AERU
Agribusiness and Economics Research Unit
A Lincoln University Research Centre.
New Zealand's specialist land-based university.

Non-market valuation of environmental impacts for biosecurity incursion Cost Benefit Analysis: A guidance manual for public policy

Dr Peter Tait
Paul Rutherford

June 2018

The Agribusiness and Economics Research Unit (AERU)

The AERU was founded in 1962 and was at the centre of early applied economics research in New Zealand. Since that time, the AERU has produced rigorous economic, market and social research for domestic and international agencies, government departments, companies and other organisations.

Now, under the leadership of Professor Caroline Saunders, the AERU continues to contribute timely, applied economic analysis for current issues facing society. It has significant experience and expertise in the areas relevant to agriculture policy, including economic analysis, workforce development research, economic impact assessments, cost–benefit analysis, research on agribusinesses and policy advice.

The unit operates as part of Lincoln University, providing it excellent access to key academic resources. Lincoln University is New Zealand's specialist land-based university. It was founded in 1878 as a School of Agriculture, became a College of Agriculture attached to the University of New Zealand in 1886 and to the University of Canterbury in 1962. It was elevated to an independent university in its own right in 1990. The AERU can call on colleagues from within the university as well as draw on an extensive network of allied researchers to supplement its in-house expertise.

Summaries of AERU Research Reports, beginning with #245, are available on the AERU website http://www.lincoln.ac.nz/aeru

Non-market valuation of environmental impacts for biosecurity incursion Cost Benefit Analysis: A guidance manual for public policy

Dr Peter Tait[1]

Paul Rutherford[1]

June 2018

1 Agribusiness and Economics Research Unit
PO Box 85084
Lincoln University
Lincoln 7647
Canterbury
New Zealand

www.lincoln.ac.nz

Contents

Tables

Figures

Acronyms

BT	Benefits Transfer
CBA	Cost Benefit Analysis
CE	Choice Experiment
CV	Contingent Valuation
NOAA	National Oceanographic and Atmospheric Association
NMV	Non-market Valuation
RP	Revealed Preference
SP	Stated Preference
TEV	Total Economic Value
WTA	Willingness to Accept
WTP	Willingness to Pay

1. Introduction

The primary purpose of this guidance is to contribute to evidence-based decision making within biosecurity response, by enabling response staff to incorporate monetary values of environmental impacts into biosecurity Cost Benefit Analyses (CBA)[1].

While some attempts have been made to incorporate monetary estimates of environmental impacts into biosecurity response CBA, the typical approach has been to evaluate commercial impacts and qualitatively describe environmental values at risk. However, in an ideal response decision framework, the value of these environmental impacts would be included. In the absence of value estimates, environmental resources may be implicitly undervalued and decisions regarding their use and stewardship may not accurately reflect their true value to society. In practical terms, any CBA omitting relevant values will be incomplete and may lead to inefficient response resource allocation. While quantitative estimates are preferred in CBA whenever possible, qualitative assessments should also be used.

A fundamental problem when considering the value of environmental impacts is how to measure the value of impacts in a way that is comparable to the costs of response options. Unlike commercial impacts, most environmental goods and services, such as clean air and water, healthy fish and wildlife populations, are not traded in markets. Their economic value - how much people would be willing to pay for them - is not revealed in market prices. The only option for assigning monetary values to them is to rely on economic non-market valuation (NMV) methods. In this way, NMV is a corrective tool for economics to capture values outside of markets. Economic valuation contributes to the demonstration of value, providing support for management actions that promote the capture of value. This view forms an important distinction in what defines economic valuation. Valuation does not advance the commodification of environmental goods and services, but rather is an avenue for assessing how changes in environmental outcomes affect individuals' welfare.

Considering the diversity of agents involved at various stages of the response options assessment process, the audience for this guidance may be broad, including persons providing biosecurity management oversight, procurement of relevant work-streams, conducting CBA, and those persons conducting preliminary assessment of the potential magnitude of environmental values impacted by an incursion event. This guidance is designed to be sufficiently accessible so as to provide general insight into the economic reasoning and practical mechanics of conducting NMV to interested agents, without the requirement of technical expertise.

A defining characteristic of conducting NMV in the context of biosecurity response is the invariably limited timeframe for gathering required information. This guide therefore, focuses on which avenues will be most practical in achieving value estimates within the shortest timeframe and the lowest cost possible. This leads to a description of basic forms of Contingent Valuation (CV) and Benefits Transfer (BT) to facilitate an in-house assessment of values where possible. These basic forms of CV and BT provide an initial assessment of value and should be regarded as part of a filtering process that gauges

[1] It should be noted that non market impacts also occur on people, in terms of human infrastructure, social amenity, cultural values and human health.

relative orders of magnitude to determine whether expert-developed valuation is applicable.

2. Economic Valuation

Economists typically approach applied valuation applications from the view point of the Total Economic Valuation (TEV) framework (blue boxes in Figure 1) that describes how something is used either directly or indirectly. This is an anthropocentric view: value is created by the preferences and choices of individuals in society. People express their preferences through the choices and tradeoffs they make in light of the constraints they face, such as income. The intended purpose of the TEV is to provide an overarching framework that considers all sources of value. The name refers to the intention to apply a broad holistic definition of value, rather than a statement of being able to measure the total sum of all values.

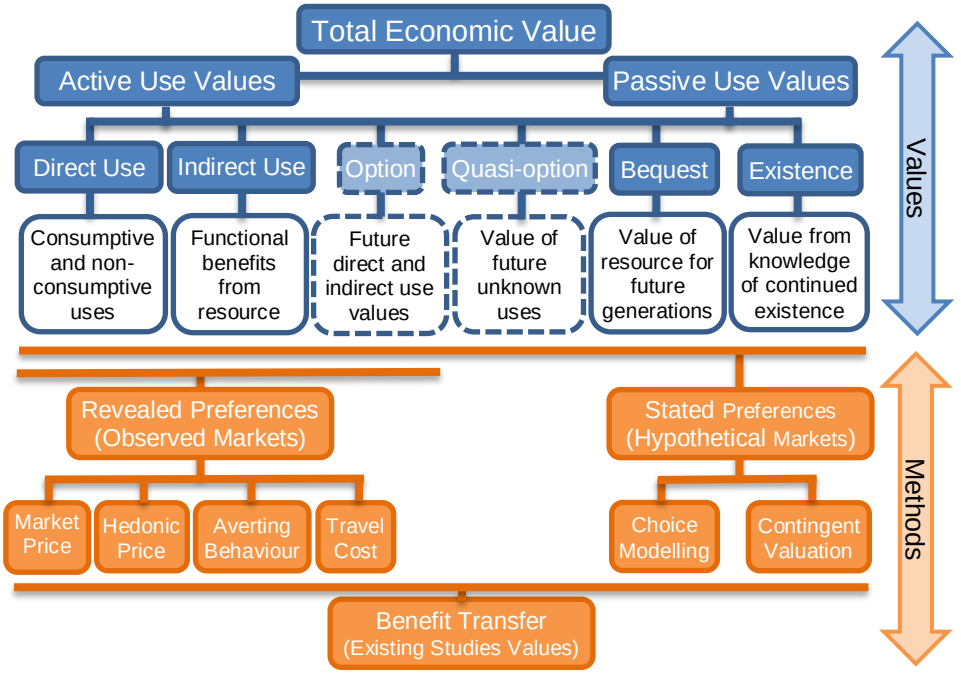

Figure 1 *The Total Economic Value framework and relevant economic valuation methods*

Active use values are those functions of an environmental good or service that individuals engage with, either directly or indirectly. Direct use values comprise both extractive values e.g. fisheries, and non-extractive values e.g. tourism and recreation. Indirect use values are derived from services that flow from the resource without using it directly e.g. ecosystem support to native biodiversity, carbon sequestration and flood mitigation. Option values consider the known types of active use that may be demanded from a resource in the future; while quasi-option values are unknown at present but new knowledge may be generated in future from the resource e.g. species, biodiversity. Passive use values are realised without consideration to any active use, derived from the knowledge that an environmental resource is maintained or preserved currently or as a

resource for future generations (bequest). Passive-use values principally take account of environmental outcomes that form part of societal welfare, identity or 'way-of-life'. For New Zealanders these can include values for preserving water quality and native biodiversity. Passive-use values are particularly important where impacted environmental resources are relatively unique or have heritage characteristics.

