Improving our understanding of the value of biosecurity research

NZIER report to Better Border Biosecurity

June 2014

About NZIER

NZIER is a specialist consulting firm that uses applied economic research and analysis to provide a wide range of strategic advice to clients in the public and private sectors, throughout New Zealand and Australia, and further afield.

NZIER is also known for its long-established Quarterly Survey of Business Opinion and Quarterly Predictions.

Our aim is to be the premier centre of applied economic research in New Zealand. We pride ourselves on our reputation for independence and delivering quality analysis in the right form, and at the right time, for our clients. We ensure quality through teamwork on individual projects, critical review at internal seminars, and by peer review at various stages through a project by a senior staff member otherwise not involved in the project.

Each year NZIER devotes resources to undertake and make freely available economic research and thinking aimed at promoting a better understanding of New Zealand's important economic challenges.

NZIER was established in 1958.

Authorship

This paper was prepared at NZIER by Chris Nixon.

It was quality approved by Dr Bill Kaye-Blake.

NZIER
NEW ZEALAND INSTITUTE OF ECONOMIC RESEARCH

L13 Grant Thornton House, 215 Lambton Quay | PO Box 3479, Wellington 6140
Tel +64 4 472 1880 | econ@nzier.org.nz

Key points

Biosecurity is at the top of the government's and business's agricultural agenda.[1] As trade and people movement increase, and trade patterns change, the potential risks of biosecurity incursions may increase. Therefore, understanding the value of current biosecurity approaches is an important first step to further improving biosecurity effectiveness and efficiency.

The purpose of this report is to provide an initial cost benefit analysis (CBA) that sets out the potential added value of border biosecurity control and research for plants and pathogens.

The implications are:

- there needs to be a commitment to collecting good data. What is collected needs to be motivated by good policy and research questions
- effective and efficient approaches are required in "new times". What those approaches are is unclear but whatever interventions are initiated require review and monitoring to gauge effectiveness
- biosecurity should be viewed as a system of different components. For example, the more difficult a pest or pathogen is to eradicate, the more effort should be put into on-shore and off-shore pathway management.

To further understand the additionality of biosecurity we have taken two approaches:

- we have developed a cost benefit approach that uses data already available to estimate two scenarios, as shown in the table below
  - the additionality of the current biosecurity system over a situation where no biosecurity is in place
  - the additionality of improved biosecurity given a 5% improvement in detection, eradication and control
- we have reviewed three case studies of biosecurity incursions to understand the potential economic impacts of future incursions.

The cost benefit approach produced results showing that current biosecurity efforts lead to significant benefits relative to having no biosecurity, with impacts in the billions of dollars per year. They also suggest significant benefits could be achieved with improvements in biosecurity effectiveness and efficiency.

1 See for example https://nz.news.yahoo.com/a/-/top-stories/24209525/minister-welcomes-kpmg-agribusiness-agenda/

Summary of initial results

	Current situation vs no biosecurity		Current situation vs slight improvement in bio security efficiency
	Lower cost of incursions ($312m per annum)	Higher cost of incursions ($519m per annum)	
Cost of biosecurity	$103m	$103m	$114m
Biosecurity benefit	$850m	$1,057m	$217m
Net benefit	$747m	$954m	$207m
BCR	8.2	10.2	20.5

Source: NZIER estimates based on Turner et al (2004) and Nimmo Bell (2009)

The case studies of incursions examined three pests and pathogens that have not been eradicated:

- clover root weevil. Having the tools and techniques to catch this type of pest before it crosses the border is preferable because once here such a pest is almost impossible to contain
- tomato / potato psyllid. This type of pest demonstrates how an incursion blunts dynamic efficiency by blunting economic opportunities. New Zealand prosperity thrives on a diversified portfolio of land-based products. Closing down these opportunities can have important regional impacts, particularly on employment
- PSA. The PSA outbreak demonstrated the importance of new approaches in “new times” where economic pressures can open up new pest and pathogen pathways. It also shows the resilience of New Zealand industries: how innovation (the introduction of new cultivars) can overcome difficult situations.

Contents

Figures

Tables

1. Introduction

The strategic priority of biosecurity research is to add value to New Zealand's biosecurity system through research on pests and their effects. While the potential value may be obvious to some, biosecurity stakeholders need to understand the following in more detail:

- should we have biosecurity control at all?
- what are the questions that need answering?
- how value is created by biosecurity science teams (the additionality)?
- can we show where funds should be targeted?

The purpose of this report is to provide an initial cost benefit analysis (CBA) that sets out the potential added value of border biosecurity control and research for plants and pathogens. The research areas of interest are:

- **risk assessment**: develop improved methodologies for identifying hazards, assessing risk, predicting impacts and optimising system mitigation measures
- **pathway risk management**: develop tools and methodologies that potentially reduce risks along the importation pathways
- **diagnostics**: develop fast, robust and accurate diagnostic methods and tools to inform biosecurity decisions at least cost
- **surveillance**: develop strategies, tools and knowledge for determining the presence or absence of invasive pests of plants
- **eradication and response**: increase preparedness for responses by providing knowledge, strategies and tools to support decision making.

Research on biosecurity has been carried out set against the background of business and government putting biosecurity at the top of agenda.[2] Because of this priority status, the first ever Government-Industry Agreement (GIA) is being signed between the kiwifruit industry and government on biosecurity cooperation. Other industries are also gearing up to sign agreements.

In our analysis, we have drawn on international and domestic studies in peer-reviewed journals, case studies, information from biosecurity scientists, perceptions of those involved in biosecurity, past assessments and other sources.

The analysis is intended to give stakeholders an initial indication of the likely costs and benefits of biosecurity research to assist in strategic decisions around biosecurity. There remain a number of important uncertainties on costs and benefits which could be refined in later analysis – the data is not of good quality. As such, the depth of the CBA reflects the initial scoping nature of the assessment.

