DRAFT

WATER RESOURCE MANAGEMENT IN NEW ZEALAND: JOBS OR ALGAL BLOOMS?

Dan Marsh
Department of Economics
University of Waikato
dmarsh@waikato.ac.nz

Presented at the Conference of the
New Zealand Association of Economists
Auckland
2 July 2010

Abstract

People's willingness to pay for water quality improvements in a typical dairy catchment in the Waikato region is estimated so enabling decision makers to consider both the costs and the benefits of different environmental policies. We describe the development of a choice modelling approach for assessing the value of water quality improvements and find that respondents would be willing to pay for water that is safer for swimming and improvements in clarity and ecological health but are concerned about job loses even when they do not expect to be directly affected.

JEL Codes

Keywords: Water Quality, Non Market Valuation, Choice Modelling, Employment

Saved: 24/06/10, 12:57

1. Introduction

Neoclassical models of consumer behaviour typically assume that consumers are individualistic and self centred in their tastes and beliefs and indifferent to the welfare of others. An alternative view of the world is described by McFadden (2010) in which “humans are social animals, and even when self-interest is paramount, one’s self is defined through the reaction and approval of others” as a result “…sociality, the influence of direct interpersonal interaction on human behaviour, must be taken into account in modelling choice behaviour.”

The debate around the neoclassical assumption of self centred behaviour has been widely canvassed for more than two hundred years[1]. Within the valuation literature individual and so-called ‘citizen’ preferences have been investigated more recently, by Blamey (1996) and Peterson et al., (1996). Bateman et al., (2005, p. 21) provide a useful synthesis of the value formation process that includes individual and social factors suggesting that the beliefs which individuals bring to a valuation experiment are also influenced by world views, cultural influences and contextual factors. McFadden (2010) sets out to model these various effects of sociality on choice behaviour and documents four stages at which this can happen; “constraints that define available choice alternatives, information about and perceptions of alternatives, preferences, and the processes used to reach decisions”.

The main contribution of this paper is to specifically address the way in which one aspect of sociality affects choice behaviour and willingness to pay (WTP) for improved water quality. More specifically, we report on the results of a choice experiment into local (catchment level) WTP for improved water quality in Lake Karapiro, New Zealand where household WTP is affected by policies that reduce local employment in dairying. These WTP 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.

Adamowicz et al., (1998) provide an early example of the inclusion of an employment variable in a choice experiment. Their paper was mainly concerned with a comparison of choice experiments and contingent valuation using a survey instrument that explored respondent’s preferences for wild life populations, wilderness area, recreation restrictions, forest industry employment, and a change in provincial income taxes. They found that employment was not significant, perhaps because the the impacts on employment occurred in several hundred kilometres away from the survey location. Several other authors have reported significant results for WTP for increased employment ‘as a public good’; for example Longo et al.,(2008) on renewable energy activities that may create more electricity sector jobs, Caparros et al., (2008) on national park visitor WTP for a reforestation program that would increase local employment and Birol and Cox (2007) on irrigation related jobs and sustainable management of the Severn Estuary wetland. One of the few studies into

[1] McFadden (2010, p. 6) sketches the history of economic thought on this topic from Adam Smith to Samuelson.

the preferences of local respondents for local jobs is provided by Colombo et al., (2005); they report a strong preference for watershed policies to reduce soil erosion that generate local employment. Birol et al., (2006) find a preference for policies that would retrain farmers in "environmentally friendly employment" but did not include choice scenarios that included a reduction in employment.

All of these studies report positive WTP for more employment, but do not focus specifically on the effect of job losses on respondent preferences for environmental improvement. Both Longo et al., and Birol and Cox used an experimental design where the employment attribute could take either a positive or a negative value. However neither report separately on model results for the negative job attribute. By contrast, in this paper the employment attribute is effects coded so as to separately estimate the effect of each level of employment reduction on WTP for environmental improvement.

