



Nimmo-Bell  
& COMPANY LTD

**An Economic Model for  
Efficient Resource Allocation to Surveillance  
A Decision Making Framework**

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## **Efficient resource allocation to Surveillance**

### **Executive Summary**

#### **Introduction**

1. Biosecurity Surveillance in New Zealand has tended to focus on high profile, high impact diseases such as Foot and Mouth Disease, and Fruit Fly. Surveillance for many other incursions has tended to be ad-hoc, or focused on those issues with the highest profile. Nimmo-Bell & Company Ltd, in association with Prime Consulting International Ltd, has been engaged to develop a framework including criteria that can be used by Government to identify Surveillance priorities and propose an Economic Model that could be used by Government to determine optimal levels of funding in the Surveillance area.
2. The decision making framework for Surveillance outlined in this project builds on the experiences obtained in other sectors . Without guidelines, rigour and analysis can vary widely between analysts and projects. The framework proposed is a methodology to ensure the appropriate tools are used and applied consistently.

#### **Proposed methodology**

3. In order to optimise resource allocation to Surveillance, resource allocation to the total Biosecurity area (Pre-border, Border, Surveillance and Response) needs to be considered as a whole. From an economic theory viewpoint total resources used in Biosecurity will be allocated efficiently when the marginal cost of the last dollar allocated equates with the marginal benefit derived from that expenditure.
4. This project focuses primarily in evaluating the return on investment from different Surveillance scenarios. It is assumed that targeted Surveillance will only be undertaken when there is an intention to mount some form of response to an unwanted organism. Thus for a given outcome the net return from a marginal dollar in Surveillance is the change in the cost of response and pest impact, should an incursion occur. This will not, however, tell us we have reached an optimal level of Surveillance. In order to do that, (because of interdependence), we need to consider the linkages with other aspects of Biosecurity. For example, if a particular risk pathway is mitigated by Pre-Border or Border activities, that may have a consequential impact on the nature and scope of Surveillance activities required.

## Quantifying Benefits and Costs

5. The marginal cost of Surveillance for a new pest may be quite low. For example, a sector group may already be monitoring the site for a number of reasons.
6. Our experience is that estimating costs is often relatively straight forward, but estimating benefits can be very difficult, particularly when social and environmental impacts are considered. There are a range of tools that can be used to measure benefits and costs. Therefore applying the tools consistently is very important. In practice, Cost Benefit Analysis (CBA) is the tool used most widely. It is attractive for a number of reasons, but it also has limitations.  
Perhaps the most vexatious concern relates to the discount rate used. Our position is that projects in the private sector should use commercial rates of discount (8 percent real), those in the public sector the social rate of time preference (5 percent) and in the long term (beyond 30 years) rates based on the long term growth rate of the economy (3 percent).
7. We consider a positive NPV, although normally a necessary condition for a project to be given the green light, is not a sufficient condition alone and other factors of a political or social nature may modify society's view of the project. Quantitative analysis provides us with information that helps decision makers, but it may not provide all the information that is necessary to make decisions, particularly when non-market factors are important.
8. Our conclusion is that CBA is the primary tool to be used where the significant benefits and costs can be quantified. Of the other quantitative tools available Cost Effectiveness Analysis is the most useful for Surveillance projects. This is used where there is a specific objective, but the benefits cannot be measured so the analysis provides the least cost way of achieving the objective.
9. From a purely economic point of view, where it is possible to quantify all benefits and costs, money should be allocated to those options or projects that give the highest return or greatest net benefit. Projects should be selected on the Net Present Value (NPV) criterion. Any project that has a positive NPV should be funded. However, where there is a capital constraint, resources are allocated efficiently when projects are ranked using the net benefit (NB) to capital cost (CC) ratio (NB/CC). We propose that this ranking is then subject to modification on the basis of non-quantitative considerations.

## **Taking into account non-quantitative benefits and costs**

10. There are a variety of techniques that are increasingly being used when monetary valuations cannot be relied on to provide the full answer. This family of tools is referred to as Multi Criteria Analysis (MCA). Use of MCA is also controversial, however as a tool it complements CBA particularly when choices are required between possible outcomes and the basis for appraising these choices is not clear.
11. A common feature of all MCA tools is the performance matrix, in which each row describes an option and each column describes the performance of the option against the criterion. To be most useful the information in the matrix is converted into consistent numerical values or scores that indicate the strength of preference for each option. Usually a scale of 0 to 100 is used where the most preferred option scores the highest on the scale. Weights are then used to define for each criterion the relative valuations of a shift between the top and bottom of the scale.
12. The key component of generating a performance matrix is the consistent use of experienced people (the same team by preference), who understand the issues, and focus on them using objective and subjective judgement. Sometimes when there are very diverse criteria the analysis stops short of weighting and even scoring.
13. The decision-making framework must also consider "non-quantitative benefit and costs". Multi Criteria Analysis (MCA) allows information to be converted into consistent numerical values, and weights defined for each criterion. The criteria used are Tradable Goods, Indigenous Ecosystems, Maori concerns, Amenity, Human Health, Lifestyles and Social benefits.
14. Nimmo-Bell has used the methodology described in this report to evaluate similar issues in a number of sectors and industry groups over the past 10 years, and our conclusion from this analysis is that the favoured approach is:
  - Determine the ranking of options on a net economic benefit basis using CBA for quantitative costs and benefits
  - Establish a performance matrix for non-quantitative benefits and costs using a linear additive MCA model to provide a single decision criterion for non-quantitative costs and benefits
  - Compare ranks under CBA and MCA and use judgement to decide on a final ranking
  - The trade-off between quantitative (CBA) and non-quantitative (MCA) criteria indicates the opportunity cost to society in monetary terms of changing the CBA ranking.

15. The Surveillance decision making process involves a series of steps in a loop that are undertaken iteratively as follows: define objectives, identify options, define criteria, analyse options, feedback and make funding decisions. This loop may need to be traversed several times before decision makers are comfortable that the process has converged. In undertaking this process both the quantitative, and non-quantitative factors are incorporated.

### **Making decisions on who pays**

16. The case for government intervention in Surveillance is based on the concept of common good and the government taking responsibility on behalf of tax payers. That accepts that the market alone cannot make decisions that result in the optimal allocation of resources. This is because there are externalities and spill overs from decisions made by individuals in the private sector and there is the possibility of free riders. Also, there needs to be an analysis of options to ensure transaction costs are minimised and resources are allocated efficiently. That analysis should address not only efficiency questions, but also equity - who should pay and how much. There are a range of tests that aid decision makers here, and one method is appended.
17. Decisions on who pays for Surveillance and related response activities undertaken by industry or the government are complex and must be treated on a case by case basis. However, there are general principles that can be applied to determine whether the government should fund Surveillance activities and whether the costs should be borne by individuals, industry or sectors. These principles are further covered in Sections one and three of this report.

### **Surveillance and Response Case Studies**

18. To demonstrate the process of defining benefits and ranking projects we have developed a model that ranks projects according to NB/CC ratios and non-quantifiable criteria.
19. **The case studies have been based on actual examples where work has been done to quantify the Benefits and Costs of specific incursions. They are analysed through the Decision Making Framework, to better demonstrate the methodology being proposed. However, it is important to note that they are presented for illustrative purposes only and no other claim is made for the results.**

20. The assumptions used in the analysis of the case studies are:

- The benefits and costs are for both Surveillance and Response activities.
- The total pool of capital available for Surveillance and Response is limited.
- An incursion will occur in year one in each case. This is based on the assumption that, given that there is a pre-identified risk of an incursion, it is still not possible to predict whether such an incursion will occur in any given year. That in turn leads to a further assumption that the nature of Surveillance spending is akin to that of buying an insurance policy i.e. once you decide to do it, the cost is a fixed spend which is written off annually as a protection against risk, rather than accrued as an asset against which a direct return is expected.
- For simplicity a discount rate of 5 percent has been used. Some incursions straddle the commercial, government and ecological timeframes.
- Actual published data has been used. Where no data existed estimates have been made.
- For simplicity only Surveillance and Response have been considered. In practice the wider issue is Biosecurity, and the consideration and strategy for Pre-border, and Border will impact on the Surveillance and Response decision making process.
- The model allows for weighting of the value of Surveillance programmes by input of the probability of an incursion occurring, where that information is available. In order to do that, a comprehensive risk analysis must first have been done. Because such risk analyses have typically not been performed for most existing Surveillance programmes and, rather, an empirical decision has been made that there is sufficient risk to warrant a Surveillance programme being undertaken, in these situations a precautionary approach has been adopted - whereby the probability of an incursion has been set at 1.0.

### **Application of the Decision Making Framework**

#### **Examining the returns on investment for different Surveillance scenarios**

21. In order to show the returns on investment for various Surveillance and Response scenarios for a specific pest or disease we have assumed that there is in fact an incursion.

Further we have assumed that this incursion occurs in year one, that there is only one incursion over a 10-year period, that a response will be mounted and that it will achieve its stated objectives.

We have examined (where information has been available) a range of pests and diseases as well as a container pathway and looked at various scenarios for each. These scenarios show a range of Surveillance and related Response expenditure for each pest/disease or pathway. In reality there will be many more pests and diseases and further scenarios for each to be assessed and the difference in value (NPV) will be much closer than in the examples shown. We have made assumptions in the various case studies, particularly in the case of the non-quantitative assessment. In practice this would be undertaken by “a consistent team of experienced people” (a panel of experts).

### **Quantitative Analysis**

22. Using existing information available for the selected pest, disease or pathway we have constructed case studies and cashflows to allow the NPV of a Surveillance and related response programme to be calculated. Using the NPV, we are able to rank the scenarios, showing those that provide the greatest benefit to New Zealand.

The following Chart One shows the various scenarios for each pest, disease or pathway ranked according to NPV.

**Chart One**

<b>QUANTITATIVE ANALYSIS</b>	
Ranking based on NPV (\$ million)	
<b>Pest/ scenario</b>	<b>Net Benefit</b>
Disease C S1	\$ 191,161
Disease C S2	\$ 190,677
Disease C S3	\$ 187,621
Container pathway S1	\$ 10,024
Container pathway S2	\$ 9,566
Pest B S1	\$ 9,192
Pest B S2	\$ 8,561
Pest D S1	\$ 68
Pest D S2	\$ 66
Pest A S1	\$ 25
Pest A S2	\$ 10

**Interpreting the results**

23. The above table shows the various scenarios. Where there is no constraint on funding for Surveillance and Response, the scenario with the highest NPV should be pursued. The shaded scenarios in the table represent those that would not be pursued where there is no constraint on funding.
24. If capital available to spend on Surveillance and Response is limited, the scenarios should be ranked according to Net Benefit/Capital Cost (NB/CC) and funding applied to pests and diseases in order of ranking. Capital cost includes the cost of Surveillance and Response as the benefit is attributed to these two inputs jointly.
25. If we rank the results shown in the above table according to NPV the pest or disease likely to cause the greatest loss is going to rank highest. This is a result of the fact that we have assumed all have an equal chance of occurring.

