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Valuing a multistate river: the case of the River Murray*

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The River Murray and the Coorong in Australia have been in a state of decline. With the prospect of extended droughts and shifts in inflows due to climate change, difficult choices loom. The options include halting the decline, triage of some assets along the River or staying with the declining river system. To support decision-making, a survey was designed to elicit willingness to pay for improvements in environmental quality. Over 3000 Australians responded to this survey. The study focuses on key River Murray environmental quality indicators: the frequency of bird breeding along the River Murray, increasing native fish populations in the River Murray, increasing the area of healthy vegetation along the River Murray, and restoring water bird habitat in the Coorong. State/Territory models were jointly estimated using a panel multinomial logit error-components model. Willingness to pay estimates for improvements in environmental quality were calculated for the River Murray and the Coorong. Respondents were found to be willing to pay most for the Coorong and to improve waterbird breeding frequency. Respondents from the Australian Capital Territory were found to have significantly higher willingness to pay whereas those in Victoria had a significantly lower willingness to pay than respondents in other states.

Key words: choice experiment, Coorong, error components, River Murray, wetlands, willingness to pay.

1. Introduction

The River Murray is of considerable agricultural, environmental and cultural importance in Australia. However, the River Murray has been seriously affected by river regulation, and more recently by drought. Diversions and flow regulation have all but removed the natural high and extreme low flow events required for healthy flora and fauna (Hillman 2008). The timing of

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releases from major storages has been largely influenced by the requirements of irrigated agriculture with only limited releases of environmental water to aid in bird and fish breeding. The decline of the River Murray has been compounded in recent years by drought with inflows between January and March, 2009 being the lowest in 117 years of records. Between 2006 and 2009, inflows were 46 per cent of the historical three-year minimum (MDBA 2009).

While the States in the Murray-Darling Basin agreed on a Cap on new diversions in 1993 (MDBMC 1996), the establishment and expansion of water trading through successive rounds of water reform has activated underutilised water licences, known as 'sleeper and dozer licenses' and the integrity of the Cap is under threat (Young and McColl 2009). The Living Murray programme established in 2002 in response to scientific evidence that the health of the River was in decline (CRC 2003) has not stemmed the decline of the River Murray. Degradation relating to over-extraction of water, regulation of the river and operation of the barrages has been compounded by drought (CSIRO 2008; MDBC 2008). Property rights, institutional arrangements and pricing policies, which shape how water is allocated among multiple uses, have not evolved sufficiently to avert environmental degradation of the riverine environment (Young and McColl 2009). Future climate change is likely to exacerbate difficult trade-offs among competing water uses.

There has been a growing consensus about the need to re-evaluate the share of the water that is set aside for the environment. The Wentworth Group of Concerned Scientists (2010) has recommended that the environment's share be increased by 4400 GL. Under the framework set out in the *Water Act 2007* (*Commonwealth*), a Basin-wide water sharing plan has suggested an additional 3000–4000 GL per year be allocated back to the environment (MDBA 2010a,b). The Productivity Commission (2010) highlights the need to consider 'the value that people place on environmental outcomes' p. XXXII. Further, this is tempered by the objectives of the *Water Act 2007* to optimise water use for social, economic and environmental outcomes acting based on the best scientific knowledge and socio-economic analysis.[1] As a contribution to this discussion, we report the results of a choice experiment designed to value improvements in the quality of the River Murray. The study is designed to investigate values across different geographic regions. The data are analysed using a panel multinomial logit error-components (EC) model. This modelling approach allows more flexibility in the specification of assumptions around the variance–covariance matrix in estimation as well as accounting for the panel nature of the data. The possibility of biased model coefficients is reduced and standard errors are improved.

The water-sharing plan will necessarily be subject to careful scrutiny and benefit-cost analysis by the Commonwealth and central agencies such as Treasury and Finance departments of the Basin States. Our analysis is on the

[1] See *Water Act 2007* sec 3 (c) and sec21 (4).

benefit side. Our results indicate that respondents are willing to pay substantively to increase the frequency of waterbird breeding, native fish populations, areas of healthy native vegetation and to improve waterbird habitat in the Coorong. While willingness to pay for respondents across New South Wales (NSW), South Australia (SA) and the rest of Australia were found to be similar, respondents in the Australian Capital Territory (ACT) were found to have a significantly higher willingness to pay and respondents in Victoria a significantly lower willingness to pay than respondents in these other States.

