The influence of local environmental quality on values for river and stream conservation programs in Canterbury

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A fundamental question when aggregating environmental values across populations is whether values systematically differ within the population being aggregated. This study combines choice experiment and biophysical data in a Geographical Information System to develop a method to evaluate the influence of local water quality on respondent's willingness-to-pay for river and stream conservation programs in Canterbury. Random Parameter Logit model results show respondents willingness-to-pay for conservation programs is influenced by local river and stream quality. Those respondents whose local waterway is of low quality are willing-to-pay more for improvements relative to those whose local waterway is of high quality. This study also provides improvements in policy analysis by constructing compensating surplus estimates conditional on respondents' local biophysical data.

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1. Introduction

Analysis of spatial relationships is well established in economics and traditionally centres on the premise that model variables are correlated based on their geographical proximity. In the field of non-market valuation estimation of spatial relationships is at the foundation of the travel-cost and hedonic methods and both are now often conducted using Geographical Information Systems (GIS) to construct spatial variables for inclusion in modelling (Bateman et. al., 2002; Bastian et al., 2002; Ready and Abdalla, 2005). Stated preference methods have also been used to examine spatial relationships (Johnston et. al., 2002). The impact of distance from a site being valued on willingness-to-pay (WTP) has received attention by Bateman (2006) who uses contingent valuation while Concu (2007) uses a choice experiment. Recently, Campbell et al. (2009) uses a choice experiment to explore the spatial distribution of WTP for rural landscape improvements.

This study combines choice experiment and biophysical data via GIS in developing a method to evaluate the influence of local water quality on respondent's willingness-to-pay for river and stream conservation programs in Canterbury. The paper proceeds as follows. Section 2 describes the study background. Section 3 presents the statistical model. Section 4 provides the survey design, biophysical data and survey logistics. Section 5 presents the model estimation, willingness-to-pay, and compensating surplus estimates of attribute improvements. Section 6 presents policy implications of the study. Finally section 7 summarizes the main conclusions.

2. Agricultural Impact on Water Quality and Quantity in Canterbury

Increasing replacement of dry land pastoral and arable farming by water intensive dairy farming is a significant current trend in the Canterbury plains. Dairy stock unit numbers in Canterbury have increased rapidly and the trend is continuing. The environmental implications of these land uses changes and intensification of production have been well researched with a growing body of scientific literature outlining the impending consequences if inadequate action is taken. Studies of trends in water quality and contrasting land cover indicate a positive relationship between dairy stock numbers and decreasing water quality (Larned et. al., 2004). Increases in water borne pathogens such as Campylobacter have been reported (Ross and Donnison, 2003, 2004), as have increases in nitrogen and dissolved reactive phosphorous in water-ways (Cameron et.al. 2002; Cameron and Di, 2004; Hamill and McBride 2003). The long term consequences of land application of animal effluent are uncertain (Wang and Magesan, 2004). The rates of fertiliser and pesticide applications have increased dramatically over the past decade and are forecast to continue increasing (PCE, 2004). There has been a significant increase in groundwater abstraction associated with land use intensification has contributed to a decline in groundwater levels and reduced flows in rivers and lowland streams. For example, Environment Canterbury (ECan) records show a 260 per cent increase in the amount of irrigated land from 1985 to 2005, and some 70 per cent of consumptive use of water in the region is for pastoral purposes (Sage 2008). Increased irrigation also means increased agricultural production and more intensive use of land.

3. Statistical Model

While the costs of environmental policies aimed at reducing agricultural impacts on Canterbury's waterways are relatively straight-forward to measure, the benefits are much more difficult to quantify. The stated preference method of choice modelling is one tool that allows the analyst to estimate benefits (values) for multiple outcomes of environmental policy. The respondent is presented with several alternatives and each alternative is made up of combinations of attributes. In this paper, each attribute has at least two levels and they are varied systematically according to an experimental design. The respondent is asked to indicate the alternative they prefer most. The variation generated between the attributes and the alternative chosen is modelled using a discrete choice probabilistic method where the dependent variable is the probability of choosing an alternative given the levels of attributes in that chosen alternative.

Choice experiments are an application of both Lancaster's characteristics theory of value and random utility theory (RUT). Lancaster proposed that utility is not derived directly from the purchase of a good, but from the attributes that the good possesses (Lancaster, 1966). This means that utilities for goods can be decomposed into separable utilities for their attributes. Thurstone (1927) proposed RUT as the basis for explaining dominance judgements among pairs of offerings. As conceived by Thurstone, consumers should try to choose the offerings they like best, subject to constraints such as time and income following usual economic theory. A consumer may not choose what appears to be the optimal alternative. Such variations in choice can be explained by proposing a random element as a component of the consumer's utility function. That is,

(1) $U_i = V_i + \varepsilon_i$

Where U_i is the unobservable true utility of offering I; V_i is the systematic (i.e. known) component of utility; and ε_i is the random component. Individuals are asked to choose between alternative goods, which are described in terms of their attributes, one of which is price (or a proxy).

(2) $Prob_i(j|C) = Prob(V_{ij} + \varepsilon_{ij} > V_{ik} + \varepsilon_{ik})$

Different probabilistic choice models can be derived depending on the specific assumptions that are made about the distribution of the random error component. If errors are assumed to be distributed according to a type 1 extreme value distribution, a conditional or multinomial logit model (McFadden, 1974) can be specified:

(3) $Prob_i(j|C) = exp(\mu(\theta_0 + \alpha P_j + \beta' X_j))/\sum_C exp(\mu(\theta_0 + \alpha P_C + \beta' X_C)$

This equation can be estimated by conventional maximum likelihood procedures. For this specification, selections from the choice set must obey the independence from irrelevant alternatives' (IIA) property. This property states that the relative probabilities of two options being selected are unaffected by the introduction or removal of other alternatives. This property follows from the independence of the error terms across the different options contained in the choice set. If the IIA assumption is violated then other models must be used that relax this assumption by employing more complex specifications of the covariance matrix of the error distribution. These include the multinomial probit, the nested logit, the random parameters logit, and the heterogeneous extreme value logit. The most widely used test for violations of IIA is provided by Hausman and McFadden (1984). This test is performed resulting in rejection of the null hypothesis of IIA/IID for all excluded options for all models presented in this paper. In view of this, an application of an advanced random utility model, that is Random Parameter Logit (RPL) was considered in this paper. The RPL model is a generalisation of the Multinomial Logit model that explicitly considers taste variation (heterogeneity) among respondents. The model provides the analyst with valuable information which accounts for different individuals making different choices when faced with the same choice sets and thus, provides a highly intuitive interpretation of choice behaviour parameter estimates (Train 2003). The model is estimated by simulating the log-likelihood function because of a non-closed form solution.