Once a set of values have been identified, the challenge for the practitioner is to select an appropriate valuation method (orange boxes in Figure 1). Revealed Preference (RP) methods are those based on observed market data either directly e.g. sale price of fish (Market Price), or through observing indirect markets e.g. the travel cost of reaching a fishing site (Travel Cost), or changes in the values of houses adjacent to polluted waterways (Hedonic Price). The cost of averting an environmental impact through mitigation actions has also been used as a proxy for the value of benefits, however there is no theoretical relationship between the value of costs and benefits, and this approach will always generate a BCA ratio equal to one.

Stated Preference (SP) methods – Choice Experiments (CE) and Contingent Valuation (CV) – do not rely on observed market data but rather generate comparative datasets through survey-based hypothetical markets for the environmental goods of interest. The CV approach asks individuals about a single event or outcome, while a CE asks them to choose their preferred option from a 'choice set' made up of different configurations of multiple events or outcomes. Respondents to these surveys express their preferences for environmental outcomes and their associated willingness to pay (WTP) for them. SP methods have been continually improved since the earliest known studies in the early1960's. There is now an extensive applied literature demonstrating internationally application to public policy, with perhaps the most famous applications to estimation of loss of passive use values associated with environmental damages caused by the Exxon Valdez and the BP Deep Water Horizon oil spills.

Benefits Transfer (BT) is the process of transferring WTP values from a previously undertaken primary study, to a new subject site where values are required to be generated. This method can take values estimated from any of the other valuation approaches and is useful because it may require less resources to undertake compared to a primary study. However, it is dependent on having a broad suite of primary studies from which to derive values.

In the context of environmental impacts related to biosecurity response, several important considerations point to the conclusion that SP methods are more appropriate than RP methods:

- RP techniques cannot be used to estimate passive-use values, only SP methods are appropriate.
- Since the RP technique requires observing individual behaviours, it is harder to apply to estimate values of public goods, especially when they are national rather than local public in nature.
- The inability to isolate the environmental value required from observed prices in RP analysis represents a common data constraint that precludes use.

- RP methods, where conceivably possible, for estimating recreation values of a native forest for example, are time-intensive and unlikely to fit the compressed time constraints of biosecurity information demands.
- RP methods are limited to analysis of past behaviour and previous market settings that require the incursion outcomes to have already occurred and to have impacted on values, whereas SP methods can be framed to reflect expected future conditions that have not yet occurred and are anticipated to be avoided through response actions.
- Empirical biophysical measurements of environmental quality change are rarely observable. As a consequence, CV and CE, which ask individuals to consider hypothetical questions, is often more useful for eliciting individuals' WTP for environmental goods and services than revealed preference techniques. and
- CV and CE are the most flexible methods available, and are able to be designed specific to context.

2.1 Summary

Although theoretically there are several NMV methods that may be used for estimating the different types of values discussed, practical and logistical constraints limit their use, particularly within the context of biosecurity response decision timeframes and available biophysical information. The most practical and flexible methods suitable for application to biosecurity response are considered to be CV, CE and BT. The following sections detail these methods.

3. Designing CV and CE Surveys

The SP approaches of CV and CE both follow similar processes (Figure 2). The first two stages of both methods rely on an initial clear identification and definition of the incursion event and the resultant environmental impacts. To develop a clear understanding of environmental impacts, early engagement with relevant ecological expertise is essential. Convening workshops, either in person or teleconference, between biosecurity response team members and ecological expertise enables iterative discussion that develops the base understanding of the context. In the case of collecting information for a basic BT or CV process these need not be protracted, and a couple of 2-3hr workshops is typically sufficient to draw out any relevant and available information. The nature of incursion impact assessment is often characterised by uncertainties across many dimensions of the response, and so collecting what information is available may be achieved relatively rapidly.

Common to all valuation methods, the next step is to identify the environmental types of values that will be impacted as a result of incursion (Figure 2, 1b.). These might include for example, recreational benefits of a fresh water resource. For the value of avoided recreation loss to be included in a CBA of response actions, it must be made clear that this value is relevant to the resource being impacted. If no one actually uses this particular resource in this way then caution must be applied in deciding whether to include this benefit in the framing of the valuation exercise. This process is aided by forming a holistic assessment of who it is that will benefit from incursion response (Figure 2, 1d) and what values they hold for an impacted resource. The TEV framework can form a basis for this process (Figure 1) with subsequent ground-truthing of impacts and values through a survey of this affected community is also recommended. Pre-testing (Section 3.4) and piloting (Section 3.5) of CV and CE surveys with affected communities can also be important in identifying whether the framing of the valuation exercise accurately reflects the relevant values.

3.1 Essential elements for both CV and CE surveys

A well-designed survey is consequential to respondents, so they are motivated to respond and to reveal truthfully because they believe the results of the survey will be used meaningfully. Many elements must be included and carefully refined to create a consequential survey. In general, a CV or CE survey questionnaire contains the following elements:

1. **Purpose**

   The purpose of the survey is typically incorporated into a covering letter for mail and online surveys which serves as the first point of contact with a respondent. Time constraints usually constrain phone or in-person interviews to convey only the most salient aspects, while self-administered mail and internet surveys allow respondents to pause and restart at will. The context of the study should be clearly and accurately stated so as to encourage realistic responses. Any covering letter should portray official recognition of the study researcher. Human Ethics considerations should be clearly stated: participation is voluntary, responses are anonymous, respondents

have the right to withdraw provided data, expected time commitment to complete the survey, email, phone and institution contact details of study lead researchers.

2. Attitudes

Attitude inquiry questions are designed to identify respondent attitudes relevant to the environmental outcomes being valued as these can influence WTP for outcomes. For example, attitudes towards the importance of biosecurity in general could be gauged using a five point Likert Scale of 'Very Important' to 'Not Important', and then repeated specifically relating to the incursion type and impacts being valued.

