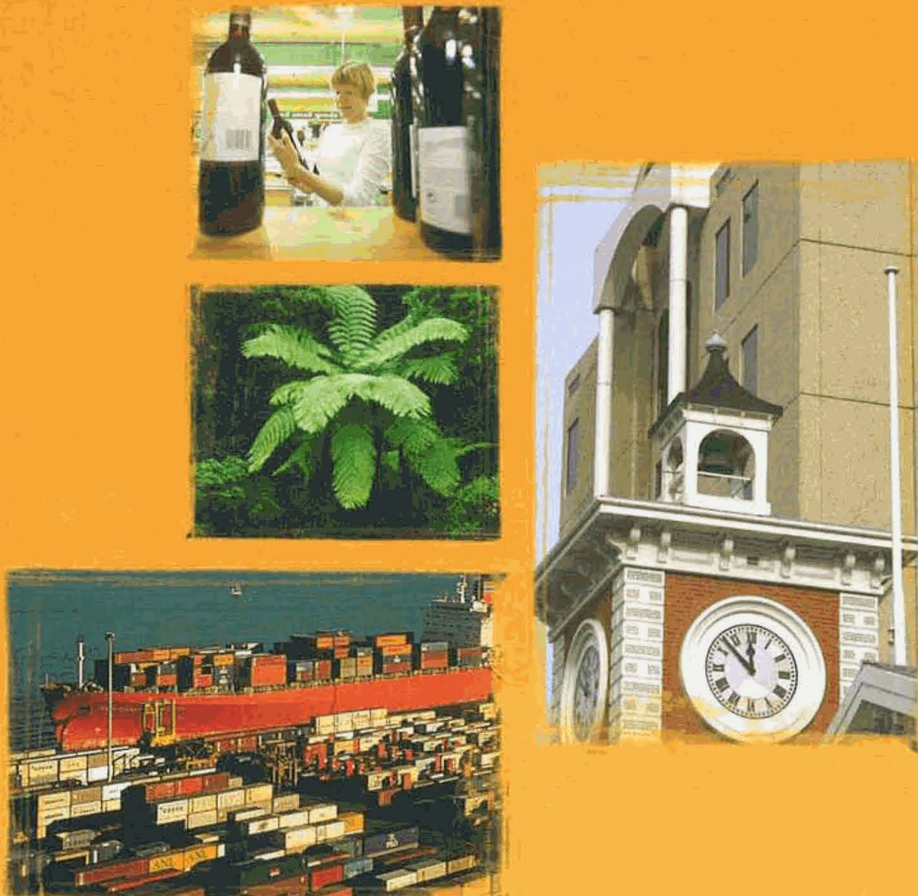
Lincoln University

Christchurch
New Zealand



Community Mitigation Preferences: A Choice Modelling Study of Auckland Streams

Geoffrey N. Kerr
and
Basil M.H. Sharp

Research Report No. 256
May 2003

AERU

LINCOLN UNIVERSITY
Te Whare Wānaka O Aoraki

PO BOX 84, LINCOLN UNIVERSITY, CANTERBURY 8150, NEW ZEALAND

Research to improve decisions and outcomes in agribusiness, resource, environmental, and social issues.

The Agribusiness and Economics Research Unit (AERU) operates from Lincoln University providing research expertise for a wide range of organisations. AERU research focuses on agribusiness, resource, environment, and social issues.

Founded as the Agricultural Economics Research Unit in 1962 the AERU has evolved to become an independent, major source of business and economic research expertise.

The Agribusiness and Economics Research Unit (AERU) has five main areas of focus.
These areas are trade and environment; economic development; business and sustainability, non-market valuation, and social research.

Research clients include Government Departments, both within New Zealand and from other countries, international agencies, New Zealand companies and organisations, individuals and farmers.

Two publication series are supported from the AERU Research Reports and Discussion Papers.

DISCLAIMER

A summary of AERU Research Reports, beginning with #242, are available at the AERU website www.lincoln.ac.nz/aeru/

Printed copies of AERU Research Reports are available from the Secretary.

Report on a study undertaken for Auckland Regional Council

Community Mitigation Preferences: A Choice Modelling Study of Auckland Streams

Geoffrey N. Kerr
Lincoln University

and

Basil M.H. Sharp
University of Auckland

May 2003

Research Report No. 256

Agribusiness and Economics Research Unit
PO Box 84
Lincoln University
Canterbury
New Zealand

Ph: (64) (3) 325 2811
Fax: (64) (3) 325 3679
http://www.lincoln.ac.nz/AERU/

ISSN 1170-7682
ISBN 0-909042-37-3

Contents

List of Tables

List of Figures

Acknowledgements

The Auckland Regional Council funded this study. It is the first of its type attempted in New Zealand. We are grateful to ARC for their willingness to investigate the use of relatively new economic methods for addressing environmental management issues. This study would not have been possible without the support and encouragement of many ARC staff. In particular, we are extremely grateful for the enthusiasm and ongoing commitment of Chris Hatton and Graeme Ridley. The surveys benefited markedly from comments made by Professor Jeff Bennett at the Australian National University and Associate Professor John Rolfe at the University of Central Queensland. Surveys of community values rely on time and goodwill of survey participants. We are grateful to the residents of South Auckland and North Shore who donated their time and opinions by participating in the surveys. Consumer Link greatly assisted in the conduct of focus groups. Debbie Sheehan at Research Solutions was extremely helpful in final design of the personal interview process and in administering the interviews.

Executive Summary

The Auckland Regional Council has direct responsibility for some of the impacts associated with urban growth. Land disturbance from urbanisation leads to on-site and off-site environmental impacts. Requiring the use of best management practices is one regulatory tool that the Council uses to mitigate adverse impacts of land disturbance. Offsetting mitigation is an additional tool that can be used to compensate for adverse environmental effects. Offsetting mitigation could be applied in the catchment undergoing development and/or in other catchments.

If the Council chooses to use offsetting mitigation as a policy instrument then it is immediately confronted with the problem of deciding on the location and level of mitigation needed to compensate for adverse effects. Key attributes of stream quality can be described from an ecological perspective using descriptors such as nutrient levels, flow rates, condition of indicator species, and so on. The cost of achieving mitigation can also be quantified. However, ecological descriptors and information on mitigation costs are not sufficient to undertake an assessment of benefits and costs as required under the Resource Management Act. Information on community mitigation preferences is needed. Without information on the benefits of mitigation the Council has no rational basis for comparing costs and benefits.

Choice modelling is a technique that has been recently developed for the valuation of environmental changes. The idea underlying choice modelling is relatively straightforward. People are asked to indicate their single preferred choice from a set of options. Each option is described by several attributes and the levels of those attributes vary across the options. Statistical methods are used to develop a mathematical model of preferences based on the choices that people made.

In this particular study, surveyed individuals were presented with a description of status quo conditions on two streams. Two alternatives to the status quo were also presented. In each of the alternatives the condition of the stream in a relatively natural state declined in some way, while improvements were made to conditions on the other, degraded stream. People therefore had the option of improving quality of the degraded stream, but only at the cost of degradation to the natural stream. Survey participants could choose the status quo or one of the alternatives, and were asked to report their preferred option. Each outcome was described in terms of water clarity, native fish species abundance, fish habitat, vegetation, and channel shape. Information on people's choices was then used to derive estimates of money value that attach to the environmental outcomes associated with mitigation. Estimates of mitigation effectiveness were also developed in non-monetary terms. Both monetary and non-monetary estimates provide managers with information on the relative value of a given attribute.

The principal aim of this project was to apply choice modelling as a tool for development of offsetting mitigation assessment in two locations within the Auckland metropolitan area. This research built upon earlier work completed for the Council. Research workshops involving environmental economists, ecologists and planners helped with the assessment of alternative approaches to measuring community preferences. Questionnaire design was aided by working with two focus groups, one from North Shore City and the other from South Auckland. These two city areas were to become the two survey populations. The results of the focus group studies provided a list of stream attributes that could be described in reasonably simple terms. Focus groups were also used to confirm that citizens understood the choice game and were willing to carefully consider the tradeoffs and make reasoned choices.

In order to compare the relative benefits of different data collection methods the study used both postal questionnaires and personal interviews. The postal questionnaire drew heavily on design parameters that have proved successful in similar Australian studies. Apart from minor format changes, choice questions used in the personal interviews were identical, but obviously delivery was different. Interviewers used large coloured display cards to present the choices. Furthermore, the interviewers were able to seek additional information on the difficulty of the choice questions. This information confirmed that most interview participants understood what they were being asked to do. Level of understanding did not have a significant impact on value estimates.

The two different survey instruments were applied in each area. Five hundred postal questionnaires were mailed out to people on the electoral rolls for each of North Shore City and South Auckland. The usable response rates were 32% and 21% respectively. A randomised sample of addresses provided a starting point for personal interviews. The response rate for contacts was 44% and 40% respectively.

Data collected from the postal surveys and personal interviews were compared against 2001 census data in order to assess the degree of representation in the surveys. Data collected by personal interview were significantly different from census data on a number of socio-economic attributes; including number of people in the household, household income and whether the respondent had a university degree. Data collected by the postal survey were statistically significantly different from census data on age, income, home ownership, and university degree.

The choice modelling results are particularly encouraging. In all cases water clarity in both natural and degraded streams is highly statistically significant. The sign that attaches to naturalisation of channel form in the degraded stream is positive and statistically significant. The sign that attaches to the number of native fish species in the natural stream is also positive and statistically significant. Responses suggest little perceived benefit in moving from moderate to plentiful streamside vegetation cover. The *Money* coefficient is highly statistically significant and negative as expected, indicating that any particular option is less likely to be selected if it costs more. Location effects are also evident in the data. People in South Auckland place lower values on the number of native fish species in degraded streams and higher values than North Shore residents on high levels of streamside vegetation.

The monetary value of each stream attribute is reported along with 95% confidence intervals, providing the information necessary for the assessment of mitigation options. Estimates of monetary value have been used in a number of scenarios to illustrate the overall values associated with environmental degradation or enhancement proposals. One example illustrates how to derive costs of stream degradation. Another example illustrates the effectiveness of on-site mitigation. A further example illustrates how the model can be used to evaluate an off-site mitigation package.

The study examined the accuracy of transferring benefit estimates from a survey site to a project site. The two principal methods of benefits transfer are direct transfer, in which estimates of mean value are used directly at the project site; and benefits function transfer, in which the estimated valuation function is applied to the project site. Overall, money value estimates derived using valuation function benefit transfer proved not to be as accurate as direct transfer of money values. However, there were large estimation errors using either approach.

This study has successfully applied the choice modelling method to identify community willingness to trade-off stream attributes. People have understood the tasks asked of them and have given consistent responses that have allowed estimation of utility functions and money values. Interviews were superior to postal surveys, but both approaches yielded useable models that were very similar across locations. The values estimated allow the design of mitigation to offset damages in Auckland streams.

Chapter 1
Introduction

Auckland, New Zealand's largest urban area, is growing at a rate faster than the rest of the country. This growth places considerable pressure on the region's physical and social infrastructure, economy and environment. Every year hundreds of hectares of land in the Auckland region is urbanised, which can have a number of adverse environmental impacts. Onsite impacts include the loss of streams and minor waterways as well as modification and piping of streams.

Urban development can also lead to offsite impacts. Without protection measures the transformation of this land can result in accelerated erosion and greatly increase sediment yields and sedimentation of receiving environments. Various studies in the Auckland Region indicate that there is up to 100 times the sediment yield from construction sites compared to pastoral land (Hatton, *pers com.)*. Adverse ecological effects of this sediment include: modified or destroyed instream values; modified estuarine and coastal habitats; smothering and abrading of fauna and flora; changes in food sources and interruption of life cycles. In addition, there may be damage to water pumps and other structures, the quality of water supplies usually diminish, localised flooding can occur, and there is a loss of aesthetic appeal.

The Auckland Regional Council (ARC) has direct responsibility for some of the impacts which growth is having on the ambient environment. Projects in the Auckland Region involving land disturbance must incorporate erosion and sediment controls as an integral part of the development. Best management practices (BMPs) for erosion and sediment control include structural techniques such as sediment retention ponds, contour drains and silt fences. BMPs are not 100% effective and as a result it is recognised that even with appropriately designed and maintained systems in place some sediment discharge will occur. Dependent upon the nature and sensitivity of the receiving environment and the eventual sediment yield, a residual effect is likely to occur. Residual sedimentation can lead to significant cumulative effects within catchments.

In addition to BMPs the ARC can use offsetting mitigation by augmenting stream quality at one site to compensate for the adverse environmental affects associated with development at other sites. Enhancement could occur within the catchment undergoing development and/or possibly in other catchments. The idea is to use mitigation to achieve and sustain desired environmental outcomes. Ecologists can offer a range of indicators that could be used to describe a "desirable" outcome – such as species diversity, stream cover, flow rate, temperature, and so on. However, very little is known about the preferences of the community vis-à-vis alternative states of Auckland streams. Without information on community preferences it is not possible for the ARC to identify mitigation that reflects the environmental outcomes the community desires. This research project seeks to provide insights into community preferences for streams in the Auckland region.

The project builds on the outcomes of earlier work that used a series of focus groups from the community to help identify the salient aspects of waterway amenities and acceptable forms of mitigation (Kerr and Sharp, 2002). The results from this initial stage of the analysis were used to develop survey instruments to apply Choice Modelling. The project has two specific objectives:

1. Assist the ARC in undertaking a Choice Modelling Survey which is to be utilised as a tool for development of off setting mitigation assessment
    a. Undertake choice modelling in two different locations within the Auckland metropolitan area.
    b. In each case an identical impact will be assessed in a stream at the survey location.

2. Assess the prospect of benefits transfer, using the results of the Choice Modelling exercise.
    a. Test whether mitigation functions estimated at the different sites are similar and whether the mitigation estimated will produce accurate mitigation requirement estimates.

The report is structured as follows. Section 2 provides background to the study, including its evolution and a sketch of the choice problem being addressed. The theoretical framework of choice modelling is outlined in Section 3 along with an overview of the information that can be obtained from data on community choice over stream attributes. The community survey is described in Section 4. Surveys were conducted in two areas in the greater Auckland metropolitan area – North Shore City and South Auckland. The focus groups used to develop the questionnaire were drawn from these areas (Kerr and Sharp, 2002). Statistical design, survey method (personal interviews and mail survey), and the results of statistical tests on the samples relative to census data are reported in Section 4. Econometric results are presented in Section 5. The choice models are used to derive measures of value for stream attributes. Section 6 illustrates how the models can be applied to different scenarios for change. Both on-site mitigation effectiveness and evaluation is illustrated using the models. Undertaking extensive surveys involves time and cost. Even if survey cost is not an issue, obtaining timely information is important to those administering resource consents. For these reasons, an assessment of benefits transfer was undertaken. Section 7 provides an assessment of benefits transfer. Section 8 provides a conclusion to the study.

Chapter 2
Study Background

Annually the Auckland Regional Council receives applications for about 200 earthworks consents. These are processed under Sections 9 and, where relevant, Section 13 of the Resource Management Act (RMA). About one-half of these applications involve stream works that are processed under Section 13. Most applications are associated with small first or second order soft-bottomed streams in retired pasture. These streams are usually ecologically degraded before any development occurs. Works commonly involve channelisation, armouring and culverting. In a practical sense stream channels and associated riparian margins are damaged regardless of what normal BMPs are used. The scale and significance of the ecological damage varies from consent to consent.

The legal basis for requiring a Land Use Consent for land disturbing activities is the Operative Regional Plan: Sediment Control. The Plan's rules apply to land disturbing activities in general and require consents for a range of activities over a certain spatial threshold. As a condition of these consents the ARC has the ability to place specific offsetting mitigation requirements.

Offsite mitigation is a tool used to complement BMPs where some kind of ecological balance can be restored by enhancing stream quality in proximate areas. Requiring the consent holder to provide offset mitigation for the unavoidable damage caused by an activity is well established internationally. Offset mitigation is commonly provided for in the conditions imposed on resource consents. Typical examples of offset mitigation include riparian planting and stream bank retirement to offset water quality degradation, planting forests to offset greenhouse gas emissions, creating or enhancing wetlands or indigenous bush to offset land drainage. In order for the offset mitigation envisaged by section 108(2)(c) of the RMA to function effectively the community needs to have confidence in the mitigation process.

However the method for establishing the "appropriate mitigation" is far from clear and generally relies on a "best professional judgement" approach. Consequently, it is highly desirable to quantify in dollar terms the costs of both the adverse effects at the site of development and the benefits of the offset mitigation. This, of course, is the legislative intent of Section 32 of the RMA. Transparent quantification of costs and benefits ensures that the mitigation proposed offers the potential to offset, from both the ecological and the economic perspectives, the adverse effects generated.

2.1 The Choice Problem

Little is known about the community value that attaches to alternative states of the environment and this creates a problem for managers. Absent information on community preferences the Council has no rigorous basis for imposing mitigation conditions on a given resource consent. For example, is planting 500 m of riparian land sufficient compensation for the loss of fish habitat in a given catchment? Or, is it possible to substitute an increase in riparian planting in one catchment for degradation in another catchment? Offset mitigation involves choice. A conceptual model of the choice problem is illustrated in Figure 1. Ecologists can identify a range of attributes (labelled Z_k) associated with a stream in state k. These attributes improve as the state of the stream improves from degraded to high quality states. While ecologists can propose descriptors of quality, it is not clear *a priori* that people in the community view quality in the same way. That is, ecologists can provide a framework (call it f) for mapping stream attributes into an ecological value ($f(z) \rightarrow Q$). From an economic perspective we are interested in the mapping of stream attributes into preferences (u) and eventually economic value ($u(z) \rightarrow V$). The aim of this study is to provide estimates of community preferences for differing states of streams and the value that attaches to these alternative states.

