Comparing Choice Models of River Health Improvement for the Goulburn River*

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Abstract

The extent of the benefits of improved river health remain uncertain. Quantifying these benefits is useful in prioritising policy investments. This study uses the Choice Modelling technique to estimate the value that households attach to attributes of improved river health. Data from a choice modelling survey supported by DSE Victoria are employed to elicit household preferences in a case study of the Goulburn River. Results from conditional and nested logit model specifications indicate that respondents hold positive values for higher levels of fish and bird populations and for increasing riverside vegetation. The standard Hausman test for Independence-from-Irrelevant-Alternatives (IIA) assumption violations is found to give inconsistent results. The value estimates of the conditional and nested logit models are shown to be statistically similar indicating that testing for IIA violation may be more complicated than currently assumed thus raising questions about the efficacy of the more complex nested logit model.

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1. Introduction

Declining health of rivers is an important policy issue in Australia, leading to a range of public costs. The extent of the benefits of improvements in river health are uncertain. Quantifying these benefits is useful in prioritising investments in environmental management policies. Non-market valuation techniques are required to estimate the values associated with changed river management. Non-market valuation can yield value estimates in monetary units that are consistent with the principles of welfare economics (URS, 2006).

This study models individuals' preferences regarding changes in river health for a case study of the Goulburn River. Data from a non-market stated preference technique known as Choice Modelling (CM) are used to estimate the benefits associated with improvements in river health. CM is widely applied in a natural research management context to estimate the marginal utility of environmental attributes (Bennett *et al.*, 2001; Rolfe *et al.*, 2000; Morrison and Bennett, 2004). If money is one of the attributes, it is possible to express value estimates in terms of *implicit prices* (Bennett *et al.*, 2001).

Conditional logit (CL) and nested logit (NL) models are used to generate implicit prices for the Goulburn River. Results indicate that individuals attach positive values to higher levels of fish populations, higher numbers of native bird species and increased riverside vegetation. A standard Hausman test is used to test for Independence-from-Irrelevant-Alternatives (IIA) assumption violations but gives ambiguous results. The estimates from the CL model and the NL model are not significantly different. This raises questions about the efficacy of the more complex NL model specification.

The remainder of this paper is organised as follows: the next section reviews the choice modelling technique and the econometric specifications of the model. Section 3 describes the data collection process; section 4 the results of the choice models estimated for the Goulburn River. The last two sections present a discussion of the results and conclusions derived from this study.

2. Choice Modelling

The CM technique originates from the marketing and transport literature where it has been used to analyse consumers' choices of products and transport modes (Louviere et al, 2000). CM is a useful non-market valuation technique for river health changes that are outside the range of currently observed conditions.

A CM exercise typically employs a survey that describes hypothetical changes in a range of attributes and asks respondents to make a choice between different alternatives. Respondents are presented with a series of questions (choice sets), where each question includes different choice alternatives including a 'status-quo' or 'do nothing new' option for use as an 'anchor' for value estimates. Every choice alternative describes the outcome of a potential policy action, in terms of attributes or characteristics in Lancastrian demand terms, including cost, taking on different levels. The choice alternatives vary in the level of the attributes. In choosing between alternatives, respondents are expected to make a trade-off between the levels of the environmental attributes and associated costs.

2.1 The Conditional Logit model

The utility U_{ij} that individual i derives from choice alternative j is inferred indirectly through the choices people make (eq. 1). The model of respondents' choices follows from assumptions on the error distribution. If the error terms ε_{ij} are independently and identically distributed (IID), the probability of choosing alternative j can be estimated by a Conditional Logit (CL) model.

In this model, V_{ij} is the systematic component of utility and is a linear, additive function of the environmental attributes and costs of alternative j (X_j) and individual socio-economic characteristics (W_i). An alternative specific constant (ASC) accounts for systematic differences in utilities for different alternatives that are not explained by the attributes or socio-economic characteristics.

$$U_{ij} = f(X_j, W_i, \varepsilon_{ai}) = V_{ij} + \varepsilon_{ij} = ASC_j + x'_j \beta + w'_i \alpha + \varepsilon_{ij} \qquad j = 0,1,\ldots J \qquad (1)$$

The CL model is estimated by Maximum Likelihood. The socio-economic characteristics need to be interacted with the ASC to make all the parameters estimable. The coefficients on these interaction terms measure the propensity of different categories of respondents to choose alternatives other than the status quo (Wielgus et al., 2006). For example, a positive coefficient on an Income x ASC variable indicates that respondents with higher incomes are more likely to choose environmentally improving alternatives then the ‘do-nothing’ alternative.