2. Water Quality and Agriculture in New Zealand

Agricultural nutrient losses are a major contributor to water pollution both in New Zealand and internationally. Levels of nitrogen and phosphorus in rivers and lakes have increased over the last two decades leading to a decline in water quality and increased incidence of algal blooms.

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. While many European countries have already implemented regulatory measures, New Zealand has so far taken a mainly voluntary approach including an accord between New Zealand's largest dairy company Fonterra, regional councils, the Ministry for the Environment and the Ministry of Agriculture and Forestry.

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), 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[2] (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.

There is a large international literature that reports on the costs caused by loss in water quality resulting from agricultural pollution. For example Pretty et al. (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

[2] Increase in fertiliser per hectare is for the period 1996-2002.

as “good”. New Zealand research in this field is more limited but may be dated back to work by Forbes (1984) on the costs and benefits of reducing eutrophication in Lake Tutira and analysis of water pollution control in the Waikato Basin (Harris, 1983) and the Lake Taupo Catchment Control Scheme.

More recently, choice analysis has been used to estimate the value that residents attached to the condition of streams in the Auckland region (Kerr & Sharp, 2003) and the amenity value of spring fed streams and rivers in the Canterbury region (Kerr & Swaffield, 2007). Sharp and Kerr (2005) discuss non market 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.

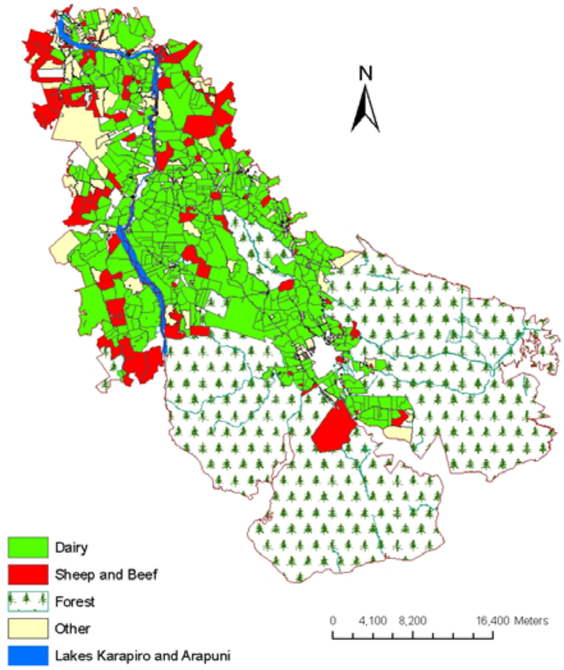
The study area for this research (the ‘Karapiro catchment’) stretches over 155,303 hectares from Lake Arapuni to the Karapiro dam including contributing tributaries (Figure 1). It forms part of the Upper Waikato catchment which has been identified as one of the water bodies in the Waikato region with a high priority for nutrient management (Broadnax, 2006). The Waikato region can be described as the heart of the New Zealand dairy industry; it accounts for around 30% of national dairy production with around 1.2 million cows being grazed on 440,000 hectares(DairyNZ, 2009). The Karapiro catchment is representative of conditions across much of the region both in terms of land use, farming intensity and the effect of farming on water quality in rives and lakes. Land use is predominantly dairy (34%), pastoral[3] (13%) and forestry (48%). Much of the areas now used for commercial pine forestry could potentially be converted to dairying. The Waikato Regional Council – Environment Waikato (EW) is seriously concerned that recent and planned land use changes in the catchment between Karapiro Dam and Taupo gates will lead to increasing levels of nitrogen and phosphorus in the Waikato River and its tributaries.

While some aspects of water quality in the Upper Waikato have improved over the past decade because of reduction in point source pollution the level of nitrogen and phosphorus 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.

The remainder of this paper is organised as follows. Methods used in the study are outlined in section 3, covering focus groups, survey instrument design, sampling and analytical approach. Our main results are outlined and discussed in section 4 followed by policy implications and conclusions.

[3] Includes grazing, drystock, sheep, beef and deer.