[2] See for example https://nz.news.yahoo.com/a/-/top-stories/24209525/minister-welcomes-kpmg-agribusiness-agenda/

2. Current situation

2.1. The data

The main problem with measuring the economic value of biosecurity is that the required data are not collected or are not of sufficient quality. At the border, biosecurity data are patchy as most records are based on chance interceptions and not on quantitative survey methodology. Conclusions can only be drawn from qualitative data and comparisons between pathways and commodities (over time) are not easy.[3]

Therefore, one of the aims of this paper is to generate interest in developing better quality data. This is required to further understand the biosecurity status quo so that the additionality of research benefits can be measured more accurately. For example, elements of the status quo that need further investigation include:

- rates of incursion per annum
- what we spend on incursions from very minor incursions (where we have little data) to significant incursions (where good data exists)
- the potential for eradication
- the potential for early detection.

The rate of incursion is a case in point, since knowing the approximate number of incursions per annum is useful in gauging biosecurity research success or failure. It also important to understand the impact of increased trade: have we increased the risk of incursions through increased trade? And if so, how much have we increased the risk by?

There may be a perception that post-border incursion rates have gone up, expert opinion and simple logic suggests this, but there is little data to support this hypothesis since there are other factors that influence detection such as increased public awareness. Possibly the harder we look for new incursions the more we find.

2.2. "New times"

Increasing integration of the world economy through greater trade flows is a feature of the post-World War II era. However, what is not generally appreciated is that globalisation also occurred in an earlier period, before World War I and the Great Depression. In fact, trade as a percentage of the world economy did not recover to 1913 levels until the mid-1970s (see Table 1).

3 One of the best sources of information at the moment is from interceptions post border through public reports to the MPI pest and disease hot line.

Table 1: World merchandise trade

Exports as percentage of world GDP

1850	1880	1913	1950	1973	1985	1993	2005
5.1[1]	9.8[1]	11.9[1]	7.1	11.7	14.5	17.1	28.1
Note: (1) OECD nations only							

Source: Krugman (1995) p331 & WTO various years

It is only since China's admission into the WTO that the world has reached levels of trade that are significantly different from pre-1914 levels. Therefore, it is only very recently that world has been in truly in "new times" in terms of the intensity of global integration.

For New Zealand the challenge is much greater. The so called "death of distance" has occurred with New Zealand's merchandise-trade-to-GDP ratio in 2012 being 44.1 percent, which is much greater than the world average.[4]

Part of the reason for this is that global transport and telecommunications services have fallen dramatically. As a result of rapid advances in information and communications technology (ICT) and the digital revolution in communications technology, the speed in which sophisticated business transactions can be carried out has exponentially increased.

Figure 1 illustrates this point, there have been large decreases in transport and communication costs since 1930 where the real cost of a three minute phone call from New York to London has fallen by 99.9 percent, while shipping and airfreight costs have fallen by nearly half since 1950 (Busse, 2002). The greater availability of satellite communications combined with their rapid fall in cost has assisted New Zealand firms in conducting business globally in 'real time' and facilitated the growth in world trade.

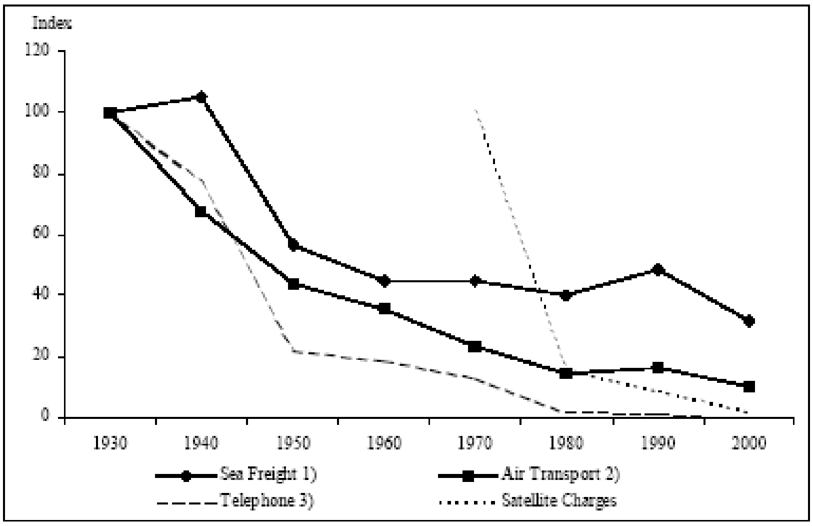
The flip side of increased trade is the increase in biosecurity threats. These threats are also coming from new sources (particularly Asia). While we have a good idea of the potential damage they can cause in their home environment, we only have partial understanding of their potential impact in New Zealand.

One hypothesis is that Asian pests and pathogens are more likely than European or North American organisms to thrive in New Zealand, because the ecosystems are more similar. We are not sure whether this is true or not, but it is a factor that needs to be tested.

4 http://data.worldbank.org/indicator/TG.VAL.TOTL.GD.ZS

Figure 1: Transport and communication costs 1930 - 2010

Base year 1990 (US Dollars)



Notes: (1) Average ocean freight and port charges per short tonne of import and export cargo

(2) Average air transport revenue per passenger mile

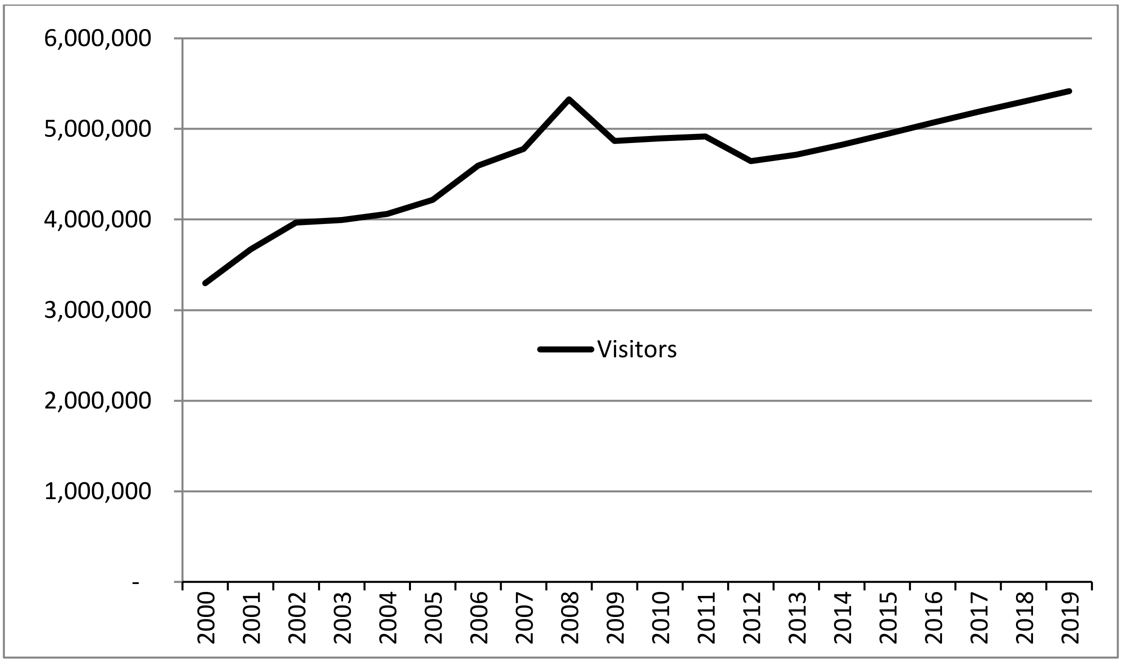
(3) Cost of a three minute telephone call from New York to London