The estimated coefficients from the CL model can be used to derive the marginal rate of substitution between attributes. If the choice set includes a monetary attribute, these marginal rates of substitution can be expressed in terms of ‘Implicit Prices’ (IP). The IP shows how much an individual is willing to pay for a unit increase in the level of the attribute, keeping everything else constant. When utility is a linear function of all attributes, the IP can be calculated as follows (Bennett and Adamowicz, 2001):

$$IP_A = -\frac{\beta_A}{\beta_C}, \tag{2}$$

where IP_A is the implicit price of attribute A, β_A is the coefficient on attribute A (expected to be positive for a “good”) and β_C is the coefficient on the monetary attribute (expected to be negatively signed).

2.2 The Nested Logit model

An important assumption in the CL model is the Independence-from-Irrelevant-Alternatives (IIA) axiom. The IIA assumption states that ‘the ratio of the probabilities of choosing one alternative over another (given that both alternatives have a non-zero probability of choice) is unaffected by the presence or absence of any additional alternatives in the choice set’ (Louviere et al, 2000). This implies that the error terms are independent across alternatives and provides a computationally convenient choice model. However, the IIA assumption is unlikely to hold if the preferences of respondents are heterogeneous (Louviere et al, 2000). Using a CL model, particularly one in which scoio-demographic parameters are not included, will then lead to biased estimators.

In this paper, Nested Logit (NL) models are used, which have less restrictive assumptions than the CL model. An NL model specifies a tree structure with several branches that are subdivided into alternative limbs. The NL model does not require the IIA assumption to hold between branches. The probability of choosing alternative *j* (Pr_{jm}) is now conditional on choosing branch *m* (Pr_m) that leads to that alternative:

$$\Pr_{jm} = \Pr_{j|m} \cdot \Pr_m \qquad (3)$$

where $$\Pr_{j|m} = \frac{\exp(V_{jm} / \alpha_m)}{\exp(IV_m)}$$

$$\Pr_m = \frac{\exp(\alpha_m IV_m)}{\sum_{k=1}^{M} \exp(\alpha_k IV_k)}$$

$$IV_m = \log\left[\sum_{i=1}^{J_m} \exp(V_{im} / \alpha_m)\right]$$

IV_m is the 'inclusive value' that captures the sum of the utility of all alternatives in branch *m*. The IV parameter α_m measures the substitutability across alternatives. α_m will lie between zero and one when substitutability is greater within rather than between branches (Blamey *et al.*, 2000). If α_m equals one, the model collapses into the single level CL model. An IV parameter that is statistically different from one therefore provides evidence that the IIA property fails to hold.

3. Data collection

This study estimates the benefits of improved environmental health of the Goulburn River using data from a CM questionnaire. This section describes the CM questionnaire and its administration in more detail.

3.1 Questionnaire design

A CM survey was designed to assess the values that respondents attach to various environmental attributes of the Goulburn River (URS, 2006). Key elements in the design include the selection of environmental attributes that are likely to be influenced by river management policies. The selection of attributes used in the CM survey was based on discussions with scientists and groups of potential respondents. The level of the attributes was determined after consultations with the Catchment Management Authority. These levels were based on expert opinion and reflected the possible outcomes of different management interventions for the Goulburn River. Four river health attributes were included in the CM questionnaire (URS, 2006):

- Native fish: number of fish species and population that are present, relative to the estimated size of the population before European settlement.
- Healthy riverside vegetation: percentage of river length with healthy native riverside vegetation on both sides of the river.
- Native birds and fauna: number of species of native waterbirds and riverine fauna with sustainable populations.
- Water quality: water quality was expressed as the percentage of the river suitable for primary contact recreation such as swimming and paddling.

A fifth attribute was the cost of the management intervention. The payment vehicle was presented as a one-off[5] compulsory payment by all households in Victoria to a Trust Fund, that would only be used to carry out river management policies. The attributes and their levels are presented in Table 1. An ASC is included in the analysis, setting a value of 0 for the status quo alternative and 1 otherwise.

