Valuation of Water Quality Improvements in the Karapiro Catchment: A Choice Modelling Approach

Dan Marsh

And

Ramesh Baskaran

A Contributed Paper to the Australian Agricultural & Resource Economics Society's Annual Conference, Cairns, February 11-13, 2009.

Valuation of Water Quality Improvements in the Karapiro Catchment: A Choice Modelling Approach

Dan Marsh[1] and Ramesh Baskaran[2]

[1]Department of Economics, University of Waikato,
Private Bag 3105, Hamilton, New Zealand,
dmarsh@waikato.ac.nz,

[2]Lincoln University
New Zealand
Ramesh.Baskaran@lincoln.ac.nz

Abstract

Water pollution is widely considered to be one of the most important environmental issues facing New Zealand. Waikato region residents have reported that water pollution is easily their most important environmental concern in each of four attitude surveys conducted by Environment Waikato. Technical and regulatory mechanisms to reduce water pollution, especially non-point source pollution from agriculture are the focus of an intensive research effort both in New Zealand and internationally. This work should assist farmers and policy makers to identify the most cost effective options for achieving any given improvement in water quality.

Research described in this paper aims to complement existing research projects by developing appropriate methodology for valuation of water quality improvements in New Zealand. It is envisaged that this type of information will inform the policy process by allowing decision makers to consider both the costs and the benefits of different levels of water quality improvements. This paper describes the first phase focussed on the Karapiro catchment which used focus groups and choice modelling in order to understand and quantify the value of water quality improvements in the catchment.

Keywords: Water Quality, Non Market Valuation, Choice Modelling

Acknowledgements

This research was carried out under FRST Programme C10X0603: Delivering tools for improved environmental performance funded by The Foundation for Research Science and Technology (FRST) and the Pastoral 21 partners Dairy New Zealand, Meat and Wool New Zealand and Fonterra.

1. Introduction

Agricultural nutrient losses are a major contributor to water pollution throughout the world. While many European countries have already implemented regulatory measures, New Zealand has so far taken a voluntary approach through an accord with industry and the main farming organisation. However, water quality in New Zealand is generally falling in parallel with a steady increase in farming intensity especially in dairying. Water pollution is now considered to be one of the most important environmental issues facing New Zealand and technical and regulatory mechanisms to reduce non-point source pollution from agriculture are the focus of an intensive research effort.

New Zealand farmers have achieved major increases in productivity over the last twenty-five years, indeed the primary sector grew faster than the national economy over the period 1978-2005 (Harrington, 2005), while the Ministry of Agriculture and Forestry reports that multi-factor productivity in agriculture has grown at a rate of 1.8 percent over the last 10 years (Ministry of Agriculture and Forestry, 2008). But growth and increasing productivity has come at a price. For example, in the dairy sector over the period 1994-2002 average production of milk solids per hectare increased by 34%. This was achieved in part, by an increase in the average number of cows per hectare and a 162% increase in use of urea fertiliser per hectare[1] (Parliamentary Commissioner for the Environment, 2004), leading to serious concern about the impact of agricultural intensification on the quality of the environment and the sustainability of farming. It is within this context that a number of initiatives have been undertaken to address the environmental sustainability of farming in New Zealand.

The research described in this paper is part of FRST[2] programme C10X0603 'delivering tools for improved environmental performance' that aims to develop tools, technologies and systems that allow the pastoral industry to monitor, measure, value and mitigate the impacts of on-farm practices on the environment. It contributes to the programme component that aims "to provide quantitative approaches to farmers and policy agents to aid their decision making around farm practice and policy development, to achieve environmental outcomes with the detailed knowledge of the impacts of these decisions on the pastoral industry, the environment and the wider community"(AgResearch et al, 2006).

This paper aims to describe and quantify people's willingness to pay for water quality improvements in the in the Karapiro catchment and to contribute to the development of methodologies for valuation of water quality improvements in New Zealand. These estimates should inform the policy process by allowing decision makers to consider both the costs and the benefits of different levels of water quality improvement so allowing farmers and policy makers to identify the most cost effective option for achieving any given improvement in water quality.

There is a large international literature attempting to value the costs caused by the loss in water quality resulting from agricultural pollution. For example Pretty et al.

[1] Increase in fertiliser per hectare is for the period 1996-2002.
[2] Foundation for Research Science and Technology

(2003) estimate the damage cost of freshwater eutrophication in England and Wales to be \$105-\$160 million per year, while Viscusi, et al. (2008) provide estimates for increasing the percentage of lakes and rivers in US regions with water quality rated as "good". New Zealand research in this field is more limited but may be dated back to work by Rod Forbes (1984) on the costs and benefits of reducing eutrophication in Lake Tutira (in northern Hawke's Bay), analysis of water pollution control in the Waikato Basin (Harris, 1983) and of the Lake Taupo Catchment Control Scheme and the Upper Taieri River Channel Scheme by Rod Forbes and WJ Orsman.[3]

More recently choice modelling has been used to estimate that value that residents attached to the condition of streams in the Auckland region. This work was commissioned by the regional council to estimate the value of mitigation that might be required when developments would adversely affect the quality of particular streams (Kerr & Sharp, 2003). Similarly, Kerr and Swaffield (2007) used the same technique to investigate the amenity value of spring fed streams and rivers in the Canterbury region. A useful supplement to this approach is provided by (Rowe *et al.*, 2006) which describes Stream Ecological Valuation (SEV); a method for scoring the ecological performance of Auckland streams and for quantifying mitigation. A somewhat different approach was taken by Bell and Yap (2004) in their evaluation of the "less tangible values of the Rotorua Lakes". They found that algal blooms affected the use of the lakes for more than half of the respondents resulting in fewer days spent for recreational activities and an economic impact on Rotorua. They estimated foregone revenues from Auckland anglers to be around \$0.8 million a year while Rotorua's willingness to pay for quality improvements was estimated to be \$91.24 per household per year. Sharp and Kerr (2005) discuss option and existence values for the Waitaki catchment as part of a national cost benefit analysis of proposals to take water from that river. They also provide a comprehensive review of all New Zealand studies in this area, including several unpublished papers that address the existence values associated with proposed changes directly affecting rivers.

The remainder of this paper is organised as follows. The main characteristics of the Karapiro catchment are described in section 2, followed by an outline of the methods used in this study (section 3), covering focus groups, survey instrument design, sampling and analytical approach. Our main results are outlined and discussed in section 4, with policy implications and conclusions being presented in sections 5 and 6.