2. Literature review

In Australia, there have been a number of studies focussing on rivers and wetlands conducted over the last 20 years. Four choice modelling, studies have been conducted valuing riverine health. Morrison and Bennett (2004) estimated separate values for improvements in the quality of five different rivers in NSW (Bega, Clarence, Georges, Gwydir and Murrumbidgee), sampled in NSW. Rolfe *et al.* (2006) separately valued changes in river health in: (i) the Commet, Nogoa and Mackenzie catchments and (ii) the Dawson catchment in Queensland, collecting samples in Emerald (a small town), in Rockhampton (a major regional centre) and in Brisbane (the State capital). The third study by Bennett *et al.* (2008) valued improvements in the quality of three rivers in Victoria (Goulburn, Moorabool and Gellibrand Rivers) with samples collected in Melbourne (the State capital), and in a few regional centres either within or outside of the catchment. Zander *et al.* (2010) assessed the benefits to urban Australians of managing three tropical, relatively pristine rivers: the Daly, Mitchell and Fitzroy Rivers with samples collected from Melbourne, Perth, Sydney, Brisbane, Canberra and Darwin. Overall, the geographic coverage of the existing studies focusses on rivers outside the Murray-Darling Basin or smaller rivers in the basin but within State sampling.

Other choice modelling studies have been conducted valuing wetlands within river systems. For example, studies have been conducted valuing the Macquarie Marshes and Gwydir Wetlands (Morrison *et al.* 1999, 2002; Morrison 2002), while Bennett *et al.* (2008) estimated the values associated with redgum forests in Victoria. Brouwer (2009) has undertaken a meta-analysis of these riverine and wetland choice modelling studies. While a range of rivers and wetlands with different biophysical characteristics have been valued, all have been rivers or portions of rivers that reside exclusively within a single State. None of these studies have considered the River Murray along the river as a whole. As such, studies that overlook the value of resources to a wider constituency outside a political boundary may underestimate the value of such resources. For these reasons, benefit transfer would provide an incomplete picture of the values people hold for environmental outcomes associated with more water for the environment.

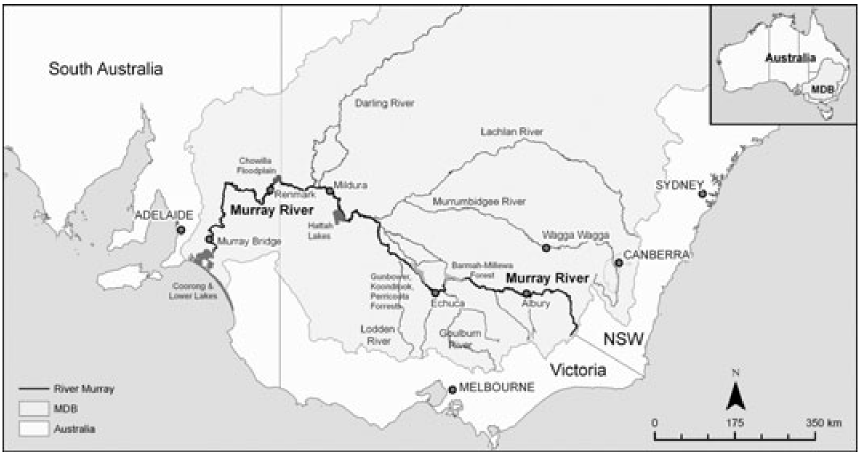

Figure 1 Murray River and location of major wetlands along the River Murray.

3. Case study area and data collection

The River Murray is Australia's longest river, starting in the Australian Alps and flowing 2575 km west where it ends, flowing into the sea at the Coorong in SA (see Figure 1). A number of major rivers flow into the River Murray, including the Darling and Murrumbidgee Rivers. There are five major wetland areas along the River Murray, which are all listed under the Ramsar Convention. These wetlands are the Barmah-Millewa Forest, Gunbower and Koondrook-Perricoota Forests, Hattah Lakes, the Chowilla Floodplain, the Coorong and the Lower Lakes; all these wetlands were identified as 'icon sites' because of their status in terms of ecological and cultural significance under the Commonwealth government's Living Murray process. The Barmah-Millewa forest is an important breeding site for colonial waterbirds, with breeding events historically occurring almost annually. The Coorong, which is at the end of the River Murray, has historically provided critical habitat for large wader bird populations, including many migratory species.