It is practically infeasible to include all possible combinations of the five attributes ('the full factorial') in a questionnaire. A selection has to be made to limit the cognitive burden for respondents. An orthogonal[6] experimental design process was used to select a set of 54 alternative river management outcomes. Each alternative contained different levels of the five attributes. Every choice set included two pairs of alternatives and a 'no-action' management option (status quo). Two of the 27 pairs of alternatives making up the choice sets were dropped from the experimental design because of dominated alternatives (where one alternative is better in every respect to the paired alternative). The remaining 25 choice sets were divided into five groups of

[5] The equity of using a one-off payment can be questioned given the potential for poorer people to be unable to afford the immediate expense whereas they may be willing to pay over a sequence of payments.
[6] Orthogonality requires that all attributes are statistically independent from one another.

five questions. The experimental design therefore resulted in five different questionnaires. An example choice set is given in appendix 1.

The attributes in each choice set were described by symbols, representing different levels of the attributes. Representative symbols were chosen to make the choice questions easier for respondents. A booklet accompanying the questionnaire included a symbol key for every attribute. The relationship between the symbols and the numerical levels of the attributes was not perfectly linear. However, the simplicity of using symbols was assumed to outweigh potential disadvantages from this non-linearity.

3.2 Survey Logistics

To capture population heterogeneity, three sub-samples were randomly drawn from an urban population (Melbourne), rural within-catchment population (Goulburn) and rural out-catchment population (Gellibrand). Data were collected through a mail-out-mail-back survey of 1000 people in each sub-sample. The survey was conducted from November 2005 to February 2006. Each questionnaire was accompanied by an information booklet with background information about river health issues and possible policy responses. The information booklet also contained instructions on how to answer the choice questions.

Table 1. Variables and attribute levels used in model

Variable	Description	Levels / Units
ASC	Alternative specific constant for the choice between 'status quo' or 'change' options.	1 for the 'change' options, otherwise 0
ASC2	Alternative specific constant for the choice between two change options	1 for the third option in the choice set, otherwise 0
Cost	Compulsory one-off payment to trust fund.	$0, 20, 50, 200
Fish	% of pre-settlement species and population levels	5, 10, 20, 30
Veg	% of river's length with healthy native vegetation.	50, 60, 70, 80
Bird	# of native waterbirds and animal species.	35, 45, 55, 65
Recr[1]	% of river suitable for primary contact recreation.	70, 80, 90, 100
GenASC	Gender * ASC	1 if male, 0 otherwise
KidsASC	Children * ASC	1 if having children, 0 otherwise
AgeASC	Age * ASC	Years
EducASC	Education * ASC	Years
IncASC	Income[2] * ASC	$ per fortnight
NoageASC	Missing age	1 if no age reported, 0 otherwise
NoeducASC	Missing education	1 if no education reported, 0 otherwise
NoincASC	Missing income	1 if no income reported, 0 otherwise
ConfusASC	Confused * ASC	1 if confused by choice question, 0 otherwise
InterestASC	Interested * ASC	1 if interested in river health issues, 0 otherwise

[1] Recreation is used as an indicator of water quality.
[2] From twelve net fortnightly income categories ranging from under A$240 to A$4001 and over.

3.3 *Descriptive statistics*

The survey response rate was approximately 17%, yielding 390 useful questionnaires. Descriptive statistics of the survey are provided in Appendix 2. There were 165 observations in the Goulburn sub-sample, 125 observations in the Gellibrand sub-sample and 100 observations in the Melbourne sub-sample. The low response rate in comparison with other survey studies is possibly due to the Christmas period, in which most of the surveying took place.

A relatively high proportion of the respondents did not answer the income, age and education questions. To prevent these observations from being dropped as 'missing data', a strategy was developed to replace the missing observations. Replacing missing observations by the average of the available values preserves the mean but distorts the marginal distribution of the variable. Instead dummy variables were included in the regression to account for the observations where no income, age or education was reported. The significance of these dummies (interacted with the ASC) indicates whether respondents who do not report their income, age or education have higher or lower probabilities of choosing change alternatives than those who have average incomes, age or education.

4. Results

STATA 9.1 was used to fit conditional and nested logit models to the data. This section presents results of the models' value estimates.