Goods that are traded in the market can be described by certain attributes. For example, a list of attributes can be used to describe a car; typical car attributes include the number of doors, engine size, colour, safety, etc. Buyers reveal their willingness to pay for this bundle of attributes in the market. However, no such market exists for "stream quality" and we must rely on the stated preference of individuals for stream quality. The bundles of attributes Z_k listed in Table 1 are used to illustrate a set of indicators of stream quality that change as the state of the stream improves from low to high ecological value. The cost of combinations of BMPs and offset mitigation can be expected to increase as restoration approaches what might be considered pristine. Figure 1 shows cost increasing as higher ecological values are attained through BMPs and offset mitigation. However, without information on the community values that attach to either state k or to the attributes Z_k it is not possible to assess the improvements in ecological value against the cost of attaining particular environmental outcomes through the application of BMPs and offsetting mitigation. The community value that attaches to different states of stream quality is the research question being addressed in this report.

Figure 1
Conceptual Model of Ecological Value

Attributes (Z_k)	**State of a Stream (k = 1,2,3)**		
	Degraded State	**Moderate Ecological Value**	**High Ecological Value**
Flow	High peak/low	Modified hydrology	Normal hydrology
Riparian zone	0-5m either side 0-100m long	5m - 15m either side 100-300m long	>15m either side > 300^{+}m long
Temperature	> 25°C	20°C -24°C	< 20°C
O_2 saturation	< 50%	50-80%	> 80%
Nutrient levels	High	Medium	Low
Shade	0-50%	50-70%	≈ 70%
Fish taxa	≤ 2	3-5	>5
Stream cover	Little	Adequate	Optimal
Complexity	Low	Medium	High

Low cost ⟶ **High cost**

Low Ecological value ⟶ **High Ecological value**

Community value?

2.2 Approach

Beginning in 2000 the Auckland Regional Council initiated a series of workshops aimed at developing an approach for quantifying community preferences. Workshop participants included environmental economists, planners and ecologists. The aim was to assist in the development of a set of robust, defensible guidelines for determining:

- When compensation is required
- What the environmental objectives of offset mitigation are
- Where mitigation can be implemented and how it is calculated
- Where works cannot be carried out, to establish a process for calculating the quantum of a financial contribution that will be put into an offset mitigation bank. These funds will be used to undertake works elsewhere.

Moving from the conceptual model presented in Figure 1 to estimates of community preferences presented an early challenge because little was known about the attributes individuals used to assess stream quality. Section 3 describes the approach used to identify community willingness to trade-off environmental and money attributes. This section provides a brief description of the theory underpinning the *choice modelling* (CM) approach. In order to apply choice modelling it is necessary to identify which attributes people value, to design a series of choice events in which people are asked to illustrate their preferences, and to implement these procedures through a survey. Section 4 describes attribute identification, survey design and data collection mechanisms. It also describes the respondents and compares them to the target population.

Chapter 3
Choice Modelling

Choice modelling is a technique that has been recently developed for the valuation of environmental changes. People are presented with a set of options and are asked to report their single preferred option from that set (Bennett and Blamey, 2001).

Choice modelling, like referendum contingent valuation, can be thought of as mimicking a political process. Participants are given several options (alternatives) from which they must pick a single best alternative. The chosen option is assumed to have higher expected utility for the respondent than any other option presented to them. If sufficient information is available on people's choices, then it is possible to use statistical methods to derive estimates of coefficients in a utility function that describes how people made those choices. Once the utility function is known it is straightforward to derive estimates of monetary compensation required in order to attain any desired reference utility level. Consequently, Hicksian compensating and equivalent surpluses can be assessed.

The choice problem can be concisely formulated using random utility theory. For any individual (i), utility associated with alternative k is a function of the characteristics of alternative k ($\mathbf{Z_k}$) and characteristics of the individual ($\mathbf{X_i}$).

$$U_{ik} = U\ (\mathbf{Z_k}, \mathbf{X_i})$$

Utility derived from each alternative has 2 components, observable and random. Letting the observable portion of utility be V (.), then:

$$U_{ik} = V\ (\mathbf{Z_k}, \mathbf{X_i}) + \varepsilon\ (\mathbf{Z_k}, \mathbf{X_i})$$

Individual i will choose alternative k over all others if it is expected to yield the most utility. Probability of choosing alternative k is:

$$P\ (k) = \text{Prob}\ \{V_k + \varepsilon_k > V_j + \varepsilon_j, \forall\ j \neq k\}$$

The probability of choosing any option can only be modelled after assumptions have been made about distributions of the error terms. The most common assumption is that the errors are Gumbel distributed, leading to the multinomial logit model.

$$P\,(k) = \frac{e^{\mu V_k}}{\sum_j e^{\mu V_j}}$$

The scale parameter (μ) is typically assumed to equal unity, implying constant variance. Model parameters are estimated by substituting for V with a parametric utility function that is dependent on the vector of attribute levels (**Z**). For example, a linear utility function takes the form:

$$V_k = V(Z_k) = \beta_0 + \beta_1 Z_1 + \beta_2 Z_2 + \ldots + \beta_n Z_n = \boldsymbol{\beta} \mathbf{Z'}$$

Data analysis entails selection of the coefficient vector **β** that maximises the probability of obtaining the observed choices. This is undertaken using maximum likelihood procedures. Interaction terms and variable transformations mean that the procedure is not constrained to simple linear utility functions. Alternative assumptions about error terms generate different models, although the underlying rationale remains unaltered.

Once the utility function has been estimated it is a straightforward matter to estimate the rate at which people are willing to trade off attributes. Economic valuation requires derivation of *part worths*, which signal the amount of money that would be traded for a unit change in any of the other attributes.

Let the last attribute in the utility function be money (Y):

$$V_k = \beta_0 + \beta_1 Z_1 + \beta_2 Z_2 + \ldots + \beta_{n-1} Z_{n-1} + \beta_Y Y = \boldsymbol{\beta Z'}$$

Now consider only attribute *m* changing. In order to identify the amount of money that would compensate for this unit change in *m* the total differential of utility is set to zero. With a linear utility function this yields:

$$dV_k = \beta_m dZ_m + \beta_Y dY = 0$$

$$\Rightarrow \quad dY = -\beta_m/\beta_Y$$

= monetary compensation for a unit change in Z_m

= Part worth for attribute m

With a linear utility function part worths are independent of the levels of any of the attributes.

Several (or all) attributes may change simultaneously. In that case, the initial utility level is maintained when:

$$dV_k = \beta_1 dZ_1 + \ldots + \beta_{n-1} dZ_{n-1} + \beta_Y dY = 0$$

$$\Rightarrow \quad dY|_{\text{constant utility}} = -(\beta_1/\beta_Y\, dZ_1 + \ldots + \beta_{n-1}/\beta_Y\, dZ_{n-1})$$

Linear utility functions also imply that the total income change required to maintain initial utility is simply the sum of the part worths multiplied by the changes in the corresponding attribute levels. A unit increase in attribute *m* requires a compensatory payment of the same magnitude, but opposite sign, to a unit decrease in attribute *m*. In other words, willingness to pay (WTP) is identical to willingness to accept compensation (WTA) by definition in the linear utility model.

The simple multinomial logit (MNL) model is easily estimated using readily available computer packages and is frequently used for analysis of choice data. However, MNL implies independence of irrelevant alternatives (IIA), which can result in perverse outcomes as new options are added because all existing options will adjust by the same proportion to account for the new alternative. Potential violations of IIA require that the analyst tests for its presence and, where necessary, uses more advanced statistical procedures that do not rely on the IIA hypothesis. Suitable alternative models include the nested logit model, the heteroscedastic extreme value model, the random parameters logit model, and the multinomial probit model, amongst others.

Chapter 4
Community Survey

4.1 Questionnaire Design

In order to design surveys for collection of choice modelling data it is necessary to identify attributes that are salient for members of the target population. Attribute identification was done in discussions with ARC personnel, and using focus groups conducted in the two case study communities.

Consumer Link, an agency that specializes in market research, was contracted to arrange the focus groups. Two group sessions – twelve individuals in each group - were feasible within the budget. In order to capture some of the diversity that exists in the Auckland region one session was run at Manukau in South Auckland, the other on the North Shore. Consumer Link endeavoured to get a mix of participants distinguished by age, ethnicity and gender. The likelihood of self-selection on the basis of personal preferences vis-à-vis stream management was minimal because participants had no prior information on the specific purpose of the meeting.

Details of the procedure followed at each focus group meeting are reported in Kerr and Sharp (2002). Each focus group was shown photographic images of thirteen streams in the Auckland region. Participants were then asked to comment on the "good things about this stream", and the "bad things about this stream", and to score the stream on a 10-point scale (1 = terrible, 10 = outstanding). In general, the average and median scores across the two focus groups were not dissimilar (Kerr and Sharp, 2002). Stream attributes mentioned in discussion included:

- Water clarity
- Flow of water
- Quality of the stream bank
- Access
- Safety
- Surrounding land use
- Natural shape of the stream
- Habitat for wildlife

Focus group discussion then moved onto causes of stream degradation and the range of management options that could be used to control degradation, and possibly enhance stream quality. Once again, visual images were used to provide information and stimulate discussion. A strong view was expressed that those creating degradation should be held responsible and should be required to pay for mitigation. Community funding was considered acceptable if there was an element of "publicness" associated with enhancement. The location (urban/rural) and proximity (with respect to residence) of stream degradation/enhancement was considered important. Significantly, participants wanted the payment of mitigation to be linked to an environmental outcome.

Each session culminated in six choice games (Kerr and Sharp, 2002). Each choice game listed stream attributes for a given management option. Two choice games involved two management options; four choice games included three management options. Three games included costs to the household of adopting a particular strategy. Both groups had no conceptual difficulty with the games, although they did find the questions involving financial cost more challenging. The relative importance of location was also highlighted at this stage of the meeting.

The results from the focus group studies indicated that stream attributes could be described in relatively simple terms that could be understood by the general population. Participants understood the idea of a choice game and were prepared to carefully consider the tradeoffs and make meaningful choices. The choice game format used in the focus groups provided the basis for developing the survey questionnaire (Appendix 2).

4.2 Statistical Design

One of the main study objectives was to identify whether off-site attributes could be used as mitigation for specified on-site environmental changes. Consequently, attributes needed to vary at two sites. Extending the utility functions presented in Section 3 to incorporate two sites yields:

$$V_k = \beta_0 + [\beta_{11}Z_{11} + \ldots + \beta_{(n-1)1} Z_{(n-1)1}] + [\beta_{12}Z_{12} + \ldots + \beta_{(n-1)2} Z_{(n-1)2}] + \beta_Y Y$$

Where β_{ij} is marginal utility of attribute i at site j and Z_{ij} is the level of attribute i at site j. On-site mitigation requires that a change in an attribute at site 1 (say Z_{11}) is offset by changes in other attributes at site 1 (i.e. by changing attributes Z_{1k} where $k \neq 1$). Off-site mitigation entails changing attributes at the other site. A change in an attribute at site 1 (say Z_{11}) is offset by changes in attributes at site 2 (i.e. by changing attributes Z_{2j} where j includes all attributes at site 2). In order to identify willingness to trade-off attributes between sites the utility function must include attributes at both sites. For similar sites, this effectively doubles the number of attributes in the utility function compared with single site models.

Typically, recent choice modelling studies have incorporated 4-6 attributes. With these numbers of attributes, survey designs are available to estimate interaction effects between the attributes. For example, willingness to pay for additional fish species might be expected to depend upon the amount of habitat available for fish, suggesting an interaction between number of fish species and available habitat. This study did not allow the possibility of interaction effects of this type. The requirement for attributes to vary at two sites, along with the number of attributes that were identified in the focus groups as being potentially significant, and the requirement for a money attribute to allow assessment of money values for site attributes, resulted in selection of the ten choice attributes in Table 1.

Table 1
Choice Attributes

Attribute	Stream types	Attribute levels	Attribute values
Water clarity	Both	2	Clear, Muddy
Native fish species	Both	3	Natural: 1, 3, 5 Degraded: 2, 3, 4
Fish habitat	Both	3	Natural: 2km, 3km, 4km Degraded: 1km, 2km, 3km
Native streamside vegetation	Both	3	Little or none, Moderate, Plentiful
Channel form	Degraded stream only	2	Straightened, Natural
Cost to household	Neither	3	$0/year, $20/year, $50/year

Because of the large number of attributes in the choice sets, the number of choice events faced by each individual was limited to five to reduce fatigue. The fractional factorial, main effects statistical design adopted (Hahn and Shapiro, 1966) required six different versions of the survey, with some choice sets occurring in more than one version. In each choice event survey participants were able to choose between the status quo (clearly labelled as such) and two unlabelled alternatives. Inclusion of a third alternative provides more information from each choice event, which improves model fit and the accuracy of coefficient estimates (Rolfe and Bennett, 2003). The first alternative in each choice event was developed from the statistical design plan and the second alternative was the fold over of the first alternative.

4.3 Surveys

Choice modelling data are normally obtained by use of self-completed postal surveys or personal interviews. Both have advantages and disadvantages. Personal interviews allow respondents to be presented with information in formats that cannot be used in mail surveys, interviewers can ensure the target recipient is the person who completes the survey, response rates are often superior, respondents cannot "skip ahead" and receive information out of the intended order, and interviewers can evaluate respondent understanding. Postal surveys are cheaper and avoid the potential of interviewer bias. Personal interviews are recommended for contingent valuation studies (Arrow *et al.,* 1993), but postal surveys are frequently used because of budget constraints. This study used both interviews and postal surveys in order to detect whether there are differences in values measured by the two approaches. If postal surveys produce similar value estimates to personal interviews then the additional expense of personal interviews may not be justified.

Mail survey

The postal questionnaire drew heavily on design parameters that have proved to be successful in similar Australian studies (Whitten & Bennett, 2001). Attribute levels were communicated wherever possible by the use of icons to allow visual identification of the trade-offs being made. Clear communication of attribute qualities is essential to ensure that all respondents are reacting to the same stimuli. This was achieved by including a two-sided A4 glossy brochure in the survey package. The brochure (Appendix 3) provided photographs of representative stream conditions alongside labelled icons.

In order to test for socio-economic effects, data were collected on sex, age, income, education, ethnicity and number of residents in the household. In order to assure respondents of anonymity, questionnaires were not numbered and individuals in the sample were not identifiable in any way. While this meant that postal costs were increased because everyone received a reminder postcard, this additional expense was more than offset by reduced complexity and labour requirements.

Minor modifications were undertaken subsequent to pre-testing the survey instrument with Auckland residents. The Lincoln University Human Ethics Committee approved the survey.

Individual names and addresses were randomly drawn from electoral rolls. The sample was further reduced by inclusion only of cases with postal codes 1701 and 1702 (South Auckland) and 1309-1311 (North Shore). The population was over-sampled, allowing division into mail survey and personal interview samples without replication.

A pre-survey letter (Appendix 1) was mailed to survey participants on 13 January 2003. The purpose of the letter was to increase the perceived importance of the survey, which has been shown to improve response rates (Dillman, 2000). Two days later (15 January 2003) the survey was mailed. The survey package included a cover letter (Appendix 2), the glossy information sheet (Appendix 3), the questionnaire (Appendix 2) and a freepost return envelope. A reminder postcard (Appendix 4) was mailed to everyone on 20 January 2003.

Response rates for the mail survey are summarised in Table 2. There is a marked difference between the response rates for the two areas. While North Shore residents responded at a rate typical of similar studies, the response rate from South Auckland was considerably lower than expected. This low response rate has potential implications for sample representativeness, and the low number of responses is likely to make statistical analysis difficult and to provide large confidence intervals on estimated parameters.

Table 2
Mail Survey Response Rates

	North Shore	South Auckland
Mailed	500	500
Undeliverable	44	42
Assumed delivered	456	458
Useable returns	145	95
% Useable	31.8%	20.7%

Personal interviews

The personal interviews were adapted from the postal surveys. Differences between interviews and postal surveys were:

- There was no pre-survey letter, cover letter, or written survey introduction. Interviewers introduced themselves and the survey using a prescribed script.
- Show cards were used to present the range of possible responses to questions 1, 2, 10, 11 and 12 (Question numbers are the same as the postal survey).
- Large, coloured show cards were used to present the choice questions. The interviewer was able to describe the items on the card and to explain the choices that were available to the respondent. The format was slightly different to the postal survey after amendments were made to clarify the nature of the choices (Appendix 5).
- Three additional questions probed the difficulty of the choice experiments. The additional questions (Questions 16-18) are presented below.

Question 16: On a scale from 1 to 10 where 1 is very easy and 10 is extremely difficult, how understandable were the choice questions?

Question 17: On a scale from 1 to 10 where 1 is very easy and 10 is extremely difficult, please rate the difficulty of making your choices

Question 18: [Completed by the interviewer]. Interviewer rate the respondent's understanding of the choice questions on the 1 to 10 scale (1 = zero understanding, 10 = completely understood)

Two sub-populations were established by randomly selecting electoral roll addresses for South Auckland and North Shore. This process was conducted simultaneously with the mail survey procedure, using identical procedures. The top 90 in each randomised list were selected, a total of 180. Sixty from each 90 were used initially, with the others as spares to be used if necessary (due to the first start point being in an industrial area, not enough houses etc). Not many of the spares were used. A quota of five per start point was set. Each interviewer was given their start point addresses and after knocking at a start point dwelling they turned left and followed the pavement, approaching every second house. The aim was to make at least two calls to each house where no response was obtained.

Response rates for personal interviews are summarised in Table 3. A total of 619 personal interviews were completed, 850 individuals refused (58% refusal rate) and interviewers failed to make contact with 1375. Reasons for failing to make contact included large dogs, business premises, not eligible because of participation in the mail survey, unoccupied dwelling, and so on.

