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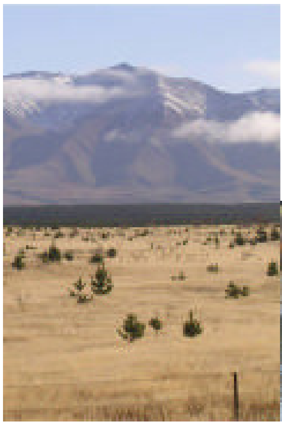
Biodiversity Valuation Manual

A technical manual for MAF BNZ

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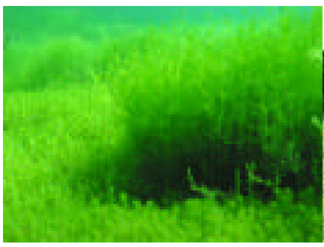


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Note on the revised version

This revised version brings the results into line with that published in Brian Bell's PhD thesis 2011. Compared with the Final version dated December 2009 the revised version has changes to the Freshwater case study that narrows the ranges of the environmental attributes (see Section 8.2.2).

Acknowledgements

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1 Executive Summary

A gap in information for decision-making

Decisions on economy–environment trade-offs face imbalanced information. Economic impacts are easily quantified comparing these to environmental impacts is complex.

Some of the most pressing problems facing New Zealand are at the margin between the economy and the environment. Impacts on the economy are relatively easy to quantify because there are market prices. Environmental impacts (such as changes in biodiversity) do not usually have market prices, and so are traditionally not quantified in money terms due to the complexity and time involved.

This is likely to result in underinvestment in the environment.

It is a tilted playing field if it is not possible to compare changes to the economy with changes to the environment in the same units. This imbalance of information is likely to result in underinvestment in the environment.

This manual begins to fill the information gap

The manual shows *how* dollar values for biodiversity can be *used* in decisions. The focus is on biosecurity, but it has wider application.

In this manual we start to fill this gap by showing how quantitative dollar values for impacts to biodiversity can be *used* for decisions[1]. The focus is on biosecurity decisions, and specifically cost benefit analysis (CBA), but the manual has wider application. It is relevant to any organisation with an interest in decision-making concerning biodiversity (e.g. the Department of Conservation (DoC) and regional councils, to name but two).

MAF BNZ's existing process for response decisions requires cost benefit analysis (CBA): This manual augments that process.

The Ministry of Agriculture and Forestry, Biosecurity New Zealand (MAF BNZ), has an existing Decision Support System (DSS) to support robust decisions about whether to respond to a new pest or disease. Part of the DSS is a requirement to estimate the net benefit of a response, using cost CBA.

[1] The manual does not set out a detailed methodology for deriving the values through choice modelling – that would be the subject for another much larger manual. The focus of this project was to establish a biodiversity values database, and a process for *using* the values in practical decision-making.

Regional council pest management decisions will also benefit from this manual as will broader natural resource trade-off decisions.

This manual is designed to be incorporated into this DSS. The manual also applies to pest management activities undertaken by regional councils, as they must also pass similar tests (e.g. CBA). The methodology is more broadly applicable to quantifying trade-offs between different natural resource uses; such as energy (wind farms), tourism (landscape values) and land use intensification (irrigation).

A process for including biodiversity passive values in decisions

The total economic value framework helps identify systematically the types of values relevant to decisions.

Value types can be described as active or passive use.

When undertaking CBA the aim is to quantify as many of the benefits and costs relevant to the decision as possible. The Total Economic Value (TEV) concept[2] provides a framework to systematically think through the range of values relevant to decisions. TEV divides value types into[3]:

- Active uses, including;
  - direct uses *e.g. industry*
  - indirect uses *e.g. recreation*
- Passive uses *e.g. existence or bequest values*

The manual focuses on incorporating biodiversity *passive* values into decisions, via:

- **A values database**
- **A process to assess values for decisions (benefit transfer)**
- **A process for using the values in CBA.**

Up till now MAF BNZ CBA has been based mainly on market prices of active use values. Indirect use values have been included, but not as a general rule[4]. This manual shows how to incorporate passive use values of biodiversity into CBA. We do this by setting out:

1. The beginnings of a database of biodiversity values.
2. A process to assess and select values in the database for new decisions - this is called **benefit transfer**.
3. A method for using these values in CBA, including how to model uncertainty.

[2] Developed by Environment Canada, it is increasingly being used as a framework for environmental economic analysis.

[3] Section 5.1 in the body of this manual discusses the TEV framework more fully.

[4] Indirect use values appear to be a gap in formal BNZ economic valuation and decision-making guidelines. Such values (e.g. recreation and ecosystem services) may be important and should be considered more systematically.

A biodiversity values database

Thirty-six biodiversity values derived from four case studies form the foundations of a Biodiversity Values Database (BVD).

Four case studies across different ecosystems have been undertaken to derive biodiversity values. These values form the foundations of a Biodiversity Values Database (BVD). The 36 value estimates across 11 different populations throughout New Zealand were derived using similar methodology (choice modelling). This forms a rich information base about the values people hold for various attributes ranging from the extinction of plants and animals to local removal only.

Values were derived using choice modelling (CM), a survey method that asks people their willingness to pay (WTP) for certain environmental outcomes.

Valuing changes to the environment requires indirect survey methods (unlike changes to the economy where market prices guide values). We used one such survey method, choice modelling (CM), to derive the values in the BVD.

It is NOT about the total value of an ecosystem or a species, but marginal changes related to impacts (e.g. from a pest, or wider programme).

These surveys ask people what they are willing to pay (WTP) for certain *marginal changes* to the environment. This is not about trying to determine the total value of an ecosystem or a particular species. We are interested in the value people attach to *impacts in the ecosystem* brought about by some change, in this case a pest. Because the focus was on quantifying *biodiversity impacts*, the values and the methodology are also applicable to site-focussed programmes as well as species-focussed programmes.

So we cannot say that a particular ecosystem is worth $x, but we can say people are WTP $y to improve the environment or avoid a deterioration in the environment.

CM also provides non-monetary estimates of value, helping to overcome objections to valuing biodiversity in dollars.

A major advantage CM has over the alternative method, contingent valuation, is that CM also provides *non-monetary* values of environmental attributes. These are called the marginal rates of substitution (MRS) of one attribute for another. We can, for example, say that people value extinction of a species at 10 times that of local loss of a species. This helps to overcome a major objection that some ecologists have of the use of economic tools to value biodiversity.

WTP values are akin to market prices, but are they real? Yes: They are being used in the real world to justify taxes and to inform court decisions.

The WTP concept is the equivalent of the market price. But how real are the WTP values? It is difficult to verify whether stated WTP in a hypothetical situation would be backed up by actual payments in a real situation. But there are examples of WTP studies being used to justify special taxes for environmental policies that are then accepted by communities[5].

But good decisions require an understanding of the context WTP values were derived in. The process to do this is *benefit transfer (BT)*.

So WTP is real, but because it cannot be estimated directly in a market, the context in which it is derived is important to understand whether and how the values can be used for decision-making. The process of assessing this context is called benefit transfer (BT).

A process for judging if values are appropriate - Benefit transfer

BT uses existing information in new situations; and, as it is much cheaper than full CM, is utilised more often.

BT is about applying the results of an existing study (study site) to a new situation (policy site). It is therefore relatively quick and less expensive to carry out than primary CM studies; however, it is complex process and is still an evolving discipline. So careful case-by-case analysis is required to carry it out effectively.

The BT process compares the original research to the new situation to see whether WTP values can be transferred with confidence.

The BT process involves comparing key features of the original research with the new situation. The aim is to determine whether transferring WTP values will be accurate enough to give confidence to decision-makers in the information.

Assessments are made in three core areas :

- **Physical site characteristics.**

  Environmental impacts measured at the study site are compared with impacts expected at the policy site. For this project, the impacts measured were biodiversity impacts caused by pest incursions.

[5] For example, a special tax was implemented in Lake Rotorua based on community WTP to improve water quality. Overseas, stated preference studies help inform environment court decisions, particularly when environmental degradation is involved. These studies go back to the famous Exxon Valdez oil spill case. Recently, benefit transfer was used in the New Zealand Environment Court to inform decisions on water allocation for the Waitaki Catchment.

Comparisons are made in three areas:

- **physical site impacts**
- **population features and**
- **how the CM survey was formulated and carried out (framing issues).**

- **Population characteristics.**

  Socio-demographic characteristics (SDCs) and other attitudinal factors are compared between both the sample and wider population at the study site and the relevant population at the new policy site. Any differences are assessed to see whether they would have a material impact on the values that people hold.

- **Framing issues.**

  'Framing' refers to how the CM study has been formulated (framed) and carried out. It is very important to understand how values are estimated in the underlying primary studies before attempting to transfer values to a new situation. If benefit transfer is to be used it is important that state-of-the-art methods are (or have been) used in designing the original CM surveys[6].

  There are a range of issues to be considered here; including scale (e.g. local, national), scope (e.g. single species, species abundance), welfare measures (e.g. WTP payment vehicle used), and wider contextual issues (e.g. economic conditions). Section 6.1.4 explains these issues more fully.

Seeking original research that is similar to the new situation is important to reduce errors in the transferred WTP values.

For each stage of the BT process there is the risk that there will be errors in the values transferred. Together these errors can be significant. The fundamental principle for improving reliability and validity of benefit transfer is "more similar is better".

Errors in the science can be significant too. Careful judgement by the analyst and involvement of relevant science and economics experts is required to carry out BT effectively.

Lying behind the biodiversity value estimates is a huge body of peer reviewed literature embodying theoretical sound concepts, such as utility theory and statistical significance. But how the science is applied is just as important to the final result. Often the uncertainties in the science may be even larger than in the economics.

Careful judgement by the analyst is therefore crucial, and should involve the relevant ecological scientists and environmental economists.

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[6] Critical issues in conducting choice modelling are touched on throughout the manual, so that any future CM surveys are well designed to ensure robust information is obtained that would be amenable for future benefit transfer. The vision is that the biodiversity values database will be built up over time with high quality data.

Ultimately it is about delivering information that is appropriate for the decision at hand; this may not require precision.

Ultimately it is about what information is critical for decision-makers. Decision-makers do not always require precise estimates of value. Often they seek a high level understanding of what values are likely to be material to the final decision, and what the order of magnitude of those values are.

Communicating the limits of the estimates and the level of uncertainty is paramount.

In using WTP values and BT the most important role of the analyst is to strive to minimise bias and provide independent and objective advice about the limits of the estimates and the uncertainty that surrounds them.

The BT process can also help inform the direction of future valuation work. Then as the BVD is further developed, it will become increasingly aligned with the priorities of decision-makers.

The BT process may also help end-users of the BVD see where future CM surveys should focus to ensure BVD values align with strategic decision-making priorities. Helpful questions might include:

- What situations do the values in the BVD cover?
- What is not covered?
- Where do any gaps align with priorities of decision-makers?

Incorporating values into Cost-Benefit Analysis

Incorporating WTP values into CBA uses the concept of compensating surplus (CS).

The third major component for using the WTP values in decisions is the process for incorporating those values into CBA. This can be done using the concept of compensating surplus (CS).

CS means how much money (compensation) would make someone indifferent to a change. Summed across society this reflects the benefit of preventing that change.

CS is the amount of money required to compensate a person for a change (e.g. pest impact) that would leave that person indifferent to the change. When summed across all affected persons, it provides an estimate of benefit to society from an action that prevents the change (e.g. a response to the pest incursion)[7].

[7] Section 8.1 sets out how to estimate CS using the values in the BVD, and how to use CS in CBA. Section 8.2.1 provides a worked example. The shorter 'Primer' that accompanies this manual also sets out these steps.

Reflecting uncertainty in WTP values is most simply done by using confidence intervals instead of point estimates.

A simple way of recognising uncertainty around WTP values is by using orders of magnitude of WTP values rather than point estimates only. In other words, the 95% confidence interval around the mean WTP value[8].

These orders of magnitude values can also be modelled in CBA using risk simulation.

These orders of magnitude values can also be modelled in CBA using risk simulation (e.g. using QuRA™) [9]. Section 8.2.2 and the shorter Primer outline how this can be done, and a worked example is provided.

Incorporating these values into the MAF BNZ DSS

Passive biodiversity values are relevant at two points – investigation and CBA.

At the investigation stage high level values are needed in rapid timeframes – BT should be used here.

At the investigation stage values are required over short timeframes as input into quick calculations on impacts. These estimates contribute to decisions on whether the pest is likely to be nationally significant and therefore detailed analysis is required, or that no action need be taken, or a range of actions in between. The BT process using estimates in the BVD is appropriate for this stage. Another concept – value bands - has potential for *future* use at the investigate stage; this is discussed below.

If the pest is significant enough that full CBA for the business case is needed, BT may be used if the WTP values are deemed accurate enough. But if not, a full CM study may be required.

Should the pest be deemed significant then a business case analysis is undertaken which includes a full CBA. The time between investigation and preparation of a CBA can be anywhere between one and seven months. This is enough time to undertake a primary study should investigation show that the pest is likely to be significant and there are no appropriate values in the BVD for decision makers to have confidence in the BT results. Otherwise the BT values from the database can be used as input into the CBA.

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[8] For further explanation of statistical terms used in this manual refer to Section 5.3.

[9] Nimmo-Bell has developed a standard approach to risk simulation called QuRA™ (Quantitative Risk Analysis), that utilises @RISK (risk simulation software for Excel) to generate distributions of key risky variables and incorporate these into a distribution of the NPV of the project (Bell 2000).

A new concept for the future – Value bands

'Value bands' is a new concept that has potential for *future* use. The idea is that similar types of environmental values could be grouped into broad WTP bands for high level, rapid use at the investigation stage.

'Value bands' is concept that has potential for use in the future at the investigation stage. This idea looks at whether there are generic trends across 'similar' types of environmental values[10]. If so, could the values be categorised and grouped (along with their confidence intervals) into broad bands? If this were possible, it would provide high level bands of WTP values that could be rapidly used at the investigate stage.

There is not yet enough data to make firm conclusions. Still the idea has promise. Further analysis is needed when more data is available.

At this point we only have a few comparisons to draw on. While our research shows the concept has promise, it is too early to make firm conclusions. More data is needed to test the idea before it can be used for real life decision-making.

That said, we did find some statistically significant ballpark relativities that could prove useful at the investigation stage[11].

We recommend the idea is revisited in the future.

We recommend that BNZ first gain practical experience with using this manual. Then, over time, as more data becomes available, that the concept is revisited in the future.

Concluding comment

CM and BT have an important role to play in enhancing decision-making.

Our concluding comment - as we look back on the wider project that led to this manual - is that, there exists a key role for CM and BT to contribute to more informed decisions in a policy environment that is full of uncertainty. Primary studies will always be better than BT studies, but there is a role for the latter when time and budgets are constrained.

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[10] For example, are WTP values related to birds similar across ecosystems?

[11] For example, people generally considered the local loss of a bird species was worth about 10% that of extinction of a bird species. Refer to Section 7 for further examples and discussion.

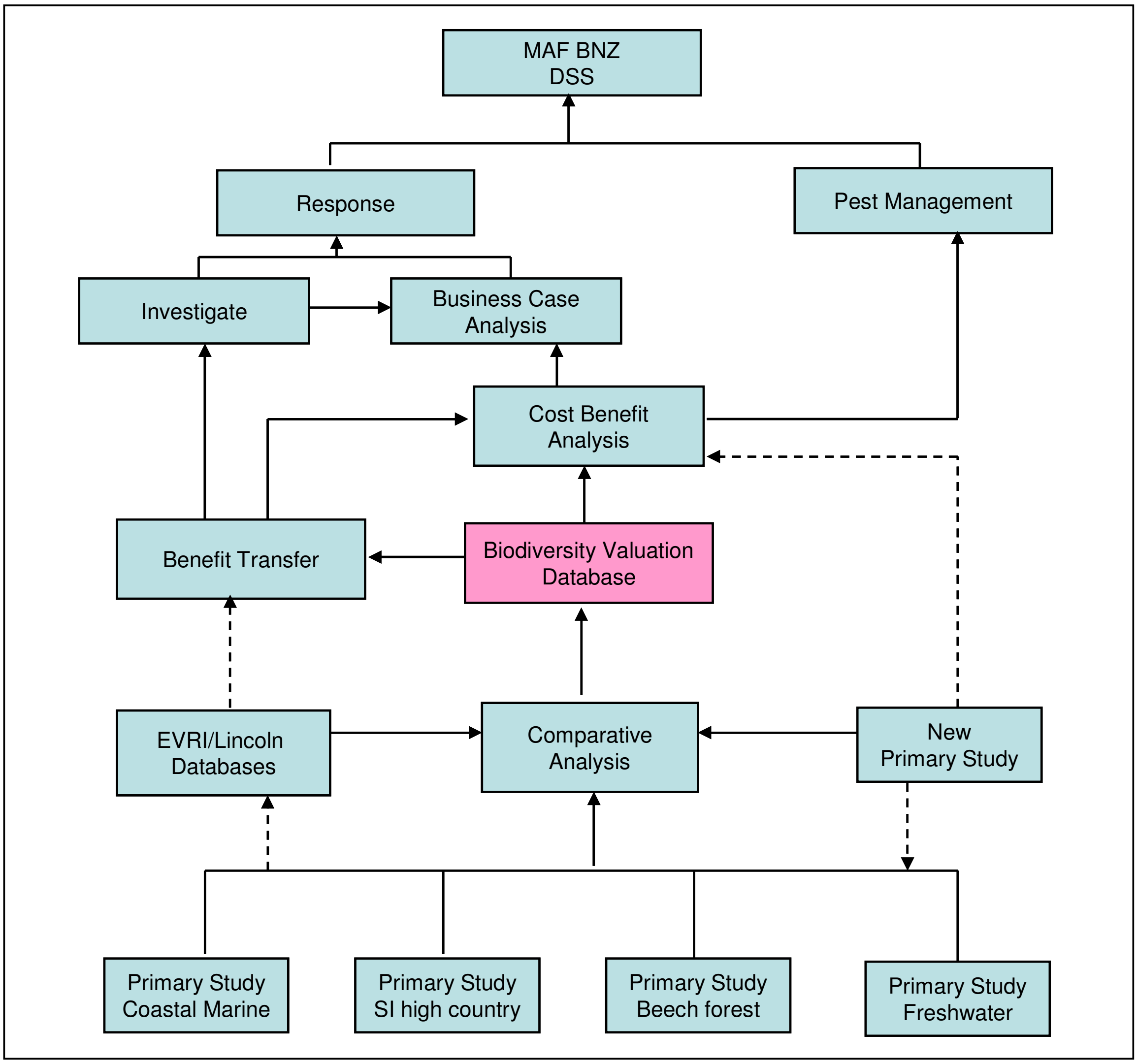
While they are still inexact tools, they sit alongside a whole range of other uncertain information that is part of the decision-making process already.

While uncertainties exist in non-market valuation, the information generated is only one component of the decision-making process, sitting alongside a range of other uncertain information (scientific, market, etc). In addition to providing quantitative values, non-market valuation can help by clarifying trade-offs, identifying magnitudes of directions and effects, and providing new insights (e.g. identifying new stakeholders).

Providing that state-of-the art methods are used and any limitations are clearly identified, the decision-making process will be improved.

Figure 1 below summaries the process of incorporating biodiversity values into Biosecurity New Zealand's decision support system.

Figure 1 Incorporating biodiversity values into the BNZ DSS



Starting at the bottom:

- Biodiversity values from a [Primary Study] are incorporated into a [Database of Values] after the individual survey data has been subject to a [Comparative Analysis].
- The primary studies also contribute to the [EVRI] database, which can also be drawn on to contribute to the database of values.
- A [New Primary Study] adds to the relevance and wider applicability of the database.
- Values in the database are used via [Benefit Transfer] to assist in decisions at the [Investigate] stage of a [Response].
- If the response develops into a significant event then the values can also contribute to the [Cost Benefit Analysis] undertaken as part of the [Business Case Analysis].
- Contribution to CBA is either via benefit transfer if the values are applicable to the event or from a new primary study.
- Values also contribute to [Pest Management] decisions in a similar way.