Figure 1: Land Use in the Karapiro Catchment



3. Methods

3.1 Survey and Experimental Design

Four focus groups were held to derive an understanding of people's views on water quality in the catchment and to identify attributes for inclusion in the choice experiment. 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 on more specific New Zealand experience from Bell (2004) and Kerr and Swaffield (2007). Further details on focus group procedures can be found in Marsh and Baskaran (2009).

Questionnaire development and improvement took place over an extended period. Testing started using focus group participants and was followed by a pilot survey using two groups of six participants and a pre-test of 21 questionnaires. The water attributes identified by focus groups participants were supplemented by literature review and discussions with experts in the field. The final questionnaire included two choice experiments; one relating to the quality of water in local streams, the other relating to the quality of water in Lakes Karapiro and Arapuni is reported here. The attributes eventually selected for the Lakes choice experiment 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.

Table 1: Attribute Levels

Attribute	Future Situation 'Do Nothing'	Option 1	Option 2	Option 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		

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).

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 geographical strata to reflect the markedly different socioeconomic characteristics of these areas; namely Tokoroa, Putaruru/Tirau and the remaining rural areas. Address lists were drawn up for each stratum and a pseudo-random number generator was used to draw up lists of addresses to be visited by each enumerator. Field work proved to be very time consuming with each enumerator only able to complete three to six surveys each day. Field work was carried out both on weekdays 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.

The socio demographic characteristics of the sample are summarised in Table 2. The fact that catchment boundaries do not 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.

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.

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.

Table 2: 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.

Table 3: 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	
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

3.2 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 (Thurstone, 1927c) used by McFadden (1973) to develop CM theory. Contingent Ranking (CR) and Choice Experiment (CE) are two common variants to this approach. This study follows the CR approach where 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.

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). 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. Our models also explicitly account for correlation in unobserved utility over repeated choices by each respondent.[4]

We estimate a multinomial logit model (MNL), a random parameter logit (RPL) model[5] and an RPL error component model. RPL models provide flexibility and may be regarded as being behaviourally more appropriate. This specification provides 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. We find that the mixed logit (RPL) specification that combines both the random parameter and error component interpretation provides best model fit and so use this specification to estimate willingness to pay and welfare changes from policy improvements. Train (2003) has shown how the mixed logit model can give rise to two different interpretations, the random coefficient and the error component interpretations. The random coefficient interpretation accounts for taste variations over the sampled individuals and has been widely applied e.g. Train (1998). On the other hand, the error component interpretation refers to the decomposition of the error term and accounts for different correlations patterns among utilities for different alternatives e.g. Brownstone and Train (1999).

Survey data from the choice experiments were analysed using NLOGIT 4.0 statistical software, the models being 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.[6]

We estimate *population* mean WTP for each of the non-monetary attributes; rather than the alternative approach of estimating the *individual-specific* WTP conditioned on the observed individual choices. We derived these estimates of population mean WTP by simulating population moments in R-Console using 50,000 random draws to obtain WTP distributions for each non-monetary attribute. We then build on the approach describe by von Haefen (2003) to estimate the consumer surplus attributable to each policy scenario (defined as a given level of improvement in each

---

[4] 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).

[5] The RPL model is a generalisation of the standard conditional logit model that explicitly considers taste variation among individuals see Chapters 15 and 16 of Hensher et al. (2005).

[6] 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.

attribute (see Table 7). Our procedure for estimating consumer surplus (equivalent variation) takes account of every choice made rather than being based simply on population estimates of beta for the different attributes. In effect we argue that if randomness is allowed when estimating the utility model, then randomness should also be allowed when estimating equivalent variation. Conditioning on the twelve choices made by each respondent, we estimate a conditional distribution of WTP for each individual. We export this matrix from NLogit into Gauss and using the mean and standard deviation of each distribution we simulate WTP for each individual ten thousand times for each policy scenario. We report the median of the 178 median welfare estimates from 10,000 draws. We also report the upper and lower quartiles e.g. the amounts that individuals would be willing to pay at least 25%/75% of the time[7]. Our focus on median values avoids bias since mean values are strongly affected by extremes and is more compatible with public policy applications since it is typically the median voter that creates WTP for public goods so influencing selection of preferred policies.

