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An Assessment of the Benefits of Cleaner Streams: A New Zealand Case Study

Dan Marsh and Lena Mkwara

Department of Economics

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Corresponding Author

Dan Marsh

Economics Department
University of Waikato
Private Bag 3105
Hamilton, New Zealand

Tel: +64 (7) 838 4045
Fax: +64 (7) 838 4331

Email: dmarsh@mngt.waikato.ac.nz

Abstract

Water pollution is now considered to be one of the most important environmental issues facing New Zealand. Water quality in rivers, lakes and streams is generally falling alongside the increase in farming intensity, especially in dairying. Currently, technical and regulatory mechanisms to reduce non-point source pollution from agriculture are the focus of an intensive effort involving industry, researchers, regulators and other stakeholders.

The research described in this non-technical paper aims to complement existing knowledge by developing appropriate methodology for valuing water quality improvements in New Zealand. It is envisaged that this type of information will assist the policy process by allowing decision makers to consider both the costs and the benefits of different levels of water quality improvements.

This research is based on a case study of the Karapiro catchment in the North Island of New Zealand. It uses choice analysis to assess people's preferences and willingness to pay for different levels of water quality improvement in catchment streams. Choice analysis methods ask respondents to choose between one group of environmental services or characteristics, at a given price or cost to the individual, and another group of environmental characteristics at a different price or cost. Each respondent is usually asked to repeat this exercise several times.

The results from this study indicate that respondents would be willing to pay for cleaner water for swimming, for better ecological health (with eels, bullies and smelt present), for the presence of trout and for better clarity such that 'you can usually see the bottom'. Respondent preferences were strongest for water suitable for swimming, followed by ecological health, presence of trout and clarity.

Keywords

non-market valuation
choice analysis
water quality
streams

JEL Classification

C51; Q25; Q51

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1. Introduction

Water pollution is now considered to be one of the most important environmental issues facing New Zealand. This paper contributes to the development of methodologies for valuing water quality improvements in New Zealand by describing and quantifying the willingness of people to pay for water quality improvements in the streams of the Karapiro catchment in the Waikato region. It is a component of the Foundation for Research Science and Technology (FRST) programme C10X0603 *Delivering Tools for Improved Environmental Performance*. The aims of this programme are 'to provide quantitative approaches to farmers and policy agents to aid their decision making around farm practice and policy development and 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).

Our contribution to the FRST programme has two components: one relating to the quality of water in local streams, as reported in this paper, and one relating to the quality of water in Lakes Karapiro and Arapuni as reported in Marsh *et al*. (2010; 2009). Both aspects are based on the choice analysis method of non-market valuation[1]. This is a very rapidly growing discipline especially in Europe, where many choice modelling studies are being undertaken to assess policies formulated to meet the requirements of the EU Water Framework Directive.

There is a substantial international literature attempting to value the costs caused by the loss in water quality resulting from agricultural pollution. New Zealand research in this field is more limited but may be dated to the work of contributors such as Forbes (1984) on the costs and benefits of reducing eutrophication in Lake Tutira (in northern Hawke's Bay). 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 addressing values associated with proposed changes directly affecting rivers.