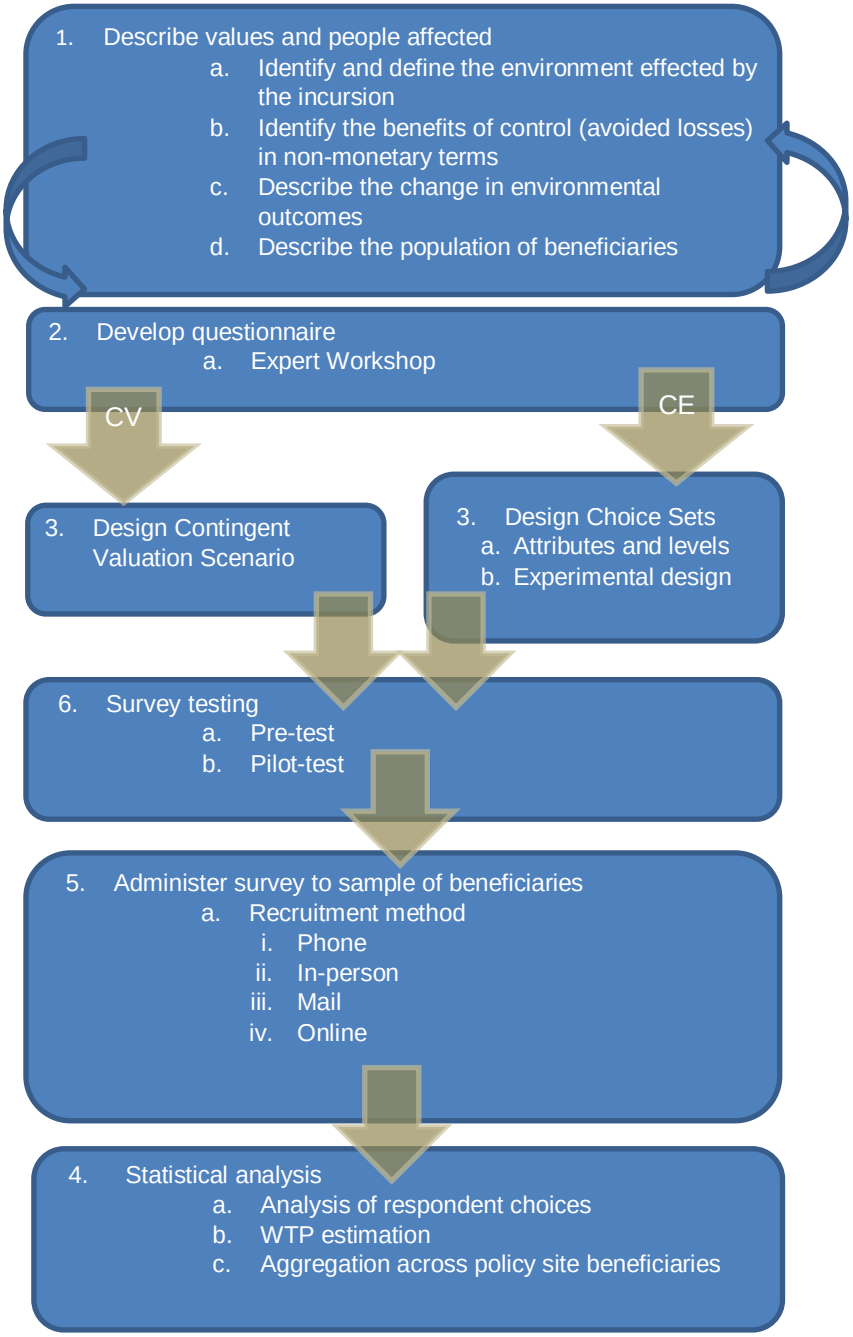

***Figure 2** Main steps in conducting Contingent Valuation and Choice Experiments*

3. Knowledge

Respondent's knowledge (perceptions) of the current state of the environmental issue under consideration can be a determinant of their WTP and should be included in the statistical analysis. For example, knowledge of the environmental issue could be gauged using a five point Likert Scale of 'Very Knowledgeable' to 'Don't Know Anything'.

4. Use of the good

How a respondent engages with the environmental goods and services being valued can influence their preferences for outcomes. Respondents who actively engage with the environmental goods and services being valued typically have stronger preferences, and associated higher WTP, for improved outcomes. These types of questions also aid in identifying familiarity with the good, and provide a distinction between active-users and passive-users. For example, use of the environmental good or service under consideration could be gauged using a five point Likert Scale of 'Very High Use' to 'Don't Use at All'.

5. Willingness to pay elicitation scenarios

While specific guidance for construction these questions is provided in sections 3.2 and 3.3 below, it is worth emphasising here the central importance of framing the willingness to pay elicitation scenarios as accurately and realistically as possible. As varying information type and structure can affect value estimates, the quality of information conveyed to survey respondents is critical to the success of the valuation exercise.

6. Follow-up questions to WTP elicitation

Survey respondents' understanding of the overall questionnaire, and the valuation exercise can influence WTP and should be included in statistical analysis. This can provide insight into the reliability of the observed responses, and allows for the grouping of data to reveal differences. For example, understanding of the WTP question could be gauged using a five point Likert Scale of 'Very Understandable' to 'Don't Understand at All'.

Follow-up questions are also used to identify if respondents 'protested' about the payment vehicle and the way the trade-offs are framed in the study.

7. Sociodemographic characteristics

Survey respondents' sociodemographic circumstances are often significant determinants of their WTP and as such should be assessed in statistical analysis. The usual set of variables includes: income, age, gender, education, and number of children.

3.2 Contingent Valuation Specifics

Contingent Valuation is a survey-based method that asks individuals to reveal their personal valuation for increases or decreases in unpriced non-market goods by using contingent (hypothetical) markets. The hypothetical market is described by the valuation scenario which typically contains the following elements:

- Defines the environmental goods impacted by the incursion. These are usually elaborated fully, earlier in survey questionnaire (see Table 3 for an example) and are represented concisely in the CV scenario.
- The status quo level of provision of the environmental goods that are impacted by the biosecurity incursion.
- The change in environmental quality and/or quantity, resulting from the incursion.
- The reduction in impact, or improvement in quality, that can be achieved with the adoption of the policy change (environmental good) that is identified in the study.
- How respondents will pay for the change (or avoided damage) in environmental quality and/or quantity. This is referred to as the payment vehicle.

This information makes up a scenario that respondents will value. An additional chief consideration in constructing the scenario concerns the choice of WTP elicitation format used to value the environmental quality and/or quantity changes. The referendum format is commonly preferred[2]. Also known as the dichotomous choice format, survey respondents are presented with the option to agree or disagree to paying a stated amount for an environmental program. Table 1 provides an illustration of this approach. The bid amount shown to each respondent is randomly selected from a pre-defined set.

The dichotomous choice format is preferred for several significant reasons:

- It mimics market place transactions where shoppers either purchase a good (or not) at the given price.
- It mimics ballot referendums (more common in the USA).

Table 1 Example of dichotomous choice Contingent Valuation WTP question

If no action is taken the impacts will be severe. Myrtle Rust infections will spread across all of the North Island and the top and western South Island. Impacts on native forests will include canopy collapse and significant loss of forest and species that live there and impacts on related ecosystem services including soil erosion control. Popular ornamentals and fruit trees in domestic orchards and gardens will die without protection. There is likely to be a high death rate of heritage and iconic urban and landscape trees, and at least ten vulnerable native species will become extinct.
To protect vulnerable trees and plants at their current condition the government will have to spend tax money. Would you be willing to pay a cost of **[BID]** per year for the next five years to fund the program?

☐ YES ☐ NO ☐ Don't know

[2] Other elicitation options include open-ended and bidding card formats.

- Is endorsed by the USA National Oceanographic and Atmospheric Association (NOAA) for use in legal cases; including for estimates of loss of passive use values associated with environmental damages caused by the Exxon Valdez and the BP Deep Water Horizon oil spills.
- Is endorsed by NZ Treasury; used to estimate the NZ Government Value of Statistical Life.

The NOAA have made a series of recommendations on conducting CV valuations (Table 2). Notably the recommendation to use WTP rather than willingness to accept (WTA) stems from well-established findings that an individual's WTA is higher than their WTP; resultant in part from the endowment effect, that is, an individual generally requires greater compensation to give up something they possess than they are prepared to pay to acquire it. Also, WTA is not constrained by income, whereas WTP is. Both these observations lead to the conservative decision to favour WTP measures over WTA.