The questionnaire[2] development was guided by extensive use of focus groups and expert opinions of bio-physical scientists in ecology and hydrology. Seven focus groups (three in Adelaide, one in Bathurst, Melbourne, Sydney and Albury) were employed to identify areas of complexity and to aid in the design of the questionnaire. For instance, the number of choice sets per respondent was reduced, and the description and number of attributes was revised.

During the data collection phase of the project, respondents received a questionnaire and a separate information sheet via the mail. On the cover of the questionnaire was a map showing the River Murray, the location of

[2] A copy of the questionnaire is available at http://www.clw.csiro.au/publiwater/waterforahealthycountry/2011/AJARE-submission/questionnaire-Darla-Hatton-Macdonald.pdf

major cities, towns in the Murray-Darling Basin and the location of all the icon sites from the Living Murray programme. Similar to other choice experiments, the questionnaire included a description of the environmental problem, a description of possible solutions, a payment scenario, choice sets, and socio-demographic and attitudinal questions.

In the questionnaire, respondents were told that the quality of the River Murray has declined over the past 40 years and is continuing to decline. Quality changes are described throughout the questionnaire in terms of the attributes: waterbird breeding along the River Murray, native fish populations in the River Murray, healthy vegetation along the River Murray and waterbird habitat in the Coorong. The information sheet provided further detail of the changes in each of these attributes. Photographs representing each of these attributes were included on the information sheet and the selection of photographs was guided by the focus groups.

The causes of the decline in the River Murray were described to respondents. This included such things as drought, irrigation reducing water available for the environment, dams disrupting the natural flow of water, competition from non-native species and land clearing.

To provide balance to the information on changes in environmental quality, the extent and value of agriculture in the region were described. A pie chart showing the extent of land use for various irrigated agricultural activities was included.

Respondents were told about ways that the quality of the River Murray and the Coorong could be improved. This included the government purchasing water from farmers willing to sell in water markets, the government providing incentives to increase irrigation efficiency, habitat rehabilitation and engineering works. These are the actual measures being considered by the States and Commonwealth government.

Respondents were told each option has an annual household cost that will be paid each year for a 10-year period through increased taxes and higher prices for food. This vehicle was chosen because of its realism. Given Australian import restrictions on fresh fruits and vegetables because of the risk of introducing pests, substantial reductions in irrigated agriculture along the River Murray would result in higher food prices. In addition, large-scale purchases of irrigation water may necessitate increased taxes. Further, empirical evidence suggests that payment vehicles that are too specific or too general are likely to be problematic (Boyle 2003). In terms of the periodicity of payment, respondents were asked their willingness to pay an annual household cost that would be paid each year for a 10 year period. Care was taken so that the choke price was not set too high. The highest level of the household cost attribute ($250) was queried in focus groups. A high choke price is recognised in the literature to lead to higher values (Morkbak *et al.* 2010).

A short cheap talk script (see Figure 2) was used to mitigate against the possibility of hypothetical bias (List *et al.* 2006). Longer cheap talk scripts

A problem

When some people answer a survey, they say that they will pay to improve environmental quality when they really would not. They ignore the cost to their household

Research has found that some people say they would pay for the change but they would not if they really had to pay

Note: It is very important that you answer the following questions as if you really had to pay

Figure 2 Cheap talk script.

have been found to lead to understate willingness to pay in the Australian context (Morrison and Brown 2009).

Respondents were asked to answer four choice questions each. Each choice question contained three alternatives, one of which is the status quo alternative (Figure 3). Each alternative has five attributes: waterbird breeding along the River Murray, native fish in the River Murray, healthy vegetation along the River Murray, waterbird habitat in the Coorong and household cost. The cost to the household was included as the last item in the choice set as this has previously been demonstrated to produce more conservative value estimates (Kjaer *et al.* 2006). The attribute levels included in the choice sets are shown in Table 1.