2. The Karapiro Catchment

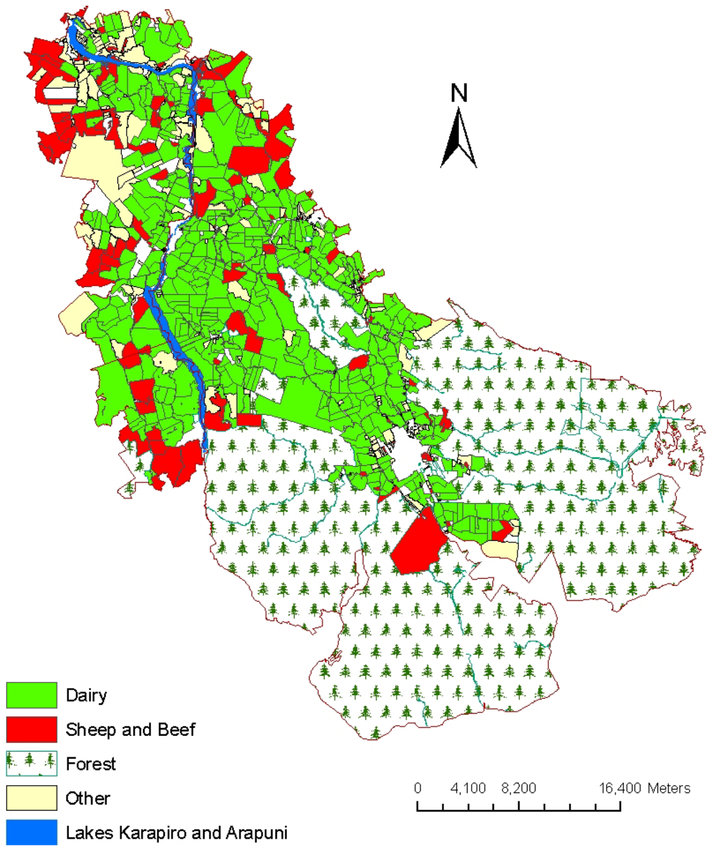
The Upper Waikato, including all land that drains into the Waikato River from the outflow of Lake Taupo to the Karapiro dam, has been identified as one of the water bodies in the Waikato region with a high priority for nutrient management (Broadnax, 2006). The study area for this research (the 'Karapiro catchment') covers over 155,303 hectares and is defined as the lower part of this catchment from Lake Arapuni to the Karapiro dam and contributing tributaries (Figure 1). Land use is predominantly dairy (34 percent), pastoral[2] (13 percent)

[1] For a good non-technical description of choice analysis (contingent choice) go to the web at http://www.ecosystemvaluation.org/contingent_choice.htm

[2] Includes grazing, dry stock, sheep, beef and deer.

and forestry (48 percent). 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[3] and planned land use changes in the catchment between Karapiro Dam and the Taupo outlet 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



Source: Ramilan (2008).

While some aspects of water quality in the Upper Waikato have improved over the past decade as a result of a reduction in point source pollution[4], the level of nitrogen and phosphorous flowing in from tributaries has generally increased. It is expected to continue to increase due to intensification and conversion of land from forestry to dairy. Even with good farm management practices, it is expected that the level of nitrogen and phosphorous in many catchment streams will continue to rise. The ecological health of many streams in the catchment is reported to be poor. The Karapiro catchment is within the lower Waikato catchment zone where Environment Waikato reports that 68 percent of ecological health readings are unsatisfactory with only two percent rated as excellent.

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[3] Approximately 10,000 to 15,000 hectares have been converted already from forest to dairy activity (personal communication).

[4] Improved wastewater treatment at Wairakei power station and Kinleith paper and pulp mill and improved sewage treatment at Taupo.

3. Method

Four focus groups were held to establish an understanding of people's views on water quality in the catchment and to identify attributes for inclusion in the choice analysis. These sessions were also used to test early versions of the questionnaire and to discuss the appropriate range of values for the payment variable. Focus groups were held at the University of Waikato and at three primary schools representing different areas of the catchment (Karapiro, Kuranui and Waotu).

Focus group discussions highlighted the increasing number of fences on farms restricting livestock access to streams and creeks, and hence livestock pollution. This was recognised as an improvement with many participants believing that stream water quality was improving, especially when streams were protected by fenced areas of bush creating a natural filter. Focus group participants from different areas had different perceptions of the quality of their local streams. Some streams observed by participants in the Karapiro focus group were perceived as having poor water quality while participants at the Waotu group reported high quality streams available for domestic drinking water and containing trout. Further details on focus group procedures can be found in Marsh & Baskaran (2009).

