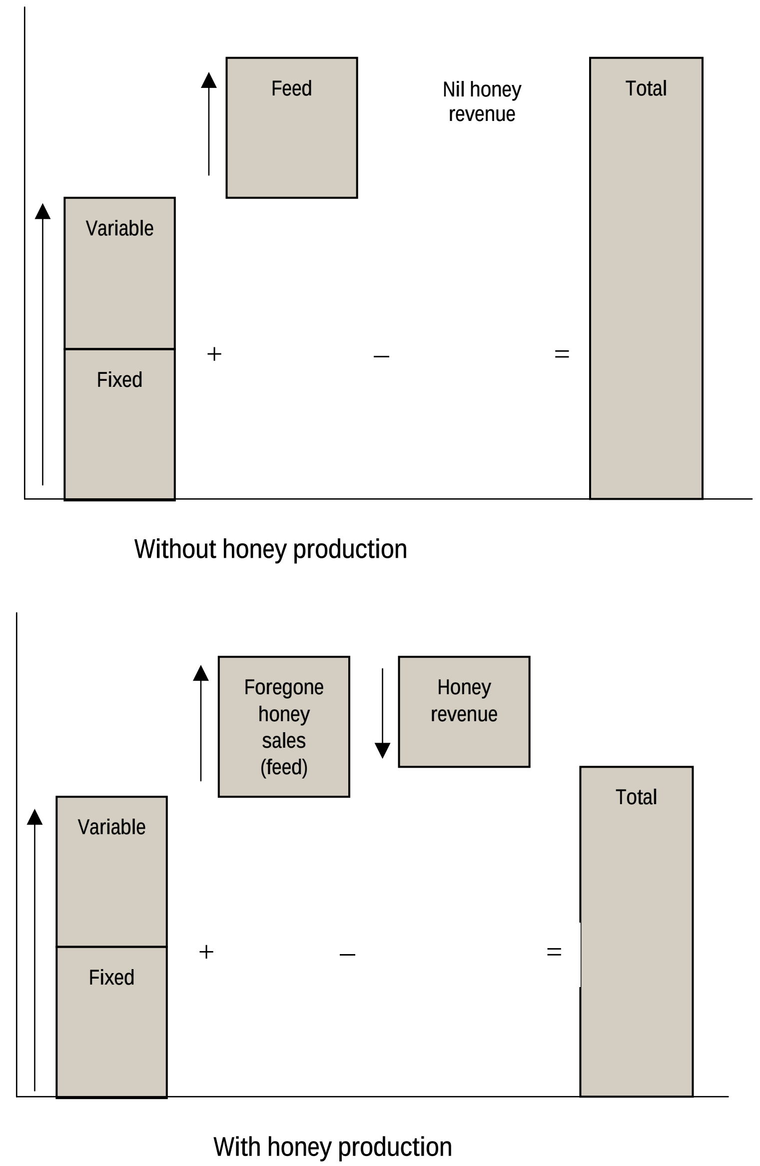
The Californian almond industry relies heavily on honeybees for pollination with the National Honey Board (2007) estimating that between 900 000 and 1 million hives are used with most services now coming from professional beekeepers. In recent years almond prices have risen from $US1 per pound to over $US3 per pound (Traynor 2005) prompting further expansion of the industry. These increases in demand coupled with supply issues have seen pollination prices rise as high as $US200 per hive during the 2006 season (CSBA 2006) spiking even higher on some occasions.

Costs involved in providing pollination services

Chart 3.1 provides a stylised costs and revenue analysis. The first bar in chart 3.1 shows fixed and variable costs for beekeeping. Fixed costs include capital outlays such as bee hives, buildings, trucks, processing equipment, queen bees and initial training. Variable costs include those items that vary with the level of output and include fuel, veterinary chemicals, and in some cases supplementary feed. When honey is produced this cost is implicit and reflected in foregone honey sales. If insufficient honey production takes place to feed the hive then the beekeeper is required to supplement food sources. Summing these inputs gives the overall costs for beekeeping.

Chart 3.1 highlights the different cost to pollination service providers if the crops they provide services to also supply good feed for the bees. This reduces the need for supplementary feeding and can also produce a revenue flow from the honey. Clover is a good example of the mutually beneficial relationship for the honey producer and the farmer. Some of the crops requiring honeybee pollination do not provide sufficient food to maintain hive health, especially in areas without alternative sources of nutrition, such as where there are large monocultures of such crops.

3.1 **Costs of providing pollination services**



Source: CIE.

Table 3.2 categorises crops on the basis of their potential for an offsetting revenue stream from honey production. Crops with a high potential revenue steam would pay a lower price for pollination services than those with a no contribution to honey production. In the modelling a fixed adjustment is made to the price paid by an industry based on the contribution to honey revenue/lower cost of feeding.

3.2 **Contribution to honey production/feeding by crops**

Low	
Almond	Cabbage
Asparagus	Carrot
Avocado	Celery
Bean	Lupin
Broccoli	Macadamia
Brussels sprout	Onion
Medium	
Apple	Mandarin
Cauliflower	Mango
Cotton lint	Orange
Cucumber	Papaya
Grapefruit	Pear
Lemon & Lime	Pumpkin
High	
Apricot	Kiwi
Blueberry	Nectarine
Cherry	Peach
Clover	Plum & Prune

Source: Crop Pollination Australia (personal communication November 2007)

Costs of production – benchmark information

The costs presented here are based on the benchmarking information based on information obtained from the honey cost of production spreadsheets developed by the NSW Department of Primary Industries. While management practices vary considerably between honey producers and pollination services, most of the later also produce honey and the expenditure on hive management is similar. Apart from transport costs, the main cost difference arises from the need to supplement food supplies for bees when pollinating crops that do not provide sufficient nectar and pollen. Table 3.3 shows detailed cost benchmark information for the beekeeping industry. Treating vehicle, depreciation and finance costs as being fixed, shows that between 48 and 52 per cent of the costs are fixed in the short term. Labour costs are one of the largest variable costs.

3.3 Cost benchmark for beekeeping industries

Cost	Farm size (hives)		
	250	*700*	*1500*
Apiary & veterinary chemicals	100	280	600
Cleaning & pest control	140	385	825
Purchases: Honey	0	0	0
Sugar	1050	2940	6300
Pollen (feed back)	0	0	0
Protein supplement	500	1000	3000
Queen bees	1250	3500	7500
Hives of bees	0	0	0
Marketing expenses	50	150	800
Accommodation & meals	900	2600	5600
Freight	900	1500	5000
Machinery maintenance.	1500	5000	10000
Building structure maintenance	940	2200	4850
Hive equipment – maintenance	2270	5270	7700
Hive equipment – purchase	0	0	0
Drums & containers	425	875	2550
Packing materials	600	1000	5000
Building, (vehicle) & liability ins.	1800	5000	10900
Small tools, equip. & supplies	440	1230	2640
Rates & land rent	520	1450	3100
Bee site rent (government)	1500	4200	9000
Bee site rent (private)	750	2100	4500
Laboratory fees	100	280	600
Protective clothing	125	350	750
Selling expenses	0	0	0
Levies	244	680	1913
Power & gas	500	1400	3000
Phone	500	1400	3000
Memberships & associations	150	420	1000
Accountancy & legal	465	1155	2790
Administration	1250	3500	7500
Bank charges	0	0	0
Miscellaneous costs	1225	3430	7350
Subtotal	20194	53295	117768
Vehicle fuel & oils	3350	9350	20000
Vehicle maintenance	2100	5860	12550
Vehicle fixed costs	950	2660	5700
Total Vehicle Costs	6400	17870	38250
Depreciation costs	6000	16800	23000
Total Depreciation Costs	6000	16800	23000
Owner-operator allowance	11400	32000	68000
Paid labour	5000	14000	35000
Labour on-costs	0	0	0
Total Labour Costs	16400	46000	103000
Add Operating Interest	0	0	0
Interest on borrowing	1700	4760	10200
Leases/HP	1400	4000	7000
Total Finance Costs	3100	8760	17200
Total Expenses	52094	142725	299218
Total expenses (per hive per year)	208.38	203.89	199.48

Source: NSW Department of Primary Industries honey cost of production spreadsheets - http://www.dpi.nsw.gov.au/agriculture/livestock/honey-bees/management/tools/software.

Constraints on supply of pollination services

The ability of the pollination services industry to grow in response to large increases in demand depends on the availability of the inputs – labour, capital, technology – and the regulatory environment. The Taking Stock and Setting Direction report (CIE 2005) identified a number of constraints for the honeybee industry that are relevant to the pollination service industry. These constraints affect both cost and the speed at which the industry can adjust.

Access to native flora

A major constraint on the number of hives that can be maintained is access to native flora. With a finite amount of native flora available and access to public land being restricted it may not be feasible for beekeepers to support their hives using natural food sources. A commercial beekeeper with 600 hives who moves his bees to 20 sites on an occasional basis will need a foraging area of native flora of around 16 000 hectares per annum (CIE 2005).

This constraint leaves beekeepers with little option but to complement food supplies with artificial supplements. The need to supplement food supplies with products such as sugar syrup increases both labour and material costs. It is also worth noting that supplements are just that, supplements. They cannot replace natural food sources entirely and so the availability of natural flora still places an upper bound on the number of hives that can be maintained.

In addition, monoculture farming practices in which large swathes of land are cleared for a single crop reduce the amount of surrounding native bushland. Removal of this natural habitat impacts on the ability of feral honeybees to provide pollination services. Furthermore, as more land is cleared the distance between this native bushland and the location where pollination is needed increases. So not only are there fewer pollinators, the bees cannot travel the distance required to successfully pollinate crops.

The analysis here assumes continuing and possibly increasing levels of access to native flora such that it is not a binding constraint on production.

Costs to new entrants

There is considerable knowledge owned by the major beekeepers that is not freely available. This ranges from knowledge of locations with flora that provides good honey flows or protein sources for hive strength, to hive management techniques. New entrants to the industry will face higher costs as they have to develop at least part of this knowledge by their own trial and error.

Should the supply of new entrants come from smaller investors their access to capital may limited, given they need to acquire the skills and business plans to secure adequate capital backing. Such entrants would probably begin small and have equally small impacts on the provision of pollination services until they can grow. Once they reach a stage whereby they have the appropriate procedures in place and have established some sort of cash flow from their business they may choose to continue expanding.

Where a pollination dependent industry has a high degree of corporate level investment, there is greater potential for industry players to develop their own pollination services. These industries have large capital backing leaving them with little (or zero effective) constraints in this regard, however the lack of available expertise in beekeeping may prevent rapid growth via this avenue. In addition, as most crops require pollination for only several weeks of the year the business would be forced to find alternative uses for the hives for the majority of the time.