Table 3
Personal Interview Response Rates

	North Shore	**South Auckland**
Dwellings visited	1302	1542
Failed to make contact	603	772
Refusals	391	459
• Refused to screen	182	273
• Qualified but refused	209	186
Interviews	308	311
• Males	159	148
• Females	149	163
Response rate for contacts	44%	40%

4.4 Sample Characteristics

Table 4 reports population and sample socio-economic characteristics. Differences between population and sample distributions are summarised using the probability of observing the chi-square statistic. Significant differences are highlighted using shaded cells. Individual level census data (sex, age, education) are from the 2001 census for people 20 years of age or older. Household level census data (number of people, income, home ownership) are drawn from the same census and include all households in the relevant regions. Because of demographic changes since the 2001 census, these data do not perfectly represent the current populations of North Shore City or South Auckland. However, they are the best data available for sample validation purposes. Postal surveys were addressed to specific, randomly selected **individuals**, so the sample should ideally conform to the individual level census data. However, personal interviews were sampled somewhat differently. The sampling frame was a specific **address** and the participant was randomly selected from people 20 years or older resident at that address. Consequently, the personal interview sample should ideally conform to the household level census data.

Tests for differences from census data for the postal surveys may not indicate significant differences because of the low numbers of responses – particularly for the South Auckland postal survey. Differences in sample sizes between personal interviews and postal surveys mean that Table 4 can be somewhat misleading and calls for caution in interpretation of the results. Chi-square scores are dependent on sample size and postal survey samples are smaller than interview samples, making postal survey sample differences less likely to be detected. This means that non-significant chi-square scores can be obtained with response distributions that show marked differences from the population. It can also mean that “better” interview samples can be statistically significantly different to the population, while “worse” postal survey samples may appear to be not significantly different.

Individual level census data
The four surveys obtained responses that are representative of the sex distributions within the populations. Although the postal surveys have over-represented older age groups, these differences are not statistically significant. Interview samples more closely matched the population age distributions. People with a university degree were more likely to respond than others. While this effect was not statistically significant for the South Auckland postal survey, the North Shore postal survey sampled twice as many degree holders as expected.

Household level census data
It is notable that the postal surveys strongly over-sampled homeowners, particularly on the North Shore. Bias towards selection of homeowners was not apparent in the personal interviews.

Both the postal survey and the personal interviews in South Auckland were over-representative of people from households with incomes less than $50,000 per year. On the North Shore, the personal interview sample matched population incomes reasonably well. However, people from households with income in excess of $100,000 per year were over-represented in the North Shore postal survey.

The two postal samples quite closely match population household size. This is a surprise because a random sample of individuals should be biased towards people from larger households. On the other hand, the personal interview samples, which are expected to match the underlying population, over-represent large households. This could be a result of the higher probability of finding someone at home in a larger household.

The impacts of sample biases can only be inferred once the significance of socio-economic attributes have been identified in the choice models. This matter will be addressed in Section 5.

Table 4
Characteristics of Survey Data Against 2001 Census

	South Auckland			North Shore City		
	Census	Interviews	Postal	Census	Interviews	Postal
Individual Level Census Data						
Sex						
Female	52.6%	54.1%	58.5%	52.8%	49.5%	53.9%
P (χ^2) =		0.605	0.253		0.256	0.790
Age						
20 - 29	21.3%	18.0%	16.1%	18.7%	14.8%	13.9%
30 - 39	24.1%	26.3%	18.4%	22.4%	19.9%	15.4%
40 - 49	20.6%	20.8%	21.8%	21.2%	22.0%	16.9%
50 - 59	15.6%	18.0%	19.5%	16.9%	17.9%	24.6%
60 - 69	9.6%	8.7%	12.6%	9.6%	12.0%	13.1%
≥70	8.8%	8.3%	11.5%	11.3%	13.4%	16.2%
P (χ^2) =		0.637	0.443		0.274	0.013
Education						
University Degree	8.3%	12.2%	10.8%	16.1%	28.9%	32.4%
P (χ^2) =		0.015	0.391		2.52E-09	1.99E-07
Household Level Census Data						
Number in household						
1	14.5%	8.3%	15.1%	19.8%	14.7%	11.4%
2	26.3%	21.5%	28.0%	32.6%	28.1%	36.2%
3	17.9%	17.5%	19.4%	18.3%	19.4%	21.3%
4	18.6%	19.5%	16.1%	18.0%	26.1%	19.2%
5	10.9%	18.1%	10.8%	7.8%	8.4%	6.4%
6 or more	11.8%	15.2%	10.8%	3.5%	3.3%	5.7%
P (χ^2) =		2.69E-05	0.987		0.005	0.126
Income						
≤ $20,001	19.7%	23.9%	22.0%	17.7%	15.8%	11.1%
$20,001 - $40,000	21.9%	27.5%	30.8%	20.1%	16.5%	17.8%
$40,001 - $50,000	10.0%	15.7%	13.2%	9.3%	11.7%	14.8%
$50,001 - $70,000	18.2%	17.6%	11.0%	17.3%	21.2%	14.8%
$70,001 - $100,000	15.6%	8.2%	8.8%	15.8%	17.2%	15.6%
>$100,000	14.6%	7.1%	14.3%	19.8%	17.6%	25.9%
P (χ^2) =		3.58E-06	0.082		0.179	0.047
Home Ownership						
Own residence	66.7%	64.7%	79.6%	69.9%	71.9%	92.1%
P (χ^2) =		0.458	6.64E-11		0.450	1.19E-31

Chapter 5
Choice Modelling Results

Choice models estimate utility functions that describe how welfare changes as a result of changes in environmental attributes. Estimated coefficients provide measures of relative marginal utilities as outlined in Section 3.. Ratios of marginal utilities can be used to identify willingness to trade-off stream attributes and also can be used to derive attribute part worths.

5.1 Econometric Results

Estimated choice model coefficients are presented in Table 5. Each of the coefficients identifies the impact on utility of a one-unit increase in the associated parameter. The models in Table 5 include all stream attributes and the money attribute in all cases, but the models include different interaction effects. While all possible interaction effects were tested for each model, only significant effects have been retained in the models presented in Table 5. The two exceptions (CKxN2 in Model C and CKxN4A in Model E) are very close to significance at the 10% level.

Wherever possible, the Heteroscedastic Extreme Value model (HEV) was fitted to avoid potential independence of irrelevant alternatives problems. In two models (E and G) the HEV model offered no improvement over the standard Multinomial Logit Model (MNL), so the MNL has been retained. Scale parameters are reported for the HEV models, but in no case are these significantly different to the scale parameter for the third option, which is identically set to unity.

Alternative specific constants (ASCs) are significant when factors other than independent variables in the model are important determinants of choice. The choice models arbitrarily set the ASC for the third choice to zero. In each choice situation the first option was labelled as the status quo, while the other two options were unlabelled. Significant second option ASCs indicate choice order effects, while significant first order effects can indicate either an order effect (which can take any sign) or a preference for the status quo over options involving change (which implies a positive sign on the ASC). In general, second-option ASCs are not significant. In four of seven cases status quo ASCs are positive, although typically of low significance.

The non-significance of ASCs indicates that order effects were not important in choices between the two alternatives to the status quo. However, there appears to be a preference, though not strongly significant, for the status quo over the alternatives to the status quo. This hypothesis was tested by utilisation of models that included an ASC on the status quo and no ASC on either of the other options. Results mirrored those of the models in Table 5, indicating a generally non-significant preference for the status quo with no significant effect on other coefficients. Since these alternative models contain less information, the more general models that allow detection of all order effects are presented in Table 5.

Coefficients on the 12 targeted attributes are highly significant in Models A and B, but in each of the other models some coefficients are not significant. In all cases coefficients on WATER CLARITY in both the natural and degraded streams are highly significant, as are coefficients on CHANNEL form in the degraded stream and number of NATIVE FISH SPECIES in the natural stream. The signs on all of these coefficients are positive, as expected. FISH HABITAT and the two VEG coefficients are frequently non-significant. The variable MODERATE VEG measures the impact of a change from little or no streamside vegetation to moderate streamside vegetation, while the variable HIGH VEG measures the impact of a change from little or no streamside vegetation to plentiful streamside vegetation. Typically, coefficients on these two variables are of similar magnitude, indicating little difference in perceived benefit in moving from moderate to plentiful streamside vegetation cover.

The coefficients on MONEY are all highly significant and of the expected negative sign, indicating that any particular option is less likely to be selected if it costs more.

Rho^2 provides an estimate of overall model fit, the ability of the model to explain observed responses. Unlike linear regression models, Rho^2 does not provide a measure of explained variance. Rho^2 scores for the postal models (C, F and G) indicate moderately good fit. The interview models (B, D and E) do not fit the data as well. However, significance of stream attribute coefficients is generally stronger in the interview models. The relatively low goodness of fit for these models indicates that there are factors that have not been included in the models that explain people's responses, or that there is considerable underlying inter-personal variance (or both).

Differences in model fit between interviews and postal surveys may have arisen for three main reasons. First, the samples were quite different (Table 4). Higher interview response rates may have resulted in less homogeneity amongst respondents and, consequently, poorer fitting models. Second, observed responses may be different for the two data collection methods, meaning the models cannot be directly compared. The two data collection methods allow for different information presentation, time constraints, and other factors. For example, respondents may feel the need for a rapid response in the presence of an interviewer, or may want to show that they are taking the interview seriously by making lengthy deliberations over each response. Conversely, postal surveys allow participants to take as much, or as little, time as they like. Interviews allow for clarification of the required task. Inability to obtain clarification may have an important effect in postal surveys if confused or uncertain respondents use heuristics to assist them in developing their responses. One such strategy that is consistent with Models C, F and G is for respondents to simplify the task by addressing only a subset of attributes. In such cases of simplified behaviour a better fitting model may not in fact be superior at identifying the underlying coefficients. Third, the two data collection methods used slightly different formats to present the choices (Appendix 2, Appendix 5), which may have influenced responses.

Interaction effects allow detection of the influence of individual-specific characteristics (such as age and income) on the probability of selecting a particular option. Interaction effects were tested in several ways. Firstly, income effects were tested by interacting the variables RICH (Household income > \$50,000 p.a.) and CK (Household income > \$100,000 p.a.) with the variable MONEY. The effects were significant in all cases and supported prior beliefs that wealthier respondents would be prepared to pay more for any given environmental enhancement. Secondly, independent variables were interacted with ASCs to test whether personal characteristics influenced choice between the options, particularly between the status quo and either of the two change options. In no case were any of these interaction effects significant. Thirdly, personal characteristics were interacted with each of the site attributes to identify whether particular groups of individuals valued attributes differently. Significant interactions are reported in Table 5. Interaction effects vary significantly between models. The personal attributes that significantly affected choices were:

- Age Respondent's age in years
- Degree 0,1 Dummy: 1 if respondent has a university degree
- Female 0,1 Dummy: 1 if respondent is Female
- People Number of people in the household
- Homeowner 0,1 Dummy: 1 if residence is owned by the inhabitants
- Maori 0,1 Dummy: 1 if respondent claims Maori ethnicity
- Rich 0,1 Dummy: 1 if household income exceeds $50,000 per year
- CK 0,1 Dummy: 1 if household income exceeds $100,000 per year
- South 0,1 Dummy: 1 if South Auckland resident
- Interview 0,1 Dummy: 1 if respondent was interviewed

The sign of the interaction effect indicates how the characteristic affects the importance of the relevant attribute. For example, the interaction (Maori x N2) is highly significant and negative, indicating that Maori place a lower value than others on increases in native fish numbers in degraded streams. Conversely, the positive sign on the interaction (Degree x D1) in model B indicates that people with university degrees more highly value enhanced water clarity on degraded streams than do other people.

Models A, B and C pool data. In Model A, all data (for North Shore and South Auckland, collected by interview and by postal survey) are included. This model allows location and data collection method impacts to be estimated simultaneously. Model A identifies location effects for two variables: People in South Auckland place lower value on numbers of NATIVE FISH SPECIES in degraded streams, and place higher values than North Shore residents on HIGH VEG. The pooled interview (Model B) and pooled postal survey (Model C) models also allow detection of location differences. As with Model A, the pooled interview model indicates that South Auckland residents place higher values on increases in streamside vegetation. No location effects were detected in Model C or in postal survey models.

Model A indicates that the data collection method had a strong influence on marginal utilities of water clarity on the natural stream, and for numbers of native fish species in both stream types. In each case these attributes were given lower values by interview participants than by respondents to the postal survey. Potential reasons for this disparity that have already been discussed include sample selection, differential behavioural responses and choice question format. These reasons do not provide clear guidance as to which data collection approach is superior.

Table 5
Choice Models

	Attribute	Model A	Model B	Model C	Model D	Model E	Model F	Model G
		"All In Model" All data pooled	All interview data pooled	All postal data pooled	North Shore Interviews	South Auckland Interviews	North Shore Postal	South Auckland Postal
Natural Stream	Water Clarity (N1)	0.9543***	0.6220***	0.9247***	0.5996***	0.6045***	0.6627***	0.9734***
	Fish Species (N2)	0.2261***	0.07483***	0.1921***	0.09642***	0.04650**	0.2420***	0.1741***
	Fish Habitat (N3)	-0.1828**	-0.2952***	0.09942*	0.01275	0.008174	0.1231*	0.08188
	Mod Veg (N4A)	0.2557***	0.1768**	0.3185**	0.2262*	0.1204	0.1777	0.4632*
	High Veg (N4B)	0.2442***	0.2148***	0.3599***	0.1918**	0.5185***	0.2136	0.5804***
Degraded Stream	Water Clarity (D1)	0.5854***	0.4997***	0.4103***	0.7627***	0.5547***	0.3196**	0.9158***
	Fish Species (D2)	0.1974***	0.07120**	0.1373**	0.2900**	0.09623*	0.08771	0.2230**
	Fish Habitat (D3)	0.2407***	0.1896***	0.06102	0.1194***	0.2148***	0.03122	0.1063
	Mod Veg (D4A)	0.2186***	0.2345***	0.1717	0.1662	0.3369**	0.05657	0.3376
	High Veg (D4B)	0.1903**	0.1648**	0.1558	0.5468**	0.4874***	0.08953	0.4873***
	Channel (D5)	0.4450***	0.4194***	0.4907***	0.2263**	0.3025***	0.2753**	0.6733***
	Money	-0.0109***	-0.00910***	-0.0142***	-0.00924***	-0.00921***	-0.0167***	-0.0134***
Interaction effects	Age x N3	0.004265***	0.006391***					
	Age x D2				-0.005732**			
	Age x D3	-0.003310**						
	Age x D4B				-0.008227*			
	Degree x N3					-0.3222***		
	Degree x N4B						0.2758*	
	Degree x D1		0.2246**					
	Degree x D5	-0.1783*	-0.2851**					
	Female x D1			0.3181**			0.3357**	
	People x D1				-0.09123**			
	People x N4B					-0.08752***		
	Homeowner x D3		-0.1410***			-0.2430***		
	Maori x N2			-0.2334***			-0.3962***	
	Maori x N4B			0.6029**			0.8681**	
	Maori x D5						0.7407*	
	Rich x N1						0.4646**	
	Rich x N4B			-0.3279**			-0.5802***	
	Rich x D5				0.4782***			
	CK x N2			0.08940				
	CK x N4A					0.9902		
	CK x N4B					1.3453***		
	CK x D1					0.6644**		-0.9887***
	CK x D2	-0.2138***	-0.2499***			-0.6541***		
	CK x D5	0.4123***	0.5843***			0.6175*		
	South x N2	-0.05885**						
	South x D4B	0.2360**	0.3027***					
	Interview x N1	-0.3086***						
	Interview x N2	-0.1171***						
	Interview x D2	-0.1361**						
Alternative constants	Status Quo	0.2763	0.4683**	0.2067	0.4171*	0.3399*	0.05679	0.5433*
	Second option	0.04347	0.03408	0.2884*	0.1098	0.02299	0.1942	0.3104*
HEV Scale Parameters	Status Quo	1.0535	1.4340	1.1141	1.3578	na	2.0000	na
	Second option	0.9790	1.0065	1.2151	1.1144	na	1.2850	na
	N	3655	2597	1129	1331	1281	674	455
	Type of Model	HEV	HEV	HEV	HEV	MNL	HEV	MNL
	LL_R	-3947.35	-2808.50	-1210.88	-1433.81	-1388.87	-718.78	-491.24
	LL_{UR}	-3591.13	-2593.33	-1038.03	-1315.38	-1273.30	-604.00	-417.17
	Rho^2	0.090	0.077	0.143	0.083	0.083	0.160	0.151

* = Significant @ 10% level, ** = Significant @ 5% level, *** = Significant @ 1% level

The models in Table 5 are used to derive measures of value. These are obtained from the utility function, which is linear in parameters.

$$V_i = ASC_i + \Sigma \beta_j Z_j + \beta_Y Y$$

Where the β_is are the estimated coefficients on the stream attributes (including interactions where appropriate), and β_Y is the estimated coefficient on MONEY.

The part worth of any attribute is then - β_j/β_Y. Because of the linearity of the utility function, willingness to pay and willingness to accept payment are identical, and equal the relevant part worths.

Figures 2-12 present part worth estimates and their 95% confidence intervals. Each graph incorporates twelve measures, three for each of the four possible [location, data collection] combinations. The three measures are derived for the fully pooled model, the relevant pooled model for the specific data collection method, and the model of each specific method at the specific location.