Questionnaire development and improvement occurred over an extended period. Testing started with 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 a literature review and discussions with experts in the field. The final questionnaire included two choice experiments: one relating to the quality of water in Lakes Karapiro and Arapuni (Marsh *et al*. 2009) the other, reported here, relating to the quality of water in local streams. The attributes selected eventually for the streams choice experiment were:

- Suitability for swimming (percentage of readings that are satisfactory for swimming);
- Ecology (percentage of excellent readings);
- Native, fish and eels (presence of);
- Trout (presence of);
- Water clarity (can you usually see the bottom?).

Attribute definitions and levels are provided in Tables 1 and 2. Suitability for swimming and ecological quality were defined using criteria established by EW whereby water is assessed as being suitable for swimming (or not) and ecological health is assessed as being excellent, satisfactory or not satisfactory. The suitability for swimming attribute aligns with the proposed national policy statement for freshwater management that aimed to ensure that appropriate freshwater reaches or exceeds a swimmable standard. This attribute is also intended as a 'catch all' that enables respondents to state their preference for water that is safe for all forms of contact recreation (such as swimming, paddling, fishing and eeling).

The ecology attribute aligns with data collected by Environment Waikato (EW) on the ecological health of waterways in the catchment. Based on 100 monitoring sites across the region, EW reports that ecological health readings for undeveloped catchments range from 23 percent to 100 percent excellent, but for developed catchments the percentage of excellent readings ranges from 0 and 25 percent. The Karapiro catchment falls under the lower Waikato catchment zone where 68 percent of ecological health readings are reported to be unsatisfactory with only two percent excellent. The ecological health and 'native fish and eels' attributes are assumed to vary together. Poor water quality, for example, results in 'only small eels being found in most catchment streams' while high water quality leads to 'large eels, bullies and smelt being found'.

Table 1: Explanation of Aspects for Choice Cards
Information provided to respondents

Suitability for Swimming	Suitability for swimming is based on levels of E. coli bacteria - an indicator of the human health risk from harmful micro-organisms present in water, for example, from human or animal faeces. The median number of E. coli bacteria present in water samples should be less than 126 per 100 ml of water if it is to be used for recreation. • Ideally, 100% of readings would be satisfactory for swimming.
Ecological Health	Ecological health is the standards Environment Waikato uses to assess whether water quality is good enough for plant and animal health. • Ideally, 100% of ecological health readings would be excellent for plant and animal health. • If water quality continues to fall then fewer than 40% of readings will be excellent and up to 40% will be unsatisfactory.
Ecological Health Readings cover these Themes	• *Dissolved oxygen* is important for fish and other aquatic life to breath. • *pH* is a measure of the acidity or alkalinity of water. • *Turbity* is a measure of the murkiness of water. • *Total ammonia.* High levels of ammonia are toxic to aquatic life, especially fish. • *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.
Presence of Native Fish, Eels and Invertebrates	Migratory native fish are not found in catchment streams because of the hydro dams. Eel numbers depend on the number of baby eels transported over the Karapiro dam. Small eels are found even in polluted water. If water quality improves, then other species, such as bullies, smelt and koura will become more common. Large eel numbers would also increase.
Presence of Trout	Currently, trout are found only in some streams with high water quality. If water quality improves, trout may be found in more streams.
Clarity	Currently, water clarity in streams is often poor such that usually the bottom cannot be seen. If water quality improves, so too will clarity and there will be more streams where the bottom can be seen.

Table 2: Attribute Levels

Attribute	Current Situation	Improvement Levels		
Suitability for Swimming (*Percent of readings rated as satisfactory for swimming*)	30%	50%	70%	90%
Variables		SWIM50	SWIM70	SWIM90
Ecology (*Percent of readings rated as excellent*)	<40%	40-70%	>70%	
	Only small eels	Small eels, bullies and smelt	Large eels, bullies and smelt	
Variable		ECOM	ECOH	
Trout	*No* Trout	Trout *are* found		
Variable		TROUT		
Water Clarity	Usually you *cannot* see the bottom	Usually you *can* see the bottom		
Variable		CLARITY		
Cost to Household (*Dollars per year for the next 10 years*)	$0	$50, $100, $200		
Variable		COST		

The ecology of rivers and streams in the catchment has been affected adversely by the clearance of forests and riverside vegetation, habitat loss and the creation of barriers to fish passage (including dams). Aquatic plants and animals have also been affected by reduced water quality, changes to flow regimes, habitat loss (due to drainage and changes in land use) and introduced species that compete with or eat native fish (Environment Waikato, 2010).