4.1 Conditional logit model

Several conditional logit (CL) models were fitted to the choice data, of which a selection is reported in appendix 3. The choice attributes fish populations, riverside vegetation, bird and animal population, recreation and costs were modelled as continuous variables. The basic model shows that respondents' choices are influenced by the level of the attributes. All the attributes are significant at the 5% level and signed as expected *a priori*, except recreation. In general, respondents prefer the choice option with lower costs, higher fish populations, more native vegetation and more native bird species. Recreation is significant in the within-catchment and urban samples of Goulburn and Melbourne.

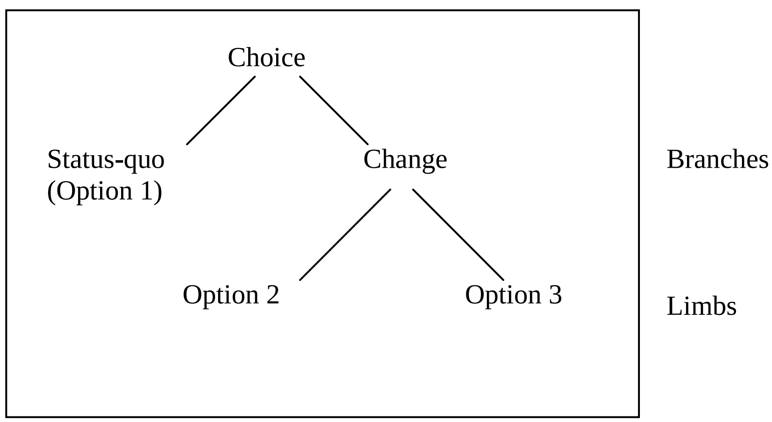
The final model includes the attributes in a linear fashion as well as variables on age, gender, education, log of income, interest in river health and confusion by the choice sets. The insignificance of the ASC indicates that there is no systematic bias toward respondents choosing the status quo alternative in both rural samples. Given that respondents choose the 'change' option, there is a bias towards the second option as indicated by the significant and negative ASC2. Age is negative and significant in the Goulburn and Melbourne sub-samples, so older respondents are more likely to choose the status quo option. Income is significant in the urban sample and has the expected positive sign. Income is significantly negative at the 10% level in the within catchment sub-sample, but the coefficient on 'no reported income' is also highly significant. It is possible that the respondents who refused to reveal their income confound the effect of income on choice.

Education is positive and significant in the rural sub-samples. The coefficient for 'confused' is significant in the Melbourne sub-sample and has the expected negative sign, indicating that respondents who are confused by the choice sets are more likely to choose the status-quo option.

4.2 Nested logit models

The results from the CL models were tested for violation of the IIA assumption using a standard Hausman and McFadden (1984) specification test[7]. The test rejected the null hypothesis but for some samples STATA reported that the difference matrix was not positive definite. Therefore, another test was performed using the Seemingly Unrelated Estimation (SUR) command in STATA. This test confirmed violation of the IIA assumption.

Figure 1. Tree structure for the Nested Logit model.



In order to relax the IIA assumption, two-level NL models were estimated for all three sub-samples (Figure 1). Respondents were assumed to first make a choice between a 'status-quo' and a 'change' option. The choice between these two "branches" is explained by the respondent's socio-economic characteristics[8]. For example, it is expected that higher income or education will lead to a higher probability of choosing the 'change' option. Within the 'change' branch, a choice between two different alternatives (option 2 and option 3) is assumed to depend on the level of the attributes. The NL model can also be used to test the IIA assumption. If the Inclusive Value

[7] This involves estimating an unrestricted choice model with all alternatives and a restricted model where one of the alternatives has been removed from the data. The null hypothesis is that there is no systematic difference between the estimated coefficients of the unrestricted model and the restricted model. Consistent coefficient estimates between the two models indicates that the IIA assumption holds.
[8] This NL structure is commonly employed in the CM literature (e.g. Blamey *et al.*, 2000; Van Bueren and Bennett, 2004).

parameters in the model are statistically equal to one, the two limbs collapse into a single branch, which is equivalent to the CL model (Hensher et al, 2005). The results of the NL models are shown in appendix 4.

The IV parameter for the "status-quo" branch has been normalized to one and the IV parameter for the "change" branch is estimated in the model. The IVs for the "change" branch in all sub-samples are significant different from one. This indicates that the IIA property is not satisfied, which strengthens the confidence in using the NL model.

