Ministry for Primary Industries
Manatū Ahu Matua

Non-market valuation of improvements in freshwater quality for New Zealand residents, from changes in stock exclusion policy

MPI Technical Paper No: 2017/08

Prepared for the Ministry for Primary Industries

ISBN No: 978-1-77665-497-0 (online)
ISSN No: 2253-3923 (online)

July 2016

New Zealand Government

Growing and Protecting New Zealand

Disclaimer

While every effort has been made to ensure the information in this publication is accurate, the Ministry for Primary Industries does not accept any responsibility or liability for error of fact, omission, interpretation or opinion that may be present, nor for the consequences of any decisions based on this information.

Requests for further copies should be directed to:

Publications Logistics Officer
Ministry for Primary Industries
PO Box 2526
WELLINGTON 6140

Email: brand@mpi.govt.nz
Telephone: 0800 00 83 33
Facsimile: 04-894 0300

This publication is also available on the Ministry for Primary Industries website at http://www.mpi.govt.nz/news-and-resources/publications/

AERU
Agribusiness and Economics Research Unit

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

Non-market valuation of improvements in freshwater quality for New Zealand residents, from changes in stock exclusion policy

Dr Peter Tait

Dr Sini Miller

Paul Rutherford

Walt Abell

July 2016

The Agribusiness and Economics Research Unit (AERU)

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

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

The unit operates as part of Lincoln University, providing it excellent access to key academic resources. Lincoln University is New Zealand's specialist land-based university. It was founded in 1878 as a School of Agriculture, became a College of Agriculture attached to the University of New Zealand in 18986 and to the University of Canterbury in 1962. It was elevated to an independent university in its own right in 1990. The AERU can call on colleagues from within the university as well as draw on an extensive network of allied researchers to supplement its in-house expertise.

Non-market valuation of improvements in freshwater quality for New Zealand residents from changes in stock exclusion policy

Dr Peter Tait[1]

Dr Sini Miller[1]

Paul Rutherford[1]

Walt Abell[2]

July 2016

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

www.lincoln.ac.nz

2 Department of Informatics and Enabling Technologies
PO Box 85084
Lincoln University
Lincoln 7647
Canterbury
New Zealand

www.lincoln.ac.nz

Acknowledgements

The AERU thanks the following for their assistance with this project:

Darran Austin, Environmental Economics Unit, Ministry for Primary Industries
Jess Grinter, Environmental Economics Unit, Ministry for Primary Industries
Mike Hayward, Environmental Economics Unit, Ministry for Primary Industries
Jane White, Environmental Economics Unit, Ministry for Primary Industries
Fiona Pearce, Climate, Land and Water, Ministry for Primary Industries
Martin Workman, Climate, Land and Water, Ministry for Primary Industries
Irene Parminter, Climate, Land and Water, Ministry for Primary Industries
Vera Power, Water Evidence, Ministry for the Environment
John Phillips, Ministry for the Environment
Rob Davies-Colley, National Institute of Water and Atmospheric Research
Dr Sandy Elliott, Catchment Processes, National Institute of Water and Atmospheric Research
Dr Annette Semadeni-Davies, National Institute of Water and Atmospheric Research
Dr John Quinn, Freshwater and Estuaries, National Institute of Water and Atmospheric Research
Mark Anderson, Department of Informatics and Enabling Technologies, Lincoln University
Prof. Geoff Kerr, Department of Environmental Management, Lincoln University
Dr Andrew Collins, Institute of Transport and Logistics Studies, University of Sydney
Prof. John Rose, Institute for Choice, University of South Australia
David Lucock, Agribusiness Group

Contents

Tables

Figures

Key Points

- The Agribusiness and Economics Research Unit at Lincoln University and the National Institute of Water and Atmospheric Research with the New Zealand Ministry for Primary Industries, has estimated economic values for benefits that the NZ public could gain from improvements to human health risk, ecological quality, and clarity in rivers, lakes and streams resultant from implementation of a farm animal stock exclusion policy.

- Biophysical modeling conducted by NIWA estimated the change in the natural capital of freshwater bodies as a result of increased stock exclusion.

- There are no observable market prices that reveal what the New Zealand public are willing to pay for water quality improvements that flow from stock exclusion policy identified by NIWA.

- A non-market valuation methodology, choice experiments was therefore used. This involved an online survey of New Zealand residents in October 2015, using a research panel.

- NIWA's work describes the flow of services from freshwater under a range of management scenarios, whereas the willingness to pay work quantifies respondents' preferences over these services relative to each other and other goods and services in the economy.

- The survey process achieved 2,032 responses with good representation of key population demographics.

- The choice experiment shows that respondents place substantial value on water quality improvements of stock exclusion policy. The average respondent's annual marginal willingness to pay was:

    - $0.70 for each 1% increase in the proportion of waterbodies that achieve a 1:20 Health Risk level
    - $1.15 for each 1% increase in the proportion of waterbodies that achieve a 1:100 Health Risk level
    - $3.31 for each 1% increase in the proportion of waterbodies that achieve a 1:1,000 Health Risk level
    - $2.14 for each 1% increase in the proportion of waterbodies that achieve Moderate Ecological quality
    - $5.68 for each 1% increase in the proportion of waterbodies that achieve Good Ecological quality
    - $4.13 for each 1% increase in the proportion of waterbodies that achieve Moderate Clarity quality
    - $7.39 for each 1% increase in the proportion of waterbodies that achieve Good Clarity quality

- We calculated the national level non-market value of water quality benefits to New Zealand residents' resultant from a range of stock exclusion policy options.
- We applied the marginal values for improvements in human health risk, to changes in *E.coli* levels derived from NIWA biophysical modelling of stock exclusion policy scenarios.
- Values were delineated by an assumption of the effectiveness of fencing to prevent *E.coli* from reaching freshwater; either low, most likely, or high.

National value of stock exclusion water quality benefits over next 25 years

$Million NZ 2015; 8% Discount Rate

Policy scenarios – stock to be excluded			Assumed effectiveness of fencing in reducing *E.coli* load to waterways		
			Low	Most Likely	High
1	Status Quo:	Current fencing, including regional requirements to be implemented by July 2017	265	863.6	837.1
2	Status Quo, PLUS:	Dairy cattle on dairy platforms by 2017	272.6	928.9	916.7
3	Scenario 2, PLUS:	Dairy cattle grazing on land owned by dairy farmers by 2020	279.5	996.9	992.8
4	Scenario 3, PLUS:	Dairy cattle grazing on land owned by a third party by 2025	290.3	1,121.4	1,143.7
5	Scenario 4, PLUS:	Beef cattle excluded by 2025 on flat land, and 2030 on rolling land (slopes less than 16 degrees)	424.8	1,8375	1,787.9
6	Scenario 5, PLUS:	Deer excluded by 2025 on flat land, and 2030 on rolling land	426.6	1,8470	1,793.9
7	ALL	Steep Hill Country Scenario: Exclude all cattle (dairy and beef) and deer into steep country (slopes up to 28 degrees) by 2017	1,062.8	4,233.4	3,868.6

1 Introduction

This report details the development and application of a Choice Experiment (CE) used to identify and measure New Zealand resident's preferences for several water quality outcomes resultant from a farm animal (stock) exclusion policy. The CE method was the primary tool employed to achieve our objective; to determine, in economic terms, the value of some of the non-market benefits to water quality that accrue from stock exclusion at a national scale. Preferences identified from the CE were combined with quantification of the biophysical impacts of management scenarios assessed by NIWA modelling.

Developing a national policy to prevent farm animals from entering waterways has the potential to improve freshwater environments. These improvements can enhance recreational opportunities, cultural values and habitat biodiversity, providing benefits to many New Zealanders.

Designing economically efficient policy requires a consideration of the benefits and costs of policy implementation. While measurement of costs, such as fencing, are relatively straightforward to obtain through observed market transactions, a lack of corresponding market transaction data makes valuing water quality improvements in economic terms more difficult. The CE method has previously been applied internationally in the public water policy arena to estimate public values of water resources. Recent application valuing benefits of improved water quality under the European Union Water Framework Directive[1] [2], and European Union Bathing Waters Directive[3] show contribution of the method to policy benefits analysis. These studies provide practical guidance for the work proposed here as they demonstrate the top-down generic value approach to providing national estimates, which has not previously been conducted in New Zealand.

We used a CE approach involving an online survey of the general public. An essential research design concern was establishing concordance between the outputs of biophysical modelling of policy effects on water quality, and the marginal estimates of value derived from the CE survey. This report provides estimates of benefits that are compared to costs within a Cost-benefit framework that is conducted outside this report. The project involved collaboration between the Agribusiness and Economics Research Unit (AERU) at Lincoln University and the New Zealand Ministry for Primary Industries.

The project comprised seven main phases.

1. Identification of the water quality outcomes that are related to stock exclusion policy.
2. Literature review identifying approaches to CE design relevant to the objectives, particularly on the construction of generic values at a national level.

---

[1] Murphy etal. 2014. Estimating the value to Irish society of benefits derived from water-related ecosystem services: A Discrete Choice Experiment. *EPA Research Report 2011-W-MS-4.*

[2] Metcalf etal. 2012. An assessment of the nonmarket benefits of the Water Framework Directive for households in England and Wales. *Water Resources Research doi: 10.1029/2010WR00952.2012*.

[3] Hynes etal. 2013. Valuing improvements to coastal waters using choice experiments: An application to revisions of the EU Bathing Waters Directive. *Marine Policy doi:10.106/j.marpol.2012.035.*

3. Development of the CE questionnaire, combining literature review findings with stakeholder workshop discussion, and results of cognitive interviews with the general public.
4. Administration of the resultant CE survey to a representative sample of New Zealand residents using an online mode.
5. Analysing data employing appropriate econometric models.
6. Estimation of monetary values that residents have for freshwater quality outcomes.
7. Reporting including analysis of stock exclusion scenarios.

2 Method

2.1 Choice Experiment Method

The selection of suitable economic measurement tools to value policy benefits is driven primarily by the availability of appropriate data that can describe the value of policy outcomes to individuals. There are no observable market prices available that reveal what New Zealand residents are willing to pay for the types of water quality improvements that flow from stock exclusion. Economists instead draw on non-market valuation methodologies, of which the CE approach is appropriate for this study[4]. The CE method simulates market observations by creating a hypothetical market scenario within a survey that enables people to indicate their preferences for changes in water quality and the associated costs to them. In this way a CE produces information on quantities and prices similar to what is found in real markets which can then be analysed to measure the benefit of changes in water quality. They are grounded in the same Welfare Economics framework that facilitates the use of observed market prices to measure changes in the value of benefits and costs.

CEs have, for over four decades, been applied in economics to value a wide variety of goods and services such as transport, cultural heritage, environmental quality and health care. This approach has been widely applied to value freshwater resources internationally [5] and has an established New Zealand literature[6].

CEs are a survey-based method in which respondents are presented with a series of choice tasks. For each choice task, respondents choose between at least two broad options. In this study, the options represent alternative scenarios for stock exclusion policy. Each option is described by a number of attributes describing water quality outcomes resultant from stock exclusion e.g. improved human health risks, or ecological quality. In each choice task, the combinations of attributes are systematically varied to denote different management options. Respondents are asked to choose the option with the combination of outcomes they prefer. We assume that the options chosen by respondents are what they think are best for them personally.

Statistical information derived from these choice tasks is econometrically modelled to quantify the relative importance of each water quality outcome. By including one key monetary attribute in choice tasks, the monetary value of other non-monetary attributes can be calculated. Economists express this as willingness to pay (WTP), e.g. how much I am willing to pay to have a program that reduces human health risks. This value can be used as the monetary estimate of the benefit of this program attribute.

---

[4] New Zealand Treasury. July 2015. Guide to Social Cost Benefit Analysis. Available at http://www.treasury.govt.nz/publications/guidance/planning/costbenefitanalysis/guide

[5] Murphy etal. 2014. Estimating the Value to Irish Society of Benefits Derived from Water-Related Ecosystem Services: A Discrete Choice Experiment. EPA Research Report 2011-W-MS-4.

[6] Phillips E. 2014. Non-market Values for Fresh Water in the Waikato Region: A Combined Revealed and Stated Preference Approach. Waikato Regional Council Technical Report 2014/17.

2.2 Choice Experiment Survey Design

Exploring and finalising the choice of attributes that describe the outcomes of stock exclusion management in the freshwater environment was undertaken primarily with the expertise of MPI, MfE and NIWA staff in conjunction with findings of cognitive interviews with the general public. The aim was to agree on what physico-chemical and ecological changes in freshwater ecosystems were likely to result from stock exclusion management, and how those changes could be characterised in the very simple terms required for an online survey.

2.2.1 Expert Workshop

To identify the potential range of impacts on freshwater resources resultant from stock exclusion in New Zealand, this study conducted a workshop in July 2015. A variety of government officials involved in developing and implementing the National Policy Statement for Freshwater Management (NPS-FM) under the joint Water Directorate were invited to participate. Care was also taken to invite leading scientific experts in freshwater quality (sediment; water chemistry, and riparian management) to provide advice and inputs during the scoping of the non-market valuation study.

Organisations represented included the Ministry for Primary Industries (Climate, Land and Water and Environmental Economics teams from the Resource Policy Directorate); Ministry for the Environment (Freshwater Guidance and Evidence teams), and National Institute of Water and Atmospheric Research (NIWA).

Each group contributed a presentation to the workshop focusing on their expertise relevant to freshwater management and probable policy impacts. Subsequent group discussion generated a list of potential impacts associated with changes to stock exclusion policy.

The main objective of the workshop was to determine which freshwater outcomes to include in the CE. To achieve this objective required prioritising the list of potential impacts identified. Workshop participants were split into groups with each group tasked with independently ranking outcomes in terms of the level of policy relevance; the most noticeable or important outcomes to the general public, and the ability to measure the outcomes reliably. The rankings of individual groups were discussed collectively to agree final prioritisation.

Three areas of impact or probable quality benefits were identified as the ‘outcome attributes’ of stock exclusion that would be relevant in the context of a national level survey. These are:

1. **Human health risk**

   Farm animals produce significant quantities of waste that contains bacteria that cause disease and make people sick. Keeping farm animals out of waterways helps limit the amount of waste that reaches the waterway. This results in a reduced risk of people becoming sick.

