

The economic value of improved environmental health in Victorian rivers

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To address the poor health of approximately one third of Victoria's rivers, current government targets include delivering significant improvements in river health by 2010. The quantification of benefits associated with improvements in river health arising from policy initiatives and projects enables the use of benefit-cost analysis to assess the viability of investment options. The non-market valuation technique known as choice modelling was used to generate benefit estimates for a selection of Victorian rivers. Monetary values were estimated for four attributes of environmental improvement: the percentage of pre-settlement fish species and populations; the percentage of the river's length with healthy vegetation on both banks; the number of native waterbird and animal species with sustainable populations; and the percentage of the river suitable for primary contact recreation without threat to public health. The relevance of the approach to management and policy issues is demonstrated.

Keywords: choice modelling, river management, healthy rivers, environmental economics

Approximately 32 per cent of Victoria's rivers are in poor to very poor condition while only 21 per cent are in good to excellent condition (DSE 2007). Information on the benefits associated with improvements in river health is essential in the application of benefit-cost analysis (BCA) to the assessment of river health programs and projects. BCA is the most widely used framework for the economic evaluation of public projects; however, the quantification of benefits that are not valued in markets is a challenge in applying BCA to river health projects.

Non-market valuation (NMV) techniques are designed to yield value estimates in monetary units that are consistent

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An earlier version of this paper was presented to the 9th Riversymposium, 4–7 September 2006, Brisbane.

with the principles of welfare economics that underpin BCA. In the choice modelling (CM) approach to non-market environmental valuation, respondents to a questionnaire are asked to select between an array of alternative future natural resource management options (Bennett & Blamey 2001). Each scenario is described in terms of a set of non-marketed environmental and social 'attributes' and a monetary cost. Different alternatives give rise to different levels of the attributes.

CM was used to estimate the benefits associated with improvements in the environmental health of rivers in the Goulburn, Broken, and Corangamite catchments¹. Specific objectives were to:

- define a set of river health attributes that captures the outcomes of management activities that are of interest to the relevant communities
- establish communities' valuations of those attributes in a form that is appropriate for use in BCA.

Methodology

Choice modelling

When a respondent makes a choice between alternative natural resource management options in a CM questionnaire, they provide information regarding the relative strength of their preferences for combinations of the attributes that go to make up the various options. When such choices are made repeatedly across a variety of options, respondents provide enough information regarding their relative preferences to allow the estimation of the amount of one attribute respondents are willing to give up, on average, to secure more of another. When one attribute is money, the trade-off across the attributes can be calibrated in monetary terms, and represents the extra amount respondents are willing to pay for an increase in the non-monetary attributes.

Applications of environmental CM in Australia have focused on the estimation of the benefits of land and water restoration (van Bueren & Bennett 2004), wetland and remnant vegetation protection (Whitten & Bennett 2004), and river health improvements (Morrison & Bennett 2004; Rolfe & Bennett 2006). The technique also

1. The full report for this study (URS 2006) provides more detail.

Table 1 **Sampling strategy**

Sub-population	Goulburn River	Moorabool River	Gellibrand River
Urban	Melbourne	Melbourne	
Rural in-catchment	Goulburn	Moorabool	Gellibrand
Rural out-of-catchment	Gellibrand		

has a rich history of applications in the transport (e.g. Hensher 2007) and health (e.g. Hall et al. 2004) fields.

Selection of rivers

A sample of rivers was selected to act as ‘representatives’ of biophysically defined classes of rivers across Victoria. In discussions with the Department of Sustainability and Environment (DSE) staff, the rivers of Victoria were classified into nine river types according to a number of factors: regulated/unregulated², flow characteristics, location (urban/peri-urban/rural), and size. The purpose of this classification was to facilitate benefit transfer (BT), allowing the results for representative rivers to be extended to rivers of similar classification (Rolfe & Bennett 2006).

The following rivers were selected, representing three of the nine river types:

- Goulburn River (large lowland regulated river - irrigation)
- Moorabool River (large peri-urban regulated river)
- Gellibrand River (large unregulated coastal river).

Sample populations

A sequence of sub-samples of the Victorian population was chosen to reflect potential differences in values held across the state. To capture information about differences in personal preference, the households selected to answer the CM questionnaire should reflect the diversity within the overall population. One aspect of this diversity is the household’s physical location. Living close to a river, for example, may give rise to differing perceptions and hence preferences for the river. To capture the elements of diversity, a population sampling strategy was developed to provide representation of urban and rural groups and households located within a river’s catchment and outside it.

Six sub-samples were selected (Table 1). The structure of the sampling strategy enables the detection of differences

in values between urban and rural sub-populations and in-catchment and out-of-catchment sub-populations.