Source: Adapted from Busse M (2002)

Tourism has also increased. By 2019 we expect that over 5 million tourists will arrive in New Zealand. Not only will tourist numbers increase but also the composition will change. Many more will come from Asia, particularly China.

Figure 2: Visitor numbers

Actuals and forecasts



Source: NZIER (2013) adapted from MBIE data

2.2.1. Biosecurity research and infrastructure costs

One main benefit of the current biosecurity system is the reduction of the economic losses associated with the incursion and establishment of pests and pathogens.

As the last two sections have shown, biosecurity is operating in a period where:

- the risk is heightened by an increase in connections with the world
- public funding generally is constrained by limited budgets
- there is an absence of policy critical data that allows us to make rational trade-offs i.e. where should we put scarce biosecurity dollars so that they are used efficiently and effectively.

The Biosecurity Strategy (2003) took submissions from practically all those working in the biosecurity space (researchers, government, industry, academics and interested stakeholders). Within the Strategy, the challenge for the biosecurity system was laid down by the Minister of Agriculture Hon Jim Sutton "*Biosecurity deals with living problems, inevitably changing, so we must ensure our systems are dynamic, constantly evolving to keep pace. New Zealand's response, one of continuous improvement, must be relentless*."[5]

Despite the lack of data, a number of papers have made attempts at further understanding the value of current biosecurity efforts. Brockerhoff et al (2010) examined the tools and techniques required for eradication to be successful, focusing particularly on forestry pests. The decision to eradicate depends on the balance of costs and benefits since in some cases eradication is feasible given the widespread expected damage, in others the expected impacts are negligible. For continued success early detection is key. Further improvements to the tools that aid early detection, and the likely impacts of incursions will assist in eradication efforts.

In the United States, Pimentel et al (2000) has made some high level estimates of environmental and economic costs of non-native species. They estimated that 50,000 non-native species have caused environmental and economic damage of $137,000 million per annum. Similarly, in New Zealand, Nimmo-Bell (2009) investigated the economic costs of pests to New Zealand by collecting information on economic costs from previous studies on individual pest species. They estimated that defensive expenditure[6] and total output losses[7] are approximately $2,000 million per annum.

Carter (1989) produced data that shows on average 2.2 new insects and 2.4 new fungi were introduced per annum over the period 1958 to 1988 in forestry. Carter argues that regular surveying of port environs and forestry areas would be beneficial. If forest health survey methods (including aerial surveys, drive through surveys and random point surveys) were introduced then it could produce a maximum benefit of $7.33[8] million assuming that 95% of new pests and pathogens were detected.

5 Letter to the Biosecurity Council in the Biosecurity Strategy for New Zealand August 2003. http://www.biosecurity.govt.nz/files/biosec/sys/ strategy/biosecurity-strategy.pdf

6 Defensive expenditures are the financial costs of resources devoted to restricting pest populations. Approximately $800 million per annum.

7 The output loss per annum as a result of the current incursion rates. Approximately $1,200 million per annum.

8 $12.68 million in 2014 dollars.

Turner et al (2004) estimated the economic benefits of preventing forestry biosecurity incursions. Costs included reduced harvest value, costs associated with eradication and control programmes, private control costs replacement of urban trees. The expected costs depend upon potential pest arrival, ability to detect, ability to eradicate or successfully control and the impact on improved research. Turner et al (2004) estimated that the benefit to New Zealand of $3.5 million spent on research funding ranges from $3,519 to 5,888 million.

Kriticos et al (2005) suggested that the number of alien species becoming established in New Zealand is increasing. They quote a number of sources to support this contention and build a simple model to estimate how (hypothetical) improvements in the biosecurity system could benefit New Zealand by preventing the establishment of pests and pathogens. Assuming improvements, the cost savings between 2005 and 2017 are estimated at NZ$ 921 million.[9]

Leung et al (2014) examined risk at the pathway level by focusing on the International Standards for Phytosanitary Measures No. 15 (ISPM15). The standard targets wood packaging material used in international trade. Wood packaging is an important pathway for wood borers, nematodes and fungi all of which have the potential to cause extensive forest damage. A pathway level risk analyses (PLRA) is developed using 100 years of insect pest invasions and 50 years of pest interceptions data to develop an ex-post assessment of border control policy. Despite high treatment costs, the application of ISPM15 yields a net benefit of NPV of $11,900 million through to 2050.

The literature indicates that there are substantial gains to be made with further improvements to biosecurity research and control. Despite this, the effect of biosecurity measures on New Zealand is difficult to measure. The literature points to positive outcomes but further work is required to understand its additionality.

- Could we achieve more benefit by investing more in biosecurity?
- Are we investing too much or even is it worth investing in at all?
- If incursions are increasing as trade and tourism increases, are we now in a race against time to “up” the biosecurity game?
- How can biosecurity research assist?
- Where is our best bang for biosecurity buck and how would we know?

These are not easy questions to address, particularly considering biosecurity is designed to keep pests and pathogens out. Biosecurity research and control aims to reduce the likelihood of an incursion, however in the absence of biosecurity it is unclear whether a pest will reach New Zealand or if they do, how much damage would occur.