2. **Ecological quality**

   Preventing farm animals from entering waterways can enhance the range of species living within the freshwater environment (biodiversity) and provide food and habitat for flora and fauna. This is achieved by enabling the establishment of overhanging vegetation creating shade and helps keep water temperatures more stable. This also provides shelter and safety from predation for aquatic life. The vegetation improves the range of habitats available for aquatic life to occupy and thrive in.

3. **Water clarity**

   Fences prevent farm animals from accessing waterways and causing damage to banks and beds of water bodies. Erosion of banks and river beds introduces extra sediment into the waterway. Sediment in waterways reduces water clarity and visibility, and settles on beds. This can smother aquatic life and prevent vital biological processes from functioning normally, and destroy spawning areas. Raised river or stream beds can increase the risk of flooding. High levels of sediment also make swimming and other recreation activities unpleasant and unsafe.

2.2.2 Attributes and Levels

The levels for each water quality attribute are presented in Table 1.The levels are represented as the percentage of freshwater sites across New Zealand that achieve a given level of quality. For each attribute, these must sum to 100%, and are presented as pie charts to respondents (Figure 1) that show the relative proportion of waterbodies in a particular quality category. This design allows us to generate estimates of the value of increasing the proportion of waterways within a particular quality category. The type of waterway improved can influence individual management preferences, we include a priority waterbody type management attribute to capture differing preferences for streams, rivers and lakes. Streams were defined as small low-flow waterways less than five metres wide; rivers were defined as permanently flowing waterways wider than five metres; and lakes were defined as large permanent bodies of water greater than two hectares in area. Likewise, the location of water quality improvements may influence individual management preferences, we include a priority management location attribute to capture differing preferences for improvements that occur locally (within 50km of respondents domicile) and those that occur within a respondents region.

To determine the proportionate split of waterbodies across the quality categories currently, we obtain water quality data from Land, Air, Water Aotearoa (LAWA), a collaboration between New Zealand’s 16 regional and unitary councils, Cawthron Institute, Ministry for the Environment and Massey University (lawa.org.nz).

1. Human health risk

Health risk is measured by the number of people who have contact with a waterway and then become sick, adopting the health risk categories employed in the National Objectives Framework National Policy Statement for Freshwater Management.[7] To determine the level of human health risk, we assessed median *E.coli* concentrations from 876 monitored sites throughout New Zealand between 2012 and 2013.

2. Ecological quality

Ecological quality was measured using Macroinvertebrate Community Index (MCI) scores, which are based on the presence (or absence) of different kinds of invertebrates such as insects, worms and snails that respond to changes in habitat condition. Higher index scores indicate healthier waterbodies. We assessed median MCI scores for 876 monitored sites throughout New Zealand, between 2012 and 2013.

3. Water clarity

Water clarity is influenced by the amount of sediment suspended within the water column. A common measurement used to estimate water clarity in New Zealand is the Black Disk method. This method is used to determine the depth through water that is visible to the human eye.[8] Typically, greater visibility indicates lower sediment levels. For this study, we assessed median Black Disk measurements taken at 675 monitored sites throughout New Zealand for the years 2012 - 2013.

Table 1. Attribute descriptions and levels for choice tasks

Attribute	Management outcome	Levels (% of waterbodies achieving outcome across NZ)			
Human Health Risk	1/10 visitors sick each year	0	10	20	30*
	1/20 visitors sick each year	0	10*	20	
	1/100 visitors sick each year	10*	20	30	40
	1/1,000 visitors sick each year	50*	60	70	80
Ecological Quality	Poor: MCI score less than 80	10	20	30	40*
	Moderate: MCI score between 80 and 99	10	20*	30	
	Good: MCI score greater than 100	40*	50	60	70
Water Clarity	Poor: Visibility of 1.1m or less	20	40	60*	
	Moderate: Visibility between 1.2 and 2.4m	20*	30	40	
	Good: Visibility of 2.5m or more	20*	30	50	
Management Priority Location		No Priority*	Local	Regional	
Management Priority Waterbody Type		No Priority*	Streams	Rivers	Lakes
Annual Cost ($NZ)		0*, 50, 100, 150, 200			

* denotes levels of 'no waterway animal management' alternative employed in each choice set.

[7] National Policy Statement for Freshwater Management (2014). National Objectives Framework Appendix 2: Attribute Tables/Human health for recreation/Lakes and rivers/E.coli. Retrieved 11 June 2015 from http://www.mfe.govt.nz/sites/default/files/media/Fresh%20water/nps-freshwater-management-jul-14.pdf.
[8] NIWA 2013 'How is water clarity measured and what is its significance?', viewed on 11 February 2016, https://www.niwa.co.nz/freshwater-and-estuaries/faq/how-is-water-clarity-measured-and-what-is-its-significance

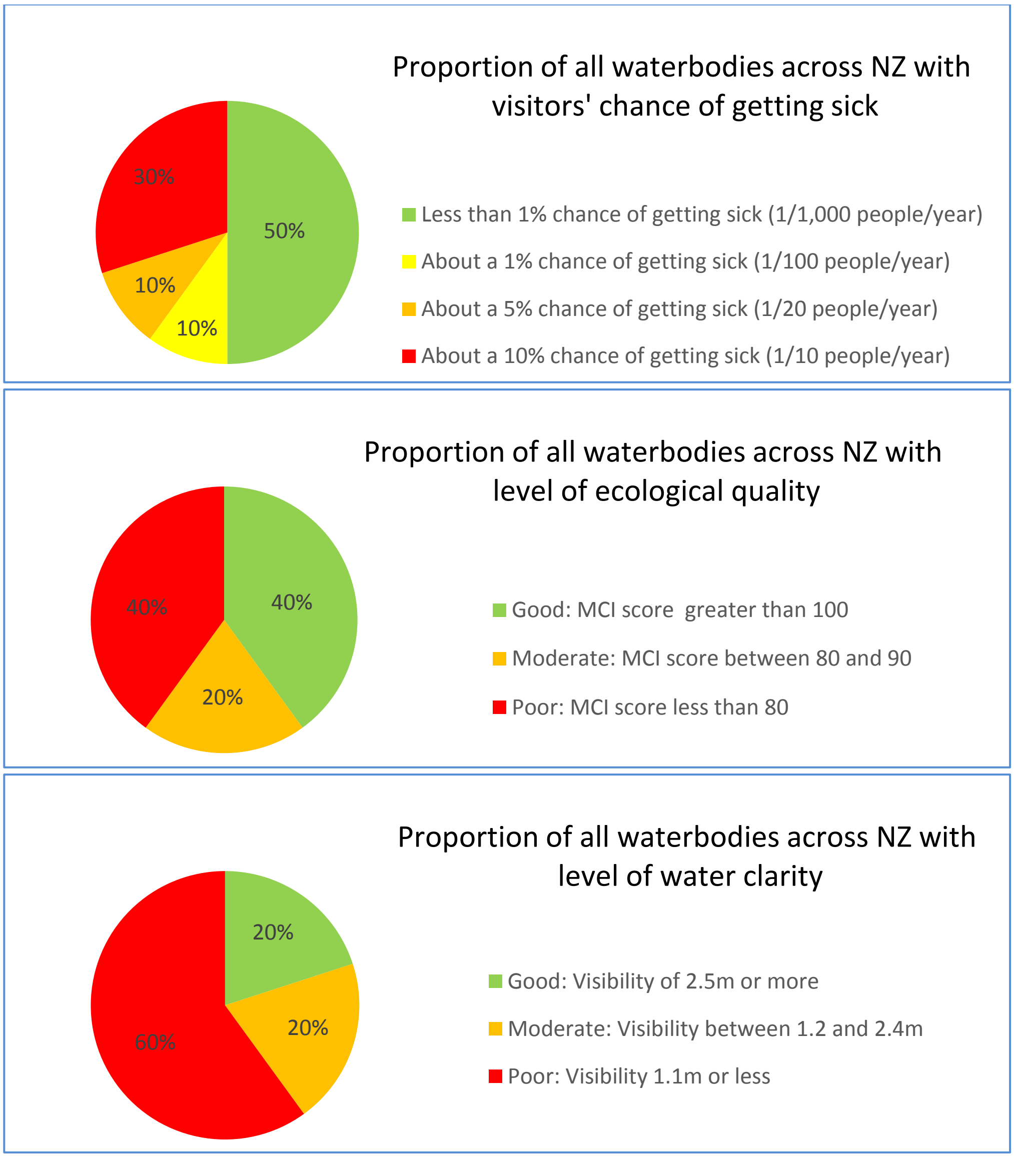

Figure 1. Example of pie chart format of water quality attributes human health, ecological quality and water clarity

2.2.3 Experimental Design

It is not possible to present respondents with all possible combinations of attribute levels (Table 1). Instead, Experimental Design methodology is used to create combinations of attribute levels, which represent a subset of the total combinations possible, and maximise the amount of statistical information available. These combinations are formed into choice sets. Figure 2 presents an example of a choice set shown to respondents. Each choice set comprises three options, of which respondents chose their preferred option. The first option is a 'no waterway animal management' option that represents a scenario in which stock exclusion policy is not expanded from current levels, and therefore no additional cost is imposed on respondents. This option is the same for all choice sets that a respondent sees, and is known as the constant base that respondents compare other options against. The other two options represent scenarios in which stock exclusion policy is expanded, and contain improvements in water quality outcomes for each attribute compared to the constant base option. These two management change options do impose an additional annual cost on respondents.

The study employs NGene[9] software to apply a Modified Federov algorithm[10] design approach. This approach first forms all possible combinations of water quality outcomes given in Table 1, and then searches for the combination that provides the greatest statistical information. Providing information on the likely values of model coefficient estimates improves this process. For the initial experimental design we looked at similar studies for design parameters, then update these with coefficient estimates from a model fitted to pilot survey data (n=300). The resulting updated experimental design is applied to the remaining number of respondents (n=1,732) with each respondent answering six choice sets.

[9] ChoiceMetrics (2014) Ngene 1.1.2 User Manual & Reference Guide, Australia.

[10] Cook RD. Nachtsheim CJ. 1980. A comparison of algorithms for constructing exact D-optimal designs. Techometrics 22:315-324.

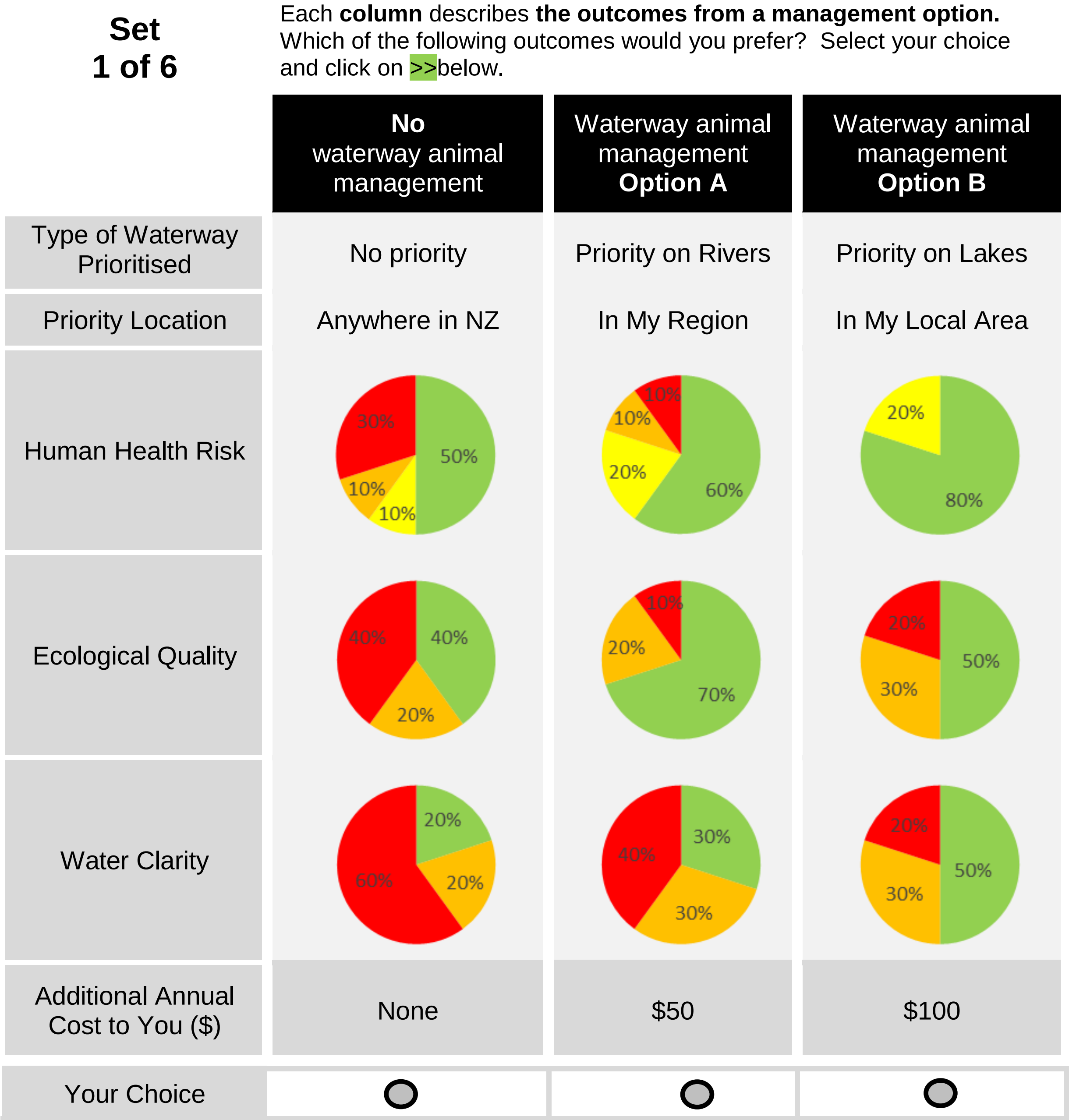

Figure 2. Example choice set presented to respondents

2.2.4 Cognitive Interviews

Cognitive Interviews are a leading methodology for testing questionnaires during design and implementation phases. The central aim is an assessment of whether respondents comprehend questions as intended by the researcher and whether questions can be answered accurately[11]. The method involves respondents being prompted individually to respond to a questionnaire by an interviewer who asks them to think out loud as they go through the survey and tell the interviewer what is being thought about the questions and how answers are being formed. The interviewer probes in order to explore issues including interpretation of questions.