Native fish populations in the Waikato Region are documented in Joy (2005) and more recently in the chapter on native fish (David & Speirs, 2010) in the book 'The Waters of the Waikato'. These species are highly affected by the Waikato dams which prevent fish migration. The population of eels depends on recruitment (which has been falling steadily in recent years) and the number of elvers transported over the hydro dams. Shortfin eels (Anguilla australis) are very tolerant of poor water quality and may even increase with rising levels of N and P. In poor conditions these eels are mainly 30 to 40 cms in length. If water quality increases (and sufficient numbers are moved over the hydro dams), then the population of longfin eels (Anguilla dieffenbachia) should increase. This species is far less tolerant of poor water quality and can grow to two metres in length. Native bullies and smelt should be migratory, but landlocked populations exist in Lake Taupo. Numbers are expected to increase with better water quality.

Respondents were asked for their assessment of the condition of streams in the catchment based on the attributes and levels used for the choice cards. Respondents who indicated that they had ‘no idea’ of the quality of the streams in the catchment were presented with the *status quo* defined as ‘our assessment of the current overall condition of streams in the catchment’ (see Table 1). In this case, we described the current situation as fewer than 30 percent of readings are rated as satisfactory for swimming, fewer than 40 percent of ecological health readings are excellent and no native fish other than small eels are found, trout are not present and clarity is poor such that usually you cannot see the bottom of streams.

During the survey, respondents who felt able to make their own assessment of stream quality used their perceived quality assessment as the *status quo*. In this case, attribute levels were entered onto a transparent overlay and placed on top of each page of choice cards to make it easier for respondents to compare their perceived *status quo* with the alternative levels offered in each choice card. This aspect of our methodological approach is discussed in more detail in Marsh *et al*. 2010).

The initial sample for this study was drawn using the Land Information New Zealand (LINZ) property title database to produce a list of all 7627 properties in the catchment including physical location, territorial authority and other variables. The population was separated into three strata to reflect the markedly different socioeconomic characteristics of these areas, namely, Tokoroa, Putaruru/Tirau and the remaining rural areas. Table 3 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 3: Estimated Population and Number of Completed Surveys

Stratum	Population	Number 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.
Source: Statistics New Zealand and authors.

4. Sample Characteristics and Perceptions

Table 4 provides details of the proportion of respondents who lived adjacent to lakes, rivers and streams. Overall, 25 percent have a stream adjoining their property with 30 percent being adjacent to a water body of some sort. Respondent perceptions of the quality of water in catchment streams are reported in Tables 5 and 6.

Table 4: Number of Sample Households Living Next to Lakes, Rivers and Streams

	Tokoroa		Putaruru/ Tirau		Rural		All	
Lake	0	0%	1	2%	7	11%	8	4%
River	0	0%	0	0%	14	9%	9	5%
Stream/Creek	8	14%	5	9%	32	50%	45	25%
Any water body	8	14%	6	11%	40	63%	54	30%
Total Interviewed	58		56		64		178	100%

Note: In the rural stratum, some households had more than one type of water body on their property, hence 53 Lakes Rivers or streams, but only 40 households indicating water body's present.