The biosecurity challenge is about managing risks that have relatively small probabilities of occurrence, but can potentially have extremely large consequences. Further, measuring improvements to biosecurity systems is also important since measuring progress links directly to questions around the appropriate level of funding.

[9] $1.121 million in 2014 dollars.

In the next section we attempt to examine some of these questions or at least shed some light on how they might be looked at by examining the potential benefits of reducing the risks of an incursion.

3. Benefits of improving biosecurity outcomes through research

We have used two approaches to examine the potential benefits of the New Zealand biosecurity system:

- cost benefit analysis to further explore the relationship between benefits and costs.
- the value of past incursions (case studies) to illustrate the data gaps that we have is estimating the total economic benefits.

The aim has been to keep the approaches as simple as possible given the limitations of the New Zealand specific data.

3.1. Cost benefit analysis

We have used a cost benefit framework to examine the value of biosecurity research.

CBA is a long-established technique intended to identify the economic efficiency of a proposed project or policy change. Efficiency is broadly about maximising outputs obtained from available inputs, but there are different variants used in economics:

- **technical efficiency** refers to the most cost-effective way of providing a given service, for instance if technology could be used to replace labour, then the per unit cost of biosecurity might be reduced
- **allocative efficiency** considers whether products are reaching the best end-use to produce the most economic welfare or satisfaction. It is less relevant to biosecurity, because the benefits of biosecurity are available to everyone[10]
- **dynamic efficiency** refers to innovation and changing to new activities over time.

If research does reduce the community-wide costs of biosecurity overtime, it will improve technical efficiency. To the extent that it shifts resources from one less productive activity to a more productive activity, it also improves the allocative efficiency of resource use. If it also allows new, more efficient ways to provide for biosecurity then it also improves dynamic efficiency over time.

[10] Biosecurity is a 'public good', because the benefits are (mostly) non-rival and non-excludable. Generally speaking, pests and pathogens are excluded from the whole country, not from specific parts or for specific people. In addition, biosecurity is not consumed in the sense that biosecurity consumers use it up. There are some subtleties to this. For example, specific islands and areas have been made predator-free sanctuaries through careful and costly local biosecurity measures.

A cost benefit analysis proceeds by comparing effects and outcomes associated "with" the current situation – current border control and biosecurity research (the factual situation) against what would have occurred under a counterfactual, "without" biosecurity research and a situation where some unspecific improvements were made to border controls and or application of research outcomes.

3.2. The counterfactuals

Setting up the counterfactual scenarios to analyse is difficult because there is:

- limited baseline data from which to measure any change
- uncertainty about what would occur without biosecurity control.

Therefore, there are potentially a number of credible counterfactuals. The ones we assume here are open to question, and should be treated as "work in progress". Two scenarios have been developed.

Scenario 1. No biosecurity

Scenario 1 assumes that "without" biosecurity controls there is:

- no spending on plant biosecurity research or border control
- increased control costs
- increased output losses.

Industry and national authorities would be more reactive to biosecurity threats attempting to deal with the incursion after the pest or pathogen has arrived. While this approach will stop some biosecurity incursions it would not anticipate entry of new pests and greater resources over time would be put into controlling costs and output losses.

This approach to biosecurity is likely to:

- be more expensive since the biosecurity system will be more reactive in its spending as it puts more money into chasing the last incursion
- have little understanding about where threats are likely to come from and the possible pathways
- be configured in a similar pattern without considering new threats, which possibly raises the cost since more pests are likely to arrive, and the cost of eradication is higher than prevention
- be riskier, since little integration between the various stakeholders has occurred.

There will be some learning by doing as industry, policy and operational teams adapt as they learn from each control and output losses.

Scenario 2. Improvement in biosecurity

Scenario 2 assumes that there is an improvement in biosecurity. This includes:

- a small increase in resources for biosecurity research and border control
- improvements in detection

- improvements in control
- improvements in eradication.

3.3. Qualitative assessment of scenarios

This is a partial cost benefit analysis in the sense that some effects will be too difficult to quantify reliably. For instance, it may well be that there are non-market benefits to society and the environment from better biosecurity protection. These benefits can be described in terms of amenity benefits, option values, existence values, and other non-market benefits. While we can identify these benefits, it is not feasible to value them in economic terms, given time and resources. For practical reasons the analysis has concentrated on quantifying effects that are readily quantified and valued, and describing in a qualitative way the effects that cannot be readily quantified or valued.

From the feedback from various stakeholders a number of benefits have been identified that need to be considered, whether they can be quantified or not. Groups considered to be important are:

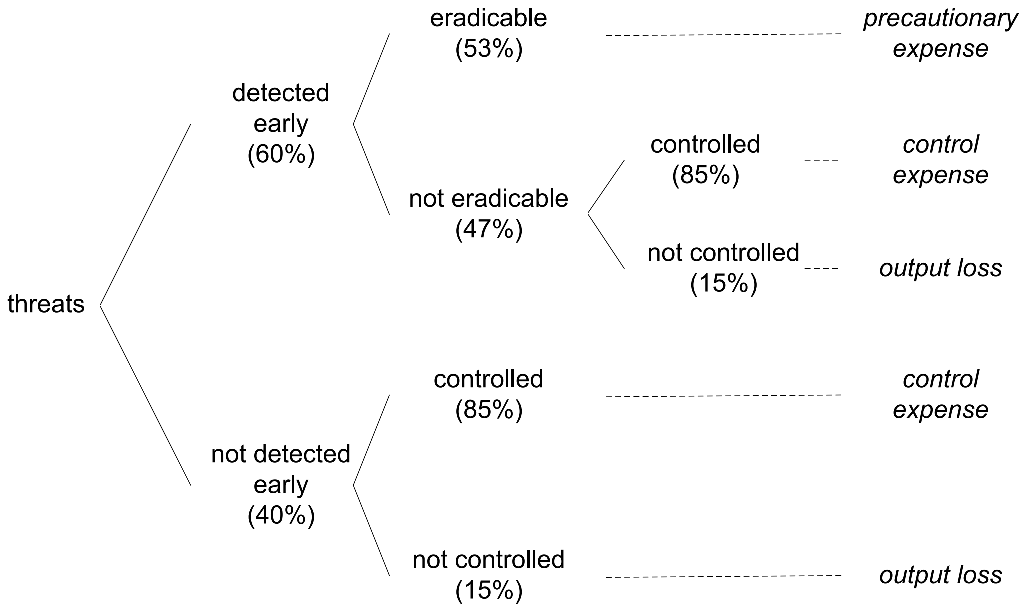
- **industry**. The main costs and benefits for industry is the potential to reduce incursions, and an incremental improvement in their competitive position relative to competitors who have more incursions
- **Ministry for Primary Industries**. Improved efficiency is likely with biosecurity system improvements since we expect a more efficient approach to reducing the risk along each pathway
- **the research community**. Improved integration of research objectives with end user needs will assist in shifting research effort to where it is assumed to have the largest impact
- **the wider economy**. Benefits will be faced by the wider economy, since the reduction in incursions is likely reduce the impact on the wider economy. Therefore, less private resources are likely to devoted to mitigation and/or avoidance of control agents
- **New Zealanders.** All New Zealanders including Māori are likely to be better off since the reduction in incursions will have a greater impact on commercial and non-commercial activities.