Despite the evidence of IIA violation, the results of the CL and the NL models are very similar. The estimated coefficients have the same signs and similar magnitudes with comparable standard errors. Interest in river health is significant and positive in all samples, indicating that interest in river health raises the probability of choosing a "change" branch. Older respondents are more likely to choose the "status-quo" alternative, while more years of education leads to a higher probability of choosing one of the change options. The ASC parameter is positive and significant for the Goulburn sub-sample, indicating a preference for changed environmental management for within catchment respondents, all else equal.

The choice between the two "change" alternatives is explained by the level of the attributes. Higher costs reduce the choice probability while the alternative with higher levels of the environmental attributes has a higher probability of being chosen. As in the CL model, the ASC2 parameter is negative and significant across the sub-samples[9].

4.3 Implicit prices

Using equation (2), Implicit Prices (IP) for each attribute were calculated using both the CL models and the NL models (Table 2). The implicit prices represent the willingness to pay (WTP) per household (as a one-off compulsory payment) for a one-unit improvement in the relevant attribute.

All IPs are positive except for recreation in the Gellibrand sub-sample, indicating that respondents hold a positive value for improvements in environmental health of the Goulburn

[9] This indicates that there is a systematic tendency to choose option 2 (the middle option in every choice set) when choosing for changed environmental management.

River. The average WTP for increasing the number of fish and bird species lies between A$4.02 and A$5.86 per fish species, and between A$2.18 and A$3.48 per species of waterbirds and native animals. The average WTP for native riverside vegetation lies between A$3.21 and A$5.39 for each one per cent increase in healthy vegetation along the river Goulburn. The IP calculated for recreation is only significant in the within-catchment sub-sample using the CL model. This implies that only the local population values recreation in their adjacent river. It is important to note that the attributes are defined in different units when comparing the IPs across attributes (Bennett and Adamowicz, 2001).

Table 2. Estimated Implicit Prices[1]

	Goulburn (in-catchment)		**Gellibrand (out-catchment)**		**Melbourne (urban)**	
Attribute	**CL model**	**NL model**	**CL model**	**NL model**	**CL model**	**NL model**
Fish	4.024***	4.201***	5.665***	5.862**	4.798***	4.878**
	(1.97~6.08)	(1.61-6.797)	(1.70~9.62)	(0.57~11.15)	(2.48~7.11)	(0.91~8.84)
Veg	3.208***	3.216**	4.987***	4.483	5.374***	5.392***
	(1.09~5.33)	(0.38~6.06)	(1.75~8.22)	(-1.48~10.4)	(2.88~7.87)	(1.62~9.16)
Birds	3.410***	3.475**	2.183	3.103	3.143***	3.252*
	(1.38~5.44)	(0.47~6.49)	(-0.98~5.34)	(-3.31~9.51)	(0.55~5.74)	(-0.22~6.71)
Recr	1.939**	2.156	-1.124	-0.566	1.598	1.823
	(0.06~3.82)	(-0.74~5.05)	(-4.34~2.09)	(-5.13~3.99)	(-0.80~3.99)	(-1.60~5.25)
Obs.	2175	2175	1635	1635	1380	1380

Implicit Prices in A$. * p<0.1; ** p<0.05; *** p<0.01. 95% confidence interval in parentheses.
[1] Calculated using non-parametric bootstrapping in STATA 9.1 with 200 replications.

5. Discussion

This study used CL and NL models to estimate the IPs for improvements in river health. The CL model requires independently distributed error terms (IIA property). Econometric reasoning suggest that the IIA property is unlikely to hold in the conditional logit specification. Therefore, a nested logit model should be used to estimate respondents' preferences over different choice alternatives.

Most studies to date have used a Hausman test to test for violation of the IIA property. In this test, one choice option is dropped from the choice sets and a restricted model is estimated. If there are significant differences between the estimated coefficients from a restricted and unrestricted choice model, the IIA assumptions is violated. This could work well if there are a large number of choice alternatives. Given that the Goulburn River survey had three options in every choice set, it is highly likely that the coefficients from a restricted and unrestricted model are different. Using a Hausman test for IIA violations has proved ambiguous. It is hypothesised that the test is affected by the structure of the choice sets making it ineffective as a test of the IIA assumption when only three choice alternatives make up the choice sets. A more general SUR procedure is in such cases potentially superior to test the IIA property.