26. If we rank the projects according to NB/CC and assume that the scenario with the highest NB/CC ratio is selected for each pest, disease or pathway we would select the unshaded scenarios shown in the following Chart Two.

**Chart Two**

<b>QUANTITATIVE ANALYSIS</b>				
Ranking based on Net Benefit to Capital Cost ratio				
(\$ million)				
<b>Pest/ scenario</b>	<b>Net Benefit</b>	<b>NB/Capital Cost</b>	<b>Annual surveillance cost</b>	<b>Cumulated annual surveillance cost</b>
<b>Disease C S1</b>	\$ 191,161.0	1679.0	\$ 2.4	\$ 2.4
<b>Disease C S2</b>	\$ 190,677.0	1220.0	\$ 1.2	
<b>Pest B S1</b>	\$ 9,192.0	736.0	\$ 1.0	\$ 3.4
<b>Container pathway S1</b>	\$ 10,024.0	470.9	\$ 0.03	\$ 3.43
<b>Disease C S3</b>	\$ 187,621.0	428.0	\$ 0.8	
<b>Pest B S2</b>	\$ 8,561.0	88.0	\$ 0.2	
<b>Container pathway S2</b>	\$ 9,566.2	46.8	\$ 0.025	
<b>Pest D S1</b>	\$ 68.0	13.8	\$ 0.3	\$ 3.72
<b>Pest D S2</b>	\$ 66.0	13.0	\$ 0.2	
<b>Pest A S2</b>	\$ 10.0	1.2	\$ 0.1	\$ 3.82
<b>Pest A S1</b>	\$ 25.0	1.0	\$ 0.6	

27. Assuming we have a budget for Surveillance of \$3.75m and based on the quantitative analysis only we would undertake a Surveillance programme for Disease C, Pest B, container pathway S1 and Pest D, which best utilises the available \$3.75 million. A programme for Pest A would be excluded due to insufficient funding.

**Non quantitative analysis**

28. The next step in the framework is to assess the non-quantitative factors. Non quantitative analysis has been conducted for each pest and disease using the methodology proposed.

Weightings for the various factors included in this analysis have been determined through a Delphi survey of industry experts. Full details of the calculation of the non-quantitative scores are included in Section Four. The same scenarios examined under the quantitative analysis are shown, ranked according to their non-quantitative score.

When considering the scores for each pest, disease or pathway we need to be mindful that a lower score reflects a lower non-quantifiable impact.

**Chart Three**

<b>NON-QUANTITATIVE ANALYSIS</b>			
Ranking based on weighted score			
	Weighted Score	Ranking	Quantitative ranking of preferred scenario
<b>Disease C S3</b>	37.4	1	
<b>Pest B S2</b>	35.9	2	
<b>Disease C S2</b>	29.9	3	
<b>Disease C S1</b>	24.7	4	1
<b>Pest B S1</b>	24.0	5	2
<b>Pest A S2</b>	20.9	6	5
<b>Container pathway S2</b>	18.4	7	
<b>Pest A S1</b>	15.3	8	
<b>Pest D S2</b>	14.7	9	
<b>Container pathway S1</b>	11.5	10	3
<b>Pest D S1</b>	10.0	11	4

29. The non-quantitative score rises with the lower Surveillance scenarios within each pest. This reflects the higher non-quantifiable impact of each pest or disease where detection is slower through lower Surveillance. The non-quantitative scores are of limited use when considering scenarios within a pest or disease. They do however provide an assessment of the non quantitative impact between pests and diseases which provides the ranking above. To recap, based on the scores under the quantitative analysis we have already excluded the shaded scenarios.

### Combining the analyses

30. The quantitative and non-quantitative analyses can then be combined and decisions made on the final ranking.

Where a ranking is changed based on the non-quantitative analysis, the cost of doing this is equal to the NPV of any projects displaced. A summary of the rankings using both the quantitative and non-quantitative analyses is shown below in chart four.

31. If the panel of experts assume for the purposes of this example that the strength of the non-quantitative score for Pest A scenario 2 is sufficient to select it in preference to Pest D scenario 1 (i.e. assume that the non quantifiable value of having a Surveillance and Response programme for Pest A is greater than NPV \$57.5 million – the benefit forgone from excluding Pest D) then one must alter the ranking of projects to be as follows.

**Chart Four**

<b>COMBINED ANALYSIS</b>					
Combined ranking based on both analyses					
(\$ million)					
	Quantitative Ranking	Non-quantitative Ranking	Ranking Selected	Annual surveillance cost	Cumulated annual surveillance cost
Disease C S1	1	1	1	\$ 2.4	\$ 2.4
Pest B S1	2	2	2	\$ 1.0	\$ 3.4
Container pathway S1	3	4	3	\$ 0.03	\$ 3.43
Pest A S2	5	3	4	\$ 0.1	\$ 3.53
Pest D S1	4	5	5	\$ 0.3	\$ 3.82

32. This means that if the total budget available is again \$3.75 million one would fund programmes for Disease C, Pest B, the container pathway and Pest A. That is, as a result of incorporating the non-quantitative factors, Pest D is now excluded, Pest A taking its place.

### Selecting alternative scenarios for a Pest, Disease or Pathway

33. Once the ranking has been finalised taking account of both quantitative and non-quantitative analysis the selected scenario for each project may be changed to allow inclusion of those that are unable to be undertaken as a result of budget constraints.

34. Using the example provided, the panel of experts may have eliminated Pest D from the selected projects to undertake.
35. If however it is considered that Pest D should still be included, then a less than optimal scenario for one of the programmes (already selected) can be considered, where the reduction in budgeted annual Surveillance cost will cover the cost of including the additional programme (in doing this the higher Response cost must also be considered).
36. Using the example the expert panel could include Pest D if scenario 2 for Pest B is used. Scenario 2 for pest B has an NPV that is \$648m lower than the preferred scenario 1. The cost of including Pest D is therefore this forgone benefit, less the value received from including Pest D.

This is demonstrated in the following table:

Scenario	\$m NPV
Pest B original scenario selected	\$ 736
Pest B revised scenario selected	\$ 88
Reduction in benefit	\$ 648
Less benefit of including Pest D scenario	\$ 69
Cost of including Pest D	\$ 579

37. This process is somewhat simplistic in that it assumes a certain cost of Surveillance and related Response for each scenario. There is an assumption that either scenario 1 or scenario 2 is selected and there is no scenario at a point between these two, which in practice there often will be.
38. The process outlined above is an iterative one and given a wider range of pests and disease it may take several iterations to select the required mix to be included in an overall portfolio of Surveillance programmes.

### **Finalising the selection**

39. The above selection of pests and diseases for which a Surveillance programme is to be undertaken is based on the overall return on capital invested in Surveillance and Response. Therefore, in selecting the scenarios the expert panel must take into account the cost of Response. Selecting a Surveillance programme for a pest or disease will make an assumption that a certain level of Response is possible. Selecting scenarios for Surveillance must therefore always be conducted in conjunction with determining the expected Response spending required.

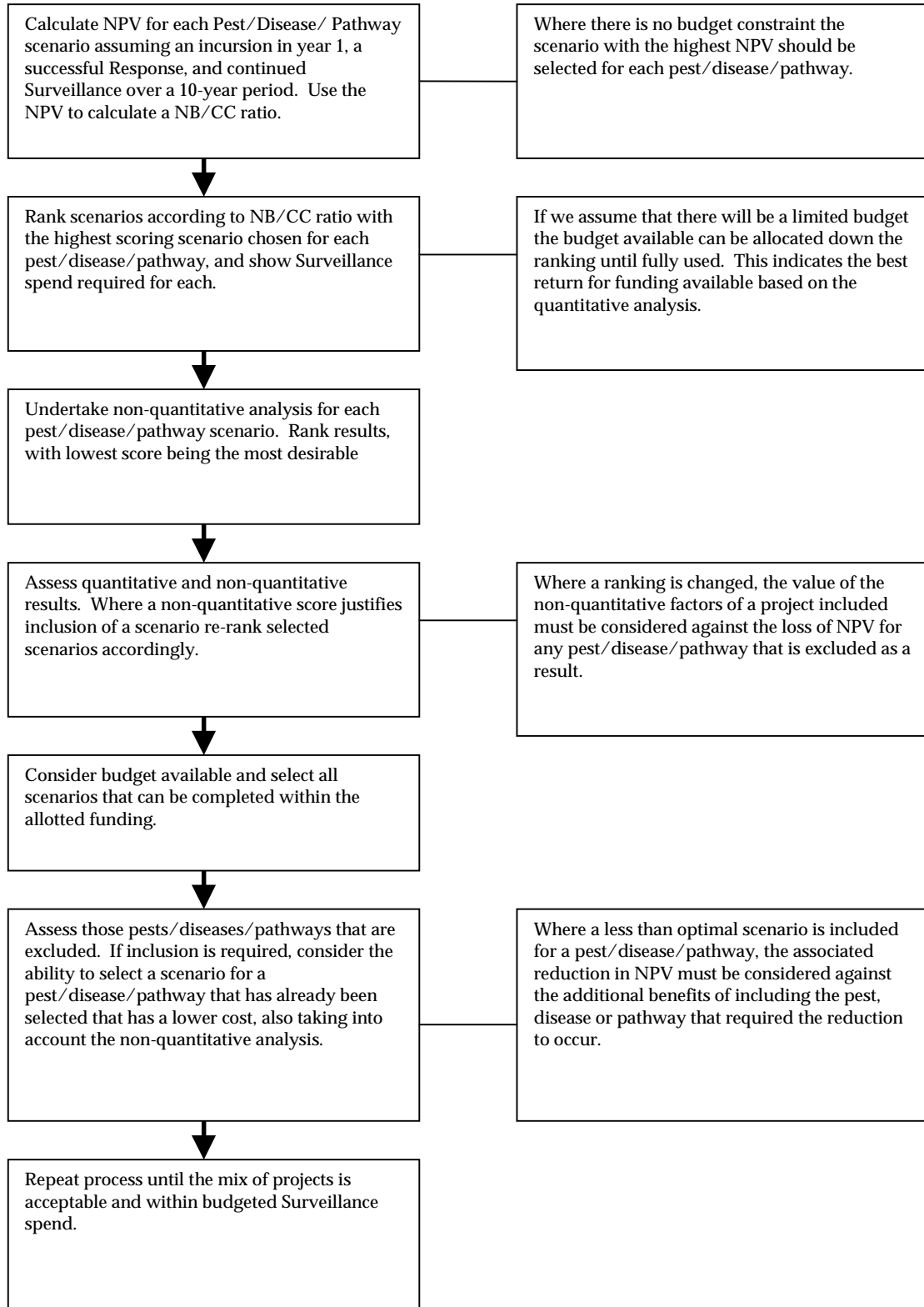
Likewise the level of Border and Pre-Border activity will need to have been considered prior to the decision on Surveillance spend.