4. The benefits

4.1. Using a CBA approach

We have described the current situation using the following diagram from Turner et al (2004). Turner et al set out a decision-tree diagram based on literature limited to the forestry sector. We must stress that figures for early detection, eradication, and control are only illustrative. While the probabilities are tentatively applied to the forestry sector, they are not necessarily representative of the wider biosecurity pest and pathogen biosecurity approach. We are applying the probabilities, however, in order to demonstrate a simple method for examining the cost and benefits and populating the approach with some illustrative figures which can be refined at a later stage.

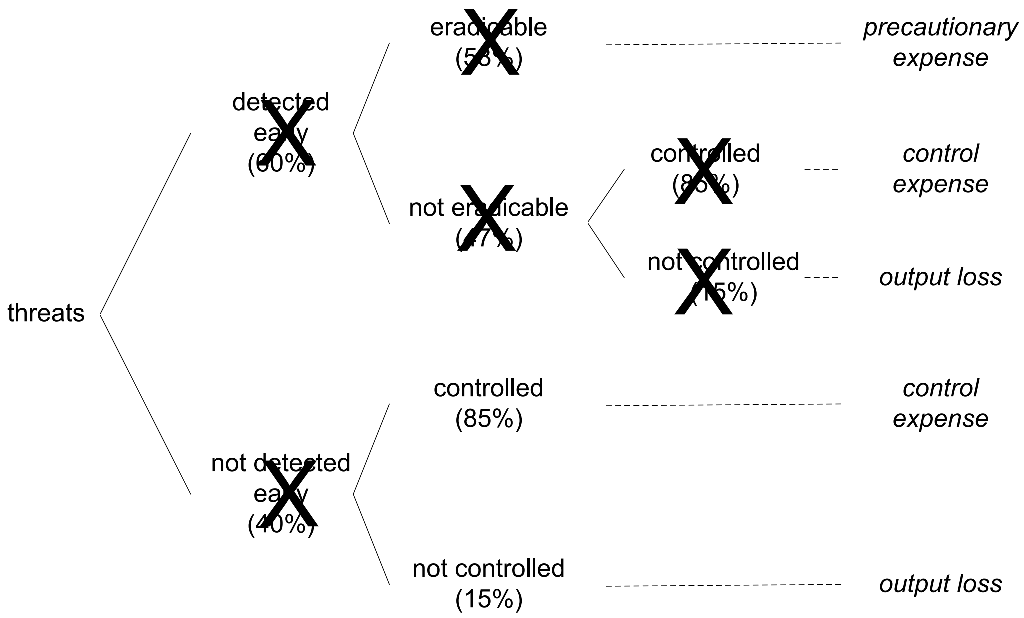
Figure 3: Illustrative approach to the counterfactual



Source: Turner et al (2004)

It is useful to understand what occurs if no biosecurity exists. In Scenario 1 with no biosecurity, the figure focuses in on the control expense and output loss (see Figure 4).

Figure 4 Scenario 1: no biosecurity



Source: Adapted from Turner et al (2004)

To motivate the example we have used figures from Nimmo Bell's (2009) stocktake of biosecurity activities:

- where a pest is detected early (precautionary expenses, control expenses, and output losses)
- where a pest is not detected early (control and output expenses).

Table 2 puts the decision tree in Figure 3 into table form. Each row of the table is a path in the decision tree e.g. the detection (60%) pathway in Figure 3 is set out in in the first row of Table 2. The 2008 value attached to each path is related to figures in Nimmo-Bell (2009). This provides a quantitative description of the current biosecurity situation.

Table 2: Current situation

Step 1	Step 2	Step 3	Step 4	Probability	Type of expense	2008 Impact
Threats	Detected early	Eradicable	Eradicable	0.32	Precautionary	$103m
Threats	Detected early	Not eradicable	Controlled	0.24	Control	$97m
Threats	Detected early	Not eradicable	Not controlled	0.04	Loss	$283m
Threats	Not detected early	Controlled	Controlled	0.34	Control	$138m
Threats	Not detected early	Not controlled	Not controlled	0.06	Loss	$401m
Total				**1.00**		**$1,022m**

Source: Adapted from Turner et al (2004) and Nimmo Bell (2009)

To estimate the impacts of biosecurity, we update the decision tree by removing the branches relating to detection. The remaining branches then describe the probabilities associated with a lack of biosecurity. The expected values (probability X impact) can then be updated to estimate the impact of having no biosecurity. Table 3 probabilities and impacts are based on Figure 4 with only the control and loss expenses counted under the "not detected early" path. The threat control value is calculated by the control costs in the current situation ($138m) divided by its probability (0.34) multiplied by its probability in the no biosecurity scenario (0.85), a use of Bayesian logic. The production cost is worked out in a similar fashion.