As the conducted tests rejected the IIA assumption, a NL model was used to estimate implicit prices. Yet, the overlapping 95% confidence intervals show that the IP results from the NL and the CL model are not significantly different across sub-samples[10]. The CL model seems to performs adequately, which raises questions about the efficacy of a complicated NL model in analysing CM data.

6. Conclusion

This research estimates the economic values of improved river health for a case-study of the Goulburn River, Victoria. Choice Modelling is used to estimate the values that households attach to fish populations, vegetation, native birds and fauna and recreation. Respondents' preferences are modelled using conditional logit and nested logit specifications. The results of this research are useful inputs into decision-making, enabling policy makers to prioritise investment decisions.

Results indicate that households hold positive values for the protection of fish species, birds and native water animals and for riverside vegetation. Values are expressed in terms of implicit prices for the levels of attributes specified in the questionnaire. Implicit prices range from A$4.02 to A$5.86 per fish species and from A$2.18 to A$3.48 per fauna species. The implicit price estimate for a percentage increase in healthy riverside vegetation along the Goulburn River ranges from A$3.21 to A$5.39. The value estimates for recreation are largely insignificant across models. On average, Goulburn households attach higher values to native waterbirds and fauna while Gellibrand and Melbourne households generally attach higher values to fish populations and riverside vegetation of the Goulburn River.

[10] Other studies (e.g. Wang *et al.*, 2006) have also found insignificant differences between IP estimates from a NL and a CL model, in that instance using LIMDEP rather than STATA.

As well as providing valuable information for decision makers, this study demonstrates the application of two different logit models in analysing CM data. The generally used Hausman test for violation of the IIA assumption does not perform adequately and should be employed with caution. Results indicate that similar estimates are derived from conditional and nested logit specifications. Although the nested logit model is commonly preferred to avoid violations of the IIA property, its complexity makes application difficult. Future research should focus on the appropriateness of nested logit models in CM studies.

References

Bennett, J.W. and V. Adamowicz (2001). 'Some Fundamentals of Environmental Choice Modelling', In: Bennett, J.W. and Blamey, R.K. (2001). *The Choice Modelling Approach to Environmental Valuation*. Edward Elgar Publishing, Cheltenham.

Bennett, J.W., J. Rolfe and M. Morrison (2001). 'Remnant Vegetation and Wetlands Protection: Non-market Valuation'. In: Bennett, J.W. and R.K. Blamey (2001). *The Choice Modelling Approach to Environmental Valuation*. Edward Elgar Publishing, Cheltenham.

Blamey, R. J. Rolfe, J. Bennett and M. Morrison (2000). 'Valuing remnant vegetation in Central Queensland using choice modelling', *The Australian Journal of Agricultural and Resource Economics*, vol.44(3): 439-456.

Cameron, A.C. and P.K. Trivedi (2005). *Microeconometrics: methods and applications.* Cambridge University Press, New York.

Hausman, J. and McFadden, D. (1984). 'Specification tests for the multinomial logit model', *Econometrica*, vol. 52, pp. 1219–1240.

Hensher, David A., J.M. Rose, and W.H. Greene (2005). *Applied Choice Analysis: A Primer.* Cambridge University Press, Cambridge.

Louviere, J.J., Hensher, D.A. and Swait, J.D. (2000). *Stated Choice Methods – Analysis and Application*, Cambridge University Press, Cambridge.

Morrison M. and J.W. Bennett (2004). 'Valuing New South Wales rivers for use in benefit transfer', *The Australian Journal of Agricultural and Resource Economics*, 48:4, pp. 591–611.

Rolfe, J., J.W. Bennett and J. Louviere (2000). 'Choice Modelling and its potential application to tropical rainforest preservation', *Ecological Economics*, 35, pp. 289-302.

URS (2006). *The Value of Improved Environmental Health in Victorian Rivers: Results from the Pilot Phase*, Report prepared for the Victorian Department of Sustainability and Environment, 17 July 2006.

Van Bueren, M. and J. Bennett (2004). 'Towards the development of a transferable set of value estimates for environmental attributes', *Australian Journal of Agricultural and Resource Economics*, 48(1): 1-32.