Values for river health improvements were estimated for the Goulburn River among households located out of the catchment in both the city (Melbourne) and a rural area (the Gellibrand catchment area). Values for the

Moorabool were estimated for households in Melbourne and in-catchment. Only in-catchment households were surveyed for the Gellibrand.

Questionnaire design

Applying CM requires the development of a questionnaire in which respondents are presented with a sequence of choice sets that show the options for resource use. Three questionnaires were developed that were the same apart from the specifics of the three rivers.

A key part of the initial design work involved the selection of river health attributes to be used to convey information to respondents about the outcomes of alternative management options. The selection of attributes was based around a two-phase process. The first involved the gathering of information about river health outcomes from river managers and scientists. The second used focus groups of potential respondents to the survey to determine the suitability of attributes in conveying information.

Expert opinion and focus groups

An expert panel, consisting of representatives from environmental consulting, La Trobe University, Parks Victoria, DSE, Goulburn Broken Catchment Management Authority (GBCMA), Corangamite CMA and URS Australia, defined an initial list of important river health attributes. These were then refined in discussions with experts and managers, as well as with members of the public in focus groups, held in Melbourne, Meredith (near Geelong), and Trawool (near Seymour).

In general, the focus group participants were comfortable with the attributes selected and were willing to leave the definition of levels of attributes to the experts. They did not feel that there was overlap between the attributes, and understood that they were selected to represent easily understood measures of the benefits that healthy rivers provide.

2. Regulated /unregulated refers to the presence/absence of flow control structures (e.g. dams and weirs) on rivers.

The four river health attributes selected related to native fish, riverside vegetation, native waterbirds and other animals, and water quality/recreation opportunities.

Native fish: A healthy river will have an abundant and self-sustaining population of native fish. The population of native fish will be related to both the number of species present and the numbers of fish of each species. The measure used was the ‘percentage of pre-settlement species and population levels’³. A fish symbol was used to represent this attribute.

Riverside vegetation: A healthy river-side zone has more than 60 per cent of the ground cover as native species, and the vegetation belt on each side of the river is more than about 1.5 times as wide as the channel. More than 50 per cent of the river’s wetlands and billabongs are well-connected to the river and are in good condition with regard to the naturalness and quantity of fringing vegetation. The measure used was the ‘percentage of river’s length with healthy vegetation on both banks’. A tree/shrub symbol was used to represent this attribute.

Native waterbirds and other animals: The emphasis in this attribute is that the observed populations of native birds and animals (e.g. platypus and gliders) are sustainable; that is, the observed populations are not casual ‘visitors’. Sustainable populations of migratory waterbirds that use the river are regular, long-term visitors. The measure was the ‘number of native waterbirds and other animal species with sustainable populations’. A waterbird symbol was used to represent this attribute.

Water quality/recreation opportunities: The quality of water can be indicated by the recreational opportunities that could be undertaken. The measure used was ‘percent of the river suitable for primary contact recreation without threat to public health’. A symbol representing a swimmer was used to represent this attribute.

The levels of each attribute applicable for each river were then determined by staff of the relevant catchment management authority. Outcomes were considered over a twenty year period, with and without management interventions. The levels of each attribute were set in the context of what could be achieved in practice for each river, through management initiatives. In other words, they were not the same for all rivers and reflected the likely potential for improvement in each case. In general,

they were based on the best estimates of the experts: quantitative evidence from formal studies was seldom available.

Experimental design

The next step in the design of the questionnaire involved combining the attribute levels to form the choice sets. This was achieved through the use of an experimental design.

CM relies on an analysis of the choices respondents make between an array of potential resource management options. The choice information is only useful if the options presented cover the full range of possible combinations of attribute levels. Because there are so many possible combinations (the ‘full factorial’), it is impossible to present them all to respondents, so a fraction of the full factorial is selected.

In choosing an experimental design to generate this fraction, a trade-off is made between the completeness of the fraction used and the cognitive burden imposed on respondents. The more complete the fraction, the more choice observations are generated, but each respondent is then faced with a greater number of choice sets. Because the attributes selected for this study were found to be largely independent of each other in the minds of focus group respondents, a ‘main effects’ experimental design was selected. A further reason for keeping the experimental design simple was to reduce the number of choice sets each respondent needed to answer. Even so, for each river, a total of 25 choice sets was created under the experimental design. These were divided into five ‘blocks’ or versions of the questionnaires, each containing five choice sets. This blocking process is necessary to reduce the cognitive burden on respondents.

Communications

Various strategies were developed to ensure that the questionnaires communicated the requirements of the methodology adequately to the respondents. These strategies are particularly important for mail-out-mail-back surveys; the type used in this project due to the wide dispersion of survey respondents. The overall design of the questionnaire benefited from previous work on NSW rivers (Morrison & Bennett 2004).