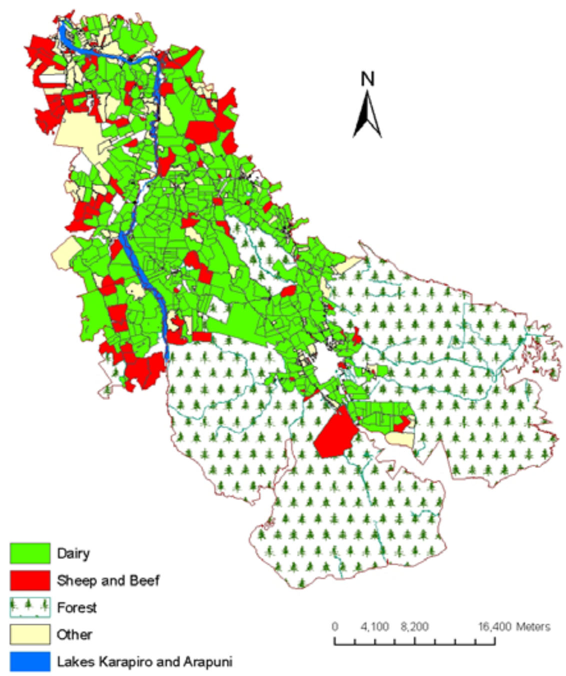
2. The Karapiro Catchment

The Upper Waikato including all land that drains into the Waikato River from the outflow of Lake Taupo to the Karapiro dam has been identified as one of the water bodies in the Waikato region with a high priority for nutrient management (Broadnax, 2006). The study area for this research (the 'Karapiro catchment') stretches over 155,303 hectares and is defined as the lower part of this catchment from Lake Arapuni to the Karapiro dam including contributing tributaries (Figure 1).

[3] Cited in Forbes (1984).

Land use is predominantly dairy (34%), pastoral[4] (13%) and forestry (48%). Much of the areas now used for commercial pine forestry could potentially be converted to dairying. The Waikato Regional Council is seriously concerned that recent[5] and planned land use changes in the catchment between Karapiro Dam and Taupo gates will lead to increasing levels of nitrogen and phosphorous in the Waikato River and its tributaries.

Figure 1: Land Use in the Karapiro Catchment



While some aspects of water quality in the Upper Waikato have improved over the past ten years or so because of reduction in point source pollution[6] the level of nitrogen and phosphorous flowing in from tributaries has generally increased and is expected to continue to rise because of intensification and conversion of land from forestry to dairy. Even with good farm management practices it is expected that the river will support more algae, clarity will fall, the lakes will become slightly greener and there will be an increased risk that blooms of potentially toxic blue green algae will occur (Environment Waikato, 2005). Levels of E.coli may also increase (pers. com).

[4] Includes grazing, drystock, sheep, beef and deer.
[5] Approx. 10-15,000 ha have already been converted from forest to dairy (pers. com.)
[6] Improved wastewater treatment at Wairakei power station, and Kinleith paper and pulp mill and improved sewage treatment at Taupo.

3. Method

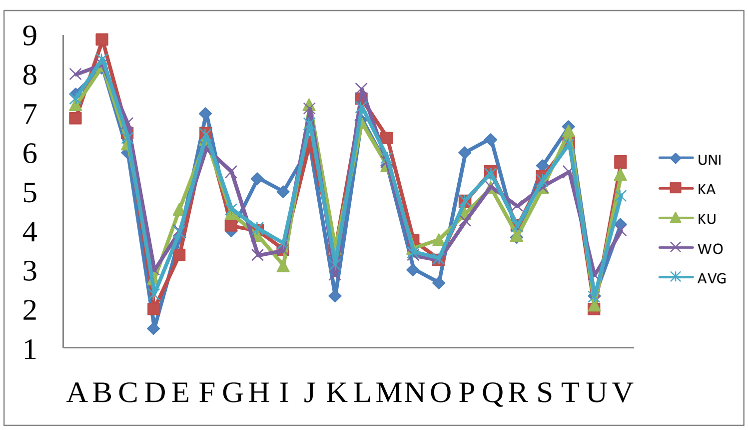
4.1 Focus Groups

Four focus groups were held to build up an understanding of people's views on water quality in the catchment and to identify attributes for inclusion in the choice modelling. These sessions were also used to test early versions of the questionnaire and to discuss the appropriate range of values for the payment variable. Procedures for running the focus groups were developed drawing on Krueger (1994) and New Zealand experience from Bell (2004) and Kerr and Swaffield (2007).

Focus groups were held at the University of Waikato and at three primary schools representing different areas of the catchment (Karapiro, Kuranui and Waotu). The University focus group was a trial run using students who either lived or had grown up in the catchment. The Karapiro, Kuranui and Waotu focus groups were arranged by contacting the principal of the local primary school and asking if they would arrange for a suitable group of adults to attend the session in exchange for a donation to school funds. Schools were asked to provide six to eight people to attend the sessions that lasted for about two hours. Participants were not told about the focus group topic in advance to try to avoid any bias towards those with a particular interest in water quality issues. Participants were roughly even in gender, normally resident in the local area of the school, from a range of age groups and included no more than one couple.

All sessions followed the same format starting with a photo ranking exercise where participants were asked to examine a set of 22 images and identify the river/lake/stream environments that in their opinion had the highest and lowest amenity value. This exercise was included both as an 'icebreaker' and to get people thinking about the different aspects of water quality that they value. Interestingly, there was a strong correlation between the photo rankings provided by different focus groups with a photo of Lake Karapiro and minor rapids on the Waikato River the clear winners, while a close up of a patch of water showing high weed and algal growth was deemed to have the lowest amenity value.

Figure 2: Amenity Value of Photographs (by group and overall)



Note: Vertical scale denotes average rank where 1 denotes an average rank of 1st.

Figure 3: Photos Ranked with Highest and Lowest Amenity Value

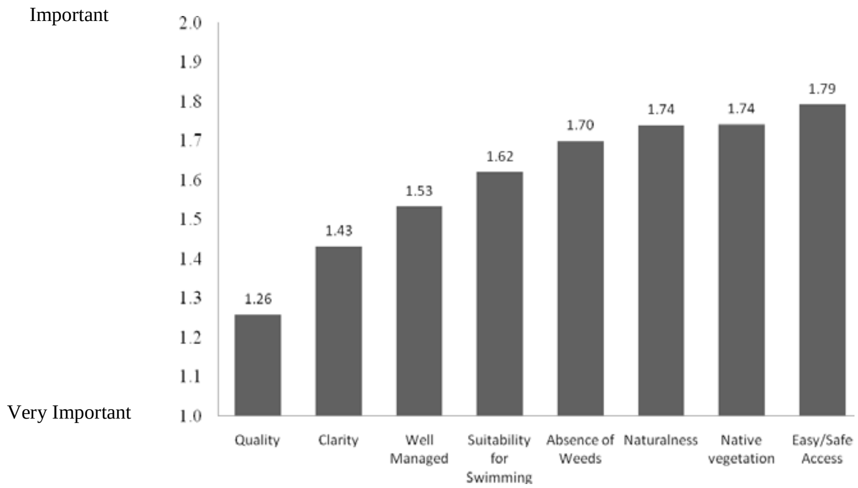
Highest Amenity Value (D and U)

Lowest Amenity Value (B)

The first part of the focus group sessions investigated how participants use or have contact with lakes and streams in the catchment, their views on and experience of water quality in the catchment and which attributes are important in providing amenity value. This was followed by an explanation of choice modelling and testing and discussion of early versions of the payment cards.