2 Preface

In 2004 Nimmo-Bell was asked by MAF BNZ to survey the international literature on valuing biodiversity for biosecurity decision making. The resulting report (Bell & Kaval 2004) found no useful work that BNZ could draw on. After discussions with BNZ, Nimmo-Bell applied for a FRST grant to undertake the necessary work. The application was successful and work on project NIMMO501 Valuing Biodiversity, a four year programme of research, commenced in October 2005.

The team consisted of Brian Bell as team leader and science manager (a Director of Nimmo-Bell) assisted by Sharon Menzies, Michael Yap and Charlotte Cudby, consultants in Nimmo-Bell. In addition, the team was augmented by academics from Waikato University – Professor Frank Scrimgeour, Dr Pam Kaval and Professor Riccardo Scarpa, Lincoln University - Associate Professor Geoff Kerr, and Auckland University – Dr Basil Sharp.

3 Introduction

3.1 Objectives of the manual

Our objective is to provide biosecurity managers and analysts with the tools, data and process to incorporate biodiversity values into biosecurity decision making and guide their use.

We see a number of key areas where biodiversity values can aid biosecurity decision making: including;

1. for assessing the risks associated with species not yet in New Zealand;
2. for surveillance decisions;
3. for rapid response to incursions of exotic pests and diseases; and
4. for routine decision making on the management of established pests and diseases.

The focus of the manual is on **Response** decisions, which can be further broken down into the **Investigation** phase when high level information is needed to make the initial decision on whether the pest or disease warrants attention beyond the initial response and then during the detailed **Cost Benefit Analysis (CBA)** phase of major response programmes.

Biodiversity values have relevance to decisions beyond biosecurity and this manual is applicable wherever such values are required. Examples include resource allocation decisions on conservation programmes in the Department of Conservation, land use change and water policy decisions by regional councils, and also the Ministry for the Environment and MAF Policy.

This manual is about how to incorporate biodiversity values into CBA (specifically passive use values; explained in Section 5). It does not describe a detailed methodology for deriving the actual values themselves. That would be the subject for another much larger manual. This manual does, however, set out – at a high level - the process by which biodiversity values were generated for the four case studies that form the foundation of a database on biodiversity values for New Zealand. We then show how the values can be incorporated into the decision making processes in MAF BNZ.

3.2 Outline of the manual

Section 4 briefly describes the context, structures and processes of current biosecurity decision making and identifies where and how biodiversity values can inform these decisions through augmentation of the existing Decision Support System (DSS).

In Section 5 we introduce the concept of Total Economic Value (TEV) drawing attention to passive use values of biodiversity which break down into bequest and existence values. We then briefly survey the tools that are available to estimate passive use values and elaborate on choice modelling, which is the preferred tool. We also define key statistical terms used throughout the manual.

In Section 6 we introduce the concept of benefit transfer, which is the process for utilising values from past studies in new studies, and show how values can be made accessible through an international database of values, the Environmental Valuation Reference Inventory (EVRI), as well as its New Zealand equivalent maintained by Lincoln University. The Biodiversity Values Database (BVD) is then set out in a number or tables covering; the values themselves, important statistical data, and supporting information to help interpret the different attribute types and samples. This section is concluded by an elaboration of the practical issues that need to be addressed to ensure appropriate use of the values.

Section 7 discusses a new concept called 'value bands' that has potential for *future* use at the investigation stage, but for which there is not yet enough data.

Section 8 details how the values are incorporated into decision making during the investigation and detailed CBA phases of a response. We note that this approach is also applicable for more routine decision making for the management of existing pests and diseases. A worked example is used to illustrate how the method would be applied. It goes through the steps of estimating compensating surplus from point estimates of biodiversity values. It then extends this by incorporating the probability distributions associated with each biodiversity value to give the probability distribution of the Net Present Value (NPV) of a response.

The last section (9) makes some final comments and suggests the next steps in the valuation of indigenous biodiversity. The emphasis is on ensuring future studies add value to the database and broaden the range of biodiversity values in a consistent way for use in CBA.

Annex 1 introduces the four case studies (coastal marine, South Island high country, freshwater and beech forest) that have been used to estimate biodiversity values. We highlight the special features of each study and detail the results that are relevant to improving the DSS.

4 Decision making on pest management

4.1 BNZ Decision Support System

MAF BNZ has responsibility to lead incursion responses to exotic pest and diseases where there are significant public benefits of doing so (e.g. the Painted Apple Moth incursion). MAF BNZ led responses also include long-term control of established organisms.

The aim is to achieve the best overall outcome for New Zealand by minimising the net impacts of both the risk organism and the response method (e.g. a spraying programme) on things that people value (e.g. the environment, industries) within an agreed decision framework. The process needs to be completed in a timely way with the best scientific and other information, recognising that uncertainty should not delay action. Emergency management approaches follow the four R's of risk management: reduction, readiness, response and recovery.

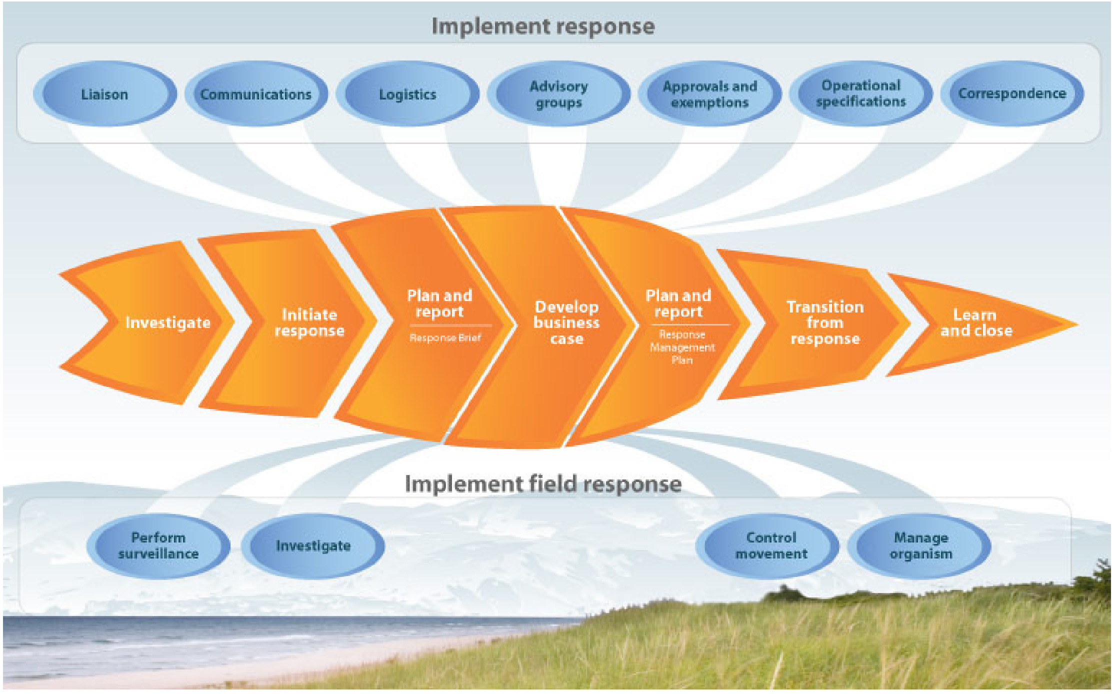
Value criteria for assessing benefits and costs cover the full range of effects across all sectors; in particular, human health, economic, socio-cultural, environmental and Maori values. How these are categorised for economic analysis is outlined in Section 5.

In July 2008 Cabinet approved a new biosecurity response policy that set out the processes and analytical tools to ensure an appropriate response is undertaken. (http://www.biosecurity.govt.nz/bio-strategy/library/policy-incursion.htmn). This replaced the Biosecurity Council policy statement on responding to an exotic organism incursion announced in September 2001.

Figure 2 (over the page) sets out are the essential features of the general response process[12]. The process maps and procedures that underlie the response policy are contained in a document titled "response model", which is referred to as the rocket ship (see Figure 2). For each task that needs to be completed e.g. develop response options working paper, assess impacts of options etc, there are processes (process maps), policies, guidelines and templates to assist people in completing these tasks.

[12] Thanks to Kelly Dustow, MAF Policy Analyst (Economics), who led me though this process. The names within brackets (<<*name*>>) refer to documents in the system.

Figure 2 The rocket ship: A model of the response process



Source (MAFBNZ 2007)

We have reviewed this updated policy, process and tools and concluded that the new MAF DSS on response provides international best practice on the policies, processes and guidelines for decision making on allocating resources. However, there are two facets where further development could improve the information available to decision makers:

1. Utilisation of stated preference techniques to quantify the benefits of response programmes where environmental impacts (including on indigenous biodiversity) are significant. This can be broken down into:

    a. High level values derived from benefit transfer for use at the **Investigation stage** and

    b. Use of either benefit transfer or primary choice modelling studies at the full CBA stage (part of **Develop Business Case**).

2. Using risk analyses to more clearly demonstrate the likelihood of different outcomes, and in particular the probability that a response will have a positive welfare effect for society.

The remainder of this manual elaborates on these two points.

4.1.1 Investigate

When a response is being investigated (first step of the rocket ship), there is a template that must be filled out called the "rapid assessment report" to help determine whether to initiate a response or not. This report includes a risk assessment which sets out current knowledge on potential adverse impacts to human health, economic, environmental and socio-cultural values from the pest. Currently this is done by analysts in the field, with MAF BNZ becoming involved later at the Develop Business Case stage.

As part of the risk assessment, field analysts currently undertake a rough quantitative calculation of market / trade impacts, with environmental, health and cultural issues assessed qualitatively (e.g. simply noting a low, medium or high impact). ***It is here that high level values of environmental impacts could be utilized from benefit transfer studies.***

That said, benefit transfer ought to be conducted by a qualified economist, because the risk of applying the values incorrectly is high. So it is appropriate that BNZ economists become involved at the Investigate stage of the 'rocket ship' process. This may also provide an opportunity to front-load the later CBA stage by identifying relevant information needs and any gaps. Furthermore, applying transfer values at this early stage may highlight that a primary choice survey may be required for the full CBA (this is discussed in Section 6.1.1). This will enable the necessary work to design a choice survey, to begin; as such surveys typically have long lead times (6-12 months).

Section 7 explores a concept called 'value bands' that also has future potential for use at this stage, however, it is too early to draw firm conclusions on the concept. The idea needs further data to be tested.

Figure 3 Investigate

Source: (MAF BNZ 2007)

4.1.2 Develop Business Case

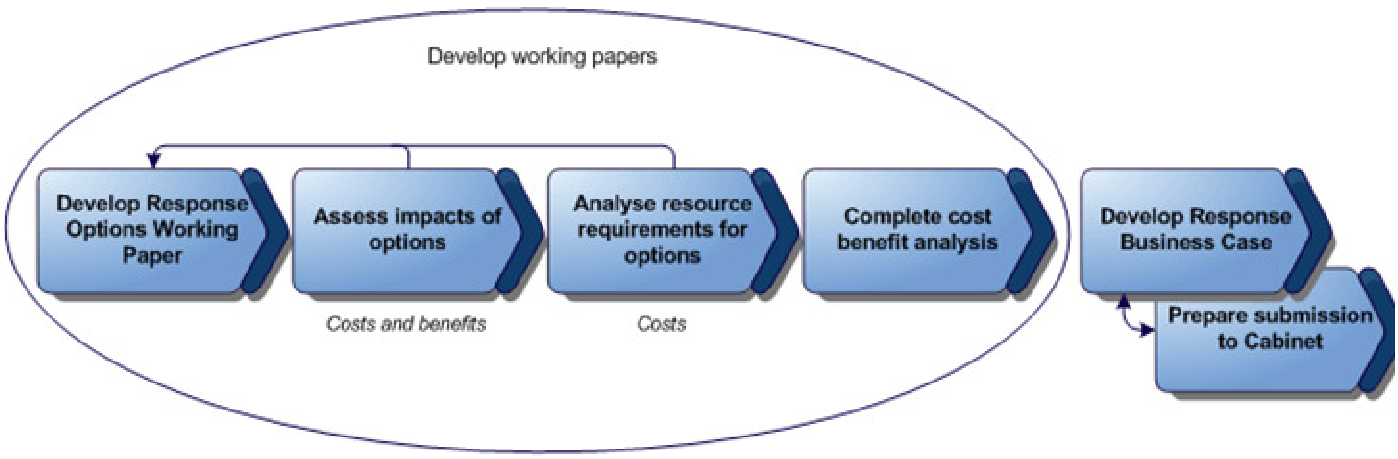
From here a response team is set up and the response moves into the second and third parts of the rocket ship (initiate response and plan and report) where a "response brief" is completed to:

- Clearly state the biosecurity risk to values that triggered this Response Brief.
- Articulate the outcomes the response is trying to achieve.
- Define the approach and resources required to run this response, until a Business Case is approved, including:
    - Developing the Business Case.
    - Implementing interim measures to ensure the response outcomes are achievable.
    - Obtaining Response Strategic Leadership's approval for the resources and funding required to proceed with this work.

After this phase the business case is developed (see Figure 4) using the following templates: "response-business-case", "response budget working paper – summary", "cost-benefit-analysis", "response-options-working-paper". Guidelines on how to use these templates are provided in the "response model" document above. The steps in this process relevant to this manual (refer Figure 4) are:

- assess the impacts of options (costs and benefits); and
- complete a cost benefit analysis.

Figure 4 Develop Business Case



Source: (MAF BNZ 2007)

4.1.3 Cost Benefit Analysis

The CBA guidelines in the response model for unwanted organism or pest response options are dated 2002. They comprehensively detail the steps required to undertake a robust analysis.

However, it is often the case that time constraints mean that a primary economic impact assessment (EIA) or CBA is not undertaken and data from comparable studies are modified for the new situation. This occurred with Varroa and Sabella. Where quantitative information is not able to be estimated, a breakeven analysis may be employed. This estimates the quantum of benefits required to cover the costs. A qualitative assessment is then made as to the likelihood of this occurring.

The valuation of effects is a key component of the CBA and the guidelines cover stated preference techniques, which are the standard way environmental benefits can be quantified. The guidelines note that these techniques are expensive and time consuming with estimation of Willingness to Pay (WTP) complex and often contentious. The guidelines also recommend that the assistance of research providers with expertise in the area is sought when it is necessary to undertake such studies. Our experience with choice surveys supports this recommendation.

This manual augments this particular part of the CBA guidelines, by providing a holistic framework (total economic value) to help break down economic assessment of environmental impacts in a methodical way. In addition, Sections 6 & 8 provide an alternative to using primary stated preference techniques – benefit transfer – including setting out the process for assessing whether conducting benefit transfer is appropriate or whether a primary study is required.

Where benefits and costs can be quantified, a discounted cashflows analysis is undertaken with a standard project life of 20 years. The standard Treasury[13] discount rate of 10% is applied to estimate the Net Present Value (NPV) and Benefit Cost Ratio (B/C) of the control option. But the guidelines note that overseas studies often use a discount rate six to eight per cent and it is sometimes suggested that a much lower rate (or even zero) may be applied to non-commercial or social effects. The guidelines state that the preferred approach is to explicitly model increasing values of annual cost or benefit rather than apply a lower discount rate.

Uncertainty is handled through what-if, sensitivity and scenario analysis, while the guidelines advise that risk analysis be undertaken by research

[13] The Treasury's standard methodology for Cost Benefit Analysis and methodology for estimating public sector discount rates can be found online at http://www.treasury.govt.nz/publications/guidance/costbenefitanalysis/primer. http://www.treasury.govt.nz/publications/guidance/costbenefitanalysis/discountrates.

providers with specialist expertise. **Quantitative risk analysis using risk simulation is a logical extension of the analysis to better inform decision makers of the likelihood of a positive NPV or that the B/C ratio hurdle is likely to be exceeded (Bell 2000).**

Timeframes to undertake an EIA or CBA vary depending on the urgency to make a decision and could be as short as one week for an in-house analysis. A minimum of three months is normal if the analysis is contracted out even if the analysis is based on a previously prepared CBA.

Once a draft EIA or CBA has been prepared there may be a number of revisions as more information becomes available on the cost of response options or impacts.

Table 1 provides a list of the economic impact assessment studies undertaken since 2000 and ranks them according to the level of impact assessed after converting each to 2007 dollar values (where 1 is highest impact and 5 lowest impact). This comparison is based largely on quantitative assessments which focus on impacts on industry such as agriculture and forestry. Impacts on indigenous biodiversity are mostly not quantified and thus have a lesser weight in the rating. Were biodiversity values incorporated into the economic impact assessments this may have changed the ranking in the table (potentially significantly) thus may have affected resource allocation. There is the potential for mis-allocation of resources if environmental values are underweighted.

Table 1 Comparison of Economic Impact Assessments

Ranking	Year study undertaken	Economic Impact Assessment
1	2005	Clover Root Weevil
	2001	Red Imported Fire Ant
2	2007	Asian Tiger Mosquito
	2000	Varroa
	2002	Painted Apple Moth (reassessment)
	2006	Didymo
	2004	Asian Gypsy Moth (revision)
3	2005	Pitch Canker
	2007	Equine influenza (updated)
	2004	Dutch Elm Disease
	2003	Gum leaf skeletoniser
4	2005	Styela
	2001	Mycoplasma mycoides
5	2003	Fall webworm (revision)
	2002	Brucella suis
	2007	Orange fruit borer

Source: (MAFBNZ 2008)

While there is often extreme pressure to complete an EIA or CBA the process from Options Analysis to Business Case can extend for a number of months (Varroa revision 2 months, Kauri dieback 5 months and Sabella 7 months). This provides an opportunity to undertake a more thorough analysis if the need is identified early in the response process.

Documents are handled in the Enterprise Content Management System (ECMS) and all staff are provided with training on how to use it. The file structure is at the top level by business function with a few basic rules under a Microsoft shop with Office desktop. Stand alone systems that need supporting use the Incursion Response System (IRS) while standard document and spreadsheet files are managed within folders via the ECMS.

4.1.4 Conclusion

Biodiversity values can augment the MAF BNZ DSS as follows:

		Section in Manual
Investigate	Benefit transfer values, using the BVD	5, 6 & 8
	Value bands concept *(potential for future use)*	7
Develop Business Case (CBA)	Benefit transfer values, using the BVD	5, 6 & 8
	Primary choice survey	n/a[14]

4.2 Regional Councils

Regional Councils have the responsibility to undertake a CBA when a pest or disease is to be accorded status under a Regional Pest Management Strategy. These studies are mostly undertaken by consultant as councils are generally not resourced to do this work in-house. There appears to be little coordination between councils on undertaking CBA. As a result the quality and comprehensiveness of such studies is variable. They typically focus on quantifying market costs and benefits and thus the same issues arise as with MAF BNZ's analysis. Under the Biosecurity Act (1993), the MAF CBA guidelines for response should apply to pest management, but these are applied inconsistently. Occasionally MAF BNZ is asked to comment on these CBA.