Table 2 Important NOAA recommendations for Contingent Valuation
• Use willingness to pay rather than willingness to accept • Use a dichotomous choice WTP elicitation format • Provide accurate detailed information on the resource being valued, including threats and protection measures • Remind respondents of budget constraints • Adequately pre-test the survey instrument • Use a representative sample • Use personal interviews to conduct the survey • Include follow-up questions to the WTP question to ensure respondents understood the question posed, believed the scenarios, and explained 'No' responses

3.3 Choice Experiment Specifics

The main defining difference between CV and CE methods is in the construction of the valuation scenarios and associated WTP elicitation.

The CE method simulates market observations by creating a hypothetical market within a survey that enables people to indicate their preferences for changes in biodiversity outcomes associated with incursion mitigation actions, and the associated costs to them. In this way, a CE produces information on quantities and prices similar to what is found in observed markets, which can then be analysed to measure the benefit of changes in biodiversity outcomes resultant from incursion mitigation actions. They are grounded in the same Welfare Economics framework that underpins the use of observed market prices to measure changes in the value of benefits and costs.

CEs have, for over four decades, been applied in economics to value a wide variety of goods and services such as transport, cultural heritage, environmental quality and health

care. This approach has also been widely applied to value environmental benefits of pest and disease management internationally[3] and has an established New Zealand literature[4].

While the CV approach asks individuals about a single event or outcome, a CE asks them to choose their preferred option from a 'choice set' made up of different configurations of multiple events or outcomes. Each configuration consists of a different set of attributes. Figure 3 shows a choice set used in the Myrtle Rust study. Descriptions of the changes in attributes assessed are provided in Table 4.

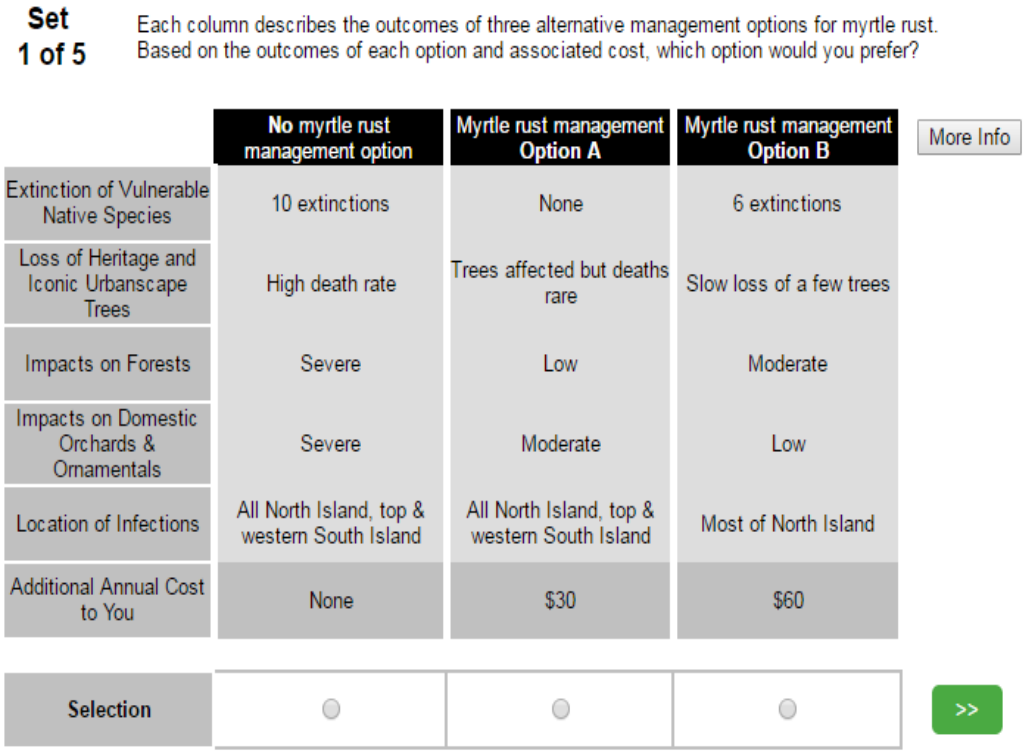

Figure 3 *Example of a choice set shown to respondents*

The key advantage of using a CE over a CV, therefore, is that the method does not rely on a specific case of environmental change. Rather it relies on multiple attributes in a choice situation. This is important as it means that multiple scenarios can be explored, rather than the single CV scenario.

In a CE, respondents are presented with the choice between an option depicting the status-quo (within the context of biosecurity response this usually describes the environmental outcomes if no management is undertaken), and several alternative options that describe environmental outcomes consistent with active management (improvements over the status-quo option). A monetary attribute is attached to each

[3]Meldrum J. et al. 2013. Heterogeneous nonmarket benefits of managing white pine bluster rust in high-elevation pine forests. J. For. Econ. 19:61–77. http://dx.doi.org/10.1016/j.jfe.2012.10.001.
Chang W. et al. 2012. Benefit-cost analysis of spruce budworm (Choristoneura fumiferana Clem.) control: Incorporating market and non-market values. J. Environ. Manage. 93:104-112. doi:10.1016/j.jenvman.2011.08.022.

[4]Tait P et al. 2017. Valuing conservation benefits of disease control in wildlife: A choice experiment approach to bovine tuberculosis management in New Zealand's native forests. J. Environ. Manage. 189:142-149. https://doi.org/10.1016/j.jenvman.2016.12.045.

option representing a payment vehicle. Respondents are faced with a choice of a no management option (maintaining the status-quo) whereby no cost is incurred but no environmental benefits are secured either, versus cost-incurring options that provide environmental benefits.

The CE approach offers some significant advantages over CV:

- Statistically more precise WTP estimates.
- CE estimates WTP values for changes in individual outcomes, whereas CV combines a bundle of management outcomes into a single scenario to be valued.
- Individual WTP for outcomes can be combined in various ways as required to reflect a range of possible management options.
- Respondents are not asked directly for their WTP, but rather WTP is derived from their choices and observed trade-offs, minimising strategic behaviour and other implicit biases.

Like CV, the CE process starts with defining the environmental outcomes impacted by the incursion. However, CE typically requires greater amounts of detail in forming descriptions and definitions of the individual environmental impacts presented to respondents, as it is changes in these outcomes that respondents are being asked to express their preferences over. In general CE applications include the following additional process:

1. Selection of management attributes:
    - These are the environmental impacts from incursion that are to be valued
    - Monetary cost is an additional management attribute that is included to allow the estimation of WTP.
    - A rule of thumb is to select 4-5 attributes additional to monetary cost. This helps reduce respondent effort, and increases the reliability of associated data.

    An example from Myrtle Rust is shown in Table 3.

Table 3 Example of Environmental Impacts of Incursion: The case of Myrtle Rust in New Zealand

1. Extinction of susceptible native species

Some susceptible native species could be so severely affected that there is the risk that they vanish completely from the natural environment. If this occurs, species that rely on these type of plants for food and habitat, such as insects and birds will also be affected. The loss of any native species, or the species that depend on them, will have a large cultural impact for Māori and other New Zealanders.

2. Loss of heritage and iconic urban and landscape trees

Some individual trees or collections of trees have a disproportionately large amenity, social or cultural value. This includes trees that line urban streets, trees in public parks, trees lining beaches and camping grounds, and large specimen trees that may be focal points for communities. Māori place particular emphasis on individual trees with connection to important events in history or cultural traditions and stories.

3. Impacts on forests

If there is a major loss of susceptible trees and plants from our native forests this would have flow-on effects on the makeup of the landscape. These effects could potentially include canopy collapse, increased erosion, and exacerbated invasion of pest plants requiring additional management. Again, damage to the health of a forest or ecosystem, or the species that depend on them, will have a large cultural impact for Māori.