Table 5: Household Assessment of the Condition of Streams, Creeks and Small Rivers
Karapiro Catchment, Swimming and Clarity

	Tokoroa		Putaruru/ Tirau		Rural		All	
Suitability for Swimming								
High (90%)	8	20%	11	31%	16	33%	35	28%
Medium (30-90%)	13	32%	14	39%	21	43%	48	38%
Low (30% or less)	20	49%	11	31%	12	24%	43	34%
Total	41		36		49		126	100%
Clarity: Able to See the Bottom								
Usually yes	27	60%	23	58%	33	63%	83	61%
Usually no	18	40%	17	43%	19	37%	54	39%
Total	45		40		52		137	100%

Note: Household who responded 'don't know' are excluded.

Table 6: Household Assessment of the Condition of Lakes and Streams
Karapiro Catchment, Ecology, Fish/Eels and Trout

	Tokoroa		Putaruru/ Tirau		Rural		All	
Ecology								
High (70% or more)	5	14%	10	33%	16	36%	31	28%
Medium (40-70%)	15	41%	11	37%	19	43%	45	41%
Low (40% or less)	17	46%	9	30%	9	20%	35	32%
Total	37		30		44		111	101%
Fish/Eels								
Large eels, bullies and smelt found	12	41%	10	34%	19	48%	41	42%
Small eels, bullies and smelt found	7	24%	12	41%	14	35%	33	34%
Only small eels found	10	34%	7	24%	7	18%	24	24%
Total	29		29		40		98	100%
Trout								
Trout are present	10	28%	11	33%	9	23%	30	28%
Trout are absent	26	72%	22	67%	30	77%	78	72%
Total	36		33		39		108	100%

Note: Household who responded 'don't know' are excluded.

Overall, 29 percent of respondents stated that they had no idea regarding the suitability of the catchment streams for swimming. In addition:

- 23% had no idea regarding clarity,
- 38% had no idea regarding ecological health
- 45% had no idea regarding the presence of native fish and eels
- 39% had no idea whether trout were present or absent.

As might be expected, rural residents were somewhat less likely to report that they had ‘no idea’ about these attributes. Respondent perceptions on suitability of streams for swimming were widely distributed. 28 percent thought suitability was high, 38 percent thought that it was medium and only 34 percent agreed with our assessment of the *status quo*, namely, that suitability was low (excluding ‘don’t knows’). Similar results were obtained for ecological health with 28 percent reporting excellent ecological health, 41 percent medium and 32 percent low ecological health. Only 28 percent of respondents agreed with our assessment of the *status quo*, namely, that only small eels are usually found, with large eels, bullies and smelt being generally absent.

5. Key Results

Table 7 shows our estimation results based on the Random Parameter Logit (RPL) Model. This model takes account of the fact that different individuals often have different preferences. Some individuals, for example, may be concerned about ecological health and native fish and not concerned with whether trout are present. Others may be concerned with safety for swimming and less concerned about ecological health.

Table 7: Estimation Results for MNL and RPL Models

	MNL Model		**RPL Model**		
Variable	**Coefficient**	**Std Error**	**Coefficient**	**Std Error**	
ASC	-0.505***	0.106	-0.148	0.277	*R*
SWIM50	0.411***	0.115	0.601***	0.184	*F*
SWIM70	0.687***	0.133	1.200***	0.201	*F*
SWIM90	1.042***	0.120	1.695***	0.243	*R*
ECOM	0.280***	0.108	0.611***	0.166	*F*
ECOH	0.707***	0.105	1.253***	0.212	*R*
TROUT	0.591***	0.100	1.095***	0.169	*R*
CLARITY	0.558***	0.088	0.790***	0.144	*F*
COST	-0.009***	0.001	-0.019***	0.002	*R*
Summary Statistics					
Log L		-986.3		-825.8	
AIC		1.885		1.589	
BIC		1.927		1.65	
R^2 (McFadden)		0.135		0.288	
N (Respondents)		176		176	

Notes: *******, ****** and ***** denote significance at 1%, 5% and 10% respectively. MNL (Multinomial Logit Model). RPL (Random Parameter Logit Model). R and F denote parameter is fixed or random in the RPL model.