Other sources of constraints

Beekeeping is relatively labour intensive. A shortage of the skilled labour required to address this need would have to be overcome before any significant expansion could take place.

The ability to expand the number of hives from existing stocks could also pose a limiting factor. Quarantine restrictions and a world shortage of breeders mean little opportunity to purchase honeybees from international sources so the majority of growth needs to come from local supplies. Beekeepers can split hives and build new ones, however there is roughly a three year time frame to double hives from the current base (Trevor Monson personal communication November 2007). A *Varroa* incursion would compound the issues of available breeding stock and labour needs and skills and could lengthen the time required.

Long run versus short run cost curves

The short run supply curve for an industry usually differs from its long run supply curve as it takes time for existing producers to increase their capital investments and the scale of their business and for new entrants to join the industry.

The short run supply curve

In the short run pollination services can expand as existing beekeepers shift from a focus on honey production to including pollination services. This means that supply will expand in response to price up to the limits arising from the current number of hives. This defines the short run supply curve.

The price at which existing honeybee producers are willing to supply more pollinations services depends on the additional costs they face in providing paid pollination services. These could include:

- loss of honey production, from shifting their bees to areas with lower honey flows
- additional transport costs if areas are further away or bees are moved more often
- addition labour costs associated with movements
- husbandry costs, if pollination service provision impacts on hive health
- training costs, to learn more about management for pollination services
- brokerage fees, or administration costs required to arrange contracts with farmers.

These costs tend to rise as the supply of services increases. Culture also matters as beekeepers may not want to change what they have been doing for years and require a significant premium over their current income to change what they do. Existing sales contracts and long term relationships with honey customers can also reduce the willingness of beekeepers to shift into providing pollination services. These factors make the short run supply curve less responsive to price (more inelastic) as the volume of services provided rises. At some level of supply it is very difficult to expand services beyond this point in the short run. Currently the limit on supply of pollination services is around 500,000 hives.

The long run supply curve

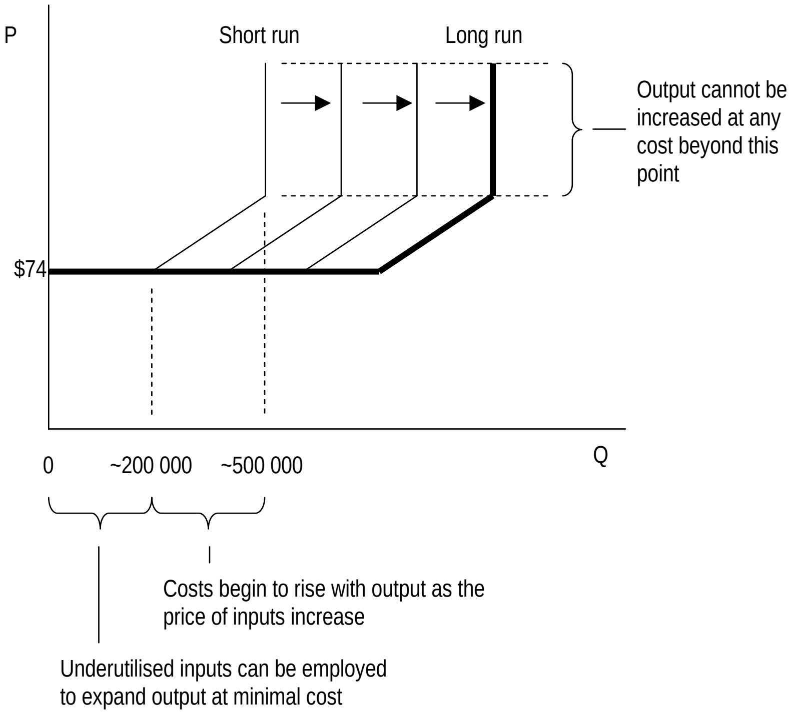
The long run supply curve tracks what happens over time as existing beekeepers adjust to the new opportunities, and new entrants enter the market. Constraints that apply in the short run are overcome allowing further expansion of the industry up to a point at which new constraints emerge. The long run is the envelope of a series of short run supply functions. What defines the function is how quickly the industry can grow. The modelling makes the assumption that the industry can double the number of hives available in three years.

The relationship between the short and long run supply curves

As the industry expands output the short run cost curve will shift to the right. The industry will then further evolve and the short run cost curve moves out as higher levels can be produced for the same cost as investments are made over time in hives, training and other fixed inputs. Chart 3.4 shows a stylised curve for the industry.

The cost curve for the short run is the leftmost curve which is show as consisting of three sections for ease of explanation. In the flat part of the supply curve beekeepers can easily expand the supply of services at the same cost per unit using existing capital. In the middle section of the curve the costs of providing every additional unit rises and so the curve slope upwards. It is at this stage that beekeepers begin hitting constraints that force costs higher. The final part of the curve is vertical. This reflects the constraints that prevent beekeepers from expanding output at any cost. In reality output would respond very much to higher prices but such levels of service would not be sustainable unless constraints can be addressed so the stylised shape is a reasonable approximation.

3.4 **The transition from the short run to the long run**



Source: CIE

The long run supply curve is the frontier of the short run curves. The bold line in chart 3.4 illustrates this. Preparing for expansion in the industry allows the time frame between the short run and the long run to be reduced effectively allowing faster growth in the industry. Research and development and other innovations can increase productivity and lower unit costs which is represented by a downward shift in the long run supply curve.

The paid pollination service market in Australia currently uses around 200,000 managed hives (an estimated additional 140,000 are also provided as unpaid services) for pollination, and on average receive around $60 per hive for a pollination service. This cost is for placement of a hive for a period from around 10 days to 6 weeks in most cases during crop flowering. Timing of crops flowering means that some hives can pollinate a number of crops, or follow the climate for the same crop where climatic variations space out flowering times. Based on the overlap in flowering period of Australian crops it is assumed that a hive can pollinate three crops a year in Australia.

The current market

Currently around 200,000 hives are used for paid pollination services. Of these an estimated 100,000 are used for almonds alone. A further 140,000 hives provide services through incidental pollination or by being placed on farmers land by mutual agreement (personal communication, Crop Pollination Association, November 2007). In addition to the managed hive population the feral population also provides pollination services. These are, in large part, unrecognised by many farmers and it is difficult to estimate the true level of pollination obtained. Nonetheless having access to these free sources of pollination reduces the demand for paid services. The price of pollination services varies between crops and is dependent upon the amount of honey that can be gained (see table 3.2). The average price paid is currently around $60 per hive.

4. The market for pollination services: three scenarios

The purpose of this study is to analyse the market for pollination services. This is useful to understand the effects of demand and supply shocks such as a *Varroa* incursion and the benefits of investment in improving supply.

The market for pollination services is complex and there is not one price for hives as the costs of supply differ across regions, time of year, and the effect of providing the pollination service on honey production. A simplified analysis is still useful to understand how the market will react to some predictable shocks, and how actions to improve supply can reduce the costs to pollination dependent industries as well as pollination services providers.

Scenario 1: Business as usual

Projections of growth in demand due to growth in pollination dependent industries

It is estimated that by 2015 Australia's almond crops alone will require over 370,000 hives for pollination (RIRDC 2007). With an estimated 200,000 managed hives currently employed for pollination a substantial increase in managed pollination services will be required to meet the needs of this industry alone. When considering other crops that also require pollination services the potential for a shortfall is even greater.

Table 4.1 shows the projected changes in area of production of a number of pollination dependent industries from 2006 to 2020. The expansion in the highly pollination dependant nut crops is especially notable. This expansion alone implies higher demand for pollination services over the next decade.

4.1 **Crop area planted by year**

	2008	2009	2010	2011	2012	2013	2014	2015
Almond	18500	20612	22724	24836	26948	29060	31173	33285
Apple	17000	17000	17000	17000	17000	17000	17000	17000
Apricot	3100	3100	3100	3100	3100	3100	3100	3100
Asparagus	2500	2500	2500	2500	2500	2500	2500	2500
Avocado	2400	2512	2624	2736	2848	2960	3072	3184
Bean (seed)	54	54	54	54	54	54	54	54
Blueberry	Na	Na	Na	Na	Na	Na	Na	Na
Broccoli	6800	6800	6800	6800	6800	6800	6800	6800
Brussels sprout	Na	Na	Na	Na	Na	Na	Na	Na
Cabbage	Na	Na	Na	Na	Na	Na	Na	Na
Carrot (seed)	65	65	65	65	65	65	65	65
Cauliflower (seed)	96	96	96	96	96	96	96	96
Celery	Na	Na	Na	Na	Na	Na	Na	Na
Cherry	1900	1900	1900	1900	1900	1900	1900	1900
Clover (seed)	25	25	25	25	25	25	25	25
Cotton lint	Na	Na	Na	Na	Na	Na	Na	Na
Cucumber	1000	1000	1000	1000	1000	1000	1000	1000
Grapefruit	800	800	800	800	800	800	800	800
Kiwi	230	230	230	230	230	230	230	230
Lemon & Lime	1250	1250	1250	1250	1250	1250	1250	1250
Lettuce (seed)	58	58	58	58	58	58	58	58
Lucerne (seed)	25	25	25	25	25	25	25	25
Lupin	500000	500000	500000	500000	500000	500000	500000	500000
Macadamia	17700	18733	19765	20798	21830	22863	23895	24928
Mandarin	3700	3722	3743	3765	3786	3808	3830	3851
Mango	5000	5092	5183	5275	5367	5458	5550	5642
Nectarine	Na	Na	Na	Na	Na	Na	Na	Na
Onion	4500	4500	4500	4500	4500	4500	4500	4500
Orange	14500	14476	14452	14428	14403	14379	14355	14331
Papaya	400	400	400	400	400	400	400	400
Peach	19750	19750	19750	19750	19750	19750	19750	19750
Pear	3500	3500	3500	3500	3500	3500	3500	3500
Plum & Prune	3500	3500	3500	3500	3500	3500	3500	3500
Pumpkin	5800	5800	5800	5800	5800	5800	5800	5800
Strawberry	1300	1300	1300	1300	1300	1300	1300	1300
Watermelon	4000	4000	4000	4000	4000	4000	4000	4000

Notes: Na – not available

Source: Future Focus (forthcoming CIE study for Horticulture Australia Limited)

Estimating the change in stocking rate

Currently a number of growers use paid pollination services. The first column in table 4.9 lists crops and the corresponding proportion of growers that use paid services. For some crops the proportion of growers buying services may be higher than shown however the figures account for the fact that some growers are using sub-optimal levels of paid pollination (see table 2.2). The end result is equivalent, that is, saying 80 per cent of growers use pollination services is equivalent to saying 100 per cent of growers are using 80 per cent of the optimal number of hives. When constructing the baseline scenario the proportion of growers assumed to be using paid pollination remains at the present 2008 levels.