The questionnaire material was in two booklets: one entitled ‘Information booklet’, the other ‘A survey of your views’. All questions were in the second booklet,

3. Because the number of fish species and the size of fish population were seen to be strongly correlated, they were combined to form a single ‘native fish’ attribute. ‘Percentage of pre-settlement’ levels was used as the attribute metric because it was the most complete form of information that experts in the field were able to provide.





Score	Percentage of pre-settlement species and population levels
	30
	20
	10
	5

Figure 1 Symbol key for native fish

enabling respondents to retain the information booklet about the river and its management. The information booklet cover featured a map of the river catchment, while the survey booklet cover included photographs of the river.

A feature of the questionnaire was its use of symbols to communicate attribute levels in the choice sets. Hence, instead of using numbers to tell respondents the percentage of pre-settlement fish species and population levels that would occur under each option, a symbol, similar to the star system used to characterise hotels, was used. Multiple fish symbols represented differing fish attribute levels and a key to this symbolic representation was provided in the information booklet (e.g. Figure 1).

A disadvantage of using the symbol approach is that unless part-symbols are used, the relationship between the number of symbols and the numerical level of the attributes is not linear. It was considered that the advantage in terms of simplicity outweighed the disadvantage in terms of non-linearity⁴.

Information concerning the rivers was sourced from Victorian CMA waterway managers. The difficult balance between detail, complexity and ‘user-friendliness’ was achieved by testing the questionnaire in focus group sessions. Respondents who were not satisfied with the level of detail provided in the information booklet were referred to relevant web sites and to the local CMA⁵.

The survey booklet detailed the survey’s purpose and requirements. Initial questions focused on visitation and

interest levels. The choice set questions were prefaced with explanations of their rationale and the task involved. Framing statements regarding respondents’ budget constraints were included:

When deciding on the options you prefer, keep in mind your available income and all other things you have to spend money on.

The ‘payment vehicle’, representing the cost of providing the alternative options, was expressed as:

...all households in Victoria making a one-off compulsory payment into a Trust Fund⁶. The money raised in this way would only be used to pay for river health improvements.

A short version of ‘cheap talk’ script was also included. This was designed to induce respondents to answer the essentially hypothetical questions that constitute the choice sets in an honest, well-considered manner:

IMPORTANT NOTE: Even though the options you are being asked to consider are hypothetical, your answers will provide information that is very important to improving the management of the Goulburn River below Eildon. Please consider the options carefully and make your choices as if they were real.

This text involves the explicit recognition of the potential for respondents to misrepresent their preferences, either inadvertently by not taking the time to think through what their preferences are, or strategically in an effort to distort the results of the survey in favour of their preferred outcome.

One choice set was presented on each double page of a survey booklet (e.g. Figure 2). Options were individually numbered to avoid confusion. Outcomes were framed in the time period of 20 years into the future. The status quo (no new initiatives) option appeared as Option 1 in every choice set. Respondents were asked to select only one of the three options, or to indicate ‘not sure’. Follow up questions on the choice set sought to identify ‘protest’ responses whereby respondents always chose the status quo as a protest against the ways in which the choice set questions were asked or framed (e.g. the payment vehicle) rather than as an established preference. The final section of the questionnaire focused on respondents’ socio-economic details.

4. The use of symbols to represent attribute levels has not received attention in the CM literature and so it remains unclear what effects, if any, their use has on the derived value estimates. In particular, the impact of a non-linear relationship between the number of symbols and the level of the attribute remains unexplored.

5. Source of additional information were provided in response to the requests of some focus group members who found the level of detail provided in the questionnaire to be insufficient for them to make choices. This strategy runs the risk of creating two ‘classes’ of respondents – those with and without the extra information. However, it also increases the probability that a respondent will complete the questionnaire.

6. Payment was made compulsory to ensure that respondents were not encouraged to ‘free-ride’ on others’ willingness to pay (Carson & Groves 2007).













		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	\$50				
Option 3	\$20				

Figure 2 A choice set for the Goulburn River

Survey logistics

Sampling

Six sub-samples of 1000 respondents were drawn at random (from a database of the Australian population) on the basis of address postcodes for the geographic locations required. Three sub-samples were drawn from the Melbourne population, two from the Gellibrand catchment area, and one from the Moorabool catchment area. Each sub-sample was randomly split five ways for the distribution of the five versions of each questionnaire.