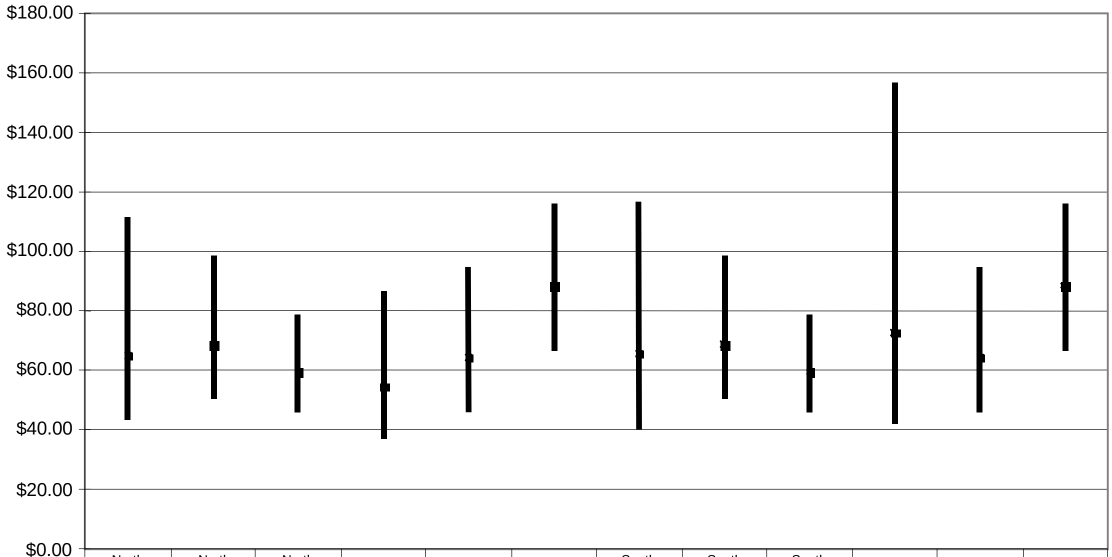
In general, the more pooling that occurs the narrower the 95% confidence interval for the estimated part worths. Some observations on part worth estimates for each of the attributes are made in Table 6.

Marginal rates of substitution between any two attributes can be identified from the coefficients. The increase in attribute i required to offset a one-unit decrease in attribute j is the ratio β_j/β_i. For example, using Model G, it is necessary to increase native fish habitat by about 2.7km on a natural stream to offset the loss of one native fish species on a degraded stream [β_j/β_i = D2/N3 = 0.2230 ÷ 0.08188 = 2.72]. Marginal rates of substitution are relevant guides for policy where mitigation occurs from manipulation of the natural environment. Part worths are relevant for identifying monetary mitigation measures.

Table 6
Comparison of Benefit Measures from Alternative Models

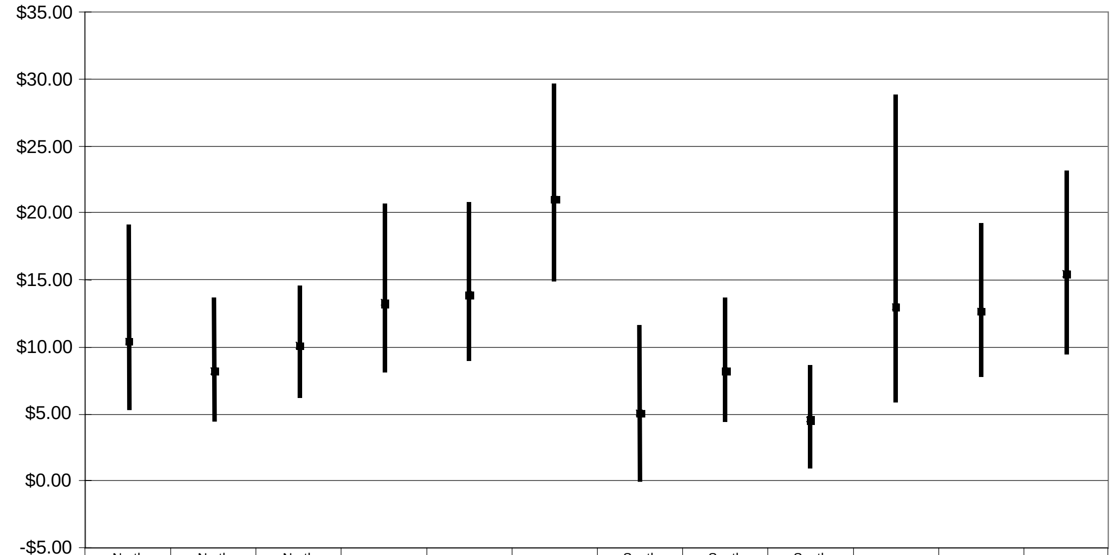
Stream Type	Attribute	Expected value ranges	Comments on part worths
Natural Stream	Water clarity	NS: $54 - $88 SA: $59 - $88	Relatively uniform. Large 95% confidence interval in South Auckland postal model may be attributable to the small sample size.
	Native Fish Species	NS: $8 - $21 SA: $5 - $13	South Auckland part worths for interviews appear somewhat lower than for postal surveys and have smaller 95% confidence ranges.
	Fish Habitat	NS: $0 - $7 SA: -$3 - $7	No values are significantly different from zero. Large 95% confidence interval in South Auckland postal model may be attributable to the small sample size.
	Moderate streamside vegetation	NS: $10 - $24 SA: $19 - 34	Relatively uniform. Large 95% confidence interval in South Auckland postal model may be attributable to the small sample size.
	Plentiful streamside vegetation	NS: $0 - $23 SA: $19 - $43	While all 95% confidence ranges overlap, there is wide variance in expected values. Large 95% confidence intervals for specific data collection methods in South Auckland indicate likely higher variance in South Auckland.
Degraded Stream	Water clarity	NS: $30 - $63 SA: $41 - $65	Expected values range from $30-$65, although all 95% confidence intervals overlap. Large 95% confidence interval in South Auckland postal model may be attributable to the small sample size.
	Native Fish Species	NS: $2 - $14 SA: $3 - $17	Only five of twelve models produce part worths significantly different from zero.
	Fish Habitat	NS: $2 - $13 SA: $4 - $10	Only seven of twelve models produce part worths significantly different from zero.
	Moderate streamside vegetation	NS: $3 - $26 SA: $11 - $37	Relatively uniform. Only seven of twelve models produce part worths significantly different from zero. Large 95% confidence intervals for specific data collection methods in South Auckland indicate likely higher variance in South Auckland, although the small sample may have contributed to the postal confidence interval.
	Plentiful streamside vegetation	NS: $1 - $18 SA: $17 - $53	Some 95% confidence intervals do not overlap. Large 95% confidence intervals for specific data collection methods in South Auckland indicate likely higher variance in South Auckland, although the small sample may have contributed to the postal confidence interval. South Auckland part worths appear to be larger than North Shore part worths.
	Channel	NS: $19 - $54 SA: $34 - $53	Some 95% confidence intervals do not overlap. Large 95% confidence intervals for specific data collection methods in South Auckland indicate likely higher variance in South Auckland, although the small sample may have contributed to the postal confidence interval. Large 95% confidence interval in South Auckland postal model may be attributable to the small sample size.

Figure 2
Part Worth Confidence Intervals – Natural Stream: Water Clarity



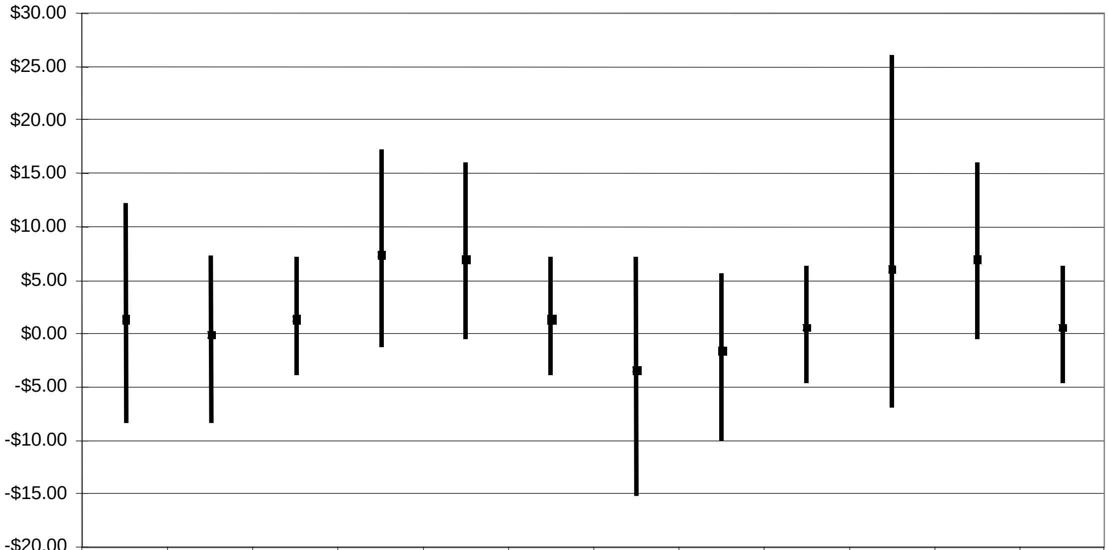
	North Interviews: NSI only	North Interviews: NSI&SAI	North Interviews: All in model	North Postal: NSP only	North Postal: NSP&SAP	North Postal: All in model	South Interviews: SAI only	South Interviews: NSI&SAI	South Interviews: All in model	South Postal: SAP only	South Postal: NSP&SAP	South Postal: All in model
UPPER 95%	$111.65	$98.69	$78.99	$86.34	$95.04	$116.19	$116.43	$98.69	$78.99	$156.66	$95.04	$116.19
LOWER 95%	$43.41	$50.28	$45.76	$37.05	$45.49	$66.78	$40.07	$50.28	$45.76	$42.08	$45.49	$66.78
EXPECTED	$64.92	$68.39	$59.30	$54.53	$64.19	$88.30	$65.61	$68.39	$59.30	$72.51	$64.19	$88.30

Figure 3
Part Worth Confidence Intervals – Natural Stream: Native Fish Species



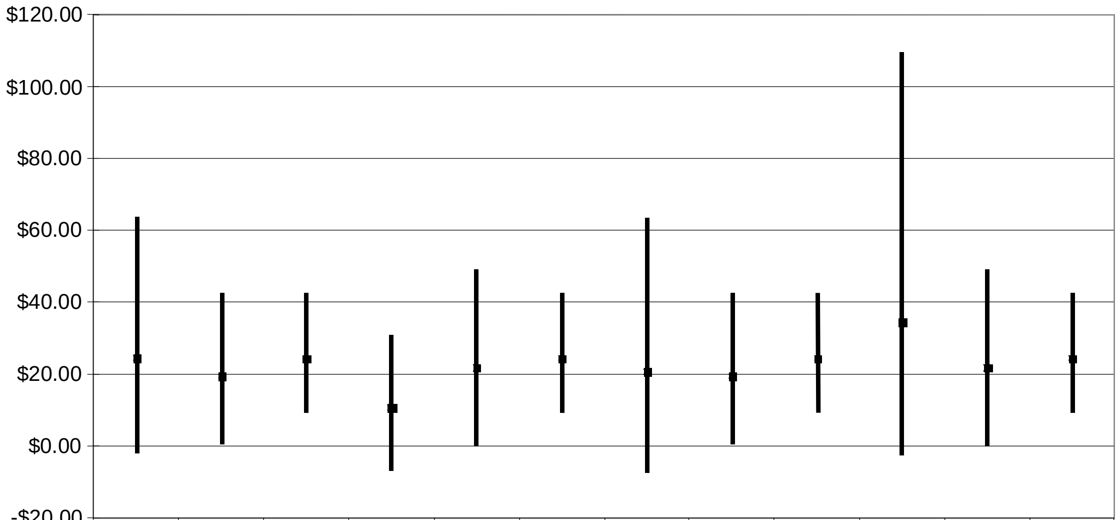
	North Interviews: NSI only	North Interviews: NSI&SAI	North Interviews: All in model	North Postal: NSP only	North Postal: NSP&SAP	North Postal: All in model	South Interviews: SAI only	South Interviews: NSI&SAI	South Interviews: All in model	South Postal: SAP only	South Postal: NSP&SAP	South Postal: All in model
UPPER 95%	$19.19	$13.64	$14.61	$20.69	$20.77	$29.71	$11.61	$13.64	$8.60	$28.91	$19.25	$23.15
LOWER 95%	$5.32	$4.41	$6.18	$8.08	$8.98	$14.89	-$0.09	$4.41	$0.91	$5.83	$7.78	$9.48
EXPECTED	$10.44	$8.23	$10.11	$13.31	$13.93	$21.04	$5.05	$8.23	$4.55	$12.97	$12.67	$15.48

Figure 4
Part Worth Confidence Intervals – Natural Stream: Fish Habitat



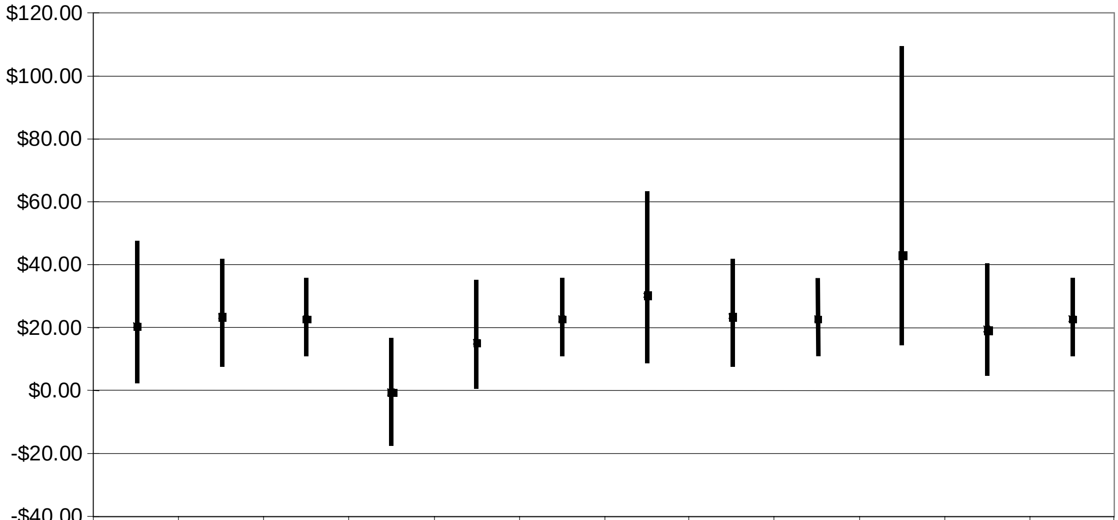
	North Interviews: NSI only	North Interviews: NSI&SAI	North Interviews: All in model	North Postal: NSP only	North Postal: NSP&SAP	North Postal: All in model	South Interviews: SAI only	South Interviews: NSI&SAI	South Interviews: All in model	South Postal: SAP only	South Postal: NSP&SAP	South Postal: All in model
UPPER 95%	$12.23	$7.32	$7.11	$17.22	$16.02	$7.11	$7.19	$5.62	$6.36	$26.02	$16.02	$6.36
LOWER 95%	-$8.34	-$8.32	-$3.88	-$1.16	-$0.48	-$3.88	-$15.30	-$9.99	-$4.65	-$6.92	-$0.48	-$4.65
EXPECTED	$1.38	-$0.14	$1.37	$7.39	$6.96	$1.37	-$3.38	-$1.54	$0.57	$6.10	$6.96	$0.57

Figure 5
Part Worth Confidence Intervals – Natural Stream: Moderate Streamside Vegetation



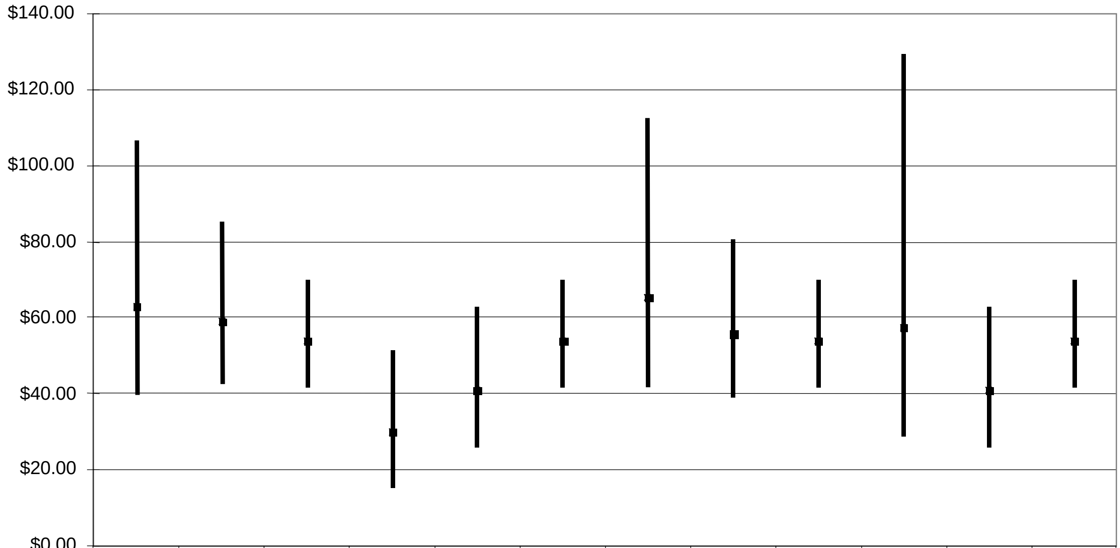
	North Interviews: NSI only	North Interviews: NSI&SAI	North Interviews: All in model	North Postal: NSP only	North Postal: NSP&SAP	North Postal: All in model	South Interviews: SAI only	South Interviews: NSI&SAI	South Interviews: All in model	South Postal: SAP only	South Postal: NSP&SAP	South Postal: All in model
UPPER 95%	$63.75	$42.69	$42.58	$31.05	$49.18	$42.58	$63.28	$42.69	$42.58	$109.67	$49.18	$42.58
LOWER 95%	-$2.03	$0.39	$9.04	-$7.01	-$0.02	$9.04	-$7.60	$0.39	$9.04	-$2.45	-$0.02	$9.04
EXPECTED	$24.50	$19.44	$24.44	$10.67	$21.76	$24.44	$20.70	$19.44	$24.44	$34.50	$21.76	$24.44