Wang, X., J. Bennett, C. Xie, Z. Zhang, D. Liang, L. Zhang, G. Dai, J. Zhao and L. Jiang (2006). *Non-Market Valuation of the Environmental Benefits from the Conversion of Cropland to Forest and Grassland Program*. Sustainable Land Use Change in the North West Provinces of China, Research Report No. 5. Australian Centre for International Agricultural Research.

Wielgus, J., L.R. Gerber, E. Sala, J. Bennett (2006). *Including Scenario Uncertainty in Stated Preference Valuation: A Choice Experiment on Marine Recreational Resources.* Paper for the 8th International BIOECON Conference on "Economic Analysis of Ecology and Biodiversity", Kings College Cambridge, 29-30 August 2006.

APPENDIX 1 Example choice question.

Question 5: Carefully consider each of the following three options for the Goulburn River downstream of Lake Eildon. Suppose that Options 1, 2 and 3 are the ONLY ones available. Which one would you choose?

		Outcomes for the Goulburn River in 20 years time			
	Your one-off payment	Native fish	Riverside vegetation	Native waterbirds and animals	Recreation opportunities
Option 1 No new initiatives	**$0**				
Option 2	**$20**				
Option 3	**$50**				

APPENDIX 2 Descriptive statistics of survey sample (n=390).

Variable	Sub-sample	Goulburn rural in-catchment	Gellibrand rural out-catchment	Melbourne urban	Total
# of responses		165	125	100	390
Adjusted response rate[1]		20%	15%	15%	17%
Gender	Male	61%	59%	61%	60%
	Female	32%	34%	34%	33%
	NK[2]	7%	7%	5%	7%
Children	Yes	76%	78%	75%	76%
	No	16%	15%	20%	17%
	NK	7%	7%	5%	7%
Age	Min	24	25	27	24
	Mean	53.5	55	51	54
	Max	85	85	89	89
Education	NK	8%	9%	5%	7%
6 years	Primary	3%	4%	3%	3%
10 years	Junior	12%	11%	5%	19%
12 years	Secondary	28%	26%	21%	26%
13 years	Diploma	15%	15%	10%	14%
15 years	Tertiary	24%	30%	55%	34%
	Other	10%	5%	1%	6%
	Mean	12.6	12.7	13.6	13
Income	NK	18%	20%	14%	17%
(class mid	$200	2%	1%	0%	1%
point per	$320	4%	5%	1%	4%
fortnight)	$500	5%	6%	1%	6%
	$700	5%	7%	3%	7%
	$900	7%	6%	1%	6%
	$1,100	5%	3%	2%	5%
	$1,300	6%	10%	6%	9%
	$1,500	9%	4%	6%	8%
	$1,800	8%	11%	11%	12%
	$2,500	16%	10%	25%	20%
	$3,500	9%	10%	12%	12%
	$4,500	5%	6%	18%	10%
	Mean	$1837	$1796	$2652	$2,042

[1] Adjusted for non-response due to incorrect addresses and deceased persons.

[2] NK = not known.

APPENDIX 3 Conditional logit model results for the attribute only and final model.