4. Impacts on domestic orchards and ornamentals

Many households grow feijoa trees that provide popular fruit, and also other susceptible ornamental species. Effects could include reduced harvests and the need to use fungicide sprays for feijoa trees, and removal of larger eucalyptus trees that pose safety risks. Hobbyist beekeepers also rely on the flowering of many myrtle species for honey production, including natives such as mānuka, kanuka, rata, etc., and non-native bottlebrushes and eucalypts.

5. Location of myrtle rust infections

Myrtle rust fungus has the potential to spread to many parts of NZ, but will ultimately be restricted to places where the climate is most suitable. Infections may be relatively contained or could occur over large parts of New Zealand.

2. Selection of the levels that environmental outcomes can take:

- This stage is usually conducted within the same expert workshops used to define the environmental impacts.
- Given the inherent uncertainty of what actual outcomes will be, one strategy is to focus on defining the upper and lower levels – the optimistic and worst-case outcomes for each environmental impact, then construct a middle ground level. The worst case level will be defined as the 'do nothing' management situation.
- While more than three levels are possible, no more than four is a good rule of thumb, as respondents will find it difficult to make choices over smaller incremental changes.
- In general, the wider the interval between levels, the easier the choices will be for respondents. This can also improve statistical estimates. However, the trade-off is that wider intervals weaken the assumption of constant marginal values within the range. Attention should be given to whether the marginal value is likely to be constant across the range estimated.

An example from the Myrtle Rust study is shown in Table 4.

Table 4 Example of levels for environmental outcomes

Management attributes	Attribute levels		
Extinction of susceptible native species (# species)	10*,6,3,0		
Loss of heritage and iconic urban and landscape trees	**Severe** High death rate*	**Moderate** Trees affected but death rare	**Low** Slow loss of a few trees
Impacts on forests	**Severe** Canopy collapse, significant loss of forest and species that live there, impacts on related ecosystem	**Moderate** Forest canopy intact but with some loss of susceptible trees and plants	**Low** Forest canopy intact but contains some sickly trees and plants

	services including erosion control*		
Impacts on domestic orchards and ornamentals	**Severe** Popular ornamentals and fruit trees die without protection*	**Moderate** Reduced yield, less resilience, die younger	**Low** Little effect
Location of myrtle rust infections	**Severe** All of North Island, Top and Western South Island*	**Moderate** Most of North Island	**Low** Raoul Island and Northland
Additional individual annual cost ($NZ)	0*,30,60,90,150		
* denotes levels of 'no myrtle rust management option' employed in each choice task			

3. Experimental design:

- Presenting all possible combinations is not practical, so an experimental design aims to form a subset of combinations while maximising the available statistical information.
- Experimental design is the process of forming combinations of the attributes levels into scenarios to be presented to respondents.
- There are many different statistical criteria for selecting a particular design based on orthogonality and efficiency.
- While relatively sophisticated approaches are required to develop efficient designs (Figure 4), orthogonal designs are openly accessible (see for example http://support.sas.com/techsup/technote/ts723_Designs.txt).

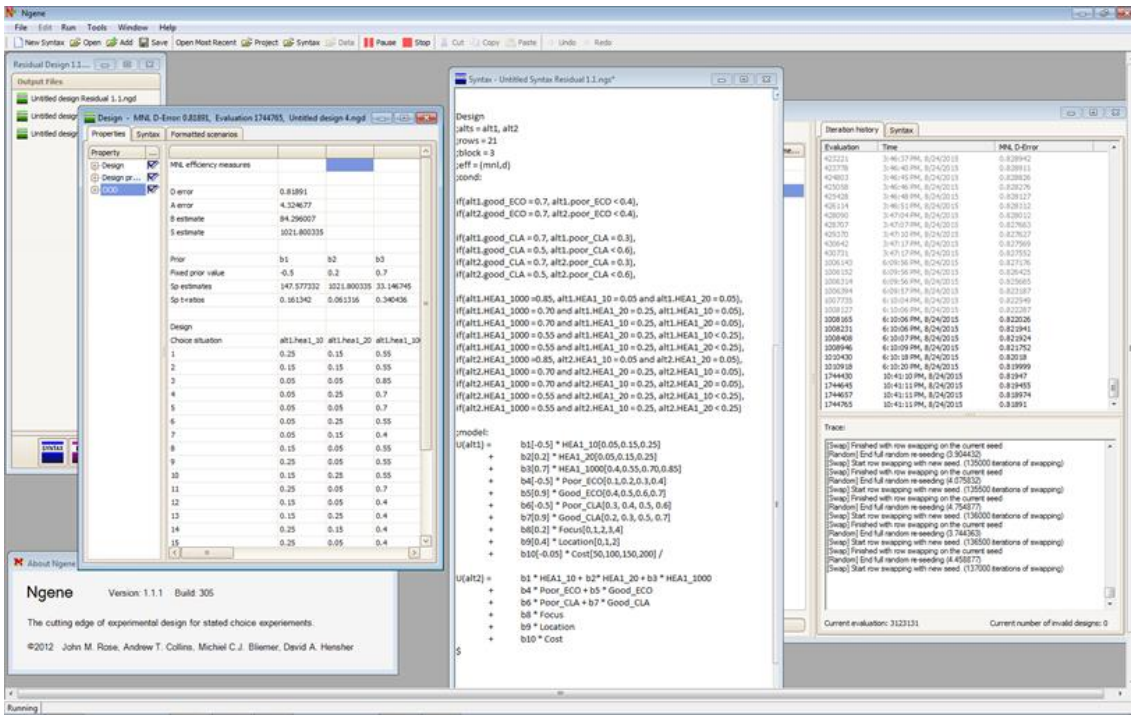

Figure 4 *Screen shot of NGene™ Experimental Design software*

4. Construction of choice sets:

   - The profiles generated in the experimental design are combined to form choice sets.
   - A series of choice sets are presented to respondents. While presenting more sets provides additional data, respondents can become fatigued and begin to answer randomly, resulting in poor data quality. This is particularly the case when the environmental change being valued is unfamiliar to respondents. A general rule of thumb is to present around five sets to each respondent.

   A choice set used in the Myrtle Rust study is shown in Figure 3.

3.4 Pre-testing

Pre testing aims to identify issues with the questionnaire prior to it going in-field, and is a crucial component of any survey process that should be adequately addressed.

Feedback should be obtained on the draft questionnaire from a number of people, each of whom has specialised knowledge of some aspect of questionnaire content and quality. Cognitive interviews are recommended for pre-testing as they can be organised and carried out in a timely manner.

Cognitive Interviews are a leading methodology for testing questionnaires during design and implementation phases. The central aim is an assessment of whether respondents comprehend questions as intended by the researcher and whether questions can be answered accurately[5]. The method involves respondents being prompted individually to respond to a questionnaire by an interviewer who asks them to think out loud as they go through the survey and tell the interviewer what is being thought about the questions and how answers are being formed. The interviewer probes in order to explore issues including interpretation of questions.

A rule of thumb is to conduct cognitive interviews on about five individuals from the target population across a mix of gender, age and occupation. For a short (5 minute) survey, each interview will take approximately half an hour.

3.5 Pilot testing

Conducting pilot testing is an important step in administering a survey and should receive adequate attention.

- Pilot tests are small scale surveys of the questionnaire prior to full launch to the entire sample.
- The purpose of a pilot test is to identify any practical administrative issues in running the survey including implementation procedures. For online surveys these include identifying whether response data is being recorded correctly, and any associated technical issues.

[5] Dillman DA. etal. 2009. Internet, Mail, and Mixed-Mode Surveys: The Tailored Design Method. -3rd ed. John Wiley & Sons Inc., Hoboken, New Jersey.