The output of our model can be used to estimate respondent's marginal willingness to pay, that is, how much a household would be willing to pay per year to improve water quality from the *status quo* to the defined level, holding other attributes constant. The absolute values in Table 8 should, however, be interpreted with caution. In particular, it should be noted that there is a wide distribution ranging from zero, that is, respondents who would not be willing to pay anything for improved water quality to those who state that they would be willing to pay quite large amounts. In general, it is more appropriate to report median values (for example, the amount that 50 percent of the population would be willing to pay, while 50 percent would be willing to pay less). This is justified partly by reference to the political and policy making process where the views of the 'median' voter tend to have a greater influence on policy making.

Table 8: Willingness to Pay for Water Quality Improvements in Streams
Household Per Year, Dollars

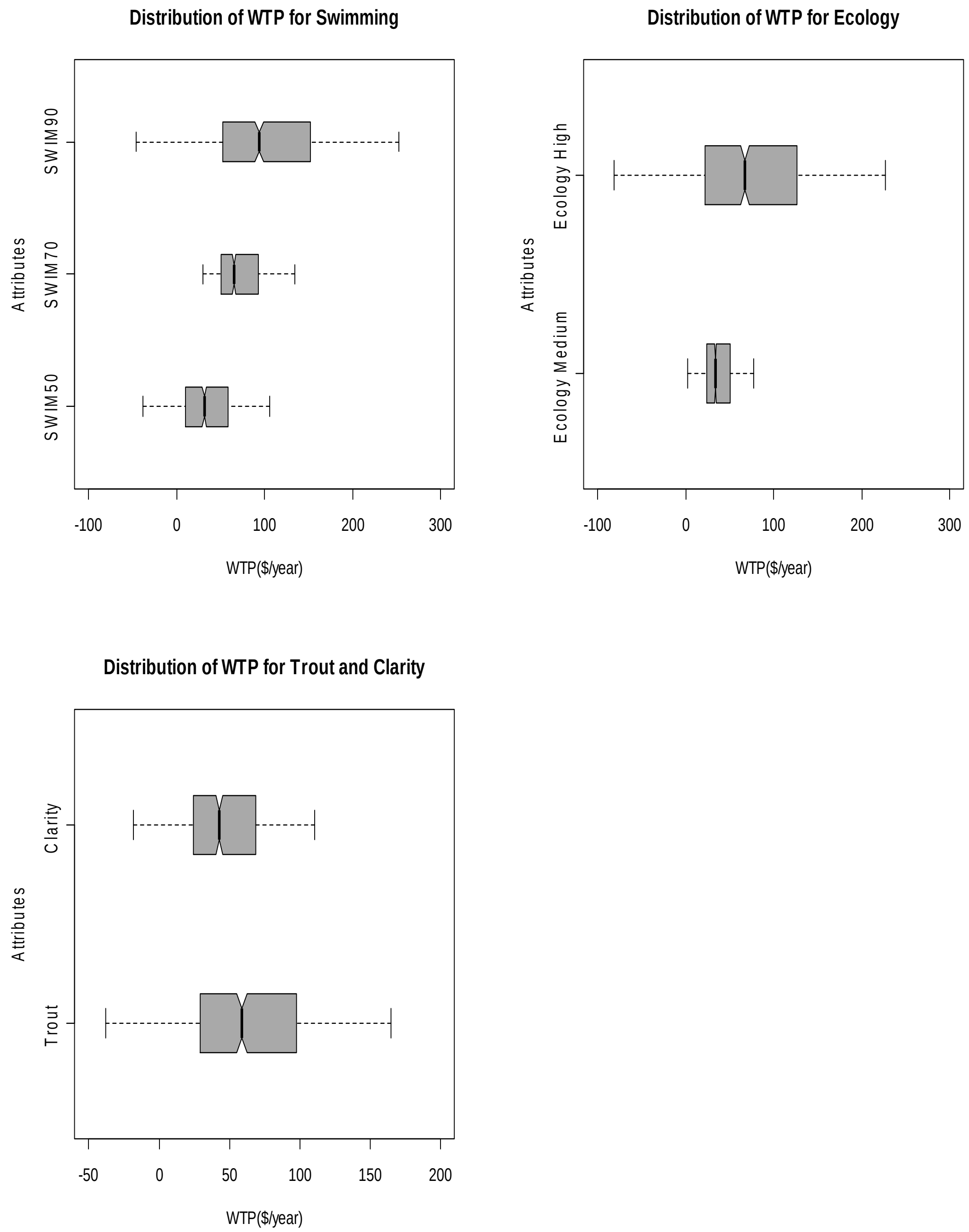
Attribute		**1st Quartile**	**Median**	**Mean**	**3rd Quartile**
Suitability for swimming	SWIM 50	12	33	45	59
	SWIM 70	51	66	92	95
(*Percent of readings satisfactory for swimming)*	SWIM90	55	96	134	154
Ecological health	ECOM	24	34	47	50
(*Percent excellent readings*)	ECOH	26	70	97	126
Water Clarity (*Ability to see the bottom*)	CLARITY	26	44	61	70
Trout (*presence of*)	TROUT	32	60	84	99