Stocking rates

The baseline scenario is also used to assist in calculating the implied stocking rates in terms of hives per hectare. Using 2008 as a base year, the proportions of growers using paid pollination services in table 4.9, and the number of hives currently used for paid services (managed hives that provide incidental and other unpaid pollination services are not included) the stocking rate is calculated for each crop. Table 4.3 shows these implied rates. It should be noted that these rates are not intended to represent the actual stocking rate of any given grower but rather an average stocking rate across each sector.

4.2 **Implied stocking rates**

Crop	Stocking rate	Crop	Stocking rate
	Hives per Ha		*Hives per Ha*
Almond	6.1	Kiwi	6.9
Apple	10.8	Lemon & Lime	1.7
Apricot	4.3	Lettuce (seed)	8.7
Asparagus	4.3	Lucerne (seed)	4.3
Avocado	6.9	Lupin	6.9
Bean (seed)	2.2	Macadamia	2.7
Blueberry	2.7	Mandarin	2.6
Broccoli	2.7	Mango	2.6
Brussels sprout	2.7	Nectarine	2.6
Cabbage	2.7	Onion	2.7
Carrot (seed)	6.9	Orange	1.7
Cauliflower (seed)	8.7	Papaya	10.4
Celery	6.9	Peach	10.4
Cherry	4.3	Pear	4.3
Clover (seed)	4.3	Plum & Prune	2.6
Cotton lint	2.6	Pumpkin	6.5
Cucumber	6.5	Strawberry	1.1
Grapefruit	1.7	Watermelon	10.4

Notes: Calibrated to number of hives used to provide paid pollination services in 2008 (estimated to be 102,000)
Source: CIE estimates

Estimating the demand shock

Table 4.3 shows the combined impact of the growth in area planted and the growth in use of paid pollination services. Using almonds as an example the growth in demand for hives from 2008 to 2009 is 15 per cent, from 2009 to 2010 it is 14 per cent and so forth.

4.3 **Growth in demand for paid pollination services by industry**

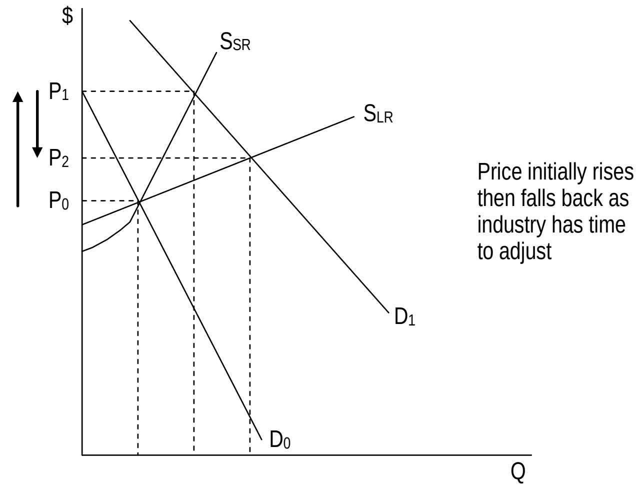
	2009	2010	2011	2012	2013	2014	2015
	%	%	%	%	%	%	%
Almond	15	14	13	12	11	11	10
Apple	29	22	18	15	13	12	11
Apricot	29	22	18	15	13	12	11
Asparagus	0	100	50	33	25	20	17
Avocado	0	109	56	39	30	25	21
Bean (seed)	24	19	16	14	12	11	10
Carrot (seed)	24	19	16	14	12	11	10
Cauliflower (seed)	24	19	16	14	12	11	10
Celery	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Cherry	29	22	18	15	13	12	11
Clover (seed)	29	22	18	15	13	12	11
Cucumber	0	100	50	33	25	20	17
Grapefruit	29	22	18	15	13	12	11
Kiwi	29	22	18	15	13	12	11
Lemon & Lime	29	22	18	15	13	12	11
Lettuce (seed)	29	22	18	15	13	12	11
Lucerne (seed)	29	22	18	15	13	12	11
Lupin	0	100	50	33	25	20	17
Orange	28	22	18	15	13	12	10
Papaya	0	100	50	33	25	20	17
Peach	29	22	18	15	13	12	11
Pear	29	22	18	15	13	12	11
Plum & Prune	29	22	18	15	13	12	11
Pumpkin	0	100	50	33	25	20	17
Strawberry	0	100	50	33	25	20	17
Watermelon	24	19	16	14	12	11	10

Notes: N/A – not applicable
Source: CIE estimates

Modelling the baseline

The business as usual case is straight forward. High value tree crops such as almonds are growing in Australia and will require increasing levels of pollination. To the extent that the supply comes from feral bees this will not cause an increase in price of pollination services, but where the increase in plantings results in an increase in the demand for paid services there will be a resulting change in price and quantity. The increase in price of pollination services in response to this shift in demand depends on how responsive the supply of pollination services is at the current level of services provided. This in turn depends on the costs of production in the pollination services industry and how quickly industry members can expand production and new members enter the industry (see chapter 3). Some factors of production, such as hives, trucks and chemicals are readily available, others, such as technical skills, knowledge of flora and locations, and access to native vegetation, and possibly breeding stock, are less readily available. Chart 4.4 illustrates the effects of a rise in demand (D_0 to D_1) on prices in the short run (P_1) and in the long run (P_2) as the industry has time to adjust to the demand shock.

4.4 **The effect on the market from growth in demand over the short and long run**



Source: CIE.

Scenario 2: A *Varroa* incursion resulting in loss of feral bees by 2010

The potential for an incursion of *Varroa* is a primary motivation for the Alliance and this study as it will result in a major increase in the demand for pollination services. It will also increase the costs of beekeepers thereby raising the costs of supplying pollination services.

Impact on demand

In this scenario *Varroa* is assumed to begin adversely impacting pollination dependent industries from 2011 onwards. From this point forward demand will increase as these growers all attempt to purchase services to meet their needs. Beginning in 2011, and for all subsequent years, all growers attempt to purchase hives from beekeepers so the proportion of growers using hives immediately rises to 1. It is assumed that growers will still attempt to expand plantings which will further increase the demand for hives. Table 4.5 shows the change in demand in terms of a percentage change on the year earlier.

4.5 Growth in demand with Varroa

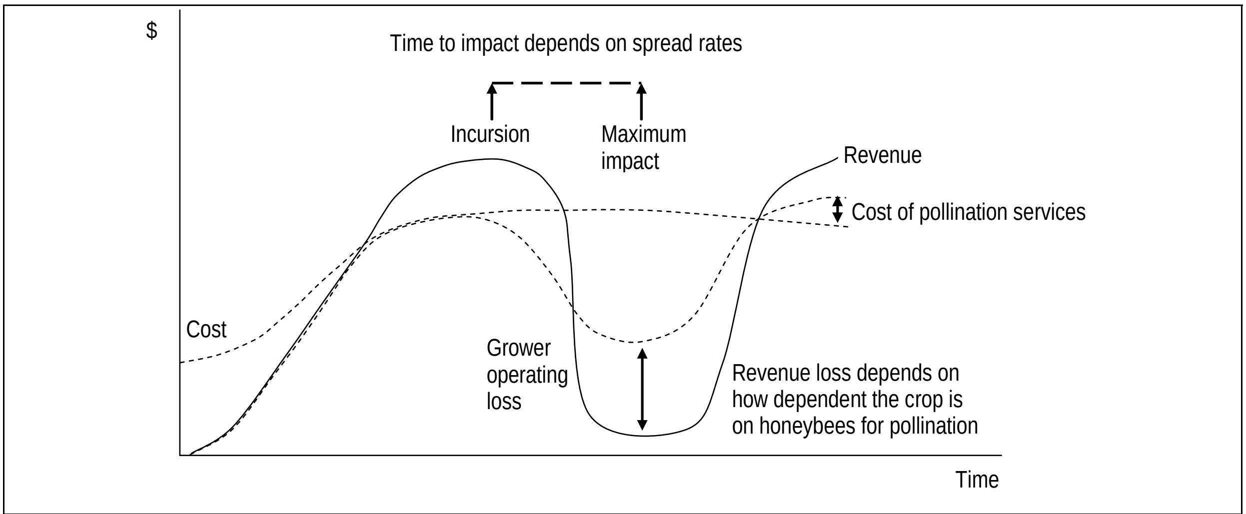
	2009	2010	2011	2012	2013	2014	2015
	%	%	%	%	%	%	%
Almond	15	14	28	9	8	7	7
Apple	29	22	536	0	0	0	0
Apricot	29	22	536	0	0	0	0
Asparagus	0	100	3400	0	0	0	0
Avocado	0	109	3549	4	4	4	4
Bean	24	19	126	0	0	0	0
Carrot	24	19	126	0	0	0	0
Cauliflower	24	19	126	0	0	0	0
Celery	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Cherry	29	22	536	0	0	0	0
Clover	29	22	536	0	0	0	0
Cucumber	0	100	3400	0	0	0	0
Grapefruit	29	22	536	0	0	0	0
Kiwi	29	22	536	0	0	0	0
Lemon & Lime	29	22	536	0	0	0	0
Lettuce	29	22	536	0	0	0	0
Lucerne	29	22	536	0	0	0	0
Lupin	0	100	3400	0	0	0	0
Orange	28	22	535	0	0	0	0
Papaya	0	100	3400	0	0	0	0
Peach	29	22	536	0	0	0	0
Pear	29	22	536	0	0	0	0
Plum & Prune	29	22	536	0	0	0	0
Pumpkin	0	100	3400	0	0	0	0
Strawberry	0	100	3400	0	0	0	0
Watermelon	24	19	126	0	0	0	0

Notes: N/A – not applicable. *Source:* CIE estimates

Adjustment over time

Chart 4.6 illustrates what can happen to an industry where a *Varroa* incursion occurs. Depending on the time of the incursion there may be little immediate impact on production as trees will be pollinated by existing pollinators and bear fruit accordingly. Over time the negative effects on production and hence revenue increase as feral bees populations decline. While costs associated with harvesting may also decline other operational costs will remain in place and the profitability of honeybee pollination-dependent crops will decline, with many incurring losses. The extent of these losses will depend in large part on two factors — the dependency of each crop on honeybees for pollination and the time it takes to replace the feral pollinators with a managed alternative.

4.6 Adjustment period of impact



Source: CIE.

The chart shows the decline in revenue, as well as the decline in costs. The impact on revenue also depends on what happens to the price of the product in response to the decline in supply. This in turn depends largely on the import restrictions currently in place and whether in face of an industry's reduction in production, import restrictions would be lifted. The adjustment period can be managed (or even avoided) by the grower if they are able to access pollination services. This depends on how quickly the pollination industry can expand in response to the increase in demand. If it can expand supply of services quickly then the potential losses for growers are likely to be greatly reduced.