The survey

The survey involved a three-stage process. Initially, a letter of invitation was mailed to the selected respondents. The aim of this letter was to generate interest in the survey and also to 'clean' the sample of respondents who were no longer at the address selected,

or were unwilling to respond for any reason. The second stage involved mailing the two booklets with a covering letter and a reply paid envelope to be used for returning the completed questionnaire. Finally, a reminder postcard was posted to respondents who had not already returned completed questionnaires.

The main mail-out of the booklets took place in mid November 2005. This meant that the survey process began to encroach on the pre-Christmas period, a time when

it is very difficult to divert respondents' attention from end of year activities. Because of this problematic timing, an experimental re-mail of questionnaires to non-respondents was carried out in February in an attempt to increase the response rate achieved.

The sample

The response rates and respondent socio-economic characteristics in the six sub-samples are set out in Table 2. Respondents were asked to answer the questions on behalf of all members of their household. In total, 806 valid responses were recorded: a response rate of 13 per cent of the original 6000 respondents selected. However, when the sample size is adjusted for the incorrect addresses and deceased persons detected after the first invitation letter was sent, the response rate rises to 17 per cent. Response rates were generally better in the in-catchment sub-samples, reaching 20 per cent for the

Table 2 Sub-sample demographic characteristics

River		Moorabool		Gellibrand		Goulburn		All
		Local	Melbourne	Local	Gellibrand	Local	Melbourne	
Population								
Sample size		1000	1000	1000	1000	1000	1000	6000
Respondents		152	117	147	125	165	100	806
Revised sample*		852	684	828	807	818	667	4,656
Adjusted response rate*:		18%	17%	18%	15%	20%	15%	17%
Children	Not known	9%	5%	3%	7%	7%	5%	6%
	Yes	84%	68%	82%	78%	76%	75%	77%
	No	8%	27%	16%	15%	16%	20%	17%
Gender	Not known	8%	6%	1%	6%	8%	5%	6%
	Male	55%	57%	52%	59%	61%	61%	57%
	Female	38%	37%	47%	34%	32%	34%	37%
Average age (years)		52.6	53.1	49.2	55.0	54.5	51.0	52.6
Average education (years)		11.9	13.4	12.7	12.7	12.6	13.6	13.0
Average household income (per fortnight, before taxes)		\$2255	\$2650	\$1902	\$1795	\$1836	\$2652	\$2142

*Sample size and response rate adjusted for wrong addresses and deceased persons

Table 3 Independent variables for the choice models

Variable Name	Description	Levels/ unit: Goulburn	Levels/ unit: Gellibrand	Levels/ unit: Moorabool
ASC (change)	Alternative specific constant	0 for status quo option otherwise 1	0 for status quo option otherwise 1	0 for status quo option otherwise 1
Cost	Compulsory one-off payment to trust fund	\$0, 20, 50, 200	\$0, 20, 50, 200	\$0, 20, 50, 200
Fish	Percentage of pre-settlement species and population levels	5, 10, 20, 30	15, 20, 30, 45	5, 10, 20, 30
Vegetation	Percentage of river's length with healthy native vegetation on both banks	50, 60, 70, 80	12, 18, 28, 40	25, 35, 45, 55
Birds	Number of native waterbirds and other animal species with sustainable populations	35, 45, 55, 65	3, 5, 7, 9	5, 10, 12, 15
Water quality	Percent of the river suitable for primary contact recreation without threat to public health	70, 80, 90, 100	60, 70, 80, 90	20, 30, 40, 55
Age × ASC	Age × ASC	Years		
Inc × ASC	Household income × ASC	\$ per fortnight		
Ed × ASC	Years at school × ASC	Years		
Gen × ASC	Gender dummy	1 for male otherwise 0		
Kids × ASC	Children dummy	1 for has children otherwise 0		
No age dummy × ASC	Missing age	1 if no age reported otherwise 0		
No inc dummy × ASC	Missing income	1 if no income reported otherwise 0		
No ed dummy × ASC	Missing years at school	1 if no education reported otherwise 0		
IV	Inclusive value	Indicates the significance of the nesting structure		

Goulburn, and lower in the out-of-catchment sub-samples, both urban and rural, where they ranged from 15–17 per cent.

It is possible that only those with a real interest in river management responded to the survey. A conservative approach that avoids bias is to extrapolate the results only to the percentage of the population represented by the response rate, viz. 17 per cent of the population overall, with the remaining 83 per cent assumed to hold zero willingness to pay for improvement in river health⁷.

Results

Modelling procedures

The CM approach to non-market valuation requires the estimation of models that explain respondents' selections of their preferred option in each choice set in terms of the

levels of the attributes and the respondents' socio-economic characteristics (Table 3).

Estimated choice models

Choice models were fitted for each of the six sub-samples surveyed. The modeling was performed using 'Stata' econometric software. Linear additive utility functions were estimated using a nested logit model⁸. The coefficients of the independent variables and their statistical significance are reported in Table 4.