In other words, to optimise the total level of Biosecurity spending, decisions need to be made about what components of a particular risk can be and should be managed at what point in the Biosecurity process.

40. The above methodology, however provides an example of how the benefits of Surveillance can be calculated and decisions made on Surveillance spending when all other factors remain constant.

## Summarising the process

41. To summarise the process outlined above, the following table has been constructed.



## Section One

### Efficient resource allocation to Surveillance

In order to optimise resource allocation to Surveillance, resource allocation to the total Biosecurity area needs to be considered as a whole. The reason for this is that decisions on options taken in one part of Biosecurity are usually not mutually independent of decisions taken on options in another part. For example, strict Pre-Border controls may reduce the need for additional expenditure on Border Control, Surveillance and Response.

### **Increased Surveillance is likely to reduce expenditure on response if additional Surveillance results in earlier detection than otherwise.**

New Zealand's Biosecurity system comprises four main components:

- Pre-Border
- Border
- **Surveillance** and
- Response.

Often, Surveillance, which includes monitoring existing pests and diseases, is overlooked and in some areas it has had a declining share of Biosecurity resources as budgetary cuts have sliced deeper. Out of total MAF Biosecurity budget of \$80 million, Surveillance accounts for approx. \$5-10 million.

From an economic theory viewpoint total resources to Biosecurity will be allocated efficiently when the marginal cost of the last dollar allocated equates with the marginal benefit derived from that expenditure. Similarly for each component, resources will be allocated efficiently to pre-border when the marginal cost of the last dollar allocated equates with the marginal revenue derived from that expenditure in pre-border control, and so on for border, Surveillance and response. When marginal cost equals marginal revenue for each component then resource allocation to the overall Biosecurity system will be optimised.

When setting priorities, money should be allocated to those options that give the highest return or greatest net benefit. Money should continue to be allocated until the benefit from the last dollar spent equals the cost. In practice the determination of the optimal involves complex trade-offs between the various components and decisions are not easy to make. When selecting projects based on economics, the Net Present Value (NPV) is appropriate to determine which projects to fund. Any project that has a positive NPV should be funded.

However, where there is a capital constraint, resources are allocated efficiently when projects are ranked using the net benefit (NB) to capital cost (CC) ratio (NB/CC). The project with the highest benefit cost ratio is undertaken first and the project with the second highest ratio is undertaken second and so on until all the capital allocated is used up. No further money should be spent if the net benefit to capital cost ratio for a project is negative. This ensures that the limited capital available is used most efficiently.

In an ideal world, to allocate resources efficiently all the projects that could be undertaken in the Biosecurity area would be evaluated and the net benefits determined for each. Simultaneously, projects within components of Biosecurity would be ranked and adjustments made between components until all capital is allocated such that marginal revenue minus marginal costs are zero across the whole Biosecurity area. This would determine how much would be spent on each component (such as Surveillance) in comparison with other components of Biosecurity and which projects within components would be funded.

The table below summarises this concept.

**An economic framework for efficient resource allocation to Biosecurity**

<b>Biosecurity</b>			
<b>Pre-border</b>	<b>Border</b>	<b>Surveillance</b>	<b>Response</b>
(MR-MC=0)	(MR-MC=0)	<b>(MR-MC=0)</b>	(MR-MC=0)
Rank Projects from high to low	Rank Projects from high to low	<b>Rank Projects from high to low</b>	Rank Projects from high to low
NB/CC >= 0	NB/CC >= 0	<b>NB/CC &gt;= 0</b>	NB/CC >= 0

MR Marginal Revenue  
 MC Marginal Cost  
 NB Net Benefits (Benefits - Costs)  
 CC Capital Costs

In reality, the process is never so clear cut:

- There is likely to be a high shared cost element for Surveillance so that the marginal cost for one new pest or programme may be quite low. For example, a sector group may already be monitoring the site for a number of reasons.
- Difficulties of timing and measurement mean that estimates and approximations may need to be made in order to make decisions
- Costs and benefits between components are often interdependent and decisions on allocation for one component will affect another
- Some benefits and costs are more readily quantifiable than others are so a combination of economic tools may be required to help decision making
- There are other objectives besides maximising dollar returns that need to be taken into account
- In practice these non-profit objectives, such as equity of distribution of benefits and sharing of costs, often require society to reach a consensus through debate. The final arbitrators are politicians who make the decisions based on their judgement of the national interest.

Despite these difficulties, the economic framework does guide us on what we should be attempting to achieve. In practice the approach is to first allocate resources to each pest/disease or pathway in an optimal way and then look at the overall optimisation to Biosecurity.

While it is possible to look at Surveillance in isolation, this can only apply in the case where other areas are taken as a given. Thus for a given Biosecurity outcome the net return from a marginal dollar in Surveillance is the change in the cost of response. This will not, however, tell us we have reached an optimal level of Surveillance. In order to do that, because of interdependence, we need to consider all areas of the Biosecurity spend together.

Having established the economic framework, the next issue is the decision making process that ensures society maximises benefit from Surveillance activities.

## Section Two

### The decision making process

The decision making process involves breaking a complex problem into a series of steps as follows:

- Defining objectives  
Objectives should be specific and measurable. For example, the **high level objective of Surveillance** could be:  
“to devote the appropriate level of resources to minimise the costs of unwanted pests and diseases and mitigate their impact if they are introduced”
- Identifying options for achieving the objectives
  - Options should be finite.
    - They should take into account the allocation of rights between interest groups and transaction costs
- Defining the criteria for choosing between options
  - Criteria should be measurable, at least to the extent that it is possible to assess how an option could perform in relation to a criterion
- Analysing the options
  - Analysis requires tools such as Cost Benefit Analysis (CBA) and Multi Criteria Analysis (MCA). A focus on marginal costs (rather than total cost) is a key element here
- Feedback to learn from the experience
  - Feedback is important so that we can learn from the experience of the past.
- Making decisions on funding
  - Choice of who pays involves judgement and relies not only on the output of analysis like CBA but includes consideration of transaction cost, equity distribution and political considerations

Our focus is on determining efficient economic resource allocation and setting priorities for expenditure for Surveillance. A major difficulty is in measuring costs and benefits. This is the area we turn to next.

## Tools for analysing costs and benefits

Our experience is that estimating costs is often relatively simple, but estimating benefits can be very difficult, particularly when social and environmental impacts are considered.

We can categorise the range of different types of impacts where Surveillance is required as follows:

Range of Impacts	Example
Tradeable goods	Foot and Mouth Disease
Indigenous ecosystems	Kiwi habitat
Maori concerns	Native trout protected
Amenity	Rainbow trout
Human health	Exotic mosquitos - increased disease
Lifestyle/social benefits	Fire ants - not able to enjoy a public place.

Economists have a range of tools that can be used to measure benefits and costs. Each of these tools has strengths and weaknesses and no one tool is universally accepted as providing the whole answer. Also, the rigour and depth of analysis can vary widely from analyst to analyst and project to project. It is this aspect that causes greatest concern as often comparisons are made from different bases and different assumptions, that is, like is not compared with like. **Therefore applying the tools consistently is very important.**

## Cost Benefit Analysis

In practice, Cost Benefit Analysis (CBA) is the tool used most widely. The attributes of CBA that make it attractive as a tool are that:

- It takes into account the benefits and costs faced by society
- It values impacts in terms of a single and familiar item – money
- It shows whether the impact on society is more beneficial compared with not undertaking the option (with minus without)
- Money values are used to weight the importance of different impacts based on peoples' preferences as established through market prices (willingness to pay).

CBA also has limitations:

- Relevant data to quantify benefits and costs may not be available or too expensive to collect
- Some impacts are not readily quantifiable in monetary terms eg societal values
- There are technical difficulties like the choice of discount rate
- In general CBA does not take into account interactions between different impacts, e.g. a combination of social and environmental costs may have a greater negative impact than adding them separately.

## Section three

### Allocating Accountability

Various groups have potential responsibility and accountability in Biosecurity and Surveillance (including industry and other interest groups that are not so easily defined). The case for government intervention in Surveillance is based on the concept of common good and the government taking responsibility on behalf of tax payers. This accepts that the market alone cannot make decisions that result in the optimal allocation of resources. This is because there are externalities and spill overs from decisions made by individuals in the private sector. In addition, because of the nature of Surveillance there is the possibility of "free riders" - those people or groups who resist paying their fair share of the cost on the basis that others will pay for them.

In order to maximise the benefit from government intervention there needs to be an analysis of options to ensure transaction costs are minimised and resources are allocated efficiently. This analysis should address not only efficiency questions, but also equity. Who should pay and how much - how much should individuals or industry groups pay for the private benefit they receive and how much should general taxation be used to pay for the public good.

Wilkinson (2001) has proposed a schema containing the principles government should apply when considering the imposition of a new law or regulation. A slightly modified version of Wilkinson's test that could be applied to a proposed government intervention on Surveillance has been proposed and is included as Appendix 2.

#### *Framework for assessing whether regulation is required for Biosecurity*

Regulations are likely to be satisfactory if:

- The problem that is being addressed is clear
- The paramount objective is clear where there are conflicting objectives
- They take adequate account of problem areas such as the difficulties of limited information, regulatory bias, interest group capture and loss of consumer choice
- They adequately consider alternative options
- The criteria for choosing between options are efficient.

Credit Suisse First Boston (CSFB, 1998) in an analysis of regulation in the food and beverage industry take the view economic efficiency should be the primary criterion for assessing regulation options. We consider this is appropriate for Surveillance regulation in the tradeable goods sector. This approach asks which option is best at allocating scarce resources to the chosen objectives and involves the comparison of costs and benefits. It assumes that costs and benefits can be quantified with reasonable precision and objectivity. Where this is not so, such as in the case of issues like protecting the environment for future generations, lifestyle, cultural or human health benefits, then judgement is required about the probabilities of outcomes that are difficult to quantify or uncertain, and society's views need to be taken into account regarding the level of risk that is acceptable.