Table 3: No biosecurity

Step 1	Step 2	Step 3	Step 4	Probability	Type of expense	2008 Impact
Threats	Detected early	Eradicable	Eradicable	0.00	Precautionary	-
Threats	Detected early	Not eradicable	Controlled	0.00	Control	-
Threats	Detected early	Not eradicable	Not controlled	0.00	Loss	-
Threats	Not detected early	Controlled	Controlled	0.85	Control	$344m
Threats	Not detected early	Not controlled	Not controlled	0.15	Loss	$1,004m
Total				**1.00**		**$1,348m**

Source: Adapted from Turner et al (2004) and Nimmo Bell (2009)

Table 3 is only an initial estimate. Table 4 sets out the impacts with the following adjustments:

- Nimmo Bell (2009) does not include labour costs for control of incursions. This is likely to be a substantial cost. According to Nimmo Bell the labour costs are likely to be double the control costs
- biosecurity incursions so far in New Zealand have not precluded trade with rich industrialised countries. Some incursions, such as a fruit fly, would be a major cost if allowed to reach New Zealand –for its impact not on New Zealand orchards but on New Zealand's ability to sell into premium markets. After examining Underwood (2007) on eradications costs of fruit fly and the total estimated costs of the clover root weevil (NZIER, 2005) we have assumed two scenarios:
  - three major incursions over 30 years which increase costs from year 5 by $312 million per annum. These incursions are at the approximate cost level of the clover root weevil
  - three major incursions over 30 years which increase costs from year 5 by $519 million per annum. These approximate costs are at the level of a fruit fly incursion

The potential impact on tourism is not valued in Table 4. A lack of biosecurity could affect the ability of New Zealand to attract tourists since it is likely to compromise the tourism image. Table 4 also does not capture the dynamic gains associated with biosecurity border control and research as the nature of the threats change.

Table 4: No biosecurity: includes labour and trade impacts

Step 1	Step 2	Step 3	Step 4	Probability	Type of expense	2008 Impact
Threats	Detected early	Eradicable	Eradicable	0.00	Precautionary	-
Threats	Detected early	Not eradicable	Controlled	0.00	Control	-
Threats	Detected early	Not eradicable	Not controlled	0.00	Loss	-
Threats	Not detected early	Controlled	Controlled	0.85	Control	$688m
Threats	Not detected early	Not controlled	Not controlled	0.15	Loss	$1,004m
Trade impacts						$312m – $519m
Total						**$2,004 - $2,211m**

Source: Adapted from Turner et al (2004) and Nimmo Bell (2009)

In Scenario 2, we have assumed a 5% improvement in:

- detection – detection improves from 60% to 63%
- eradication – eradication improves from 53% to 56%
- control – control improves from 85% to 89%.

The calculations are similar those done for Table 3 and the result show a significant improvement in biosecurity efficiency.

Table 5: Better biosecurity (small improvement)

Step 1	Step 2	Step 3	Step 4	Probability	Type of expense	2008 Impact
Threats	Detected early	Eradicable	Eradicable	0.35	Precautionary	$114m
Threats	Detected early	Not eradicable	Controlled	0.25	Control	$101m
Threats	Detected early	Not eradicable	Not controlled	0.03	Loss	$201m
Threats	Not detected early	Controlled	Controlled	0.33	Control	$134m
Threats	Not detected early	Not controlled	Not controlled	0.04	Loss	$266m
Total						**$816m**

Source: Adapted from Turner et al and Nimmo Bell (2009)

A summary of the results are set out in

Table **6**:

- comparing the current situation with no biosecurity, the trade effects have a major impact on the analysis. Keeping pests and pathogens out of New Zealand is necessary so that New Zealand producers can trade in premium world markets is the main benefit from biosecurity (BCR of between 8 and 11)
- small improvements in biosecurity from the current situation are also worthwhile (BCR 20.5).

Table 6 Summary of initial results

	Current situation vs no biosecurity		Current situation vs slight improvement in bio security efficiency
	Lower cost of incursions ($312m per annum)	Higher cost of incursions ($519m per annum)	
Cost of biosecurity	$103m	$103m	$114m
Biosecurity benefit	$850m	$1,057m	$217m
Net benefit	$747m	$954m	$207m
BCR	8.2	10.2	20.5

Source: NZIER estimates based on Turner et al (2004) and Nimmo Bell (2009)

The value of having biosecurity versus not having biosecurity is immediately apparent from

Table **6**. The main benefit is a result of the trade effects: maintaining access to premium markets is the most important benefit.

The small improvement in efficiency of biosecurity research and control does have a major impact. This suggests – using this data – that there are high fixed costs associated with biosecurity. Once the cost threshold is past, the economic gains can be significant.

However, we are constrained by the lack of data and the assumed parameters set out in Table 2 and Figure 3. Further, we have no metrics to measure an improvement in biosecurity border control or research. There is a further difficulty in describing how to achieve the improvement, and in particular where in the biosecurity system the funding could be put to best use.

4.2. The impact of one-off incursions

The previous example shows the effect of trade impacts with no biosecurity, using a high-level approach. However there are other important benefits that could be forgone with incursions. To further understand these benefits we also used a case-study approach:

- examine three cases (clover root weevil, tomato/potato psyllid, and PSA) where incursions have occurred and New Zealand has not been able to eradicate
- make assumptions about the likely impact of research given past incursions and their impacts informed by expert opinion.

4.2.1. Clover root weevil

Introduction

Clover root weevil (*Sitona lepidus*) was first detected on a Waikato dairy farm in 1996. Since then it has spread to many parts of the North and South Island.[11] How clover root weevil arrived in New Zealand is unknown.[12] It quickly established itself, as no suitable eradication tools were available.

Clover root weevil is a major threat to white clover which is roughly 20% of the nutrition requirements for livestock. It attacks the white clover during two stages of its life cycle:

- the larvae of the clover root weevil feed on the root system of white clover reducing nitrogen fixing capability and vigour
- the adult feeds on the foliage particularly new pasture.

Farmers have responded by applying increasing amounts of nitrogen and buying supplementary feeds to maintain output.

[11] For the latest information on spread see http://www.agresearch.co.nz/our-science/biocontrol-biosecurity/pest-control/clover-root-weevil/Pages/default.aspx

[12] It has spread through Asia, North America, and Europe.

To mitigate the impacts, efforts have focused on obtaining biocontrol agents (e.g. the Irish parasitoid wasps) and exploring alternative pasture and feed options.

Impact

The impact of clover root weevil is large. NZIER (2005) estimated that the impact would be as much as $3.5 billion in 2004 dollars (over thirty-five years).[13] This is made up of extra nitrogen application and increased supplementary feed.