4. Survey Design

The development of the set of attributes to be valued consisted of two main procedures, first a survey of relevant policy documents and expert based opinion, and second focus groups and cognitive interviews (Dillman, 2007) of Canterbury residents. To elicit expert opinion on which impacts were the most significant from a policy maker perspective, several meetings were conducted with Environment Canterbury (ECan) policy analysts and their information were used to construct a survey which were eventually sent to relevant ECan staff. Table 1 shows the main questions contained in that survey.

Table 1: Expert opinion ECan survey

Question 1	What agricultural impacts on rivers and streams are you familiar with in your general activities at Environment Canterbury?
Question 2	Please rank the 4 most significant impacts in order by placing a number next to the list above with 1 representing the most significant impact.
Question 3	How are these impacts measured?
Question 4	What is the range of typically observed values for these measurements?

The survey revealed that the variables which are scientific and technical in nature that are most relevant to the policy process. For example, question 2 stated the top four were E.Coli (mpn/100ml), Nitrate (mg/L), Phosphate(mg/L) and Pesticides (mg/l).

The challenge is to take the scientific measures and match them up with descriptions of impacts that are salient to Canterbury residents. A starting point is to recognise that it is not the pollutant *per se* that has dissatisfaction for Canterbury residents but the values for rivers and streams held by those residents that are impinged on by the presence of pollutants. To explore these issues further, two focus groups interviews were conducted with Canterbury residents. Participants for focus groups were randomly selected from phone listings. First interview was held in central Christchurch aimed at gaining an urban perspective and the other was conducted in Lincoln to get a rural sample perspective. There were 10 cognitive interviews conducted each in central Christchurch and Lincoln,respectively.Three environmental attributes were indentified to be included in the choice experiment and these are shown in Table 2. The cost attribute is defined as an annual household payment via local council tax rates. The first environmental attribute is the risk of people getting sick from microorganisms in animal waste that end up in waterways. Exposure is via recreational contact, and risk is measured as the number of people out of one thousand that would become sick annually. The definition level of risk is similar to Adamowicz (2007) who uses one out of one hundred thousand people. The magnitude of changes in levels was guided by studies that examined current and potential water borne pathogen risks to human health in New Zealand (Ball, 2006; McBride et al., 2002).

Table 2: Attributes and levels used in choice sets

Attribute	Base Level	Improvement Level
Health Risk	60	10 and 30 people/1000/year
Ecology	Poor	Fair and Good
Flow	5	1 and 3 months of low-flow/year
Cost	$0	$15,$30,$45,$60,$75 and $90/household/year

The second attribute allows the analyst to value the impact of excess nutrients on the ecological quality of rivers and streams. The descriptions of the ecological levels for water quality were in accordance to ECan (2007) measurement. For example, the ecological levels were constructed using the Quantitative Macro invertebrate Index developed by ECan (2003) and other studies (Stark 1998; Stark and Maxted 2007; Stark and Maxted 2007b). Table 3 shows the descriptions used.

Table 3: Ecology attribute level definitions

Poor quality	**Weeds** are the only aquatic plants present and cover **most** of the stream channel. The stream-bed is covered **mostly** by thick green algae mats. Only pollution tolerant insect populations are present. **No fish** species are present.
Fair quality	**About 50%** of stream channel covered by plants. **Few** types of aquatic plants, insects and fish. Algae covering **about 20%** of stream bed. Population densities are **reduced**.

Good quality	**Less than 50%** of stream channel covered by plants. Algae cover **less than 20%** of stream-bed, there is a **diverse** and **abundant** range of aquatic plants, fish and insects. Insect communities are dominated by favourable species with pollution sensitive populations present.

The third environmental attribute allows us to value the impact of low-flow conditions. This attribute is measured as the number of months that a river is in low-flow. The description of the impact of low-flow conditions on rivers and streams was recommended by Ministry for the Environment (2008a, 2008b). A waterway is experiencing low-flow conditions when flow rate fall below a minimum level necessary to protect recreational and ecological quality. The range in levels was defined by flow rate data from the Environment Canterbury website (www.ecan.govt.nz) and ECan (2001).

The experimental design used is D-efficient main effects fractional factorial design constructed utilising procedures from Street and Burgess (2005). The experimental design consisted of 18 treatments which were randomly blocked into 3 blocks of 6 choice sets. Figure 1 provides an example of a choice set. The constant base alternative (Option 1) was assumed to be a worsening condition of rivers and streams if no change in management occurs. In the 'No change' scenario there would be no annual tax payment by the household, however it is assumed the risk of getting sick will be at its greatest, ecological quality will be poor, and the number of low-flow months will be at its highest.

Figure: 1 Example choice set

Outcomes	Option 1: No change	Option 2	Option 3
For every 1000 people, the number who become sick from recreational contact each year would be	60	30	10
Ecological quality of local streams and rivers	Poor	Good	Good
Number of low flow months	5	5	1
Annual cost to Canterbury households	$0	$15	$75

☐ I would choose option 1

☐ I would choose option 2

☐ I would choose option 3

The survey consisted of three parts. The first part of the survey, some questions were asked in order to measure respondents' attitudes towards agri-environmental policy in Canterbury. The second part consists of choice sets and the third part of the survey concluded with households' socio-demographic questions. The first and third parts are designed to capture preference heterogeneity that are not captured by the attributes in the choice sets. The first part of the survey, in Section 1, respondents were asked to indicate agreement or disagreement statements on a Likert scale of 5 levels (disagree strongly, disagree, agree, agree strongly, and don't know). Table 4 provides the statements used.