Under the approach outlined by Wilkinson [refer Appendix] the distribution of benefits and costs is a secondary consideration to economic efficiency. Efficiency is about ensuring society as a whole is better off. Distribution is concerned about the government's use of tax and welfare policies to achieve equitable outcomes. In other words, how the costs and benefits are shared out between various stakeholders such as industry and other interest groups including society as a whole.

The first step in assessing whether regulation is required is to determine the problem that the intervention seeks to address. Once this is known it becomes much easier to define the alternative options that could be applied to address the problem.

Government intervention in Surveillance may be justified on the basis of market failure. This has diverse sources, which can be categorised as follows:

- Externalities - where an individual's behaviour can impose costs or benefits on another party that is outside the particular contractual agreement (an individual brings plant material into New Zealand that can harbour exotic diseases affecting a whole industry)
- Outputs are public goods - where one person's consumption does not affect another person's consumption and where non-paying users can 'free ride' or not be excluded from consumption (surveys to monitor pest status e.g. fruit fly surveys around ports of entry)
- Uncertainties exist over information about the product (the possible introduction of an unknown pest or disease)
- Where individuals or groups may over-react or under-react to perceived risks (the identification of a new type of ant that could be benign or extremely aggressive).

In different situations these problems arise to varying degrees and the market may or may not solve them adequately. A pertinent question is whether government intervention will improve the situation and there is no guarantee that it will. This question is important as there are many instances where government intervention has led to a loss of net national benefit. This is referred to as 'government failure'.

The process of assessing Surveillance options should compare the costs and benefits of likely market failure with likely government failure.

### **Who should pay?**

Decisions on funding of Surveillance depend on the criteria chosen, in this case, efficiency or equity (CSFB op cit) i.e. is it more important to decide how to make the cake bigger or how to divide the cake up?

Using the efficiency criterion aims at maximising the net benefits to society from the application of scarce resources through modifying the actions of individuals. Under this criterion government should charge the marginal cost of Surveillance to industry for services that are provided solely for the benefit of the purchasers of the industry's products. When Surveillance is provided in whole or part for non-users of the industry's products then transaction costs become an issue and funding from general taxation may be the most efficient option.

An alternative, which has equity as its main concern, is referred to as the benefit standard. This approach seeks to apportion the costs of Surveillance to the user i.e. user pays. However, if the costs of Surveillance do not equal the benefits then this may result in an unequal distribution of the net benefit. In addition, the benefit standard makes no distinction about the equality of cost imposition. And thus the application of the principle may not result in a move to more equality of wealth distribution. The benefit standard does not handle common costs well and decisions still need to be made about how these should be apportioned among the ultimate beneficiaries. It is our view that the benefit standard is not generally applicable to Surveillance because of these factors.

When there is a significant element of public good the decision on who should pay for Surveillance is not so clear cut. A number of options are possible:

- Industry determines the funding it is prepared to contribute to Surveillance and contracts with government for the supply of services
- Government determines the level of Surveillance and charges a levy on industry

- Government funds Surveillance from general taxation
- A combination of these.

The option chosen depends on a number of complex considerations including:

- The likelihood of industry members free-riding if Surveillance levies are voluntary
- The dead-weight cost of taxation if a higher level of Surveillance is provided than is optimal
- The efficiency of mandatory charges on individuals for Surveillance
- The level of organisation of the industry and therefore the ability to recover Surveillance charges from members
- The ability of industry to affect the level of output if it does not pay the cost of Surveillance
- The likelihood that the industry would lobby for excess levels of Surveillance if it did not bear the cost
- The extent to which Surveillance for one pest or disease that impact on one interest group may provide protection against another pest or disease that impacts on another interest group
- The nature of the Surveillance – public versus private

If there is a high element of public good in the Surveillance option chosen (i.e. no rivalry in consumption and exclusion is costly) then funding should be through general taxation. Examples of public goods include policy advice on Surveillance, policing of the Surveillance intervention and international negotiation. Otherwise, options should be determined on a case-by-case basis (CSFB op cit). This is particularly so for the tradeable goods sector.

Preferred arrangements for Surveillance are likely to involve a combination of:

- Taxation funding of public good Surveillance in a way that least distorts behaviour and provides the production of the optimal amount of Surveillance at minimal cost
- Charging the marginal cost of Surveillance services to industry groups where there is a well organised group of beneficiaries. This assumes that the industry group has a better incentive or ability to determine the optimal level of expenditure on Surveillance than the government and thus meets the efficiency criterion.
- Fines imposed for breaches of standards. e.g. failure to report notifiable diseases.

The tests are summarised below:

## Who should pay for Surveillance?

<b>Charge industry at marginal cost</b>	←	→	<b>Provide service through general taxation at least cost and least distortion</b>
	Exclusion costly?		
	No	Yes	
	Likelihood of free-riding?		
	Low	High	
	Dead-weight of taxation?		
	High	Low	
	Efficiency of mandatory charging?		
	High	Low	
	Organisation of industry?		
	High	Low	
	Ability of industry to affect output?		
	Low	High	
	Lobbying power of industry?		
	Low	High	
	Impact on different interest groups?		
Low	High		
Nature of service?			
Private	Public		

The overall process is summarised in the Surveillance Decision Making flow chart at the end of section four of this report.

## Conclusions

We favour efficiency criteria as the basis for decisions on resource allocation to Surveillance. This includes the use of both quantitative (CBA) and non-quantitative criteria (MCA) to assist decision-makers. Net benefit maximisation is the primary criterion and CBA is used to rank options where benefits and costs can be quantified. Where benefits and costs cannot be quantified then MCA is used. A comparison of ranks allows decision-makers to decide on a final rank. On the basis of MCA the opportunity cost of the change is the reduction in NPV due to the change.

While we believe it is not possible to determine the optimal allocation of resources to Surveillance in isolation from other components of Biosecurity because of the dependency between components, taking other components as “given” allows us to focus on Surveillance.

Decisions on who pays for Surveillance activities undertaken by the government are complex and must be treated on a case by case basis. However, there are principles that can be applied to determine whether the government should fund Surveillance activities and whether the costs should be borne by individuals, industry or be funded from general taxation. These principles are further elaborated on in the Funding Section of this report.

## Section four

### Case Studies : Quantitative and Non-Quantitative Analysis

To demonstrate the process of defining benefits and ranking projects we have examined 4 individual pests and diseases along with a container pathway covering the following categories:

- virulent insect pest
- destructive horticultural insect pest
- contagious virus affecting livestock
- invasive marine weed
- container pathway importing machinery parts

In order to calculate the NPV of each pest/disease/pathway scenario the likely impact of an incursion given a range of Surveillance and related Response scenarios was determined using researched data where possible. Having established the impact and cost of a Surveillance and Response programme at varying levels of tolerance, some base assumptions were made. These included an assumption that an incursion would occur in year 1, a successful response and ongoing Surveillance over a 10-year period. Using a discount rate of 5%, Net Present Values (NPV's) were calculated to arrive at the overall cost of Surveillance, response and impact over the period.

For a pathway to be included, an assessment of the cost of unwanted pests or diseases that may be introduced this way must be included. For the example container pathway used, we have assumed there are 3 significant pests most likely to be introduced.

To allow consistency with the pests/diseases examined we have assumed that there will be an incursion in year 1 and an associated response. We have made an assumption of the relative probability of an incursion of each pest and used a weighted cost of the cumulative impact and response based on this.

When considering a pathway that includes specific pests where Surveillance options for these pests are also being considered, care needs to be taken not to double count the costs of impact and therefore, the benefits to Surveillance and Response. In such a case, the benefits of preventing an incursion need to be split between the pathway and specific pest programmes.

Having determined the quantitative NPV, the impact on non-quantitative factors were then addressed using 6 criteria with weightings apportioned using a 'Delphi' process. Weighted scores for each scenario for each pest/disease/pathway emerged from this multi-criteria analysis process. These scores were then ranked according to their overall impact.

A preferred scenario then emerged for each pest/disease/pathway and this was then taken and compared with the remaining scenarios to provide an overall ranking of the scenarios under a budget constraint.

The case studies with associated NPV's follow:

## **Pest A – Virulent insect pest**

### **1. Objective(s) of Surveillance**

The objective of Surveillance is to establish the extent of the spread of Pest A and then undertake either eradication or containment in comparison to local control only.

#### *Description of Pest/Disease*

Pest A is an insect pest acting as a vector for the likely introduction of one or more viral human health disease(s).

#### *Current Status*

The vector Pest A was first identified in late 1998 in a region on the east coast of the North Island in localised populations. The pest was not carrying the disease and there are no signs of the disease as yet.

#### *Assessment of Risk*

Without eradication or control the pest is likely to spread to Auckland and North Auckland and then to Canterbury, the three main urban areas with suitable pest habitats.

An incursion of the pest carrying the disease is assumed to occur in 2002. Surveillance followed by eradication slows the spread and delays reintroduction for 5 years. In one scenario, an active Surveillance programme allows for initial eradication of the pest which is followed by another cycle of incursion and eradication 5 years later.

Another scenario has low Surveillance outside the known endemic area(s) and a containment policy resulting in the lowering of the impact by 25%.

Contributing factors are increasing trade from endemic areas which may result in goods arriving that harbour Pest A and increasing numbers of tourists from endemic areas who may be carriers of the disease.

### **2. Options for Surveillance**

Under uncontrolled conditions three possible intensity of disease scenarios are considered: High, Medium and Low infection, under two Surveillance scenarios. Assumed low level pest introduction causes a low level of residual disease cases. Pre-border and border Surveillance as given.

1. High intensive Surveillance of Pest A before and after eradication programme including public relations and education.

2. Low Surveillance outside the known infected area under a containment scenario with public relations and education followed by local control.

Containment assumes efforts are made to ensure the pest carrying the disease is contained within the region. Local control is the treatment of the specific diseased pest outbreak in the local infected area.