4. Results and Discussion

4.1 Model Results

Model results for the multinomial logit (MNL) model, random parameter logit (RPL) model and RPL – error component model are presented as Table 5. Based on log likelihood and AIC and BIC criteria it can be seen that the RPL – EC model provides the best fit. The coefficient signs for the different attributes correspond with *a priori* expectations, in all cases where the coefficient value is significant. 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 all 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 and ECO80 were found to be positively significant in the RPL model while only ECO80 is significant in the error correction model.

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. All 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

[7] My thanks to Ric Scarpa for providing Gauss code and assisting me with this procedure.

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.

Table 5: Results for CR and CE Models

	MNL	RPL	RPL (EC)
ASC	0.3210***	0.5407***	0.2791**
SWIM20	0.0750	0.5962***	0.1844
SWIM10	0.5443***	1.1368***	0.9174***
SWIM2	0.3229***	1.0838***	0.6673***
CLAR15	0.0114	-0.0554	0.0810
CLAR2	-0.0434	0.2104	0.1316
CLAR4	0.0656	0.4340***	0.3894***
ECO50	0.3960***	0.5004***	0.2378
ECO60	0.1569	0.0069	0.0064
ECO80	0.4750***	0.9805***	0.6672***
JOB5	-0.4165***	0.4855***	-0.5983***
JOB10	0.0359	-0.2566*	-0.3293***
JOB20	-0.6630***	-1.2864***	-1.1298***
COST	-0.0026***	-0.0092***	-0.0065***
Model Statistics			
N (Observation)	2136	2136	2136
Log L	-1651	-1396	-1347
AIC (finite sample)	1.559	1.333	1.276
BIC	1.596	1.404	1.316
R^2 (McFadden)		0.405	0.426

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

The ASC is positive with a large and significant coefficient for all models, suggesting 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.

4.2 Estimates of Marginal Willingness to Pay

Estimates of population mean, marginal WTP for specific attributes, 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 median WTP for all attributes is positive except for JOB, implying that on average, respondents value increases in the quality or quantity of each attribute.

Table 6: Marginal WTP for attributes ($ per household per year)

Attribute		1st Quartile	Median	Mean	3rd Quartile
Suitability for swimming (Probability of algal bloom)	SWIM20***	8	28	39	52
	SWIM10***	44	141	190	260
	SWIM2***	32	102	141	191
Water clarity *You can usually see for ..m underwater*	CLAR1.5				
	CLAR2				
	CLAR4***	18	58	82	110
Ecological health *Percentage of excellent readings*	ECO50***	12	37	51	69
	ECO60				
	ECO80***	32	103	136	190
Job losses in dairying % reduction	JOB5***	-28	-90	-126	-169
	JOB10*	-16	-51	-67	-94
	JOB20***	-57	-177	-241	-328

Note: Values that are not statistically significant are omitted.

Clean water and ecological health are the most valued attributes with median annual willingness to pay of $102 to reduce the risk of algal blooms to 2% per year and $103 to increase the proportion of excellent ecological health readings to above 80%. Data for the 1st and 3rd quartiles indicate that 25% of people would be willing to pay more than $191 and 75% of people would be willing to pay at least $32 for the same reduction in algal blooms.

Coefficients for CLAR 1.5 and CLAR2 are insignificant in both models but the median respondent would be willing to pay $58 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, model estimates for JOB20 indicate that the WTP of the median respondent was reduced by $177 per year when a choice scenario was associated with a 20% reduction in dairy related jobs.

4.3 Welfare Gains from Specific Policies

We estimate the overall consumer surplus associated with a change from the *status quo* to an improved outcome based on different combinations of attributes. Such estimates provide one of the most useful cost-benefit analysis tools for policy makers drawing-up management plans. It should be noted however that procedures for correctly estimating these benefits are not well established. There has for example, been a tendency to focus on part worth estimates for individual attributes while ignoring the fact that these estimates are valid only for marginal changes and are based on a ceteris paribus assumption. There has also been a tendency to estimate WTP using RPL models but to ignore this assumption of randomness when estimating the benefits of multi attribute policy improvements. It should further be noted that procedures that take account of randomness tend to produce lower benefit estimates – since for example, individuals who highly value clean water may care less about water clarity. When these factors are considered together these two effects may to some extent, cancel each other out.