Figure 6
Part Worth Confidence Intervals – Natural Stream: Plentiful Streamside Vegetation



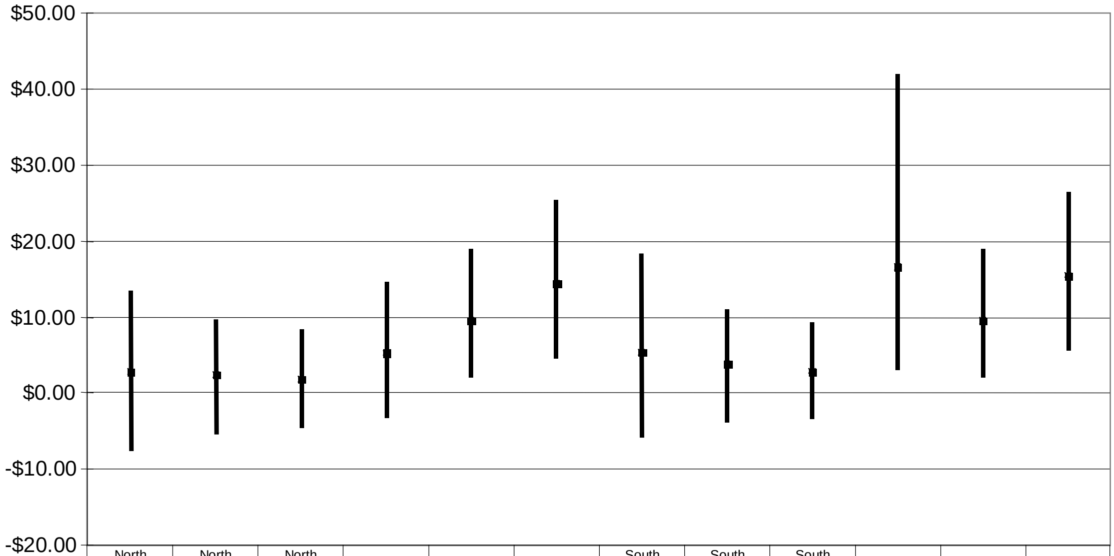
	North Interviews: NSI only	North Interviews: NSI&SAI	North Interviews: All in model	North Postal: NSP only	North Postal: NSP&SAP	North Postal: All in model	South Interviews: SAI only	South Interviews: NSI&SAI	South Interviews: All in model	South Postal: SAP only	South Postal: NSP&SAP	South Postal: All in model
UPPER 95%	$47.50	$41.78	$35.80	$16.68	$35.42	$35.80	$63.22	$41.78	$35.80	$109.81	$40.45	$35.80
LOWER 95%	$2.39	$7.57	$11.13	-$17.76	$0.57	$11.13	$8.54	$7.57	$11.13	$14.43	$4.62	$11.13
EXPECTED	$20.76	$23.62	$22.98	-$0.28	$15.53	$22.98	$30.28	$23.62	$22.98	$43.24	$19.47	$22.98

Figure 7
Part Worth Confidence Intervals – Degraded Stream: Water Clarity



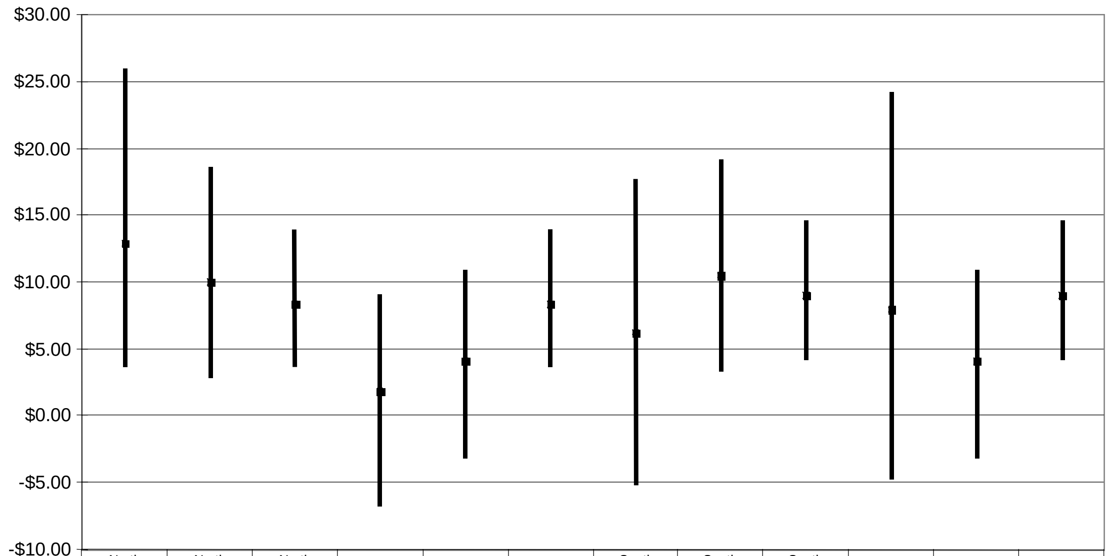
	North Interviews: NSI only	North Interviews: NSI&SAI	North Interviews: All in model	North Postal: NSP only	North Postal: NSP&SAP	North Postal: All in model	South Interviews: SAI only	South Interviews: NSI&SAI	South Interviews: All in model	South Postal: SAP only	South Postal: NSP&SAP	South Postal: All in model
UPPER 95%	$106.50	$85.11	$69.75	$51.61	$62.91	$69.75	$112.21	$80.73	$69.75	$129.29	$62.86	$69.75
LOWER 95%	$39.59	$42.58	$41.77	$15.38	$26.08	$41.77	$41.86	$38.96	$41.77	$28.73	$26.04	$41.77
EXPECTED	$62.83	$58.92	$53.91	$29.83	$40.88	$53.91	$65.32	$55.68	$53.91	$57.47	$40.83	$53.91

Figure 8
Part Worth Confidence Intervals – Degraded Stream: Native Fish Species



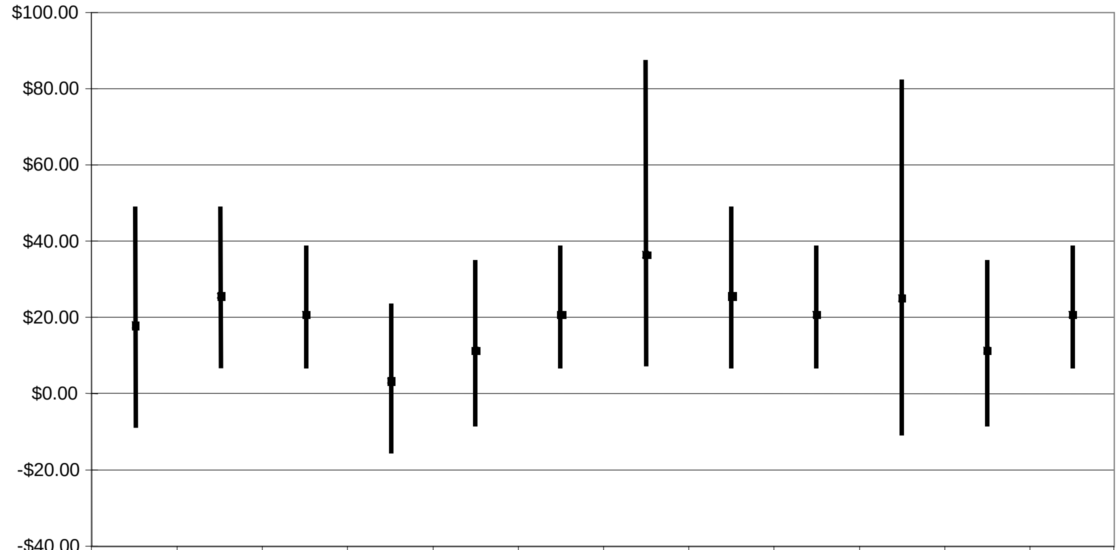
	North Interviews: NSI only	North Interviews: NSI&SAI	North Interviews: All in model	North Postal: NSP only	North Postal: NSP&SAP	North Postal: All in model	South Interviews: SAI only	South Interviews: NSI&SAI	South Interviews: All in model	South Postal: SAP only	South Postal: NSP&SAP	South Postal: All in model
UPPER 95%	$13.37	$9.67	$8.36	$14.70	$18.98	$25.34	$18.42	$11.12	$9.26	$42.00	$18.98	$26.46
LOWER 95%	-$7.57	-$5.40	-$4.72	-$3.38	$2.08	$4.60	-$5.90	-$3.83	-$3.53	$2.99	$2.08	$5.53
EXPECTED	$2.85	$2.39	$1.87	$5.27	$9.54	$14.46	$5.40	$3.82	$2.90	$16.61	$9.54	$15.49

Figure 9
Part Worth Confidence Intervals – Degraded Stream: Fish Habitat



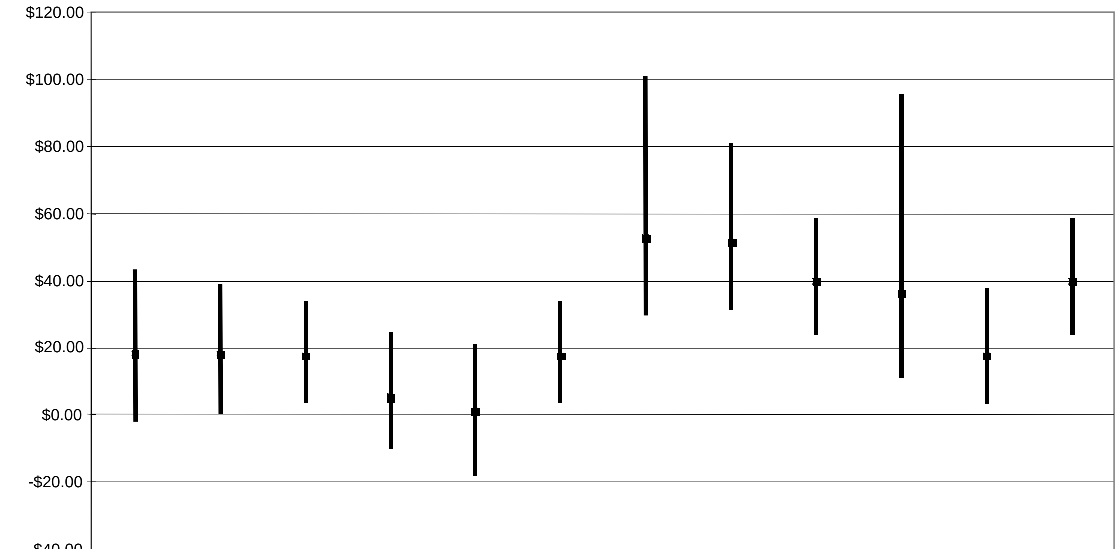
	North Interviews: NSI only	North Interviews: NSI&SAI	North Interviews: All in model	North Postal: NSP only	North Postal: NSP&SAP	North Postal: All in model	South Interviews: SAI only	South Interviews: NSI&SAI	South Interviews: All in model	South Postal: SAP only	South Postal: NSP&SAP	South Postal: All in model
UPPER 95%	$25.97	$18.56	$13.86	$9.09	$10.85	$13.86	$17.73	$19.17	$14.53	$24.23	$10.85	$14.53
LOWER 95%	$3.60	$2.83	$3.62	-$6.76	-$3.22	$3.62	-$5.22	$3.30	$4.19	-$4.75	-$3.22	$4.19
EXPECTED	$12.93	$10.01	$8.34	$1.87	$4.09	$8.34	$6.25	$10.50	$8.96	$7.92	$4.09	$8.96

Figure 10
Part Worth Confidence Intervals – Degraded Stream: Moderate Streamside Vegetation



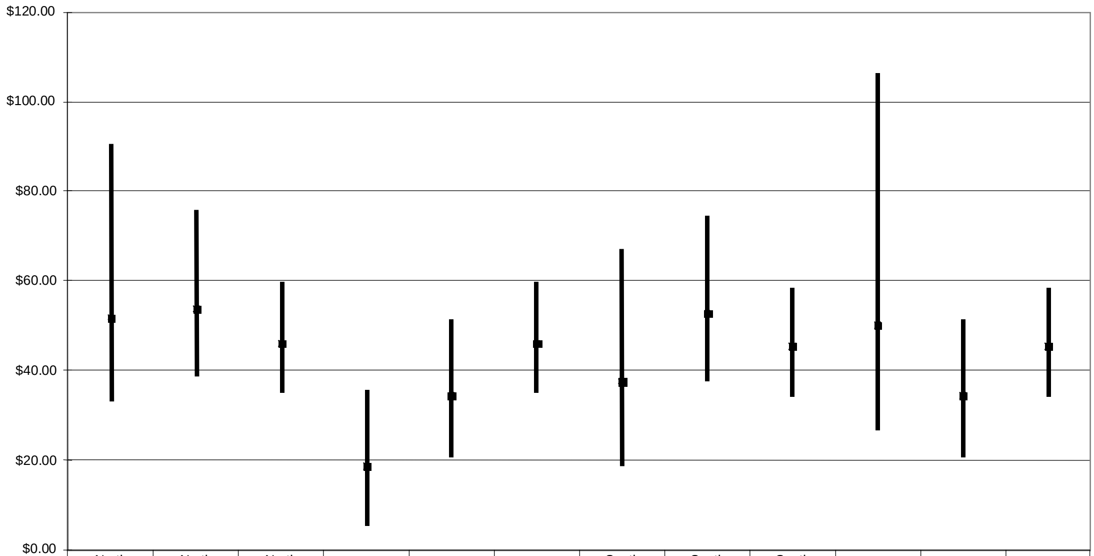
	North Interviews: NSI only	North Interviews: NSI&SAI	North Interviews: All in model	North Postal: NSP only	North Postal: NSP&SAP	North Postal: All in model	South Interviews: SAI only	South Interviews: NSI&SAI	South Interviews: All in model	South Postal: SAP only	South Postal: NSP&SAP	South Postal: All in model
UPPER 95%	$48.99	$48.96	$38.78	$23.59	$34.81	$38.78	$87.32	$48.96	$38.78	$82.37	$34.81	$38.78
LOWER 95%	-$9.12	$6.76	$6.71	-$15.86	-$8.46	$6.71	$7.04	$6.76	$6.71	-$10.91	-$8.46	$6.71
EXPECTED	$17.99	$25.78	$20.82	$3.40	$11.44	$20.82	$36.57	$25.78	$20.82	$25.15	$11.44	$20.82

Figure 11
Part Worth Confidence Intervals: Degraded Stream: Plentiful Streamside Vegetation



	North Interviews: NSI only	North Interviews: NSI&SAI	North Interviews: All in model	North Postal: NSP only	North Postal: NSP&SAP	North Postal: All in model	South Interviews: SAI only	South Interviews: NSI&SAI	South Interviews: All in model	South Postal: SAP only	South Postal: NSP&SAP	South Postal: All in model
UPPER 95%	$43.49	$38.95	$33.81	$24.63	$21.29	$33.81	$101.18	$81.08	$58.73	$95.75	$37.56	$58.73
LOWER 95%	-$1.83	-$0.05	$3.54	-$10.19	-$18.18	$3.54	$29.59	$31.43	$23.95	$10.73	$3.22	$23.95
EXPECTED	$18.23	$18.12	$17.74	$5.37	$1.06	$17.74	$52.90	$51.40	$39.79	$36.30	$17.56	$39.79

Figure 12
Part Worth Confidence Intervals – Degraded Stream: Channel Form



	North Interviews: NSI only	North Interviews: NSI&SAI	North Interviews: All in model	North Postal: NSP only	North Postal: NSP&SAP	North Postal: All in model	South Interviews: SAI only	South Interviews: NSI&SAI	South Interviews: All in model	South Postal: SAP only	South Postal: NSP&SAP	South Postal: All in model
UPPER 95%	$90.44	$75.70	$59.68	$35.82	$51.54	$59.68	$67.04	$74.35	$58.32	$106.11	$51.54	$58.32
LOWER 95%	$33.07	$38.76	$34.92	$5.21	$20.88	$34.92	$18.79	$37.89	$34.21	$26.78	$20.88	$34.21
EXPECTED	$51.90	$53.79	$46.09	$18.79	$34.45	$46.09	$37.59	$52.90	$45.43	$50.16	$34.45	$45.43

5.2 Understanding

Application of choice modelling to evaluate mitigation is novel. Because the large number of attributes involved places a significant burden on respondents, the question of respondent understanding arises. Related is the ease of making choices between three alternatives with 10 attributes each. These effects have been addressed in the personal interviews by inclusion of two self-evaluation questions and one interviewer evaluation question. Results are summarised in Table 7.