Table 4: Agri-environmental attitudinal statements measured on Likert scale

Statement 1	Agricultural production today is environmentally safe
Statement 2	Canterbury ratepayers as a whole should pay the costs of cleaning up and preventing agriculture's impact on water resources
Statement 3	Farmers should pay for the costs of cleaning up and preventing agriculture's

	impact on water
Statement 4	The agricultural landscape is important in Canterbury
Statement 5	A price should be charged for water for irrigation
Statement 6	Agriculture should fully convert to organic farming methods

The second set of questions in Section One, respondents were asked to indicate how rivers and streams are important to them. Table 5 shows the options respondents had to choose from. They were able to select more than one.

Table 5: Importance of Canterbury rivers and streams to respondents

Importance 1	Resource for future generations
Importance 2	Recreational opportunities
Importance 3	Habitat for plants and animals
Importance 4	Resource for commercial development
Importance 5	I just like knowing that they are there
Importance 6	Drinking water resource for public

4.1. Biophysical Data and GIS method

Three biophysical datasets were obtained from Environment Canterbury that relate to attributes being considered. The first dataset relates to the Health Risk attribute and contains recreation grades for 56 sites that indicate the suitability of a site for recreational contact. The grade is constructed based on measured E.Coli levels in the rivers which are an indicator of pathogen presence. The higher the measured levels of E.Coli, the lower the Recreation Grade, and therefore the likelihood of becoming sick is higher for the swimmers.

The second dataset relates to the Ecology attribute which consists of Semi Quantitative Macro Invertebrate Community Index (SQMCI) scores. This will be used as indicators for ecological qualities on 431 sites. The higher the score the better the ecological quality. ECan has a target of achieving a score of five or more.

The third dataset relates to the Flow attribute which contains of daily flow rate measures for 70 sites. To indicate rivers that are experiencing low flows relative to historical trends, the flow sites were categorised into stratum according to daily median flow for the last hydrological year relative to the median daily flow rate over the entire data series, typically three hydrological years.

Respondents' addresses were geocoded into a Geographical Information System, ArcView 9. The geographically closest biophysical data points, one for each of the three biophysical variables, were obtained for use in the econometric models. Table 6 below shows the distribution of respondents in relation to their closest biophysical data point. For example, the closest Recreation Grade for 70% of respondents was 'Very Poor'.

Table 6: Respondent distribution of biophysical data

Recreation Grade	% of Sample	SQMCI Median Score	% of Sample	Flow Change	% of sample
Very Poor	70	0 to 1	0	Increase	6
Poor	4	1 to 2	13	0 to 10% less	44
Fair	7	2 to 3	26	10% to 20% less	9
Good	4	3 to 4	17	20% to 30% less	14
Very Good	15	4 to 5	12	30% to 40% less	18
		5 to 6	12	>50% less	9
		6 to 7	11		
		>7	9		

The inclusion of this spatially related biophysical data into the valuation method will facilitate the testing of the following spatial hypotheses relating river and stream quality to respondent's willingness-to-pay for conservation program attributes:

Ecological Quality

H_0: Respondents' local ecological quality influences their WTP for improvements in ecological quality.

H_1: Respondents' local ecological quality does not influence their WTP for improvements in ecological quality.

Under the null hypothesis, respondents who experience poor ecological quality have higher WTP for improving the Ecology attribute.

Risk of Sickness from Recreational Contact

H_0: Respondents' local Recreation Grade influences their WTP to decrease the risk of sickness from recreation.

H_1: Respondents' local Recreation Grade does not influence their WTP to decrease the risk of sickness from recreation.

Under the null hypothesis, respondents who experience poor local recreational grade have higher WTP for improving the Health Risk attribute.

Low-Flow Conditions

H_0: Respondents' local Flow conditions influences their WTP to decrease the number of low-flow months.

H_0: Respondents' local Flow conditions do not influence their WTP to decrease the number of low-flow months.

Under the null hypothesis, respondents who experience poor local flow conditions have higher WTP for improving the Flow attribute.

These hypotheses will be tested empirically by interacting the Cost attribute with each biophysical variable. The reason for doing this is to see whether respondents who experience poor qualities or lives in the poor quality areas tend to pay more or support the conservation programs. Wald tests of significance of the parameter on the interaction term will be conducted and if significant, the interaction parameters are used in the calculation of willingness-to-pay and compensating surplus.

4.2 Welfare Analysis

Marginal willingness-to-pay estimates for attributes accounting for respondents' local stream and river quality are calculated using the estimated model parameters and Equation (4) where δ_i is the parameter on the biophysical data (variable) interaction with cost attribute. This gives the marginal value of a particular attribute dependent on the level of the selected biophysical data. For these calculations the values of the biophysical data are averaged within three groups producing three willingness-to-pay estimates for each attribute. The ranges of the three groups are given in table 10. This paper will also calculate WTP with and without biophysical data as a comparison.

$$\text{(4)} \qquad \text{WTP} = -1\left(\frac{\beta_{Attribute}}{\beta_{Cost} + \delta_i \times Biophysical\_Data}\right)$$

4.3. Survey Logistics

During the month of July and August 2008,1500 surveys were mailed using a stratified random sampling method to Canterbury residents. The sample was stratified by Territorial Local Authority to achieve a geographically representative sample. The survey consists of a covering letter and a booklet along with a free-post reply envelope. A reminder postcard was sent two weeks later. The mail-out procedure yielded 349 usable responses with an effective response rate of 25%.

In order to assess the sample size to be representative of a popullation, a Chi-squared test was conducted. If the null hypothesis is rejected, it can be concluded that the Census 2006 population data are statistically significantly different than the sample data. Table 7 presents the *p*-values of the Chi-squared tests. It is apparent that the null hypotheses are rejected for income, education and house tenure. This mean that the sample respondents have higher income, educated and more owning homes.This may indicate sample selection bias toward affluent and educated groups and thus, caution should to be taken when using these variables on the WTP estimation. However, the combination of RPL model and the biophysical data should be able to account this biasness in terms of individual heterogeneity within income groups and spatial differences amongst respondents in valuing the attributes.