In our analysis, we define three policy outcomes and estimate the median welfare gain associated with each outcome relative to expected future conditions under the *status quo*. In each case we estimate welfare gain with no job losses, then again *with* job losses of 5, 10 and 20%. Attribute levels for each policy are defined in Table 7 along with estimates of median welfare gain.

As expected, consumer surplus (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 1.5 metres and 50% excellent readings for ecological health), median welfare gain is $26 per year. Greater improvements under policies 2 and 3 increase the median gain to $51 and $86 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.

The results of this analysis also highlight the importance of attribute tradeoffs for environmental improvements since we find that welfare gain is much reduced when environmental improvement is accompanied by job losses in dairying. For instance, policy 1 is associated with a welfare gain of $26 per household per year, in the absence of job losses, but is associated with a loss of $4 when jobs in dairying fall by 5%. Median welfare gain for Policy 2 (10% chance of algal blooms, clarity of 2 metres and 60% excellent readings for ecological health) is $35 when associated with a 10% reduction in jobs in dairying, but falls to $30 for Policy 3 – when associated with a 20% reduction in jobs in dairying. In this case it appears that the welfare gains from policy 3 are more than offset by the welfare losses associated with an increase in job losses from ten to twenty percent.

The distributions of median welfare changes associated with a move to the different policy outcomes are plotted in Figures 2 and 3. These figures highlight a narrow distribution for policy 1 and successively broader distributions for policies 2 and 3. For policy 3 - *with no job losses*, the distribution plot is relatively flat with kernel density remaining relatively high even above $200. This is in sharp contrast to policies *with job losses*, where distributions are narrower and kernel density falls to close to zero at WTP less than $200.

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

Attribute	*Status Quo*	Policy 1	Policy 2	Policy 3
SWIM (Chance of Algal Bloom)	50%	20%	10%	2%
CLARITY (metres)	1 m	1.5 m	2 m	4 m
ECOLOGY (% excellent)	40	50	60	80
Median welfare gain – *no job losses* ($ per year)		$26	$51	$86
Mean welfare gain – *no job losses*		$37	$77	$126
JOBS (% jobs lost)	0	-5%	-10%	-20%
Median welfare gain - *with job losses*		$-4	$35	$30
Mean welfare gain - *with job losses*		$-7	$53	$46

The CS estimates derived above can be aggregated as an initial step in determining the overall willingness to pay for improved water quality in Lakes Karapiro and Arapuni. Thus some indication of CS may be gained by multiplying our estimate for median welfare gain from policy 1 ($26) by the approximately 7800 households resident in the catchment, giving a value of $0.2 million per year (or $0.3 million if we take the less conservative approach of using mean values)[8]. 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. 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 household willingness to pay.

[8] These values are intended to indicate orders of magnitude only. Aggregation issues are discussed in Morrison (2000), Bateman et al., (2006) and Borghi (2008).