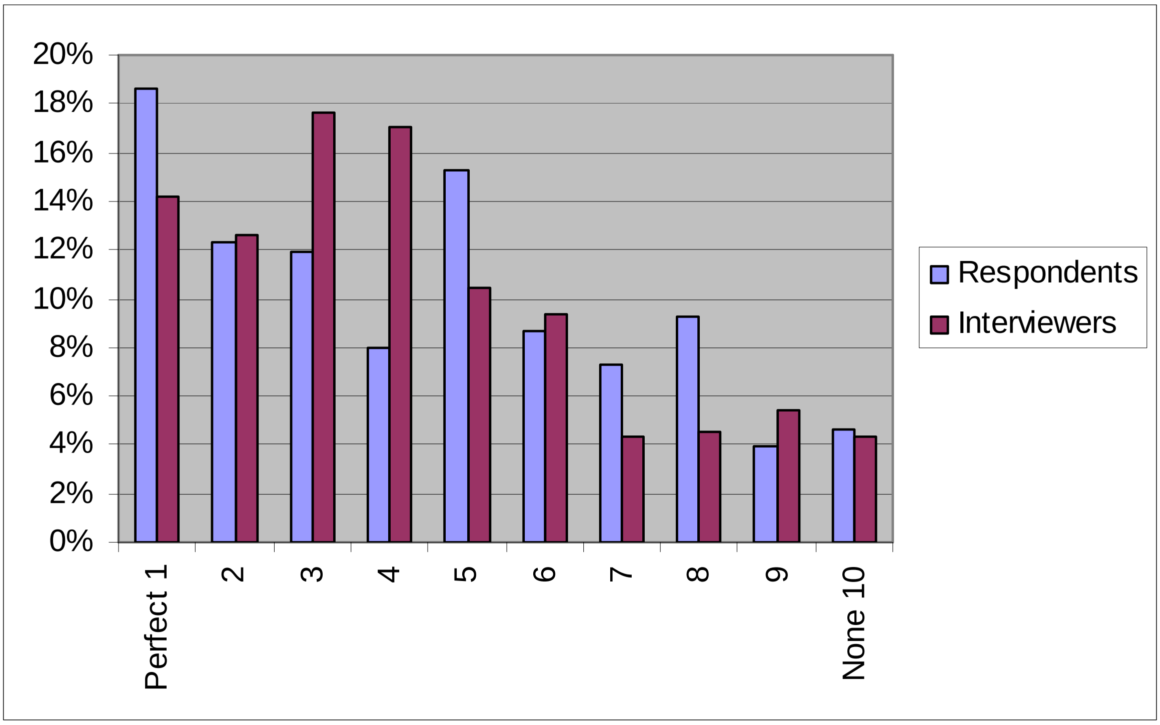
Table 7
Respondents' Understanding of the Choice Questions

	Respondent Evaluation of Understanding		Ease of Making Choices		Interviewer Evaluation of Understanding	
	North Shore	South Auckland	North Shore	South Auckland	North Shore	South Auckland
Mean	4.4603	4.026	4.2517	4.1022	6.8427	6.6367
Standard Error	0.1567	0.1450	0.1435	0.1383	0.1679	0.1293
Median	4	3	4	4	8	7
Mode	1	1	2	2	10	7
Range	1: Very easy 10: Extremely difficult		1: Very easy 10: Extremely difficult		1: Zero understanding 10: Completely understood	
Count	302	313	302	313	286	311
95% Confidence Level	± 0.3084	± 0.2853	± 0.2825	± 0.2722	± 0.3305	± 0.2544

The means are consistent across all measures and are not significantly different between North Shore and South Auckland respondents. Response distributions are not significantly different between locations for respondent-evaluated understanding or respondent-evaluated ease of making choices. However, interviewer evaluation response distributions do differ between North Shore and South Auckland.

Respondents typically found choices moderately easy to make, with median scores of 4 and modal scores of 2 for both locations. Interviewer and respondent evaluations of understanding have been measured on different scales. Converting the interviewer evaluations to a similar scale [by subtracting the interviewer's score from 11] yields mean scores of 4.16 (North Shore) and 4.36 (South Auckland), which are very similar to respondent evaluations (4.46 and 4.03 respectively). Respondent evaluations and transformed interviewer evaluations of understanding are reported in Figure 13.

Figure 13
Evaluations of Understanding of Choice Questions
(Interviewer Evaluations have been Recoded)

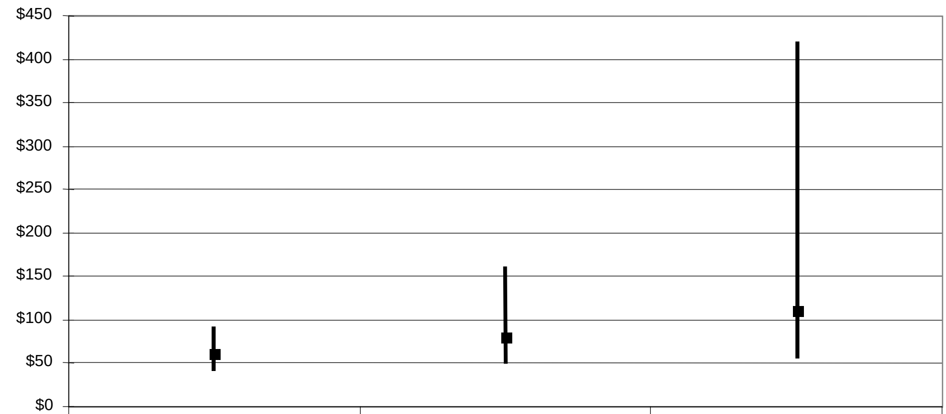


In general, most respondents appear to have understood the choice task quite well. In order to detect any potential biases because of differences in understanding, part worths have been estimated from simple multinomial logit models (without interactions) for three groups of North Shore respondents. The groups are:

- High understanding: respondents who evaluated their own understanding with a score of 3 or less.
- Moderate understanding: respondents who evaluated their own understanding with a score of 5 or less.
- All: all respondents, regardless of level of understanding

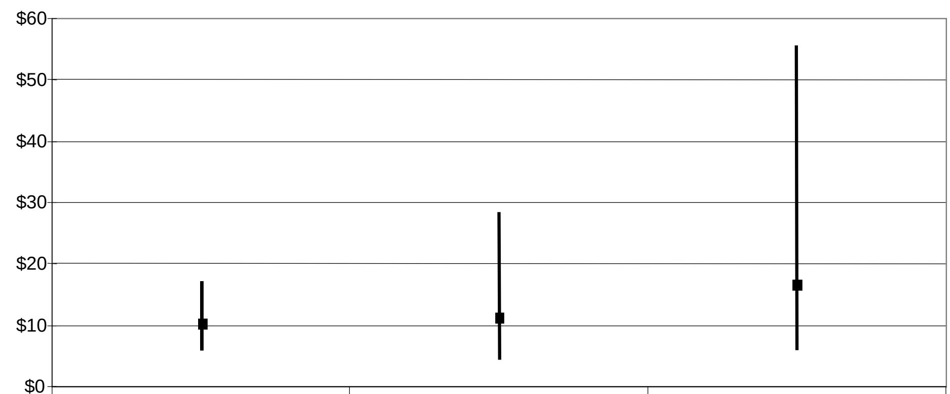
Figures 14 – 24 report part worths for the three scenarios.

Figure 14
North Shore Part Worths by Understanding: Natural Stream Water Clarity



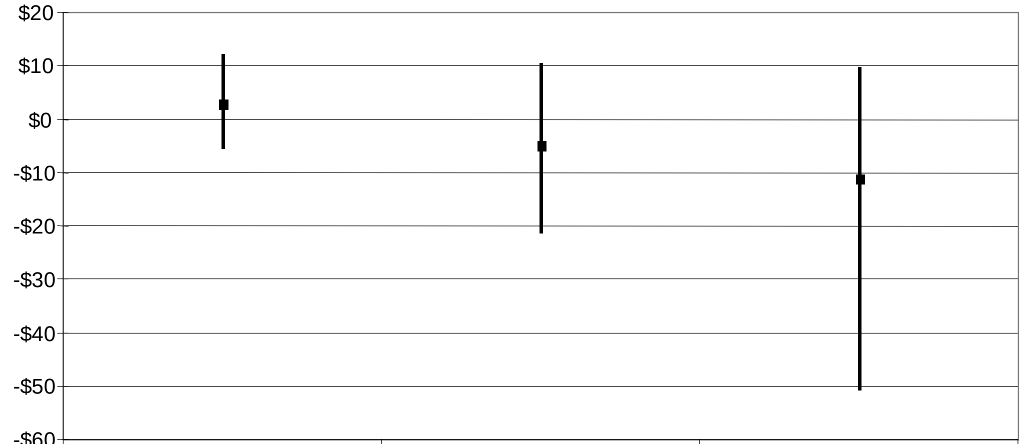
	All	Moderate understanding	High understanding
Upper 95%	$93	$162	$419
Lower 95%	$42	$48	$55
Expected	$62	$81	$111

Figure 15
North Shore Part Worths by Understanding: Natural Stream Native Fish Species



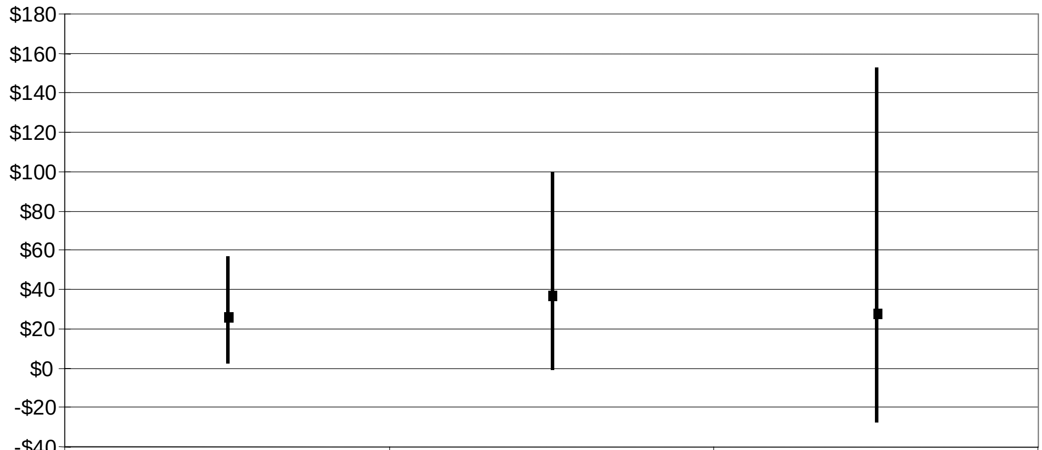
	All	Moderate	High
Upper	$17	$29	$56
Lower	$6	$4	$6
Expecte	$10	$12	$17

Figure 16
North Shore Part Worths by Understanding: Natural Stream Fish Habitat



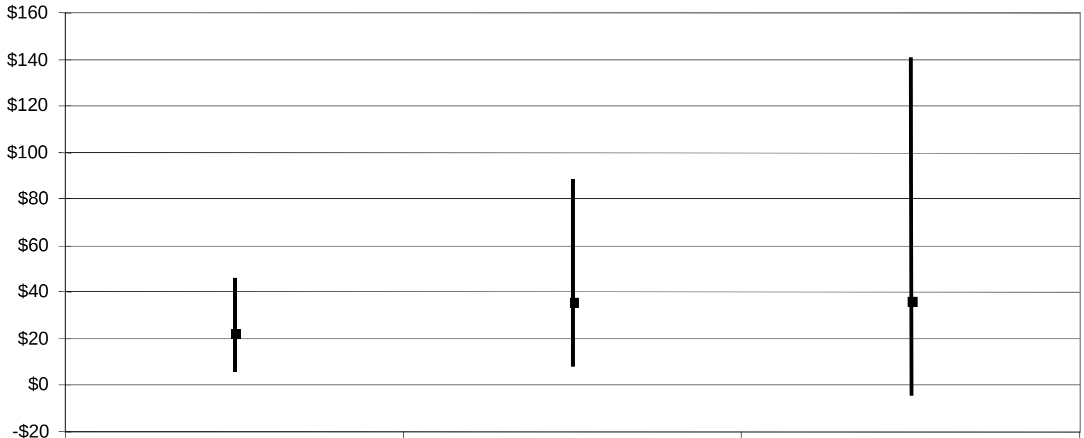
	All	Moderate	High
Upper	$12	$11	$10
Lower	-$5	-$21	-$51
Expecte	$3	-$5	-$11

Figure 17
North Shore Part Worths by Understanding: Natural Stream Moderate Streamside Vegetation



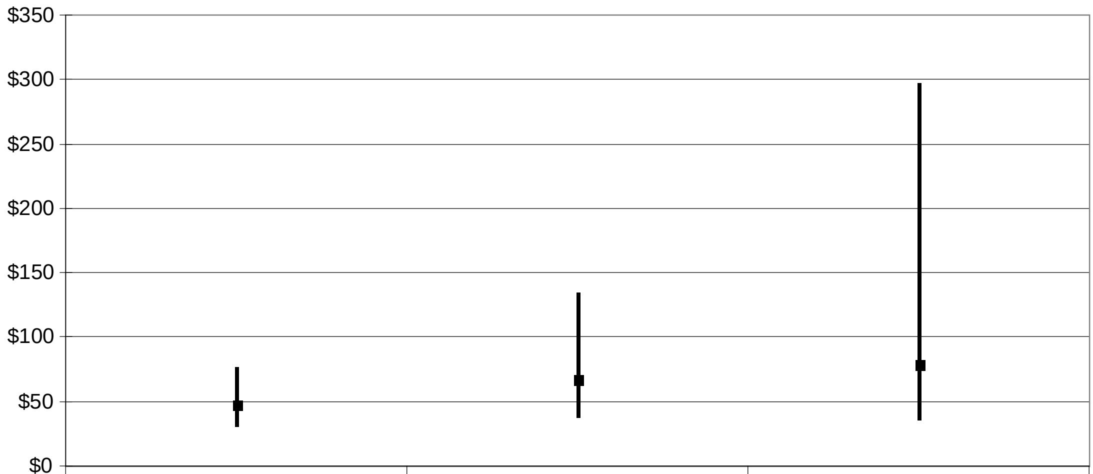
	All	Moderate	High
Upper	$57	$100	$153
Lower	$3	-$1	-$28
Expecte	$26	$37	$28

Figure 18
North Shore Part Worths by Understanding: Natural Stream Plentiful Streamside Vegetation



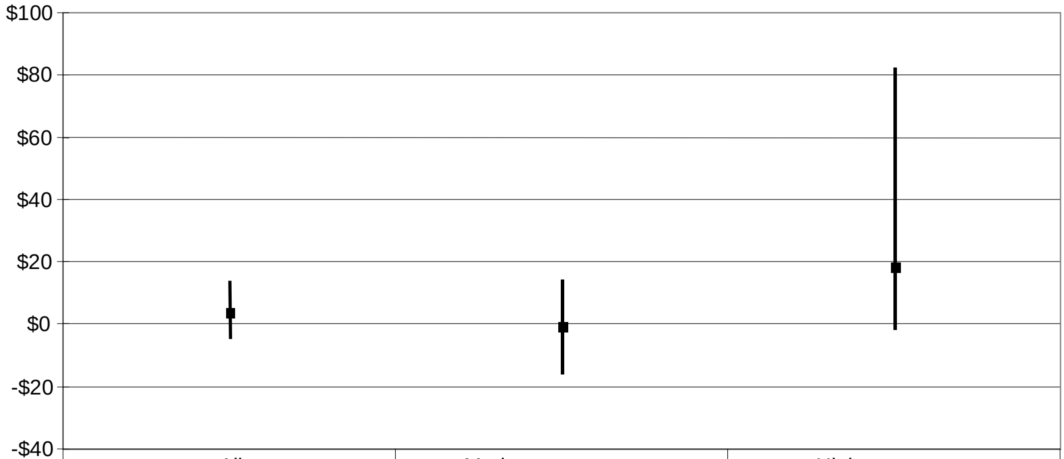
	All	Moderate understanding	High understanding
Upper 95%	$46	$89	$141
Lower 95%	$6	$8	-$4
Expected	$23	$36	$37

Figure 19
North Shore Part Worths by Understanding: Degraded Stream Water Clarity



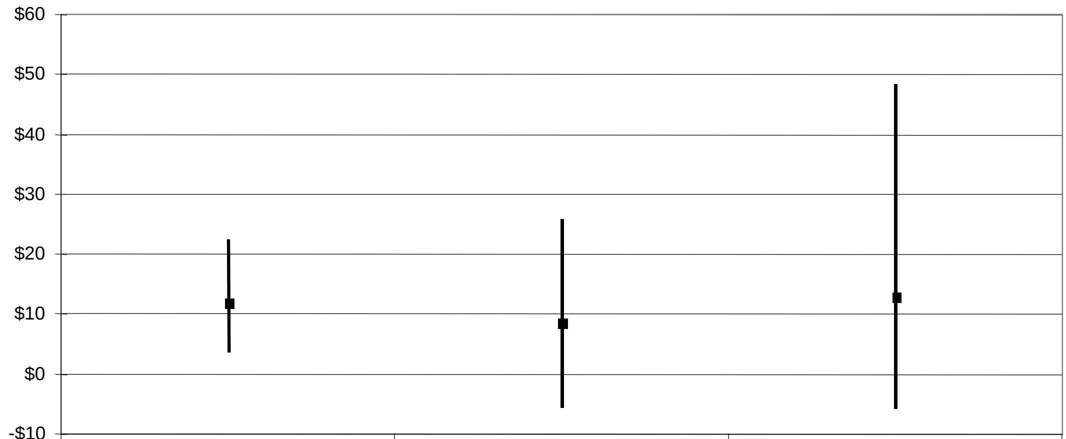
	All	Moderate	High
Upper	$77	$134	$297
Lower	$30	$38	$36
Expecte	$48	$67	$79

Figure 20
North Shore Part Worths by Understanding: Degraded Stream Native Fish Species