All groups had similar views on the importance of different water quality attributes with cleanliness, clarity, good management and suitability for swimming receiving the highest ranking (Figure 4). Two additional attributes were included and tested in the focus groups; ecological health and jobs in dairying. Both of these are judged to be important by policy makers and so are likely to be included in the decision making process. Participants did not volunteer that ecological health was an important attribute, but generally supported inclusion of this variable when it was explained to them. The 'jobs in dairying' variable was included to investigate people's views on who should pay for water quality improvements; households through some form of tax, or the dairy sector through regulations or economic instruments that might reduce profitability and so employment. This aspect encouraged some lively discussions with some dairy farmers supporting improved water quality even at the expense of jobs.

Figure 4: Focus Group Ranking of Water Quality Attributes



Note: Vertical scale denotes 'importance' from 1 'very important' to 5 'not at all important'.

4.2 Survey Instrument Design and Attributes

Questionnaire development and improvement took place over an extended period. Testing started using focus group participants, this was followed by a pilot survey using two groups of six participants and a pretest of 21 questionnaires. The attributes selected for the final study were

- Suitability for swimming and recreation (probability of health warnings)
- Water clarity (visibility under water in metres)
- Ecological Health (percentage of excellent readings)
- Jobs in dairying (number and percentage of jobs lost)
- Cost to household ($ per year for the next ten years)

A full explanation of the attributes used in the choice cards is included as Appendix 1, while Table 1 summarises the attributes and levels. The status quo was defined as the likely condition of the lakes within the next 10 years if nothing is done. In this case we estimate that there may be:

- A 50% chance of health warnings advising recreational users not to use the lake because of algal blooms; for 1-2 weeks every summer;
- Clarity of around 1 metre (less than the NZ standard for safe swimming);
- Fewer than 40% excellent ecological health readings.

The design used was a multi-stage one following Scarpa *et al.* (2007). In the first wave of interviews (33 from the pilot study and pretest), we used an orthogonal design for half of the surveys and a Bayesian C-efficient design for the remainder. Using the MNL estimates obtained from this first set of data we obtained prior values for the coefficient estimates. We used these to develop a Bayesian C-efficient design which minimizes the expected variance of WTP estimates for each attribute and accounts for parameter uncertainty (Rose & Scarpa, 2008). The resulting design was used for the remainder of the survey respondents (157 usable responses)[7].

Table 1: Attribute Levels

Attribute	Future Situation 'Do Nothing'	Level 1	Level 2	Level 3
Suitability for Swimming and Recreation	Every summer there is a 50% chance of health warnings for 1-2 weeks.	20% chance	10% chance	2% chance
Water Clarity	You can usually see up to:- 1 metre underwater	1.5 metres	2 metres	4 metres
Ecological Health	Less than 40% of readings are excellent	50% are excellent	60% are excellent	More than 80% are excellent
Jobs in Dairying	Stay about the same	Reduce by 5%	Reduce by 10%	Reduce by 20%
Cost to Household ($ per year for the next 10 years)	Stay about the same	$50, $100	$300, $600	$1000

Note: All attributes have four levels including the status quo, while the payment variable (Cost to Household) has six levels.

4.3 The Sample

The initial sample for this study was drawn by intersecting the Land Information New Zealand (LINZ) property title database with the catchment boundary layer in ArcGIS. In this way a list of all 7627 properties in the catchment was produced including physical location, territorial authority and other variables. The population was broken down into three strata to reflect the markedly different socioeconomic characteristics of these areas; namely Tokoroa, Putaruru/Tirau and the remaining rural areas.

Tokoroa is based around the forestry industry with the Kinleith timber mill being one of the largest employers. It has a population of around 15,000 with a relatively high population of Maori and Pacific Peoples with income levels being 15% below the New Zealand median. Putaruru and Tirau are smaller rural service centres located along state highway one, while the remaining areas of the catchment are predominantly rural with the dairy industry being one of the largest employers. The catchment includes smaller settlements such as Karapiro and Arapuni (built to service construction of the hydro dams) and some areas of higher income 'lifestyle' properties especially along the shores of Lake Karapiro. While the catchment boundary passes through the middle of Tirau and Putaruru it was decided that the

[7] We gratefully acknowledge assistance from Ric Scarpa in these aspects of survey design.

whole of these towns should be included in the survey population for the purposes of this study.

The sampling strategy aimed to complete sufficient questionnaires to be able to draw separate conclusions for each of the three strata. Address lists were drawn up for each strata and a random number generator used to draw up lists of addresses which were assigned to each enumerator. Field work proved to be very time consuming with each enumerator only able to complete three to six surveys each day. In order to try and reduce the amount of travel involved the sampling strategy was modified to allow enumerators to contact properties adjacent to those selected in the random draw, when the named property did not result in a completed interview. Field work was carried out both during the day and at weekends to try to avoid bias towards people staying at home. In the later stages of the survey a quota system was used to try and reduce bias towards people over 60.

Table 2 provides estimates for the population and number of households in each stratum based on data from the 2006 and 2001 census. These figures, especially for the rural stratum, are subject to a margin of error since the catchment boundaries do not coincide with Statistics New Zealand population area units.

Table 2: Estimated Population and Number of Completed Surveys

Stratum	Population	No. of Households	Sample	Sample %
Tokoroa	13,302	4,587	58	1.3%
Putaruru/Tirau	4,509	1,692	56	3.3%
Rural	4,112	1,523	64	4.2%
Catchment	*21,923*	*7,802*	*178*	*2.3%*

Notes: Tokoroa - based on 2006 population and household size of 2.9, Putaruru/ Tirau - based on 2001 census, Rural - assumes one household per address and 2.7 per household.

4.4 Analytical Approach

Choice modelling refers to survey-based methods "for modelling preferences for goods, where goods are described in terms of their attributes and of the levels that these take"(Hanley *et al.*, 2001). Typically respondents are offered a number of alternatives with each being characterized by a number of attributes, which are offered at different levels across options and are asked to rank them or chose their most preferred. The theoretical basis of CM is the random utility model (RUM) developed by McFadden (1973). The study encompasses two types of CM: Contingent Ranking (CR) and Choice Experiment (CE). In CR models, respondents are asked to rank a set of alternative options from most to least preferred, while in CE models, respondents are presented with a series of alternatives and are asked to choose their most preferred option.

The CE model was first developed by McFadden (1973) who derived a conditional logit model. Subsequently, the model was extended and applied to contingent ranking (CR) which is a rank ordered or exploded logit model (Bergs et al. 1981;

Chapman and Staelin 1982; Hausman and Ruud 1987). Both CR and CE methods assume a random utility function and generate results that are consistent with welfare theory. An important assumption of early conditional logit models was the assumption of independence of irrelevant alternatives (IIA).[8] This implies that for each individual, the ratio of the choice probabilities of any two alternatives is independent of the utility of any other alternative. In other words, an option being chosen should be unaffected by the inclusion or omission of other alternatives. This can lead to unrealistic estimates of individual behaviour when alternatives are added to or deleted from the choice set.