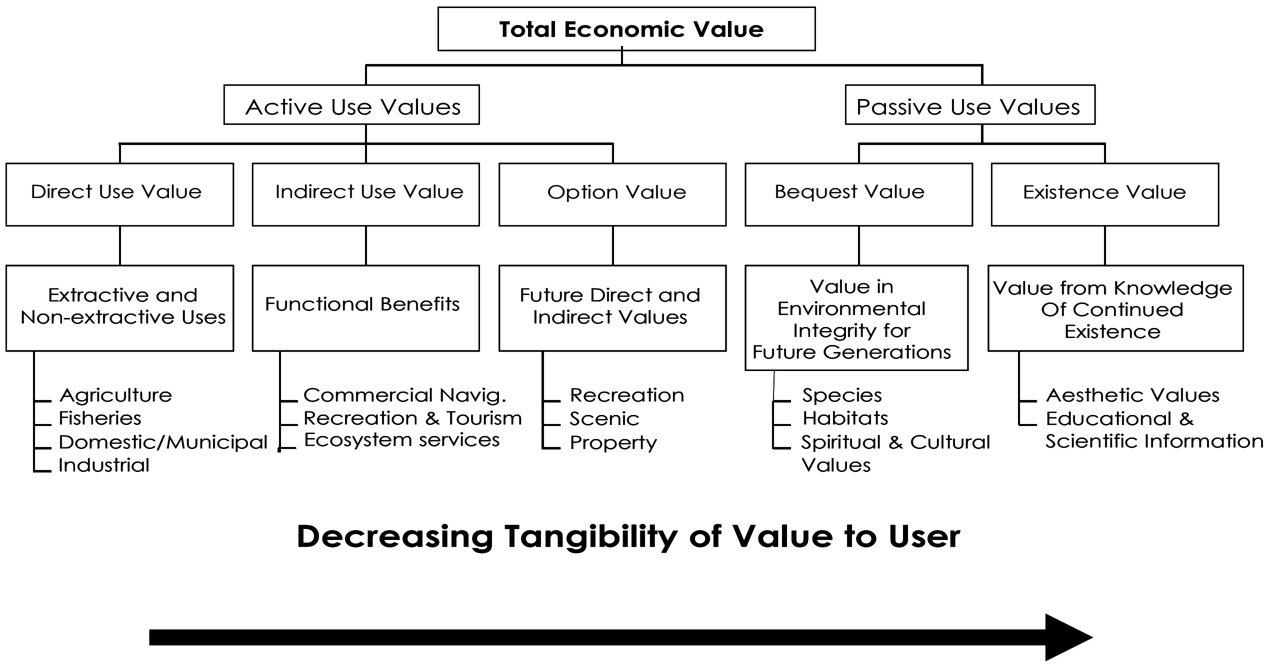
[14] Sections 5 and 6 provide *insights* into issues that must be considered in designing and conducting a primary choice survey to facilitate future benefit transfer and use in the BVD. But this manual does not outline how to carry out a primary choice survey.

5 Estimating values

5.1 Total economic value

When undertaking CBA of a response option the aim is to quantify as many of the benefits and costs relevant to the decision as possible. The Total Economic Value (TEV) framework, shown in Figure 5, illustrates the range of values relevant to decisions.

Figure 5 Total Economic Value



Source:(EVRI 2009)

Typically however quantification is limited to those costs and benefits for which there are market prices; these are usually the direct use values shown in Figure 5. It is relatively easy to quantify market impacts (e.g. impacts to farming, industry), but much more difficult to quantify non-market impacts (e.g. impacts to recreation, habitat, native species). It is the nature of decision making that quantitative information seems to receive greater weight than qualitative information and thus the imbalance is likely to result in decisions that under invest in areas where the benefits are difficult to quantify, such as the environment.

The CBA guidelines currently only cover direct use values. This manual is about extending quantification of indigenous biodiversity impacts to encompass more components of Total Economic Value (TEV), primarily on passive use values[15] (and partially option values; this is explained further below). The TEV of indigenous biodiversity spans both active and passive uses, but it is the passive uses that, to date, have been the most difficult to quantify and incorporate into decision-making.

This manual does **not** specifically cover indirect use values, the remaining strand of TEV. MAF BNZ does, however, assess indirect use values on an ad-hoc basis where these values are deemed to be relevant. To date, different methods have been employed[16]; such as travel cost for recreation, and the use of timber value as a proxy minimum value for Kauri. This remains a gap in the formal guidelines that MAF BNZ may wish to address.

When quantifying passive use values, it is difficult to separate out the individual components; such as bequest, existence, aesthetics, spiritual/cultural values, and even option values. This is because spiritual and cultural views influence how individuals respond to choice surveys. Similarly the choices respondents make in the survey (e.g. preferences about bird species) will be influenced by how they perceive ecosystem aesthetics to be affected by birds[17]. Developments in choice modelling methodology are increasing practitioners' understanding in this area (for example, choice surveys that explore preferences for intergenerational equity), but it is too early for practical application.

Because of this, these passive use values can be thought of as one, because we use the one tool – choice modelling - to provide estimates of community values for these types of benefit.

A concluding comment about TEV as applied to ecosystems. Valuing biodiversity is about marginal values rather than absolute values. We are interested in the magnitude of the values communities place on changes in the environment, not the absolute value of the environment per say. We cannot say that a particular ecosystem is worth $x, but we can say people are WTP $y to improve the environment or avoid a deterioration in the environment. The key with aggregating values for CBA is to identify the range of impacts the pest is likely to have on the environment, and to ensure that values for the CBA are matched to those impacts. This is explained further in Section 6.1.2.

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[15] Note we do not refer to passive values as non-use because passive use may preclude or allow active use.

[16] Section 5.2 touches on these methods, and the databases noted in Section 6.2 may also contain useful studies that BNZ could draw on for indirect use transfer values.

[17] That said, this is not the same as quantifying aesthetic values specifically e.g. related to landscape changes brought about by a proposed wind farm development. In order to make trade-off decisions in that context it would be more appropriate to carry out a choice modelling survey specifically targeted to landscape aesthetic changes.

5.2 Tools for estimating non-market values

There are basically two non-market valuation tools used to quantify passive use values and these are **contingent valuation** (CV) and **choice modelling** (CM). Both tools fall into the category of **stated preference** techniques, where people are asked to state their preferences for different states of the environment. Choice modelling is a tool which can quantify multiple environmental and social values in one survey, thus providing more objective information on what New Zealand society is willing to trade-off (and what they are not) to achieve environmental improvements or stop degradation.

The other main branch of non-market tools are referred to as **revealed preference** as respondents reveal their preferences through their actions:

1. the **travel cost method** adds up the costs people undertake to enjoy something, such as travel to a national park for recreation and scenic values, and
2. **hedonistic pricing** which uses the price differential between property with particular features and those that don't have that feature to value it e.g. the value of scenery.

Another class of valuation tools used to value ecosystems for their active use uses market prices indirectly by applying the **opportunity cost principle**. The value of **ecosystem services** such as those provided by a wetland is the cost of providing the function through other mechanisms e.g. a water purification plant.

Both revealed preference and opportunity cost techniques are currently employed in CBA by MAF BNZ, mainly for indirect use values. As neither revealed preference nor the opportunity cost approach is suitable for valuing passive use, they will not be discussed further in this manual.

Of the stated preference techniques CM has a number of advantages over CV, the most important of which is in regard to framing effects (a subject that will be dealt with in Section 6.1.4). CM also provides non-monetary values of environmental attributes, which overcomes a major objection that some ecologists have of the use of economic tools to value biodiversity. Furthermore, the closer values are to faiths or beliefs the less relevant dollar values become. These non-monetary values are called marginal rates of substitution (MRS), which described the rate at which people are willing to substitute one attribute for another. We can, for example, say that people value extinction of a species at 10 times that of local loss of a species.

This manual does not attempt to set out the detailed methodology for undertaking a choice modelling study as this should be undertaken by a non-market valuation specialist. For those wishing to know more about CM there are a number of texts (Bennett & Blamey 2001; Champ *et al.* 2003; Hensher *et* *al.* 2005; Kanninen 2007) and the course run by Hensher *et al* at Sydney University, both provide an excellent introduction to the theory and practice.

5.2.1 Choice modelling

The foundations of CM are in welfare economics. CM aims to estimate changes in welfare (utility) due to changes in the things people value, such as indigenous biodiversity. It involves a carefully structured process which incorporates environmental, social and economic disciplines. In practical terms this could mean, for example, estimating the Willingness to Pay (WTP) to avoid either the local loss of a species or total extinction.

Information is obtained from sample surveys of people so that the values derived reflect the spectrum of values held by the wider New Zealand community rather than just the views of a few lobby groups who may reflect extreme views or vested interests.

Analysis of the survey provides both non-monetary and monetary estimates of values. Non-monetary estimates of value are obtained by relating the value of each attribute to the most valuable one – the marginal rate of substitution (MRS) of one for the other. They are thus relative values that indicate how much more or less particular attributes are valued relative to each other. For example, the loss of a bird might be valued twice as much as loss of an insect. Monetary values indicate in dollar terms WTP for changes to attributes. For example, Nelson people were WTP $431 per household per annum to prevent the loss of birds from the native beech forest, but only $222 for the loss of insects.

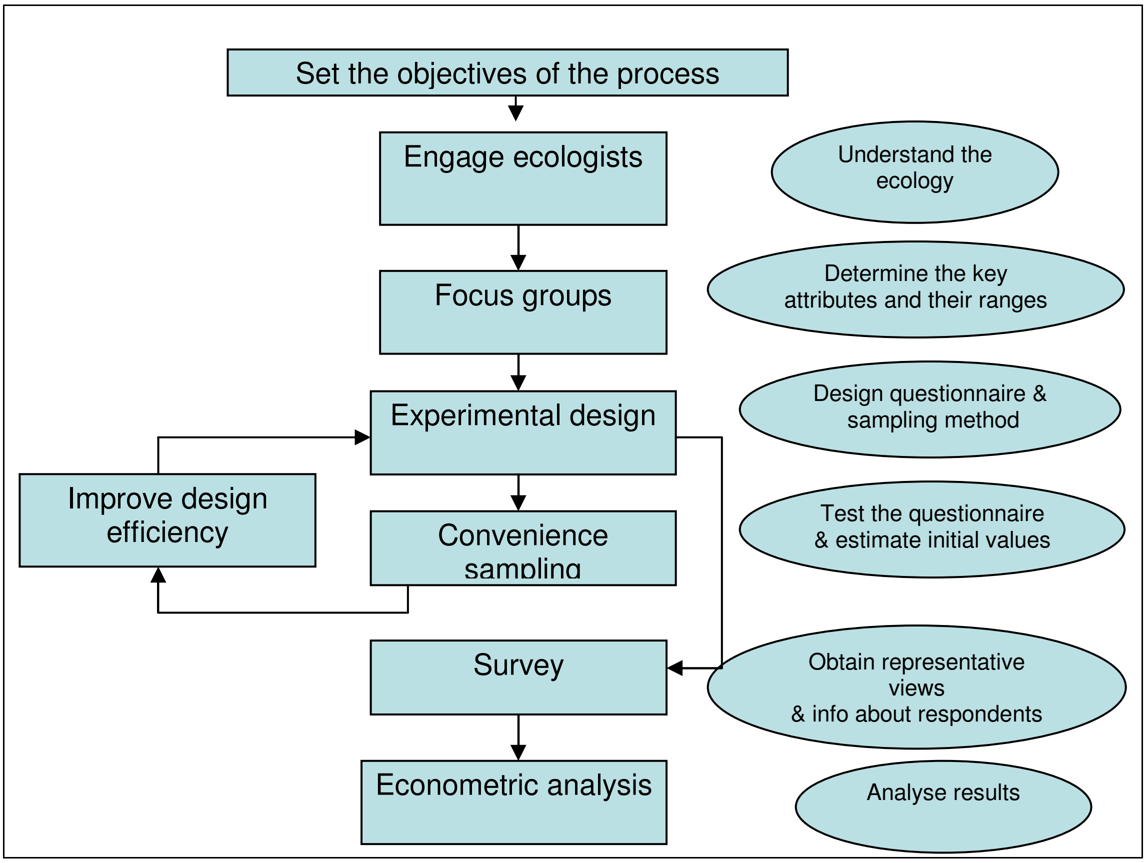
5.2.2 Case study process

Four choice experiments were conducted in representative ecosystems that were carefully selected with benefit transfer in mind. They were:

- Coastal marine
- South Island high country
- Freshwater, and
- Beech forest.

A summary of the key points about each survey is contained in Annex one. The full studies are available on the Nimmo-Bell and Lincoln University web sites, which are referenced in the Annex. At this point it is enough to know the general process which is outlined in Figure 6.

Figure 6 The Choice Modelling Process



Our objective was to estimate marginal changes in biodiversity values from pest impacts using choice modelling.

The first step involved working with ecologists to ensure we understood the links between a hypothetical pest incursion and that which would be expected to happen in each ecosystem. The changes in value depend on changes to environmental attributes. These are the aspects of a particular ecosystem, such as a lake or forest that are considered to be most important to people. An environmental attribute might be a particular species that represents the essential feature of the ecosystem, such as a bird of fish.

Focus groups were then used to identify salient attributes of the environment to include in the survey, and the levels of those attributes (e.g. % coverage of native meadow grass in a lake bed) including for the money variable.

Next we tested the questionnaire and improved the efficiency of the experimental design[18], thus obtaining statistically significant results from small survey samples.

[18] Newly released software (Ngene) enables us to design efficient experiments that produce statistically significant results using relatively small samples of the populations that might be

Data collection was done using face-to-face meetings beginning with a background presentation to bring participants up to a common level of understanding about the key issues. We used community service group leaders (schools, Lions Clubs) to organise meetings of diverse groups of around 50 people.

It is important that socio-demographic statistics are collected on the respondents that make up the samples in studies and that these are then compared to census information. In order that meaningful conclusions can be drawn from surveys of this sort the samples need to be reasonably representative of the overall population. Where samples vary significantly from the population this should be made clear so that this can be taken into account by decision makers.

The last step is the analysis of the survey data which we started by using the Multinomial Logit (MNL) model[19], which is the most restrictive of the available models, but it is computationally relatively simple. This forms the baseline on which more sophisticated methods are measured against. We basically look for improved model fit and higher levels of confidence in the variables. More advanced models relax the underlying restrictive assumptions of MNL[20]. The two key models tested and found superior were latent class (LC) and cross sectional Random Parameters Logit (RPL)[21]. The former allows for different taste preferences to be divided into groups, while the latter allows for individual preferences to be modelled rather than assuming they are all the same.

In Section 6 we review how the case studies have been used to develop a database of biodiversity values that can be drawn on for CBA.

affected by pests and subsequent responses. Ngene was used to validate the efficiency of the designs used for the case studies.

[19] The MNL model essentially regresses the logarithm of the probability that an alternative is chosen against the levels of the attributes in the alternative (Rolfe and Bennett, 2006).

[20] The ratio of choice probabilities is independent of other irrelevant alternatives (IIA) and the corollary that the unobserved components of respondent choices are independent and identically distributed (IID).

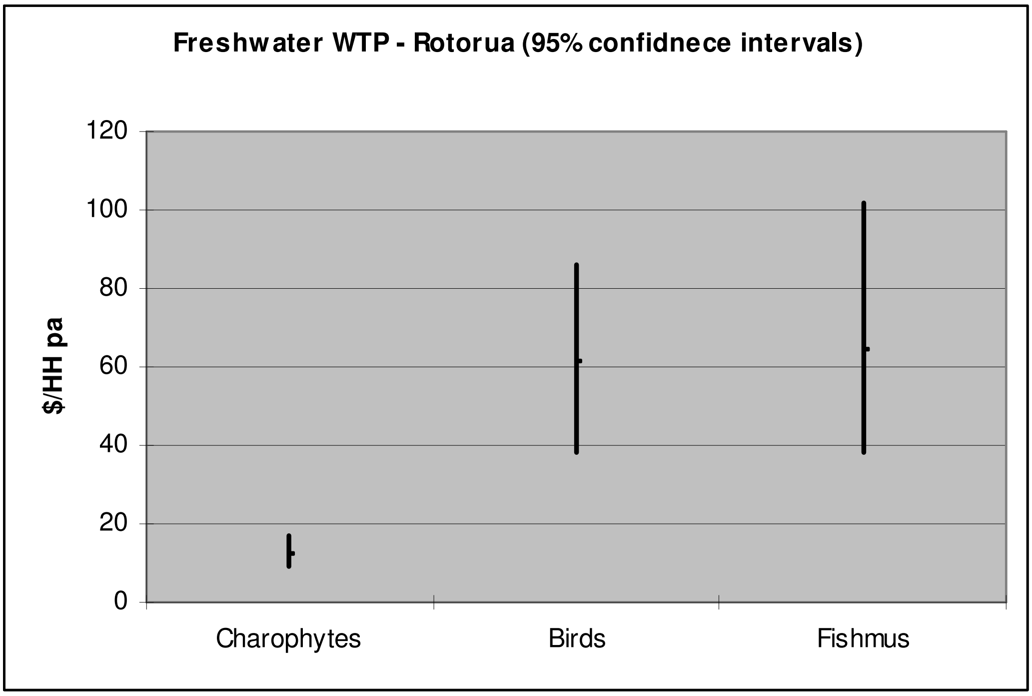
[21] Also referred to as Mixed Logit (ML).

5.3 Statistical measures and uncertainty

This section explains some key terms used in this manual in relation to statistical measures and uncertainty.

Best estimates and confidence limits
Figure 7 uses attributes of the freshwater ecosystem to illustrate the best estimates of WTP and confidence limits. The dot mark on each line shows the best point estimate of mean household WTP. The extent of the line either side of the dot represents +/- two standard deviations either side of the mean, and can be interpreted as the range over which there is 95% confidence the mean will lie somewhere on the line.

Figure 7 Attribute best estimates and confidence intervals



For charophytes a 1% change in the coverage of Charophytes in the lake is valued at $12/HH per annum for 5 years for people living in close proximity to the lake. Similarly the WTP for loss of one bird species is $61 and for loss of one fish species $64.

While the range is much wider for birds and fish compared with charophytes, relative to the size of the best estimate the ranges are similar all resulting in high levels of statistical significance. Meaning we can be quite confident that the values are different from zero.

Statistical significance
WTP values are considered statistically significant if there is a 95% chance that the value is above zero. In other words, the 'band' comprising the point WTP estimate +/- two standard deviations is greater than zero dollars.

Statistically different
Two WTP values are considered statistically different from each other when the two 'bands' around each point WTP estimate +/- two standard deviations do not overlap with each other. This means there is a 95% chance the two values are statistically different from each other (or they are NOT statistically similar).

Orders of magnitude
'Orders of magnitude' for attribute values refers to the use of confidence limits rather than just the point estimates / mean values in decision-making. Using orders of magnitude for values allows the uncertainty in the values to be reflected in the analyses that support decision-making, allowing greater confidence to be had in the final decision. Unless explicitly stated, all orders of magnitude values reflected in this manual are at the 95% confidence level (or approx two standard deviations either side of the mean).

Risk simulation
Risk simulation refers to the process via which orders of magnitude values (or confidence limits) are incorporated into cost benefit analysis calculations.
This is covered in Sections 4.1.3, and 8.2.2.

6 A database of biodiversity values

We now have four case studies across very different ecosystems, undertaken using similar methodology, providing 36 estimates of environmental attributes across 11 different populations throughout New Zealand. This forms a rich information base about the values people hold for various attributes ranging from the extinction of plants and animals to local removal only.

This section sets out how these values can form the foundations of a Biodiversity Values Database (BVD) for use in benefit transfer. First the concept of, and issues involved in, benefit transfer is introduced (Section 6.1), existing databases of non-market values are outlined (Section 6.2), and the BVD is outlined (Section 6.3).

6.1 Benefit transfer

Policy and decision-makers wanting to improve their decisions using non-market values are often constrained by budgets and time limitations as primary choice modelling studies are expensive. Benefit transfer is the process of applying the results of existing studies to new situations (values thus obtained are called transfer values). Benefit transfer is therefore relatively quick and less expensive to carry out.

Conducting benefit transfer is, however, a complex process and is still an evolving discipline. Most of the work undertaken to compare methods of benefit transfer, and the accuracy of the methods, have been conducted on CV studies. For values derived from choice modelling, benefit transfer is still relatively new. Usually original CV or CM studies were undertaken without the thought of benefit transfer in mind so differences in experimental design, data collection and econometric model make comparisons very difficult and large transfer errors have been found. The quality of the analysis for the original study site or sites is a major determinant of the quality of the value estimates at the site to which transfer values are being applied (this is called the policy site).