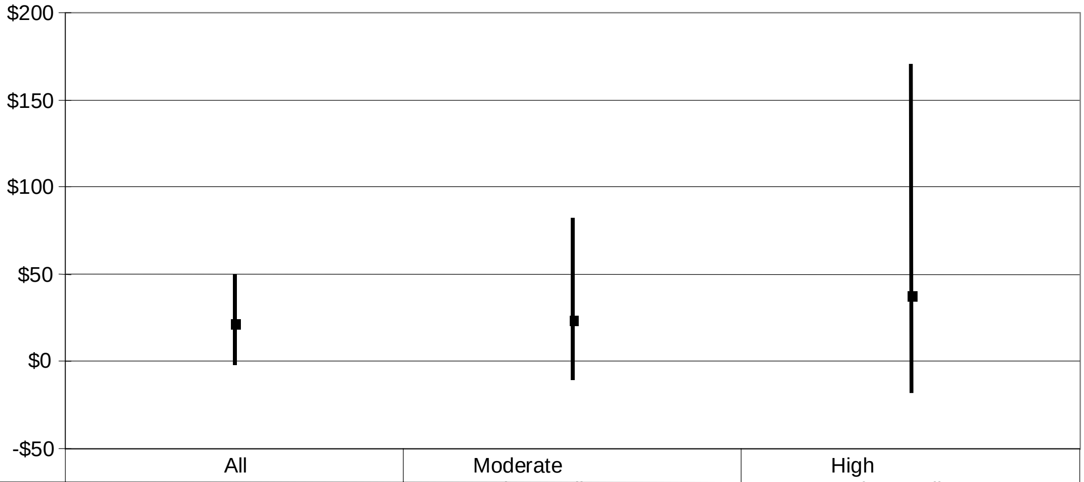
	All	Moderate	High
Upper	$14	$14	$82
Lower	-$5	-$16	-$2
Expecte	$4	-$1	$18

Figure 21
North Shore Part Worths by Understanding: Degraded Stream Fish Habitat



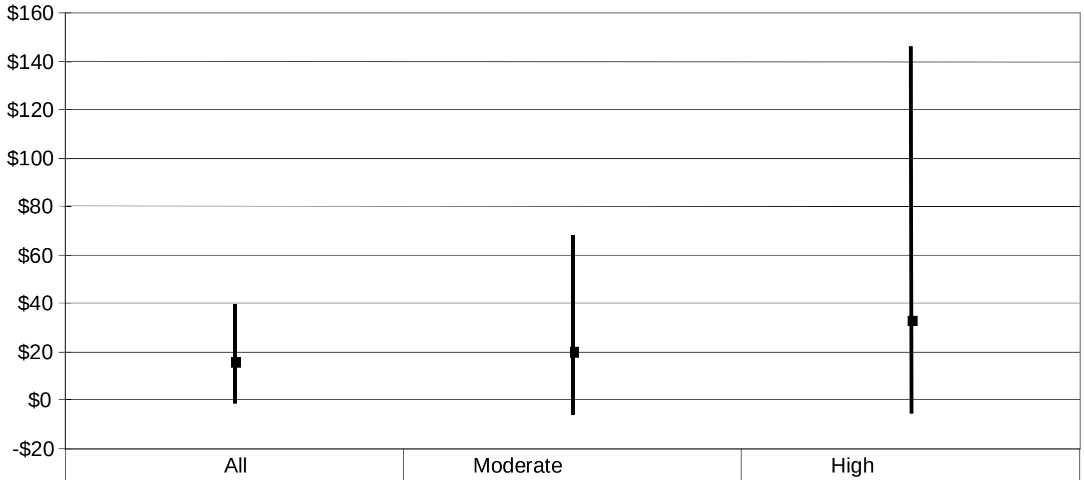
	All	Moderate understanding	High understanding
Upper 95%	$23	$26	$48
Lower 95%	$4	-$6	-$6
Expected	$12	$9	$13

Figure 22
North Shore Part Worths by Understanding: Degraded Stream
Moderate Streamside Vegetation



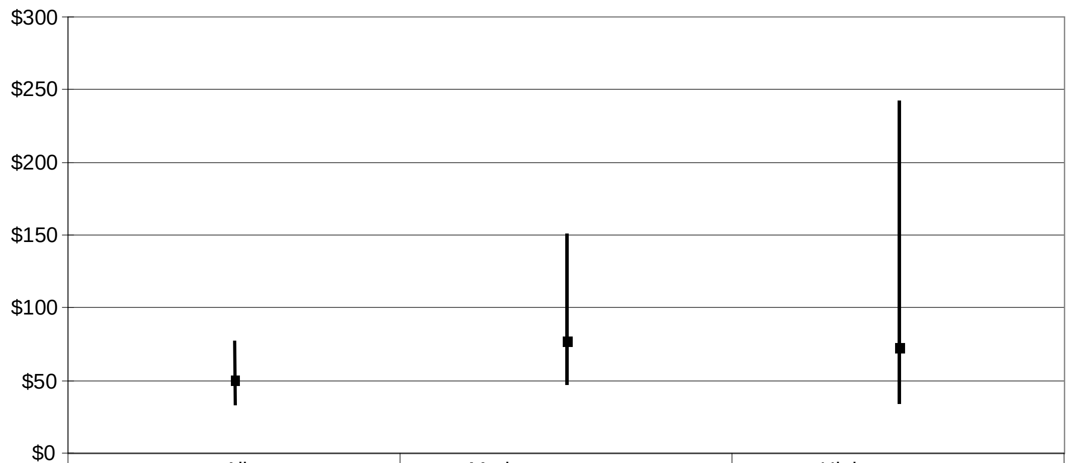
	All	Moderate	High
Upper	$50	$82	$171
Lower	-$2	-$11	-$18
Expecte	$21	$24	$38

Figure 23
North Shore Part Worths by Understanding: Degraded Stream
Plentiful Streamside Vegetation



	All	Moderate	High
Upper	$40	$68	$146
Lower	-$2	-$6	-$6
Expecte	$16	$21	$33

Figure 24
North Shore Part Worths by Understanding: Degraded Stream Channel



	All	Moderate	High
Upper	$77	$151	$242
Lower	$33	$47	$34
Expecte	$50	$77	$73

There are no significant differences between estimated part worths for the three scenarios. While the reduced numbers in the high understanding category result in very broad confidence intervals, point estimates are very similar. There is no evidence to suggest that use of information from respondents with lower levels of understanding has systematically biased results. The only instance in which a high understanding part worth is lower than the part worth from the full sample is natural stream fish habitat.

Whilst it is acknowledged that the choice tasks presented to survey respondents were relatively difficult, most respondents appear to have understood what was requested of them and have been able to make well-reasoned choices.

Chapter 6
Application to Mitigation

Study results can be used to

1. measure the money costs of environmental damage,
2. measure the money benefits of environmental enhancements,
3. measure the effectiveness of on-site mitigation,
4. measure the effectiveness of off-site mitigation.

This section of the report illustrates how parameter estimates from Table 5 and part worth estimates from Figures 2-12 can be used for these purposes[1].

6.1 Costs of Environmental Damage and Benefits of Environmental Enhancements

Table 8 illustrates a scenario for change on a "natural" stream (as defined in the survey) and Table 9 defines a scenario for enhancement of a degraded stream. These tables illustrate how knowledge of part worths can be used to estimate values associated with environmental degradation or enhancement.

Table 8
Natural Stream Degradation Scenario

	Initial attribute levels	Final attribute levels	Attribute change	Part worths (Model D)	Change in value (attribute change * part worth)
Water clarity	Clear	Muddy	-1	$64.92	-$64.92
Fish species	5	3	-2	$10.44	-$20.88
Fish habitat	4 Km	2 Km	-2	$1.38	-$2.76
Native Bush	Plentiful	Little	-1	$20.76	-$20.76
Annual cost of environmental damage					$109/household
Lump sum cost @ 10%					$1093/household

The average household would be willing to make a once-only payment of $1093 to prevent the hypothetical degradation, or would accept the degradation if paid compensation of $1093.

[1] Any of the models could have been chosen for this purpose, there is no significance to the selection of Models D and E.

Table 9
Degraded Stream Enhancement Scenario

	Initial attribute levels	Final attribute levels	Attribute change	Part worths (Model E)	Change in value (attribute change * part worth)
Water clarity	Muddy	Muddy	0	$65.32	$0
Fish species	2	3	+1	$5.40	$5.40
Fish habitat	1 Km	3 Km	+2	$6.25	$12.50
Native Bush	Little	Little	0	$0	$0
Channel	Straight	Natural	+1	$37.59	$37.59
Annual benefits of environmental enhancement					$55/household
Lump sum benefit @ 10%					$555/household

The benefit measures could be aggregated over all relevant households to derive the value to the community of the proposed enhancements. Value estimates could then be employed in cost-benefit analysis (once costs of enhancement are known) to identify the efficiency of undertaking the proposed enhancements (requiring positive NPV or the benefit-cost ratio to exceed one), or to rank the proposal amongst others for prioritisation (using benefit-cost ratios).

6.2 On-site Mitigation Effectiveness

The preceding examples illustrate how money values can be placed on degradation or enhancement of a single stream. On-site mitigation entails making enhancements to a damaged stream to offset the damage that is done on that stream. Consequently, it is often desirable to evaluate the adequacy of a "package" of enhancements and degradations on the same stream. Table 10 illustrates the case for a potential set of changes on a natural condition North Shore stream, using model D estimated from North Shore interviews. The package entails a loss of water clarity. It is proposed to offset this damage by addition of one native fish species, creation of two additional kilometres of fish habitat and an increase in vegetation from low to plentiful.

Table 10
On-site Mitigation Scenario Effectiveness

Attributes	Initial attribute levels	Final attribute levels	Attribute change	Part worths (Model D)	Change in value (attribute change * part worth)
Water clarity	Clear	Muddy	-1	$64.92	-$64.92
Fish species	4	5	+1	$10.44	+$10.44
Fish habitat	2 Km	4 Km	+2	$1.38	+$2.76
Native Bush	Low	Plentiful	+1	$20.76	+$20.76
Annual net benefits (per household)					-$30.96

Household annual net benefits are negative, implying that the proposed mitigation is inadequate to offset the loss in water clarity. It is apparent from the part worths in Table 10 that it would not be possible to design a mitigation package that would offset the loss of water clarity. This result occurs because water clarity is valued very highly relative to other stream attributes.

It should be noted that evaluation of mitigation effectiveness is **NOT** dependent on monetary valuation. Any attribute can be used as the numeraire. For example, if one natural stream fish species is used as the numeraire, then the value of each other attribute can be measured in "natural stream fish species equivalents". Table 11 illustrates the case for on-site mitigation in the North Shore

Table 11
On-site Mitigation Scenario Effectiveness Without Monetisation

Attributes	**Initial attribute levels**	**Final attribute levels**	**Attribute change**	**Model D coefficients**	**Fish-species equivalents (FSE)**	**Change in value (attribute change * FSE)**
Water clarity	Clear	Muddy	-1	0.5996	6.22	-6.22
Fish species	4	5	+1	0.09642	1	1.00
Fish habitat	2 Km	4 Km	+2	0.01275	0.13	0.26
Native Bush	Low	Plentiful	+1	0.1918	1.99	1.99
Net Change						-2.97

The Fish Species Equivalents (FSE) are derived by dividing each of the attribute coefficients by the coefficient on fish species. From the FSEs it is apparent that an improvement from little or no streamside vegetation to plentiful streamside vegetation is equivalent to the loss or gain of 1.99 native fish species. The overall change mooted in the scenario of Table 11 is judged to be equivalent to the loss of three fish species. Because the net change is negative, the mitigation proposed to offset the degradation in water clarity can be seen to be inadequate from a community perspective. This conclusion does not require monetary valuation.

However, the monetary valuation approach is equivalent to the non-monetary approach. Table 10 uses part worths (money values on attribute changes) from the data used in Table 11 and develops a money value for the proposed changes. Allowing for rounding error, the overall value of the change proposed in this scenario (-$30.96) is the same as the net change in Table 11 (-2.97 FSEs) multiplied by the value of a fish species ($10.44). In either case a negative result indicates that the community views mitigation to be inadequate, while a positive net change would signal community acceptance.

6.3 Off-site Mitigation Evaluation

An alternative to on-site mitigation is to offset damage to one stream by making enhancements to another stream. Table 12 illustrates how such proposals can be evaluated in money terms. Again, monetisation is not necessary; it yields an identical evaluation of acceptability to the non-monetised approach.

Table 12
Off-site Mitigation Scenario Effectiveness

	Attributes	Initial attribute levels	Final attribute levels	Attribute change	Part worths (Model D)	Change in value (attribute change * part worth)
Natural Stream	Water clarity	Clear	Muddy	-1	$64.92	-$64.92
	Fish species	5	4	-1	$10.44	-$10.44
	Fish habitat	4 Km	2 Km	-2	$1.38	-$2.76
	Native Bush	Plentiful	Plentiful	0	$0	$0
Degraded stream	Water clarity	Muddy	Clear	+1	$65.32	+$65.32
	Fish species	2	4	+2	$5.40	+$10.80
	Fish habitat	1 Km	2 Km	+1	$6.25	+$12.50
	Native Bush	Little	Moderate	+1	$36.57	+$36.57
	Channel	Straight	Straight	0	$0	$0
Net environmental benefit (per household per year)						$47.07
Lump sum net benefit @ 10% (per household)						$471

The scenario in Table 12 illustrates a proposal to offset loss of water clarity, one native fish species and two kilometres of fish habitat on a natural stream by riparian planting, water clarification, fish habitat extension and reestablishment of an additional native fish species on a degraded stream in the same locality. In this case positive net benefits signal that the proposed mitigation package would be acceptable to the community for offsetting the proposed damage to the natural stream.

Chapter 7
Benefits Transfer

The two principal methods of transferring benefits from a survey site to a project site are direct transfer, in which mean values estimated at the survey site are used directly at the project site, and benefits function transfer, in which the valuation function derived at the study site is applied using project site parameters. The valuation function approach is generally thought to be the more accurate (VandenBerg *et al.*, 2001).

Valuation function transfer requires models that allow either site attributes or personal characteristics to vary between locations. The study design used here removed the need to address some site attribute effects, because the goods valued at each site were identical. While substitutes do differ between the two survey locations, their impacts can only be addressed in multi-site studies, which allow identification of these effects. Consequently, only respondent characteristics can be addressed using valuation functions in the current study.

Because of low response numbers to the South Auckland postal survey, investigation of benefits transfer has been undertaken only for personal interviews. The models of Table 5 incorporate interaction effects for respondent characteristics, which differ between locations. In addition to the more sophisticated models in Table 5, simple HEV models without interactions were estimated for each location to assess accuracy of simple direct benefits transfer.

Direct benefit transfers

The simplest test of benefit transfer accuracy is identification of non-overlapping confidence intervals. This test has little power to validate benefits transfer, but can invalidate the process where confidence intervals do not overlap. There are no cases where North Shore interview and South Auckland interview part worth confidence intervals do not overlap substantially, so benefits transfer of the part worths estimated in this study cannot be rejected using this test.

An alternative measure of the merits of direct benefit transfer validity is the error in using one point estimate to predict another point estimate. (Vandenberg *et al.*, 2001). Table 13 shows part worth point estimates and the errors arising from using point estimates at one location to predict point estimates at the other location. The results in Table 13 show wide variability, with errors ranging from 1% to 345%. The disparity is somewhat less when consideration is given only to cases in which both point estimates of part worths are significantly different from zero (the lightly shaded cells in Table 13). Benefits transfer errors in these cases range from 1% to 119%. The models with covariates were much better than the simple models, the maximum estimation error was 46% for cases in which the attribute values were significantly different from zero.

Table 13
Errors from Direct Benefits Transfer

	Simple HEV models				**Models with covariates (Table 5)**			
	North Shore Part Worth (NSPW)	**South Auckland Part Worth (SAPW)**	**Error in predicting SAPW from NSPW**	**Error in predicting NSPW from SAPW**	**North Shore Part Worth (NSPW)** *Model D*	**South Auckland Part Worth (SAPW)** *Model E*	**Error in predicting SAPW from NSPW**	**Error in predicting NSPW from SAPW**
Natural stream								
Water Clarity (N1)	$60.75	$73.77	-18%	21%	$64.92	$65.61	-1%	1%
Native Fish Species (N2)	$9.97	$4.55	119%	-54%	$10.44	$5.05 †	107%	-52%
Fish Habitat (N3)	$2.92 †	-$2.72 †	-207%	-193%	$1.38 †	-$3.38†	-141%	-345%
Moderate Veg (N4A)	$23.17 †	$22.45 †	3%	-3%	$24.50 †	$20.70 †	18%	-16%
High Veg (N4B)	$21.38	$31.23	-32%	46%	$20.76	$30.28	-31%	46%
Degraded stream								
Water Clarity (D1)	$46.53	$71.28	-35%	53%	$62.83	$65.32	-4%	4%
Native Fish Species (D2)	$3.81 †	$5.21 †	-27%	37%	$2.85 †	$5.40 †	-47%	89%
Fish Habitat (D3)	$11.50	$4.66 †	147%	-60%	$12.93	$6.25 †	107%	-52%
Moderate Veg (D4A)	$19.02 †	$29.58	-36%	56%	$17.99 †	$36.57	-51%	103%
High Veg (D4B)	$15.32 †	$51.07	-70%	233%	$18.23 †	$52.90	-66%	190%
Channel (D5)	$48.67	$41.17	18%	-15%	$51.90	$37.59	38%	-28%

Population means of independent variables are used for Models D and E
† Not significantly different from zero at 5% level
NSPW North Shore part worth
SAPW South Auckland part worth

Valuation function benefit transfers

Table 14 shows part worth estimates derived using valuation function benefit transfer. Use of the valuation function to transfer benefit measures between locations shows some improvements and some worse predictions. Overall, it is not as accurate as direct transfer of part worths.