Table 7: Socio-demographics of the survey sample

Variable	Frequencies (%)						P-value
Household Income	**Loss**	**0-$20k**	**$20-$40k**	**$40-$70k**	**$70-$100k**	**>$100k**	0.052*
Survey	1	12	23	31	16	18	
Census 2006	1	25	27	28	11	9	
Gender	**Male**	**Female**					0.548
Survey	52	48					
Census 2006	49	51					
Household Size	**1**	**2**	**3**	**4**	**5**	**≥6**	0.124
Survey	23	34	17	14	6	3	
Census 2006	13	43	17	18	6	3	
Age	**20-29**	**30-39**	**40-49**	**50-59**	**60-64**	**≥65**	0.194
Survey	6	12	24	29	12	16	
Census 2006	29	21	23	19	7	11	
Labour Force Status	**Unemployed**		**Employed**		**Not in Labour Force**		0.126
Survey	2		74		24		
Census 2006	2		66		32		
Ethnicity	**European**	**Maori**	**Pacific**	**Asian**	**NZ**		0.111
Survey	85	2	0	3	8		
Census 2006	76	6	2	5	13		
Education	**High School**	**Trade/technical**	**Undergraduate**	**Postgraduate**			0.000***
Survey	33	27	28	12			
Census 2006	65	22	9	4			
House Tenure	**Own**	**Rent**					0.000***
Survey	90	10					
Census 2006	71	29					

*, **, *** indicates significant difference at 10, 5 and 1% level

5. Model estimation

The attributes are effects coded into two variables for each attribute with the lowest level of quality being the fixed comparator for each attribute; Ecology Fair (coded 1 if Fair, 0 if Good, -1 if Poor) and Ecology Good (coded 1 if Good, 0 if Fair, -1 if Poor); Risk10 (1 if Risk10, 0 if Risk30, -1 if Risk60) and Risk30 (1 if Risk30, 0 if Risk10, -1 if Risk60); Flow1 (1 if Flow1, 0 if Flow3, -1 if Flow5), Flow3 (1 if Flow3, 0 if Flow1, -1 if Flow5). The non-attribute variables were interacted with the alternative specific constant. Model variables are summarised in Table 8 as below.

Table 8: Model Variables

Risk10	10 people/1000/year sick from recreational contact
Risk30	30 people/1000/year sick from recreational contact
Ecology Good	Ecological quality is good
Ecology Fair	Ecological quality is fair
Flow1	1 month of low-flow/year
Flow3	3 months of low-flow/year
Cost	$15, $30, $45, $60, $75 and $90/household/year
ASC	alternative specific constant, 1 if alternative 2 or 3, 0 if base alternative
Safe	respondent agrees that agriculture is environmentally safe
Commercial	respondent indicates commercial use of water as important
Income	household gross yearly income
Businesses	respondent indicates farms are businesses and should pay for water policy
Cost x Recreation grade	Interaction of Cost and Recreation Grade
Cost x Flow	Interaction of Cost and Flow Change
Cost x SQMCI	Interaction of Cost and SQMCI Score

All random parameters are specified as constrained triangular distributions to take into account the degree of heterogeneity whilst obtaining meaningful WTP estimates. The spread of each random parameter distribution was restricted to be equal to the mean. Five hundred shuffled Halton draws are used in maximising the simulated Log-likelihood function.

Table 9: Random Parameter Logit model with Biophysical Data Interactions

Variable	Parameters
Random parameters	
Risk10	0.496*** (0.06)
Risk30	0.201*** (0.06)
Ecology Fair	0.249*** (0.66)
Ecology Good	0.701*** (0.08)
Flow1	0.329*** (0.07)
Flow3	-0.108 (0.07)
Cost	-0.057*** (0.006)
Non-random parameters	
ASC	0.317 (0.41)
Safe	-1.28*** (0.25)
Commercial	-1.23*** (0.37)
Gender	0.699*** (0.25)
Income	0.183*** (0.06)
Businesses	-6.13*** (0.46)

Cost x Recreation grade	0.0046*** (0.001)
Cost x Flow	0.0056*** (0.001)
Cost x SQMCI	0.0018* (0.0001)

Derived standard deviations of random parameter distributions	
Risk10	0.465*** (0.06)
Risk30	0.547*** (0.13)
Ecology Fair	0.252*** (0.06)
Ecology Good	0.796*** (0.08)
Flow1	0.300*** (0.68)
Flow3	0.079 (0.08)
Cost	0.057*** (0.01)

Log Likelihood	-1464
Psuedo-R^2	0.37
Pr(Chi^2)>z	0.000
Iterations	24
Observations	2094
Note: *,**,*** indicates significance at 10,5 and 1% level, figures in the parenthesis show standard error	

To examine if the effects coded variables for an attribute should be combined into a single linear variable, a Wald test was conducted to observe whether the two parameters (one for each of the two effects coded attribute levels) are equal. The null hypothesis of inequality is retained for all attributes. Therefore preferences for the two attribute levels are statistically significantly different. This nonlinear preference finding would be ignored if the attribute was assumed linear.

Looking at the results in Table 9, the Psuedo-R^2 shows that the fully specified model has an acceptable level of explanatory power. Looking at the attribute variables, improvements in the levels of the attributes increase the probability of that option being chosen, with the magnitude of the probability increasing as the attribute level improves. All attributes except Flow3 are statistically significant at the 1% level. This may indicate that respondents did not prefer the medium level of improvement of three months of low flow but would rather see the highest level of improvement of one month of low-flow conditions. Higher household income and being a female increased the probability of choosing an alternative with improvements in water quality. Respondents who agreed that agriculture is environmentally safe were less likely to choose an alternative with improvements in water quality. Respondents who thought farmers should pay for conservation programs were less likely to choose an alternative with improvements in water quality. Respondents who indicated that commercial use of water as important were less likely to choose an alternative with improvements in water quality. All three biophysical variables that interact with cost are statistically significant. The estimated coefficients for Recreation Grade and Flow, and SQMCI are significant at the 1% and 10% levels respectively.