Figure 2: Distribution of median welfare gain/loss
Policies with No Job Losses

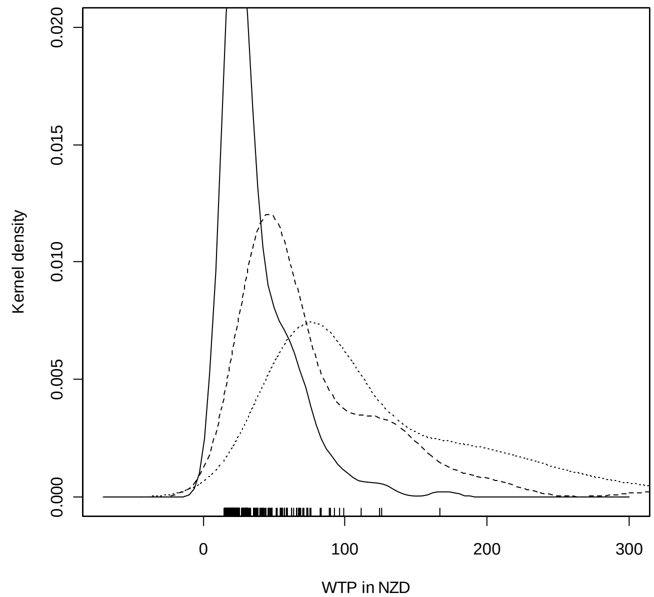
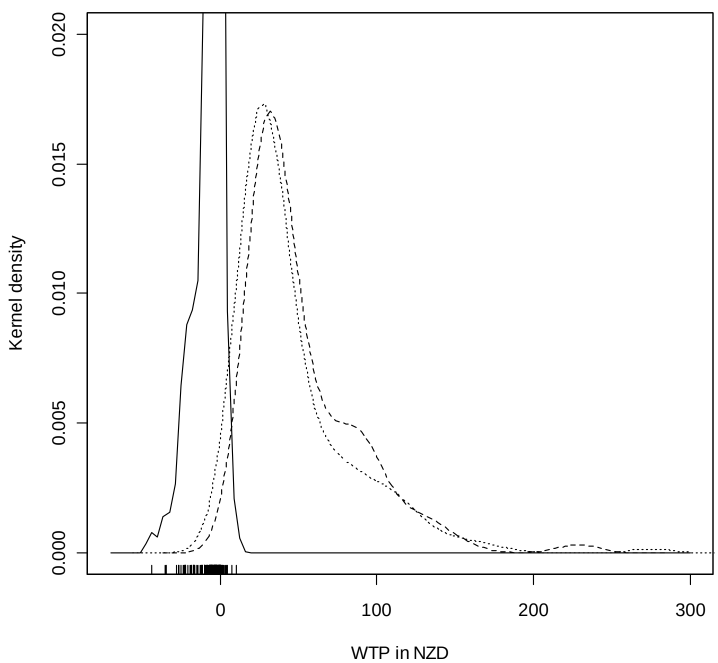


Figure 3: Distribution of median welfare gain/loss
Policies *with* Job Losses



Policy 1	Continuous line	swim20, clar15, eco50
Policy 2	Dashed line	swim10, clar2, eco60
Policy 3	Dotted line	swim2, clar4, eco80

Subject to the caveats detailed above, total catchment CS of catchment residents, for policy 3 (2% chance of algal bloom, 4 metre clarity, >80% excellent ecological health readings), with no job losses, is $0.7 million per year (taking a median value approach), but falls to $0.2 million if associated with job losses in dairying of 20%. While the outcomes associated with policy 3 are 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). Aggregate catchment level CS for this option is estimated to be around $0.2 million per year, but falls to zero if accompanied by a 5% fall in jobs in dairying.

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, especially if the policy will lead to job losses.

4. 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. Our results 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 potentially employment.

Respondents said that they would be willing to pay for water that was safer for swimming and improvements in clarity and ecological health. Median willingness to pay for slight improvements over the status quo was low ($26 per household per year) and zero if accompanied by job losses. Households had a higher willingness to pay for larger improvements with a median value of $126 per year to reduce the chance of algal blooms to 2% while improving clarity and ecological. However, respondents were concerned about job losses in dairying, even where they did not expect to be directly affected. Future work will report on a survey of recreational users and people's willingness to pay 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.

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. Thanks also to Ramesh Baskaran who worked with the author on an earlier version of this paper and wrote earlier drafts of some sections.

References

Adamowicz, W., Boxall, P., Williams, M., & Louviere, J. (1998). Stated Preference Approaches for Measuring Passive Use Values: Choice Experiments and Contingent Valuation. *American Journal of Agricultural Economics, 80*(1), 64-75.