The errors identified in Tables 13 and 14 can be somewhat misleading because estimates are not statistically different, even though they vary by large amounts. It is encouraging to see the uniformity of benefit estimates across models and locations for natural stream water clarity. This is one of the attributes most highly valued by study participants (along with degraded stream water clarity). Water clarity and channel form on degraded streams also show low errors when transferred. High benefit transfer error rates for other variables are consistent with evidence available from published benefits transfer studies (Brouwer, 2000) and counsel against indiscriminate benefits transfer.

Table 14
Valuation Function Benefit Transfer

	North Shore Part Worth (NSPW) *Model D*	South Auckland Part Worth (SAPW) *Model E*	SAPW predicted from North Shore valuation function	NSPW predicted from South Auckland valuation function	Error in predicting SAPW from North Shore valuation function	Error in predicting NSPW from South Auckland valuation function
Natural stream						
Water Clarity (N1)	$64.92	$65.61	$64.92	$65.61	-1%	1%
Native Fish Species (N2)	$10.44	$5.05 †	$10.44	$5.05 †	107%	-52%
Fish Habitat (N3)	$1.38 †	-$3.38†	$1.38 †	-$4.74†	-129%	-443%
Moderate Veg (N4A)	$24.50 †	$20.70 †	$24.50 †	$34.35 †	-29%	40%
High Veg (N4B)	$20.76	$30.28	$20.76	$66.19	-69%	219%
Degraded stream						
Water Clarity (D1)	$62.83	$65.32	$52.95	$74.48	-29%	41%
Native Fish Species (D2)	$2.85 †	$5.40 †	$4.10 †	-$3.61 †	-214%	-188%
Fish Habitat (D3)	$12.93	$6.25 †	$12.93	$4.87 †	166%	-62%
Moderate Veg (D4A)	$17.99 †	$36.57	$17.99 †	$36.57	-51%	103%
High Veg (D4B)	$18.23 †	$52.90	$20.01 †	$52.90	-62%	164%
Channel (D5)	$51.90	$37.59	$49.57	$46.10	8%	-7%

Population means of independent variables are used throughout
† Not significantly different from zero at 5% level
NSPW North Shore part worth
SAPW South Auckland part worth

Chapter 8
Conclusions

The preparatory work undertaken for this project provided a robust foundation for research. Early conversations with scientists and ARC staff helped frame the ecological and regulatory dimensions of the project. The use of focus groups was a most useful, and cost-efficient, means of identifying stream attributes and framing the choice games in a way that would be relatively easy to follow. This early step in the research process is essential. Choice modelling relies on visual images coupled with easily understood descriptors of attributes.

The usable postal survey response rates were 32% and 21% for North Shore City and South Auckland respectively. A randomised sample of addresses provided a starting point for personal interviews. The response rate for contacts was 44% and 40% respectively. Of the two different survey instruments used, it would appear that personal interviews offer better value (in terms of obtaining representative data) for money. Personal interviews also avoid the high (often hidden) costs associated with postal survey design and layout, as well as postage and printing costs, which may represent a large proportion of the costs of interviewing.

The choice modelling results are particularly encouraging. The large number of attributes in each choice raised the possibility that the approach may place overly strenuous demands on respondent cognitive abilities. These concerns appear to be largely dispelled by interview participant and interviewer evaluations of task difficulty and understanding. No conclusions can be drawn about the difficulties faced by postal survey participants. The North Shore postal survey response rate is similar to other surveys conducted in New Zealand, suggesting that the task may not have been too difficult. However, the low postal survey response rate in South Auckland may signal otherwise.

In all choice models WATER CLARITY in both natural and degraded streams is highly significant. The sign that attaches to CHANNEL FORM in the degraded stream is positive and significant. The sign that attaches to NATIVE FISH SPECIES in the natural stream is also positive and significant. Estimated coefficients for the two variables MODERATE VEGETATION and HIGH VEGETATION suggest little perceived benefit in moving from moderate to plentiful streamside vegetation cover. The MONEY coefficient is highly significant and negative as expected, indicating that any particular option that is less likely to be selected if it costs more. Location effects are also evident in the data. People in South Auckland place lower values on the number of NATIVE FISH SPECIES in degraded streams and higher values that North Shore residents on HIGH VEGETATION.

Part worth estimates provide the information necessary for the assessment of mitigation options. The utility of part worth estimates for assessing mitigation options is demonstrated in a number of scenarios in Section 6. The choice models and associated results are sufficiently flexible to allow for a number of scenarios to be assessed and evaluated. Thus community values, as described in Figure 1, can be associated with degradation/mitigation options. A range of scenarios can now be evaluated, provided of course that cost data are available.

This study has generated a large number of part worth estimates, depending on data collection method, sample aggregation and location of impact. When confidence intervals are considered for this wide array of values the difficulty of settling on one standard value to use in applied cases becomes apparent, as emphasised in Table 6. The value of estimates derived from the "all in" model are appealing because of their relatively narrow confidence intervals.

This is an artefact of sample size and hides differences that arise because of survey method and sampling. The significance of interactions with the variable INTERVIEW in this model suggests that the “all in” model should be used with great caution.

The small sample size of the South Auckland postal survey is an indicator of potential bias problems and also results in wide confidence intervals on part worths. While part worth confidence intervals for the North Island postal survey are generally of similar magnitude to those derived from interviews, there are several cases where they appear to be inconsistent with other North Shore part worth estimates (see Figures 6, 7 and 12). Larger samples, smaller confidence intervals, and better quality information favour personal interviews over the postal surveys. Results for site specific and pooled interviews are summarised in Table 15.

Expected values are remarkably consistent across the four measures in Table 15. The only case in which there is a large discrepancy between locations is degraded stream high veg, which appears to be valued more highly in South Auckland. However, the use of uniform values is risky, as evidenced by the generally poor ability to transfer part worths from one site to another.

A limitation of the existing approach may be the use of a linear utility function without interactions between site attributes. The resultant identity between willingness to pay and willingness to accept compensation measures is not consistent with theoretical or empirical results (Horowitz and McConnell, 2002). Errors introduced by this restriction are likely to be small when part worths are small relative to income. They are also likely to be avoided to a certain extent by the design of the study. By definition, natural stream attributes could only get worse when moving from the status quo, while degraded stream attributes could only improve. Consequently, the framing of the study predisposes it to estimate willingness to accept measures for damages to the natural stream, and willingness to pay measure for enhancements to the degraded stream. This is consistent with the policy question frame.

Care should be exercised in multiple applications of the values derived in this study, which measure preferences for changes on one stream of each type. The values of multiple changes cannot necessarily be aggregated. In particular, as the number of natural streams diminishes, people will require more compensation for additional losses, while willingness to pay for stream enhancements is likely to decrease as the supply of enhanced streams grows.

In conclusion, this study has successfully applied the choice modelling method to identify community willingness to trade-off stream attributes. People have understood the tasks asked of them and have given consistent responses that have allowed estimation of utility functions, marginal rates of substitution, and part worths. Interviews appear superior to postal surveys, but both approaches yielded useable models that were very similar across locations. The values estimated allow the design of mitigation to offset damages in Auckland streams.

Table 15
Site-specific and Pooled Interview Part Worths

Attribute		**North Shore**		**South Auckland**		Central tendency
		Site specific interviews	Pooled interviews	Site specific interviews	Pooled interviews	
Natural Stream Water Clarity	Upper 95%	$112	$99	$116	$99	
	Expected	$65	$68	$66	$68	$65
	Lower 95%	$43	$50	$40	$50	
Natural Stream Native Fish Species	Upper 95%	$19	$14	$12	$14	
	Expected	$10	$8	$5	$8	$8
	Lower 95%	$5	$4	$0	$4	
Natural Stream Fish Habitat	Upper 95%	$12	$7	$7	$6	
	Expected	$1	$0	-$3	-$2	zero
	Lower 95%	-$8	-$8	-$15	-$10	
Natural Stream Mod Veg	Upper 95%	$64	$43	$63	$43	
	Expected	$24	$19	$21	$19	$20
	Lower 95%	-$2	$0	-$8	$0	
Natural Stream High Veg	Upper 95%	$48	$42	$63	$42	
	Expected	$21	$24	$30	$24	$24
	Lower 95%	$2	$8	$9	$8	
Degraded Stream Water Clarity	Upper 95%	$106	$85	$112	$81	
	Expected	$63	$59	$65	$56	$60
	Lower 95%	$40	$43	$42	$39	
Degraded Stream Native Fish Species	Upper 95%	$13	$10	$18	$11	
	Expected	$3	$2	$5	$4	$3
	Lower 95%	-$8	-$5	-$6	-$4	
Degraded Stream Fish Habitat	Upper 95%	$26	$19	$18	$19	
	Expected	$13	$10	$6	$10	$10
	Lower 95%	$4	$3	-$5	$3	
Degraded Stream Mod Veg	Upper 95%	$49	$49	$87	$49	
	Expected	$18	$26	$37	$26	$26
	Lower 95%	-$9	$7	$7	$7	
Degraded Stream High Veg	Upper 95%	$43	$39	$101	$81	
	Expected	$18	$18	$53	$51	$18 / $51
	Lower 95%	-$2	$0	$30	$31	
Degraded Stream Channel	Upper 95%	$90	$76	$67	$74	
	Expected	$52	$54	$38	$53	$50
	Lower 95%	$33	$39	$19	$38	

References

Arrow, K.; Solow, R; Portney, P.R.; Leamer, E.E.; Radner, R. and H. Schuman (1993). Report of the NOAA Panel on Contingent Valuation. *Federal Register 58(10)*: 4601-4614.

Adamowicz, W., Boxall, P., Williams, M. and Louviere, J.J. (1998). Stated preference approaches for measuring passive use values: Choice experiments and contingent valuation. *American Journal of Agricultural Economics* 80: 64-75.

Bennett, J. and Blamey, R. (Eds) (2001). *The choice modelling approach to environmental valuation*. Cheltenham, UK: Edward Elgar.

Bockstael, N.E., Freeman, A.M. III, Kopp, R.J., Portney, P.R. and V.K. Smith. (2000). On measuring economic values for nature. *Environmental Science and Technology 34*: 1384-1389.

Boxall, P.C., Adamowicz, W.L., Swait, J., Williams, M. and Louviere, J.J. (1996). A comparison of stated preference methods for environmental valuation. *Ecological Economics* 18: 243-253.

Boyle, K.J., Holmes, T.P., Teisl, M.F. and Roe, B. (2001). A comparison of conjoint analysis response formats. *American Journal of Agricultural Economics* 83(2): 441-454.

Brouwer, R. (2000). Environmental value transfer: state of the art and future prospects. *Ecological Economics* 32: 137-152.

Carlsson, F. and Martinsson, P. (2001). Do hypothetical and actual marginal willingness to pay differ in choice experiments? *Journal of Environmental Economics and Management* 41: 179-192.

Carson, R.T., Flores, N.E., Martin, K.M. and J. Wright (1996a). Contingent valuation and revealed preference methodologies: Comparing estimates for Quasi-Public goods. *Land Economics 72(1):* 80-99.

Carson, R.T., Hanemann, W.M., Kopp, R.J., Krosnick, J.A., Mitchell, R.C., Presser, S., Ruud, P.A., Smith, V.K., Conaway, M. and K. Martin (1996b). Was the NOAA Panel correct about contingent valuation? *Resources for the Future Discussion Paper 96-20.* Washington D.C.: Resources for the Future.

Diamond, P.A. and J.A. Hausman (1994). Contingent valuation: is some number better than no number? *Journal of Economic Perspectives 8(4)*: 45-64.

Dillman, D. A. (2000). *Mail and Internet Surveys: The tailored design method, second edition.* John Wiley & Sons.

Downing, M. and T. Ozuna (1996). Testing the Reliability of the Benefit Function Transfer Approach. *Journal of Environmental Economics and Management* 30: 316-322.

Forbes, R.N. (1984). *The valuation of non-market costs and benefits in the New Zealand water and soil area*. Technical Paper 4/84. Palmerston North: Economics Division, Ministry of Agriculture and Fisheries.

Haener, M.K., Boxall, P.C. and Adamowicz, W.L. (2001). Modelling recreation site choice: Do hypothetical choices reflect actual behaviour? *American Journal of Agricultural Economics* 83(3): 629-642.

Hahn, G.J. and Shapiro, S.S. (1966). *A catalogue and computer programme for the design and analysis of symmetric and asymmetric fractional factorial experiments*. Report No. 66-0-165, General Electric Research and Development Centre, New York.

Hatton, C. Auckland Regional Council. Personal communication.

Horowitz, J.K. and McConnell, K.E. (2002). A review of WTA/WTP studies. *Journal of Environmental Economics and Management* 44(3): 426-447.

Kerr, G.N. and B.M.H. Sharp (2002.) *Community perceptions of Stream Attributes: Focus Group Results*. Report to Auckland Regional Council. Agribusiness and Economics Research Unit, Lincoln University, Canterbury.

Morrison, M.D., Bennett, J.W. and Blamey, R.K. (1997). Designing Choice Modelling Surveys Using Focus Groups: Results From the Macquarie Marshes and Gwydir Wetlands Case Studies, Research Report No. 5, University College, The University of New South Wales.

Rolfe, J. and Bennett, J.W. (2003). *WTP and WTA in relation to irrigation development in the Fitzroy Basin, Queensland*. Paper presented to the 47th annual conference of the Australian Agricultural and Resource Economics Society, Fremantle, Western Australia. 12-14 February.

VandenBerg, T.P., Poe, G.L. and Powell, J.R. (2001). Assessing the accuracy of benefits transfers: Evidence from a multi-site contingent valuation study of groundwater quality. In: Bergstrom, J.C., Boyle, K.J. and Poe, G.L. (Eds) *The economic value of water quality.* Cheltenham: Edward Elgar.

Whitten, S.M. and Bennett, J.W. Non-market values of wetlands: A choice modelling study of wetlands in the Upper South East of South Australia and the Murrumbidgee River floodplain in New South Wales. *Private and Social Values of Wetlands Research Report No.8*. School of Economics and Management, University College, University of New South Wales, Canberra.

RESEARCH REPORTS

239 **A New Zealand Trade Share Database, 1966-96.** Cagatay, S & Lattimore, R 1998

240 **A Review of Economic Reforms in Bangladesh and New Zealand, and Their Impact on Agriculture.** Jahangir Alam, 1999

241 **Public Perceptions of Natural and Modified Landscapes of the Coromandel Peninsula, New Zealand.** Fairweather, John R & Swaffield, Simon R 1999

242 **Instruments for Internalising the Environmental Externalities in Commercial Fisheries.** Hughey, K F D., Cullen, R., Kerr, G N and Memon P A 2000

243 **New Zealand Farmer and Grower Intentions to Use Genetic Engineering Technology and Organic Production Methods.** Cook, Andrew J., Fairweather, John R & Campbell, Hugh R 2000

244 **Success Factors in New Land-based Industries.** Mayell, Peter J. & Fairweather, John R 2000

245 **Smallholders in Canterbury: Characteristics, Motivations, Land Use and Intentions to Move.** Fairweather, John R & Robertson, Nicola J 2000

246 **A Comparison of the Employment Generated by Forestry and Agriculture in New Zealand.** Fairweather, John R., Mayell, Peter J and Swaffield, Simon R 2000

247 **Forestry and Agriculture on the New Zealand EastCoast: Socio-economic Characteristics Associated with Land Use Change.** Fairweather John R., Mayell, Peter J and Swaffield, Simon R 2000

248 **Community Perception of Forest Sector Development on the New Zealand East Coast: Likely and Acceptable Employment Activities, Infrastructure and Landscape Change.** Swaffield, Simon R and Fairweather, John R 2000

249 **Gisborne/East Coast Field Research on Attitudes to Land Use Change: An Analysis of Impediments to Forest Sector Development.** Tomlinson, Craig J., Fairweather, John R and Swaffield, Simon R 2000

250 **Criteria to Evaluate the Application of Policy Instruments Designed to Internalise Externalities from Commercial Fisheries.** Cullen, Ross., Hughey, Ken F D., Kerr, Geoffrey N and Memon, Ali 2000

251 **Environmental Beliefs and Farm Practices of New Zealand organic, Conventional and GE Intending Farmers.** Fairweather, John R., Campbell, Hugh R., Tomlinson, Craig J. and Cook, Andrew J. 2001

252 **An Assessment of the Economic Costs of Relapsing-Remitting Multiple Sclerosis in the Canterbury/Westland Region of New Zealand.** Jackson, Diana., Tomlinson, Craig J., Fairweather, J. and Donaldson, I. 2001

253 **Research on the Consequences of Converting to Organic Production: A Review of International Literature and outline of a Research Design for New Zealand.** Fairweather, J.R. and Campbell, H.R. 2001

254 **Lincoln Trade and Environment Model: An Agricultural Multi-Country, Multi-Commodity Partial Equilibrium Framework.** Cagatay, S. and Saunders, C. 2003

255 **North Canterbury: An Analysis of the Current Economic Base of the Region.** Cross, Tracy-Anne., Dalziel, Paul and Saunders, C. 2003

DISCUSSION PAPERS

142 **Papers Presented at the 2nd Annual Conference of the NZ Agricultural Economics Society. Blenheim 1995**

143 **The Implications of Government Reform in New Zealand for the Canadian Agri-Food Sector.** Storey, Gary G 1996

144 **Papers Presented at the 3rd Annual Conference of the NZ Agricultural Economics Society. Blenheim 1996**

145 **Papers Presented at the 4th Annual Conference of the NZ Agricultural Economics Society. Blenheim 1997**

146 **Papers Presented at the 5th Annual Conference of the NZ Agricultural Economics Society. Blenheim 1998**

147 **Papers Presented at the 6th Annual Conference of the NZ Agricultural Economics Society. Blenheim 2000**

148 **Papers Presented at the 7th Annual Conference of the NZ Agricultural Economics Society. Blenheim 2001.**