5.1. Willingness-to-pay and Compensating Surplus Estimates

Table 10 below shows WTP using equation 4 for the three groupings of biophysical data for each attribute.

Table 10: Attribute Willingness-To-Pay

	WTP with local biophysical data			**No Biophysical WTP calculation**
Rec Grade / Risk attribute	**<2**	**2≤grade≤ 4**	**4<**	
Risk10	20.45 (0.60 - 40.29)	16.64 (1.34 - 31.94)	14.05 (1.58-26.52)	19.08 (2.23-34.62)
Risk30	16.08 (2.33 - 34.50)	13.05 (1.40 - 27.50)	11.00 (0.94-22.93)	14.89 (2.36-20.95)
SQMCI Score / Ecology attribute	**≤ 2**	**2<score<5**	**5≤**	
Ecology Good	27.37 (5.74 - 48.88)	24.66 (5.77 - 43.56)	23.14 (5.72-40.57)	25.58 (8.52-41.32)
Ecology Fair	18.88 (3.68 - 34.08)	17.01 (3.72 - 30.29)	15.96 (3.71-28.21)	16.13 (4.71-26.57)
Flow Change / Flow attribute	**Increase**	**up to 30% less**	**>30% less**	
Flow1	5.65 (1.66 - 12.96)	9.56 (2.66 - 18.79)	15 (4.72-27.45)	7.1 (1.7-13.4)

95% Confidence intervals in brackets calculated from the unconditional parameter distributions

Looking at Table 10, we can see that respondent's willingness-to-pay increases as the biophysical variable deteriorates. Respondents with low Recreation Grades have higher WTP in order to lower the risk of getting sick relative to respondents with high Recreation Grades. Respondents with low SQMCI Scores have higher WTP in order to improve Ecological quality relative to respondents with high SQMCI Scores. Respondents who experience high number of low-flow months are willing to pay more as Flow conditions worsen. Notice that the WTP values with and without biophysical data differ substantially suggesting that valuing attributes by stratifying individuals based on biophysical data provides more plausible results than the overall average respondents with no biophysical data. As mentioned, the sample is bias toward affluent and more educated respondents that may over or under estimate the 'true' WTP if we depend on the usual standard WTP estimation without biophysical data.

The value of benefits from combinations of attribute level changes can be calculated as compensating surplus (CS) estimates. Estimates of CS are calculated using the standard Hanemann utility difference expression (Hanemann, 1984):

(5) $$CS = (-1/\beta_{cost})\,(V_{No\ Change} - V_{Change})$$

Where $V_{No\ Change}$ is the utility derived from the 'No change' base alternative and V_{Change} is the utility derived from the new management (policy) alternatives. The 'no change' base and two scenarios are as follows:

No change 60 people per 1000 get sick from recreational contact each year, ecological quality is poor, and there are 5 months of low-flow conditions.

Management Fair	30 people per 1000 get sick from recreational contact each year, ecological quality is fair, and there are 3 months of low-flow conditions.
Management Good	10 people per 1000 get sick from recreational contact each year, ecological quality is good, and there is 1 month of low-flow conditions.

In the same way that the implicit price formula was modified to include respondent's biophysical data so too the CS calculation is modified to include the influence of the combination of respondent's three biophysical variables. This necessitates calculating the CS for each combination of biophysical data that is present in the sample. Table 12 below shows the twenty combinations and the frequency distribution of respondents with that particular combination.

Table 11: Respondents Biophysical Data and Compensating Surplus for Policy Scenarios

Respondents local biophysical data			% of Respondents	Individual Compensating Surplus	
Recreation Grade	Flow Change	SQMCI Score		Management Fair	Management Good
<2	up to 30% less	2<score<5	**24**	118.64 (33-203)	141.40 (20-262)
<2	up to 30% less	5≤	**16**	106.91 (39-174)	127.12 (28-225)
<2	>30% less	2<score<5	**11**	147.54 (33-260)	177.46 (20-330)
<2	up to 30% less	≤2	**9**	132.84 (30-236)	158.85 (14-304)
2≤grade≤4	up to 30% less	2<score<5	**7**	100.94 (42-160)	119.85 (32-208)
<2	>30% less	5≤	**5**	132.55 (30-236)	158.41 (13-304)
4<	up to 30% less	2<score<5	**4**	83.02 (44-122)	98.19 (37-160)
4<	>30% less	2<score<5	**3**	97.23 (43-152)	115.36 (33-197)
4<	up to 30% less	5≤	**3**	77.44 (44-111)	91.47 (37-146)
2≤grade≤4	>30% less	2<score<5	**3**	124.00 (31-217)	147.94 (16-280)
2≤grade≤4	up to 30% less	5≤	**2**	92.59 (43-141)	109.74 (35-185)
2≤grade≤4	>30% less	5≤	**2**	111.11 (38-184)	132.21 (27-238)
<2	Increase	5≤	**2**	77.63 (44-111)	91.69 (37-146)
<2	Increase	2<score<5	**2**	83.23 (44-122)	98.44 (37-160)
<2	>30% less	≤2	**1**	168.82 (16-322)	201.90 (8-396)
2≤grade≤4	up to 30% less	≤2	**1**	111.15 (38-184)	132.26 (27-238)
4<	>30% less	5≤	**1**	89.51 (44-135)	106.02 (36-176)
4<	Increase	5≤	**1**	61.27 (40-82)	72.07 (36-109)
4<	Increase	2<score<5	**1**	64.62 (42-87)	76.08 (36-116)
4<	up to 30% less	≤2	**1**	89.53 (44-135)	106.05 (36-176)