Cognitive interviews were employed to obtain feedback on draft questionnaires from a number of people, including those with specialised knowledge of some aspect of questionnaire quality, particularly regarding CE design elements, and end-user usability of the online mode format being used. Cognitive interviews were also conducted with the complete questionnaire in order to identify wording, question order, visual design, and navigation problems. A total of six interviews were conducted across a mix of gender, age and occupation, each with duration of 1.5 to 2.5 hours.

2.2.5 Survey Administration

The sample of New Zealand resident respondents was obtained from Research Now (researchnow.com), a research consultancy that provides analytical services and maintains one of the largest global databases of survey respondents. Their panel of members is paid for completed surveys. This sampling method allowed for the pre-stratification of the sample by age, gender, income, and regional location. That would not be possible if drawing a sample from the commonly used Electoral Roll which does not include most of these variables.

Prior to full launch of the survey instrument, we conducted a pilot study with a subsample of the population (n=300) in order to evaluate interconnections among questions, the questionnaire, and the implementation procedure.

An Internet-based survey of a sample of New Zealand residents from an online panel was conducted in September 2015 using names and contact details obtained from a database maintained by Research Now. The final sample consisted of 2,032 residents from throughout New Zealand.

The survey was administered using an online survey mode employing Qualtrics™ online survey software, and proprietary software for implementing CE surveys maintained by AERU. The process consisted of contact through an email invitation to New Zealand residents that contained a link to the online survey.

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

3 Results

3.1 Sample Characteristics

A total of 2,032 New Zealand residents provided responses to the survey. Table 2 describes the composition of the sample by various demographic variables, including location. To determine whether the sample is representative of the general NZ population, we statistically tested that the distribution of the observed sample demographics was consistent with that of the general population, as provided by Statistics NZ 2013 data. Table 2 indicates that the sample composition was overall a good representation of the NZ population, with only education being skewed towards higher levels relative to that of the general population.

Table 2. Sample characteristics

Demographic Variable		Sample Distribution (%)	NZ Population Distribution (%)[1]
Age [p = 0.90][2]	65 years or more	21	19
	55 – 64 years	16	15
	45 – 54 years	19	19
	35 – 44 years	17	18
	25 – 34 years	17	16
	18 – 24 years	10	13
Gender [p = 0.84]	Female	50	51
Education [p = 0.00]	High school	28	50
	Trade/technical qualification or similar	22	9
	Undergraduate diploma/certificate/degree	30	14
	Postgraduate degree	18	6
	None	2	21
Occupation[3] [p = 0.74]	Unemployed	5	4
	Retired	19	14
	Unpaid voluntary work	1	1
	Student	7	6
	Paid employment	60	65
	Home duties	7	8
Personal Income [p = 0.38]	Loss	1	1
	$0 - $20,000	25	38
	$20,001 - $40,000	30	26
	$40,001 - $50,000	12	10
	$50,001 - $70,000	16	13
	$70,001 - $100,000	9	8
	$100,001 or more	7	6
Household Size [p = 0.34]	One	15	22
	Two	40	34
	Three	17	17
	Four or more	28	27
Region [p = 0.81]	Auckland	22	33
	Bay of Plenty	7	6
	Canterbury	12	13
	Gisborne	1	1
	Hawke's Bay	6	4
	Manawatu-Wanganui	7	5
	Marlborough	2	1
	Nelson	2	1
	Northland	4	4
	Otago	4	5
	Southland	2	2
	Taranaki	4	3
	Tasman	1	1
	Waikato	12	10
	Wellington	13	11
	West Coast	1	1

[1] Distributions from Statistics NZ Census 2013. [2] Values in brackets are p-values for Pearson's Chi-squared test of the null hypothesis that the frequency distribution of the observed sample demographic variable is consistent with the population distribution provided by Statistics NZ Census 2013 data. A p-value less than 0.1 indicates a statistically significant difference between the distributions; p-values greater than 0.1 indicate that the demographic distribution is not statistically different to the population and therefore are representative of the general population. [3] Population distributions from 2013 Household Labour Force Survey.

3.2 Freshwater Perceptions and Experiences

Differing perceptions, attitudes, and experiences of survey respondents in relation to freshwater resources can influence their preferences for how these resources are managed, and for different types of water quality outcomes. The survey began by asking respondents a series of questions focused on these three elements. These questions also provide context and framing that enables respondents to think about and recall what benefits they derive from water quality outcomes in freshwater environments.

3.2.1 Perceived Quality of Freshwater Resources

Preferences for water management efforts may be influenced by respondents' desire to address areas of greatest need. Respondents were asked to describe what they thought was the overall quality of river, lake and stream environments in New Zealand, on a scale of very-unsatisfactory; unsatisfactory; neither; satisfactory, or very-satisfactory (Figure 3).

- The greatest levels of satisfaction are for lakes, with 52% of respondents believing lake environments to be in a satisfactory or very satisfactory condition. Lakes also have the lowest levels of dissatisfaction, with 25% believing lake environments to be in an unsatisfactory or very unsatisfactory condition.

- Stream environments are perceived to be in the worst condition with 39% of respondents believing stream environments to be in an unsatisfactory or very unsatisfactory condition and 38% believing stream environments to in a satisfactory or very satisfactory condition.

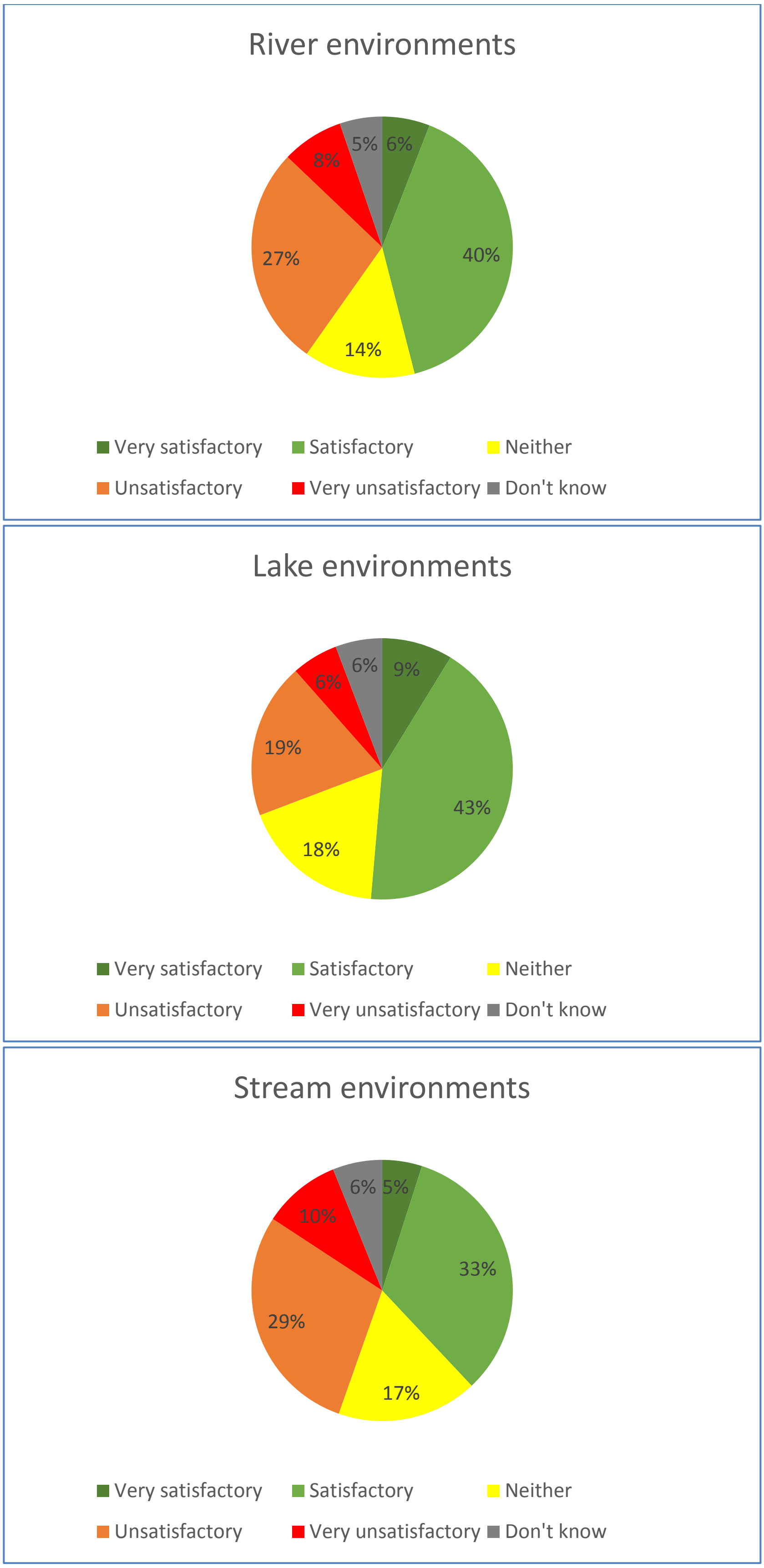

Figure 3. Respondent perceptions of overall quality of river, lake and stream environments in New Zealand

3.2.2 Important Uses of Freshwater Resources

Respondents were asked to indicate their views on the importance of different uses of freshwater resources in New Zealand on a scale of very important; important; neither; unimportant, and very unimportant (Figure 4). This allowed for exploration of the relative importance of the attributes valued in the CE - habitat for plants and wildlife, and recreational opportunities - against other aspects of value that the public derives from freshwater.

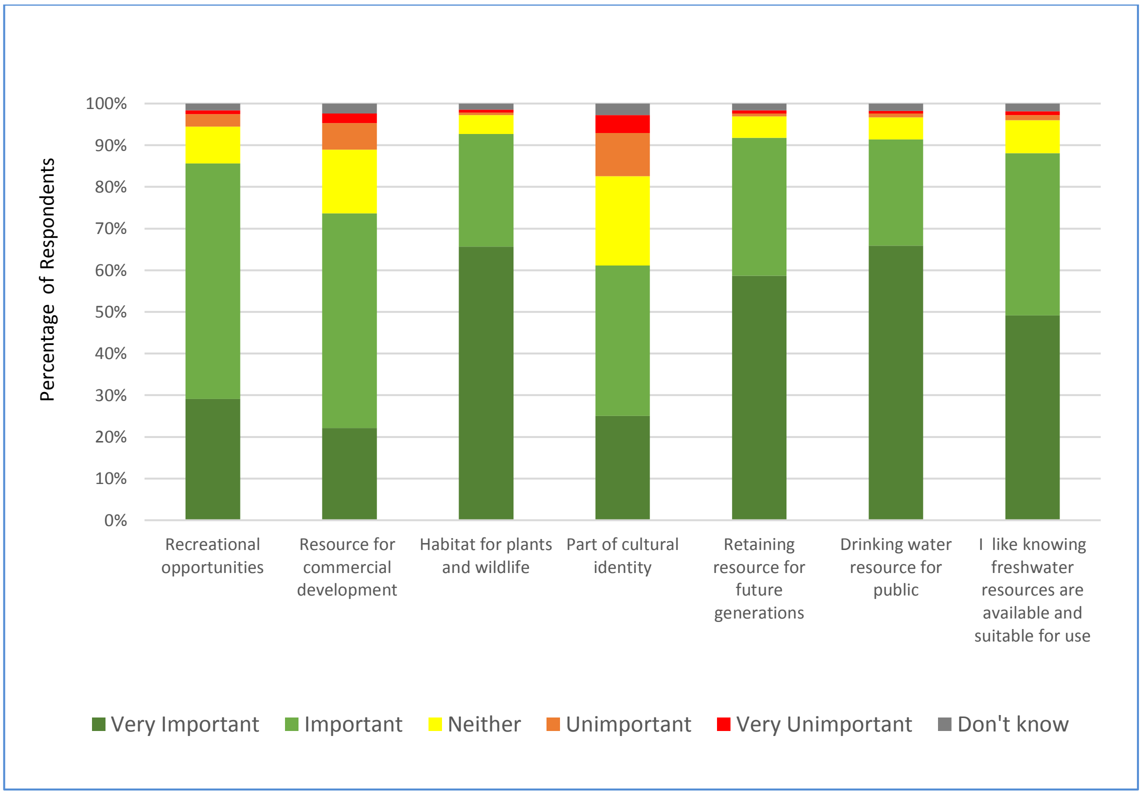

Figure 4. Important uses of freshwater resources

When looking at the 'very important' responses, freshwater resources for habitat for plants and wildlife is considered comparatively as important as a human drinking water resource. Resource for commercial development was the least important with 22% of respondents indicating that this was very important to them. Overall, this analysis suggests that passive-use values, those that do not consume water resources directly, are as relatively important to NZ residents as direct-use activities such as recreation.

3.2.3 Participation in Freshwater Based Activities

Respondent's preferences for the freshwater attributes used in this study - human health risk, ecological quality, and water clarity - are likely to be influenced by the amount of contact with waterways they have. To capture this potential source of preference differences, respondents were presented with a series of questions exploring the range of activities undertaken by them the last 12 months at rivers, streams and lakes.

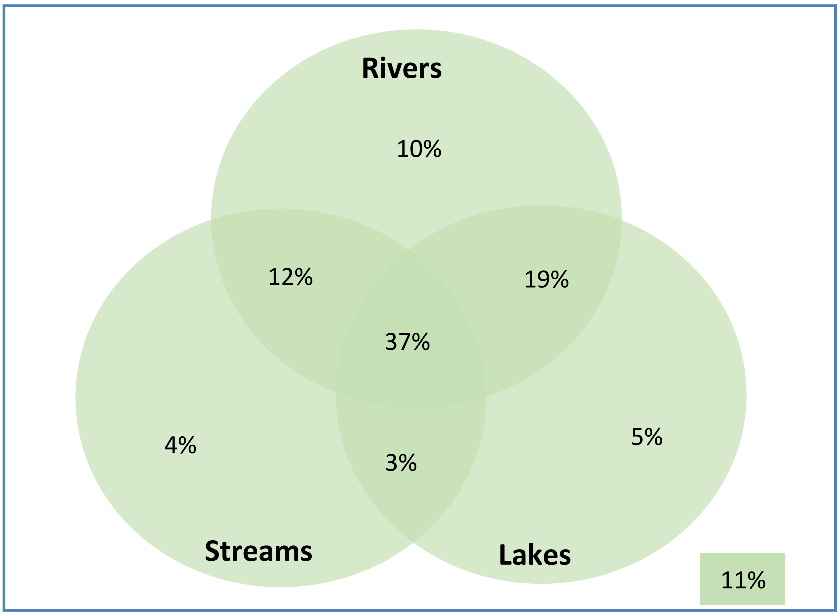

Figure 5. Proportions of respondents visiting rivers, lakes and streams in last 12 months

Figure 5 shows that relatively few respondents had not visited a river, lake or stream at least once in the last 12 months (11%). Respondents were most likely to have visited rivers in the last 12 months (78%) followed by lakes (64%) and were least likely to have visited streams (56%). Notably, respondents were more likely to visit all three waterbody types (37%) than just a single waterbody type alone (19%).