### 3. Criteria & Analysis

#### Quantifiable Costs and Benefits of Surveillance

*(discount rate 5%, impact assessed over 10 years)*

<b>Base Case</b> – Diseased pest becomes endemic; local pest control only as and when required (as indicated by virus cycles in human population)	
Total Cost – Medical/work/nuisance/environment	NPV \$72.7 m

<b>Scenario 1</b> – eradication followed by 2 years of intensive monitoring	
Estimated Surveillance costs:	\$ 0.6m pa
Estimated cost of response	NPV \$24.6 m
Total Cost : Surveillance/response/medical/work/nuisance/ environment	NPV \$47.6 m

<b>Scenario 2</b> – containment for 2 years followed by local control within the area	
Estimated Surveillance costs:	\$0.1m pa
Estimated cost of response	NPV \$7.0 m
Total Cost : Surveillance/response/medical/work/nuisance/ environment	NPV \$54.5m

Scenario 1 is preferred as total costs are lowest compared with the Base Case and Scenario 2. Benefits of Surveillance are the slow down in spread of disease, or in the case of Scenario 1, elimination of the threat for most of the period?, reduction in cost of treatment, reduction in cost of loss of work, reduction in nuisance costs and reduction in environmental costs.

*Non-quantifiable Impacts*

Criteria	Impacts	Score (out of 100)		
		B	S1	S2
Tradeable goods	Possible reduction in tourists to infected areas although this has not been documented in other countries	20	10	15
Indigenous ecosystems	Displacement of native insects in infected areas	20	10	15
Maori concerns	Use of wetlands and shore areas, relationship with ancestral waters and sites likely to be affected	20	10	15
Amenity	None known	0	0	0
Human Health	A human health disease that has significant health and considerable nuisance value	60	30	40
Lifestyle/social benefits	Significant impact to a small proportion of population and small impact to majority of population. Impacts on outdoor activities especially near fresh water and may require screening of houses and public buildings.	60	30	35

## Pest B – Destructive horticultural insect pest

### 1. Objective(s) of Surveillance

The early detection of pest B to trigger an appropriate response.

#### *Description of Pest/Disease*

Pest B – is one of the worlds most destructive horticultural pests. It is known to effect more than 250 different types of horticultural product. Left uncontrolled the pest would have a significant impact on the New Zealand horticulture industry. Control is possible through three methods. There are significant benefits from eradication.

#### *Current Status*

Pest B has been found in NZ once before and successfully eradicated. It is present in several countries overseas with whom NZ trades.

#### *Assessment of Risk*

Border controls reduce the risk of an incursion significantly. There is however a residual risk of accidental importation in goods or illegal importation of associated products.

Early detection of an incursion will provide the best chances of a successful eradication response and at least an opportunity to contain spread of the pest. Slowing spread of the pest has the potential has the ability to provide significant economic benefits.

### 2. Options for Surveillance

Active Surveillance has been undertaken since the first incursion was detected and much of this has been part of the response. Due to the nature of the pest, passive Surveillance levels are relatively high. Public awareness is therefore a key part of Surveillance for this pest.

### 3. Criteria & Analysis

Quantifiable Costs and Benefits of Surveillance

*(discount rate 5%, impact assessed over 10 years)*

<b>Base Case – No Surveillance, no control.</b>	
Total Cost – Medical/work/nuisance/environment	NPV \$9,266 m
<b>Scenario 1 – High Surveillance, quick response</b>	
Estimated Surveillance costs:	\$1.0m pa
Estimated cost of response	NPV \$5.0m
Total Cost : Surveillance/response/medical/work/nuisance/ environment	NPV \$74m

<b>Scenario 2 – Moderate Surveillance and response</b>	
Estimated Surveillance costs:	\$0.19m pa
Estimated cost of response	NPV \$100m
Total Cost : Surveillance/response/medical/work/nuisance/ environment	NPV \$705m

Scenario 1 is preferred as total costs are lowest compared with the Base case and Scenario 2. Benefits of high Surveillance are the rapid detection of the disease and the confinement of the disease to a very limited area, reduced eradication costs, reduction in cost of employment, reduction in economic impact, reduction in nuisance costs and reduction in environmental costs.

*Non-quantifiable Impacts*

Criteria	Impacts	Score (out of 100)		
		B	S1	S2
Tradeable goods	Likely to be significant costs to NZ and barriers to trade.	50	40	20
Indigenous ecosystems	Likely to have a significant impact on native NZ fruit and vegetable species	30	20	10
Maori concerns	Likely to be some minor concerns to Maori in relation to there traditional horticultural methods.	10	5	0
Amenity	Likely to be moderate impacts.	30	20	10
Human Health	None known.	0	0	0
Lifestyle/social benefits	Will impact on a small proportion of population.	10	5	0

## Disease C – Contagious virus affecting livestock

### 1. Objective of Surveillance

The early detection of disease C to trigger an appropriate response.

#### *Description of Disease*

Disease C – a disease with the potential to have a catastrophic economic and environmental impact in New Zealand. Disease C is a highly contagious virus that impacts on the health and productivity of livestock and can result in mortality. It can also threaten wildlife. Economic impacts are at the high level of any pest or disease and are centred predominantly on international trade with the consequences regarded as immediate and severe. The disease is not regarded as a threat to humans and infections are rare and of minor clinical significance.

#### *Current Status*

Disease C has never been found in New Zealand. Awareness of the importance of detecting the disease is high and Surveillance is carried out predominantly by livestock owners/handlers and veterinary practitioners.

#### *Assessment of Risk*

- *Number of incursions:* There have been no incursions to date. Strong pre-border and border controls combined with a high level of public awareness have helped prevent an incursion to date.
  
- *Risk of incursion by various means:*
- Airborne spread: negligible – some risk of spread within NZ if disease becomes established.
- Live animals: Negligible – NZ does not import from countries where disease C is present. Some risk from the illegal importation of live animals
- Genetic material: Negligible – NZ does not import from countries where disease C is present.
- Food products: Meat products from countries with disease C must be cooked. Milk products must be subject to UHT (Ultra High Treatment). Low risk from seepage of food products carried in personal luggage of visitors and/or mail. Generally, these products tend to be cooked/processed and of little risk. Illegal importation of uncooked food products is a risk.
- Carriage by humans: Current border controls ensure a remote risk of introduction via humans or their clothing.
- Animal hides/skins: Provided international processing standards are adhered to, the risk of introduction is considered negligible

## 2. Options for Surveillance

- Public education/awareness programmes to encourage ongoing passive Surveillance
- Survey of production units
- Surveillance around potential ports of entry
- Regulations preventing the consumption of by-products from the food service sectors being fed to livestock

Pre-border and border Surveillance is taken as given.

## 3. Criteria and Analysis

Quantifiable Costs and Benefits of Surveillance  
(discount rate 5%, impact assessed over 10 years)

<b>Base Case</b> – No Surveillance, no control	
Total Cost – Medical/work/nuisance/environment	NPV \$193,043 m

<b>Scenario 1</b> – High Surveillance, quick response	
Estimated Surveillance costs:	\$2.37m pa
Estimated cost of response	NPV \$103m
Total Cost : Surveillance/response/medical/work/nuisance/ environment	NPV \$1,827m

<b>Scenario 2</b> – Moderate Surveillance and response	
Estimated Surveillance costs:	\$1.18m pa
Estimated cost of response	NPV \$150.4m
Total Cost : Surveillance/response/medical/work/nuisance/ environment	NPV \$2,366m

<b>Scenario 3</b> – Low Surveillance and slow response	
Estimated Surveillance costs:	\$0.83m pa
Estimated cost of response	NPV \$450.4m
Total Cost : Surveillance/response/medical/work/nuisance/ environment	NPV \$5,422m

Scenario 1 is preferred as total costs are lowest compared with the Base Case and Scenarios 2 & 3. Benefits of high Surveillance are the rapid detection of the disease and the confinement of the disease to a very limited number of sites, reduction in the eradication cost, reduction in cost of employment, reduction in the economic impact, reduction in nuisance costs and reduction in environmental costs.

*Non-quantifiable Impacts*

Criteria	Impacts	Score (out of 100)			
		B	S1	S2	S3
Tradeable goods	There is likely to be significant impacts on trade via barriers to entry for some important markets, and in-bound tourism. Impact linked to timeframes for response	90	50	60	75
Indigenous ecosystems	Unlikely to have an impact on native species.	0	0	0	0
Maori concerns	Likely to be few concerns with the disease affecting exotic species only.	5	0	0	0
Amenity	Potential to be significant, having a large impact on a wide range of resources.	40	10	15	20
Human Health	There are no known human health impacts associated with the disease	0	0	0	0
Lifestyle/ social benefits	Will have a major impact on the lifestyles of those directly affected and those involved in or employed by the livestock industry. High social impact likely.	90	50	60	75

## Pest D – Invasive marine weed

### 1. Objective(s) of Surveillance

To slow the spread of the Pest D in New Zealand.

#### *Description of Pest/Disease*

Pest D is a highly invasive weed that arrived in New Zealand in the mid-1980s. The long-term impacts of Pest D on the marine environment are not well understood, although, it is known to change the structure of ecosystems, especially in areas where native seaweeds are absent. Other potential impacts include decreased recruitment of paua by displacement of native coralline algae (which influence paua settlement), displacement of native macroalgal (seaweed) communities, and decreased encrusting and sub-canopy sessile diversity.

#### *Current Status*

Pest D is present in NZ. It has proved to be well adapted to New Zealand conditions, particularly the cooler waters of the South Island and southern North Island. It is also present in the waters of several of our major trading partners.

#### *Assessment of Risk*

Pest D is well established in New Zealand and in several of its major trading partners. Controls are in place to reduce the spread. Early detection of an incursion will provide the best chances of restricting the spread of the weed. Slowing spread of the pest has the potential to provide significant economic benefits.

### 2. Options for Surveillance

1. Educating stakeholders and the general public to report the weed if it occurs in new areas
2. Site inspections at high-risk sites

### 3. Criteria & Analysis

Quantifiable Costs and Benefits of Surveillance

*(discount rate 5%, impact assessed over 10 years)*

<b>Base Case – No Surveillance, no control</b>	
Total Cost – Medical/work/nuisance/environment	NPV \$77.0 m

<b>Scenario 1 – High Surveillance, quick response</b>	
Estimated Surveillance costs:	\$0.292m pa
Estimated cost of response	NPV \$2.04m
Total Cost : Surveillance/response/medical/work/nuisance/ environment	NPV \$9.25m

<b>Scenario 2 – Moderate Surveillance and response</b>	
Estimated Surveillance costs:	\$0.203m pa
Estimated cost of response	NPV \$3.14m
Total Cost : Surveillance/response/medical/work/nuisance/ environment	NPV \$10.89m

Scenario 1 involves a greater level of inspection sites and a wider coverage of the awareness campaign. Scenario 1 is preferred as total costs are lowest compared with the Base case and Scenario 2. Benefits of high Surveillance are the rapid detection of the weed and confinement to a limited area, reduced eradication costs, reduction in cost of employment, reduction in economic impact, reduction in nuisance costs and reduction in environmental costs.