As the discussion above demonstrates estimating the demand for pollination services under the situation of a *Varroa* incursion is not simple. It is a derived demand depending on:

- demand for the pollination dependent crop products, which also often depends on the treatment of imports
- dependence of production volumes and quality on honeybee pollinators
- in the short run, operating costs relative to revenue
- in the long run, the total cost relative to revenue and the extent to which the cost of pollination services changes the profitability of enterprises in each affected industry
- age profile of the fixed capital, which influences the likelihood of switching to alternative uses of the resources.

Imports of fruit and vegetables impact demand for pollination services as they influence the extent to which growers can pass on higher costs to consumers. If local supplies are reduced for a significant period import restrictions may be reviewed. Once imports begin there may be further impetus for agricultural industries to reduce output and more farmers may switch to non-honeybee reliant crops or leave the land entirely. Pollination providers would then face lower demand than would otherwise be the case if these industries maintained current output levels.

In the analysis we group crops into one of three categories – crops that would not be imported even if an incursion took place, crops that are already imported and crops that are not currently imported but would be likely to be imported if *Varroa* was to enter the country. This means most crops would ultimately be imported with a few exceptions such as clover and lucerne however imports of seed are likely for these latter crops. These crops are predominantly grown as animal feed and would be more readily replaced with grains or other pastures. Table 4.7 summarises the likelihood of imports under the situation of a large decline in production due to loss of feral honeybees. Crops with 'post incursion imports likely' will probably be imported if local production experiences a downturn large enough to prompt revision of current quarantine provisions. The other crops listed are already imported and would probably be imported in higher quantities after an incursion.

4.7 **Likelihood of imports for selected crops**

Crop	Imports	Crop	Imports
Tree crops		*Vine crops*	
Almond	Post incursion imports likely	Blueberry	Post incursion imports likely
Apple	Post incursion imports likely	Cucumber	Post incursion imports likely
Apricot	Imported already	Kiwi	Imported already
Avocado	Imported already	Pumpkin	Post incursion imports likely
Cherries	Imported already	Rock melon	Post incursion imports likely
Citrus	Imported already	Squash	Post incursion imports likely
Grapefruit	Imported already	Water melon	Post incursion imports likely
Lemon & Lime	Imported already		
Macadamia	Post incursion imports likely	*Seed production*	
Mandarin	Imported already	Beans	Imported already
Nectarine	Post incursion imports likely	Broccoli	Post incursion imports likely
Orange	Imported already	Brussels sprout	Post incursion imports likely
Mango	Imported already	Cabbage	Post incursion imports likely

Crop	Imports	Crop	Imports
Papaya	Imported already	Canola	Post incursion imports likely
Peach	Post incursion imports likely	Carrot	Imported already
Pear	Imported already	Cauliflower	Post incursion imports likely
Plum & Prune	Post incursion imports likely	Celery	Post incursion imports likely
		Clover	Post incursion imports likely
Ground crops		Lucerne	Post incursion imports likely
Peanut	Imported already	Mustard	Post incursion imports likely
		Onions	Post incursion imports likely

Source: CIE. analysis

The actual change in demand depends on the price of pollination services, hence on the supply response.

The impact of *Varroa* on the supply of pollination services

When *Varroa* first infects a hive the beekeeper will be forced to introduce mite control measures and costs will rise by approximately $40 per hive (Trevor Monson, personal communication November 2007). This reflects the extra labour and material inputs required to treat the mite. It is estimated that as a result of *Varroa* a beekeeper that previously maintained 500 hives would only be able to support 400 hives due to the increased burden of the mite.

In the short run scenario the supply of pollination will decrease due mainly to labour constraints. Existing beekeepers will no longer be able to maintain the current number of hives given the extra labour requirements. Until this labour problem can be overcome output of pollination services will be reduced. The simulations are based on an assumption of an initial 20 per cent drop in the number of hives available for pollination. Simultaneous to the decrease in hive numbers is an increase in costs of maintaining the surviving stock of honeybees. In addition to the higher labour costs for each hive there are increased pest control costs in the form of material inputs such as miticide strips. These costs have been factored in as an on-going 25 per cent increase in overall hive costs.

Modelling the impact of *Varroa* on demand and supply

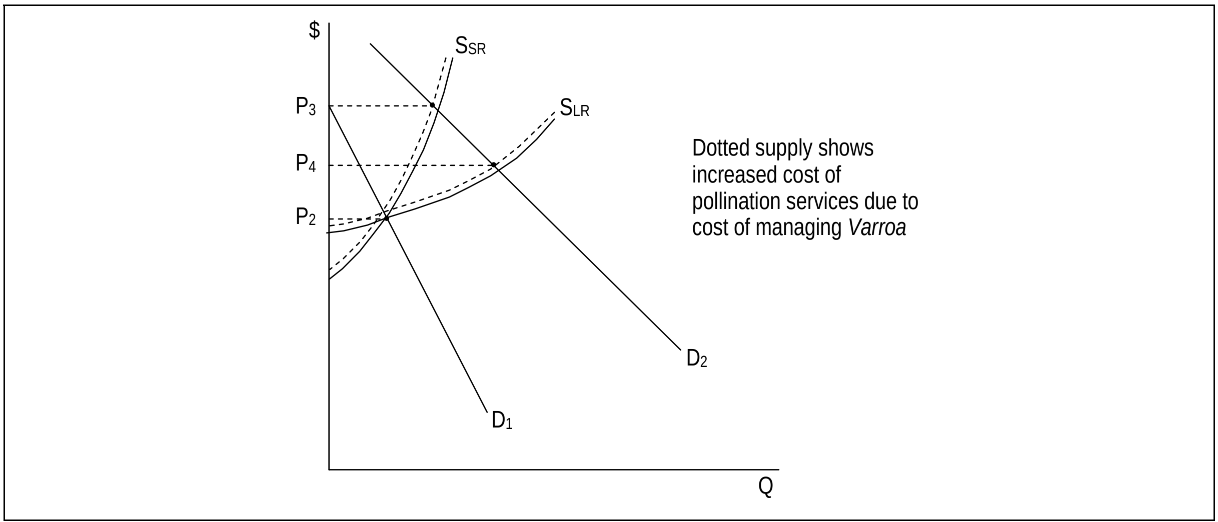
The shocks applied assume that *Varroa* results in a worst case scenario for the post 2010 pollination seasons. No feral bees will be available will be available throughout this period resulting in increased demand for services. In reality these circumstances would not prevail, *Varroa* would slowly wipe out the feral bees over time rather than an 'overnight eradication' taking place, but it provides a useful benchmark. The immediate price effects that result from this assumption also reflect the experience of the New Zealand market where prices rose almost immediately in response to the new that Varroa had entered the country (Mark Goodwin, personal communication 2008). This price rise came despite the fact that the true impacts were yet to be felt and reflects the forward looking expectations of the suppliers and consumers of pollination services.

Under this scenario, *Varroa* with no change to the existing pollination industry supply response, demand for paid pollination will increase as the feral bee population progressively declines. If farmers wish to maintain their current output levels the demand curve for paid pollination services will shift out driving up prices for pollination services in order to attract the current suppliers to expand supply. As discussed above, the extent to which the demand curve shifts will depend on whether farmers elect to continue with their current crops, or switch to alternatives that are not honeybee pollination dependent. The CIE model estimates the derived demand under this scenario. This is strongly influenced by the extent to which the industry can pass additional costs onto consumers, so the assumptions made about import restrictions is critical to the analysis.

Over the long run the supply is more responsive so prices for pollination services will adjust downward from the initial price rise, but how quickly and the final price will depend on the long run supply curve. Under this scenario both the short and long run cost curves will shift up as pollination services providers, like honey producers, will face higher production costs due to increased bee mortality rates, higher miticide costs, etc. that arise from the presence of *Varroa* and the changes in management strategies required to maintain hive health.

Chart 4.8 shows the massive shift in demand from business as usual (D_1 to D_2). The increase in costs in the short run are likely to be higher than in the long run, so in the short run the prices of pollination services will rise dramatically (P_3). As supply responds prices will fall back (P_4), but how much will depend on how responsive supply is in the long run.

4.8 **The effect of a Varroa incursion on the market for pollination services**



Source: CIE.

Scenario 3 – speeding up the responsiveness of industry

The final scenario is based on actions being undertaken to speed-up the supply response together with a more proactive approach to adoption of paid pollination services by the agricultural industries. This could only be achieved by reducing or removing the short term constraints on supply such as skilled labour, and access to breeding stock. That is action will assist the industry to respond quickly so prices of pollination services will settle at long run (P_4) more quickly. This is of benefit to the pollination suppliers as well as agriculture as the longer the price of pollination services remains high the lower the demand will be as more growers will shift out of pollination dependent crops (or not plant replacement trees).

Estimating the supply shock

In previous scenarios expansion of supply was restricted to post 2010, in this scenario the same rate of expansion takes place but it begins immediately in 2008. This assumes that some sort of proactive approach is taken to overcome the current supply side constraints in place. Higher costs of production still apply as in the as the previous *Varroa* incursion scenario.

Estimating the demand shock

This scenario uses the baseline growth rates of industry as a starting point but also increases the proportion of growers using paid pollination services over time. The proportion that adopt paid services varies by crop as shown in table 4.9. Almond growers for example are assumed to all be using optimal levels of pollination by 2015 while some crops such as blueberries are assumed to only be using 10 per cent of optimal levels by the same time.