Implications

Stopping the incursion of a pest such as the clover root weevil has major benefits for New Zealand relative to the costs of research and implementation of biosecurity controls. Having the tools and techniques to catch this type of pest before it crosses the border are preferable because once here it is almost impossible to contain. The costs are extremely large because the pest affects a key part of the New Zealand economy: livestock production.

4.2.2. Tomato/potato psyllid

Introduction

The tomato/potato psyllid, a native of North America, was first found in 2006 and has spread throughout New Zealand. How it arrived in New Zealand is unknown and eradication was not considered an option.

The psyllid is a major threat to potato and tomato production by feeding on the leaves and by transmitting a bacterial pathogen, Liberibacter, that lives in the plants. The bacterium causes psyllid yellows in tomatoes and potatoes and zebra chip symptoms in potato tubers. This has a major impact on the quality and yield of the crop.

Impact

The tomato and potato industries in New Zealand are relatively small. Fresh tomatoes producers earn approximately $150 million at the farmgate. The potato industry is of a similar size worth about $142 million at the farmgate.

No work has been done on the costs to these industries; however, the potato industry and Tomatoes New Zealand have put at least a million dollars into researching the psyllid issue. This illustrates the importance of the pysllid problem to New Zealand.

Implications

New Zealand's prosperity thrives on a diversified portfolio of land-based products; the spread of the psyllid has closed down options and blunted dynamic efficiency gains by cutting down economic opportunities. This is particularly important in regions with high unemployment particularly Māori unemployment.

---

13 The NZIER figure is based on control costs of approximately $300 million per annum

4.2.3. PSA

Introduction

Pseudomonas syringae pv. actinidaiae (PSA) was first detected in the Bay of Plenty in November 2010. It was relatively quickly determined that PSA was relatively widespread and that eradication was not an option. The seriousness of the outbreak was also well understood because of the severe damage done by PSA to yellow kiwifruit in the Latina region of Italy. The virulent bacterial disease spread quickly and has destroyed the gold 16A kiwifruit variety which accounted for 30% of total kiwifruit value.

There is no conclusive evidence of how PSA arrived in New Zealand. An independent report "*found shortcomings in the way MPI's (then MAF) systems and processes were applied to the importation of kiwifruit, kiwifruit pollen, kiwifruit nursery stock, kiwifruit seeds and horticultural equipment, prior to the PSA outbreak*"[14].

The industry has responded by developing two new cultivars (G3 and G14) which have shown resistance to PSA, so much so, that green and particularly gold kiwifruit are likely to be back to their pre-2012 production levels by 2015.[15]

Impact

The cost of PSA was estimated by Greer and Saunders (2012) between $310 and $410 million in net present value terms over the next five years. These estimates were put together prior to the known effectiveness of the two new variety (G3 and G14). Therefore, the loss estimates are likely to be at the bottom end of this forecast or possibly lower. Despite this, the short term losses are significant, and the Greer and Saunders estimates are of the right magnitude.

Implications

The outbreak of PSA provides a number of lessons for biosecurity stakeholders:

- new times means new approaches by farmers to cut costs in a competitive international market. A possible source of the incursion may have been the pollen pathway. Growers were applying imported pollen on an industrial scale because it was cheaper than pollination by bees
- new channels of entry are always a possible biosecurity threat when new markets are opened up. Therefore prior to approvals careful thought needs to be given to how this might influence biosecurity threats
- industries can bounce back and are surprisingly resilient. The response to PSA has been astounding. Not only are kiwifruit exports expected to bounce back relatively quickly but it may shift more growers into the higher value yellow kiwifruit than would have otherwise have happened in the absence of PSA.

14 http://www.biosecurity.govt.nz/media/04-07-2012/independent-report-on-psa-released

15 http://www.interest.co.nz/rural-news/68757/kiwifruit-industry-rebounds-record-returns-and-demands-orchards-back-pre-psa-levels

4.2.4. Lessons from the case studies

The case study highlight some of the forgone benefits that cannot be captured by a cost benefit analysis. Of particularly interest are:

- the way that biosecurity incursions close off options for further economic development
- “new times” means new channels for biosecurity incursions
- on and off shore channel management is required if pests and pathogens are difficult to control once they arrive in New Zealand.

5. Implications

5.1. Analysis limited by lack of data

We have developed a cost benefit approach that is best suited to an ideal situation where the relevant data was available. Unfortunately, not all relevant data is not available, so the analysis provides tentative conclusions only.

It does however give stakeholders the opportunity to set up a blueprint that systematically answers the biosecurity questions we wish to address. It follows also that if stakeholders ask the right questions, then data can begin to be collected that allows them to further understand the biosecurity system.

Table 7 sets out a way of thinking about the questions that biosecurity stakeholders may wish to answer. The table is built on the main elements of biosecurity, which are indicated in both the rows and column headers. The result is a grid. The diagonal represents each element or issues by itself. The off-diagonal elements represent the interaction between different elements in the biosecurity system. By using a systematic approach stakeholders can automatically see where the gaps are in the knowledge. For example, determining value of each sector/industry is important because control authorities wish to know the size of the problem facing them. What we find is that we have:

- good data on exports and imports
- little data on the contribution of processing of plants into consumer products (with the exception of the livestock industries)
- very little information on domestic consumption. If a product is mainly consumed domestically information sources are scare
- no or very little information on environmental values
- no or very little information on social and cultural values.

Abstracting from the data issues around processing and domestic consumption, we expect the “flashpoints” about eradication resources to be in areas where there are significant environmental, social and cultural values involved since “value” to New Zealanders of these amenities is not well understood.

The more information on value of all commercial and non-commercial plants the better we are able to make more rational resource allocation decisions. This underlines the point that economic activity and output do not give a complete measure of total economic welfare and further may not be the only objective of governments.