Model validity

The choice models estimated for the six sub-samples demonstrate consistency. In all cases, the cost, fish, vegetation, and bird attributes are significant in explaining respondents' choice behaviour and have the *a priori* expected signs. That is, increasing fish species and populations,

increasing areas of riverside vegetation and more native waterbirds and other animals increases respondents' well being. This means that respondents made choices with reference to the levels of the attributes in each option. Put simply, the respondents did not answer the choice set questions randomly.

The water quality attribute was significant only for the Goulburn River in-catchment and Melbourne sub-samples. This indicates that the water quality attribute in the Moorabool and Gellibrand was not important to respondents in their choices of preferred river futures. Respondents in the Gellibrand catchment did not consider the Goulburn River water quality attribute as important⁹.

In all six models, the alternative specific constant was not significantly different from zero. There was no inherent preponderance for respondents to select the change

7. This approach is likely to underestimate the aggregate willingness to pay. Based on follow-up interviews with non-respondents, Morrison (2000) assumed that at least 30 per cent of non-respondents are likely to have similar preferences to the survey sample. Applying this assumption would justify extrapolating results to 34 per cent of the population for this study.

8. Nested logit models were estimated because of breaches in the Irrelevance of Independent Alternatives assumption that is required to hold for the standard conditional logit models.

9. The reason for the lack of importance placed on the water quality attribute by respondents is conjectural. A failure to comprehend the attribute would be one explanation. Alternatively, other interpretations may be made. For example, swimming in inland rivers may have been perceived by respondents as being unsafe with that negative impact of the attribute counteracting the positive aspects of water quality.

Table 4 Estimated choice models

	Moorabool/ in-catchment	Moorabool/ Melbourne	Gellibrand/ in-catchment	Goulburn/ Gellibrand	Goulburn/ in-catchment	Goulburn/ Melbourne
ASC (change)	0.698	5.570	-0.654	6.736	6.011	2.679
Cost	-0.011*	-0.013*	-0.011*	-0.008*	-0.009*	-0.011*
Fish	0.056*	0.068*	0.025*	0.046*	0.041*	0.049*
Vegetation	0.063*	0.068*	0.033*	0.038*	0.033*	0.061*
Birds	0.250*	0.232*	0.198*	0.025*	0.037*	0.037*
Water qual.	0.001	0.004	-0.001	-0.005	0.020*	0.018*
Age x ASC	0.000	-0.011	-0.016	-0.010	-0.035*	0.003
Inc x ASC	0.500*	0.216	0.214*	0.161	-0.153	0.312*
Ed x ASC	0.135*	-0.106	0.199*	0.061	0.096*	0.179*
Gen x ASC	-0.360	0.057	0.264	-0.031	0.672*	-0.055
Kids X ASC	-1.242*	-0.514	-0.365	-0.203	0.181	-0.881*
No age dum x ASC	0.282	0.597	-0.027	0.106	-0.567*	0.064
No inc dum x ASC	-1.507*	-1.041*	-2.23*	-1.614*	-0.835*	-0.879*
No ed dum x ASC	0.462	-0.559	-0.392	0.909*	1.279*	17.953
IV	0.381	0.319	0.38	0.32*	0.576	0.42*

* Significant at the five per cent level. Differences may arise due to rounding.

options over the status quo. Because the alternative specific constant acts to ‘collect’ the impacts of relevant but unobserved explanatory variables, its insignificance gives confidence in the model specification.

The significance of the socio-economic variables in explaining choice behaviour is also instructive in terms of model validity. Consistency with *a priori* expectations regarding the effects of factors such as income and educational status strengthens the claim that the models are valid.

In three of the six models, respondent income is a significant variable and is positively signed. In other words, for these samples, river health is confirmed as a ‘normal good’ in so far as income and value are

explain the lack of significance of the income variable in three of the choice models.

These findings indicate that, within reasonable bounds, the models estimated are robust and hence can be used with reasonable confidence to estimate values associated with river health improvements.

Implicit prices

The choice models detailed above are the basis of the value estimation process. Implicit prices are detailed for each attribute in each of the sub-samples. Implicit prices are defined as the amount, on average, that respondents are willing to pay to enjoy an increase of one unit in a river health attribute. Recall that these amounts are per household rather than per individual as the survey

positively correlated. Similarly, the number of years spent at school and the values held are also positively correlated, as would be expected. In two of the six models, the age variable is significant and negatively signed indicating that younger respondents are more likely to choose environmentally improving options than older respondents.