4.9 **Proportion of growers using paid pollination services**

	2008	2009	2010	2011	2012	2013	2014	2015
Almond	0.8	0.8	0.9	0.9	0.9	0.9	1.0	1.0
Apple	0.1	0.1	0.2	0.2	0.2	0.2	0.3	0.3
Apricot	0.1	0.1	0.2	0.2	0.2	0.2	0.3	0.3
Asparagus	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1
Avocado	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1
Bean (seed)	0.3	0.4	0.4	0.5	0.6	0.7	0.7	0.8
Blueberry	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1
Broccoli	0.3	0.4	0.4	0.5	0.6	0.7	0.7	0.8
Brussel sprout	0.3	0.4	0.4	0.5	0.6	0.7	0.7	0.8
Cabbage	0.3	0.4	0.4	0.5	0.6	0.7	0.7	0.8
Carrot (seed)	0.3	0.4	0.4	0.5	0.6	0.7	0.7	0.8
Cauliflower (seed)	0.3	0.4	0.4	0.5	0.6	0.7	0.7	0.8
Celery	0.3	0.4	0.4	0.5	0.6	0.7	0.7	0.8
Cherry	0.1	0.1	0.2	0.2	0.2	0.2	0.3	0.3
Cotton lint	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1
Cucumber	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1
Grapefruit	0.1	0.1	0.2	0.2	0.2	0.2	0.3	0.3
Kiwi	0.1	0.1	0.2	0.2	0.2	0.2	0.3	0.3

Continued on next page

4.9 **Proportion of growers using paid pollination services** continued

	2008	2009	2010	2011	2012	2013	2014	2015
Lemon & Lime	0.1	0.1	0.2	0.2	0.2	0.2	0.3	0.3
Lettuce (seed)	0.1	0.1	0.2	0.2	0.2	0.2	0.3	0.3
Lucerne (seed)	0.1	0.1	0.2	0.2	0.2	0.2	0.3	0.3
Lupin	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1
Macadamia	0.3	0.4	0.4	0.5	0.6	0.7	0.7	0.8
Mandarin	0.1	0.1	0.2	0.2	0.2	0.2	0.3	0.3
Mango	0.1	0.1	0.2	0.2	0.2	0.2	0.3	0.3
Nectarine	0.1	0.1	0.2	0.2	0.2	0.2	0.3	0.3
Onion	0.3	0.4	0.4	0.5	0.6	0.7	0.7	0.8
Orange	0.1	0.1	0.2	0.2	0.2	0.2	0.3	0.3
Papaya	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1
Peach	0.1	0.1	0.2	0.2	0.2	0.2	0.3	0.3
Pear	0.1	0.1	0.2	0.2	0.2	0.2	0.3	0.3
Plum & Prune	0.1	0.1	0.2	0.2	0.2	0.2	0.3	0.3
Pumpkin	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1
Strawberry	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1
Watermelon	0.3	0.4	0.4	0.5	0.6	0.7	0.7	0.8

Source: CIE estimates

Details of the model are given in annex B. The results of the scenarios are presented in chapter 5.

5. Results and implications

For simplicity and tractability the results are presented as charts. For a complete set of results in tabular form see annex B.

Scenario 1 – Business as usual

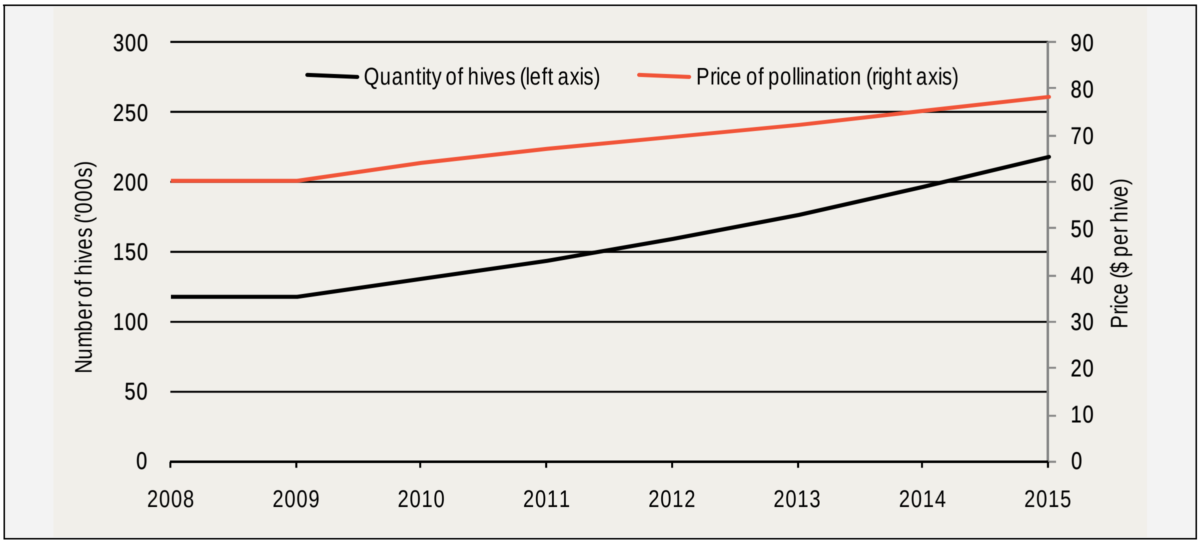
Scenario

This scenario applies the expected growth in pollination dependant crops and an increase in use in pollination services to generate a growth in demand for pollination services. The growth in demand for paid pollination services, all else equal, increases at between 10 and 20 per cent per annum over the period 2008 to 2015, albeit from a small base. Supply is relatively elastic in the short run and if given time (by the relatively slow expansion in demand) can expand to accommodate the increase in demand fairly easily.

Impacts

Chart 5.1 shows what happens to the number of quantity of hives and the average price of pollination over the period. Prices rise slightly to $64 in 2010 to attract more honey producers to shift to providing pollination services. Steady growth sees the pollination service industry providing nearly 220,000 hives in 2015.

5.1 **Business as usual price and quantity over time**



Source: CIE simulations

What this scenario demonstrates is that the honeybee industry is able to respond to a steady growth in demand, at least up toward current total hive numbers. The business as usual scenario suggests that in a world of no risk to feral honeybees the industry would follow a slow and steady growth path as honeybee producers recognise the opportunities being created and respond to demand. While pollination dependant industries would increase the use of paid services many would remain predominantly reliant on incidental pollination. Importantly, apart for temporary local issues, all industries wanting to buy pollination services at the market price should be able to access services.

Implications for industry

The almond industry remains the largest user of pollination services with the number if hives in use growing from 93,000 in 2008 to 189,000 in 2015. This is based on a conservative growth estimate for almonds and also takes into account the way price impacts the quantity demanded making the hives numbers lower than some previous estimates. In 2015 almonds make up half of the pollination services market. Apples make up 6 per cent of the market with the remainder of the industries making up the rest.

Prices rise for the almond industry to $76 in 2015 up from an average of $57 in 2008. Most of the industries examined pay around $74 per hive and this will rise to $92 in 2015. Carrot seed currently pays the highest price at around $120 a hive, and the cost will rise to almost $139 a hive. Details are given in annex B.

Scenario 2 – *Varroa* incursion with no change to the current pollination services industry

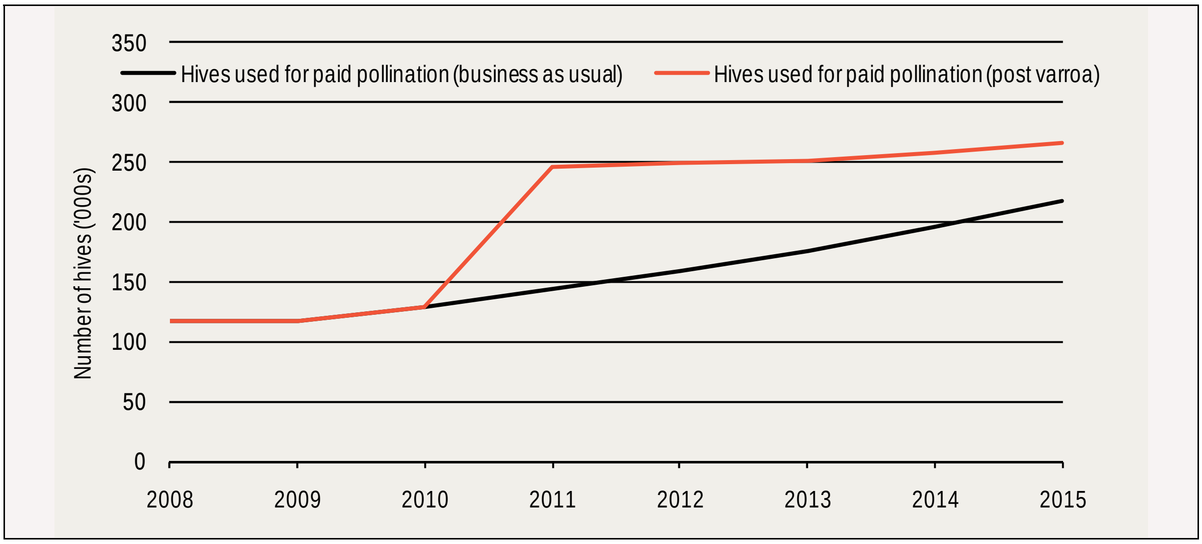
Scenario

Under this scenario demand for pollination services increased dramatically from 2010. If price was not an issue, an additional 530,000 hives would be required in 2011 to replace the services provided by feral honeybees and free incidental services from honey producers. This massive increase in demand is well beyond the honeybee industry’s capacity to supply services. In addition, the costs of providing pollination services rise due to a once off loss of 20 percent of the existing stock of hives and an on-going increase in costs of production of 25 per cent.

Impacts

The initial impact of the incursion is a massive increase in the price of pollination services as enterprises compete for the hives available. A firm will notionally pay up to the loss they will experience in the absence of the pollination service. The modelling predicts that the price of pollination services will rise to $193 in 2011. The industries that will be able to pay and hence access pollination services are given in table 5.3.

5.2 **The impact of Varroa on the quantity of hives**



Source: CIE simulations

The peak in prices in 2011 provides a signal to pollination providers to expand output and so prices begin to fall in 2012. By 2015 demand increases due to industry expansion and they once again reach $149 per hive. By 2015 the number of hives in pollination service provision is estimated to be 267,000. This assumes that there are no long run constraints to this level of production.

Implications for industry

Table 5.3 tracks the impacts on a selected set of industries to demonstrate which industries will be able to access pollination services and which would miss out under the scenario (full results are presented in annex B). The ten industries listed in the table are those that have the biggest increase in demand in terms of hive numbers. Some industries such as apricots have a smaller increase in hive numbers compared to other industries shown however they start from a relatively small base so the increase in percentage terms is somewhat similar.

Overall the biggest growth in use of pollination services comes from the apple industry. This industry goes from consuming 7 per cent of pollination services in 2015 under the business as usual scenario to 19 per cent under the *Varroa* scenario. The almond industry loses some hives to other industry with the number obtained dropping by 6 per cent in 2015. Despite this almonds remain the single largest consumer of pollination services although their share falls from 86 per cent to 67 per cent.

Prices of pollination services rise by 222 per cent in 2011 for the almond industry and by between 109 per cent (carrot seed) and 211 per cent (clover seed, kiwi, lucerne seed and watermelon) for all other industries. By 2015 prices have fall back but remain 73 per cent (carrot seed) to 151 per cent (almonds) higher than the 2008 price. These prices are in 2008 dollars and assume all costs remain the same except for the costs related to *Varroa* management.