These individual CS values can be aggregated to provide estimates of policy outcomes (combination of attributes changes). In order to do so, it is assumed that the geographic distribution of Canterbury households is same as the respondent distribution in Table 11. Combining the frequency distribution of respondent's biophysical data and CS values, the aggregate CS estimates for Canterbury are calculated as the biophysical aggregation which are presented in Table 12. The usual standard aggregation is calculated as No Biophysical aggregation where CS estimates do not account for respondents local river and stream biophysical characteristics. This will be a comparison to observe the CS estimates with and without biophysical data. To aggregate the CS across the population an assumption has to be made about the non-respondents who did not return the survey. Mitchell and Carson (1989) have suggested a rather simple approach to address the non-response bias. In the following we assume that are r respondents who have answered the survey and m non-respondents who have not. We calculate the aggregate CS as follows:

(6) $$\overline{CS}_{\alpha} = \frac{1}{r+m}\left[\sum_{r} CS_i + \sum_{m} (\alpha) CS_i\right]$$

where *a* is the multiplier that expresses the non-respondents CS in relation to the CS of the respondents. Using different multipliers in place of *a*, we can calculate the appropriate WTP estimates for different assumptions of non-respondents' CS. If *a* = 1, non-respondents are assumed to have the same mean CS as respondents and if *a* = 0, non-respondents are assumed to have zero CS. Also multipliers between 0 and 1 can be used. The chosen multiplier has a significant effect on the aggregate CS estimate. To examine this effect, we calculate the aggregate CS using the multipliers 0, 0.5 and 1. When we use 0 as a multiplier we assume that non-respondents are not willing to pay anything (Bishop and Boyle, 1985). If we use the multiplier 0.5 we assume that each non-respondent's CS is half of the CS of a similar respondent and use the multiplier of 0.5. The third assumption is that non-respondents have the same mean CS as respondents and the multiplier is 1. However, it is possible that using 1 as a multiplier leads to an overestimation of the aggregate CS (Bateman et al., 2002). This CS value is then multiplied by the number of households in Canterbury. The results of these calculations are presented in Table 12 below.

Table 12: Canterbury Compensating Surplus (Millions$)

Aggregation multiplier	α = 1		α = 0.5		α = 0	
Management Scenario	**Fair**	**Good**	**Fair**	**Good**	**Fair**	**Good**
No Biophysical aggregation	10.2	11.9	6.3	7.4	2.5	2.9
Biophysical aggregation	22.9	27.4	13.7	17.1	5.6	6.7
Percentage difference	+125	+130	+117	+131	+124	+131

The percentage differences calculated between the No Biophysical aggregation and the Biophysical aggregation are shown in Table 12. We can see that the aggregation that takes into account the respondents biophysical data is 125% and 130% higher for the Fair and Good scenarios respectively. This suggests that water management programs in Canterbury will be undervalued if sample average CS is used to assess aggregate benefits. Using respondents' biophysical data facilitates a better reflection of the distribution of benefits and therefore a more appropriate estimation method. The more than doubling of CS estimates reflects that respondent's local rivers and streams are generally poor quality. This translates as more high WTP amounts than low ones. Approximately 80% of respondents had a local biophysical variable that was at its poorest level. Almost a third of respondents had a combination of the three biophysical variables that included two of the lowest levels of quality. If more respondents local biophysical data was good then we could expect that the two methods to converge. There would be less high WTP amounts and more low amounts.

6. Policy Implications

In the application of agri-environmental policy some progress has been made in reducing point sources of pollution such as from dairy sheds or animal processing plants however it is the non-point sources of pollution that remain the most difficult to manage. Three public policies aimed at protecting and improving streams and rivers in Canterbury are: the Dairying and Clean Streams Accord; the Restorative Programme for Lowland Streams and the Living Streams project.

Environment Canterbury launched the Living Streams project in 2003 aimed at encouraging sustainable land use and riparian management practices to improve the quality of Canterbury's streams. Each year the programme selects a number of areas of focus for its efforts. Stream care initiatives, education programmes in schools and the Environment Enhancement Fund (EEF) support this work and the protection of wetlands and bush habitat (ECan, 2007b). The Dairying and Clean Streams Accord is a co-operative agreement between Fonterra Co-operative Group, Regional Councils, Ministry for the Environment and Ministry of Agriculture and Forestry. The accord focuses on reducing the impacts of dairying on the quality of New Zealand streams, rivers, lakes, groundwater and wetlands (MfE, 2003). Regional councils will be carrying out work to monitor the environmental effects of implementing the targets of the Accord (MfE, 2007). In 2006 Environment Canterbury announced its Restorative Programme for Lowland Streams Policy. The principal purpose of the restorative programme is to return water to dry streams and to ensure environmental flows that will preserve the intrinsic values of lowland aquatic ecosystems (ECan, 2008).

Practical application of these polices by water resource managers with strict budget constraints inevitably necessitates trade-offs being made. The trade-offs could be related on what aspects of water quality, which rivers and streams are to be targeted, and which one to choose first? The results of this study may help to answer these questions. Firstly, the value of benefits from improving the selected attributes. The Canterbury residents will be more beneficial in improving the ecology attribute, followed by reducing the risk of sickness and finally, reducing the low-flow occurrences. Secondly by showing that further benefit is gained by targeting the relatively lower quality rivers and streams initially. As for the policy practitioners, modelling the relationship between the GIS based biophysical data using the method developed in this paper, they could able to use the estimation values as proxies of benefits to evaluate policy actions.

7. Conclusions

The primary purpose of this paper is to test spatial hypotheses regarding respondents' local water quality and quantity and their WTP for improvements in water conservation policy attributes. Respondents' WTP for improvements in ecological quality is influenced by the ecological quality of their local rivers and streams. The lower the ecological quality the higher is their WTP to improve it. Respondents' WTP for improvements in low-flow conditions is influenced by flow conditions in their local rivers and streams. The poorer the flow conditions the higher is their WTP to decrease the number of low-flow months. Respondents' WTP for decreasing the risk of getting sick is influenced by the Recreation Grade of their local rivers and streams. The lower the grade the higher is their WTP to decrease the risk of people becoming sick. These findings advocate that regional water management authorities may better allocate their limited resources by targeting relatively low quality waterways.

Respondents valued improvements in ecological quality the most, followed by decreasing the risk of sickness and lastly, decreasing the number of low flow months.