Banzhaf, M. R., Johnson, F. R., & Mathews, K. E. (2001). Opt-out alternatives and anglers' stated preferences. In J. Bennett & R. Blamey (Eds.), *The choice modelling approach to environmental valuation* (pp. 157-177). London Edward Elgar.

Bateman, I. J., Day, B. H., Georgiou, S., & Lake, I. (2006). The aggregation of environmental benefit values: Welfare measures, distance decay and total WTP. *Ecological Economics, 60*(2), 450-460.

Bateman, I. J., Lovett, A. A., & Brainard, J. S. (2005). *Applied Environmental Economics: A GIS Approach to Cost-Benefit Analysis*. Cambridge, .

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

Birol, E., & Cox, V. (2007). Using Choice Experiments to Design Wetland Management Programmes: The Case of Severn Estuary Wetland, UK. *Journal of Environmental Planning and Management, 50*(3), 363-380.

Birol, E., Karousakis, K., & Koundouri, P. (2006). Using a choice experiment to account for preference heterogeneity in wetland attributes: The case of Cheimaditida wetland in Greece. *Ecological Economics*, *60*(1), 145-156.

Blamey, R. K. (1996). Citizens, Consumers and Contingent Valuation: Clarification and the Expression of Citizen Values and Issue-Opinions. In W. Adamowicz, P. Boxall, M. Luckert, W. Phillips & W. White (Eds.), *Forestry, Economics and the Environment*. Wallingford, Oxon: CAB International.

Borghi, J. (2008). Aggregation Rules for Cost-Benefit Analysis: A Health Economics Perspective. *Health Economics, 17*, 863-875.

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.

Caparros, A., Oviedo, J. L., & Campos, P. (2008). Would You Choose Your Preferred Option? Comparing Choice and Recoded Ranking Experiments. *American Journal of Agricultural Economics, 90*(3), 843-855.

Colombo, S., Hanley, N., & Requena, J.-C. (2005). Designing Policy for Reducing the Off-farm Effects of Soil Erosion Using Choice Experiments *Journal of Agricultural Economics, 56(1)*(January), 81-96.

DairyNZ. (2009). *DairyNZ Economic Survey 2007-08*.

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.

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

Longo, A., Markandya, A., & Petrucci, M. (2008). The internalization of externalities in the production of electricity: Willingness to pay for the attributes of a policy for renewable energy. *Ecological Economics, 67*(1), 140-152.

Marsh, D., & Baskaran, R. (2009). Valuation of Water Quality Improvements in the Karapiro Catchment: a Choice Modelling Approach, *Australian Agricultural and Resource Economics Society 53rd Annual Conference*. Cairns, Australia.

McFadden, D. (2010). Sociality, Rationality, and the Ecology of Choice. In S. Hess & A. Daly (Eds.), *Choice Modelling the State-of-the-Art and the State-of-Practice. Proceedings from the Inaugural International Choice Modelling Conference*.

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

Morrison, M. (2000). Aggregation Biases in Stated Preference Studies. *Australian Economic Papers, 39(2)*(June), 215-230.

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

Peterson, G., Brown, T., DW, M., Bell, P., Birjulin, A., & Clarke, A. (1996). Moral Responsibility Effects in Valuation of WTA for Public and Private Goods by the Method of Paired Comparisons. In W. Adamowicz, P. Boxall, M. Luckert, W. Phillips & W. White (Eds.), *Forestry, Economics and the Environment*. Wallingford, Oxon: CAB International.

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).

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.

Thurstone, L. L. (1927c). The Method of Paired Comparisons for Social Values. *Journal of Abnormal and Cocial Psychology, 21*(4), 384-400.

Train, K. (2003). *Discrete choice methods with simulation*. Cambridge: Cambridge University Press.

Train, K. E. (1998). Recreation Demand Models with Taste Differences over People. *Land Economics*, *74*(2), 230-239.

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

von Haefen, R. H. (2003). Incorporating observed choice into the construction of welfare measures from random utility models. *Journal of Environmental Economics and Management*, *45*(2), 145-165.

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.