5.3 **Demand for pollination services for selected industries 2015**

Crop	Increase in hives numbers demanded	Increase in hive numbers
	No of hives	*%*
Apple	34432	227.5
Peach	4870	213.2
Orange	4506	229.0
Pear	3070	231.2
Plum	2736	225.7
Apricot	2364	220.3
Lupins	1946	807.3
Cherries	1563	232.5
Watermelon	1070	24.6
Clover (seed)	709	869.9

Source: CIE simulations

Scenario 3 – Action to reduce the cost of providing pollination services

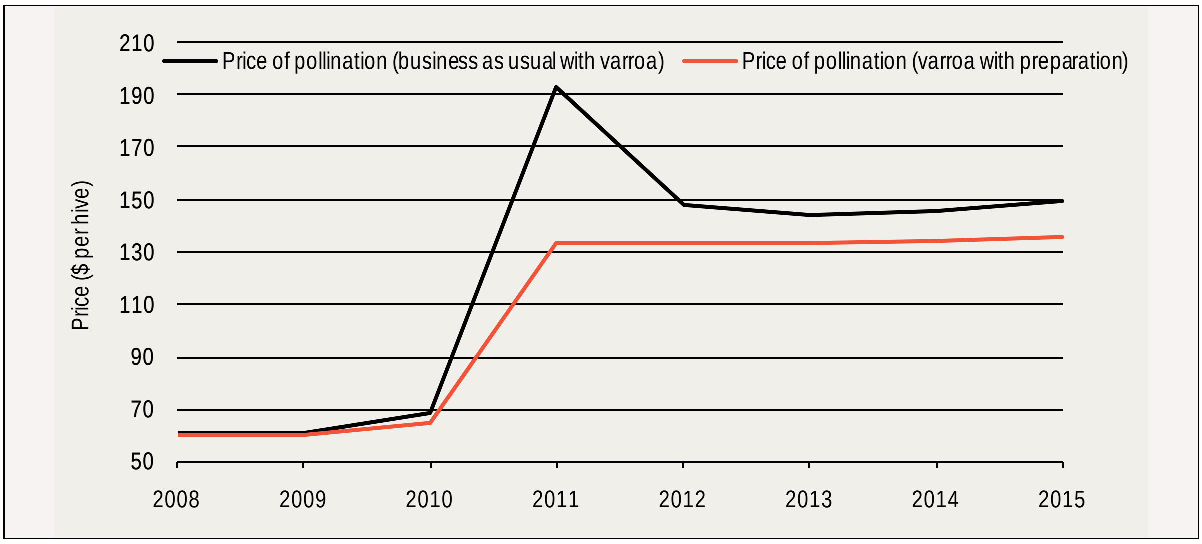
Scenario

Under this scenario there is a substantial increase in demand due to a *Varroa* incursion however the pollination industry has an increased level of readiness and is able to respond more rapidly. Prices still increase due to higher costs of maintaining hives when the mite is present but the higher number of hives available prevents pollination prices from rising as high as they do in the previous scenario.

Impacts

Early preparation allows the pollination industry to expand and better meet demand requirements by the agricultural industry. Whereas in the previous scenario prices reached $193 prices, under this scenario prices jump to $133 in 2011 and 387,000 are provided as the pollination industry is better prepared. After 2011 the prices steadily increase due to increased demand as growers expand production levels. Despite this continued upward pressure the price still remains below what it would be otherwise in 2015.

5.4 **The impact of *Varroa* on the quantity of hives**



Source: CIE simulations

Implications for industries

In the years immediately following the incursion the pollination services industry is able to supply significantly more hives at a lower price than in the previous scenario. In 2011 the almond industry is able to source 20 per cent more hives than they could under the previous scenario while the lupins industry is able to source 194 per cent more hives. Furthermore these extra services come at a lower price than was previously the case. Almonds only experience a 120 per cent increase in price from the baseline scenario compared to a 151 per cent increase with no preparation.

In the longer term the results will converge with those in the previous scenario however the large losses that are incurred by the agricultural sector in the earlier years are avoided when industry preparation is undertaken.

Implications for agriculture and pollination

The implications for both the pollination and the agricultural industry are clear. While preparing for an event that would prove catastrophic to honeybees is costly there are benefits to be gained. By growing the market for pollination services prior to a *Varroa* incursion the pollination industry can expand with relative ease and deal with issues including training, education and R&D without further complicating matters by having to deal with new pests. The agricultural industry can also benefit from higher levels of output or at the very least, maintain current levels by changing the mix of inputs used in production.

A *Varroa* incursion that takes out feral honeybees in 2011 results in reductions in output of up to 13 per cent with an average decline of 2.5 per cent. By 2015 the output is reduced by an average of 1.5 per cent. The total cost to the Australian economy is ambiguous. Losses to the agricultural sector will be lower than the individual industry losses as farmers switch to non-honeybee dependant crops and find other uses for the factors of production that would otherwise have been used in the production of the crops. Costs will also be imposed on consumers as they are forced to pay more for the affected products or substitute other products for those no longer available. Thus the total cost depends on the alternatives available to producers and consumers. Estimating these costs was beyond the scope of this modelling exercise.

By readying themselves for an adverse impact some agricultural industries will be exposing themselves to higher costs in the short run by purchasing pollination services however this is may yield benefits in the form of increased yield and quality (neither of which is included in the analysis). Furthermore, if *Varroa* does establish itself and the industry is prepared for such an incursion the scenario analysis suggests that the reduction in output will be reduced to an average of 1.7 per cent in 2011. Over time the cumulative losses will be lower due to smaller declines in output in the years immediately following the incursion.

The results shown here are not exclusive to a *Varroa* incursion. Any pest or disease outbreak within the honeybee industry that has similar consequences for hive health and population numbers would yield results not unlike those demonstrated in this study. Countries around the world are currently dealing with a range of pests and disease that are devastating their honeybee industries. Australia is unique in that it is largely unaffected by these problems at present. Nevertheless, Australia is not immune so preparation for these events would be valuable in assisting both the beekeeping and agricultural industries to avoid wide spread losses and disruption.

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Appendix A – Model

We use a general equilibrium model to assess the impacts of *Varroa* demand and supply shocks in the pollination service and pollination dependant industries. General equilibrium modelling permits us to model related several sectors of an economy simultaneously while allowing for adjustment between industry sectors, inputs and outputs.

The model

The model used in the analysis consists of several agricultural sectors using two inputs to production. The first of these inputs is pollination services while the second incorporates all other inputs required for production. Output is sold subject to a demand curve that exhibits almost constant elasticity. That is, a given change in price (in percentage terms) will result in similar changes in the quantity demanded (also in percentage terms) regardless of the starting point along the curve.

Beekeepers are broken into two groups, those who produce honey and pollination services and those who only produce pollination services, with each having two inputs to production – hives and other inputs. The honey producers choose between producing honey and supplying pollination services to the agricultural sector in order to maximise profits. As with agricultural produce honey is sold subject to a nearly constant elasticity demand curve.

Agricultural sector inputs

Each agricultural sector produces its output using a cost-minimising CES combination of ‘technologies’. An elasticity of substitution of two is used. Each technology consists of pollination services and an ‘other input’ used in constant proportions. At present two technologies are used. The first consists entirely of the ‘other input’. The second uses both pollination services and the ‘other input’. For the input data to the model the initial mix between the two technologies is determined by the dependence of the agricultural sector on honeybee pollination. Sectors that are 100 per cent dependent have a zero level of the first technology. The shares of pollination services and the ‘other input’ in the second technology are determined from a consideration of:

- the maximum share of pollination services in total costs (assumed to be ten per cent)
- the optimal number of hives per acre for each agricultural sector
- the area harvested for each agricultural sector
- some sparse information of the different costs per hive charged to each sector
- an estimate of the likely presence of feral honeybees.

Agricultural sector outputs

Each agricultural sector in the model faces transport, wholesale and retail costs when delivering their final product to the consumer. Based on estimates from unpublished CIE work (HAL, forthcoming) the model assumes this adds an extra 65 per cent to the price. Using the elasticity estimates from the same study demand curves have been estimated for each commodity included in the analysis. Where an estimate is not available an average of the estimates has been applied. The demand curves are constant elasticity demand curves that have been shifted to the left slightly so that they intersect the (vertical) price axis. This allows the quantity demanded to be zero for a sufficiently high price. It also allows agricultural sectors for which sufficient information is currently unavailable to be ‘carried along’ in the model database with their output held at zero during model simulations.

Pollination services

There are two sectors that produce pollination services – a ‘honey and pollination services’ sector and a ‘pollination services only’ sector. Each of these sectors produces pollination services at a single supply price. But the price paid for pollination services varies across agricultural sectors. Therefore, a margin is added to the supply price of pollination services to capture the differential pricing of pollination services to different agricultural sectors. This margin reflects the difference in transport costs and honey production across different crops.

Some crops require large numbers of hives for pollination and will thus benefit from economies of scale. Other crops require less and the provision of services is therefore more costly. Likewise some providers are smaller than others and their transport costs are likely higher than some of the larger providers.

At the same time the production of honey varies across different crop types as well. Those crops that yield higher honey outputs are less costly in terms of providing pollination services. This is due to the reduced need for food supplements and the potential sales of honey. Where honey production is low extra costs are incurred by the beekeeper who then passes them on to the agricultural sector in the form of higher prices.

Honey production

The ‘honey and pollination services’ sector maximises revenue, and hence profits, by choosing how much honey to produce and how much pollination to provide. The model employs a constant elasticity of transformation equal to two. That is, it is relatively easy for a beekeeper to switch between pollination and honey production which makes the two activities reasonable substitutes. In a similar way to agricultural production extra costs are incurred in getting honey to the final consumer. A margin is applied to reflect this. The demand for honey is also constructed in a similar way to that for agricultural products in that it is a ‘shifted’ constant elasticity demand curve.