A consistent finding across all six models is that respondents who chose not to reveal their income were less likely to support river health improvement options. This helps to

respondents were asked to answer on behalf of their household. They can be interpreted as marginal values or marginal willingness to pay for the attributes (Table 5).

Only the in-catchment respondents and Melbourne respondents were willing to pay for water quality improvements in the Goulburn River. The amount that respondents in

Table 5 Implicit prices

	Moorabool/ in-catchment (\$)	Moorabool/ Melbourne (\$)	Gellibrand/ in-catchment (\$)	Goulburn/ Gellibrand (\$)	Goulburn/ in-catchment (\$)	Goulburn/ Melbourne (\$)
Fish	4.95* (3.02-6.87)	5.34* (3.30-7.38)	2.19* (0.92-3.46)	5.56* (2.97-8.14)	4.39* (2.59-6.10)	4.47* (2.40-6.55)
Vegetation	5.56* (3.73-7.38)	5.33* (3.43-7.23)	2.91* (1.51-4.31)	4.65* (2.36-6.94)	3.56* (1.94-5.19)	5.53* (3.35-7.70)
Birds	22.07* (14.41-25.41)	18.19* (10.98-25.41)	17.33* (9.16-25.5)	3.04* (0.82-5.27)	3.90* (2.19-5.6)	3.35* (1.52-5.19)
Water quality	0.09 (-0.99-1.18)	0.34 (-0.76-1.44)	-0.05 (-1.45-1.35)	-0.59 (-2.57-1.38)	2.12* (0.60-3.63)	1.64* (-0.08-3.35)

* Significant at the five per cent level. Differences may arise due to rounding. Confidence intervals of 95 per cent are in parentheses.

both these sub-samples were willing to pay was approximately \$2 for a one per cent increase in the length of the river suitable for primary contact recreation. The water quality implicit prices were not significant for the other samples. However, since primary contact recreation was used as a surrogate measure of water quality, in future work it may be necessary to distinguish between those who have actually visited the rivers and those who have not, to test any confounding effects between recreation and water quality. It may be that some respondents were valuing the river for swimming rather than water quality – asking themselves the question ‘is it deep enough?’ rather than ‘is it clean enough?’, despite the questionnaire referring to ‘...recreation without threat to public health’.

Fish health was consistently valued by respondents at around \$5 for a one per cent increase in species and population levels. Gellibrand in-catchment respondents were willing to pay \$2 for more native fish in their river¹⁰.

Willingness to pay for improvements in riverside vegetation was also significantly different from zero and ranged between \$3 and \$6. This value was for an additional one per cent of the river’s length with healthy vegetation on both banks¹¹.

Waterbird and other animal species were of less interest in the Goulburn River than in either the Moorabool or Gellibrand, but implicit prices were consistently significantly different from zero in all sub-samples. Moorabool in-catchment respondents were willing to pay over \$20 for each additional native species of waterbird or other animal that could be re-introduced into the riverine area. In contrast, the marginal value expressed by Gellibrand catchment resident respondents for Goulburn River species was around \$3. A possible reason for these differences is that the attribute was starting from a low base for the Moorabool, with potential for significant improvement, compared with the Goulburn¹².

Application to management and policy

The values estimated in this study provide river managers and policy makers with information on the *non-marketed benefits* associated with alternative river management strategies that is directly comparable to the monetary values associated with *marketed benefits*.

The process involved in using these estimates involves several stages. Where the policy or management decision

to be made involves one of the rivers included in this study, the process requires an extrapolation of the estimates derived from the survey to the population. First, changes in the levels of the attributes must be forecast. This is a task for biophysical scientists, expert in predicting river health outcomes. A typical question to be answered is ‘what will happen to fish species numbers over the next 20 years if this management strategy is implemented compared to what would happen if the existing management strategy was maintained?’ Similar questions that relate to the other attributes must be answered. The difficulty and complexity of this task should not be under-estimated: the experts will frequently need to make judgments and assumptions based on their experience rather than on the outcomes of formal published research studies.

With the biophysical predictions completed, the next step is to multiply the predicted changes in attribute levels by the relevant per unit implicit prices. Summing across all attributes will yield the per household average value of the environmental health benefits associated with the change.

Extrapolating to the population requires the estimation of the populations that are represented by the sub-samples. Multiplying the average value from the survey by the number of households in each segment of the population yields the overall value of the change. Where differences in implicit prices have been observed across the sub-samples, the different implicit prices must be multiplied by the populations in the relevant sub-population. This multiplication process must be modified to reflect non-response rates. As noted earlier, if the response rate was 17 per cent then a conservative approach is to extrapolate only to 17 per cent of the population.

An example

Members of a CMA decide to assess the viability of an investment in excluding stock from the riparian zone along a 30 kilometre stretch of a river. The investment would involve fencing and alternative stock watering facilities. The river under consideration is a large inland river.