- If large enough, pilot studies provide preliminary data sets that when analysed can be used to amend questionnaire design including detecting question non-response, and providing inputs to experimental designs for CE.

3.6 Choice of Survey Mode

There are four main approaches to administering survey questionnaires. Figure 5 depicts typical (minimum) costs per usable response and in-field time requirements for the four main survey modes. All approaches have pros and cons, however within the context of biosecurity response and compressed timeframes, the most practical approach appears to be the use of online panels, which has the following benefits:

- Online panel approaches are faster and cheaper than all other modes
- For a simple survey of up to 5 minutes long, which is sufficient for a basic CV survey, cost is approx. $5 per person (2017) and in-field time for a survey of around 500 respondents can be concluded in approximately one week.
- Quotas can be applied to achieve representativeness for selected demographic variables.
- Subsequent analysis is faster as the data inputting stage is not required.
- The main downside of this approach is that unless internet access is widespread, bias may be introduced into the sample as members of the target population (those that benefit from biosecurity response actions) may not have the chance to be included in the sample. In 2017 it was estimated that 89% of NZ population were active internet users.

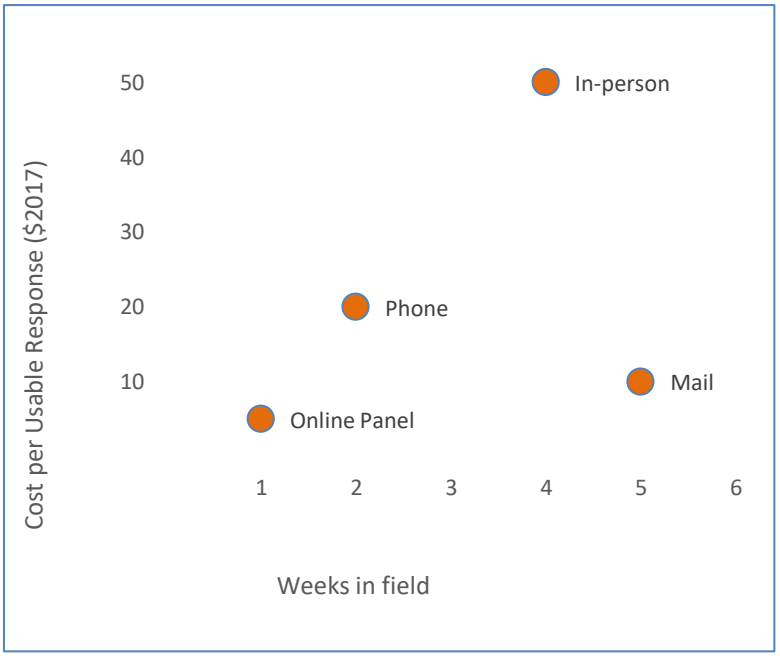

Figure 5 *Survey mode costs and time requirements*

3.7 Data Analysis

3.7.1 Contingent Valuation Data Analysis

CV survey response data consists primarily of a binary yes/no response to the valuation scenario, along with responses to the other questions concerning attitudes, use etc. and demographics of the respondent. Figure 6 illustrates what this data generally looks like. Starting from the left hand side, the first column contains an indication as to whether the respondent agreed to making the payment presented to them (1 = yes, 0 = no); the next column contains the bid amount presented; then the responses to a series of Likert Scale and demographic questions as detailed above in the essential design elements section.

Yes/No	Bid offer	Attitude	Knowedge	Use	Understanding	Income	Age	Gender	Number of children	Education
0	60	1	2	2	2	7	63	1	3	4
0	80	5	3	1	4	6	26	1	0	2
1	40	3	4	3	4	7	40	0	0	3
0	80	4	3	4	4	7	40	1	0	5
0	40	4	5	5	2	5	28	1	3	7
1	20	1	2	2	4	5	38	0	4	4

Figure 6 *Example data format for a basic Contingent Valuation survey*

The standard approach to analysis for data of this nature is the Binary Logit model, which models the probability of a respondent agreeing to make the payment offered, given the values of the other response variables including the bid amount. The Binary Logit model function takes the general form:

$$F(x) = \frac{1}{1 + e^{-(\beta_0 + \beta_1 x)}}$$

Where $F(x)$ is the probability of the dependent variable (bid agreement) equaling a 'yes' and the β's are parameters to be estimated for each of the explanatory x variables. This model can be estimated using most statistical packages, and is possible to estimate in Excel. Model output is generally presented in the form:

$$y' = \beta_0 + \beta_1 x + \varepsilon$$

The value estimate of central interest, the conditional mean WTP, is estimated using $\widehat{WTP_i} = \frac{\beta_0 + \beta_1 x_i}{\beta_{BID}}$ where the top line contains those variables that were statistically significant in the estimated model in explaining respondents choices (including a constant), and the bottom line contains the parameter for the bid variable.

3.7.2 Choice Experiment Analysis

Choice Experiment survey response data consists of a binary yes/no response for each of the choice sets that indicates which option within a set most chosen by the respondent, along with responses to the other questions concerning attitudes, use etc. and demographics of the respondent. Figure 7 shows a snapshot of the raw data generated from the Myrtle Rust CE choice sets (Figure 3). Starting from the left hand side, the first column is the choice set that was presented (we can see two sets shown), then each alternative within each choice set (three alternatives with the first being the status-quo

option), then the third column shows which alternative the respondent choose from the choice set (1 = yes, 0 = no); the next columns contain the coded levels of the management attributes, with the last column comprising the cost amount presented in each alternative.

Structuring the data correctly is necessary to perform analysis, notice that the data are grouped as three cases per choice set, with the first alternative (case) being the 'no management' option that imposes no cost. The respondent in this example selected the second alternative in both of the first two choice sets presented to them.

Set	Case	Choice	Extinct	Heritage	Forest	Domestic	Location	Cost
1	1	0	10	3	3	3	1	0
1	2	1	0	2	1	2	1	30
1	3	0	6	1	2	1	3	60
2	1	0	10	3	3	3	1	0
2	2	1	6	2	2	1	2	30
2	3	0	0	1	1	2	2	30

Figure 7 *Example data format for a Choice Experiment survey*

While most contemporary econometric-development effort has gone into developing specifications for CE data as this method has grown in application, there are some considerably sophisticated binary dependent variable models used for CVM data analysis. However, the modelling approach described here can be considered to be at a relatively rudimentary level.

The standard approach to analysis for data of this nature is the Multinomial Logit model, which models the probability of a respondent choosing a particular alternative within each choice set, given the values of management outcomes contained in each of the alternatives within the choice set. The logistic model function takes the general form:

$$F(choice\ j) = \frac{\exp(\beta'_j x_{ij}}{\sum_{q=0}^{J} \exp(\beta'_q x_i)}, j = 0, \dots, J.$$

Where $F(x)$ is the probability of a particular alternative j being chosen and the β's are parameters to be estimated for each of the management outcome x variables. This model can be estimated using any statistical package. Model output is generally presented as:

$$y' = \beta_0 + \beta_1 x + \varepsilon$$

The mean WTP for a unit change in a particular management attribute is estimated using:

$$\widehat{WTP_i} = \frac{\beta_1 x_i}{\beta_{COST}} \ . -1$$

where the top line contains a statistically significant attribute parameter multiplied by the unit change in that management outcome, and the bottom line contains the parameter for the cost variable.