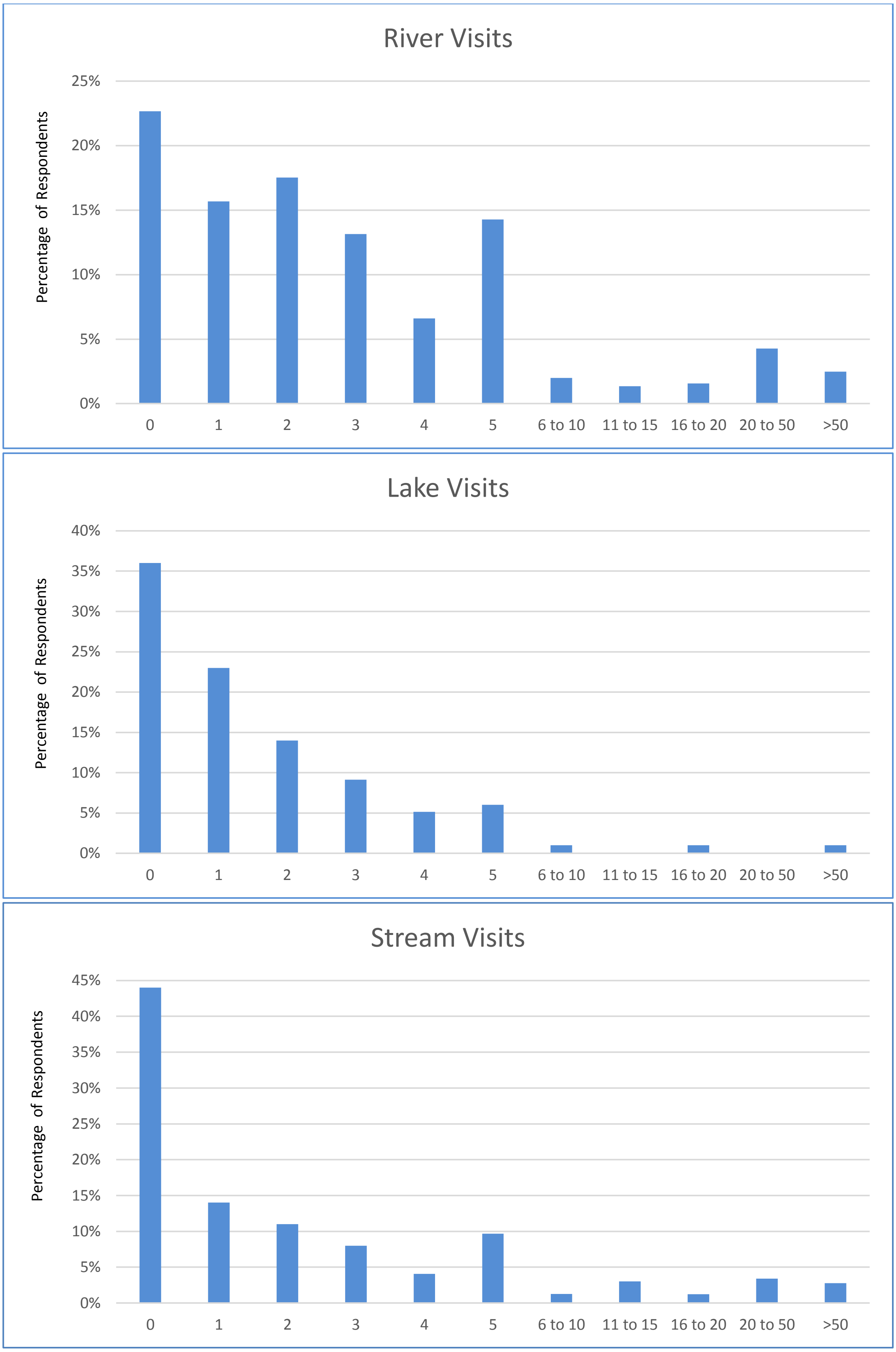

Figure 6. Distribution of number of visits to rivers, lakes and streams in last 12 months

Examining visit frequency reveals that a proportion of the sample have relatively high frequency of use (Figure 6). This group is categorized into respondents who make 50 or more visits in the last 12 months and contains a number of respondents making 100+ visits to rivers (2%), lakes (1.5%) and streams (2.5%). Figure 6 also shows that the most common number of visits to a river in the last twelve months is two times, with 18 per cent of respondents engaging at this frequency. For lakes, the most frequent visit rate is once, with 23% of respondents visiting a lake in the last twelve months. Likewise for streams, 14 per cent of respondents had visited once in the last twelve months

Respondents who indicated that they had visited a river, lake or stream, were then asked which activities they engaged in at these waterbody types (Figure 7). The key results for this question were as follows:

- **Rivers** The highest number of visitors to rivers went there for sightseeing (73%) followed closely by walking, running or jogging (71%) and then picnicking (68%).
- **Lakes** The same pattern of behaviour is revealed as for river visitors but at a lower frequency. The highest number of visitors to lakes went there for sightseeing (53%) followed closely by walking, running or jogging (47%) and then picnicking (46%).
- **Streams** Similarly, visitors to streams most often went there for walking, running or jogging (38%) followed by sightseeing (32%), albeit that nature and birdwatching is now the third most engaged in activity by stream visitors (31%).

Overall, Figure 7 shows that more visitors engage in visual and secondary recreation activities rather than primary recreation such as swimming and fishing. This observation is confirmed in Figure 8 which shows that across rivers, streams and lakes:

- 83 per cent of visitors engaged in **secondary** recreation activities (walking, running or jogging, picnicking, hunting)
- 81 per cent of visitors engaged in **visual** recreation activities (nature/bird watching, sightseeing)
- 53 per cent engaged in **primary** recreation activities (swimming, fishing, rowing/boating/canoeing).

Notably, very few respondents participated in one type of activity alone (9%) and 46 per cent participate in all three types of activities (46%) primary, secondary and visual.

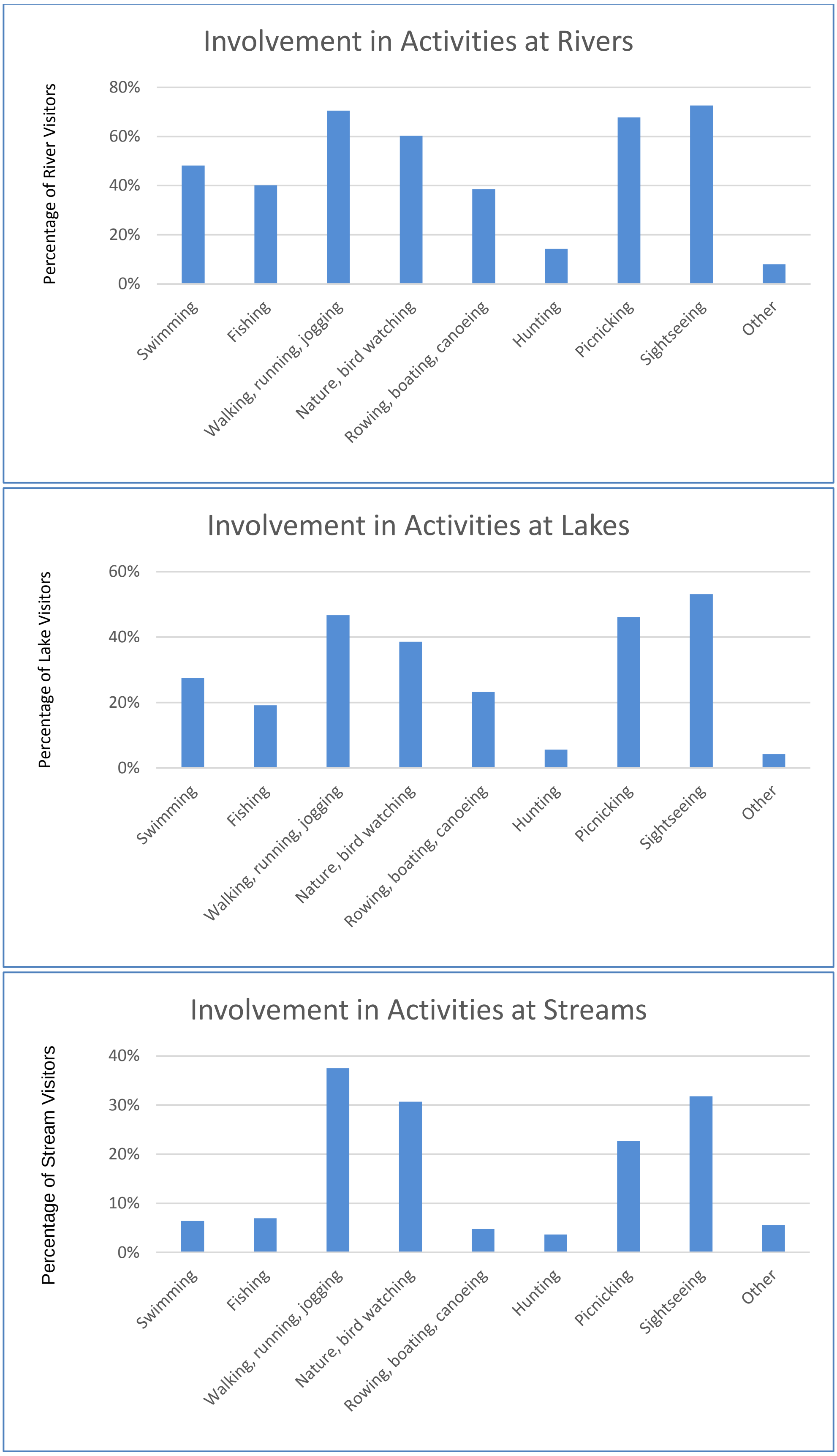

Figure 7. Respondent involvement in activities at rivers, lakes and streams in last 12 months

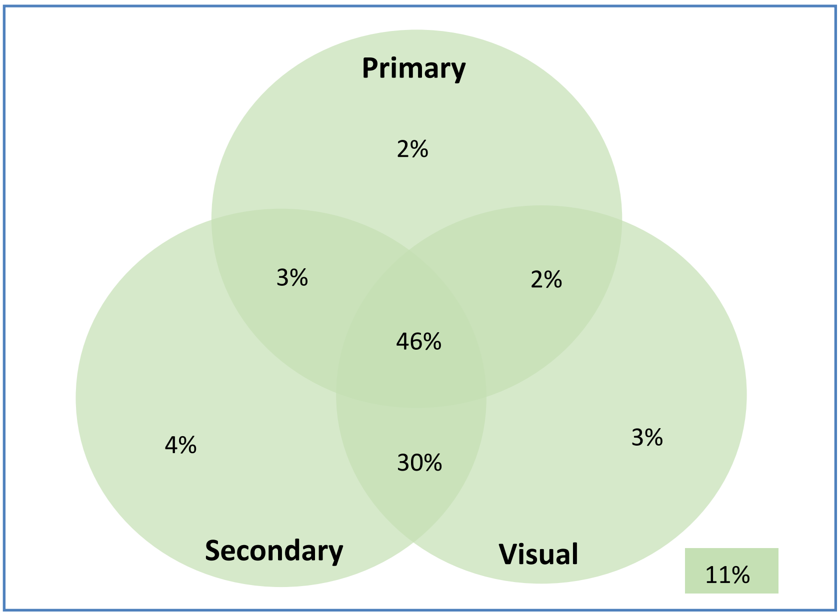

Figure 8. Proportions of respondents participating in primary, secondary and visual recreation

Respondents who engaged in activities were also asked to indicate the distance they traveled on their most recent visit for each particular activity. Figure 9 shows the average number of visits to rivers, lakes and streams in the last twelve months over all respondents, alongside the average distance travelled of most recent visits. This shows that the highest average number of visits is to rivers (9 visits) followed closely by streams (8 visits) and lakes (4 visits). Average distance travelled to lakes is the highest (34km) with rivers (9.6km) and streams (2.2km) exhibiting considerably shorter travel distances.