In this study, the ranked-ordered logit model developed by Hausman and Ruud (1987) is applied. This model has the advantage of exploiting additional information contained in rank ordering of all alternatives in respondents' choice sets and thus, improves the estimation of model parameters. This study estimates a CE model using data generated from the CR database. In other words, the study uses CR format survey data to derive datasets for the CE assuming respondents would have expressed choices totally consistent with the rankings given. For example, a respondent that ranked alternative one above two and the status quo is assumed to choose one (most preferred option) when compared to two and one when compared to the status quo. In this way, it can be tested whether there is a significant difference in the estimated WTP values derived from the CR and CE methods from a single sample rather than from different samples.

In order to utilise a behaviourally more appropriate and flexible method, the Random Parameter Logit (RPL) model is adopted.[9] RPL specifications provide the analyst with valuable information incorporating unobserved heterogeneity in the data while estimating unbiased parameters estimates. In addition, the RPL model does not assume the IIA property.

[8] The IIA assumption is identical to the assumption of Independent and Identically Distributed (IID) random components of each alternative.

[9] The RPL model is a generalisation of the standard conditional logit model that explicitly considers taste variation among individuals. Those who are interested in the theoretical underpinnings of RPL can refer to the Chapters 15 and 16 of Hensher et al. (2005).

4. Results and Discussion

4.1 Socioeconomic and Attitudinal Characterization of the Sample

The socio demographic characteristics of the sample are summarised in Table 3. The fact that catchment boundaries do no coincide with boundaries used by Statistics New Zealand (SNZ) mean that catchment level population data is unavailable. Nonetheless some conclusions may be drawn by comparison with data for the Waikato Region as a whole.

Table 3: Socio-Demographic Data for the Sample and Region

	Sample	Region
Gender (%)		
Males	62	49
Females	38	51
Age (%)		
Under 30	14	18
30-44	20	30
45-59	29	28
60+	37	25
Ethnicity (%)		
NZ/European	78	70
Maori	13	21
Asian	2	3
Pacific Island	2	5
Education (%)		
Any post secondary qual.	47	
Vocational/trades	16	
Diploma or certificate (>1 year)	24	
Bachelors degree	5	
Higher degree	2	
Income (%)		
<$30,000	30	53
$30 to $50,000	19	21
$50 to $70,000	16	9
$70 to $100, 000	13	4
>$100,000	11	3
Missing	11	11
Work on or own a farm (%)	25	
Location (%)		
Town	57	
Settlement	13	
Rural	11	
Farm	19	

Note: Regional data may not represent population statistics for the catchment. Population data for the catchment is unavailable. Sample size 178 except where some respondents declined to answer specific questions.

The sample probably over represents males and older people, with the 30-44 age range being particularly under represented. NZ/European people appear to be over represented with Maori and Pacific People's being under represented. For example SNZ reports that in Tokoroa 36% are Maori with 20% being Pacific Peoples however the relevant proportions for our sample in that stratum are 19% and 7%. The sample also under represents people with lower incomes. Given that the sampling methodology was random it can only be concluded that these biases arose because of the characteristics of people who were at home when interviewers called (e.g. older people) or who were not willing to participate in the survey. In this context it should be noted that the refusal rate was particularly high in Tokoroa with only 30% of addresses where a suitable respondent was at home, agreeing to take part in the survey, compared to 60% in other areas.

Table 4: Contact with and Experience of Water Quality

Variable	Sample	
Households living next to lakes, rivers or streams (%)		
Lake	4	
River	5	
Stream	25	
Any water body	30	
Households visiting in the last 12 months (%)		
Lake Karapiro	31	
Lake Arapuni	39	
Streams and Creeks	31	
Frequency of visits (%)		
No visits	32	
1-3 times	25	
4+ times	43	
Reason for visiting		
Water sports (powered)	15	
Water sports (row, sail, kayak)	16	
Spectator/watcher	34	
Walking/picnics	43	
Fishing	15	
Irrigation	2	
Number of households experiencing water quality issues last 12 months (%)	Karapiro	Arapuni
Too much algae or water weed	21	33
Looking or smelling unpleasant	13	16
Became sick after contact	3	3

Some of the key variables describing respondents contact with and experience of water quality are summarised in Table 4. While only 4% or 5% of respondents live next to a lake or river, 25% have streams bordering or running through their properties. 31% had visited Lake Karapiro (39% for Arapuni) in the last 12 months with walking/picnics and watching watersports indicated as the most frequent reason for visiting. 21% of housheholds had experienced too much algae or waterweed on Lake Karapiro (33% for Arapuni) but only 3% had experienced household members becoming sick or suffering infection after contact with the Lakes.

4.2 Comparing CR and CE Models

The choice modelling data were analysed using NLOGIT 4.0 statistical software. Table 5 presents RPL models for CR and CE in which the socioeconomic and attitudinal characteristics of respondents have been added. The models were estimated using 100 Halton draws with model parameters assumed to be independent and random within a normal distribution. The normal distribution for the non-monetary attributes was used because respondents may be indifferent to increasing or diminishing quality or quantity of the attributes. The cost attribute was assumed to follow a triangular distribution to ensure non-negative WTP for water quality improvements over the entire range of the distribution which guarantees deriving behaviourally meaningful WTP measures while allowing taste heterogeneity for this attribute.[10] Attributes which repeatedly indicate an insignificant standard deviation over the range of draws were then re-estimated as non-random variables with fixed parameter estimates. The models also explicitly account for correlation in unobserved utility over repeated choices by each respondent.[11]

The results show that both CR and CE models are statistically significant with signs corresponding with *a priori* expectation. The positive coefficients for SWIM, CLAR and ECO attributes indicate that respondents are willing to pay for improvements in these attributes. As expected, coefficients for the COST and JOB attributes are negative, indicating that respondents preferred lower levels of cost to their household and fewer job losses in dairying. The SWIM attribute levels are highly significant indicating that respondents' utilities increase if the risk of algal blooms resulting in health warnings is reduced. It is interesting to note that respondents are willing to pay for the highest level of water clarity (up to 4 metres visibility) but both models show that the coefficients for clarity levels of 1.5 and 2 metres are insignificant; perhaps these levels are seen as insufficient improvements over the *status quo* where visibility is expected to fall to around 1 metre.

The ECO attributes assess respondents' willingness to pay for an increase in the proportion of ecological health readings that are 'excellent', compared to the status quo (fewer than 40% of excellent readings). ECO50, ECO60 and ECO80 were found to be positively significant in the CR model while the CE model shows only ECO50 and ECO80 levels as positively significant.

The JOB attribute looked at peoples reactions to the job losses in dairying that might be caused if stricter environmental regulations fall heavily on farmers. Both CR and CE models show the JOB attributes to be negative and highly significant suggesting respondents do not want people to people lose their jobs in the dairy industry in order to achieve to water quality improvement. As expected, cost is highly significant and has a negative sign for both models, showing that the higher the cost associated with a policy option, the less likely a given respondent is to choose that option.