Consultations with ecologists familiar with this river have led the CMA to form predictions of the changes in the four river condition attributes that would occur given the implementation of the stock exclusion investment:

10. For comparison, the implicit price of the fish species attribute in the NSW study of Morrison and Bennett (2004) averaged around \$3-4.

11. In the comparable NSW study, the vegetation implicit price was approximately \$2.

12. The implicit price for the (broadly) comparable attribute in the Morrison and Bennett (2004) study was \$1-2.

- percentage of pre-settlement native fish species and populations (ΔF): an increase of five per cent
- percentage of the river's length with healthy native vegetation on both banks (ΔV): an increase of two per cent
- number of native bird and animal species with sustainable populations (ΔB): an increase of one species
- percentage of the river suitable for primary contact recreation (ΔR): no change.

Estimating the per household value for these anticipated changes involves multiplying the per unit implicit prices (IP) for each attribute by the number of units of change:

$$\text{Value/household} = \Delta F \times IP_F + \Delta V \times IP_V + \Delta B \times IP_B + \Delta R \times IP_R$$

The implicit price estimates to be used depend on the type of river under consideration and the population of relevance. In this case, the estimates for the Goulburn River are relevant (large inland river) and implicit prices have been estimated for three different sub-populations (Table 6).

Hence, per household values can be estimated for in-catchment residents, rural out-of catchment residents and Melbourne residents. Substituting these implicit price estimates into the value equation yields:

$$\text{Value/household (in catchment)} = 5 \times 4.39 + 2 \times 3.56 + 1 \times 3.90 + 0 \times 2.12 = \$32.97$$

$$\text{Value/household (rural out-of catchment)} = 5 \times 5.56 + 2 \times 4.65 + 1 \times 3.04 + 0 \times 0 = \$40.14$$

$$\text{Value/household (Melbourne)} = 5 \times 4.47 + 2 \times 5.53 + 1 \times 3.35 + 0 \times 1.64 = \$36.76$$

The next step in the estimation process involves the extrapolation of the per household values to the relevant populations. Using ABS data and assuming 2.2 people per household yields household estimates of 2.2 million for Victoria, 1.6 million for Melbourne and 0.6 million for regional Victoria. With an in-catchment population

for the river of interest at 50 000 households, the out of catchment regional household number is 550 000.

Extrapolation across the whole of these sub-populations is unwise given that the implicit price estimates relate only to the proportion of the sample that responded to the survey. Hence, extrapolation at its most conservative involves multiplication of the sub-populations by the sample response rate:

$$\text{Extrapolated value} = \text{population} \times \text{sample response rate} \times \text{household value}$$

For this case:

$$\text{In-catchment value} = 50,000 \times 0.2 \times \$32.97 = \$329\,700$$

$$\text{Regional out-of catchment value} = 550,000 \times 0.15 \times \$40.14 = \$3\,311\,550$$

$$\text{Melbourne value} = 1.6\text{m} \times 0.15 \times \$36.76 = \$8\,822\,400$$

In total across the state, the environmental health improvements generated by the proposed riparian zone fencing project is estimated at around \$12.5 million. The logic of BCA therefore suggests that if the cost of the fencing initiative is less than \$12.5 million (taking into account all costs including the financial costs of fencing material and labour, as well as any lost profits from changed land use arrangements caused by the project) then the project should be undertaken.

Summary and conclusions

River management presents decision makers with a set of trade-offs between competing uses. Information on which to base sound river management decisions should include details of the relationships between alternative uses and the biophysical condition of rivers. For example, decision makers should be aware of the consequences for attributes of river condition (such as native fish species numbers, the health of riverside vegetation, native waterbird and other animal species numbers, and water quality) of various river management strategies (such as permitting more water extraction for irrigation or excluding stock from river banks).

Providing predictions of these consequences is the province of bio-physical scientists. However, such information may not be sufficient for good decision making. Information on the values that the community holds for the predicted outcomes of the alternative management strategies is also important. These values will include the benefits to be enjoyed by the community from extracting water from a river for agricultural

Table 6 Example implicit prices for a large inland river (Goulburn)

Implicit prices per household (\$)	In catchment	Rural Out-of catchment (Gellibrand)	Melbourne
Fish	4.39	5.56	4.47
Vegetation	3.56	4.65	5.53
Birds	3.90	3.04	3.35
Water quality	2.12	0*	1.64

*Not significantly different from zero.

or domestic purposes and the benefits of improving the condition of the river achieved by restoring water flows or investing in engineering or land management options. It is only with such information that the trade-offs associated with particular strategies can be fully assessed. Estimating values associated with extractive values of water is comparatively straightforward because the goods and services so provided are bought and sold in markets. Estimating values associated with improving the environmental condition of rivers is more difficult because the goods and services so provided are not marketed. Ignoring these non-market values is likely to lead to biased decision making.