There is a burgeoning literature on benefit transfer[22], and three major factors have emerged as critical – site, population and framing differences (each of these are discussed later).

[22] Rosenberger and Loomis (2003) and Rolfe and Bennett (2006) provide excellent coverage of the issues involved in using non-market valuation techniques for the transfer of environmental values.

The most important factor of all for carrying out benefit transfer well is the need to recognise the limitations and the uncertainty inherent in the information. Recognising the scientific uncertainties involved as well, analysts should focus on the orders of magnitude for key values rather than precise point estimates. This is covered in the worked example in Section 8.2.2 on risk simulation. In addition, the value bands idea explored in Section 7 utilises orders of magnitudes values and has potential in the future for high level decision-making.

6.1.1 Benefit transfer process

The following sets out the process for benefit transfer (Brouwer 2000; Rosenberger and Loomis *op cit*):

1. Define the policy context.
2. Gather original research outcomes (e.g. from appropriate databases).
3. Screen the original research for relevance, fit to the policy context, type of units, quality of the original research.
4. Select the best value estimates.
5. Transfer the estimates, aggregate to provide the total value estimate at the policy site.

Issues to be assessed in steps 1-3 of the benefit transfer process can be grouped into three areas (Sections 6.1.2 – 6.1.4 discuss these):

- Physical site characteristics.
- Population characteristics.
- Framing issues within the choice survey.

For step 5, there are two methods of transferring values and these are described in Section 6.1.5. Steps 4-5 are also illustrated in the worked example in Section 8.

The general rule is that the more similarities there are between the policy site and the study site(s), the greater the confidence that can be had in the transferred estimates.

Once values have been estimated consideration should be made as to whether they have answered the policy question with the desired level of accuracy. If the answer is yes then no further work is necessary, but if no then a specific study may be needed. Experts and stakeholders can play an important role here to help validate estimates.

The examples given in the next few sections are illustrative only. The benefit transfer assessment process is complex and varies on a case-by-case basis. There are unfortunately no hard and fast rules (yet).

6.1.2 Physical site characteristics

This is about assessing the similarity between the **impact(s)** generated by the pest at the study site(s) and the new policy site. This will help assess whether the particular **attributes**[23] included in a study are relevant to the new study site.

Questions that might be asked include:

- What are the characteristics of the ecosystem(s) at risk? — e.g. freshwater shallow lake, urban and highly modified with common native species.
- Which parts of the ecosystem(s) would be impacted by the pest? — e.g. birds, fish, submerged vegetation
- What types of impacts are likely? — e.g. local loss of common species

  (as opposed to change in abundance of species, national/global loss common species, or impact on iconic species)

For example, if the policy site is a shallow lake with common native species, and the pest is likely to locally displace those species, then the freshwater values in the BVD are likely to be relevant for benefit transfer. On the other hand, if the policy site was a glacial lake, with iconic value (e.g. Lake Wanaka), the freshwater values in the BVD are less likely to be relevant because the impact of the pest is likely to be different.

Each situation ought to be considered on a case-by-case basis. The critical factor is to seek source studies where the **impacts** of the pest are likely to be similar, as reflected in the **attributes** included in the study. Table 3 in Section 6.3 is designed to help with this assessment.

6.1.3 Population characteristics

Appendix 3 sets out the population characteristics of each sample, relative to the 2006 census data for each location[24].

Benefit transfer requires the analyst to compare peoples' socio-demographic characteristics (SDC) between:

a) the sample and the population from which the sample was drawn from. — e.g. (beech forest case study), the SDC of the Riccarton sample would be compared with the Riccarton unit census data.

[23] As outlined in Section 5.2, the choice modelling process selects attributes of the environment to be valued that reflect the impacts of some change (e.g. species loss from a pest incursion).

[24] 2006 Census data can be obtained on CD by contacting Statistics New Zealand through http://www.stats.govt.nz/about_us/contact-details.aspx.

b) the population from which the sample was drawn from and the area for which the values are intended to represent

(see Table 4, 'value type')

e.g. (beech forest case study), the Riccarton unit census data would be compared with New Zealand census data excluding the Nelson region (because the values represent 'outside region').

c) The area for which the values are intended to represent, and the new policy site.

e.g. (beech forest case study), the New Zealand census data excluding the Nelson region would be compared to the new policy site.

But more importantly, the analyst needs to consider whether any differences in SDC are likely to have a material impact on the environmental values, and whether this impact is likely to have a material impact on the decision to be made.

With the four case studies, we found that none of the population variables had a statistically significant effect on preferences consistently across all case study samples. However, two factors - income and membership of a conservation group – did have a significant effect on some specific survey samples. This reinforces the need to assess each situation on a case-by-case basis.

In addition to SDC, other information on respondents' attitudes and beliefs may have been collected and may also be relevant, for example, whether respondents are members of a conservation group. If any of these variables are notably different between the study site and the policy site, either transfer values **may** need to be adjusted accordingly, or benefit transfer may be deemed not appropriate (and a full choice survey may be required).

Once this analysis has been done, other relevant questions might include:

- Were any socio-demographic groups over- or under-represented relative to the broader population in the original studies?

  e.g. in the freshwater case study, Rotoroa sample, high income households were over-represented (see Appendix 3).

- Which segments of the population are relevant to the TEV component being quantified?

  e.g. high income households may be under-represented at the new policy site, meaning some adjustment of values may be required such as through function transfer[25] (rather than direct transfer).

[25] Function transfer is introduced in Section 6.1.5 (b).

For passive values, the relevant population is likely to be all of New Zealand, even for common biodiversity[26]. But if (for example) the biodiversity at risk included species that are taonga to Maori, direct benefit transfer from the BVD may not be appropriate, particularly as Maori tended to be under-represented in the case study samples (but not always).

Each situation ought to be considered on a case-by-case basis, and the bottom line for the analyst should always be whether any differences in SDC are likely to have a material impact on the decision at hand.

6.1.4 Framing issues

This refers to how the choice survey has been formulated (framed) and carried out. The extent to which the framing of different studies is similar is important to the conclusions that can be drawn from comparisons when transferring values from one site to another. If framing issues are significantly different it is doubtful that meaningful values can be transferred. It is very important to understand how values are estimated in the underlying primary studies before attempting to transfer values to a new situation. The errors in the primary study estimates must be added to the errors that occur when transferring an estimate from one site to another. Together these errors can be very significant, but often the uncertainties in the science may be even larger and this will affect the uncertainty in the economic values.

Framing issues can be broken down into three areas:

- Scale and scope differences
- Welfare measure aspects
- Wider contextual issues

a) Scale and scope differences

In essence, scale and scope are both about the breadth of substitutes presented in the survey relative to available substitutes. Economic theory tells us that (all other things being equal) the fewer substitutes that are available, the higher the value.

Scale refers to the scale of the case study location; e.g. local, district, regional, or outside the region.

[26] In the four cases studies undertaken, we obtained passive values that were significantly different from zero across the New Zealand population for common biodiversity, regardless of how far the population was from the study site. This is consistent with economic theory about passive values. So, in many cases, the relevant population at the study site is likely to be all New Zealanders. But it is too early to generalise.

The four case studies were carried out in the **local frame;** in other words, the case study location was a localised site and the impacts surveyed were confined to that site. If the survey looked at catchment-wide, regional or national impacts then these would be referred to as a catchment frame, regional frame, or national frame respectively. In the four case studies, while values were elicited through sampling at different locations away from the study site (e.g. local, district, regional, and outside the region), the frame was still a local frame. The rationale being that pest incursions tend to be confined to one location initially. The purpose of a response is to contain the pest and stop its spread. Therefore the relevant frame for incursion decisions is local. For decisions about nationwide management of established pests, a national frame may be more appropriate.

Scope refers to how narrow or wide the attributes are described; e.g. narrow and based on a specific species, species abundance, or more broadly with a whole ecosystem.

Table 3 and Table 4 in Section 6.3 provide information on the scale and scope aspects of each case study. Section 7.2 also discusses the effect of distance on values: in short, we found that while there was evidence of a slight decline in values with increasing distance away from the study site, this difference was not statistically significant.

b) Welfare measure aspects

This refers to methods used in the choice modelling survey which affect values; the most important ones are:

- the payment mode (e.g. special tax, reallocation of government expenditure)
- the elicitation format (e.g. face-to-face meetings, web/mail based survey)
- the level of information provided to participants[27]
- the sensitivity to scope and/or embedding effects

[27] There is a view held by some that informing the respondents will bias the results. Our view is that we will not get sensible estimates of value without an informing process first. This is because of the complex nature of biodiversity and biosecurity issues, especially as most people will not consider such things in their daily lives. We provide the information that we would expect MAF BNZ to provide if a real incursion were to occur, but without the emphasis on response options as this would shift the emphasis from the value of the change to biodiversity to the cost of the response. In addition, much effort goes into working with relevant ecologists to ensure information provided to respondents is without bias.

c) Wider contextual issues

Surveys are undertaken at a point in time and there will be an overarching context affecting peoples' preferences (and therefore values) for environmental goods and services. As circumstances change over time, society's values shift: A value held in a by-gone era may not hold today and today's value may not hold in a future era. For example, the values that respondents give in buoyant economic conditions may be significantly different to those given during a recession.

Relevant contextual issues include; economic conditions, politics, policy, seasonal aspects and weather conditions. These issues need to be considered on a case by case basis, and will probably be more important over time as the original studies in the database become older and the prevailing conditions change.

If values are compared from different time periods that are more than a year apart then the values need to be adjusted for inflation.

6.1.5 Value transfer methods

There are two methods of transferring benefits from a study site to a policy site; direct transfer and function transfer.

Meta analysis can be used for both types of value transfer – this simply refers to the use of multiple studies (rather than just one study) in the benefit transfer process.

a) Direct transfer

This involves applying summary statistics, such as WTP, directly from the study site to the policy site. These estimates can be point estimates from a single study, estimates from multiple studies (meta-analysis – see below) or administratively approved estimates[28]. Where possible a range of estimates should be transferred including the confidence intervals to give additional information regarding the precision of the study site measures.

Direct transfer is best used when the study site characteristics are very similar to the policy site characteristics. For example, if the population SDCs are the same, and the pest impacts (and therefore relevant attributes and levels) are the same, then direct transfer may be appropriate.

[28] Administratively approved estimates have been subjected to a process that gives recognition to their use for a particular purpose, such as standard values for recreational activities in national parks.

b) Function transfer

The functions or statistical models that sit behind the WTP calculation define the relationships between vectors of data collected at the study site, such as site and population characteristics, and the WTP values. Function transfers involve transferring these functions or statistical models from the study site to a policy site.

A benefit function transfer is based on the premise that the study site estimate is a function of the study site characteristics (e.g. location, physical characteristics and climate) and other explanatory variables (e.g. socio-demographics, attitudes and time) and that these can be transferred to the policy site and adjusted for policy site characteristics. Thus the WTP estimates from the study site would be adjusted for the policy site.

Function transfers are generally considered to perform better than direct transfer because they allow values to be adjusted for different characteristics at the policy site. Demand or benefit function transfers effectively use regression coefficients from a research site to plug into a transfer function utilising summary statistics from the policy site.

Meta-analysis can be applied here by pooling the actual data from multiple studies.

6.1.6 Concluding comment on benefit transfer

Benefit transfer is complex and requires careful judgement on behalf of the analyst. The overriding criterion for the analyst is always whether any differences between the study site and policy site will have a material impact on values, which in turn will have a significant impact on the final decision.

Ideally, benefit transfer should be carried out by a qualified economist expert in the field of non-market valuation, preferably with knowledge of both stated preference and benefit transfer techniques. There is a high risk that values will be incorrectly transferred and high errors may result.

All of the issues outlined in this section are also important considerations for designing primary choice surveys to ensure that the values produced result in (1) reliable estimates of community WTP that can be relied on by decision makers, and (2) values that are amenable to future benefit transfer (i.e. can be added to the BDV). These issues are summarised in the box below.

Key issues in conducting choice modelling and benefit transfer

- How you frame the questions (scope and scale) has a big impact on values
- Record the socio-demographic characteristics of your sample
- Be aware of general economic conditions for future benefit transfer
- Your sample should be an informed one similar to a real response situation
- WTP estimates are stated preferences and difficult to verify
- We are interested in the magnitude of marginal values not absolutes
- An important output of the analysis are the relative non-monetary values of different environmental attributes
- The closer values are to faiths or beliefs the less relevant dollar values become
- There is both art and science in estimating biodiversity values.

6.2 Existing databases

Existing databases of previous studies are held in Canada and also here in New Zealand. Enough basic information is held about each study in the database for an analyst to assess whether a particular study might be useful for benefit transfer. An important piece of information is usually a link to a journal article or working paper that describes each study in full including the data and methodology adopted. The case studies that underlie this manual will be submitted to these databases.

A review of these databases was conducted in the early days of this project (Sharp, Kerr & Kaval 2006), which found that there was no relevant work on pest or disease impacts on biodiversity. Interactions with benefit transfer experts later in the project highlighted that it is the ***impact*** that is important, not the cause of the impact. So any studies modelling impacts to biodiversity could potentially be relevant, even if the impact was not caused by a biosecurity issue (e.g. a pest). In addition, new studies have been carried out on biodiversity since the 2006 review.

It may, therefore, be worth reviewing these databases again. That said, the studies undertaken as part of this project were specifically tailored for use in the context of benefit transfer for biosecurity decision-making. They used the same methodology, design, econometric models, and were all undertaken over the same timeframe. Any studies located in the EVRI or Lincoln databases would need to be assessed to ascertain whether the underlying methodology is sound and that the econometrics is consistent with the BVD (among a raft of other things). This exercise may best be left until a specific need is identified by BNZ e.g. a decision about a pest incursion is required and the values in the BVD are deemed inappropriate.

6.2.1 Environmental Valuation Reference Inventory

EVRI the Environmental Valuation Reference Inventory developed and maintained by Environment Canada has become the major world depository of environmental valuation studies (http://www.evri.ca/).

While there are many hundreds of recreational valuation studies, particularly using contingent valuation, the number of choice modelling studies is relatively small but growing rapidly.

6.2.2 New Zealand Non-Market Valuation Database

Geoff Kerr of Lincoln University also maintains an inventory of New Zealand non-market valuation studies.
(http://www.lincoln.ac.nz/nonmarketvaluation/).

6.3 Biodiversity values database

To build a BVD it is important to ensure the values within it are as comparable as possible. The four case studies all used the same survey development and data gathering process as summarised in Figure 6, and were framed in the same way as discussed in Section 6.1.4. To enhance the BVD in the future, any additional studies should endeavour to follow the same process.

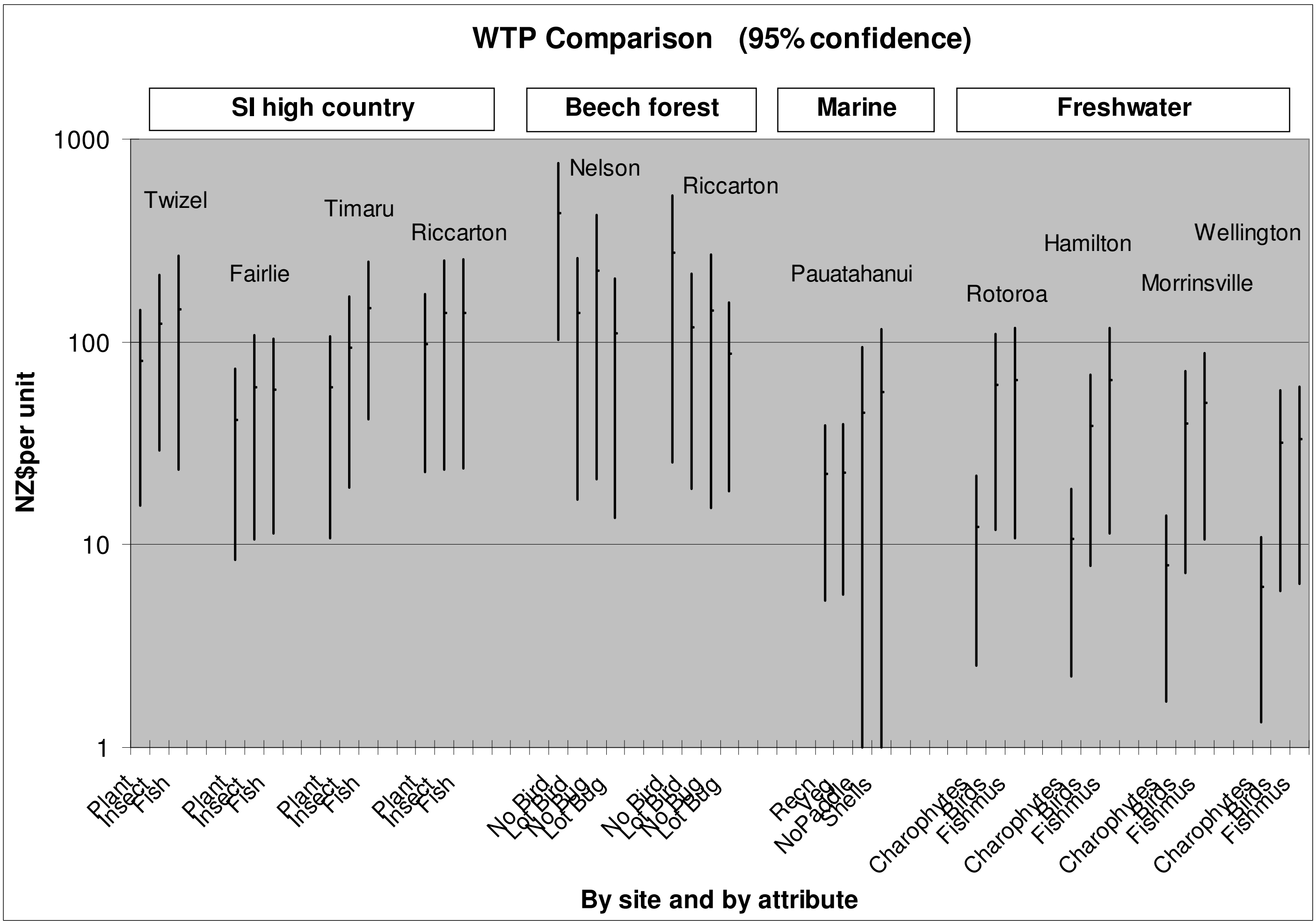
In the original studies varying econometric models were tested and the model with the best statistical fit and highest explanation of the data was chosen for the presentation of individual case study results. But here comparability **between** studies is the objective, and so the results were re-evaluated using one common model, the panel random parameters logit (RPL). All environmental attributes were assigned triangular distributions with the money attribute fixed. When the models were run all attributes were significant at the 5% level and all models had acceptable levels of explanation of the variation in the data (as shown by the pseudo-R2 statistic, a measure of model fit). A key feature of the RPL model is that it allows different individual views of respondents to be modelled.

Figure 8 and Table 2 show the results of the case study analysis using the same RPL model[29]. Together this data forms the foundation of a Biodiversity Values Database (BVD). **Table 3 and Table 4 provide a guide to attribute codes used in the BVD and other relevant information about the attributes and survey samples to assist with benefit transfer.**

A key feature of this chart is the wide confidence intervals at the 95% level. This shows that people have widely differing views of the value of the environment.

Note that all attributes are significant at the 5% confidence limit except NoPaddle and Shells in the Crabs study, which are significant at the 10% level.