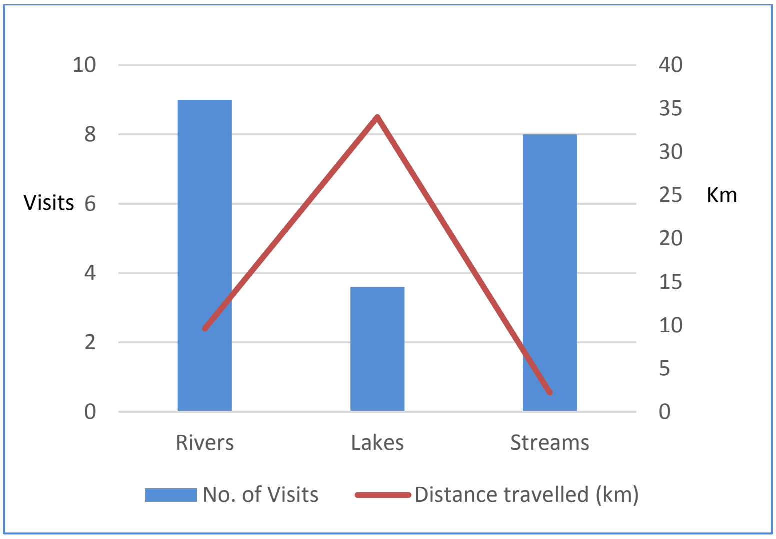

Figure 9. Average number of visits and distance traveled to rivers, lakes and streams in the last 12 months

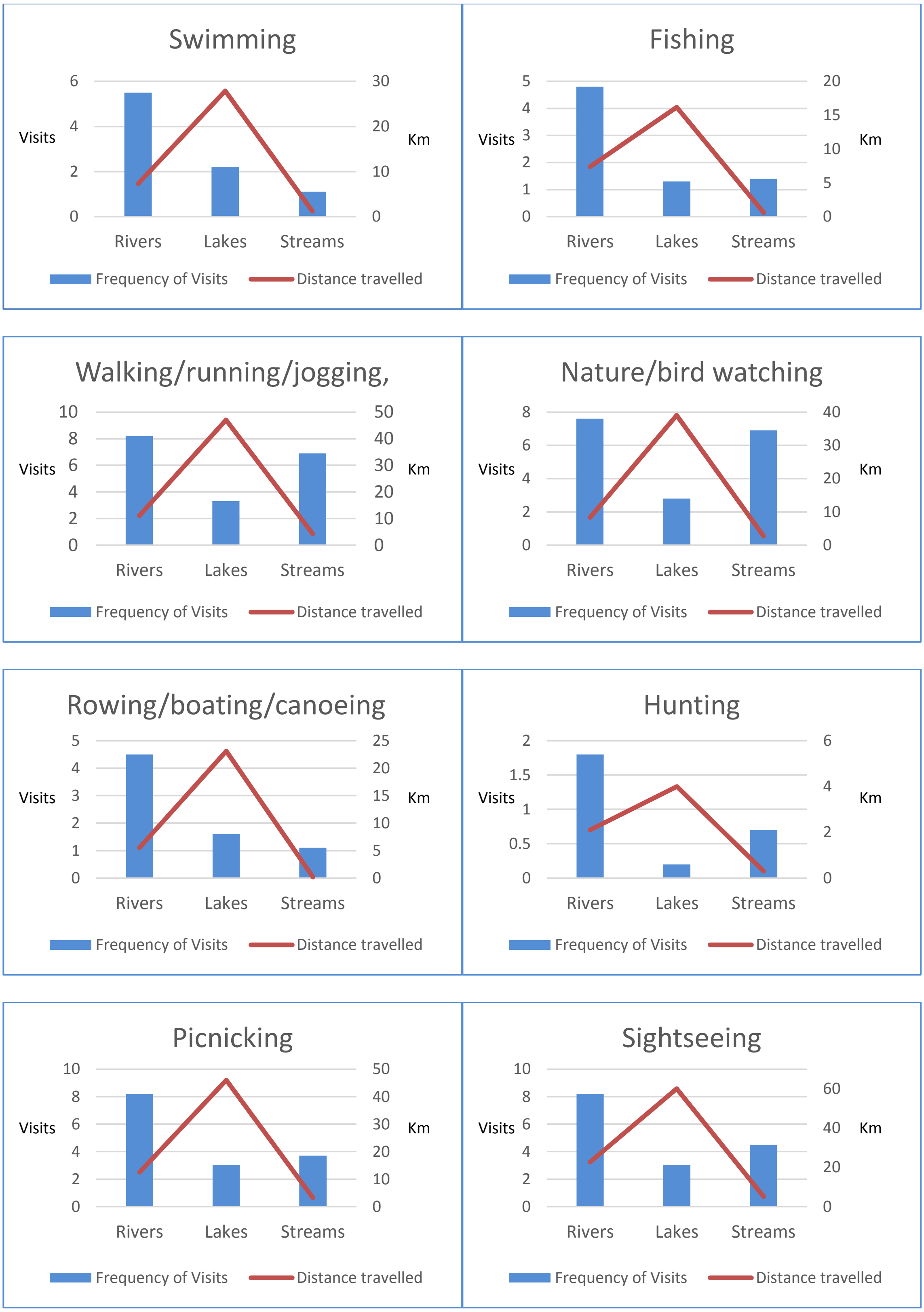

Figure 10. Average visits and distance travelled for recreation activities across rivers, lakes and streams in the last 12 months

Examining average trip frequency and distances travelled by recreational activity (Figure 10) shows that visitors most frequently go to rivers for picnicking, sightseeing and walking/jogging/running; to streams for nature/bird watching and walking/jogging/running; and to lakes for walking/jogging/running. Notably, the furthest distances travelled to each waterbody type were all for sightseeing activities. The closest distances traveled by visitors were to streams for rowing/boating/canoeing.

3.3 Choice Experiment Results

The parameter estimates presented in Table 3 are derived from a Generalised Mixed Logit (GMXL) specification (see Appendix A for technical details). This type of model exemplifies a contemporary approach with a relatively flexible form. Notably, the ability to allow parameter estimates to vary over respondents, rather than being held constant, reflects the degree of heterogeneity in preferences over freshwater attributes. This is an important modelling consideration as debate over the use of water resources shows many different points of view that need to be accommodated within modelling.

When making their choices, some respondents may select the ‘no waterway animal management’ option in a choice task as a truthful indication of their *unwillingness to pay* for improvements to New Zealand waterbodies. However, respondents who chose the no management option in every choice task may be exhibiting protest behavior, and therefore not truthfully revealing their preferences for water quality outcomes. Protest behaviour is relatively common in these types of surveys and is typically for reasons associated with the process of valuation such as the type of good being valued and who is being asked to pay for the good. Respondents who consistently chose this no cost option (21% of the sample) were asked a follow up question to ascertain their reasons for being averse to paying for water quality improvements (Figure 11).

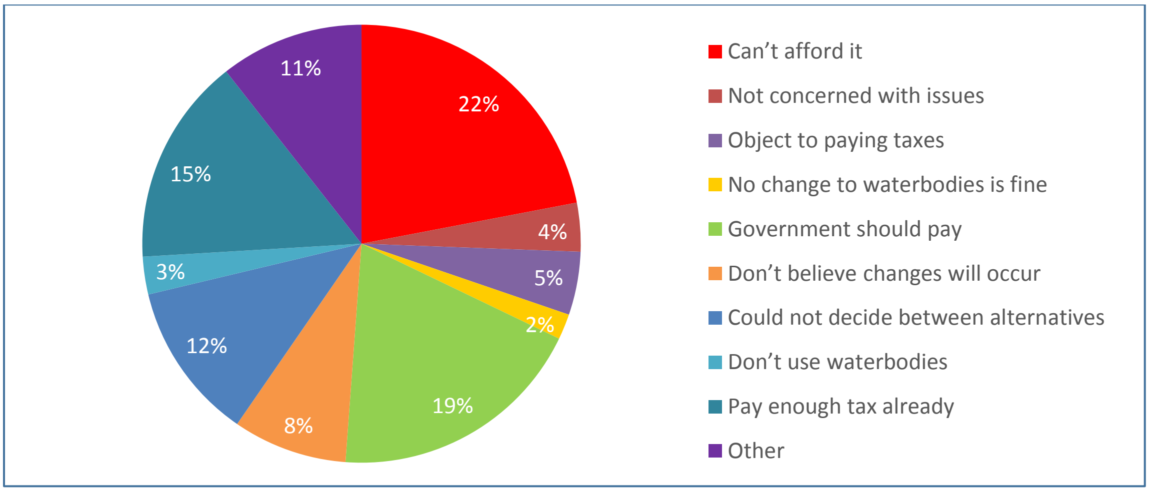

Figure 11. Reasons why respondents always chose the ‘no waterway animal management’ option in choice tasks

The majority of this group comprised protest responses (53%). These respondents considered that the government should pay (19%); they pay enough tax already (15%); do not believe changes will occur (8%), or they object to paying tax (11%). The next most common respondent said that they cannot afford to pay for improvements to waterbodies (22%). Some respondents consider that they do not get any benefits from improving water quality (21%). These respondents do not use waterbodies (3%); are not concerned with the issue (4%); think no change is waterbodies is fine (2%), or could not decide between alternatives (12%). Respondents who are viewed as protest responses are excluded from statistical modeling of preferences for water management outcomes.

By conventional econometric standards the model performs well (Table 3). All the water quality attributes are highly statistically significant, meaning that they are important factors in resident's choice of freshwater management option. The model predicts how respondents choose a particular management option based on the outcomes and costs associated with that option. The parameter estimates tell us how an attribute relates to the overall utility of residents from the benefits of freshwater stock exclusion management. The model generates a normal distribution of parameter estimates for each random parameter with the mean reported, and the standard deviation of the distribution. A larger magnitude of the standard deviation of the distribution indicates a relatively larger degree of preference differences across respondents for that water quality outcome. For example, respondents have the most similar preferences for increases in the proportion of waterways with the lowest human health risk (s.d. = 0.0136). This means that respondents typically responded in the same way where they were presented with an increase in the proportion of waterways with lowest human health risk. While preferences for improvements in water clarity are not as consistent across respondents as shown by larger standard deviations, meaning that some respondents prefer no improvements while others have strong preference for improvements. These weights (parameters) indicate that respondents are more likely to choose a management option that has higher levels of water quality outcomes, with changes in the proportion of waterways with good clarity having the largest influence, while they are less likely to choose options imposing greater financial contributions.

Modelling also shows that the total number of times respondents visit all types of waterways is a key influence on their preferences for water quality outcomes (heterogeneity in parameters). Some other main findings are:

- People prefer improvements in the highest quality categories for each water quality outcome over increases in lower quality categories.
- People prefer to have streams prioritised first, followed by lakes and then rivers.
- Improvements that are local to respondents are preferred over regional improvements, and regional improvements are preferred over those outside their region.
- People are more likely to choose a stock exclusion policy option if they perceive current overall water quality to be poor (Figure 2), or they think freshwater resources are important as habitat for plants and wildlife (Figure 3).
- Frequent visitors to streams, rivers or lakes have a higher WTP than those that are less frequent visitors.
- Those with higher income are WTP more than others.
- Older people have a higher WTP than younger people.
- People prefer to have stock exclusion management over its absence.

Table 3. Generalised Mixed Logit model results

	Parameter mean estimates[1]		Standard deviation of random parameters	
Random parameters in utility function				
Human Health: 1:20 risk	0.0096***	(0.004)	0.4088***	(0.021)
Human Health: 1:100 risk	0.0157***	(0.003)	0.2739***	(0.009)
Human Health: 1:1,000 risk	0.0451***	(0.003)	0.0136***	(0.001)
Ecological Quality: Moderate	0.0292***	(0.002)	0.2115***	(0.007)
Ecological Quality: Good	0.0774***	(0.002)	0.1982***	(0.005)
Water Clarity: Moderate	0.0563***	(0.003)	0.3948***	(0.013)
Water Clarity: Good	0.1001***	(0.002)	0.3317***	(0.011)
Annual Tax Contribution	-0.0165***	(0.001)	0.0176***	(0.001)
Nonrandom parameters in utility function				
No Stock Exclusion Management Option	-1.491***	(0.071)		
Streams Prioritised	0.3979***	(0.036)		
Rivers Prioritised	0.0271**	(0.016)		
Lakes Prioritised	0.1951***	(0.031)		
Local Area Prioritised	0.3499***	(0.046)		
Regional Area Prioritised	0.1222**	(0.054)		
Number of Visits to Streams x Tax	0.0061*	(0.003)		
Number of Visits to Rivers x Tax	0.0014**	(0.000)		
Number of Visits to Lakes x Tax	0.0025*	(0.001)		
Income x Tax	0.0012***	(0.000)		
Age x Tax	0.0005***	(0.000)		
Perception of Bad Water Quality x ASC	0.0066*	(0.002)		
Habitat is Very Important Use x ASC	1.0116***	(0.075)		
Variance parameter in scale	3.5746***	(0.071)		
Heterogeneity in scale factor				
Choice Task Difficulty	0.4191***	(0.005)		
Choice Task Understanding	0.2620***	(0.006)		
Model Fit Statistics				
Log Likelihood function	- 8,109			
Log Likelihood chi^2 stat (40 df)	2,933***			
McFadden Pseudo R^2	0.24			
Number of observations	10,825			

***, **,* denote statistical significance at the 1%, 5% and 10% levels respectively for the null hypothesis that a parameter estimate is not significantly different from zero.
Standard errors in brackets.
[1] Parameter mean estimates indicates the estimated average value in the model, for each different parameter.

The statistical model assumes that all the information that a respondent sees in a choice set has a role to play in determining the respondents' choice of option. If respondents ignore some of the water management outcomes when they select their preferred option, this assumption is weakened and requires further examination. Following each choice task, respondents were asked to indicate which, if any, of the water management outcomes being considered did they ignore (Figure 12). We can see that each outcome is ignored to a similar degree, at what can be considered to be a relatively low level. To determine whether incorporating this information improves statistical modelling we fit a stated attribute non-attendance model but find no qualitative improvement on the results presented in Table 3.

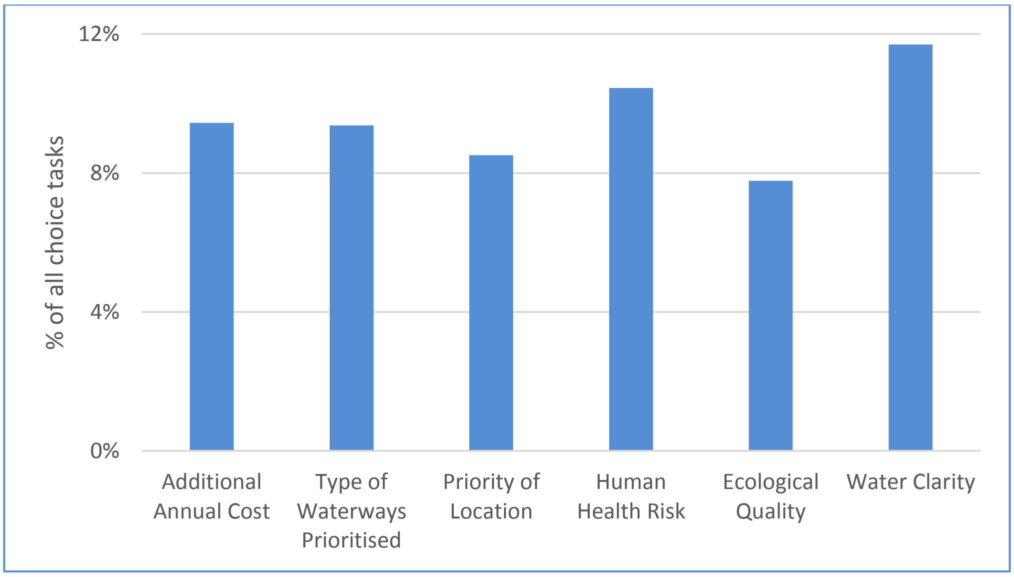

Figure 12. Freshwater management outcomes ignored by respondents in choice tasks

The GMXL model specified here also allows for modelling of unobserved influences on respondents choice variation. This is useful as sources of modelling heterogeneity may be coming from factors other than respondent preferences for the water quality outcomes presented to them. Following each choice task we ask a series of questions (Figure 13) to identify any sources of variance in the random component of utility. For example, respondents who find the choices difficult to make have higher variability in the way they make their choices compared to other respondents who do not find it difficult, that cannot be attributed to the levels of the management outcomes presented to them. We find that respondents who find the choice task relatively easy to answer or that understood the choice task exhibit lower choice error.