---

[10] Following Hensher et al., (2005), a constraint triangular distribution was used in which the variance (spread) of the distribution is made equal to the mean, which is, Cost (t, 1). Such a constraint forces the same sign for the Cost estimate across the entire distribution. This is useful where a change of sign does not make sense.

[11] The study has multiple choice tasks which require the respondents repeatedly make choices for each of the situations and therefore, the choices are correlated (Brownstone & Train, 1999; Revelt & Train, 1998).

Table 5: Results for CR and CE Models

Variable	CR (RPL)		CE (RPL)		
Random Parameters			*Random Parameters*		
SWIM20	0.5514***	(0.1732)	SWIM20	0.9333***	(0.2828)
SWIM10	1.1240***	(0.1869)	SWIM10	1.5404***	(0.3221)
SWIM2	1.0145***	(0.1696)	SWIM2	1.4424***	(0.3069)
CLAR4	0.5334***	(0.1609)	CLAR4	0.5870*	(0.3114)
ECO60	0.3302*	(0.1703)	ECO50	0.5405**	(0.2683)
JOB5	-0.5461***	(0.1563)	ECO80	1.0180***	(0.2429)
JOB20	-1.0477***	(0.1570)	JOB5	-0.9737***	(0.2444)
COST	-0.0081***	(0.0007)	JOB10	-0.7037***	(0.2407)
Non-random Parameters			JOB20	-2.1156***	(0.4075)
ASC	-2.0396***	(0.5849)	COST	-0.0098***	(0.0011)
CLAR1.5	0.0338	(0.1627)	*Non-random Parameters*		
CLAR2	0.1704	(0.1548)	ASC	-1.8789**	(0.9018)
ECO50	0.6665***	(0.1503)	CLAR1.5	0.1385	(0.2731)
ECO80	1.0236***	(0.1389)	CLAR2	0.1207	(0.2582)
JOB10	-0.2468*	(0.1302)	ECO60	-0.0055	(0.2430)
DISTANCE	0.0537***	(0.0181)	DISTANCE	0.0251	(0.0251)
TOWN	-0.9785***	(0.2643)	TOWN	-1.0557**	(0.4134)
VISITS	0.2759***	(0.1026)	VISITS	0.3586**	(0.1669)
AGE	0.0804	(0.0819)	AGE	-0.0531	(0.1296)
JOB	-0.9421***	(0.2452)	JOB	-1.0659***	(0.4075)
EDU	-0.0670	(0.0784)	EDU	0.0340	(0.1296)
UNDER	0.1808***	(0.0558)	UNDER	0.1800**	(0.0848)
INCOME	0.3202***	(0.0670)	INCOME	0.5153***	(0.1125)
Standard Deviation of Parameter Distributions			*Standard Deviation of Parameter Distributions*		
NsSWIM20	0.7519***	(0.1972)	NsSWIM20	1.2842***	(0.3849)
NsSWIM10	1.1339***	(0.2342)	NsSWIM10	2.1477***	(0.4038)
NsSWIM2	1.0832***	(0.2122)	NsSWIM2	1.7469***	(0.3387)
NsCLAR4	0.9175***	(0.2022)	NsCLAR4	1.7267***	(0.4001)
NsECO60	1.2804***	(0.1883)	NsECO50	0.9319**	(0.3989)
NsJOB5	0.6866***	(0.2203)	NsECO80	0.9161**	(0.4090)
NsJOB20	0.7670***	(0.2498)	NsJOB5	0.7696*	(0.4376)
TsCOST	0.0081***	(0.0007)	NsJOB10	1.6383***	(0.2913)
			NsJOB20	1.6750***	(0.6380)
			TsCOST	0.0098***	(0.0011)
Model Statistics			*Model Statistics*		
N (Observation)	2136		N (Observation)	1068	
Log L	-1439.67		Log L	-833.98	
AIC	1.375		AIC	1.620	
BIC	1.452		BIC	1.764	
R^2 (McFadden)	0.386		R^2 (McFadden)	0.289	

Notes: Standard errors in parentheses; *, ** and *** denote significance at the 10%, 5% and 1% levels respectively.

By interacting individual socioeconomic variables with an alternative specific constant (ASC), it is possible to enrich information about a particular sample and also to explain a part of respondent heterogeneity. In general, a negative sign indicates that, a respondent with the given characteristic is more likely to rank (choose) the status quo program as preferred, than a respondent not sharing the characteristic. A positive sign indicates the respondent with this characteristic is more likely to rank (choose) the improvement plans as most preferred relative to those who do not share the characteristic.

The ASC is negative in both models, with a large and highly significant coefficient, showing that there are systematic reasons other than attribute values that lead respondents' to choose the *status quo* option. Based on discussions with enumerators and survey participants the *status quo* was usually chosen either because the respondent felt that they could not afford the improvement options, or because they were not concerned about water quality in the lakes and so chose the *status quo* because this would not lead to any additional cost to their household.

The CR and CE models are derived from the same datasets, and produce similar results in terms of socioeconomic interactions, although the significance of some variables improves under the CR model. The CR model also produces better ordered results with the coefficient for SWIM increasing in line with the falling probability of algal blooms, whereas the coefficient for SWIM10 is larger than that for SWIM2 under the CE model. All of the standard deviation terms are significant for both models indicating preference heterogeneity does indeed exist.[12]

Both models reveal that respondents resident in rural areas (TOWN) or from higher income brackets, who visit the lakes more frequently are more inclined to support the water quality improvement plans relative to respondents of towns with lower incomes who rarely visit the lakes. For both models, neither household age nor education affects the choice of the improvement alternatives relative to the *status quo*. The DISTANCE variable is insignificant under the CE model but highly significant under the CR model. The coefficient is positive but small suggesting that respondents who live further away from the lakes value the improvement options slightly more than those who live at a lesser distance. This is an unexpected result that requires further investigation, given the large size and negative coefficient on the TOWN variable[13].

Respondent occupation significantly affects choice of the current situation relative to the various alternatives. In particular, people who work in the agricultural or resource based sectors are more likely to prefer the *status quo* over improvement plans. This may be due to concern over the impact of environmental regulation on profitability and employment in the dairy sector. This result is further confirmed by the JOB attribute which suggests that higher levels of improvement in water quality management may lead to a reduction in job opportunities in dairying and hence, people may be reluctant to support water pollution abatement plans.

[12] Note that the parameter estimate for the standard deviation of the Cost is exactly same as that of the absolute value of its mean for both models which is due to the constraints imposed on the cost distribution.

[13] Town respondents live 10-15 km. from the lakes while the mean distance from the lake of rural residents is 5 km.

Most respondents stated that they had a good understanding of the choice card questions with a mean score of 7.9 on a Likert scale where 1 denotes '*not understood'* and 10 denotes '*completely understood'*. Both models show that respondents with a better understanding of the choice card questions were more likely to choose the improvement options.