4. Benefit Transfer

Benefit Transfer is a set of methods for applying previously estimated values from a 'study site' to a 'policy site' of interest, that is, the area and environment effected by the incursion where no values are currently available. As conducting primary valuation studies can be time consuming and resource intensive, investigating the possibility of using a Benefits Transfer approach is worthwhile. Source studies may be found at the Environmental Valuation Reference Inventory (EVRI) in Canada (http://www.evri.ca/) to which the New Zealand Ministry for the Environment is a funder. Another source of potential studies is The Economics of Ecosystems and Biodiversity Valuation Database (http://www.teebweb.org). The main caveat to using BT is that, given the current limited availability of suitable source studies, estimates of WTP are unlikely to achieve equivalence with conducting a primary valuation study.

The basic-level approach is defined by a Unit Value Transfer including adjustments of source values as described below. A value function transfer is more complex and requires the expertise of a NMV economist. The general process in conducting a BT is given in Figure 8.

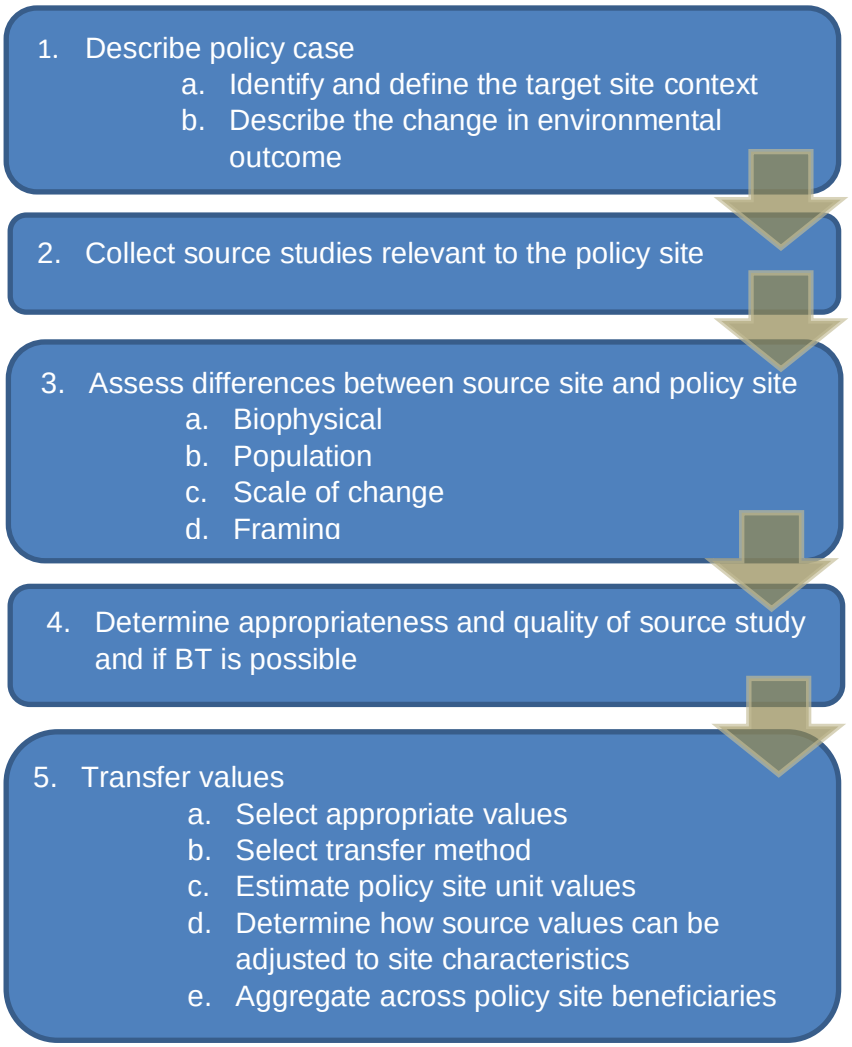

Figure 8 *Main Steps in Benefit Transfer Process*

4.1 Unit Value Transfer

The key steps in conducting a unit value BT are as follows:

- Find a value from a study site expressed as WTP per unit change in the environmental outcome of interest such as WTP for preservation of a relevant plant species, WTP for a change in water quality, WTP for recreational use. These are usually expressed as WTP per household or per person WTP, per year for a set number of years or as ongoing.
- Determine the relevant unit change at the policy site (i.e. the biosecurity impact on units).
- Multiply the unit value by the change in units at the policy site.
- Adjust source values for differences between policy and study sites; see value adjustments section below (S4.3).
- Aggregate unit values up to the total population of beneficiaries; see aggregation section below (S5).

This approach is the 'easiest' approach requiring only a low level of CBA expertise. It is the least reliable valuation approach and has been found to suffer large transfer errors. Values should be considered as indicative and are limited to demonstrating orders of magnitude and for filtering of value categories; if in-depth policy advise is required a more robust tailored approach is necessary.

Accompanying this guidance is an Excel-based template that facilitates a basic unit value transfer to be conducted. The template applies the simple adjustments detailed in the following section 4.3, and aggregation detailed in section 5. Rather than being relied on to provide a specific estimate of value the purpose of the template is to enable generation of a set of values as part of sensitivity analysis that can be used to suggest an indicative range.

4.2 Value Function Transfer

The function transfer approach is considered more appealing than simply transferring unit values because it allows differences between the study and policy sites to be accounted for in a more statistically robust manner compared to adjusting unit values. A value function is simply an equation that relates WTP for an environmental outcome to its determining factors that can be used to adjust values for study site characteristics e.g:

$$WTP_i = \beta Income + \beta Distance\ to\ nearest\ substitute + \ldots \varepsilon_i$$

Instead of simply transferring a unit value, this approach transfers the entire function from the study site over to the policy site. A value function is estimated from a single study site and can be from many valuation methods (Figure 1) including hedonic pricing, travel cost, production function, CV and CE. They can be the result of a single primary study, or the WTP equation can be estimated from the results of multiple studies to form a meta-analytic value function. The meta-analytic approach is able to represent and control for greater variation in policy site characteristics, beneficiaries and methodological aspects of primary studies. However it is uncommon in practice as a general lack of appropriate

primary studies and framing and methodological differences typically prevent estimation. Subsequently, no NZ meta-analysis are currently known to be available, although a limited number of relevant international meta-analytic value functions have been estimated including for wetlands, forests, and lakes.

The steps in this process are as follows:

- Obtain a meta-analytic value function for the environmental outcome of interest.
- Determine the relevant unit change at the policy site for the variables in the transfer function.
- Multiply the functions parameters by the unit changes at the policy site, and sum to calculate WTP.
- The WTP is typically expressed as per household, or per hectare for example and so multiply this WTP by the number of units effects at the policy site to calculate the value of environmental change.

4.3 Some Simple Adjustments for Source Values

A major focus of BT applications concerns how to appropriately adjust study values for the context of the policy site to which they are being applied. This section details some basic steps that can be applied to adjust for differences in incomes and price levels between study and policy contexts.

4.3.1 Price Level Adjustment

When transferring WTP values from past studies to the current time period, an adjustment should be made to reflect the effect of inflation on general price levels in the economy. The following formula can be used to adjust primary study estimates for changes in inflation over the time period between when the study was conducted and when the policy estimates are calculated:

$$WTP_{Policy} = WTP_{Study}\left(\frac{CPI_{Policy}}{CPI_{Study}}\right)$$

where:

WTP_{Policy}	= WTP at the policy site
WTP_{Study}	= WTP at the study site
CPI_{Policy}	= The value of the Consumer Price Index for the year of the policy site estimates
CPI_{Study}	= The value of the Consumer Price Index for the year of the study site estimates

4.3.2 Income Adjustment

Value function transfers that include income as an explanatory variable provide a way of adjustment. The following formula can be used to adjust primary study estimates for income differences:

Demand for goods and services generally increases in line with income. When transferring values, accounting for differences in income levels between study and

policy sites can be an important consideration to improve the accuracy of estimates.