This paper presents aggregate benefit values that are suitable for cost benefit analysis. Benefits of combinations of policy outcomes can be assessed using CS estimates. This study finds that inclusion of the respondent's local water quality data has a significant impact on the magnitude of CS estimates. Aggregate CS estimates with biophysical data show more than 100% larger than the standard CS estimation with no biophysical data.

The main contribution of this paper is the method of including respondent's local biophysical data via GIS in estimating the WTP and CS for agri-environmental policy. Including respondent's local biophysical data facilitated the estimation of a range of benefits dependent on the local water quality. The highest levels of WTP are greater than the sample average (WTP with no biophysical data) and the lowest levels are smaller than the sample average indicating that benefit aggregation based on sample average WTP may bias estimates in either direction.

References

Adamowicz, W.; Dupoint, D.;Krupnik and Zhang, J. (2007). Valuation of Cancer and Microbial Risk Reductions in Municipal Drinking Water: An Analysis of Risk Context Using Multiple Valuation Methods. Resources for the Future, Washington, DC, available at www.rff.org.

Ball. A. (2006). Estimation of the Burden of Water-Borne Disease in New Zealand: Preliminary Report. New Zealand Ministry of Health

Bateman, I.J. (2006). The aggregation of environmental benefit values: Welfare measures, distance decay and total WTP. Ecological Economics 60:450-60.

Bateman, I.J., Jones, A.P., Lovett, A.A., Lake, I.R. and Day, B.H. (2002) Applying Geographical Information Systems (GIS) to Environmental and Resource Economics. Environmental and Resource Economics 22:219-269.

Berrens, R., Bohara, A., Jenkins-Smith, H., Silva, C. and Weimer, D. (2004). “Information and effort in contingent valuation surveys: Application to global climate change using national Internet samples.” *Journal of Environmental Economics and Management,* 47(2): 331-363.

Berrens, R., Bohara, A., Jenkins-Smith, H., Silva, C. and Weimer, D. (2003). “The advent of Internet surveys for political research: A comparison of telephone and Internet samples.” *Political Analysis,* 11(1): 1-22.

Bewsell, D. and Kaine, G. (2005). *“Adoption of Environmental Bet Practice Amongst Dairy Farmers”.* Paper presented at the Eleventh Annual Conference of the New Zealand Agricultural and Resource Economics Society (Inc.). AERU Discussion Paper No. 152.

Johnston, R.J., Swallow, S.K. and Bauer, D.M.(2002). Spatial Factors and Stated Preference Values for Public Goods: Considerations for Rural Land Use. Land Economics 78(4):481-500.

Karousakis, K and Birol, E. (2008). Investigating household preferences for kerbside recycling services in London: A choice experiment approach. Journal of Environmental Management. 88(4):1099-1108.

Cameron, K. C. and Di, H. J. (2004). Nitrogen leaching losses from different forms and rates of farm effluent applied to a Templeton soil in Canterbury, New Zealand. New Zealand Journal of Agricultural Research, vol. 47, pp. 429-37.

Cameron, K. C.; Di, H. J.; Reijnen, B. P. A.; Li, Z.; Russell, J. M. and Barnett, J. W. (2002). Fate of nitrogen in dairy farm factory effluent irrigated onto land. New Zealand Journal of Agricultural Research, vol. 45, pp. 207-16.

Campbell, D., Hutchinson, W.G. and Scarpa, R. (2009). Using choice experiments to explore the spatial distribution of willingness to pay for rural landscape improvements. Environment and Planning 41:97-111.

Carson, R.T. and Mitchell, R.C. (1989). Using Surveys to Value Public Goods: The Contingent Valuation Method. Washington: Resources for the Future.

Concu, G.B. (2007). Investigating distance effects on environmental values: a choice modelling approach. The Australian Journal of Agricultural and Resource Economics 51:175-194.

Condon,B. Hodges, A and Matta, R. (2007). Public preferences and values for rural land preservation in Florida. Selected paper prepared for presentation at the American Agricultural Economics Association Annual Meeting, Portland, OR, July 29-August 1 2007.

Cole, S. T.(2005). Comparing Mail and Web-based Survey Distribution Methods: Results of Surveys to Leisure Travel Retailers. *Journal of Travel Research, 43:422-430.*

Dillman, Don A. *Mail and Internet Surveys: The Tailored Design Methods.* New York: John Wiley and Sons, 2000.

Dickie, M.; Gerking, S. and Goffe, W.J. (2007). Valuation of non-market goods using computer-assisted surveys: a comparison of data quality from internet and rdd samples. Available at http://goffe.oswego.edu/Survey_Comparison_3.pdf.

Deutskens, E.; Ruyter, K. D. And Wetzels, M. (2006). An Assessment of Equivalence Between Online and Mail Surveys in Service Research. *Journal of Service Research, 8(4): 346-355.*

Dillman, D. A. (2007). Mail and Internet Surveys the Tailored Design Method. Hoboken, N.J.: Wiley, c2007.

Environment Canterbury. (2008) The Restorative Programme for Lowland Streams. Available at www.ecan.govt.nz.

Environment Canterbury. (2001). Our water in the balance: Christchurch West Melton rivers and groundwater, issues and options. Environment Canterbury Report R01/1.

Environment Canterbury. (2003). Ecosystem health of Canterbury rivers: Development and implementation of biotic and habitat assessment methods 1999/2000. Report No. R03/3.

Environment Canterbury (2007). NRRP Hearing stage 12 Officer Report No.12 Chapter 4 WQL2 on Proposed Variation 1 of the Proposed Canterbury Natural Resources Regional Plan: Chapter 4 – Water Quality – Submissions on Issue WQL1, Objective WQL1.1 & 1.2, Policies WQL1, WQL2, WQL3 & WQL5. Environment Canterbury, (2007b). Freshwater contact recreational monitoring programme summary report 2006/2007.

Environment Canterbury.(2007a). The compliance status of dairy shed effluent discharges to land in the Canterbury region for the 2006/2007 season. Report No. R07/23.

Environment Canterbury (2007b) Project Outputs and Funding for 2005-2006. Available at www.ecan.govt.nz.

Fleming, C. M. and Bowden, M. (2009). Web-based surveys as an alternative to traditional mail methods. Journal of Environmental Management 90: 284-292.