Figure 8 Biodiversity values database - attributes across case studies



Note: *Table 3 provides a guide to attribute codes used in Figure 8.*

[29] Note that a log scale has been used to highlight the lower values

Table 2 Biodiversity values database - WTP estimates ($/HH/annum)

Case Study	Location	Attribute	WTP	SD	Z	P(Z)	Lower	Upper
SI high	Twizel	Plant	80	33	2.43	0.01	16	144
country	Twizel	Insect	121	47	2.58	0.01	29	213
(2007)	Twizel	Fish	144	62	2.34	0.02	23	265
	Fairlie	Plant	41	17	2.47	0.01	8	74
	Fairlie	Insect	59	25	2.39	0.02	11	107
	Fairlie	Fish	57	23	2.45	0.01	11	103
	Timaru	Plant	59	25	2.40	0.02	11	107
	Timaru	Insect	93	38	2.47	0.01	19	166
	Timaru	Fish	145	53	2.75	0.01	42	249
	Riccarton	Plant	97	38	2.55	0.01	23	172
	Riccarton	Insect	138	58	2.36	0.02	23	253
	Riccarton	Fish	139	59	2.36	0.02	24	254
Beech	Nelson	No Bird	431	167	2.57	0.01	103	759
Forest	Nelson	Lot Bird	138	62	2.23	0.03	17	259
(2008)	Nelson	No Bug	222	103	2.17	0.03	21	423
	Nelson	Lot Bug	109	49	2.24	0.03	14	204
	Riccarton	No Bird	274	127	2.16	0.03	25	523
	Riccarton	Lot Bird	118	50	2.33	0.02	19	217
	Riccarton	No Bug	142	65	2.19	0.03	15	269
	Riccarton	Lot Bug	87	35	2.48	0.01	18	156
Coastal	Pauatahanui	Recn	22	9	2.58	0.01	5	39
Marine	Pauatahanui	Veg	23	9	2.62	0.01	6	39
(2007)	Pauatahanui	NoPaddle	44	26	1.72	0.09	-6	95
	Pauatahanui	Shells	56	31	1.84	0.07	-4	116
Freshwater	Rotoroa	Charophytes	12	2	5.97	0.01	9	17
(2008)	Rotoroa	Birds	61	14	4.29	0.01	38	86
	Rotoroa	Fishmus	64	15	4.42	0.02	38	102
	Hamilton	Charophytes	11	2	5.57	0.01	7	14
	Hamilton	Birds	38	7	5.16	0.01	24	50
	Hamilton	Fishmus	64	16	4.04	0.01	38	98
	Morrinsville	Charophytes	8	1	7.31	0.01	6	10
	Morrinsville	Birds	39	9	4.57	0.01	23	60
	Morrinsville	Fishmus	49	9	5.61	0.01	31	71
	Wellington	Charophytes	7	12	6.82	0.01	5	10
	Wellington	Birds	41	113	3.65	0.01	21	65
	Wellington	Fishmus	41	8	4.91	0.01	26	59

Notes to Table 2

- WTP is the mean estimate of willingness to pay
- SD stands for Standard Deviation, a measure of the variation in the estimate
- Z is the WTP divided by SD
- P(Z) is the probability that the WTP is not significantly different from zero. The standard test is that P(Z) < 0.05 indicates the estimate is significantly different from zero
- The upper and lower bounds at the 5% level indicate the levels of the WTP at which there is a 5% chance the value will lie outside these bounds
- The WTP estimates are annual estimates over 5 years, except for Coastal marine which are over 3 years.
- Table 3 and Table 4 below provide further definition of the attributes, and information about the samples:

Table 3 Guide to attributes in BVD

Case Study	Attribute code	Attribute explanation	Impact type	Unit	Value type
South Island high country	Plant	Hebe cupressoides	Local loss Rare species	No. species (0-1)	Passive use[30]
	Insect	Robust grasshopper	Global loss Rare species	No. species (0-1)	Passive use
	Fish	Bignose galaxias	Global loss Rare species	No. species (0-1)	Passive use
Beech forest[31]	No Bird	Various species[32]	Lower abundance Mix of species	1	Passive use
	Lot Bird	Various species[32]	Higher abundance Mix of species	1	Passive use
	No Bug	Various species[33]	Lower abundance Mix of species	1	Passive use[34]
	Lot Bug	Various species[33]	Higher abundance Mix of species	1	Passive use[34]

…Continued over page…

30 Refer to Section 5.1 for a discussion of passive values.

31 The attributes for this case study were qualitative. The status quo was relatively low numbers of birds and insects; so 'no birds/bugs' relates to population abundance declining to the point where birds/bugs are 'virtually absent'. The unit of "1" is a dummy variable, which should be combined with WTP in the compensating surplus calculation (Section 8.2).

32 Specific species were not mentioned in the choice questions; but in the presentation the following birds were listed; Kaka, bush robin, tui, fantail, bellbird, kiwi, tomtit, and rifleman.

33 The following insects were listed in the presentation; Stick insects, weta, flies & bees (as important pollinators), caterpillar, ants, spiders,

34 Though pollination was mentioned; it is an ecosystem service and therefore indirect use under the TEV framework.

Case Study	Attribute code	Attribute explanation	Impact type	Unit	Value type
Coastal marine[35]	Recn	Recreational shellfish catch	Local loss (3 years)	1	Indirect use (recreation)
	Veg	Coastal vegetation	Lower abundance	40% reduction	Passive use
	NoPaddle	Children paddling	Local loss		Indirect use (recreation)
	Shells	3 shellfish species	Local loss	No. species (0 or 3)	Passive use
Freshwater	Charophytes	Submerged meadow grass species group	Lower abundance, local loss, threatened globally	1% reduction	Passive use
	Birds	Shags	Local loss Common species	No. species (0-4)	Passive use
	Fishmus	2 fish[36], 1 mussel species	Local loss Common species	No. species (0-3)	Passive use

Table 4 Guide to sample locations in BVD

Case Study	Sample location	Value type	Frame	Sample size
South Island	Twizel	Local	Local	37
High country	Fairlie	District	Local	41
	Timaru	Regional	Local	35
	Riccarton	Outside region	Local	52
Beech forest	Nelson	Regional	Local	91
	Riccarton	Outside region	Local	75
Coastal marine	Pauatahanui	Local	Local	47
Freshwater	Rotoroa	Local	Local	44
	Hamilton	District	Local	40
	Morrinsville	Regional	Local	65
	Wellington	Outside region	Local	64

Finally, Appendix 3 sets out the population characteristics of each sample, relative to the 2006 census data for each location.

[35] Specific species were not mentioned in the choice survey questions. But the presentation showed pictures of paua, cockles, mussels, kina, native crabs, pipis, and shoreline native grasses.

[36] Fish species were common bully and common smelt.

6.3.1 Building the database over time

Over time as new primary studies are undertaken they will help to build the database. To ensure that non-market valuation studies will be useful for benefit transfer there are a number of key requirements that need to be met.

1. Document the process
    a. Detail the valuation methodology including the frame (scale and scope), and
    b. Experimental design
2. Make the primary data accessible including
    a. Basic information on the site, pest and ecology
    b. Questionnaire
        i. Choice questions
        ii. SDCs of respondents
        iii. Supporting questions on beliefs and attitudes
    c. Responses
        i. Spreadsheet recording respondent answers to choice questions and the SDCs of each respondent
3. Document the results
    a. WTP
    b. MRS
    c. Discussion on interpretation.

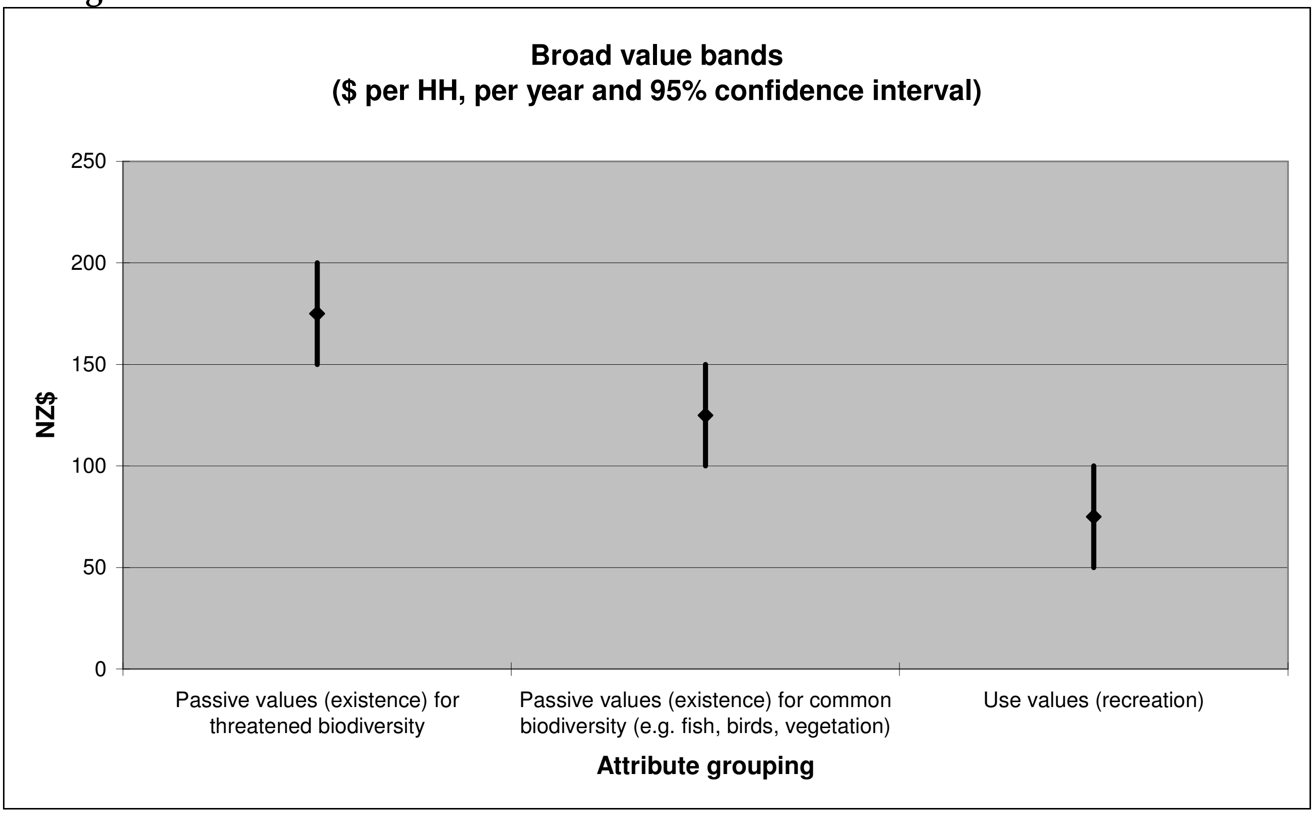
7 Value bands

As the body of choice experiments and benefit transfer research grows, general trends are beginning to emerge in the environmental values that have been measured. For example, indirect use values tend to reduce the further away from the study site, while passive use values have less variation. There are many more examples in the literature, but as far as we can tell most of these are case-specific.

A concept we explore in this section (using the data from the case studies) is whether there are in fact generic trends across attribute types. In other words, could values for certain types of environmental attributes be categorised and grouped into broad bands?

Figure 9 shows a very simple illustration of this idea. Can values be grouped into categories, say – high, medium and low? High values may include passive use existence values for endangered species. Medium level values may include passive use existence values for common biodiversity that is locally under threat. Low values may include indirect active use values such as recreation.

Figure 9 Broad value bands



If this were indeed possible, it would provide a simpler way of being able to incorporate environmental values into decision-making, especially at the investigation stage of a response where high level rapid decisions are needed to prevent the pest becoming established.

7.1 Testing the concept

Before we can test this concept, it is important that (as far as possible) any differences between the studies are related only to the environmental impacts of the pest. As discussed in Section 6.3, one common econometric model (RPL) was employed for the BVD to ensure data comparability between case studies, and so those values in the BVD were also used for this analysis.

Refer back to Figure 8 (Section 6) where the case study results were presented. A cursory look may not indicate any visual patterns that could be useful to analysts in better informing biosecurity decision makers. We need to test whether the WTP estimates for different environmental attributes for different types of ecosystems are statistically significantly different, or whether they are similar. If the latter is found to be true, are there generic bands of values that can be used generally in CBA for new incursions?

We have employed some statistical tests to see if there are indeed patterns - Appendix 1 goes through the tests that were used to confirm whether differences between WTP estimates were statistically significant.

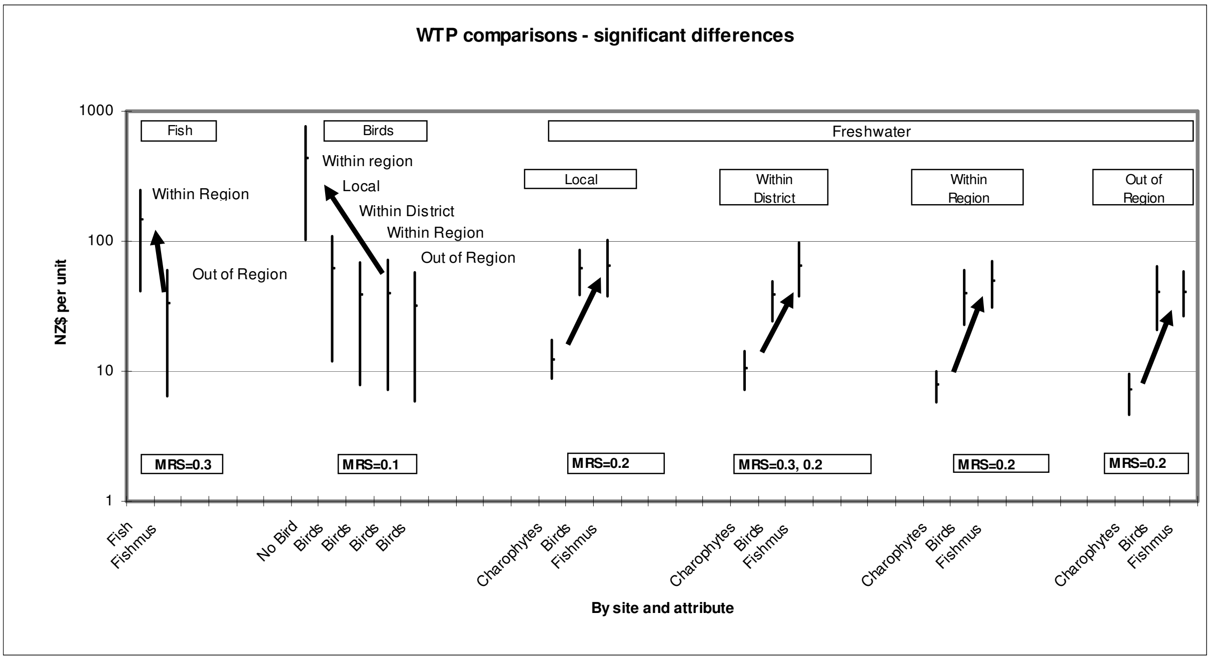
There are a number of ways the 'value bands' concept could be tested. For example, comparing all attributes;

- relating to a particular flora or fauna type e.g. all bird attributes;
- concerning changes in abundance (regardless of flora or fauna type);
- relating to local loss of species (regardless of flora or fauna type); or
- relating to global extinction of species (regardless of flora or fauna type).

The comparison presented here was deemed the most sensible comparison for the purposes of BNZ because it compared 'like' things; i.e. birds with birds and fish with fish.

Figure 10 (over the page) shows the comparisons that are statistically different at the 95% level. In other words, where there is only a 5% chance that the difference between attributes is not significant.

Figure 10 WTP comparisons with significant differences



Note: *Table 3 provides a guide to attribute codes used in Figure 10.*

For birds, the best guess is that for Nelson people the **local loss** of a bird species in Hamilton Lake was 10% of that for the loss of bird **abundance** in South Island beech forest (MRS 0.1, or a WTP of $39-$61 for Lake Rotoroa and $431 for beech forest). All the other bird comparisons were not statistically different at the 95% level.

For fish, preventing the **local loss** of a fish species in Lake Rotoroa is worth $41 to Wellington respondents, or 28% of what Timaru respondents are WTP to prevent the **extinction** of a fish species in the South Island high country ($145) (Figure 10, MRS 0.3). All the other fish comparisons were not statistically different at the 95% level.

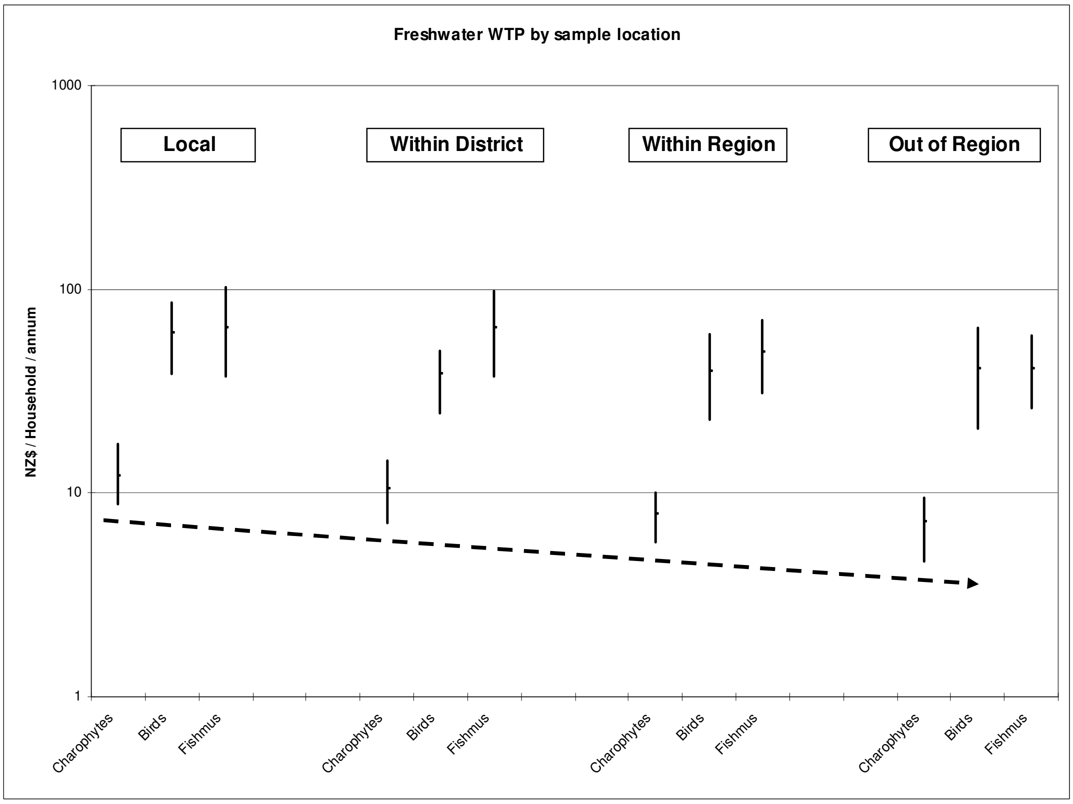
The only other comparison that is statistically different is the comparison of charophytes to birds and fish. In each of the four samples a 1% change in charophytes was valued at between 20% and 30% of the local loss of a bird or fish species (MRS 0.2 and 0.3).

7.2 Effect of distance on values

Another aspect worth testing at this point is the effect that distance may have on values. This is not only important for exploring the value bands concept, but to understand the impact of distance for the benefit transfer process (Section 6.1.4). The literature suggests that WTP might be expected to decline with distance because of the wider range of alternatives available to respondents. But this is likely to vary depending on the value type; active use values (e.g. recreation) are likely to decline faster with distance than passive use values (e.g. existence values).

Figure 11 (over the page) shows the estimates of WTP across the four freshwater samples in the survey. In this case study, populations were sampled at the local level next to the lake (Rotoroa), at the district level across the other side of Hamilton city, within the region (Morrinsville) and nationally (Wellington). This was done specifically to see whether WTP changed with distance from the resource at risk.

Figure 11 Comparison of Freshwater WTP by location of population



Note: *Table 3 provides a guide to attribute codes used in Figure 11.*

We can see from the dashed line Figure 11 that WTP declines with distance from the lake. WTP for a change in Charophyte cover declined from $12 for local to $11 for district to $8 for region and to $7 for outside the region. Similar results occurred for the other attributes (e.g. birds: $61, $38, $39, $41, and fish: $64, $64, $49, $41).