In summary, when comparing the results obtained by both models, it appears that the CR approach yields slightly better statistical efficiency in terms of goodness of fit, number of significant variables, and reduced standard errors.[14] The models differ in the estimation method, especially in the measurement scale for the dependent variable, despite both using a RPL specification. It is also important to note that the CE model is estimated using data generated from the same CR dataset. This gives the CE model fewer observations (1068) relative to CR (2136) which may influence the model estimates. Nevertheless, this argument is weak because the models appear robust and there are no significant differences between them.

Estimates of marginal WTP derived from the models are presented in Table 6. These estimates are based on a *ceteris paribus* assumption, except the attribute for which the WTP is being calculated. The confidence intervals are calculated based on the Krinsky and Robb (1986) procedure using 1000 draws for each of the models. Mean WTP estimates are calculated for each of these draws creating an empirical distribution of estimated mean WTP. The study then applies the convolutions test proposed by Poe et al., (2001) to test whether the WTP differences across models are significant or not. The Poe *et al.,* (2001) tests reveal that only attribute JOB20 is not equivalent, at the 10 per cent level, with CE suggesting a higher WTP ($215) to avoid job losses at the 20% level compared to CR ($129). There are no significant differences between models, for the other WTP attributes and hence, they are considered to be equivalent.

Since the CR model has better statistical fit and narrower confidence intervals this model is applied in the following discussion of welfare estimates. The mean WTP for all attributes is positive except for JOB, implying that on average, respondents value increases in the quality or quantity of each attribute. Clean water and ecological health are the most valued attributes with mean annual willingness to pay of $125 to reduce the risk of algal blooms to 2% per year and $126 to increase the proportion of excellent ecological health readings to above 80%. Coefficients for CLAR 1.5 and CLAR2 are insignificant in both models but respondents would be willing to pay $65 to bring water clarity up to 4 metres. Results for the JOB attribute probably reflect the perceived benefit of protecting dairy related jobs. For example, WTP estimates for JOB20 indicates that, each respondent was willing to pay an average of $129 per year to avoid a 20% reduction in dairy related jobs.

[14] The criteria for goodness of fit are Akaike Information Criteria (AIC), Bayesian Information Criteria (BIC) and R^2 McFadden. For AIC and BIC, the lower their values, the better the models. Simulations by Domencich and McFadden (1975) suggest values of R^2 between 0.2 - 0.4 are comparable to values between 0.7 - 0.9 for R^2 in the case of the ordinary linear regression.

Table 6: Mean annual WTP per household for the attributes.

Attribute	CR (RPL)	CE (RPL)	Poe et al. (2001) test
SWIM20	68.03	94.94	0.2125
	(24, 111)	(43, 155)	
SWIM10	138.69	156.70	0.3077
	(92, 188)	(100, 222)	
SWIM2	125.18	146.74	0.2732
	(84, 170)	(93, 208)	
CLAR1.5	4.17#	14.09#	0.3750
	(-37, 42)	(-36, 71)	
CLAR2	21.03#	12.28#	0.5850
	(-19, 59)	(-40, 63)	
CLAR4	65.82	59.71	0.5658
	(32, 102)	(-3, 121)	
ECO50	82.23	54.98	0.8022
	(46, 121)	(-5, 104)	
ECO60	40.74	-0.56#	0.9040
	(-3, 83)	(-50, 47)	
ECO80	126.30	103.56	0.7751
	(95, 162)	(59, 152)	
JOB5	-67.38	-99.05	0.8537
	(-112, -32)	(-149, -57)	
JOB10	-30.46	-71.59	0.9324
	(-61, 1)	(-121, -25)	
JOB20	-129.27	-215.22	0.9648*
	(-178, -86)	(-303, -132)	

Note: Confidence intervals (CIs) in parentheses at 95% level; the mean WTPs and CIs are calculated using the Krinsky and Robb (1986) procedure; * denotes significance at the 10% level; # non significant coefficient.

Compensating Surplus (CS) can be calculated in order to assess the overall WTP for a change from the *status quo* to an improved outcome based on different combinations of attributes. Estimates of compensating surplus provide one of the most useful cost-benefit analysis tools for policy makers drawing-up management plans. Four options were created for policy analysis relative to expected future conditions under the *status quo*. The first three policy options were calculated based on the level of improvements (Policy 1 – lower levels, Policy 2 – middle levels and Policy 3 – highest levels). The estimates of mean CS for the four scenarios are presented in Table 7. The Poe et al. (2001) tests show that there are no significant differences between the mean CS estimates comparing both CR and CE models.

Table 7: Mean annual CS estimates per household associated with different policy options

Attribute	*Status Quo*	Policy 1	Policy 2	Policy 3	Policy 4
SWIM	*50*	20	10	2	2
CLARITY	*1*	1.5	2	4	4
ECOLOGY	*40*	50	60	80	80
JOBS	*0*	-5%	-10%	-20%	0
CR (RPL) CS ($)	*0*	39.18 (-2, 81)	153.75 (111, 200)	150.59 (102, 197)	281.03 (237, 330)
CE (RPL) CS ($)	*0*	34.62 (-18, 85)	119.61 (58, 182)	81.08 (-11, 163)	297.96 (233, 365)
Poe et al. test		0.5539	0.8124	0.9192	0.3481

Note: Confidence intervals (CIs) in parentheses at 95% level; the mean WTPs and CIs are calculated using the Krinsky and Robb (1986) procedure.

As expected, CS increases for improvements in the expected condition of the lakes. For a change from the *status quo* to the conditions defined in Policy 1 (20% chance of algal blooms, clarity of 2 metres and 50% excellent readings for ecological health), respondents would be willing to pay $39 per year for the next ten years. Greater improvements under Policy 2 and 3 increase the mean CS to $154 and $151 respectively. This suggests that respondents, not only experience positive marginal utility for improvement in the selected attributes but also are willing to pay more for higher levels of environmental enhancement. In addition, the CS results also indicate the importance of attribute tradeoffs for environmental improvements. For instance, Policy 3 and Policy 4 differ only in terms of employment effects (with and without JOBS). The employment effect reduces WTP substantially by about 46% for Policy 3 compared to Policy 4. This may help policy makers to think about how the cost of quality improvements should be allocated knowing that willingness to pay is greatly reduced when improved water quality comes at the expense of jobs in dairying.

Different estimates of willingness to pay for water quality improvements cannot usually be compared because it is expected to vary depending on the characteristics and location of the good being valued and the income and preferences of the respective population. These differences are often further confounded by differences in the research methodology adopted. It may nonetheless be useful to explore whether such estimates are of a similar order of magnitude.

Sharp and Kerr (2005) carried out a comprehensive review of use and non use values relating to rivers and water quality in New Zealand. Mean annual willingness to pay ranged from $11 to $203 with a median value of $68 over nine separate studies. In a more comparable study that also looked at the impact of algal blooms, Bell and Yap (2004) used contingent valuation to estimate the mean household willingness to pay of $91 for a nutrient reduction programme to improve water quality in the Rotorua lakes. Our estimates of household mean CS range from $34 to $246[15] (*Dec 2003 values*) for the highest level of improvement (policy 4) and so are broadly in line with values found in other New Zealand studies[16].