Griffis, S. E.; Goldsby, T. J and Cooper, M. (2003). "Web-based and Mail Surveys: a Comparison of Response, Data and Cost". *Journal of Business Logistics, 12(2): 237-258.*

Hamill, K. D. and McBride, G. B. (2003). River water quality trends and increased dairying in Southland, New Zealand. New Zealand Journal of Marine and Freshwater Research, vol. 37, pp. 323-332

Hausman, J. and McFadden, D. (1984). Specification tests for the multinomial logit model. Econometrica, 52: 1219-1240.

Krosnick, Jon A. and LinChiat Chang. 2004. "National Surveys Via RDD Telephone Interviewing vs. the Internet: Comparing Sample Representativeness and Response Quality," Center for Survey Research, Ohio State University.

Lancaster, K. (1966). A New Approach to Consumer Theory. Journal of Political Economy, 74: 132-157.

Larned, S. T.; Scarsbrook, M. R.; Snelder, T. H.; Norton, N. J. and Briggs, B. J. F. (2004).Water quality in low-elevation streams and rivers of New Zealand: recent state and trends in contrasting land-cover classes. New Zealand Journal of Marine and Freshwater Research, vol. 38, pp. 347-66.

Lindhjem, Henrik and Navrud, Stale,Internet CV Surveys - A Cheap, Fast Way to Get Large Samples of Biased Values?(April 15, 2008). Available at SSRN: http://ssrn.com/abstract=1295521

McBride G; Till D; Ryan T; Ball A; Lewis G; Palmer S; Weinstein P. (2002). Freshwater Microbiology Research Programme. Pathogen occurrence and human health risk assessment analysis. Ministry for the Environment & Ministry of Health, Wellington.ealands Clean Green Image. Available at www.mfe.govt,nz.

Ministry for the Environment (2008a). Draft Guidelines for the Selection of Methods to Determine Ecological Flows and Water Levels. Available at www.mfe.govt.nz

Ministry for the Environment (2008b) Flow Guidelines for Instream Values. Available at www.mfe.govt.nz

Ministry for the Environment, (2003). Dairying and Clean Streams Accord. Available at www.mfe.govt.nz.

Ministry for the Environment, (2007). The Dairying and Clean Streams Accord: Snapshot of Progress-2005/2006. Available at www.mfe.govt.nz.

Parliamentary Commissioner for the Environment (PCE). 2004. Growing for good: Intensive farming, sustainability and New Zealand's environment. Wellington: Parliamentary Commissioner for the Environment.

Ready, R.; Fisher, A.; Guignet, D.; Stedman, R. and Wang, J. (2006) "A pilot test of a new stated preference valuation method: Continuous attribute-based stated choice". *Ecological Economics, 59: 247-255*

Ross, C. and Donnison, A. (2003). Campylobacter and farm dairy effluent irrigation."New Zealand Journal of Agricultural Research, vol. 46, pp 255-62.
Ross, C. and Donnison, A. (2004).Survival of Campylobacter jejuni in soil after farm dairy effluent irrigation". In: Wang, H.; Lavery, J. M. ed. Water, waste and land treatment for primary industry and rural areas. Proceedings of the 2004 New Zealand land Treatment Collective Annual Conference, Ashburton, New Zealand, pp. 102-08
Sage E 2008. Water Management Challenges in Canterbury. In Proceedings of the Environmental Defence Society "Conflict in Paradise – The Transformation of Rural New Zealand" Conference 11-12 June 2008, Langham Hotel, Auckland.
Saggar, S.; Bolan, N. S.; Bhandral, R.; Hedley, C.; Luo, J.(2004). A review of emissions of methane, ammonia and nitrous oxide from animal excreta depositionand farm effluent application in grazed pastures. New Zealand Journal of Agricultural Research 47: 513–544.
Scarpa, R., Ruto, E., Kristjanson, P., Radeny, M., Drucker, A., Rege, J.,2003. Valuing indigenous cattle breeds in Kenya: an empiricalcomparison of stated and revealed preference value estimates. Ecological Economics 45 (3), 409–426.
Stark, J.D. (1998). SQMCI: a biotic index for freshwater macroinvertebrate coded-abundance data. New Zealand Journal of Marines and Freshwater Research, 32:55-66.
Stark, J.D. and Maxted, J.R. (2007). A biotic index for New Zealand's soft-bottomed streams. New Zealand Journal of Marines and Freshwater Research, 41:43-61.
Stark, J.D. and Maxted J.R. (2007b). A user guide for the Macroinvertebrate Community Index. Prepared for the Ministry for the Environment. Cawthron Report No.1166. 58 p.
Statistics New Zealand (2007). Agricultural Statistics New Zealand. www.stats.govt.nzUTH
Thurstone, L. L. (1927). A Law of Comparative Judgement. Psychological Review, 34: 273-86.
Train, K.E. 2003. Discrete Choice Methods with Simulation. Cambridge University Press, U.K.
Tsuge, T. and Washida, T. (2003). Economic valuation of the Seto Inland Sea using an Internet CV survey. Marine Pollution Bulletin, 47: 230-236.
Van der Heide, C. M., van den Bergh, J., van Ierland, E. and Nunes, P. (2005). Measuring the economic value of two habitat defragmentation policy scenarios for the Veluwe, The Netherlands. Fondazione Eni Enrico Mattei Working Paper No. 42, Milan.
Von Stackelberg, Katharine and James K. Hammitt. (2006). Use of Contingent Valuation to Elicit Willingness-to-Pay for the Benefits of Developmental Health Risk Reductions. Harvard University, Center for Risk Analysis working paper.
Wang. H. And Magesan. G. N. (2004). An overview of the environmental effects of land application of farm effluents. New Zealand Journal of Agricultural Research v47:289-403.
Whittaker, D., J. J. Vaske, M. P. Donnelly, and D. S. De Ruiter. (1998). Mail Versus TelephoneSurveys: Potential Biases in Expenditure and Willingness-to-Pay. Journal of Park and Recreational Administration 16: 15-30.