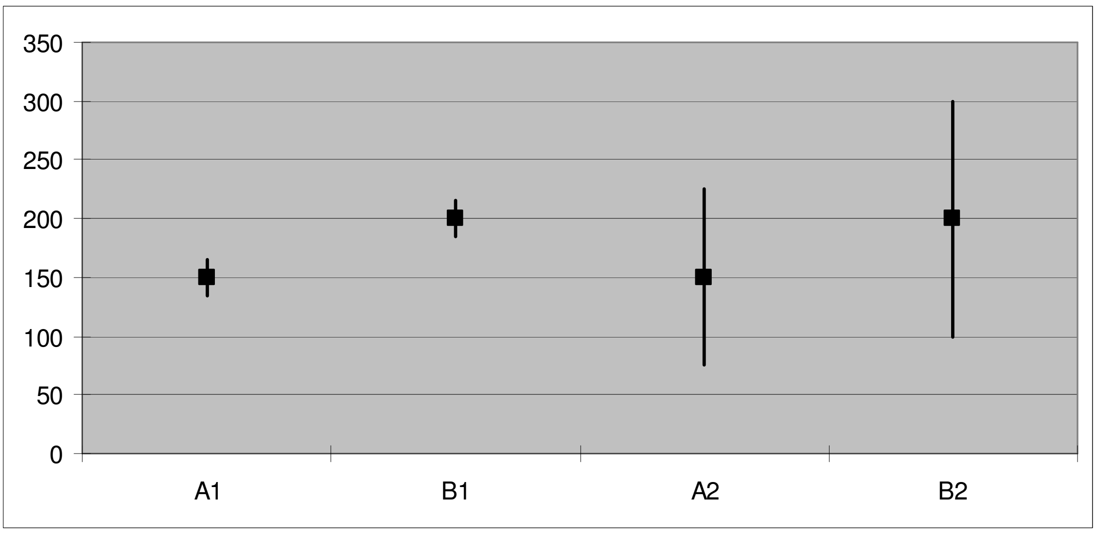
While we can see a downward trend in values, when we conducted statistical tests, we found that the values at the different sample locations were not statistically different at the 95% level. In other words, the uncertainty around the mean values (wide confidence intervals) prevents conclusions being drawn about trends.

7.3 Conclusion on value bands concept

The discussion above relates to comparisons of attributes that were statistically different at the 95% level. All other comparisons were not statistically different. ***In other words, most passive use WTP values for indigenous biodiversity are similar, both within and between studies.***

One conclusion could be that there is one band, albeit a considerably wide one. But it is too early to make that conclusion because of the considerable variability in the values either side of the mean. Consider Figure 12; it is clear that points A1 and B1 are distinctly different; that is, the confidence intervals do not overlap at all. On the other hand, points A2 and B2 have exactly the same mean point as points A1 and B2 respectively, but the wider variation about the mean precludes us from saying whether they are the same or different.

Figure 12 Impact of variation around mean



In addition to the wide variation, the small size of the samples also prevents us from making these assertions about differences. Larger samples and/or more studies may help to narrow the uncertainty around mean values, or, conversely, may confirm that the wide variability reflects the real world. In other words, that the passive values society holds about biodiversity are in fact highly variable. **One thing is certain - more data is needed to test this concept further before it can be used for real life decision-making.**

But from the limited information we have so far we can say the following:

1. It appears that people consider the local loss of a bird species is worth about 10% of extinction of a bird species.

2. People consider the local loss of a freshwater fish species is worth about 20% of extinction of a freshwater fish species.

3. A one percent change in a rare freshwater plant at the local level is worth about 20% of the local loss of a bird or fish species.

4. Increasing distance from the site may appear to reduce passive use values for indigenous biodiversity, but the differences are not statistically significant.

5. While people have values for indigenous biodiversity that can be quantified these values differ widely for any particular issue and often within sample variation is much wider than between sample variation.

6. Because of the widely differing views and limited data no clear bands for different types of losses have yet emerged.

Points 1-3 above provide *ballpark* information on relativities which could prove useful at the investigate stage. If BNZ has information on one attribute the approximate values for another attribute could be inferred.

In conclusion, the value bands concept still has potential for use at the investigation stage of decision-making[37]. Choice modelling provides a rich data source that can be interrogated in a number of ways. The best way to examine the data depends on the precise needs of decision-makers. Before taking this concept further, we first recommend that BNZ gain practical experience with using this manual so that decision-making needs for impacts to indigenous biodiversity can be better understood. During this time we expect that more data will become available from primary studies, at which time we recommend this concept should then be revisited.

[37] Experts at an Australian Agricultural and Resource Economists Society conference felt that the concept was innovative and showed promise from a theoretical perspective.

8 Incorporating biodiversity values into biosecurity decision making

8.1 Estimating the benefit of a response: compensating surplus

As outlined in Section 4, information on economic values can improve decision making at two key stages of a response: Investigation and CBA. The key difference between Investigation and CBA is the amount of time available to do the analysis and thus it influences the rigor that can be applied to the analysis.

In each case the aim is to utilise values of indigenous biodiversity (e.g. passive values) to improve the estimate of the benefit of a response. For this we utilise the concept of compensating surplus (CS).

Compensating surplus is the amount of money required to compensate a person for a change to the environment that would leave that person indifferent to the change. It is a measure of the change in utility for that person and when summed across all persons affected by the change provides an estimate of the benefit to society of the response that prevents the negative impact. Typically non-market valuation surveys focus on households (HH) and respondents are asked to state their preferences on behalf of their household (see Equation 1).

(1) $$CS_{HH} = -1/\beta_m \left(\beta_1\Delta_1 + \beta_2\Delta_2 + \ldots\ldots + \beta_n\Delta_n\right)$$

Where:

CS_{HH}	=	compensating surplus per household
β_m	=	coefficient of the money attribute
β_{1-n}	=	coefficients of the 1 to n environmental attributes
Δ_{1-n}	=	change in the quantity of the 1 to n attributes

By rearranging terms we can use the WTP estimates multiplied by the estimated changes in the quantities of the environmental attributes to estimate CS for each household as follows (Equation 2).

(2) $$CS_{HH} = \left(\beta_1 / -\beta_m\right)\Delta_1 + \left(\beta_2 / -\beta_m\right)\Delta_2 + \ldots\ldots + \left(\beta_n / -\beta_m\right)\Delta_n$$

Where:

$\left(\beta_n / -\beta_m\right) = WTP_n$ estimate for the nth environmental attribute

The CS_{HH} estimate is then multiplied by the number of households affected to provide the estimate of the total benefit. Care must be taken to ensure that the estimate applies to the correct population. For example, a WTP estimate for the local area should be multiplied by the number of households in the local area. If there is a district estimate of WTP then this should be multiplied by the district population minus the estimate for the local population, similarly for regional and national estimates of WTP. The separate estimates are then added together to obtain a total.

The estimate of the total relates to one year, but the WTP question respondents usually answer relates to a number of years, typically five, and therefore we need to discount the annual estimates over the relevant number of years to obtain a Present Value (PV). Estimating PVs requires the use of a discount rate. The particular rate for indigenous biodiversity values should be standardised so that comparisons can be made between studies. For MAF BNZ the rate is likely to be in the range of 6% to 10% and the actual rate determined following Treasury guidelines. Which ever rate is used it should be subject to a sensitivity analysis because discount rates have a material impact on PVs.

8.2 Investigation

At investigation, time is extremely limited in terms of carrying out benefit estimation. Typically, in order to be considered, values would be required in about a week. This obviously precludes undertaking a primary non-market valuation study, which may take 6 - 12 months. But, there now exists the beginnings of a database of information on indigenous biodiversity transfer values that can be drawn on.

In order to demonstrate how the database can be used we provide a simple example below using the direct transfer approach. This example is also outlined in the primer, which also identifies the relevant sections of this manual for each stage of the process.

8.2.1 Example using point estimates

Assume an exotic weed is discovered in a central North Island lake.

The first step is to assess components of total economic value (TEV) at risk from the incursion:

1. Where direct use values are affected, refer to CBA guidelines.
2. Where indirect use values are affected, refer to BNZ economist.
3. **This worked example deals with passive use values.**

Secondly, assess the characteristics of the policy site (incursion situation):

1. What physical biodiversity values are at risk from the incursion? Focus on what **impacts** the pest will have on specific **attributes** of an ecosystem, and what units are relevant[38].
2. What segments of the population are affected by the incursion, and how many households (local, district, regional, national)? Passive use values are likely to affect the whole population, but there may be some exceptions (e.g. culturally important species for Maori).
3. Assess framing issues at the policy (e.g. scale, scope, etc).

On investigation it is found that if nothing is done the incursion is likely to reduce the cover of indigenous meadow grass by 20% and one species of native bird would no longer frequent the lake through loss of food supply. Further assume there are 100 households around the lake and 1,500 households in the district that would be affected by this change to the environment.

An initial decision is required on a response strategy and a high level estimate of the benefit of a response would aid that decision.

There is not enough time to conduct a primary study at this stage and so any analysis must draw on information from previous work. The database has estimates of the mean values for both these environmental attributes (see Table 2). Taking scientific and biosecurity advice, the appropriateness of transferring these values to the new site is assessed, and it is decided that these values can be transferred without adjustment to the policy site[39],[40]. WTP estimates for example analysis ($/HH/annum over 5 years) from Table 2 are as follows:

Lake Rotoroa	Local	District
Charophytes (1% Δ)	12	11
Birds (1 spp)	61	38

[38] For example; changes to population abundance (and how much), local loss of common species (and how many), global loss of species (and how many), local loss of rare species (and how many)

[39] Adjustments could include factors to modify the biodiversity values if the site characteristics and or the population socio-demographics characteristics in the policy site vary significantly from the study site. Examples of such adjustments are given in Bell, Yap & Cudby (2009), but on the other hand, latent class modelling carried out as part of the Wildings case study suggested that SDCs did not necessarily determine values. This is an uncertain area that needs to be explored further by practitioners before hard and fast rules can be applied.

[40] Function transfer is the alternative way of adjusting values (see Section 6.1.5), but is not covered in detail here because it requires access to the econometric models behind the WTP values and therefore needs to be carried out by choice modelling experts.

The annual benefit (CS) of preventing the impact on the environment is therefore the sum of the local and district WTP:

(3) CS = ($12*20 + $61*1)*100 HH + ($11*20 + $38*1)*(1,500 – 100)HH
= ($301) * 100 + ($258) * 1400
= $391,300

The PV of the sum of benefits over 5 years at a discount rate of 8% is

PV_{CS} = $1,562,000

Assume that eradication of the weed is likely to cost around $500,000 and take one year (a one-off cost).

From this information the expected Net Present Value (NPV) and Benefit to Cost ratio (B/C) of eradication is:

NPV = $1,562,000 - $500,000 = **$1,062,000**

B/C = $1,562,000/$500,000 = **3.1**

As well as presenting the expected NPV and B/C ratio additional information would also be provided. This should include:

- a sensitivity analysis on key variables including the discount rate (e.g. NPV @ 6% = $1,648,000 and B/C = 3.3, NPV @ 10% = $1,483,000 and B/C = 3.0); and
- some "what if" analysis e.g. what if eradication costs are double expected (in this example NPV = $562,000 and B/C = 1.6)

While respondents were asked their WTP over a number of years (i.e. 3 or 5) to eradicate the pest, the benefits that those WTP values represent may well continue indefinitely into the future. On the other hand, there is the risk that that pest, or another pest, may invade some time in the future. The term of payments was made clear to respondents and similarly that the outcome (biodiversity protected) may extend into the future beyond the term of those payments.

CM surveys could be structured to ask WTP as an upfront one-off cost, over a limited number of years (as we have done), or indefinitely into the future. The literature suggests that WTP figures is indeed highly dependent on (1) the timeframe that respondents are asked to pay, and (2) the frequency of payment. The approach taken by the project team was deemed to be the most realistic option, both in terms of how long payments could be expected to be made by the public, as well as that the likelihood of reinvasion during the period would be low. Nevertheless, such uncertainties also reinforce the need to carry out risk simulation (see Section 8.2.2).

Table 5 Best Guesses of mean values – assuming point estimates

Year			(PV)	0	1	2	3	4	5
Discount rate		8%							
Benefits									
Local HH		100							
	WTP	No.							
Char	12	20	$95,825	0	24,000	24,000	24,000	24,000	24,000
Birds	61	1	$24,356	0	6,100	6,100	6,100	6,100	6,100
Sub-total			$120,181						
District HH		1400							
Char	11	20	$1,229,755	0	308,000	308,000	308,000	308,000	308,000
Birds	38	1	$212,412	0	53,200	53,200	53,200	53,200	53,200
Sub-total			$1,442,167						
Total Benefits			$1,562,347						
Costs			$500,000	500,000					
NPV			**$1,062,347**						
B/C			**3.1**						
Input cells									

Sensitivity Analysis			
Discount rate	10%	NPV	983,335
		B/C	3.0
	6%	NPV	1,148,298
		B/C	3.3
What if Analysis			
Cost double		NPV	562,347.0
		B/C	1.6

Note that the values in the BVD were estimated in surveys carried out in 2007 and 2008. The analysis we are carrying out here is in 2009 dollars so the WTP estimates in the BVD should be indexed up into 2009 dollars using the Consumers Price Index (CPI). As time goes by this will become a more important issue, but for the example we have not taken inflation into account. The cash flows for this analysis are set out in Table 5.

Based on this analysis and assuming there are no other benefits or costs the initial advice to decision makers would be to proceed with eradication. As the response is rolled out better information is likely to become available and this provides the opportunity to update the analysis.

8.2.2 Risk Simulation

The above analysis has been carried out using point estimates of the best guesses of WTP. Using point estimates alone as input to the cashflows places all the focus on the best estimates and we know that there is significant uncertainty around these figures. They were generated from relatively small samples of people from the community who as individuals expressed varying degrees of WTP. The BVD captures this through estimates of the standard deviation and upper and lower limits given 95% confidence i.e. there is a 95% chance the best guess will be inside the range.

We can incorporate this uncertainty in the analysis using the risk simulation technique QuRA™ [41] as follows.

Once the analysis has been carried out using point estimates, a sensitivity analysis will show which of the key variables contribute most to the NPV - these will be the variables that cause the NPV to change most when changed by a set percentage e.g. 5%. Once these variables have been identified the next step is to assess which of these have the most uncertainty. This requires a judgement call by the analyst having assessed the available data. Usually there will be three or four key variables that meet the above criteria (high impact on the NPV and high uncertainty).

In the example, it is clear that the WTP estimates meet the criteria of high impact of the NPV and high levels of uncertainty. Consulting the BVD provides the following estimates of the standard deviations (SD) associated with the mean values (see Table 6).

[41] Nimmo-Bell has developed a standard approach to risk simulation called QuRA™ (Quantitative Risk Analysis), which utilises @RISK (risk simulation software for Excel) to generate distributions of key risky variables and incorporate these into a distribution of the NPV of the project (Bell 2000).

Table 6 Example WTP est. – means & standard deviations (\$/HH)

Lake Rotoroa	Local sample		District sample	
	Mean	SD	Mean	SD
Charophytes (1% Δ)	12	2	11	2
Birds (1 spp)	61	14	38	7

When combining estimates to determine their overall uncertainty we also need to take into account the relationships between the uncertain estimates. These are described by the correlation coefficients which can take on values between -1 and +1. A value of zero means two estimates are independent of each other and there is no dependency relationship. A value near +1 means that the two estimates are positively correlated i.e. a high value for one estimate means there will be a high value for the other and a low value for one means there will be a low value for the other. A value near -1 means the estimates are negatively correlated i.e. a high value for one will mean a low value for the other and vice versa.

This information has been estimated for the 36 variables in the BVD and is contained in Appendix 2. For Lake Rotoroa there is a low degree of positive correlation between Charophytes and Birds with a correlation coefficient of 0.2 for both local and district populations (see Table 7). We assume the distributions and correlations will be the same for the policy site and transfer them directly.

Table 7 Correlation matrix: Charophytes / Birds

	Charophytes	Birds
Charophytes	1.0	0.2
Birds	0.2	1.0

Using @RISK (risk simulation software for Excel) we can now estimate the probability distribution of the NPV. We do this by replacing the point estimates of the key uncertain variables in the cashflows with the means and standard deviations and specifying the correlation coefficients between the uncertain variables to ensure the dependency relationships are taken into account. @RISK will then simulate the uncertainty, by drawing from the distributions, usually over 5,000 iterations and combine the results into a distribution of the NPV.

In the cashflows of benefits, the first year point estimate is replaced with a formula that specifies the correlation and distribution of the variable as shown in Equation 4.

(4) =Corrmat(B27:C28,1)+RiskNormal(WTP,SD)

(5) =Corrmat(0.2,1)+RiskNormal(12,2)

Equation 4 states that the WTP value generated for a particular iteration is based on the correlation coefficients in locations B27:C28 on the spreadsheet (the 1 stands for the first of 2 variables) along with the mean WTP value and standard deviation assuming a normal distribution (equation 5). Once the WTP value has been generated for a particular iteration it is copied into the cells for the remaining four years. This is based on the assumption that for a given iteration the WTP value will be the same each year. This seems a reasonable assumption as community values once established are unlikely to change materially from year to year (external factors held constant).

The cashflows and output for the risk simulation are shown in Table 8. Note that the NPV has remained the same as in Table 5. This is because the normal distribution we have assumed is symmetrical around the mean.

The additional information now available to decision makers from risk simulation as compared with point estimate analysis is contained in the chart of the NPV shown in Table 8. We can now say that due to the uncertainty in the WTP estimates the NPV of the response has a 100% chance of being positive. Also there is a 90% chance the value will be between $0.65 million and $1.46 million. By reference to the chart of the probability distribution of the NPV (as shown on Table 8) it is possible to estimate the likelihood of any value being exceeded. The expected NPV is $1.06 million. This gives a much more realistic view of the likely outcome of the response. As the chances of the response being positive are very high this gives decision makers confidence to proceed with the response.

Experience with using different types of distribution (other than normal) to describe uncertain variables has shown that often the distribution of the NPV changes little. However, assumptions about correlation can have a significant impact. Table 9 shows the impact on the NPV of different assumptions in the example confirming that negative correlation reduces the range of the NPV, while positive correlation increases the range.