Unit values can also be adjusted, using the following formula:

$$WTP_{Policy} = WTP_{Study} \left(\frac{Income_{Policy}}{Income_{Study}} \right)^{\rho}$$

where:

WTP_{Policy}	= WTP at the policy site
WTP_{Study}	= WTP at the study site
$Income_{Policy}$	= Income of beneficiaries at the policy site
$Income_{Study}$	= Income of beneficiaries at the study site
P	= Income elasticity of WTP

- The relevant income used in this adjustment should be consistent with the payment vehicle used in the primary study, typically either per household or per person.
- With this adjustment, WTP will increase at the policy site if incomes of beneficiaries are higher relative to those of the study site. The *income elasticity*[6] of WTP simply conditions whether WTP increases in the same proportion as rises in income, less than proportionally, or greater than proportionally
- Assuming that this elasticity is equal to one is reasonable in most cases. This has a convincing interpretation – respondents' WTP for a particular good is a constant share of their incomes, irrespective of what their levels are.
- It is also possible to make similar adjustments for other characteristics, such as gender, age, education etc., between the study and policy site populations. Applying several changes in this way is comparable to transferring benefits functions.

4.3.3 Future Values Discounting

When estimating the value of benefits over a time period into the future, those future values must be discounted back to the present day to allow for comparison with current costs and benefits. It is important to identify when costs and benefit are realised as these may differ, likewise both costs and benefits may be repeated or once-off. The following formula can be used to discount future values:

$$PV = \frac{FV}{(1+r)^t}$$

where:

PV	= the Present Value of the future stream of values
FV	= the Future Value estimate in year *t*
r	= the discount rate, NZ Treasury guidance recommends 4% and 6%

[6] Elasticities are ratios of percentage changes. In this case it is the ratio of the percentage change in income divided by the percentage change in WTP. If the ratio is greater than 1 then we can say that WTP is elastic with respect to income, and that WTP will rise (fall) faster than income rises (falls).

t = the number of years into the future when the value is realised

4.3.4 Differences in Scale and Substitutes

The majority of primary studies are framed at a relatively small spatial scale, so scaling up an impact from such a study site up to a larger policy site presents challenges. The main concern is in assuming that the marginal WTP values of interest (the WTP per unit change in the environmental outcome effected by the incursion) are constant over a large scale, which may not be correct. This is usually referred to as needing to account for differences in scale between study and policy sites. If an impact occurs at increasing scale two issues may become apparent: the impacted resource may become increasingly scarce; and/or the availability of substitute resources may decline. Conventionally, as a resource becomes more scare and/or has fewer substitutes, then the marginal value of the impact will be increasing. Unfortunately accounting for these effects can be problematic. A limited number of studies use value functions containing a parameter describing the effect of the number of substitutes on WTP, with WTP decreasing as the number of substitutes increases. For unit transfer, the adjustment approach is less clear on how to form an empirical adjustment factor when one is not available and instead relies on expert judgement in conjunction with biophysical assessment.

Using secondary data it may be possible to form a rough comparison of the extent of substitutes at the study site with that of the policy site. Consider for example the case of transferring WTP values for a change in water quality of a particular river from a region with many rivers (substitutes) to a policy site where there are many fewer rivers. In this case we might expect that the beneficiaries at the policy site may have higher WTP than those from the study site as they face fewer substitutes.

Similarly, using secondary data it may be possible to form a rough comparison of the scale of resource at the study site with that of the policy site. Consider for example the case of transferring WTP values for a change in lake quality for a relatively small lake, to a policy site lake that is relatively large (compared to the study site lake). In this case we might expect that the beneficiaries at the policy site may have higher WTP than those from the study site as they enjoy a larger quantity change in resource quality.

4.4. Summary

The selection of which BT approach to use, and if BT is possible, will be determined by the availability of relevant primary valuation estimates and the extent of differences between the source study and policy contexts. If a highly concordant source study can be found then applying unit value transfer can provide the most convenient and straightforward approach. If source study and policy sites are highly disparate then value function approaches should be used to facilitate adjustment of source values to policy site characteristics as much as possible.

To avoid over stating the reliability of any estimates, attention must be given to clear reporting of the process and assumptions used in the BT exercise. The central concern is to provide a sufficient level of transparency that allows the relevant values to be assessed by a non-expert. This requires clear detailing of all considerations in following the steps described in section 4 of Figure 8.

5. Aggregation

Aggregation is the process of taking the marginal WTP/unit values based on a sample, and applying them to form estimates for the population of beneficiaries.

- The choice of how many people are 'in the market' for the benefits provided by incursion response actions will have a significant effect on the magnitude of aggregate value estimates and so should be carefully considered and justified.
- The total number of people to aggregate up to is based on the extent of relevant beneficiaries from incursion action. Description of this extent should have already been undertaken in a qualitative manner in the first steps of conducting a NMV process. For aggregation purposes the quantity of beneficiaries must be determined numerically.
- In an NMV application where values are estimated for a single policy site, the distance from that site to a survey respondent's locale can be included in the analysis to identify the distance at which WTP falls to zero. This distance defines what is referred to as the economic jurisdiction, wherein reside the beneficiaries.
- In situations where defining the economic jurisdiction is not possible it is not uncommon to use political jurisdiction instead, which sometimes coincides with the geographic jurisdiction of funding institutions.
- One of the most relevant issues when aggregating marginal values, is whether there are differences between the sample and the population, either in preferences and/or demographics that would lead to differing WTP values. If the sample does not represent the population then aggregation could be biased.
- This underscores the need to try and increase representativeness when sampling; quota sampling for demographic representation is the most common method applied.
- It can be useful to form a range of aggregate values based on different assumptions about how many of the beneficiaries have the same preferences (WTP) as the sample of respondents.
- Response rates to surveys can be used to facilitate this approach using the following formula:

$$\overline{WTP_a} = {}^{1}/_{r+m}\left(\sum_{r} WTP_i + \sum_{m} a * WTP_i\right)$$

  where *r* respondents have answered the survey and *m* have not, *a* is the multiplier that expresses the non-respondents' WTP in relation to the WTP of the respondents. Using different multipliers in place of *a*, we can calculate WTP for different assumptions of non-respondents' WTP. If *a* = 1, non-respondents are assumed to have the same mean WTP as respondents and if *a* = 0, non-respondents are assumed to have zero WTP.

- The aggregate WTP can then be calculated as follows:

$$Aggregate\ WTP = N * \overline{WTP_a}$$

  where *N* is the number of beneficiaries.

6. Conclusions

Incorporating NMV of environmental impacts of biosecurity incursions can be problematic. The guidance contained here is intended to support someone with a relatively low level of NMV experience to carry out a basic BT or CV exercise. These are indicated as 'Basic BT' and Basic CV' in Figure 9. It also provides an overview of the essential elements of conducting CV, CE and BT that will enable those engaging with NMV practitioners, for procurement, or more generally, to participate more fully in the process.

Figure 9 summaries some main considerations for biosecurity response staff when deciding how to progress a NMV exercise. It reveals that for a basic analysis for the purposes of screening relative magnitudes of values, a basic BT or CV could be carried out in house at relatively low cost, in a short time frame, and not require a high level of expertise in CBA or NMV. The trade-off is that method robustness is relatively low. If these initial assessments reveal the need for fuller, more robust estimates to be formed, then the expertise of a specialised NMV practitioner should be sought.

Figure 9 *Valuation method scored against method robustness, required CBA experience, cost, and weeks to complete*

AERU

Agribusiness and Economics Research Unit

A Lincoln University Research Centre.
New Zealand's specialist land-based university.