Appendix B – Complete modelling results

B.1 **Equilibrium quantity of hives – business as usual**

Crop	2008	2009	2010	2011	2012	2013	2014	2015
	no of hives	*no of hives*	*no of hives*	*no of hives*	*no of hives*	*no of hives*	*no of hives*	*no of hives*
Almond	92500	92500	104065	117249	132123	148864	167695	188869
Apple	12544	12544	12942	13353	13778	14215	14667	15133
Apricot	975	975	991	1007	1023	1039	1056	1073
Asparagus	11	11	11	11	11	12	12	12
Avocado	11	11	11	11	11	12	12	12
Beans (seed)	20	20	20	20	20	20	21	21
Carrot (seed)	144	144	146	148	151	153	156	158
Cauliflower (seed)	468	468	472	477	482	486	491	496
Cherries	598	598	610	622	634	647	659	672
Clover (seed)	75	75	76	77	78	79	80	82
Cucumber	4	4	4	5	5	5	5	5
Grapefruit	97	97	99	101	103	104	107	109
Kiwi	165	165	171	176	182	188	194	201
Lemon & Lime	151	151	154	157	160	163	166	170
Lettuce (seed)	42	42	42	42	43	43	44	44
Lucerne (seed)	42	42	42	43	43	44	45	45
Lupins	222	222	225	228	231	234	238	241
Orange	1754	1754	1788	1823	1858	1894	1931	1968
Papaya	2	2	2	2	2	2	2	2
Peach	2076	2076	2109	2143	2178	2213	2248	2284
Pear	1101	1101	1136	1172	1209	1248	1287	1328
Plum	1101	1101	1119	1137	1155	1174	1193	1212
Pumpkin	26	26	26	26	27	27	27	27
Strawberry	6	6	6	6	6	6	6	6
Watermelon	3774	3774	3864	3955	4050	4146	4244	4345
Total	117907	117907	130130	143991	159562	177019	196585	218515

Source: CIE simulations

B.2 **Equilibrium quantity of hives – *Varroa* incursion**

Crop	2008	2009	2010	2011	2012	2013	2014	2015
	no of hives	*no of hives*	*no of hives*	*no of hives*	*no of hives*	*no of hives*	*no of hives*	*no of hives*
Almond	92500	92500	104065	115323	133096	147073	161605	177577
Apple	12544	12544	12942	70105	63097	57499	53091	49565
Apricot	975	975	991	5119	4574	4110	3738	3438
Asparagus	11	11	11	263	200	161	136	118
Avocado	11	11	11	260	200	164	140	123
Beans (seed)	20	20	20	35	32	29	27	25
Carrot (seed)	144	144	146	277	250	227	209	194
Cauliflower (seed)	468	468	472	836	766	695	637	589
Cherries	598	598	610	3336	2951	2656	2423	2236
Clover (seed)	75	75	76	1727	1327	1078	910	791
Cucumber	4	4	4	105	80	65	54	47
Grapefruit	97	97	99	531	471	424	387	357
Kiwi	165	165	171	941	844	770	712	665
Lemon & Lime	151	151	154	825	734	660	603	556
Lettuce (seed)	42	42	42	75	69	62	57	53
Lucerne (seed)	42	42	42	974	745	605	511	444
Lupins	222	222	225	4690	3664	2982	2519	2187
Orange	1754	1754	1788	9628	8548	7694	7019	6474
Papaya	2	2	2	43	33	27	23	20
Peach	2076	2076	2109	10556	9505	8551	7780	7155
Pear	1101	1101	1136	6251	5603	5103	4712	4399
Plum	1101	1101	1119	5920	5258	4721	4294	3948
Pumpkin	26	26	26	609	462	374	315	273
Strawberry	6	6	6	139	107	87	74	65
Watermelon	3774	3774	3864	7644	6886	6287	5807	5415
Total	117907	117907	130130	246213	249503	252105	257780	266712
Change from baseline (%)	0	0	0	71	56	42	31	22

Source: CIE simulations

B.3 Equilibrium quantity of hives – *Varroa* incursion with industry preparation

Crop	2008	2009	2010	2011	2012	2013	2014	2015
	no of hives	*no of hives*	*no of hives*	*no of hives*	*no of hives*	*no of hives*	*no of hives*	*no of hives*
Almond	98750	98750	114516	138174	155930	175937	198445	223750
Apple	12544	12544	16637	110873	117142	123019	128663	134182
Apricot	975	975	1273	8162	8493	8784	9047	9292
Asparagus	11	11	16	753	856	923	971	1009
Avocado	11	11	16	743	856	935	997	1050
Beans (seed)	20	20	24	53	55	57	58	59
Carrot (seed)	144	144	181	412	427	440	452	463
Cauliflower (seed)	468	468	584	1266	1307	1342	1374	1402
Cherries	598	598	784	5247	5479	5688	5881	6064
Clover (seed)	75	75	109	4989	5688	6150	6492	6767
Cucumber	4	4	6	301	342	369	388	404
Grapefruit	97	97	127	839	876	909	939	968
Kiwi	165	165	219	1482	1568	1648	1726	1803
Lemon & Lime	151	151	198	1305	1362	1414	1461	1506
Lettuce (seed)	42	42	52	114	117	120	123	126
Lucerne (seed)	42	42	60	2801	3195	3454	3648	3803
Lupins	222	222	321	13795	15720	16983	17915	18658
Orange	1754	1754	2299	15206	15875	16474	17027	17549
Papaya	2	2	3	123	141	154	164	173
Peach	2076	2076	2711	16964	17649	18249	18793	19296
Pear	1101	1101	1460	9846	10404	10927	11431	11923
Plum	1101	1101	1438	9383	9765	10101	10406	10690
Pumpkin	26	26	37	1742	1981	2135	2247	2335
Strawberry	6	6	8	399	457	498	528	554
Watermelon	3774	3774	4782	11300	11793	12251	12686	13106
Total	124157	124157	147861	356270	387478	418960	451865	486933
Change from baseline (%)	5	5	14	147	143	137	130	123

Source: CIE simulations

B.4 **Equilibrium price of hives – *baseline***

Crop	2008	2009	2010	2011	2012	2013	2014	2015
	$ per hive	*$ per hive*	*$ per hive*	*$ per hive*	*$ per hive*	*$ per hive*	*$ per hive*	*$ per hive*
Almond	57.20	57.20	61.33	64.23	67.01	69.90	72.95	76.16
Apple	73.48	73.48	77.61	80.51	83.29	86.18	89.23	92.44
Apricot	73.48	73.48	77.61	80.51	83.29	86.18	89.23	92.44
Asparagus	73.48	73.48	77.61	80.51	83.29	86.18	89.23	92.44
Avocado	73.48	73.48	77.61	80.51	83.29	86.18	89.23	92.44
Beans (seed)	73.48	73.48	77.61	80.51	83.29	86.18	89.23	92.44
Carrot (seed)	120.00	120.00	124.13	127.03	129.81	132.70	135.75	138.96
Cauliflower (seed)	100.00	100.00	104.13	107.03	109.81	112.70	115.75	118.96
Cherries	73.48	73.48	77.61	80.51	83.29	86.18	89.23	92.44
Clover (seed)	60.50	60.50	64.63	67.53	70.31	73.20	76.25	79.46
Cucumber	73.48	73.48	77.61	80.51	83.29	86.18	89.23	92.44
Grapefruit	73.48	73.48	77.61	80.51	83.29	86.18	89.23	92.44
Kiwi	60.50	60.50	64.63	67.53	70.31	73.20	76.25	79.46
Lemon & Lime	73.48	73.48	77.61	80.51	83.29	86.18	89.23	92.44
Lettuce (seed)	73.48	73.48	77.61	80.51	83.29	86.18	89.23	92.44
Lucerne (seed)	60.50	60.50	64.63	67.53	70.31	73.20	76.25	79.46
Lupins	73.48	73.48	77.61	80.51	83.29	86.18	89.23	92.44
Orange	73.48	73.48	77.61	80.51	83.29	86.18	89.23	92.44
Papaya	73.48	73.48	77.61	80.51	83.29	86.18	89.23	92.44
Peach	73.48	73.48	77.61	80.51	83.29	86.18	89.23	92.44
Pear	73.48	73.48	77.61	80.51	83.29	86.18	89.23	92.44
Plum	73.48	73.48	77.61	80.51	83.29	86.18	89.23	92.44
Pumpkin	73.48	73.48	77.61	80.51	83.29	86.18	89.23	92.44
Strawberry	73.48	73.48	77.61	80.51	83.29	86.18	89.23	92.44
Watermelon	60.50	60.50	64.63	67.53	70.31	73.20	76.25	79.46
Average	60.42	60.42	64.32	67.01	69.58	72.28	75.14	78.19

Source: CIE simulations

B.5 **Equilibrium price of hives – *Varroa* incursion**

Crop	2008	2009	2010	2011	2012	2013	2014	2015
	$ per hive	*$ per hive*	*$ per hive*	*$ per hive*	*$ per hive*	*$ per hive*	*$ per hive*	*$ per hive*
Almond	57.20	57.20	65.04	184.39	140.47	137.26	140.07	143.82
Apple	73.48	73.48	81.32	202.03	157.44	154.09	156.85	160.55
Apricot	73.48	73.48	81.32	202.03	157.44	154.09	156.85	160.55
Asparagus	73.48	73.48	81.32	202.03	157.44	154.09	156.85	160.55
Avocado	73.48	73.48	81.32	202.03	157.44	154.09	156.85	160.55
Beans (seed)	73.48	73.48	81.32	202.03	157.44	154.09	156.85	160.55
Carrot (seed)	120.00	120.00	127.84	250.68	205.07	201.52	204.20	207.84
Cauliflower (seed)	100.00	100.00	107.84	229.97	184.69	181.21	183.91	187.57
Cherries	73.48	73.48	81.32	202.03	157.44	154.09	156.85	160.55
Clover (seed)	60.50	60.50	68.34	188.01	143.93	140.69	143.49	147.22
Cucumber	73.48	73.48	81.32	202.03	157.44	154.09	156.85	160.55
Grapefruit	73.48	73.48	81.32	202.03	157.44	154.09	156.85	160.55
Kiwi	60.50	60.50	68.34	188.01	143.93	140.69	143.49	147.22
Lemon & Lime	73.48	73.48	81.32	202.03	157.44	154.09	156.85	160.55
Lettuce (seed)	73.48	73.48	81.32	202.03	157.44	154.09	156.85	160.55
Lucerne (seed)	60.50	60.50	68.34	188.01	143.93	140.69	143.49	147.22
Lupins	73.48	73.48	81.32	202.03	157.44	154.09	156.85	160.55
Orange	73.48	73.48	81.32	202.03	157.44	154.09	156.85	160.55
Papaya	73.48	73.48	81.32	202.03	157.44	154.09	156.85	160.55
Peach	73.48	73.48	81.32	202.03	157.44	154.09	156.85	160.55
Pear	73.48	73.48	81.32	202.03	157.44	154.09	156.85	160.55
Plum	73.48	73.48	81.32	202.03	157.44	154.09	156.85	160.55
Pumpkin	73.48	73.48	81.32	202.03	157.44	154.09	156.85	160.55
Strawberry	73.48	73.48	81.32	202.03	157.44	154.09	156.85	160.55
Watermelon	60.50	60.50	68.34	188.01	143.93	140.69	143.49	147.22
Average	60.42	60.42	68.03	193.28	147.99	143.93	146.03	149.14

Source: CIE simulations

B.6 **Equilibrium price of hives – *Varroa* incursion with industry preparation**