Table 7 Possible questions

	Pathway	Sector/industry	Organism	Geography & climates	Biosecurity action/response
Pathway	***Describe the pathways***				
Sector/industry	Do industries have vulnerabilities?	***Determine value***			
Organism	Are some organisms more likely through some pathways?	What is the potential impact of organisms by sector?	***Classify organisms***		
Geography & climates	How do pathways change? (e.g. increased trade affected risks?	Are some sectors more vulnerable to changing trade patterns?	What are the organism risks by geographic source?	***Compare geographies & climates***	
Biosecurity action/response	Are some measures more effective for some pathways?	Are some measures more effective for some sectors?	Which measures are more effective for each organism?	Which measures are more appropriate for each geographic region?	***Identify actions/ responses***

Source: NZIER

5.2. Effective biosecurity solutions are required in new times

One of the questions that needs to be asked is how to measure the impacts of any particular solution. To gauge the effectiveness, stakeholders need to demand more transparent approaches to performance other than "inputs equal outputs".

However, new times suggest new solutions. What these new solutions will be is not immediately clear, since we are unsure of what will and will not be effective. What is clear is that measuring the effectiveness of biosecurity methods and interventions needs more rigorous attention. And a more systematic approach is required including:

- disaggregated indicators
- indications of the quality of the interventions made to stop incursions (despite the difficulties)
- comparison to best practice approaches, as far as possible.

It also means that a number of approaches are required to capture performance improvements since it unlikely that one single metric will reflect advancement. Also, information needs to suit its purpose. For example, degrees of aggregation are required for different organisations: a manager examining the effectiveness of a specific intervention will require disaggregated data, whereas the Biosecurity Minister may only want to know whether the programme is working and the results can be trusted.

As the world becomes more connected the transparency with which research, control agencies and industry work together is likely to become more important since:

- government want assurance that we have border integrity at least cost
- government agencies (research, policy and delivery) want to deliver solutions professionally
- businesses want effective border protection
- the public want to be comfortable that border integrity is sustained at the "right" level.

5.3. Thinking systemically: eradication vs. pathway management

Possibly the best place to start is to develop biosecurity approaches based on what we do know. For example, if a particular pest or pathogen is difficult to eradicate when it arrives in New Zealand then possibly the best alternative is to focus on the on-shore and off-shore pathways that prevent it arriving.

This is straightforward logic, however the real question is not that we are not doing it (there are many examples of how we are doing this within the biosecurity system), but are we doing too much of it, just enough, or are we underinvesting in pathway management and how would we know? This question connects with the first two parts in Section 5 i.e. if this is a question we need answered, what are the data that we need to collect to show the effectiveness of interventions?

6. Conclusions

The tentative conclusion is that there are good returns from an active biosecurity policy that involves industry and research. We have used two different approaches, and they both suggest this same conclusion. Further money for biosecurity research and a tighter integration between government, industry and research are likely to improve results further.

However the paper leaves us with more questions than answers.

- Tighter integration is required between industry, research and industry. But what are the mechanisms that will make this happen? More industry participation (voice and resources) is likely to improve integration, but this is likely to be the start of the process not the end
- Which data is important and how do we get it? This paper suggests a way forward with the matrix of questions (Table 7). A broader question is: if we had another $1m to spend on biosecurity where would we put it? And how would research helps us answer that question?
- How do we determine best value for money without data? Expert opinion will take us some way, but when does expert opinion cross the line into advocacy or lobbying? While expert opinion can establish workable assumptions these assumptions need to be tested not validated
- How do we measure and factor dynamics into the equation? On the benefit side, a lot has been learned about how to eradicate incursions from pests such as fruit fly (the system has learned from repeat incursions). On the cost side, how do cope with the opening up of new pathways which allowed diseases such as PSA into New Zealand.

Biosecurity is a challenging area for New Zealand. It is also a vital for New Zealand to remain “insiders” in world trade (i.e. to maintain access to the rich industrialised north). The alternative of “no biosecurity” is not acceptable since it likely to have large economic consequences. The questions then become, what is the right level of biosecurity and what is the best way to achieve it?

7. Reference

Biosecurity Council (2003), Protect New Zealand: The Biosecurity Strategy for New Zealand. August 2003. http://www.biosecurity.govt.nz/files/biosec/sys/strategy/biosecurity-strategy.pdf

Brockerhoff E G, Liebhold AM, Richardson B and Suckling DM (2010), *New Zealand Journal of Forestry Science* 40 suppl. (2010) S117-S135

Busse, M. (2002) Tariffs, Transport Costs and the WTO Doha Round: The Case of Developing Countries, Hamburg Institute of International Economics, accessed from: http://www.hwwa.de/PersHome/Busse_M/Tariffs,TransportCosts.pdf

Carter P (1989), Risk Assessment and Pest Detection Surveys for Exotic Pests and Diseases which Threaten Commercial Forestry in New Zealand. New Zealand Journal of Forestry Science. 19(2/3) : 353-74 (1989).

Greer G and Saunders C (2012), The Costs of PSA-V to the New Zealand Kiwifruit Industry and the Wider Community. *Report to Kiwifruit Vine Health*. Agribusiness and Economic Research Unit (AERU) Lincoln University.

Kriticos DJ, Phillips CB and Suckling DM (2005), Improving Border Biosecurity: Potential Economic Benefits to New Zealand. *New Zealand Plant Protection Society 58: 1-6 (2005)*.

Leung B, Springborn M, Turner J, and Brockerhoff E (2014), Pathway level risk analysis: the net present value of an Invasive Species Policy in the US (ISPM15). Frontiers in Ecology and the Environment 12: 273-279 http://dx.doi.org/10.1890/130311

Nimmo Bell (2009), Economic Costs of Pests to New Zealand. MAF Biosecurity New Zealand Technical Paper No: 2009/31

NZIER (2005), Clover Root Weevil Economic impact assessment. Report to Biosecurity New Zealand, Ministry of Agriculture and Forestry, August 2005.

NZIER (2013) Tourism outlook 2013-19. Report to Ministry of Business Innovation and Employment. June 2013

Pimentel D, Lach L, Zuniga R, and Morrison D (2000), Environmental and Economic Costs of Nonindigenous Species in the United States. *BioScience 53 January 2000, Vol 50 No.1*.

Turner J, Bulman L, Richardson B, and Moore J (2004), Cost-Benefit Analysis of Biosecurity and Forest Health Research. New Zealand Journal of Forestry Science 34(3): 324-343 (2004)

Underwood R (2007), Fruit Fly, Likely Impact of a Fruit fly incursion in the Bay of Plenty, Hawkes Bay and Nelson. *Report to Horticulture New Zealand*. Fruition Horticulture.