1. Policy Implications

The literature on the economics of pollution control generally seeks to answer two main questions; what is the 'efficient' level of pollution and how should this be achieved? While policy makers and the general public may believe that the efficient level of pollution in the Waikato River is zero this is probably not the case. For example, the Waikato River could perhaps be returned to its condition before the arrival of Europeans, by removal of all hydro dams, relocation of most people now living in the catchment and reforestation with native trees. Faced with this scenario many people would feel that the price of 'pure water' was too high. The key issue then is, what level of water quality should policy seek to attain? Given that improved water quality will have significant costs, these can be compared with the benefits that would accrue from these improvements in order to try to decide on the best policy outcome.

Table 8: Mean and Total Estimates of Compensating Surplus

Stratum	No. of Households	Sample	Policy 1	Policy 2	Policy 3	Policy 4
				Mean CS ($ per year – Rank RPL)		
Tokoroa	4,587	58	42	88	62	137
Putaruru/Tirau	1,692	56	-74	93	85	230
Rural	1,523	64	84	136	116	421
Catchment	7,802	178	39	154	151	281
				Total Annual CS ($ millions)		
Tokoroa			0.19	0.41	0.28	0.63
Putaruru/Tirau			-0.13	0.16	0.14	0.39
Rural			0.13	0.21	0.18	0.64
Catchment [1]	7,802	178	0.19	0.77	0.61	1.66
Catchment [2]	*7,802*	*178*	0.31	1.20	1.17	2.19

Note: 1 Total catchment CS is weighted by stratum, 2 CS is averaged across the whole population.

The CS estimates derived in the previous section can be aggregated to determine the overall willingness to pay for improved water quality in Lakes Karapiro and Arapuni (Table 8). CS was estimated separately for each of the three strata, with total

[15] Converted to December 2003 values to allow direct comparison with the estimates reviewed in Sharp and Kerr (2005).
[16] Note that direct comparisons are not possible since our estimates are for CS, while most of the studies reported in Kerr and Sharp are WTP based on contingent valuation studies.

catchment CS being weighted by stratum in order to adjust for the different sampling rates It can be seen that CS is generally much higher in rural areas and lowest in Tokoroa; possibly because of lower incomes and greater distance to the Lakes.

It should be noted that these estimates represent a lower bound for the value of water quality improvements to all who value the lakes. This is because the lakes are used by large numbers of recreational users who are not resident in the catchment and so were not captured by the catchment survey described above. These users are the subject of a complementary survey of recreational users that is now in progress. It is also likely that the non-use value of the lake will be larger than our estimates suggest, since there will be households in the region or New Zealand as a whole who live outside the catchment and do not use the Lakes for recreation, but who would still value water quality improvements. At the same time it should be acknowledged that our estimates are based on an imperfect sample of the catchment population; with Maori and lower income households being under represented. This may have exerted some upward bias on our estimates of mean household willingness to pay. Subject to these caveats, the overall benefits of alternative policy outcomes are discussed below.

Total catchment CS for Policy 4 (2% chance of algal bloom, 4 metre clarity, >80% excellent ecological health readings) is \$1.7 million per year based on the weighted mean CS in each stratum (Table 8). Using confidence intervals for the catchment level estimate[17] this suggests a 95% probability that catchment CS is in the range \$1.4 - 1.9 million. Total Annual CS can be broken down to around \$0.6 million for Tokoroa, \$0.4 million for Putaruru and Tirau and \$0.6 million for remaining rural areas.

While the outcomes associated with policy 4 are highly desirable they are probably not achievable within the foreseeable future. It is expected that major changes in farming practice will be required even to reverse the current deterioration in water quality and achieve the outcomes for policy 1 (20% chance of algal bloom, 1.5 metre clarity, >50% excellent ecological health readings, 5% reduction in jobs in dairying). Aggregate catchment level CS for this option is estimated to be around \$0.2 million per year, with average CS per household being \$39. Our estimates for this level of improvement are less certain with the 95% confidence interval ranging from \$-2 to \$81 per household (Table 7). Expected benefits and certainty increase with the level of improvement, so for example, benefits for policy 2 (10% chance of algal bloom, 2 metre clarity, >60% excellent ecological health readings, 10% reduction in jobs in dairying) are \$154 per household, with 95% certainty that they are in the range \$111 to \$200.

Full assessment of the policy implications of our results can only be completed when results for the recreational survey and data on the costs of different mitigation options are available. Nonetheless, the difficulty of achieving even minor improvements in water quality may pose a significant problem. If a set of policies will result in large costs but minor water quality improvements it seems quite possible that the costs of such a programme may exceed our estimates of benefits.

[17] 95% confidence level estimate for mean annual CS per household for policy 4 is \$237 to \$330 (Table 7). Confidence interval for weighted mean CS (Table 8) has not been calculated.

This may provide a rationale for a more ambitious water quality improvement target that would improve attributes to the level where residents of the catchment indicate that they would gain large and certain benefits (e.g Policy 2,3 or 4).

2. Conclusions

We have described the development of a choice modelling approach for assessing the value of water quality improvements in New Zealand lakes. Focus groups and literature reviews were used to select relevant attributes and experts were consulted to help identify the attributes most likely to be impacted by policy. A novel feature was the inclusion of a social cost variable to investigate whether people's preferences for improved water quality are affected by the potential for job losses in the dairy sector. This data may assist policy makers considering who should pay for water quality improvements; households through some form of tax, or the dairy sector through regulations or economic instruments that might reduce profitability and so employment.

Utilisation of a multi-stage, Bayesian C-efficient design enabled estimation of choice experiment and contingent ranking models with good statistical fit, from a relatively small sample of 178 respondents. The CR approach making use of the ranking given to all three options produced slightly better results with statistically significant coefficients in line with our *a priori* expectations.

Respondents were found to be willing to pay for reduction in the chance of algal blooms and improvements in clarity and ecological health but were also concerned about job losses in dairying, even where they did not expect to be directly affected. Willingness to pay for slight improvements over the status quo was fairly low ($39 per household per year) and uncertain, indeed the coefficients for slight improvements in water clarity were insignificant. Households had a higher and more certain willingness to pay for larger improvements with a mean CS of $281 for reducing the chance of algal blooms to 2%, with clarity of 4 metres and more than 80% of ecological health readings being excellent.

The JOB attribute looked at people's reactions to the job losses in dairying that might be caused if stricter environmental regulations fall heavily on farmers. Both CR and CE models show the JOB attributes to be negative and highly significant suggesting respondents do not want people to lose their jobs in the dairy industry in order to achieve to water quality improvement.

Future work will report on a survey of recreational users and people's WTP for water quality improvements in the catchment streams, in order to build up a more comprehensive picture. This data will then be combined with research into the cost of achieving different levels of water quality improvements. Outputs from this research should allow decision makers to consider both the costs and the benefits of different levels of water quality improvements so allowing farmers and policy makers to identify the most cost effective options for achieving any given improvement in water quality.