Crop	2008	2009	2010	2011	2012	2013	2014	2015
	$ per hive	*$ per hive*	*$ per hive*	*$ per hive*	*$ per hive*	*$ per hive*	*$ per hive*	*$ per hive*
Almond	57.20	57.20	61.33	122.60	122.95	123.66	124.77	126.27
Apple	73.48	73.48	77.61	140.64	141.04	141.75	142.85	144.32
Apricot	73.48	73.48	77.61	140.64	141.04	141.75	142.85	144.32
Asparagus	73.48	73.48	77.61	140.64	141.04	141.75	142.85	144.32
Avocado	73.48	73.48	77.61	140.64	141.04	141.75	142.85	144.32
Beans (seed)	73.48	73.48	77.61	140.64	141.04	141.75	142.85	144.32
Carrot (seed)	120.00	120.00	124.13	189.89	190.44	191.25	192.40	193.87
Cauliflower (seed)	100.00	100.00	104.13	168.98	169.47	170.24	171.36	172.82
Cherries	73.48	73.48	77.61	140.64	141.04	141.75	142.85	144.32
Clover (seed)	60.50	60.50	64.63	126.32	126.67	127.38	128.49	129.98
Cucumber	73.48	73.48	77.61	140.64	141.04	141.75	142.85	144.32
Grapefruit	73.48	73.48	77.61	140.64	141.04	141.75	142.85	144.32
Kiwi	60.50	60.50	64.63	126.32	126.67	127.38	128.49	129.98
Lemon & Lime	73.48	73.48	77.61	140.64	141.04	141.75	142.85	144.32
Lettuce (seed)	73.48	73.48	77.61	140.64	141.04	141.75	142.85	144.32
Lucerne (seed)	60.50	60.50	64.63	126.32	126.67	127.38	128.49	129.98
Lupins	73.48	73.48	77.61	140.64	141.04	141.75	142.85	144.32
Orange	73.48	73.48	77.61	140.64	141.04	141.75	142.85	144.32
Papaya	73.48	73.48	77.61	140.64	141.04	141.75	142.85	144.32
Peach	73.48	73.48	77.61	140.64	141.04	141.75	142.85	144.32
Pear	73.48	73.48	77.61	140.64	141.04	141.75	142.85	144.32
Plum	73.48	73.48	77.61	140.64	141.04	141.75	142.85	144.32
Pumpkin	73.48	73.48	77.61	140.64	141.04	141.75	142.85	144.32
Strawberry	73.48	73.48	77.61	140.64	141.04	141.75	142.85	144.32
Watermelon	60.50	60.50	64.63	126.32	126.67	127.38	128.49	129.98
Average	60.26	60.26	64.71	132.98	133.08	133.49	134.27	135.41

Source: CIE simulations

B.7 Industry output – baseline

Crop	2008	2009	2010	2011	2012	2013	2014	2015
	tonnes	*tonnes*	*tonnes*	*tonnes*	*tonnes*	*tonnes*	*tonnes*	*tonnes*
Almond	11755	11755	13097	14439	15781	17123	18465	19807
Apple	452112	452112	452112	452112	452112	452112	452112	452112
Apricot	19698	19698	19698	19698	19698	19698	19698	19698
Asparagus	11293	11293	11293	11293	11293	11293	11293	11293
Avocado	32634	32634	34157	35680	37203	38726	40249	41772
Beans (seed)	90	90	90	90	90	90	90	90
Carrot (seed)	870	870	870	870	870	870	870	870
Cauliflower (seed)	228	228	228	228	228	228	228	228
Cherries	10000	10000	10000	10000	10000	10000	10000	10000
Clover (seed)	3350	3350	3397	3445	3493	3541	3590	3640
Cucumber	14394	14394	14394	14394	14394	14394	14394	14394
Grapefruit	19558	19558	19558	19558	19558	19558	19558	19558
Kiwi	4222	4222	4222	4222	4222	4222	4222	4222
Lemon & Lime	38000	38000	38000	38000	38000	38000	38000	38000
Lettuce (seed)	150	150	150	150	150	150	150	150
Lucerne (seed)	5000	5000	5070	5141	5213	5286	5360	5435
Lupins	174000	174000	174000	174000	174000	174000	174000	174000
Orange	571000	571000	570048	569097	568145	567193	566242	565290
Papaya	5648	5648	5648	5648	5648	5648	5648	5648
Peach	90261	90261	90261	90261	90261	90261	90261	90261
Pear	142400	142400	142400	142400	142400	142400	142400	142400
Plum	32000	32000	32000	32000	32000	32000	32000	32000
Pumpkin	89948	89948	89948	89948	89948	89948	89948	89948
Strawberry	23737	23737	23737	23737	23737	23737	23737	23737
Watermelon	108352	108352	108352	108352	108352	108352	108352	108352

Source: CIE simulations

B.8 **Change in industry output – *Varroa* incursion**

Crop	2008	2009	2010	2011	2012	2013	2014	2015
	%	%	%	%	%	%	%	%
Almond	0.0	0.0	0.0	-12.9	-7.9	-7.2	-6.9	-6.4
Apple	0.0	0.0	0.0	-2.5	-1.9	-1.8	-1.8	-1.8
Apricot	0.0	0.0	0.0	-4.4	-3.3	-3.2	-3.2	-3.1
Asparagus	0.0	0.0	0.0	-0.3	-0.3	-0.3	-0.3	-0.3
Avocado	0.0	0.0	0.0	-0.1	-0.1	-0.1	-0.1	-0.1
Beans (seed)	0.0	0.0	0.0	-1.1	-0.8	-0.7	-0.6	-0.6
Carrot (seed)	0.0	0.0	0.0	-4.1	-2.9	-2.6	-2.3	-2.1
Cauliflower (seed)	0.0	0.0	0.0	-9.9	-6.9	-6.3	-5.7	-5.2
Cherries	0.0	0.0	0.0	-0.3	-0.2	-0.2	-0.2	-0.2
Clover (seed)	0.0	0.0	0.0	-4.1	-3.1	-3.1	-3.1	-3.1
Cucumber	0.0	0.0	0.0	-0.3	-0.2	-0.2	-0.2	-0.2
Grapefruit	0.0	0.0	0.0	-1.7	-1.3	-1.2	-1.2	-1.2
Kiwi	0.0	0.0	0.0	-0.8	-0.6	-0.6	-0.6	-0.6
Lemon & Lime	0.0	0.0	0.0	-0.8	-0.6	-0.5	-0.5	-0.5
Lettuce (seed)	0.0	0.0	0.0	-0.6	-0.4	-0.4	-0.4	-0.3
Lucerne (seed)	0.0	0.0	0.0	-2.5	-1.9	-1.9	-1.9	-1.9
Lupins	0.0	0.0	0.0	-3.5	-2.7	-2.7	-2.7	-2.7
Orange	0.0	0.0	0.0	-0.8	-0.6	-0.6	-0.6	-0.6
Papaya	0.0	0.0	0.0	-0.1	-0.1	-0.1	-0.1	-0.1
Peach	0.0	0.0	0.0	-6.0	-4.5	-4.4	-4.4	-4.3
Pear	0.0	0.0	0.0	-0.5	-0.4	-0.4	-0.4	-0.4
Plum	0.0	0.0	0.0	-2.6	-1.9	-1.9	-1.8	-1.8
Pumpkin	0.0	0.0	0.0	-0.7	-0.5	-0.5	-0.5	-0.5
Strawberry	0.0	0.0	0.0	-0.1	-0.1	-0.1	-0.1	-0.1
Watermelon	0.0	0.0	0.0	-0.6	-0.4	-0.4	-0.3	-0.3

Source: CIE simulations

B.9 **Change in industry output – *Varroa* incursion with industry preparation**

Crop	2008	2009	2010	2011	2012	2013	2014	2015
	%	%	%	%	%	%	%	%
Almond	0.0	0.0	0.0	-8.0	-7.6	-6.9	-6.4	-6.0
Apple	0.0	0.0	0.0	-1.8	-1.8	-1.8	-1.8	-1.8
Apricot	0.0	0.0	0.0	-3.2	-3.2	-3.1	-3.1	-3.0
Asparagus	0.0	0.0	0.0	-0.3	-0.3	-0.3	-0.3	-0.3
Avocado	0.0	0.0	0.0	-0.1	-0.1	-0.1	-0.1	-0.1
Beans (seed)	0.0	0.0	0.0	-0.8	-0.7	-0.7	-0.6	-0.5
Carrot (seed)	0.0	0.0	0.0	-3.0	-2.8	-2.5	-2.2	-2.0
Cauliflower (seed)	0.0	0.0	0.0	-7.2	-6.7	-6.0	-5.5	-4.9
Cherries	0.0	0.0	0.0	-0.2	-0.2	-0.2	-0.2	-0.2
Clover (seed)	0.0	0.0	0.0	-3.0	-3.0	-3.0	-3.0	-3.0
Cucumber	0.0	0.0	0.0	-0.2	-0.2	-0.2	-0.2	-0.2
Grapefruit	0.0	0.0	0.0	-1.2	-1.2	-1.2	-1.2	-1.2
Kiwi	0.0	0.0	0.0	-0.6	-0.6	-0.5	-0.5	-0.5
Lemon & Lime	0.0	0.0	0.0	-0.6	-0.6	-0.5	-0.5	-0.5
Lettuce (seed)	0.0	0.0	0.0	-0.4	-0.4	-0.4	-0.3	-0.3
Lucerne (seed)	0.0	0.0	0.0	-1.9	-1.9	-1.8	-1.9	-1.9
Lupins	0.0	0.0	0.0	-2.6	-2.7	-2.6	-2.6	-2.7
Orange	0.0	0.0	0.0	-0.6	-0.6	-0.6	-0.6	-0.6
Papaya	0.0	0.0	0.0	-0.1	-0.1	-0.1	-0.1	-0.1
Peach	0.0	0.0	0.0	-4.4	-4.4	-4.3	-4.2	-4.2
Pear	0.0	0.0	0.0	-0.4	-0.4	-0.4	-0.4	-0.4
Plum	0.0	0.0	0.0	-1.9	-1.9	-1.8	-1.8	-1.8
Pumpkin	0.0	0.0	0.0	-0.5	-0.5	-0.5	-0.5	-0.5
Strawberry	0.0	0.0	0.0	-0.1	-0.1	-0.1	-0.1	-0.1
Watermelon	0.0	0.0	0.0	-0.4	-0.4	-0.4	-0.3	-0.3

Source: CIE simulations

Analysis of the Market for Pollination Services in Australia

by Michael Monck, Jenny Gordon Kevin Hanslow, Centre for International Economics

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Pollination services are the paid use of domestic honeybees to pollinate crops. Australia currently has a very small market for pollination services, with an estimated 200,000 hives being used for paid pollination. Feral honeybees and incidental pollination provided by honey producers supply the remaining needs for pollination of Australian pollination-dependent crops.

This report examines the market for pollination services in Australia and how it is expected to evolve over time under three scenarios:- business as usual (where there is some growth in demand with expansion of some pollination dependant crops); a Varroa incursion (that raises supply costs and sparks a massive increase in demand); and this same scenario but where industry is proactive to improve the responsiveness of supply.

The report provides an assessment of the prices and access to pollination services for the major honeybee pollination dependent industries. It should inform the development of the business plan for the proposed industry alliance, Pollination Australia, made up of agricultural industries and the honeybee industry.

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