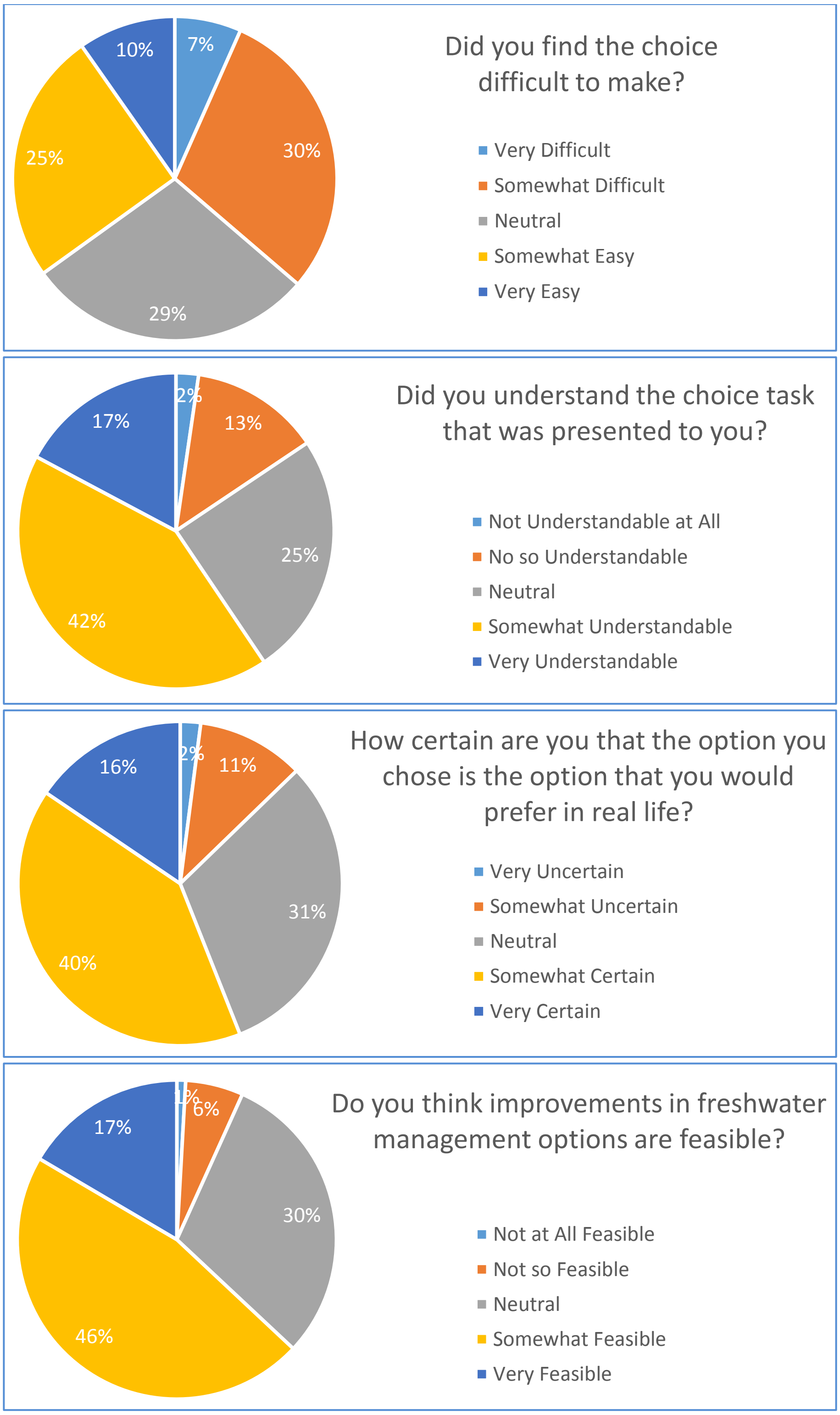

Figure 13. Freshwater management choice task debriefing questions: Difficulty, understanding, certainty, and feasibility.

3.4 Monetary Value of Benefits

Applying the model estimates (Table 3) and equation 1.1 (Appendix A) generates estimates of respondents Willingness to Pay (WTP) for water quality improvements. WTP is an estimate of how much money a respondent would be willing to give up for a change in the relevant water quality outcome, and is calculated using the ratio of an attribute parameter and the cost parameter. Table 4 presents respondent annual WTP for each percentage point increase in the proportion of waterbodies that achieve a particular water quality outcome. These estimates reveal that the highest marginal WTP is for good water clarity followed by good ecological quality.

Table 4. Willingness to pay for water quality outcomes

Water quality outcome	Willingness to pay for a percentage point increase in water quality outcomes
Human Health Risk 1:20	0.70 (0.22,1.28)
Human Health Risk 1:100	$1.15 (0.65,1.65)
Human Health Risk 1:1,000	$3.31 (2.79,3.83)
Moderate Ecological Quality	$2.14 (1.73,2.54)
Good Ecological Quality	$5.68 (5.41,5.93)
Moderate Clarity	$4.13 (3.64,4.62)
Good Clarity	$7.39 (6.93,7.86)

$NZ 2015 Median (5th percentile, 95th percentile)

The individual marginal WTP results found here are consistent with those of comparable choice experiment studies, finding significant public support for enhancement of freshwater environments. Miller et al. (2015) estimate that Canterbury residents are WTP about $0.60 per one per cent increase in the number of monitored sites suitable for swimming in the region. Their swimming quality classification concords with the 1:100 human health risk category used in this study. Our estimate of $1.15 is consistent with the results obtained by Miller et al. (2015); while being higher reflects the difference in scale between regional and national outcomes employed across studies.

Phillips (2014) provides another comparison with our estimates of WTP for the 1:1,000 human health risk category. The author estimates that Waikato residents are WTP about $2.00 per one per cent increase in the proportion of monitored sites with less than one infection per 1,000 swimmers. Again, our higher estimate of value reflects the larger scale of national versus regional outcomes, while remaining comparable. Our results are also consistent with Phillips (2014) finding that improvements in water clarity were valued higher compared to ecological quality or human health risk improvements.

Although these comparisons vary over research contexts and design elements, they do reveal that the WTP estimates found in this study are in the range of those found in comparable studies.

3.4.1 Policy Scenario Valuation

This section forms a central contribution of this report. Combining the estimates of public preferences for water quality outcomes (Table 3), with estimates of the biophysical changes resultant from stock exclusion (Semadeni-Davies and Elliot, 2016). This process provides monetary estimates of the effects of differing policy settings. Comparisons of these estimates to the costs associated with implementing policy, conducted in reporting elsewhere, will contribute to a Benefit-Cost Analysis helping to assess the feasibility of policy implementation.

The biophysical data employed are modeled total lengths (km) of rivers, streams and lakes for each human health risk category (Table 1). Lake outlet reach lengths in each category are used as a proxy for water quality within the lake waterbody. Outlet reaches are considered consistent with lake concentrations as they account for lake attenuation. The scenarios used to generate the biophysical data are described in Table 5.

We first compare *E.coli* outcomes under the current level of fencing (2015), to a forward looking status quo that extends current policy with the additional impact of planned or actual regional requirements as identified by LAWF (2015). The value of water quality improvements resultant when moving from current to LAWF (2015) levels is referred to as the ‘Status Quo’ scenario (Table 5 onward).

The next set of policy comparisons add on various LAWF Progressive (2015) improvements in a cumulative manner. These extend stock exclusion application from the status quo to include enactment to different relevant farming activities for Water Accord streams on plains or lowland hill country (less than 16 ° slope).

The highest level of policy application is indicated as the ‘All’ scenario. This scenario expands exclusion policy from the status quo level to all cattle and deer into hill country up to 28 ° slope.

Values are delineated by an assumption of the ability of fencing to prevent E.coli from reaching freshwater; either low, most likely, or high.

Table 5. Scenario descriptions

Policy scenarios – stock to be excluded		
1	Status Quo:	Current fencing, including regional requirements to be implemented by July 2017
2	Status Quo, PLUS:	Dairy cattle on dairy platforms by 2017
3	Scenario 2, PLUS:	Dairy cattle grazing on land owned by dairy farmers by 2020
4	Scenario 3, PLUS:	Dairy cattle grazing on land owned by a third party by 2025
5	Scenario 4, PLUS:	Beef cattle excluded by 2025 on flat land, and 2030 on rolling land (slopes less than 16 degrees)
6	Scenario 5, PLUS:	Deer excluded by 2025 on flat land, and 2030 on rolling land
7	ALL	Steep Hill Country Scenario: Exclude all cattle (dairy and beef) and deer into steep country (slopes up to 28 degrees) by 2017

We calculate the percentage point change in health risk category lengths between the baseline and all other scenarios. These percentage point changes are interacted with model estimates (Table 3) employed in equation 1.11 (Appendix A) to calculate monetary estimates of benefits of increases in the proportion of waterbodies with low human health risk for stock exclusion policy changes. We take into account spatial influences on values by assessing the degree of local and regional improvements specific to each Territorial Authority (TA) population. Improvements inside a TA are specified to be local to that population, and improvements outside a TA but within a region, to be regional to that TAs population. The individual WTP per person for each policy scenario is shown in Figure 14.

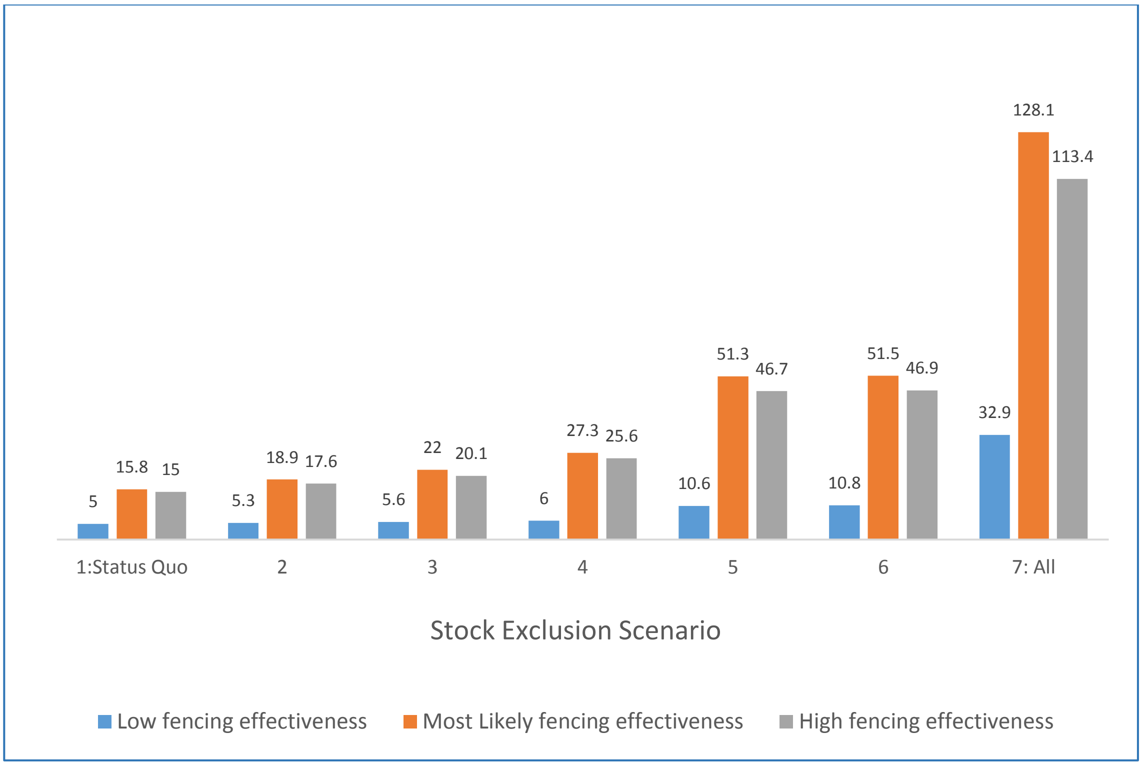

Figure 14. Average annual per person willingness to pay for policy scenarios

Estimates of individual welfare values are aggregated up to the population level using New Zealand Census 2013 estimate of the 18+ age population (3,197,916). We multiply this by the proportion of the survey sample who were willing to pay for water quality improvements (79%). Table 6 presents estimates of the value of water quality improvements for each scenario by rivers, streams and lakes. Table 7 gives the totals across waterbody types for each scenario, with Figure 15 depicting these results graphically. Table 8 and Figure 16 provide estimates of the present value of benefits over a 25 year horizon discounted at 8 per cent per annum[12].

[12] www.treasury.govt.nz/publications/guidance/planning/costbenefitanalysis/guide

Table 6. Annual benefits for each policy scenario by waterbody type

Policy scenarios – stock to be excluded				$Million 2015 Low[13]	$Million 2015 Most Likely	$Million 2015 High
1	Status Quo:	Current fencing, including regional requirements to be implemented by July 2017	Streams	6.8	27	23.8
			Rivers	2.4	14.5	10.4
			Lakes	13.9	33.4	38.4
2	Status Quo, PLUS:	Dairy cattle on dairy platforms by 2017	Streams	7	29.2	26
			Rivers	2.8	15.9	11.7
			Lakes	13.9	35.5	41.8
3	Scenario 2, PLUS:	Dairy cattle grazing on land owned by dairy farmers by 2020	Streams	7.1	31.6	27.9
			Rivers	3.2	17.3	12.9
			Lakes	13.9	37.6	45.2
4	Scenario 3, PLUS:	Dairy cattle grazing on land owned by a third party by 2025	Streams	7.6	35.7	32.4
			Rivers	3.7	20.9	16.1
			Lakes	13.9	40.7	50.7
5	Scenario 4, PLUS:	Beef cattle excluded by 2025 on flat land, and 2030 on rolling land (slopes less than 16 degrees)	Streams	11.9	57.6	52.6
			Rivers	7.9	42	34.4
			Lakes	17	59.8	68.2
6	Scenario 5, PLUS:	Deer excluded by 2025 on flat land, and 2030 on rolling land	Streams	12.1	58.1	53
			Rivers	7.9	42.3	34.5
			Lakes	17	59.8	68.2
7	ALL	Steep Hill Country Scenario: Exclude all cattle (dairy and beef) and deer into steep country (slopes up to 28 degrees) by 2017	Streams	40	154.1	140.7
			Rivers	13.6	68.6	52.9
			Lakes	38.4	144.5	142

[13] Low, Most Likely and High are assumptions of the different effectiveness of fencing in reducing the *E.coli* load to waterways.