Table 8 Risk simulation (assume WTP est. are normally distributed)

				(PV)	0	1	2	3	4	5
Year				(PV)	0	1	2	3	4	5
Discount rate	8%									

Benefits

Local HH		100									
		WTP	SD	No.							
	Char	12	2	20	$95,825	0	24000	24000	24000	24000	24000
	Birds	61	14	1	$24,356	0	6100	6100	6100	6100	6100
	Sub-total				$120,181						
District HH		1400									
	Char	11	2	20	$1,229,755	0	308000	308000	308000	308000	308000
	Birds	38	7	1	$212,412	0	53200	53200	53200	53200	53200
	Sub-total				$1,442,167						
Total Benefits					$1,562,347						

Costs

Costs		$500,000	500,000
Input cells	(yellow)		

NPV $1,062,347
B/C 3

Risk variable format = RiskCorrmat(B27:C28,1)+RiskNormal(WTP,SD)

Correlation matrix

	Char	Birds
Char	1.0	0.2
Birds	0.2	1.0

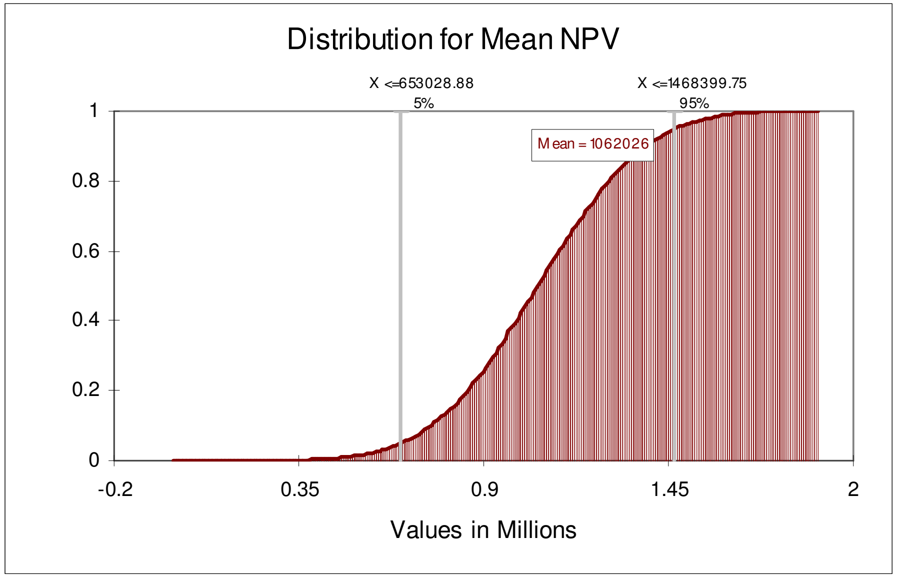


Table 9 Impact of the correlation assumption on the NPV range

Correlation coefficient	NPVs ($m) at the 5% & 95% limits	
	x<= 5%	x<=95%
-1	0.74	1.38
0.2	0.65	1.47
+1	0.59	1.53

Of course real life is much more complex and decisions may be much less clear cut, but the example shows how the database could be used to aid in making quick high level decisions.

8.3 Cost Benefit Analysis

Information gathered at the Investigation stage will likely indicate whether environmental and social benefits will be material to the decision on a major response. If such benefits are deemed to be material to the decision, then it is time to assess whether these values will be adequate or whether a primary non-market valuation survey and analysis using choice modelling should be undertaken. Such decisions require value judgements by management as to whether the values are reasonable given the study site they are based on and how similar this is to the policy site. For example, the benefit transfer process conducted at Investigation stage (outlined in 6.1 and 8.2.1) may have determined: that pest impacts of interest were not covered by the BVD; or values in the BVD were deemed inappropriate for direct transfer to new policy site. In both cases, a primary study is likely to add value to the decision.

Sections 5.2.2, 6.1, and the case studies in Annex 1 all provide information on the process that would be undertaken to carry out a primary study. Care ought to be taken to design the CM survey so that it can add value to the BVD and be used for future benefit transfer. This is best done by a CM expert familiar with the benefit transfer process.

Incorporating biodiversity values into the BNZ DSS

1. Assess the components of TEV at risk from the incursion
2. Assess for benefit transfer the characteristics of the policy site and compare against possible values in the database
3. Select from the database the relevant biodiversity values
4. Estimate the benefits of a response from Compensating Surplus by taking the sum of WTP values weighted by the quantitative change of each multiplied by the relevant number of households affected
5. Discount the future compensating surplus values to obtain a PV of benefits
6. Estimate the PV of the cost of a response that relates to the benefits
7. Subtract the costs from the benefits to obtain the NPV
8. Divide the benefits by the costs to obtain the Benefit/Cost ratio
9. Conduct a sensitivity analysis on key variables including the discount rate
10. Conduct 'what if' analysis on key sensitive variables
11. Carry out risk simulation using QuRA™ to highlight the uncertainty in the estimate of the NPV and likelihood of a positive NPV
12. Provide initial recommendation on the appropriate response
13. Revise estimates as new information comes to hand
14. If there are no relevant values in the database assess whether a primary study is required

8.4 Pest management

Once a weed or pest has become established ongoing decisions are required on appropriate management. A pest of national significance requires the development of a National Pest Management Strategy and a pest of only regional significance, requires the development of a Regional Pest Management Strategy. Both such strategies require a CBA to be undertaken.

As with incursion responses, currently pest management usually focuses on quantifying active use values i.e. those benefits pertaining to industry that can be quantified using market prices. The *methodology* outlined in Section 8.2 is equally applicable to decisions on pest management. Yet depending on the case in question, WTP values may need to be in a different frame e.g. regional frame for regional pests rather than local frame, unless the pest management problem is a local one.

This manual is as equally relevant to site-led programmes as it is to species-led programmes; as previously explained, the values in this manual relate to biodiversity impacts rather than the impacts of a specific pest. The key thing is to identify the relevant impacts, and apply the values in the BVD to those impacts (following the benefit transfer process in Section 6.1).

8.5 Biodiversity management

Organisations making resource allocation decisions related to biodiversity (e.g. DoC) may also find this manual and the process outlined in Section 8.2 relevant in quantifying the value to New Zealanders of changes in biodiversity. While values in the BVD were obtained using pests as the case studies, the economic literature on eliciting values and conducting benefit transfer notes that it is the **impacts to biodiversity** that are important, rather than pest impacts specifically.

9 Final comments and next steps

Biodiversity values are increasingly important to people

Some of the most pressing problems facing New Zealand are at the margin between the economy and the environment. Once basic needs have been met there appears to be a declining marginal utility for additional income. In other words, each addition to income is worth slightly less in terms of increased well being or happiness[42]. Other considerations of well being such as the environment start to have an increasing influence. Examples of this are the concern that the general public has over human induced climate change, the concerns over water quality in lakes and waterways from nutrients that spill over from the ever increasing intensification of pastoral farming and loss of native plants and animals due to pests and diseases.

Excluding quantitative biodiversity values from decisions results in underinvestment

It is a tilted playing field if it is not possible to directly compare changes to the economy with changes to the environment. By using dollars as a common metric we can determine the on impact on our overall well being[43]. For example, when the biosecurity budget is constrained, weighing up the net benefit of a response against a pest attacking agriculture, which is quantified in money terms, will win out against the response to a pest attacking native bush, which is not quantified in money terms.

Tools can help quantify biodiversity values

Stated preference techniques (e.g. choice modelling) enable analysts to place dollar values on biodiversity changes and thus there is the ability to make direct comparisons between benefits and costs in the economy and the environment. Unlike changes to the economy where market prices guide values, changes to the environment require indirect survey methods incorporating non-market values that can be estimated through stated preferences. The WTP concept is the equivalent of the market price. It is real, but cannot be estimated directly and therefore the context within which it is derived is important.

But a question often asked is, how real are stated preferences? It is very difficult to verify whether stated willingness to pay in a hypothetical situation would be backed up by actual payments in a real situation. But the proof is in the pudding! There are examples of WTP studies being used to justify special taxes for environmental policies

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[42] At the extreme, another million to a billionaire is worth far less to well being than an extra $100,000 to someone who is on the dole.

[43] While environmental values are the subject of this manual, social/cultural values are also important in determining impacts on overall well-being. CM also has the potential for deriving social values and possibly cultural values although for the latter more work is needed in different cultural contexts to determine whether the tool is culturally appropriate.

that are then accepted by communities. For example, a special tax to improve water quality in Lake Rotorua. Overseas stated preference studies help inform environment court decisions, particularly when environmental degradation is involved. These studies go back to the famous Exxon Valdez oil spill case.

The use of such tools is complex process, but no more complex than the science

There is both art and science in estimating biodiversity values. Lying behind the estimates is a huge body of peer reviewed economic literature embodying theoretically sound concepts, such as utility theory and statistical significance. The literature supports a key role for CM and benefit transfer in contributing to more informed decisions in a policy environment that is full of uncertainty. Primary studies will always be better than benefit transfer studies, but there is a role for the latter when time and budget are constrained. Transferring values from one site to another or one environmental attribute to another can embody significant errors. The key to reliability and validity of benefit transfer is "more similar is better".

While uncertainties exist in non-market valuation, the information generated is only one component of the decision-making process, sitting alongside a range of other uncertain information (scientific, market, etc). It is critical that non-market valuation is carried out in close cooperation with relevant scientists because how the science is applied is just as important to the final result. The role of the analyst is to strive to minimise bias and provide independent and objective advice to inform decision makers. So long as state-of-the art methods are used and any limitations are clearly identified and communicated, the decision-making process will be improved. Sections 5.2 and 6.1 drew attention to the key issues in using choice modelling and benefit transfer.

And uncertainty can be reflected in CBA

Section 8.2.2 outlined how to highlight the uncertainty that is inherent in conducting CBA by applying risk simulation using QuRA™.

This manual has outlined how these tools can add value to decisions

The primary focus of this manual has been on incorporating biodiversity values[44] into biosecurity decisions: specifically, establishing a database of biodiversity values (the BVD) and how to incorporate these into cost benefit analyses using either benefit transfer or primary choice modelling studies. But the methodology also has wider relevance to any decisions involving economic information and environmental impacts, especially concerning ongoing pest and biodiversity management (e.g. as carried out by Regional Councils and DoC).

[44] Mainly passive values

For BNZ, there are two points in the 'rocket ship' response process to incorporate biodiversity values to aid decision making:

1. **Investigation** - when basic information on the pest and its likely impact is being collected, for the decision on whether to initiate a response, and later at
2. **Cost Benefit Analysis** - when response options are analysed in detail.

At the investigation stage, an early high level assessment of biodiversity values at risk utilising benefit transfer techniques can greatly assist the response decision, particularly whether environmental and social benefits will be material to the outcome. This is also the point to assess whether values held in the BVD will be adequate for the CBA stage, or whether a primary choice modelling survey should be undertaken. If it is decided to undertake a primary study, the survey process should be initiated as early as possible so that there is enough time for the results of the study to be incorporated into the CBA.

In addition to providing quantitative values, non-market valuation can help by clarifying trade-offs, identifying magnitudes of directions and effects, and providing new insights (e.g. how various stakeholder groups' values differ).

Building up the database of values

Over time as new primary studies are undertaken they will help to grow the database and increase its relevance to decisions. This is the start.

Sections 5.2, 6.1, and 6.3.1 all set out issues that should be considered in designing choice modelling surveys to ensure that values elicited through the studies result in (1) reliable estimates of community WTP that can be relied on by decision makers, and (2) values that are amenable to future benefit transfer (i.e. can be added to the BDV).

The benefit transfer process in particular (Section 6.1) may be useful in thinking about strategic policy priorities; namely:

- What situations do the values in the BVD cover?
- What is not covered?
- Where do any gaps align with priorities of decision-makers?

  The answer to this question may help to focus any future choice modelling studies to top priority areas / issues.

The concept – bands of value – has future potential for decision-making

During this project we explored an idea about whether similar types of biodiversity values could be grouped into 'bands' for high level decision-making (e.g. at the investigation stage). Our analysis set out in Section 7 showed that this concept has potential, but is still at an early stage of testing. There are currently only a few comparisons to draw upon to establish whether there are bands of value for different types of environmental attribute. As more studies are undertaken to estimate biodiversity values these can be added to the Biodiversity Valuation Database and the concept can be explored further and thus the database will become increasingly useful.

There is still a missing link to complete the Total Economic Value picture

Section 5.1 introduced the concept of total economic value (TEV), where the value attached to an environmental resource (e.g. indigenous biodiversity) is made up of direct use, indirect use and passive use values[45]. This manual has focused on incorporating (mainly) passive use values of biodiversity into response decisions. The BNZ CBA guidelines cover direct use values well. In terms of formal guidelines, what is still missing is a consistent methodology to incorporate indirect use values (such as recreation) into CBA.

[45] We have included option value here as part of passive use value – refer to section 5.1 for an explanation.

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11 Acronyms

AERU	Agricultural Economics Research Unit
BDV	Biodiversity Values Database
BT	Benefit Transfer
CBA	Cost Benefit Analysis
CE	Choice Experiment
CM	Choice Modelling
CPI	Consumers Price Index
CS	Compensating Surplus
CV	Contingent Valuation
B/C	Benefit Cost Ratio
DSS	Decision Support System
ECMS	Enterprise Content Management System
EIA	Economic Impact Assessment
EVRI	Environmental Valuation Reference Inventory
FMD	Foot and Mouth Disease
IRS	Incursion Response System
LC	Latent Class
MAF	Ministry of Agriculture and Forestry
ML	Mixed Logit
MNL	Multinomial Logit
MRS	Marginal Rate of Substitution
NPV	Net Present Value
QuRA™	Quantified Risk Analysis
RPL	Random Parameters Logit
SD	Standard Deviation
SDC	Socio-Demographic Characteristic
TEV	Total Economic Value
WTP	Willingness To Pay

12 Appendix One: Significance of WTP estimates

In order to determine whether the comparisons were significant we estimated the standard deviations of the ratio of the two WTPs in the comparison using the Delta Method, which finds the approximate variance based on the Taylor series expansions of the variances of functions of random variables as per the equations below.

$$Var\frac{A}{B} = \left(\frac{\mu_A^2}{\mu_B^4}\right)\sigma_B^2 + \left(\frac{1}{\mu_B^2}\right)\sigma_A^2 - 2\left(\frac{\mu_A}{\mu_B^3}\right)\rho\sigma_A\sigma_B$$

Where:	A	=	WTP of attribute A
	B	=	WTP of attribute B
	μ	=	mean
	σ^2	=	variance
	ρ	=	correlation coefficient

The standard deviation is simply the square root of the variance.

$$SD\left(\frac{A}{B}\right) = \sqrt{Var\left(\frac{A}{B}\right)}$$

And the correlation coefficient is derived as per the equation below.

$$CorrA/B = CovAB/\left(\sqrt{VarA} * \sqrt{VarB}\right)$$

The means, variances and covariances were obtained from the variance covariance matrix, which is an output of the NLogit RPL model (VARB).

Unfortunately, depending on whether the larger WTP was the numerator or the denominator of the ratio varying results were obtained. If the larger WTP was the numerator then there was a greater chance of the comparison being non-significant, whereas the reverse was true if it was the denominator. To overcome this anomaly we estimated the standard deviation (SD) from the variance of the difference of two random variables where variable A is always larger than variable B, as per the equations below:

$$Var(A-B) = \mu_A^2\sigma_B^2 + \mu_B^2\sigma_A^2 - 2\rho\sigma_A\sigma_B$$

$$SD(A-B) = \sqrt{Var(A-B)}$$

This allows unambiguous results to be estimated based on Z values and P(Z) being less than 0.05 showing that the difference is significant at the 5% level i.e. there is less than a 5% chance of there being no significant difference. Where:

$$Z = \mu / \sigma$$

$$P(Z) = 2\left(1 - NORMSDIST\left(ABS\left(Z\right)\right)\right)$$

NORMSDIST is the standard normal cumulative distribution with mean zero and standard deviation one, and ABS is the absolute value.

13 Appendix Two: Correlation Coefficients

Table 1. Pauatahanui Correlation coefficients

	Recn	Veg	Shells	NoPaddle
Recn	1.0			
Veg	0.0	1.0		
Shells	0.4	0.2	1.0	
NoPaddle	0.4	0.3	0.5	1.0

Table 2. Twizel Correlation coefficients

	Plant	Insect	Fish
Plant	1.0		
Insect	0.1	1.0	
Fish	0.2	0.3	1.0

Table 3. Fairlie Correlation coefficients

	Plant	Insect	Fish
Plant	1.0		
Insect	0.2	1.0	
Fish	0.3	0.2	1.0

Table 4. Timaru Correlation coefficients

	Plant	Insect	Fish
Plant	1.0		
Insect	0.4	1.0	
Fish	0.5	0.5	1.0

Table 5. Riccarton Correlation coefficients

	Plant	Insect	Fish
Plant	1.0		
Insect	0.3	1.0	
Fish	0.2	0.4	1.0

Table 6. Rotoroa Correlation coefficients

	Cha	Bir	FishMus
Cha	1.0		
Bir	0.2	1.0	
FishMus	0.4	0.3	1.0

Table 7. Hamilton Correlation coefficients

	Cha	Bir	FishMus
Cha	1.0		
Bir	0.2	1.0	
FishMus	0.3	0.2	1.0

Table 8. Morrinsville Correlation coefficients

	Cha	Bir	FishMus
Cha	1.0		
Bir	0.1	1.0	
FishMus	0.3	0.2	1.0

Table 9. Wellington Correlation coefficients

	Cha	Bir	FishMus
Cha	1.0		
Bir	0.2	1.0	
FishMus	0.3	0.2	1.0

Table 10. Nelson Correlation coefficients

	Stings	No birds	Lot birds	No bugs	Lot bugs
Stings	1.0				
No birds	0.1	1.0			
Lot birds	-0.3	0.0	1.0		
No bugs	0.2	0.0	-0.4	1.0	
Lot bugs	-0.4	-0.3	0.2	0.0	1.0

Table 11. Riccarton Correlation coefficients

	Stings	No birds	Lot birds	No bugs	Lot bugs
Stings	1.0				
No birds	0.1	1.0			
Lot birds	-0.2	0.1	1.0		
No bugs	0.1	0.0	-0.2	1.0	
Lot bugs	-0.2	-0.2	0.0	0.4	1.0

14 Appendix Three: Sample demographics

Demographic information for sample populations relative to the 2006 Census data is provided in the tables on the following pages; while explanatory notes for these tables are below.

Explanatory notes:

Source: Statistics New Zealand (2006) Census data

Confidence intervals relate to the population. The sample needs to be within the lower and upper limit for 95% confidence level.

Definitions:

OLD	Over 60 years
YOUNG	Under 30 years
MIDAGE	30-60 years
HIGH INCOME	(household income > $100,000 pa) or (personal income > $50,000 pa)

Ethnicity: Note that percentages may not add to 100% as people may belong to more than one ethnic group.