(Industry sources have been unable to quantify benefits however, have assumed that they are positive. For the purposes of this exercise we have assumed that net benefits to Surveillance equal the total cost giving a NB/CC equal to 1. Non-quantifiable benefits have been accounted for in the subjective assessment of Surveillance projects.).

*Non-quantifiable Impacts*

Criteria	Impacts	Score (out of 100)		
		B	S1	S2
Tradeable goods	Possible reduction in trade, although this has not been documented in other countries	20	10	15
Indigenous ecosystems	Serious displacement of native seaweeds in infected areas	50	20	30
Maori concerns	Use of coastal areas, relationship with ancestral waters and sites will be affected	30	20	25
Amenity	None known	0	0	0
Human Health	A low impact weed that has no real human health concerns.	0	0	0
Lifestyle/social benefits	Moderate impacts on outdoor activities especially coastal areas.	20	10	15

## Container Pathway

### 1. Objective(s) of Surveillance

To stop the establishment of Pests in New Zealand through this high risk pathway.

#### *Description of pest/disease/pathway*

The selected pathway involves the importing of forestry machinery (and parts) from North America to New Zealand. Once in New Zealand this machinery is distributed around various sites for use by the NZ forestry industry. Three pests have been identified as high risk in this pathway.

Pest 1. Is an insect pest with the potential to have a significant economic, environmental and social impact in New Zealand. Pest E1 can also cause death to humans and livestock. Economic impacts are potentially at the higher level of any pest or disease.

Pest 2. Is an insect pest with the potential to have a significant economic, environmental and social impact on New Zealand's forests through defoliation. The insect is not regarded as a threat to humans.

Pest 3. Is an insect pest, which causes damage to the inner bark of recently felled logs creating problems in export material. It has also been known to attack the root collar of seedlings. This pest could have a significant impact on New Zealand's forestry sector.

#### *Current Status*

Pest 1 has been found in NZ once before and successfully eradicated. It is present in several countries overseas with whom NZ trades. Pest 2 has been found in NZ previously and is in the process of being eradicated. Pest 3 is already established in parts of New Zealand however attempts are being made to control its spread.

#### *Assessment of Risk*

Existing border controls reduce the risk of an incursion significantly. There is however a residual risk of accidental importation in goods or illegal importation of associated products in this container pathway.

Early detection of an incursion will provide the best chances of a successful eradication response and at least an opportunity to contain spread of any of these pests. Slowing spread of the pests has the potential to provide significant economic benefits.

## 2. Options for Surveillance

1. Traps are operated at high-risk sites in areas with high levels of forest activity and in areas with forest significance.
2. Public education programmes are used to raise awareness.

## 3. Criteria & Analysis

### Quantifiable Costs and Benefits of Surveillance

(discount rate of 5%, impact assessed over 10 years).

<b>Base Case</b> – No surveillance, no control	
Total Cost – Medical/work/nuisance/environment	NPV \$10,077 m

<b>Scenario 1</b> – High surveillance, quick response	
Estimated Surveillance costs:	\$0.3m pa
Estimated cost of response	NPV \$21m
Total Cost : Surveillance/response/medical/work/nuisance/ environment	NPV \$31.4m

<b>Scenario 2</b> – Low Surveillance and delayed Response	
Estimated Surveillance costs:	\$0.03m pa
Estimated cost of Response	NPV \$204.5m
Total Cost : Surveillance/Response/medical/work/nuisance/ environment	NPV \$306.2m

Scenario 1 is preferred as total costs are lowest compared with the Base case and Scenario 2. Benefits of high surveillance are the rapid detection of the pests and the confinement of the pests to a very limited site, reduced eradication costs, reduction in cost of employment, reduction in economic impact, reduction in nuisance costs and reduction in environmental costs.

### *Non-quantifiable impacts*

Criteria	Impacts	Score (out of 100)		
		B	S1	S2
Tradeable goods	Likely to be significant costs to NZ and barriers to trade.	40	20	30
Indigenous ecosystems	Likely to have a impact on native NZ tree species.	20	10	15
Maori concerns	Likely to be some minor concerns to Maori.	5	0	0
Amenity	Likely to be moderate impacts.	30	10	20
Human Health	Some risk from 1 of the three pests.	15	5	10
Lifestyle/social benefits	Will impact on a small proportion of population.	15	5	10

<b>QUANTITATIVE ANALYSIS</b>										
Ranking based on Net Benefit to Capital Cost										
Using NPV's over 10 year time frame discounted at 5% (\$m)										
PEST scenario	10 years impact to NZ of incursion without surv. or response \$m	Assumed likelihood of incursion	10 year cost of surveillance	10 year cost of response	Total cost of surv. & response (C+D)	10 year impact to NZ with surv. &/or response	Difference in impact = Total Benefit (A-F)	Net Benefit (G-E)	NB/Capital Cost	
	A	B	C	D	E	F	G	H	I	
<b>Pest A base</b>	\$ 72.7	100%	\$ -	\$ -	\$ -	\$ 72.7	\$ -	\$ -		
<b>Pest A S1</b>	\$ 72.7	100%	\$ 3.5	\$ 21.5	\$ 25.0	\$ 22.6	\$ 50.0	\$ 25.0	1.0	
<b>Pest A S2</b>	\$ 72.7	100%	\$ 1.0	\$ 7.0	\$ 8.1	\$ 54.5	\$ 18.2	\$ 10.1	1.3	
<b>Pest B base</b>	\$ 9,266	100%	\$ -	\$ -	\$ -	\$ 9,266.0	\$ -	\$ -		
<b>Pest B S1</b>	\$ 9,266	100%	\$ 6.8	\$ 5.7	\$ 12.5	\$ 61.9	\$ 9,204.1	\$ 9,191.6	736.3	
<b>Pest B S2</b>	\$ 9,266	100%	\$ 1.9	\$ 95.4	\$ 97.3	\$ 607.6	\$ 8,658.4	\$ 8,561.0	87.9	
<b>Disease C base</b>	\$ 193,043	100%	\$ -	\$ -	\$ -	\$ 193,043	\$ -	\$ -		
<b>Disease C S1</b>	\$ 193,043	100%	\$ 16.0	\$ 97.8	\$ 113.9	\$ 1,767.6	\$ 191,275.4	\$ 191,161.5	1679.1	
<b>Disease C S2</b>	\$ 193,043	100%	\$ 12.0	\$ 144.3	\$ 156.3	\$ 2,209.5	\$ 190,833.5	\$ 190,677.1	1219.6	
<b>Disease C S3</b>	\$ 193,043	100%	\$ 8.4	\$ 429.7	\$ 438.1	\$ 4,983.9	\$ 188,059.1	\$ 187,621.0	428.2	
<b>Pest D base</b>	\$ 77	100%	\$ -	\$ -	\$ -	\$ 77	\$ -	\$ -		
<b>Pest D S1</b>	\$ 77	100%	\$ 2.9	\$ 2.0	\$ 4.9	\$ 4.3	\$ 72.7	\$ 67.8	13.8	
<b>Pest D S2</b>	\$ 77	100%	\$ 2.0	\$ 3.1	\$ 5.1	\$ 5.7	\$ 71.3	\$ 66.2	13.0	
<b>Container pathway base</b>	\$ 10,077	100%	\$ -	\$ -	\$ -	\$ 10,077	\$ -	\$ -		
<b>Pathway S1</b>	\$ 10,077	100%	\$ 0.3	\$ 21.0	\$ 21.3	\$ 31.4	\$ 10,045.6	\$ 10,024.3	470.9	
<b>Pathway S2</b>	\$ 10,077	100%	\$ 0.03	\$ 204.5	\$ 204.6	\$ 306.2	\$ 9,770.8	\$ 9,566.2	46.8	

Notes:  
S1 = Scenario 1 for the respective pest/disease

Summary of key conclusions of the Quantitative Analysis:

- Once a decision has been made to have a Surveillance and response programme then this model can then be used to identify the most beneficial scenario (using quantitative criteria), that should be selected for the respective pest/disease.
- For pest A the preferred scenario is S2 that for a response cost of \$7.0m a Net Benefit of \$10m would result in a Net Benefit to Capital Cost of 1.26 or for every \$1 spent a benefit of \$1.26 would result. This is preferable to S1 which has a Net Benefit of \$25m which is equal to the cost of Surveillance and response.
- For pest B the preferred scenario is S1 that delivers a Net Benefit of \$9,192m against a cost of \$12.5m, resulting in a NB/Capital Cost of 736.3 (for every \$1 spent there is a benefit of \$736.3)
- For disease C the preferred scenario is S1 that delivers a Net Benefit of \$191,162m against a cost of \$113.9m, resulting in a NB/Capital Cost of 1679.1 (for every \$1 spent under this scenario there is a benefit of \$1,679).
- For **pest D** the preferred scenario is S1 that delivers a Net Benefit of \$67.8m against a cost of \$5.1m, resulting in a NB/Capital Cost of 13.8 (for every \$1 spent under this scenario there is a benefit of \$13.80).
- For the **container pathway** the preferred scenario is S1 that delivers a Net Benefit of \$10,024m against a cost of \$21.3m, resulting in a NB/Capital Cost of 470.9 (for every \$1 spent under this scenario there is a benefit of \$470.90).