Appendix 1: Explanation of Aspects for Choice Cards

(Information provided to respondents)

Suitability for swimming and recreation

Is about whether Lakes Karapiro and Arapuni are safe for swimming.

- Sometimes the water in the Lakes is not safe for swimming and recreation because of algal blooms. This has happened twice in the last five years.
- If water quality continues to fall there may be a 50% chance of 'lake closure' for 1-2 weeks every summer – because of algal blooms or high levels of the bacteria e.coli.
- If water quality improves the risk of algal blooms and lake closures should fall.

Water Clarity

A measure of how clear the water is – how far you can see underwater

- At the moment clarity in the lakes is between one and two metres and is expected to fall because of increased growth of algae.
- Water is regarded as unsafe for swimming if clarity is less than 1.5 metres – because you cannot see your feet.
- Clear rivers with high water quality have clarity of 4-5 metres. Clarity in Lake Taupo is up to 15 metres.

Ecological Health

This is about the standards Environment Waikato uses to assess whether water quality is good enough for plant and animal health.

- Ideally 100% or ecological health readings would be excellent for plant and animal health.
- If water quality continues to fall fewer than 40% of readings will be excellent and up to 40% will be unsatisfactory.

Ecological health readings cover these aspects:-

Dissolved oxygen	Dissolved oxygen is important for fish and other aquatic life to breathe.
pH	pH is a measure of the acidity or alkalinity of water.
Turbidity	Turbidity is a measure of the murkiness of water
Total ammonia	High levels of ammonia are toxic to aquatic life, especially fish.
Temperature Water	temperature is important for fish spawning and aquatic life.
Total phosphorus	Phosphorus is a nutrient that can encourage the growth of nuisance aquatic plants.
Total nitrogen	Nitrogen is a nutrient that can encourage the growth of nuisance aquatic plants.

Jobs

- About 700 people work in the dairy industry in the catchment.
- If dairy farmers face strict environmental regulations their profits may fall.
- This could mean fewer people employed in dairying.
- For example a 20% drop would mean 140 fewer jobs or a 10% drop would mean 70 fewer jobs.
- Fewer jobs in dairying does not necessarily mean people would be unemployed. Rather if dairying is less profitable then, over time, people may find different jobs.

References

AgResearch et al. (2006). *Delivering Tools for Improved Environmental Performance*.

Bell, B., & Yap, M. (2004). *The Rotorua Lakes. Evaluation of Less Tangible Values*. Wellington: Nimmo-Bell & Company.

Broadnax, R. (2006). The Environment Waikato Approach to Managing Agriculture's Impact on the Environment. *Primary Industry Management, 9*(2), 7-10.

Brownstone, D., & Train, K. (1999). Forecasting New Product Penetration with Flexible Substitution Patterns. *Journal of Econometrics, 89*(1-2), 109-129.

Domencich, T., & McFadden, D. L. (1975). *Urban Travel Demand: A Behavioral Analysis*. New York North-Holland Publishing Company

Environment Waikato. (2005). Report to Policy and Strategy Committee. Update re: Land Use Changes in the Waikato Catchment Between Taupo Gates and Karapiro: Environment Waikato.

Forbes, R. N. (1984). The Valuation of Non-Market Costs and Benefits in the New Zealand Water and Soil Area: Palmerston North: Economics Division, Ministry of Agriculture and Fisheries.

Hanley, N., Mourato, S., & Wright, R. E. (2001). Choice Modelling Approaches: A Superior Alternative for Environmental Valuation? *Journal of Economic Surveys, 15*(3), 435-462.

Harrington, A. (2005). The Contribution of the Primary Sector to New Zealand's Economic Growth: The Treasury.

Harris, B. (1983). Valuation of Non Market Goods : An Application of Contingent Valuation to Water Pollution control in the Waikato Basin: Waikato Valley Authority. .

Hausman, D. A., & Ruud, P. (1987). Specifying and Testing Econometric Models for Rank-Ordered Data. *Journal of Econometrics, 34*(1-2), 83-104.

Hensher, D. A., Rose, J. M., & Greene, W. H. (2005). *Applied Choice Analysis. A Primer*: Cambridge.

Kerr, G., & Sharp, B. (2003). *Transfer of Choice Model Benefits: A Case Study of Stream Mitigation*.

Kerr, G., & Swaffield, S. R. (2007). *Amenity Values of Spring Fed Streams and Rivers in Canterbury, New Zealand: A Methodological Exploration*: Agribusiness and Economics Research Unit.

Krinsky, I., & Robb, A. L. (1986). On Approximating the Statistical Properties of Elasticities. *The Review of Economics and Statistics, 68*(4), 715-719.

Krueger, R. A. (1994). *Focus Groups. A Practical Guide for Applied Research*: Sage.

McFadden, D. L. (1973). Conditional Logit Analysis of Qualitative Choice Behavior. In P. Zarembka (Ed.), *Frontiers in Econometrics (Economic Theory and Mathematical Economics)* New York Academic Press

Ministry of Agriculture and Forestry. (2008). *Situation and Outlook for New Zealand Agriculture and Forestry*. New Zealand: Ministry of Agriculture and Forestry,.

Parliamentary Commissioner for the Environment. (2004). *Growing for Good. Intensive Farming, Sustainability and New Zealand's Environment*. Wellington.

Poe, G. L., Giraud, K. L., & Loomis, J. B. (2001). Simple Computational Methods for Measuring the Differences of Empirical Distributions: Application to Internal and External Scope Tests in Contingent Valuation: Department of Agricultural, Resource and Managerial Economics, Cornell University

Pretty, J. N., Mason, C. F., Nedwell, D. B., Hine, R. E., Leaf, S., & Dils, R. (2003). Environmental Costs of Freshwater Eutrophication in England and Wales. *Environ. Sci. Technol., 37*(2), 201-208.

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.

Rose, J. M., & Scarpa, R. (2008). Design Efficiency for Nonmarket Valuation with Choice Modelling: How to Measure it, What to Report and Why. *Australian Journal of Agricultural and Resource Economics, 52(3)*(September).

Rowe, D., Quinn, J. M., Parkyn, S., Collier, K., Hatton, C., Joy, M., et al. (2006). *Stream Ecological Valuation (SEV): A Method for Scoring the Ecological Performance of Auckland Streams and for Quantifying Mitigation* (No. NIWA Client Report HAM2006-084): Auckland Regional Council, NIWA.

Scarpa, R., Campbell, D., & Hutchinson, W. G. (2007). Benefit Estimates for Landscape Improvements: Sequential Bayesian Design and Respondents' Rationality in a Choice Experiment. *Land Economics, 83*(4), 617-634.

Sharp, B., & Kerr, G. (2005). *Option and Existence Values for the Waitaki Catchment*: Report prepared for Ministry for the Environment.

Viscusi, W. K., Huber, J., & Bell, J. (2008). The Economic Value of Water Quality *Journal Environmental and Resource Economics 41(2)*(October), 169-187