Sub-sample	Goulburn		Gellibrand		Melbourne	
Variable	**Attribute only**	**Final**	**Attribute only**	**Final**	**Attribute only**	**Final**
ASC	-0.241	1.546	-0.424	-2.019	-0.570	-9.043^{***}
	(0.309)	(1.866)	(0.349)	(1.788)	(0.404)	(2.355)
Cost	-0.009^{***}	-0.009^{***}	-0.007^{***}	-0.007^{***}	-0.009^{***}	-0.010^{***}
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Fish	0.037^{***}	0.038^{***}	0.036^{***}	0.041^{***}	0.042^{***}	0.050^{***}
	(0.007)	(0.007)	(0.008)	(0.009)	(0.009)	(0.010)
Veg	0.030^{***}	0.030^{***}	0.034^{***}	0.036^{***}	0.053^{***}	0.056^{***}
	(0.007)	(0.007)	(0.008)	(0.008)	(0.009)	(0.009)
Bird	0.029^{***}	0.032^{***}	0.018^{**}	0.015^{*}	0.030^{***}	0.033^{***}
	(0.007)	(0.007)	(0.008)	(0.008)	(0.008)	(0.009)
Recr	0.018^{***}	0.015^{***}	-0.005	-0.008	0.015^{*}	0.017^{*}
	(0.007)	(0.007)	(0.007)	(0.008)	(0.008)	(0.009)
ASC2	-0.186^{**}	-0.255^{***}	-0.216^{**}	-0.215^{**}	-0.122	-0.183
	(0.087)	(0.095)	(0.100)	(0.108)	(0.113)	(0.122)
Age*ASC		-0.044^{***}		-0.009		-0.022^{*}
		(0.014)		(0.012)		(0.012)
Gen*ASC		0.807^{***}		-0.714^{**}		-0.256
		(0.269)		(0.295)		(0.381)
LnInc*ASC		-0.371^{*}		-0.048		1.053^{***}
		(0.203)		(0.199)		(0.323)
Edu*ASC		0.108^{*}		0.199^{***}		0.042
		(0.065)		(0.063)		(0.076)
Noage*ASC		-0.952^{***}		0.137		0.210
		(0.261)		(0.277)		(0.432)
Noinc*ASC		-3.915^{***}		-2.145		6.738^{***}
		(1.402)		(1.344)		(2.209)
Noedu*ASC[1]		0.226		-1.278^{***}		9.683
		(0.407)		(0.439)		(499.57)
Int*ASC		2.199^{***}		1.228^{***}		1.8232^{***}
		(0.509)		(0.278)		(0.358)
Conf*ASC		-0.272		-0.205		-0.965^{**}
		(0.312)		(0.277)		(0.432)
Pseudo R^2	0.1848	0.248	0.098	0.193	0.234	0.315
Log likelihood	-738.83	-598.98	-619.40	-483.46	-420.93	-346.29
Observations	2475	2175	1875	1635	1500	1380

Legend: * p<0.1; ** p<0.05; *** p<0.01. Standard error in parentheses.

[1] The large coefficient and standard error for no reported education in the Melbourne sub-sample are due to the small number of respondents. Only three respondents in the sub-sample did not report their years of education.

APPENDIX 4 Nested logit model results.

Variable	Goulburn		Gellibrand		Melbourne	
Limb choice						
ASC2	-0.288***	(0.100)	-0.290**	(0.117)	-0.275**	(0.135)
Cost	-0.010***	(0.001)	-0.009***	(0.001)	-0.012***	(0.002)
Fish	0.044***	(0.008)	0.052***	(0.010)	0.061***	(0.011)
Veg	0.033***	(0.008)	0.040***	(0.009)	0.067***	(0.011)
Bird	0.036***	(0.008)	0.027***	(0.010)	0.040***	(0.010)
Recr	0.022***	(0.008)	-0.005	(0.009)	0.023**	(0.011)
Branch choice						
ASC	3.658*	(2.100)	1.694	(2.152)	-2.804	(2.995)
Age*ASC	-0.044***	(0.013)	-0.010	(0.012)	-0.020*	(0.011)
Gen*ASC	0.760***	(0.265)	-0.734**	(0.291)	-0.211	(0.371)
LnInc*ASC	-0.347*	(0.198)	-0.042	(0.193)	0.956***	(0.310)
Edu*ASC	0.112*	(0.064)	0.179***	(0.062)	0.038	(0.074)
Noedu*ASC	0.209	(0.401)	-1.253***	(0.435)	18.45[1]	(30951.06)
Noage*ASC	-0.930***	(0.256)	0.152	(0.271)	0.185	(0.418)
Noinc*ASC	-3.710***	(1.374)	-1.959***	(1.306)	6.165***	(2.108)
Int*ASC	2.150***	(0.502)	1.168***	(0.274)	1.750***	(0.348)
Conf*ASC	-0.223	(0.306)	-0.212	(0.270)	-0.922**	(0.421)
IV						
Status-quo	1.000	(0.000)	1.000	(0.000)	1.000	(0.000)
Change	0.633***	(0.165)	0.201	(0.190)	0.370**	(0.170)
Log likelihood	-597.00		-477.12		-341.41	
Observations	2175		1635		1380	

Legend: * p<0.1; ** p<0.05; *** p<0.01. Standard error in parentheses.
[1] The large coefficient and standard error for no reported education in the Melbourne sub-sample are due to the small number of respondents. Only three respondents in the sub-sample did not report their years of education.