Non-quantitative criteria to be considered							
	Tradable Goods	Indigenous ecosystems	Maori Concerns	Amenity	Human Health	Lifestyle/Social	Weighted Score
	Weight						100%
	37%	19%	7%	7%	19%	11%	
<b>Pest A base</b>	20	20	20	0	60	60	30.6
<b>Pest A S1</b>	10	10	10	0	30	30	15.3
<b>Pest A S2</b>	15	15	15	0	40	35	20.9
<b>Pest B base</b>	80	70	70	0	60	50	64.7
<b>Pest B S1</b>	40	20	20	0	15	10	24.0
<b>Pest B S2</b>	50	40	40	0	25	20	35.9
<b>Disease C base</b>	90	0	5	40	0	90	46.4
<b>Disease C S1</b>	50	0	0	10	0	50	24.7
<b>Disease C S2</b>	60	0	0	15	0	60	29.9
<b>Disease C S3</b>	75	0	0	20	0	75	37.4
<b>Pest D base</b>	20	50	30	0	0	20	21.2
<b>Pest D S1</b>	10	20	20	0	0	10	10.0
<b>Pest D S2</b>	15	30	25	0	0	15	14.7
<b>Pathway E base</b>	40	20	5	30	15	15	25.6
<b>Pathway E S1</b>	20	10	0	10	5	5	11.5
<b>Pathway E S2</b>	30	15	0	20	10	10	18.4

Summary of key conclusions of the Non- Quantitative Analysis:

1. The consideration of non-quantitative criteria is consistent with the MCA (multi-criteria analysis) method.
2. The respective weightings apportioned to the 6 criteria in this example have emerged using a 'Delphi' process across a sample of interest groups. The weightings are indicative and should only be used to demonstrate the operation of the model.
3. The lowest score shows the least impact and is the preferred option In this example. It is assumed that the base case scenario for each pest will have a higher impact on the non-quantitative criteria than Surveillance and response programmes.
4. For **pest A** the least impact on non-quantitative criteria is achieved by S1 with S2 showing a 30% increased impact over S1. Using the quantitative criteria S2 emerged as the preferred option however this may/may not be offset by the disadvantages under the non-quantitative criteria. The result will be dependant on the overall weighting apportioned to non-quantitative criteria vs quantitative.
5. For **pest B** the preferred scenario is S1. The non-quantitative impact of S1 is 37% of that under a 'do nothing' base case.
6. For **disease C** the preferred scenario is again S1 with the non-quantitative impact minimised and approximately 50% of the level under a base case.
7. For **pest D** the preferred scenario is S1 for reasons outlined above
8. For the **container pathway**, the preferred scenario is S1. There are 3 pests assessed under this pathway and each will have its own non-quantitative impact relative to the other.

Summary Ranking by pest/disease/pathway					
		Net Benefit (NPV \$m)	Quantitative ranking (highest NPV)	Non- quantitative weighted score	Non- quantitative Ranking (lowest score = least impact)
<b>Disease C base</b>	Disease C – a disease with the potential to have a catastrophic economic and significant environmental impact in New Zealand.	\$ -	na	46.4	15
<b>Disease C S1</b>	Disease C with a high level of surveillance and quick response	\$ 191,161.5	1	24.7	9
<b>Disease C S2</b>	Disease C with a moderate level of surveillance and relatively quick response	\$ 190,677.1	2	29.9	11
<b>Disease C S3</b>	Disease C with a low level of surveillance, slow response and costly eradication	\$ 187,621.0	3	37.4	14
<b>Container Pathway base</b>	Container pathway for industrial goods for the timber industry. Assumed 3 + pests gain entry via this pathway. Significant economic and environmental impacts anticipated	\$ -	na	25.6	10
<b>Container Pathway S1</b>	Container pathway with an awareness programme and site inspections	\$ 10,024.3	4	11.5	2
<b>Container Pathway S2</b>	Container pathway with an awareness programme but no site inspections	\$ 9,566.2	5	18.4	5
<b>Pest B base</b>	Pest B – a high impact insect pest with the potential to have a significant economic, environmental and social cost to New Zealand.	\$ -	na	64.7	16
<b>Pest B S1</b>	Pest B with high surveillance and quick response	\$ 9,191.6	6	24.0	8
<b>Pest B S2</b>	Pest B with moderate surveillance and response	\$ 8,561.0	7	35.9	13
<b>Pest D base</b>	Pest D is a highly invasive weed with long-term implications for the marine environment.	\$ -	na	21.2	7
<b>Pest D S1</b>	Pest D is a highly invasive weed with long-term implications for the marine environment.	\$ 67.8	8	10.0	1
<b>Pest D S2</b>	Pest D is a highly invasive weed with long-term implications for the marine environment	\$ 66.2	9	14.7	3
<b>Pest A base</b>	Pest A is an insect pest acting as a vector for the likely introduction of a viral human health disease. No surveillance or response	\$ -	na	30.6	12
<b>Pest A S1</b>	Pest A with moderate surveillance, eradication but response cyclic	\$ 25.0	10	15.3	4
<b>Pest A S2</b>	Pest A with low surveillance, containment for 2 years then a reliance on local control	\$ 10.1	11	20.9	6

Comment:

1. **Disease C:** S1 is the preferred option under both quantitative and non-quantitative criteria.

2. **Container pathway:** S1 is the preferred option under both quantitative and non-quantitative criteria

3. **Pest B:** S1 is the preferred option under both quantitative and non-quantitative criteria.

4. **Pest D:** S1 is the preferred option under both quantitative and non-quantitative criteria.

5. **Pest A:** The weighting attached to quantitative vs non-quantitative will determine whether the disadvantage under S2 non-quantitative is sufficient to overturn the preferred quantitative ranking.

## Surveillance Decision Making Flow Chart

### *Using a consistent team of experienced people*

<b>1) Define Objectives</b>			
	Define the specific problem		
	The need for Surveillance is pre-determined by Risk Assessment Does it justify government intervention?	→	Apply Regulation Test
<b>2) Identify Options for Surveillance</b>			
	What are the alternatives? Build scenarios for different options for Surveillance using 'what if' analysis e.g.: 1. Current industry practice 2. Government intervention 3. Enhanced industry & public activity	→	A mix of: Awareness Surveys Education Inspection Tests Data Recording
<b>3) Define Criteria</b> (How the options will be judged)			
	Adopt standard approach to Cost Benefit Analysis (CBA) including discount rate, timeframe etc, and standard Multi Criteria Analysis (MCA) matrix weights and scoring	→	1. Quantitative - NPV & NB/CC 2. Non-quantitative - MCA
<b>4) Analyse Options</b>			
	For each option compare 'with' Surveillance scenarios to 'without' (the Base Case of uncontrolled incursion). Rank Surveillance options for different pathways/pests/diseases	→	Compare CBA ranking with MCA ranking and make trade-offs
<b>5) Feed Back</b>			
	Iterative process with expert technical team reconstructing scenarios within options until convergence reached on best options		
<b>6) Make Funding Decisions</b>			
	Fund most efficient option, subject to technical, financial and political factors.  When Precautionary Principle adopted analysis collapses to least cost approach	→	1. Marginal cost to industry 2. Least cost and distortion through general taxation 3. Penalties

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## **APPENDIX ONE: Analysis tools**

### **Economic tools**

Cost benefit analysis has been widely used in aiding decision making in the agricultural sector since the late 1960s. MAF has been a leading exponent of CBA using the tool as an aid for decisions on land improvement (including irrigation, flood control and land use change), research and policy development (MAF, 1984). More recently, emphasis in developing the tool has focussed on valuing non-market benefits particularly for natural resource management projects. See Krausse et al (1999) for a recent review of non-market valuation in the New Zealand context. The CBA is routinely used for assisting decision-makers, with some controversy, in allocating resources to applied research. A further development to the CBA tool is the incorporation of risk analysis to improve the specification of future uncertain variables (Nimmo-Bell, 1999). MAF (2002a) has developed a methodology for managing the risks associated with importing live animals and products of animal origin using a similar risk analysis tool.

Mumford (1999) developed procedures for cost benefit analysis for national and regional pest management strategies, providing examples to illustrate the approach. MAF (2002b) endorses the use of CBA for the analysis of unwanted organism or pest response options. In MAF's view, CBA can contribute to public sector policy analysis not only in examining the effects of a proposed policy, but also in informing the choice of policy option and guiding the efficient allocation of limited resources.

### *Discount Rate*

There is no area that causes more debate with CBA than the discount rate. The issue is particularly fraught when different types of projects are being considered together or project lives have different lengths - as is the case with Surveillance.

The literature is relatively equivocal about commercial projects. Here the appropriate discount rate is the opportunity cost of capital and the rate is determined using the Capital Asset Pricing Model (CAPM) see Brealey and Myers (1988). Typical discount rates are in the vicinity of 8% real (after inflation), but vary according to the risk. Low risk projects such as in the utility sector have discount rates around 5% or lower and high risk projects such as computer software development have rates exceeding 15%.

In the public sector, Treasury has long required a 10% discount rate hurdle to justify spending taxpayers' money on public investments. But, does this

mean that any alternative view on discount rates for the public funding of Surveillance is gazumped? We think not.

When considering options in the environment or other projects that require society to make choices over the long term (beyond 25 – 30 years) economists tend to reduce the discount rate often using society's social time preference rate to discount future cashflows. This results in rates of around 5%. Another view is that in the long term discount rates should tend to the growth rate of the economy (Randell, 2001). In New Zealand this would imply long term discount rates of around 3%. Rates as low as 1% or not discounting at all for projects with implications in the long term are also advocated. However, this flies in the face of observed behaviour and leads to inefficiencies or inconsistencies (Schilizzi, 2001).

While low discount rates may appear to favour environmental projects this may not be the case because other projects of lesser economic merit that would not meet higher discount rate hurdles would be seen to meet the criteria and be accepted. In areas where non-market considerations are undervalued this can result in serious environmental damage that would not occur if the discount rate had been higher and these projects not approved (MacDonald and Young, 2001).

Discount rates used for Biosecurity projects in New Zealand seem to have varied in the range of 5 – 7%. Carter (1989) used 7% to assess the optimal national allocation of survey effort for exotic pests and diseases that threaten commercial forestry. Meister and Alexander (1994) used 6% for the economic analysis of *Nasella* Tussock control. Nimmo-Bell (1999a) used 5% for the cost benefit analysis of the exotic mosquito national pest management strategy.

When consideration is given to ethical as well as efficiency goals then the choice of discount rate is very difficult to resolve. Some economists (Pearce and Turner, 1990) reason that some equity and non-market values are more appropriately dealt with as constraints. These constraints could be imposed via property rights in a form that limit the range of choices to those that are sustainable.

Our position is that projects in the private sector should use commercial rates of discount, those in the public sector the social rate of time preference and in the long term rates based on the long term growth rate of the economy. We consider a positive NPV is a necessary condition for a project to be given the green light, but it is not a sufficient condition and other factors of a political or social nature may modify society's view of the project. Quantitative analysis provides us with information that helps decision makers, but it may not provide all the information that is necessary to make decisions, particularly when non-market factors are important.

Our conclusion is that CBA is the primary tool to be used where the significant benefits and costs can be quantified. This is the accepted tool for analysis of options in the traded goods sector and it should be used in all other cases as the initial analysis tool. Application of CBA leads to a series of NPV and net benefit cost ratios that provide a first order ranking on economic efficiency grounds. Where benefits are too difficult to quantify at reasonable cost then other quantitative tools such as financial analysis and cost effectiveness analysis are useful.