Relevant population:

Rotoroa:	Hamilton Lake area unit
Hamilton:	Rototuna area unit
Morrinsville:	Matamata-Piako District
Wellington:	Karori North, Karori Park, Karori East and Karori South area units
Pauatahanui:	Papakowhai, Plimmerton, Mana-Camborne, Paramata-Postgate area units
Nelson:	Atawhai, Port Nelson, The Wood, Britannia, Washington, Trafalgar, Maitai, Kirks, Bronte, Atmore, Tahunanui, Tahuna Hills, Toi Toi, Broads, Grampians, and The Brook area units.
Riccarton:	Masham, Avonhead, Ilam, Upper Riccarton, Wharenui, Sockburn and Broomfeild area units
Twizel:	Twizel community area unit
Fairlie:	Fairlie area unit
Timaru:	Timaru district

South Island high country

	Sample				Population Census				Lower Limit				Upper Limit			
	Twizel	Fairlie	Timaru	Ch-Ch	Twizel	Fairlie	Timaru	Ch-Ch	Twizel	Fairlie	Timaru	Ch-Ch	Twizel	Fairlie	Timaru	Ch-Ch
GENDER																
Male	59.46%	29.27%	25.71%	38.46%	52.21%	47.28%	48.55%	48.69%	43.95%	40.25%	40.51%	43.19%	60.47%	54.31%	56.59%	54.19%
Female	40.54%	70.73%	74.29%	61.54%	47.79%	52.72%	51.48%	51.31%	40.23%	44.88%	42.95%	45.51%	55.35%	60.56%	60.00%	57.11%
QUALIFICATION																
Degree	32.43%	19.51%	5.71%	40.38%	9.42%	8.59%	6.95%	16.59%	7.93%	7.31%	5.80%	14.72%	10.91%	9.87%	8.10%	18.46%
AGE																
Young	2.86%	4.88%	2.94%	10.00%	17.75%	11.96%	19.04%	32.12%	14.94%	10.18%	15.89%	28.49%	20.56%	13.74%	22.19%	35.75%
Mid-age	68.57%	85.37%	97.06%	80.00%	53.26%	35.14%	51.76%	33.04%	44.83%	29.91%	43.19%	29.31%	61.69%	40.37%	60.33%	36.77%
Old	28.57%	9.76%	0.00%	10.00%	28.62%	24.28%	29.21%	20.65%	24.09%	20.67%	24.37%	18.32%	33.15%	27.89%	34.05%	22.98%
PERSONAL INCOME																
High income	42.86%	37.50%	43.33%	21.15%	10.87%	9.60%	11.70%	10.95%	9.15%	8.17%	9.76%	9.71%	12.59%	11.03%	13.64%	12.19%
Low income	57.14%	62.50%	56.67%	78.85%	82.61%	83.33%	80.82%	81.57%	69.54%	70.94%	67.44%	72.35%	95.68%	95.72%	94.20%	90.79%
ETHNICITY																
NZ European	89.47%	69.05%	97.14%	72.22%	78.61%	79.24%	81.25%	66.82%	66.17%	67.46%	67.80%	59.27%	91.05%	91.02%	94.71%	74.37%
NZ Maori	2.63%	4.76%	2.86%	5.56%	7.23%	3.81%	6.23%	5.04%	6.09%	3.24%	5.20%	4.47%	8.37%	4.38%	7.26%	5.61%
Others	7.89%	26.19%	0.00%	22.22%	21.08%	23.73%	18.71%	33.90%	17.75%	20.20%	15.61%	30.07%	24.41%	27.26%	21.81%	37.73%

Beech forest

	Sample		Population Census		Lower Limit		Upper Limit	
	Nelson	Ch-Ch	Nelson	Ch-Ch	Nelson	Ch-Ch	Nelson	Ch-Ch
GENDER								
Male	46.20%	40.00%	48.67%	48.69%	43.68%	43.19%	53.66%	54.19%
Female	53.80%	60.00%	51.33%	51.31%	46.07%	45.51%	56.59%	57.11%
QUALIFICATION								
Degree	38.50%	32.00%	15.06%	16.59%	13.52%	14.72%	16.60%	18.46%
AGE								
Young	4.60%	6.80%	19.89%	32.12%	17.85%	28.49%	21.93%	35.75%
Mid-age	86.20%	79.50%	44.34%	33.04%	39.80%	29.31%	48.88%	36.77%
Old	9.20%	13.70%	16.98%	20.65%	15.24%	18.32%	18.72%	22.98%
PERSONAL INCOME								
High income	31.90%	31.00%	13.30%	10.95%	11.94%	9.71%	14.66%	12.19%
Low income	68.10%	69.00%	78.27%	81.57%	70.25%	72.35%	86.29%	90.79%
ETHNICITY								
NZ European	81.30%	68.00%	80.03%	66.82%	71.83%	59.27%	88.23%	74.37%
NZ Maori	8.80%	5.30%	9.75%	5.04%	8.75%	4.47%	10.75%	5.61%
Others	9.90%	26.70%	18.72%	33.90%	16.80%	30.07%	20.64%	37.73%

Coastal marine

	Pauatahanui		Population Census	Lower Limit	Upper Limit
	Initial	Follow-up			
GENDER					
Male	43.6%	44.7%	49.1%	42.7%	55.5%
Female	56.4%	55.3%	51.0%	44.3%	57.6%
QUALIFICATION					
Degree	56.4%	57.4%	23.1%	20.1%	26.1%
AGE					
Young	7.3%	21.3%	13.9%	12.1%	15.7%
Mid-age	92.7%	78.7%	64.5%	56.0%	72.9%
Old	0.0%	0.0%	21.6%	18.8%	24.5%
HOUSEHOLD INCOME					
High income	54.5%	36.2%	34.3%	29.5%	39.2%
Low income	45.5%	63.8%	56.0%	48.0%	63.9%
ETHNICITY					
NZ European	86.2%	80.9%	78.7%	68.4%	89.0%
NZ Maori	6.9%	4.3%	10.4%	9.0%	11.8%
Others	6.9%	14.9%	10.9%	9.5%	12.3%

Freshwater

	Sample				Population Census				Lower Limit				Upper Limit			
	Rotoroa	Hamilton	M'ville[46]	Karori	Rotoroa	Hamilton	M'ville	Karori	Rotoroa	Hamilton	M'ville	Karori	Rotoroa	Hamilton	M'ville	Karori
GENDER																
Male	40.9%	42.5%	66.2%	51.6%	48.3%	48.5%	49.1%	47.7%	41.2%	41.0%	43.2%	41.8%	55.4%	56.0%	55.1%	53.5%
Female	59.1%	57.5%	33.8%	48.4%	51.7%	51.4%	50.9%	52.3%	44.1%	43.5%	44.7%	46.0%	59.3%	59.3%	57.0%	58.7%
QUALIFICATION																
Degree	31.8%	43.6%	27.7%	60.9%	24.8%	19.5%	6.4%	40.4%	21.2%	16.5%	5.6%	35.5%	28.5%	22.5%	7.1%	45.3%
AGE																
Young	22.7%	11.4%	35.4%	17.2%	35.2%	19.3%	21.8%	18.2%	30.0%	16.3%	19.1%	16.0%	40.4%	22.2%	24.4%	20.4%
Mid-age	77.3%	75.0%	46.2%	57.8%	47.9%	58.5%	51.8%	62.5%	40.9%	49.5%	45.5%	54.9%	55.0%	67.5%	58.0%	70.2%
Old	0.0%	2.3%	18.5%	25.0%	16.9%	22.3%	26.5%	19.3%	14.4%	18.9%	23.3%	16.9%	19.3%	25.8%	29.7%	21.6%
HOUSEHOLD INCOME																
High income	31.8%	35.0%	43.1%	57.8%	22.1%	32.6%	13.7%	37.0%	18.9%	27.6%	12.1%	32.5%	25.3%	37.5%	15.4%	41.5%
Low income	68.2%	65.0%	56.9%	42.2%	62.3%	55.4%	72.1%	52.0%	53.2%	47.0%	63.4%	45.7%	71.4%	63.9%	80.8%	58.3%
ETHNICITY																
NZ European	70.5%	67.5%	90.8%	89.1%	60.3%	68.4%	72.4%	67.6%	51.4%	57.9%	63.6%	59.3%	69.2%	78.9%	81.2%	75.8%
NZ Maori	22.7%	12.5%	3.1%	0.0%	13.2%	7.2%	12.2%	4.6%	11.3%	6.1%	10.8%	4.1%	15.2%	8.3%	13.7%	5.2%
Others	6.8%	20.0%	6.2%	10.9%	26.5%	24.4%	15.3%	27.8%	22.6%	20.7%	13.5%	24.4%	30.3%	28.2%	17.2%	31.2%

Other questions asked of respondents

	Freshwater				Coastal Marine		Beech forest		South island high country			
	Rotoroa	Rototuna	Morrinsville	Karori	Pauatahanui		Nelson	Ch-Ch	Twizel	Fairlie	Timaru	Ch-Ch
					Initial	Follow-up						
Member of environment group	23.0%	8.0%	14.0%	16.0%	na	na	9.9%	8.1%	10.8%	2.4%	2.9%	11.5%
Live on farm	na	na	na	na	na	na	1.1%	8.0%	13.5%	31.7%	5.7%	0.0%
Activities affected by wasps	na	na	na	na	na	na	89.0%	78.7%	na	na	na	na
Visited Rotoiti	na	na	na	na	na	na	75.8%	20.3%	na	na	na	na

46 Morrinsville

ANNEX 1: Case Studies

This section summarises the four case studies used to estimate dollar values for marginal changes to indigenous biodiversity. These values support the larger study for Biosecurity New Zealand (BNZ) aimed at developing a decision support system for invasive species impacting on indigenous biodiversity. The case studies undertaken during 2007 and 2008 were chosen to depict key aspects of New Zealand's natural environment namely: coastal marine, freshwater, South Island high country and beech forest.

Coastal marine

Pest. The study uses the European Shore Crab (*Carcinas maenas*) as the example alien invasive species.

Study location. The Pauatahanui Inlet 30 kilometres north of Wellington on the west coast being representative of New Zealand's coastal marine environment.

Potential impacts. This crab is particularly aggressive threatening indigenous species in the estuary and sheltered coastline, including:

- possible elimination of species e.g crabs and shellfish
- predation of a range of fish and shellfish species that could result in significant reductions in customary and amateur catch
- die back of coastal vegetation through burrowing and subsequent salt intrusion, and
- restrictions on recreational activity such as children paddling along the waters edge.

The crab has spread from its native habitat in Northern Europe to a number of places around the world and has established itself along the south east coast of Australia. Biosecurity New Zealand considers it a matter of when not if it will arrive in New Zealand waters. The Pauatahanui Inlet is one of 350 estuaries around the coast of New Zealand that would provide a suitable habitat for the European Shore Crab.

Four sub-samples of around 50 people were surveyed representing populations adjacent to the inlet, in the Wellington region and different ends of the country at Dunedin and Auckland (the Auckland sub-sample was subsequently dropped through lack of participants).

Survey results

Initial surveying used reallocation of government expenditure as the payment mechanism, but this failed to give significant results and so the local sub-sample (Pauatahanui) was resurveyed using a special tax on households with much improved and statistically significant results. In order to ensure the results would be consistent with the initial survey, the only change made was the money variable which became a special tax with values of zero, $25, $50 and $100 per household per annum for three years instead of zero or $2 million one-off reallocation of government expenditure.

This resulted in a total WTP per household over the four attributes of $185 per annum, with the greatest value placed on loss of shellfish species at $57. Interestingly, loss of ability for children to paddle along the water's edge had only a marginally lower value at $54. Loss of recreational fishing had a value of $37 per annum and loss of vegetation around the estuary $36.

In terms of relativity, loss of shellfish species and loss of paddling for children had approximately 50% higher value than loss of recreational fishing or loss of marginal vegetation.

Coastal marine case study

Threat – Estuarine system threatened by alien aggressive crab

Key insights

- A special tax on households provided superior results compared with reallocation of government expenditure as the payment mechanism

- WTP results per HH per annum over 3 years
    - Loss of shellfish species $57
    - Loss of paddling by children $54
    - Loss of recreational fishing $37
    - Loss of shoreline vegetation $36

- The range of views on value were much wider for loss of shell fish species and no paddling compared with loss of recreational fishing and loss of shoreline vegetation.

When these figures are extrapolated across the whole of the community of 3,372 households[47] around the estuary and over the three years of the loss period then the present value of the total loss (discounted at 10%) is $1.7 million with $530,000 of this due to loss of shellfish species.

Calculating marginal rates of substitution (MRS) between attributes enables comparisons to be made between attributes based on relative values and without reference to money. In this study the relative value for the loss of biodiversity (at 1.0) is slightly higher than the loss of children's ability to paddle along the water's edge 0.95 and significantly higher than the loss the loss of recreational fishing had a MRS of 0.65, loss of vegetation 0.63.

The full study is available at http://www.nimmo-bell.co.nz

South Island high country

Pest. Wilding pines

Study location. Tussock grasslands of South Island high country, Mackenzie Basin.

Potential impacts. Environmental attributes including landscape, endangered flora (*Hebe cupressoides*) and fauna (robust grasshopper and the white bait species bignose galaxias).

Wilding trees threaten to invade large areas (private land, pastoral leases and conservation and unoccupied Crown land) of the South Island. Wilding pines, with seeds mostly dispersed by wind, have demonstrated an ability to spread from an initial 250 hectares to cover an area over 100,000 hectares. The impacts of wilding pine incursion into the high country range from smothering indigenous biota (plant communities, plant and animal species) to merely visual effects (landscape). Intervening impacts include recreational (changing character of recreation sites) and economic (compete with pastoral land use and reduce water availability). With the range of impacts of wilding pines, controlling its spread delivers benefits in the form of avoidance of reduction of amenity values (recreation and tourism) from the high country. The Mackenzie Basin was chosen as the case study site as it hosts several species at risk due to wilding pines and is the area of research focus for the extent and effects of wilding pines.

The location of the four survey groups were from varying distances from the Mackenzie Basin: local - Twizel, district - Fairlie, region - Timaru and national - Christchurch.

[47] Based on Statistics NZ 2006 Census data

Key findings

People prefer less wilding pine coverage and for any given amount of coverage, people do not favour large, contiguous blocks. People value the continued existence of the three endangered species and prefer lower personal costs. Of the environmental attributes, bignose galaxias had the highest value at $110 per year for 5 years followed by robust grasshopper ($95/year) and hebe ($58/year). Households were willing to pay $60 per year for 5 years to prevent large blocks of wilding pines rather than scattered plots over the next 20 years.

South Island high country case study

Threat – Sub alpine tussock grasslands threatened by wilding pines

Key insights

- WTP results per HH per annum over 5 years
  - Prevent extinction of
    - Bignose galaxias $110
    - Robust grasshopper $ 95
    - Hebe $ 58
  - Prevention of large blocks of wilding pines compared with scattered plots over the next 20 years $ 60
- Different value preferences can occur that are not systematically related to particular sectors of the community e.g. irrespective of socio-economic level people may have a strong or a weak affinity for the environment
- The survey results represent the views of "informed citizens" in a scenario that would exist following a community awareness campaign and debate during an actual response rather than the views of the community at large.

The full study is available from the Agricultural Economics Research Unit (AERU), Lincoln University: http://www.lincoln.ac.nz/story_images/4020_RR303w_s13361.pdf).

Freshwater

Pest. Submerged aquatic weed hydrilla (*Hydrilla verticillata)*

Study location. Lake Rotoroa (Hamilton Lake) urban lake highly modified, but retaining native species.

Potential impact. Local loss of native species including submerged meadow grass (charophyte species), birds, and fish and mussels, and restriction of recreational activities.

Hydrilla was chosen as the case study invasive as it is BNZ's top priority weed. Although restricted to only three lakes in Hawkes Bay area, it has the greatest potential for negative impacts on New Zealand's freshwater systems. Hydrilla is a submerged freshwater perennial plant that is characterised by prolific growth and tolerance of a wide range of freshwater habitats from clear, murky, still or flowing water; temperature between 0 and 35°C; water depths from a few centimetres to 9 meters; low light to full sun; and a wide range of acidity and nutrient levels.

Potential negative impacts of hydrilla span the range of environmental, economic and social conditions. Hydrilla can dominate freshwater systems displacing indigenous biodiversity (charophytes, pond weeds, milfoils, shags, smelts and common bully), necessitate chemical use for control and increase flooding and erosion risk by clogging waterways. Water quality is reduced by lowering water circulation, reducing light and oxygen availability and the carbon uptake can cause quite large pH fluctuations. Economic impacts include clogging of irrigation and hydro power systems, increased costs for fishers, reduced tourism and increased eradication, control, surveillance, monitoring and public awareness costs to managers of water systems. Social impacts include reduced recreational activity, and negative impacts on public health and Maori cultural and spiritual matters

In conjunction with Biosecurity New Zealand, we chose Lake Rotoroa (also known as Hamilton Lake) as the freshwater system under threat. Lake Rotoroa was chosen as it has a higher risk of hydrilla invasion, has a long history of management, the lake itself is still largely in a native state, but has a highly modified shoreline and a profile due to surrounding housing and recreational use. This lake has features typical of many lakes in New Zealand that make it useful to extrapolate from.

Key findings

Overall people were willing to pay more to avoid hydrilla infestation than to protect individual existing attributes of the environment. This is in line with the expected large negative impact of the weed and the likelihood that once in the lake there would be a high probability of it spreading to other waterways. Of the existing environmental attributes charophytes, which are of international significance and at high risk from hydrilla, rated highest followed by birds and fish and freshwater mussels.

Table. Household WTP $ per annum over 5 years

	Local	District	Regional	National
Hydrilla	244	179	234	151
Charophytes	200	176	146	129
Birds	264	112	138	127
Fish/mussels	235	146	120	99

Freshwater case study

Threat – Urban lake threatened by the alien competitive submerged aquatic weed hydrilla

Key insights

- WTP results per HH per annum over 5 years, local sample
  - Avoidance of hydrilla $244
  - Loss of charophytes $200
  - Loss of a native bird species $164
  - Loss of a fish /mussel species $135
- People are willing to pay more to avoid hydrilla getting into the system than to protect existing biodiversity once it is there. This is due to the high chance hydrilla will spread to other water ways
- Loss of the native submerged water plant (charophytes) which are of international significance had the highest biodiversity value, followed by birds, fish and freshwater mussels
- The further people live from the lake the less they are WTP for biodiversity, but this is a relatively weak relationship
- While uncertainties exist for biodiversity values these are not out of line with physical uncertainties.

The full study is available at http://www.nimmo-bell.co.nz.

Beech forest

Pest. European wasp

Study location. Beech forest at Lake Rotoiti, Nelson Lakes National Park

Potential impacts.

The objective of this case study is to estimate community preferences and values associated with the impact of wasps and/or their management on indigenous species in the South Island. In the case of wasps, the aim is to measure the change in utility that attaches to changes in indigenous biodiversity particularly the abundance of birds and insects.

Invertebrates are particularly successful in gaining entry into New Zealand (often as stowaways) and this threat is expected to increase with the volume of trade. While most of these exotic species have no adverse impact, social wasps' impacts include:

- Alteration indigenous biodiversity food chains resulting in reduction in native birds (e.g. directly competing for food (honeydew and invertebrates) and
- Preying on pollinators (hover and bristle flies)
- Affecting commercial agriculture through reduction in bees and
- Recreational activities through wasp stings.

With the significant impact of wasps, management strategies to control wasps have value in terms of the damages avoided.

Key findings

Overall people value native species and the avoidance of stings. For both birds and insects, there is a higher value attached to preventing native species becoming virtually absent (i.e. locally extinct) relative to building a bigger very healthy population. Of the existing environmental attributes, birds have a higher value (Nelson WTP of $325 per year for too few birds) compared with insects (Nelson WTP of $198 per year for too few insects). Nelson households were willing to pay $5.25 per year to prevent a 1% increase in the probability of wasp stings. Lastly, there were similar WTP between Christchurch and Nelson households.

Beech forest case study

Threat – beech forest birds and insects threatened by European wasp

Key insights

- Overall people value native species and the avoidance of stings.
- For both birds and insects, there is a higher value attached to preventing native species becoming virtually absent (i.e. extinct) relative to maintaining a very healthy population.
- WTP results per HH per annum over 5 years, regional sample
  - Preventing too few birds $325
  - Preventing too few insects $198
  - Prevent a 1% increase in wasp stings $ 5
- There were similar WTP between Nelson (regional) and Christchurch (national) households with no statistical distance decay effect.
- While the survey was not aimed to be representative of each community or to be representative of the whole of South Island, the results provide an understanding of the likely magnitude of values people hold for attributes which will be useful for cost-benefit analysis of species protection programmes.

The Full study is available from the AERU, Lincoln University.
http://researcharchive.lincoln.ac.nz/dspace/bitstream/10182/801/1/aeru_rr_310.pdf

Key insights from the case studies

The key insights from the case studies are:

- The use of schools and community service groups to recruit community members in group meeting-based surveys was quick and cheap, conveyed high quality background information and had educational benefits for biosecurity as well.

- Simple statistical models were able to explain a large proportion of the variance in people's choices. Statistical power was enhanced significantly by the use of models that allowed for respondent heterogeneity.

- Different tastes can occur that are not systematically related to particular sectors of the community. For example, irrespective of socio-economic level people may have a strong affinity for the environment or a weak affinity.

- Uncertainty embodied in the estimates of WTP, while significant, is not out of line with the uncertainties inherent in the estimates of physical damage from a pest incursion.

- Respondents were willing to pay more for the avoidance of pests than for the local preservation of indigenous biodiversity. This is likely to be related to the high chance of pests spreading from the initial incursion to the rest of New Zealand.

- Results support previous studies, which show active use values, such as boating, tend to reduce much more significantly with distance than passive use values, such as loss of biodiversity. The case studies generally show a statistically non-significant distant decay effect for indigenous biodiversity values.

- The survey represents the response of "informed citizens" in a scenario that would exist following a community awareness campaign and debate about control pest management options rather than the views of the community at large.

- While the survey was not aimed to be representative of each community the results provide an understanding of the likely magnitude of values of the attributes which will be useful for cost-benefit analysis of species protection programmes.