Table 7. Annual total benefits, per policy scenario

Policy scenarios – stock to be excluded			$Million NZ 2015		
			Low	Most Likely	High
1	Status Quo:	Current fencing, including regional requirements to be implemented by July 2017	23.1	74.9	72.6
2	Status Quo, PLUS:	Dairy cattle on dairy platforms by 2017	23.6	80.6	79.5
3	Scenario 2, PLUS:	Dairy cattle grazing on land owned by dairy farmers by 2020	24.4	86.5	86.1
4	Scenario 3, PLUS:	Dairy cattle grazing on land owned by a third party by 2025	25.2	97.3	99.2
5	Scenario 4, PLUS:	Beef cattle excluded by 2025 on flat land, and 2030 on rolling land (slopes less than 16 degrees)	36.8	159.4	155.1
6	Scenario 5, PLUS:	Deer excluded by 2025 on flat land, and 2030 on rolling land	37	160.2	155.6
7	ALL	Steep Hill Country Scenario: Exclude all cattle (dairy and beef) and deer into steep country (slopes up to 28 degrees) by 2017	92.2	367.2	335.6

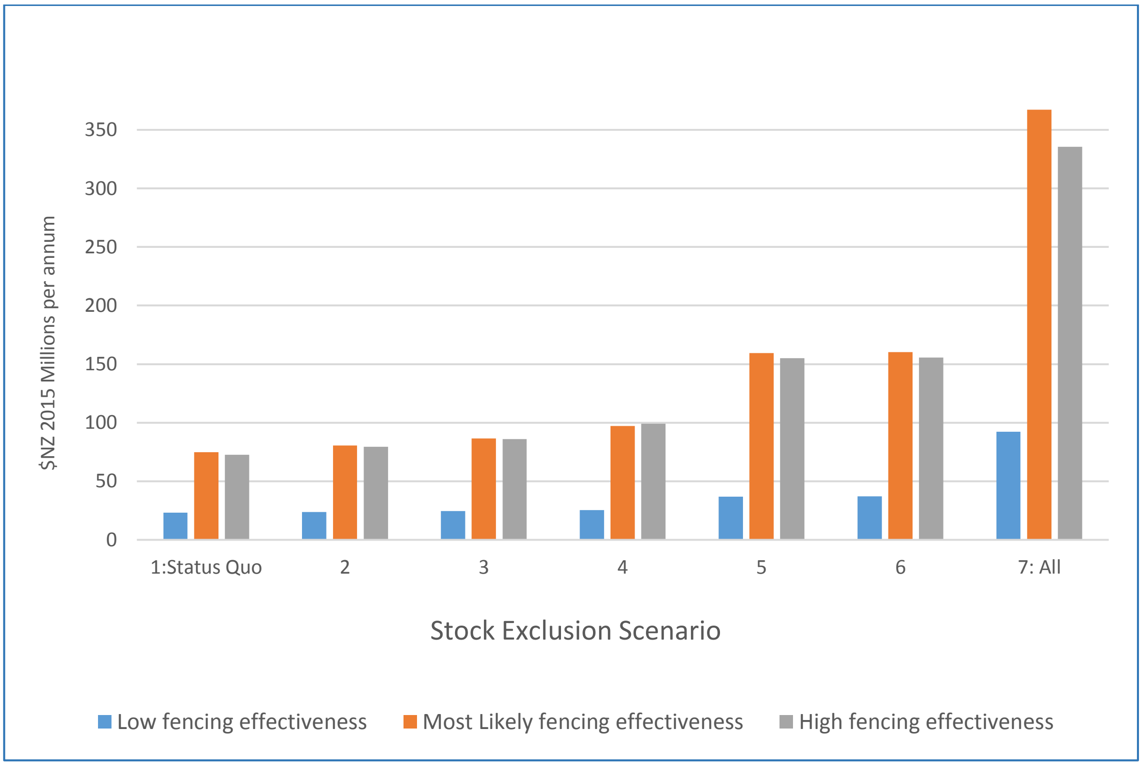

Figure 15. Comparison of annual benefits for policy scenarios

Table 8. Present values of policy scenarios over a 25 year horizon

Policy scenarios – stock to be excluded			$Million NZ 2015 8% Discount Rate Low	 Most Likely	 High
1	Status Quo:	Current fencing, including regional requirements to be implemented by July 2017	265	863.6	837.1
2	Status Quo, PLUS:	Dairy cattle on dairy platforms by 2017	272.6	928.9	916.7
3	Scenario 2, PLUS:	Dairy cattle grazing on land owned by dairy farmers by 2020	279.5	996.9	992.8
4	Scenario 3, PLUS:	Dairy cattle grazing on land owned by a third party by 2025	290.3	1,121.4	1,143.7
5	Scenario 4, PLUS:	Beef cattle excluded by 2025 on flat land, and 2030 on rolling land (slopes less than 16 degrees)	424.8	1,837.5	1,787.9
6	Scenario 5, PLUS:	Deer excluded by 2025 on flat land, and 2030 on rolling land	426.6	1,847	1,793.9
7	ALL	Steep Hill Country Scenario: Exclude all cattle (dairy and beef) and deer into steep country (slopes up to 28 degrees) by 2017	1,062.8	4,233.4	3,868.6

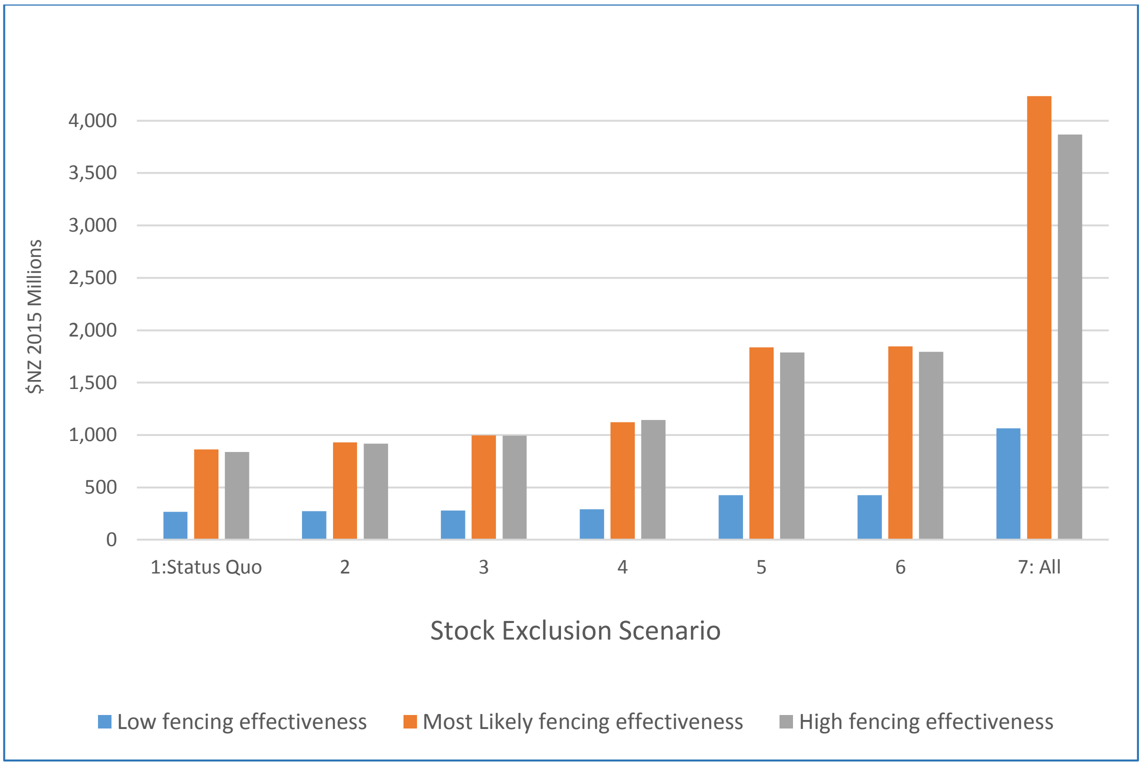

Figure 16. Comparison of 25year present value of policy scenarios

4 Conclusions

While the direct costs associated with stock exclusion policy are observable in market transactions, such as the costs of fencing, many of the benefits do not have associated market signals with which to measure the value of water quality improvements. This report applied the economic non-market valuation approach of choice experiments, to estimate the value that New Zealand residents place on reductions in human health risk, resultant from stock exclusion policy scenarios. The WTP results found here are consistent with those of comparable choice experiment studies, finding significant public support for enhancement of freshwater environments. Central conclusions include:

- The survey process achieved a sample of 2,032 respondents demographically representative of the NZ population.
- The highest level of perceived quality was for lakes, 52% of respondents believe lake environments to be of a satisfactory or very satisfactory quality.
- Lowest level of perceived water quality was for streams, 39% believe stream environments to be of unsatisfactory or very unsatisfactory quality.
- Reasonably equal consideration was given to the importance of freshwater resources being utilised either directly in recreation or commercial activities, or indirectly in providing environmental outcomes and future opportunities.
- Respondents have significant engagement with freshwater resources: 78% of respondents visited a river, 64% a lake and 56% a stream at least once in the previous twelve months.
- Average visitor frequency was highest for rivers (9 visits) and lowest for lakes (4 visits); streams (8 visits).
- Visitors travelled on average the furthest to lakes (34km) and the least distance to streams (2km); rivers (10km).
- Visitors engaged predominantly in activities not directly in water contact such as walking, running or jogging, picnicking and hunting (83%); rather than those activities directly in contact such as swimming, fishing or boating (53%).
- Respondents overall have a strong preference for implementing stock exclusion management over its absence.
- Respondents are willing to pay the most for improvements in water clarity, followed by ecological quality.
- Improvements in the highest quality categories for each water quality outcome are preferred to increases in lower quality categories.
- Respondents prefer to have streams prioritised first, followed by lakes and then rivers.
- Improvements that are local to respondents are preferred over regional improvements, and regional improvements are preferred over those outside their region.
- Status Quo Scenario policy settings of planned or actual regional requirements as identified by LAWF (2015) generate $74.9 million of annual benefits to the NZ public; $863.6 million over 25 years.
- Value of LAWF Progressive (2015) scenarios do not substantially increase above those under LAWF (2015) until policy is extended to exclude Beef cattle on flat and rolling land (slopes less than 16 degrees); adding a further $84.5 million benefits annually, $974 million over 25 years (assuming Most Likely efficacy of fencing to reduce *E.coli* loads).
- The most expansive policy settings considered here drove benefits to increase by $292.3 million per annum over current status quo policy settings; $3.37billion over 25 years.

There has been some criticism of using choice experiments to form monetary estimates of people's preferences on the basis that it uses stated preferences rather than market observations. The contention is that this approach can introduce hypothetical bias, whereby respondents may overstate their true willingness to pay. Tests of external validity that can assess the legitimacy of these concerns are difficult to form and only possible where concordant market data are available. While observed market data is unlikely to ever be available regarding water quality, in contexts such as food product choices, external validity has been tested by comparing results with market data. These studies suggest that CE does not bias values compared to market data. Examples include findings that: CE and scanner data for milk choices are equally good predictors of consumer choice (Brooks and Lusk, 2010); food values are significantly related to actual grocery store purchases (Lusk, 2011); estimated premiums are reasonable when comparing existing market prices(Mørkbak and Nordström, 2009). In other contexts CEs have been shown to accurately predict consumer behaviour over transport mode (Beaton et al., 2007), health care product choices (Mark and Swait, 2004) and recreation site choice (Haener et al., 2001).

5 References

Beaton P. Chen C. Meghdir H. 2007. Stated choice for transportation demand management models: Using a disaggregate truth set to study predictive validity. Transportation Research Record 1598.

Brooks K. Lusk JL. 2010. Stated and revealed preferences for organic and cloned milk: Combining choice experiment and scanner data. American Journal of Agricultural Economics, 92, pp. 1229-1241.

Cicia G. Cembalo L. Del Giudice T. Scarpa R. 2013. Country-of-origin effects on Russian wine consumers. Journal of Food Products Marketing, 19(4):247-260.

Czajkowski M. Bartczak A. Giergiczny M. Navrud S. Żylicz T. 2014. Providing preference-based support for forest ecosystem service management. Forest Policy and Economics, 39:1-12.

Daly A. Hess S. Train K. 2012. Assuring finite moments for willingness to pay in random coefficient models. Transportation, 39(1):19-31.

Fiebig DG. Keane MP. Louviere J. Wasi N. 2010. The generalized multinomial logit model: Accounting for scale and coefficient heterogeneity. Marketing Science, 29(3):393-421.

Hanemann WM. 1984. Welfare Evaluations in Contingent Valuation Experiments with Discrete Responses. American Journal of Agricultural Economics, 66(3):332-341.

Hanley N. Shogren JF. White B. 2013. Introduction to environmental economics. Oxford: Oxford University Press.

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

Hensher DA. Rose JM. Greene WH. 2015. *Applied choice analysis* (2nd Ed.). Cambridge University Press: UK.

Juutinen A. Svento R. Mitani Y. Mäntymaa E. Shojie Y. Siikamäki P. 2012. Modeling observed and unobserved heterogeneity in choice experiments. Environmental Economics, 3(2):57-65.

Kragt ME. 2013. The effects of chancing cost vectors in choices and scale heterogeneity. Environmental and Resource Economics, 54(2):201-221.

Lancaster KJ. 1966. A new approach to consumer theory. The Journal of Political Economy, 74(2):132-157.

Lancsar E. Savage E. 2004. Deriving welfare measures from discrete choice experiments: Inconsistency between current methods and random utility and welfare theory. Health Economics, 13(9):901-907.

Louviere JJ. Eagle TC. 2006. Confound it! That pesky little scale constant messes up our convenient assumptions. Proceedings of the Sawtooth Software Conference: 211-228.

Lusk JL. 2011. External validity of the food values scale. Food Quality and Preference, 22, pp. 452-462.