Applying CM to the non-market valuation task involves samples of people to be affected by proposed changes in river management being asked to choose from a range of alternative 'futures'. These alternatives are described in terms of their likely river condition outcomes and their cost to the respondent. Through an analysis of the trade-offs that people make in deciding their preferred alternatives, monetary values for unit increases in the environmental condition attributes can be estimated.

Three rivers were selected as the focus of the work reported here: the Gellibrand, Moorabool and Goulburn rivers. Values were estimated for these rivers across respondents living within their catchments, in Melbourne and elsewhere in the state.

Models of the data provided by over 800 respondents were found to be statistically robust in their overall capacity to predict respondents' choices. Estimates of respondents' willingness to pay for improved numbers of native fish species, length of river with healthy native vegetation, and numbers of native waterbirds and other animals proved to be significantly different from zero, showing that people do value the environmental condition of rivers. Differences in values between the Goulburn River and the other two rivers were detected for the numbers of waterbirds and other animals. Location of the respondents did not affect their values; although, it was clear that differences in respondents' incomes, age, and education do influence their preferences for river condition attributes.

The picture for water quality is mixed. While significant values were detected for water quality improvements in the Goulburn River amongst locals and Melbourne respondents, values in other rivers were found to be insignificant. It should be recalled that recreation was

employed as a surrogate measure of water quality and it may be necessary to refine this attribute in future work.

The main conclusions to be drawn from the study relate to the method and the results. CM has been demonstrated to be capable of application in the context of the assessment of investments in Victorian river health. Furthermore, its application has been shown to be relatively robust. The results derived from the application have direct and immediate use in the assessment of actual river health investments. The implicit price estimates provided are theoretically consistent with the principles of BCA and so can be used in any BCA of proposed river management options along with already established values for extractive uses of water. Such BCA applications provide useful inputs to the process of developing policy on a river by river basis and across all rivers in the state¹³.

The consistency of implicit price estimates across rivers and samples of different populations indicates that there is potential to use the results as sources for benefit transfer exercises. Put simply, the value estimates derived in this study will be useful not only in assessments of river management strategies in the Goulburn, Gellibrand and Moorabool Rivers but, with due care, will also be useful as indicators of values arising in similar rivers in Victoria. As well as providing policy relevant results, the study, as a pilot, has delivered important lessons for the application of the technique to all river types in Victoria.

It was found that the sample frame used for the pilot included numerous people who had moved house or who were deceased. Alternative sampling frames need to be sourced or other sampling methods used, such as geographically randomized drop-off-pick-up surveying. Surveying over the Christmas period was detrimental to the response rate achieved and avoiding that period, and other key holiday periods such as Easter and school holidays, is a key lesson of the study.

Measures to simplify the questionnaire format warrant investigation. Increased use of photographic material to give respondents quick and easy access to the relevant information is one possibility. The use of full colour photographs, particularly on the cover of the survey booklet would increase the visual attraction of the package delivered to respondents. It may be less daunting to respondents to use an information *sheet* rather than an information booklet.

The use of symbols to represent the attribute levels in the choice sets is also worth re-assessing, particularly where

13. Decision makers may of course consider other inputs to the policy development process. For instance distributional impacts across various groups in society can have important political implications.

there is no clear proportional relationship between the numbers of symbols and the progression of the levels. Numeric representation is an alternative as is a combination of symbols and numbers.

One attribute warrants special mention: the payment vehicle. A one-off payment was specified in the pilot and this has implications for budget-constrained respondents who whilst wishing to support river condition improvements may be unduly restricted in their choices compared to what they could do if payment was scheduled over a longer period.

To the best of the authors' knowledge, this is the first study in Victoria to deal with the difficult-to-quantify 'unpriced' or 'non-market' values associated with improvements in river health. These values can be large relative to market-based values for improvements and have been commonly ignored in other studies, or at best extrapolated from other states or countries. The omission of these values can lead to serious under-estimation of the returns to investment in river health.

The results of the study will be useful in setting priorities for river management projects within and between catchments and regions. In a policy context, it will be possible to quantify the economic benefits of the DSE Healthy Rivers program. The results can be incorporated in BCA, providing support to funding applications for existing or new programs and projects in river health.

Acknowledgements

The authors acknowledge the support of the Victorian Department of Sustainability and Environment, Corangamite Catchment Management Authority, Goulburn Broken Catchment Management Authority and Melbourne Water Corporation.

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