### **Other quantitative tools**

- Financial analysis can be used to determine the impacts of various options on an entity's (company, government department etc) budget. It can help decide on whether certain measures are needed. When the impacts are spread over future years discounting is required.
- Cost effectiveness analysis is used where there is a specific objective, but the benefits cannot be measured so the analysis provides the least cost way of achieving the objective. Discounting may also be required. An example of least cost analysis in the Biosecurity area is the justification of the National Pest Management Strategy for Tb. The objective was the retention of market access for a range of traded goods and the analysis focussed on least cost options of achieving that (Nimmo-Bell, 1995).
- Decision tree analysis can be helpful when a series of sequential decisions need to be made over time. The process aids in developing contingent decision strategies where decisions are dependent on choice between uncertain events over time (Golob, 1997).

When quantitative data is not available or may be too expensive to collect (Surveillance falls into this category) then non-quantitative tools are required to further assist decision makers. Some tools have elements of quantitative and non-quantitative analysis.

### **Multi Criteria Analysis**

There are a variety of techniques that are increasingly being used when monetary valuations cannot be relied on to provide the full answer. This family of tools is referred to as Multi Criteria Analysis (MCA). MCA includes such tools as multi-criteria decision analysis, multi-attribute decision theory, analytical hierarchy decision process and fuzzy set theory. There are a number of other tools in this group, but they are either still at a theoretical stage or have little support among the mainstream of analysts. Details of these tools is set out in a manual on MCA published by the UK government and the discussion below is based on reference to this work. (DETR, 2000).

The use of MCA techniques is controversial. Their usefulness is that they provide alternatives to defining monetary values for all the major costs and benefits when using money values is impractical. They complement quantitative techniques particularly when choices are required between possible outcomes and the basis for appraising these choices is not clear. All approaches make the criteria explicit and require the exercise of judgement. They have a role in providing a consistent approach for decision makers confronted with large amounts of complex information.

Non-quantitative tools can also be criticised and may suffer from some of the same criticisms as CBA, but in general they are more comprehensive and more flexible. In doing so they may provide less clear-cut decision criteria compared with the single NPV or NB/CC decision criteria of CBA although some of these tools attempt to combine scores into a single criterion.

Key features required for MCA techniques to be useful for decision makers are:

- Internal consistency and logical soundness
- Transparency
- Data requirements consistent with the importance of the issue
- Realistic time and human resource requirements for the analysis process
- Ability to provide an audit trail
- Software available, where needed.

MCA brings a degree of structure, analysis and openness to decisions where the significant and relevant data available is non-quantitative. In comparison with ad hoc processes and informal judgement in these situations (the current situation for Surveillance decisions) MCA tools have the following advantages:

- They are open and explicit
- The choice of objectives and criteria are open to analysis
- Scores and weights are explicit
- Expert advice can be incorporated
- The structure provides an important means of communicating with decision makers and stakeholders generally.

So, in combination with CBA, MCA can assist decision makers by providing more information than quantitative analysis alone can do. A key part of MCA is the performance matrix. This is discussed below.

#### *The performance matrix*

A common feature of all MCA tools is the performance matrix, in which each row describes an option and each column describes the performance of the option against the criterion. To be most useful the information in the matrix is converted into consistent numerical values or scores that indicate the strength of preference for each option. Usually a scale of 0 to 100 is used where the most preferred option scores the highest on the scale. Weights are then used to define for each criterion the relative valuations of a shift between the top and bottom of the scale. The larger the weight the more important that criterion is to the overall result. The weights must add to one. By multiplying the scores along a row by the weights an overall score is obtained for each option. The options are then ranked with the highest scoring option being the most preferred taking into account all the criteria.

**The key component of generating a performance matrix is the consistent use of experienced people, who understand the issues, and focus on them using objective and subjective judgement.**

An illustrative example of how this matrix might look for Surveillance is shown below (note that the weights and scores are purely illustrative -- the weights have been developed in a delphi process, using an informed sample of people involved with Surveillance across all sectors in New Zealand.

### Illustrative Surveillance Performance matrix

<i>Criteria</i>	<i>Amenity</i>	<i>Human Health</i>	<i>Indigenous Ecosystems</i>	<i>Maori concerns</i>	<i>Score</i>
<i>Weight</i>	7%	19%	19%	7%	
<i>Option</i>					
<i>Trout virus</i>	50	10	0		5.4
<i>Moth 1</i>	0	0	40	30	9.8
<i>Moth 2</i>	15	0	0	10	1.7

This simple weighted average of scores is satisfactory where it is reasonable for compensation of a low score on one criterion to be offset by a high score on another. In most cases such trade-offs are acceptable, but where ethical considerations, for example, are important then this may not hold. Also, use of weighted averages implies mutual independence of preferences, i.e. the judged strength for an option on one criterion is independent of its judged strength of preference on another. Another factor that must hold is that there are a finite number of options to evaluate. These simplifying assumptions are usually accepted, but if not then more complex procedures may be justified to assist decision makers.

Our conclusion is that MCA type analysis is needed in making decisions on the allocation of resources to Surveillance as there are often significant non-quantitative benefits and costs. MCA is used in conjunction with CBA to provide an overall ranking system.

The principle difference between the types of MCA tools is in the way the scores are aggregated across the criteria for each option. Set out below are the key features of each of the main MCA tools.

#### *Multi-attribute utility theory*

Multi-attribute utility theory has three building blocks:

1. The performance matrix
2. Procedures to determine whether criteria are independent or not, and
3. Ways of estimating the parameters in the matrix to allow the calculation of a single number index (U) that expresses the decision makers' overall valuation for an option.

This tool can take uncertainty formally into account, allows attributes to interact with each other in other than a simple additive way, and does not assume mutual independence of preferences. In practice, these refinements are usually ignored in the interest of allowing a quicker, more transparent process.

### *Linear additive models*

This model assumes the criteria are mutually preference independent and allows simple addition of weighted scores in the preference matrix (i.e. multi-attribute utility theory without the refinements). Models of this type have a well established record of providing robust and effective support to decision makers on a range of problems and in various circumstances (DETR, op cit).

### *The analytical hierarchy process*

This also uses linear additive assumptions, but weights and scores are derived using pair wise comparisons between criteria and between options. Serious doubts have arisen with this tool, in particular rank reversal has caused concern.

### *Outranking methods*

Outranking eliminates alternatives that are dominated. An option outranks another if it outperforms that option on enough criteria of sufficient importance and is not outperformed by the other option on any one criterion. The main concern about outranking is that it is dependent on rather arbitrary assumptions and on how the threshold parameters are set and later manipulated by decision makers, and is therefore seen to have limited use.

### *Fuzzy Sets*

Fuzzy set theory attempts to capture qualified assessments of data in terms of converting expressions like “fairly attractive” into mathematical functions. The method does not have clear theoretical foundations in regard to modelling decision makers’ preferences and does not seem to have any critical advantages over more conventional methods.

## **Summary and conclusion on analysis tools**

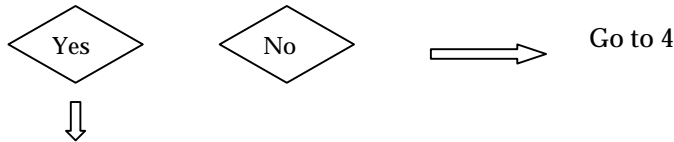
Our conclusion from this analysis of tools is that the favoured approach is:

- Determine the ranking of options on a relative net economic benefit basis using CBA for quantitative costs and benefits
- Establish a performance matrix for non-quantitative benefits and costs using a linear additive MCA model to provide a single decision criterion for non-quantitative costs and benefits
- Compare ranks under CBA and MCA and use judgement to decide on a final ranking
- The trade-off between quantitative (CBA) and non-quantitative (MCA) criteria indicates the opportunity cost to society in monetary terms of changing the CBA ranking.

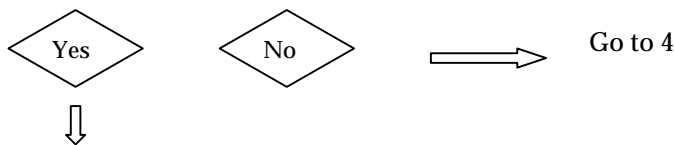
## Appendix Two: The intervention test

### Tests to determine whether government intervention in Surveillance is justified and appropriate

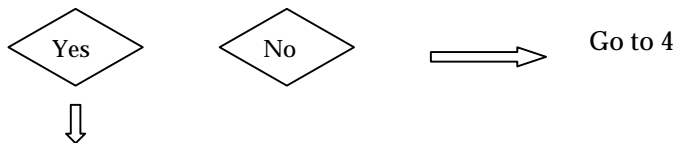
Test 1 Does the intervention increase individual freedom of action, contract and exchange?



Test 2 Does it preserve venerable common law causes of action against harm or remove novel or expanded definitions of legal harms?

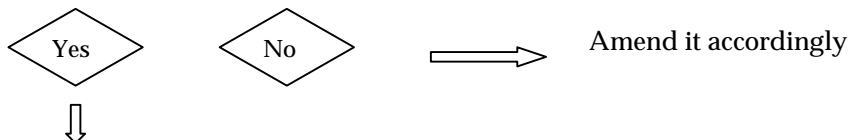


Test 3 Does it preserve existing legal rights and other elements of the rule of law?

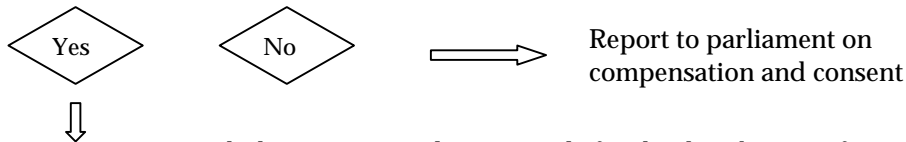


This intervention complies with principles of preservation of common law, enlarging the scope for individual action and voluntary co-operative action, and otherwise preserves or enhances the rule of law (see Wilkinson p206 for an expansion of these principles)

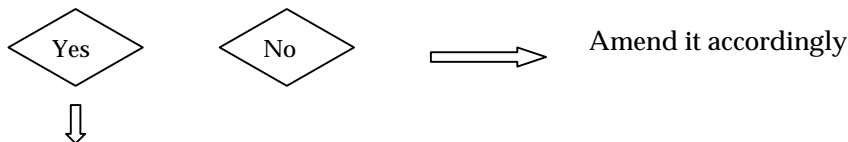
Test 4 Is each and every element that violates Tests 1, 2, and 3 necessary (i.e. otherwise impossible) in order to obtain the benefit that is essential (i.e. makes a major contribution to community welfare) to the well-being of the public at large?



Test 5 Does the proposed intervention preserve existing legal rights?



Test 6 Is it consistent with the proportionality principle for the distribution of surpluses?



Test 7 Does it effectively tie a tax to a permit without explicit parliamentary scrutiny?