Mark T. Swait J. 2004. Using stated preference and revealed preference modeling to evaluate prescribing decisions. Health Economics 13:563-573.

McFadden D. 1974. Conditional logit analysis of qualitative choice behavior. In P. Zarembka (Ed.), *Frontiers of econometrics* (pp. 105-142). New York: Academic Press.

Miller S. Tait P. Saunders C. 2015. Estimating indigenous cultural values of freshwater: A choice experiment approach to Māori values in New Zealand. Ecological Economics, 118:207-214. http://dx.doi.org/10.1016/j.ecolecon.2015.07.031.

Mørkbak, M. R. and J. Nordstrom. 2009. The impact of information on consumer preferences for different animal food production methods. Journal of Consumer Policy, 32, pp. 313-331.

Phillips Y. 2014. Non-market values for fresh water in the Waikato region: a combined revealed and stated preference approach. Waikato Regional Council Technical Report number 2014/17. Waikato Regional Council, Hamilton, New Zealand.

Revelt D. Train K. 1998. Mixed logit with repeated choices: Households' choices of appliance efficiency level. The Review of Economics and Statistics, 80(4):647-657.

Scarpa R. Ferrini S. Willis K. 2005. Performance of error component models for status quo effects in choice experiments. In: Scarpa, R. and Alberini, A. (Eds.), Applications of Simulation Methods in Environmental and Resource Economics, 6th ed. Springer Netherlands, Dordrecht, pp. 247–273.

Semandeni-Davis A. Elliot S. 2016. Modelling the effect of stock exclusion on *E.coli* in rivers and streams: National application. Prepared for the New Zealand Ministry of Primary Industries by the National Institute of Water and Atmospheric Research Limited, Auckland, New Zealand.

Thurstone LL. 1927. A law of comparative judgement. Psychological Review, 34(4):273-286.

Train KE. 2009. Discrete choice methods with simulation 2nd Edition. Cambridge, UK: Cambridge University press.

Appendix A: Statistical Method

This appendix provides technical details of statistical analysis of choice data. The appendix includes a brief description of the theoretical foundations of choice analysis followed by statistical probability estimation approaches, focusing on contemporary models applied in this report. Lastly, the method used in generating monetary estimates is described.

A.1 Conceptual Framework

In Choice Experiments (CEs), researchers are interested of what influences, on average, the survey respondents' decisions to choose one alternative over others. These influences are driven by people's preferences towards the attributes but also the individual circumstances such as their demographics or perceptions of the choice task (e.g., the level of difficulty or understanding) (Hensher et al. 2015).

Each alternative in a choice set is described by attributes that differ in their levels, both across the alternatives and across the choice sets. The levels can be measured either qualitatively (e.g., poor and good) or quantitatively (e.g., kilometres). This concept is based on the characteristics theory of value (Lancaster 1966) stating that these attributes, when combined, provide people a level of utility[14] *U* hence providing a starting point for measuring preferences in CE (Hanley et al. 2013; Hensher et al. 2015). The alternative chosen, by assumption, is the one that maximises people's utility[15] providing the behavioural rule underlying choice analysis:

$$U_j > U_i \tag{1.1}$$

where the individual *n* chooses the alternative *j* if this provides higher utility than alternative *i*. A cornerstone of this framework is Random Utility Theory, dated back to early research on choice making (e.g., Thurstone 1927) and related probability estimation. This theory postulates that utility can be decomposed into systematic (explainable or observed) utility *V* and a stochastic (unobserved) utility ε (Hensher et al. 2015; Lancsar and Savage 2004).

$$U_{nj} = V_{nj} + \varepsilon_{nj} \tag{1.2}$$

where *j* belongs to a set of J alternatives. The importance of this decomposition is the concept of utility only partly being observable to the researcher, and remaining unobserved sources of utility can be treated as random (Hensher et al. 2015). The

[14]Related terminology used in psychology discipline is *the level of satisfaction* (Hensher et al. 2015).
[15]In choice analysis, utility is considered as *ordinal utility* where the relative values of utility are measured (Hensher et al. 2015).

observed component includes information of the attributes as a linear function of them and their preference weights (coefficient estimates).

$$V_{nsj} = \sum_{k=1}^{K} \beta_k x_{nsjk} \quad (1.3)$$

with *k* attributes in vector x for a choice set s. Essentially, the estimated parameter β shows "the effect on utility of a change in the level of each attribute" (Hanley et al. 2013, p. 65). This change can be specified as linear across the attribute levels, or as non-linear using either dummy coding or effect coding approaches. The latter coding approach has a benefit of not confounding with an alternative specific constant (ASC) when included in the model (Hensher et al. 2015).

A.2 Statistical Modelling of Choice Probabilities

The statistical analysis aims to explain as much as possible of the observed utility using the data obtained from the CE and other relevant survey data. In order to do so, the behavioural rule (eq. 1.1) and the utility function (eq. 1.2) are combined (Hensher et al. 2015; Lancsar and Savage 2004) to estimate the probability of selecting an alternative *j*:

$$\Pr_{nsj} = \Pr\left(U_{nsj} > U_{nsi}\right) = \Pr\left(V_{nsj} + \varepsilon_{nsj} > V_{nsi} + \varepsilon_{nsi}\right) = \Pr\left(\varepsilon_{nsi} - \varepsilon_{nsj} < V_{nsj} - V_{nsi}\right) \forall j \neq i \quad (1.4)$$

where the probability of selecting alternative *j* states that differences in the random part of utility are smaller than differences in the observed part. A standard approach to estimate this probability is a conditional logit, or multinomial logit (MNL) model (McFadden 1974). This model can be derived from the above equations (1.2 and 1.3) by assuming that the unobserved component is independently and identically distributed (IID) following the Extreme Value type 1 distribution (see e.g. Hensher et al. 2015; Train, 2003). Although the MNL model provides a "workhorse" approach in CE, it includes a range of major limitations (see e.g. Fiebig et al. 2010; Greene and Hensher 2007; Hensher et al. 2015):

- Restrictive assumption of the IID error components
- Systematic, or homogenous, preferences allowing no heterogeneity across the sample
- Restrictive substitution patterns, namely the existence of independence of irrelevant alternatives property where introduction (or reduction) of a new alternative would not impact on the relativity of the other alternatives
- The fixed scale parameter obscures potential source of variation

Some or all of these assumptions are often not realised in collected data. These restrictive limitations can be relaxed in contemporary choice models. In particular, the random parameter logit (RPL) model (aka, the mixed logit model) has emerged in empirical application allowing preference estimates to vary across respondents (Fiebig, et al. 2010; Hensher et al. 2015; Revelt and Train, 1998). This is done by specifying a known distribution of variation to be parameter means. The RPL model probability of choosing alternative *j* can be written as:

$$\Pr_{nsj} = \frac{\exp(\beta_n^{'} x_{nsj})}{\sum_J \exp(\beta_n^{'} x_{nsj})} \tag{1.5}$$

where, in the basic specification, $\beta_n = \beta + \eta_n$ with *η* being a specific variation around the mean for *k* attributes in vector *x* (Fiebig, et al. 2010; Hensher et al. 2015). Typical distributional assumptions for the random parameters include normal, triangular and lognormal distributions, amongst others. The normal distribution captures both positive and negative preferences (i.e., *utility* and *disutility*) (Revelt and Train, 1998). The lognormal function can be used in cases where the researcher wants to ensure the parameter has a certain sign (positive or negative), a disadvantage is the resultant long tail of estimate distributions (Hensher et al. 2015). The triangular distribution provides an alternative functional form, where the spread can be constrained (i.e., the mean parameter is free whereas spread is fixed equal to mean) to ensure behaviourally plausible signs in estimation (Hensher et al. 2015). Further specifications used in modelling include parameters associated with individual specific characteristics (e.g, income) that can influence the heterogeneity around the mean, or allowing correlation across the random parameters. The heterogeneity in mean, for example, captures whether individual specific characteristics influence the location of an observation on the random distribution (Hensher et al. 2015). In this study, the frequency of visits to rivers, streams and lakes was used to explain such variance.

Another way to write this probability function (in eq. 1.4) (Hensher et al. 2015) involves an integral of the estimated likelihood over the population:

$$L_{njs} = \int_{\beta} \Pr_{nsj}(\beta) f(\beta|\theta) d\beta \tag{1.6}$$

In this specification, the parameter θ is now the probability density function conditional to the distributional assumption of β. As this integral has no closed form solution, the approximation of the probabilities requires a simulation process (Hensher et al. 2015; Train, 2003). In this process for data *X*, *R* number of draws are taken from the random distributions (i.e. the assumption made by the researcher) followed by averaging probabilities from these draws; furthermore these simulated draws are used to compute the expected likelihood functions:

$$L_{nsj} = E(\Pr_{nsj}) \approx \frac{1}{R}\sum_{R} f(\beta^{(r)} | X) \quad (1.7)$$

where the $E(\Pr_{nsj})$ is maximised through Maximum Likelihood Estimation. This specification (in eq. 1.6) can be found in Hensher et al. (2015). In practice, a popular simulation method is the Halton sequence which is considered a systematic method to draw parameters from distributions compared to for example, pseudo-random type approaches (Hensher et al. 2015).

A.3 Econometric Extensions

Common variations of the RPL model include specification of an additional error component (EC) in the unobserved part of the model. This EC extension captures the unobserved variance that is alternative-specific (Greene and Hensher 2007) hence relating to substitution patterns between the alternatives (Hensher et al. 2015). Empirically, one way to explain significant EC in a model is SQ-bias depicted in the stochastic part of utility if the EC is defined to capture correlation between the non-SQ alternatives (Scarpa et al., 2005).

Another extension which has gained increasing attention in recent CE literature, is the Generalized Mixed Logit (GMXL) model (Czajkowski et al. 2014; Hensher et al. 2015; Juutinen et al. 2012; Kragt 2013; Phillips 2014). This model aims to capture remaining unobserved components in utility as a source of choice variability by allowing estimation of the scale heterogeneity alongside the preference heterogeneity (Fiebig et al. 2010; Hensher et al. 2015). This scale parameter is (inversely) related to the error variance, and in convenient applications such as MNL or RPL, this is normalised to one to allow identification (Fiebig et al. 2010; Louviere and Eagle 2006). However, it is possible that the level of error variance differs between or within individuals, due to reasons such as behavioural outcomes, individual characteristics or contextual factors (Louviere and Eagle 2006).

Recent GMXL application builds on model specifications presented in Fiebig et al. (2010), stating that β_n (in eq. 1.4) becomes:

$$\beta_n = \sigma_n\beta + \gamma\eta_n + (1-\gamma)\sigma_n\eta_n \quad (1.8)$$

where σ is the scale factor (typically = 1) and $\gamma \in \{0,1\}$ is a weighting parameter indicating variance in the residual component. In the case the scale factor equals 1, this reduces to the RPL model. The importance of the weighting parameter is the impact on the scaling effect on the overall utility function (population means) versus the individual preference weights (individual means): when γ parameter approaches zero the scale heterogeneity affects both means, whereas when this approaches one the scale heterogeneity affects only the population means (Hensher et al. 2015; Juutinen et al. 2015). Interpretation of these parameters includes

- If γ is close to zero, and statistically significant, this supports the model specification with the variance of residual taste heterogeneity increases with scale (Juutinen et al. 2012); and
- If γ is not statistically significant from one, this suggests that the unobserved residual taste heterogeneity is independent of the scale effect, that is the individual-level parameter estimates differ in means but not variances around the mean (Kragt, 2013)

The scale factor specification (eq. 1.7) can also be extended to respondent specific characteristics associated with the unobserved scale heterogeneity (Hensher et al. 2015; Juutinen et al. 2015):

$$\sigma_n = \exp\{\bar{\sigma} + \tau\omega_n\} \quad (1.9)$$

where $\bar{\sigma}$ *is* the mean parameter in the error variance; and ω is unobserved scale heterogeneity (normally distributed) captured with coefficient τ (Hensher et al. 2015; Juutinen et al. 2015; Kragt, 2013). Juutinen et al. (2012), for example, in context of natural park management found that respondents' education level and the time spent in the park explained the scale heterogeneity ($\tau > 0$, p-value < 0.01). In this study, the respondents indicated levels of choice task understanding and difficulty were used to explain scale heterogeneity.

A.4 Estimation of Monetary Values

Typically the final step of interest in the CE application is the estimation of monetary values of respondent preferences for the attributes considered in utility functions. These are commonly referred to as marginal willingness-to-pay (WTP). WTP estimation is based on the marginal rate of substitution expressed in dollar terms providing a trade-off between some attribute k and the cost involved (Hensher et al. 2015) and is calculated using the ratio of an attribute parameter and the cost parameter. WTP can take into account interaction effects, if statistically significant, such as with the respondent demographics. WTP of attribute *j* by respondent *i* is calculated as the ratio of the estimated model parameters accommodating the influence of the random component (Cicia et al. 2013) as:

$$WTP_i^j = -\left(\frac{\beta_j + \varepsilon_{ij}}{\beta_{price} + \varepsilon_{ip}}\right) \quad (1.10)$$

The estimated mode parameters can also be used to estimate compensating surplus (CS) as a result of policy or quality change in a combination of attributes, using (Hanemann, 1984):

$$\mathbf{CS} = \frac{-1}{\beta cost}\left[\ln\sum_{j=1}^{J}\exp\left\{V_j^0\right\} - \ln\sum_{j=1}^{J}\exp\left\{V_j^1\right\}\right] \quad (1.11)$$

which calculates the difference in utilities before the policy or quality change (V_0) and after the policy or quality change (V_1) (Hanley et al. 2013; Lancsar and Savage 2004). Similar to WTP, the monetary estimation of this change is possible by using the estimate for the monetary attribute $\beta_{cost.}$. Lastly, there are some challenges associated with the empirical estimation of the WTP in the RPL based models. One approach is to use a fixed cost, which simplifies the WTP estimation (Daly et al. 2012) but which may not be as behaviourally a plausible consideration as allowing heterogeneous preferences towards the cost attribute (Bliemer and Rose, 2013; Daziano and Achtnicht, 2014). Conceptually, the estimated cost parameter is a proxy for the marginal utility of income for respondents and economic theory suggests individuals will respondent differently to varying income levels. The use of a random cost parameter however, presents complications in deriving population distribution moments from the ratio of two random parameters.

AERU

Agribusiness
and Economics
Research Unit

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