Note: Values here are based on the RPL Model.

Respondents value and state that they would be willing to pay for cleaner water (higher percentage of readings satisfactory for swimming), water with better ecological health (with eels, bullies and smelt present), presence of trout and with better clarity such that 'you can usually see the bottom'. Respondent preferences were strongest for water suitable for swimming (SWIM90) followed by excellent ecological health (ECOH), presence of trout and clarity.

Figure 2 provides an alternative representation of the distribution of willingness to pay for the different attributes. The upper and the lower limits of the cumulative distributions are indicated by the short vertical lines at the end of the dotted lines. The upper and lower quartiles are indicated by the shaded area, with the median value being designated by a notch. The width of the notch shows the 95% confidence interval for the median.

Figure 2: Box plots Showing Distribution of WTP in $ per Household per Year



Respondents had an average (median) willingness to pay of $96 per year to increase suitability for swimming from the current level (fewer than 30 percent satisfactory readings) to at least 90 percent of satisfactory readings. In addition:

- 75% of people would be willing to pay at least $55 for the same improvement (1st quartile);
- 25% of people would be willing to pay more than $154 (3rd quartile).

Respondents had an average (median) willingness to pay of $70 per year to increase ecological health from the current level (fewer than 40 percent excellent readings) to at least 90 percent of excellent readings.

- 75% of people would be willing to pay at least $26 for the same improvement (1st quartile);
- 25% of people would be willing to pay more than $126 (3rd quartile).

Respondents had an average (median) willingness to pay of $60 per year to improve water quality so that trout are usually present in streams and $44 to improve clarity such that ‘you can usually see the bottom’.

6. Conclusions

The economic approach to pollution control typically seeks to answer two main questions, namely, what is the ‘efficient’ level of pollution and how should this level be achieved? While some policy makers and the general public may believe that the efficient level of pollution is zero this is probably not the case. The Waikato River, for example, could, perhaps, be returned to its condition before the arrival of Europeans by the 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 costs should be compared with the benefits that would accrue from these improvements in order to decide the best policy outcome.

We have described the development of a choice analysis approach for assessing the value of water quality improvements in New Zealand streams. 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. Respondents say that they would be willing to pay for cleaner water to a level that is satisfactory for swimming, has better ecological health (with eels, bullies and smelt present), presence of trout and with a better clarity such that ‘you can usually see the bottom’. Respondent preferences were strongest for water suitable for swimming, followed by ecological health, presence of trout and clarity.

To build a more comprehensive assessment, future work will include an investigation into people’s willingness to pay for water quality improvements in Lakes Karapiro and Arapuni (Marsh, 2010) together with the views of recreational users. This data will then be combined with research into the cost of achieving different levels of water quality improvements. The outcomes from this research should allow decision makers to consider both the costs and the benefits of different policies, thereby allowing farmers and policy makers to identify the most cost effective options for achieving any given improvement in water quality.

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