Attributes were selected through consultation with hydrologists, ecologists and reactions by participants of focus groups. The choice modelling exercise needed to provide information for water managers that would assist them in

Features		Option A Maintain Current Situation	Option B Improve quality of Murray River and Coorong	Option C Improve quality of Murray River and Coorong
Waterbird Breeding along the Murray River		Every 10 years	Every 7 years	Every year
Native fish in the Murray River		30% of original population	30% of original population	60% of original population
Healthy Vegetation along the Murray River		50% of original area	70% of original area	70% of original area
Waterbird Habitat in the Coorong		Poor quality	Good quality	Poor quality
Household cost per year for 10 y	$	$0	$75	$150
I would choose				

Figure 3 Example of a Choice set.

Table 1 Attribute levels used in choice sets

Attributes	Current situation	Levels in options B and C
Waterbird breeding along the River Murray	Every 10 years	10, 7, 4, 1
Native fish in the River Murray	30% of original population	30%, 40%, 50%, 60%
Healthy vegetation along the River Murray	50% of original area	50%, 60%, 70%, 80%
Waterbird habitat in the Coorong	Poor quality	Poor quality, good quality
Household cost per year for 10 years	$0	$20, $50, $75, $100, $125, $150, $200, $250

making trade-offs about how to prioritise water for the environment in and along the River Murray. Of particular concern was whether to allocate water for upstream uses (e.g. for waterbird breeding at locations such as the Barmah-Millewa wetland) versus downstream uses (e.g. for the Coorong). Furthermore, information was also needed about community priorities for other upstream uses, such as for maintaining fish population and native vegetation.

The levels for the waterbird breeding attribute are based on the frequency of waterbird breeding events observed. Colonial waterbird breeding now occurs in some wetlands along the Murray one in every 10 years. The current native fish species population levels is 30 per cent of the original, and the highest level of native fish populations of 60 per cent corresponds to the targets in the Murray-Darling Fish Strategy (MDBMC 2003). The current area of healthy vegetation is approximately 178,000 ha, about 50 per cent of the original pre-river regulation area. It is anticipated that an area of up to 80 per cent of the original can be recovered based on vegetation modelling for different flow regimes (Overton and Doody 2008).

Binary levels were used for representing waterbird habitat in the Coorong (poor quality, good quality), as there is a strong threshold effect for the quality of the Coorong. Hypersalinity in parts of the Coorong has reduced the main food source (*Ruppia*) for migratory waterbirds (DWLBC 2006). The consequence of increasing salinity levels has been the collapse in the number of birds observed in the Coorong (Paton 2000 and Paton *et al.* 2009). A good-quality Coorong would restore waterbird habitat. Focus groups confirmed that respondents understood the meanings attached to the two levels; however, the limitations associated with using qualitative descriptors for this attribute should be noted. For example, these descriptors do not indicate precisely what number of waterbirds will use the Coorong across the two levels. It should also be recognised that the attribute includes multiple values, that is, the value for habitat, as well as values for increased numbers of wader and other waterbirds that use the habitat, and possibly other values associated with improved habitat of the Coorong.

4. Sample and survey administration

A sample of 6000 households, stratified by geographic areas of Australia, was randomly drawn from the Australia Post database, for the Murray-Darling Basin, NSW, Victoria, SA and the rest of Australia. As this paper focusses on differences among States and Territories, ACT households in the Murray-Darling Basin were identified by postal code and the non-ACT households reassigned back to each of the Basin States. Reporting from hereon is in terms of NSW, ACT, Victoria, SA, and the rest of Australia. Mail-out occurred between November 2008 and March 2009 and an overall response rate of 54.2 per cent was achieved (see Table 2).

The socio-demographic and attitudinal characteristics of the five samples are presented in Table 3. Our sample has a higher household income than Australian Bureau of Statistics data in NSW, Victoria, SA and the rest of Australia but not in the ACT. Our sample is also older (statistically significant), and a higher proportion of women answered the questionnaire

Table 2 Response rates

	NSW	Murray Darling Basin	Victoria	South Australia	Rest of Australia	Total
Number mailed out	1400	1000	1200	1000	1400	6000
Number returned	650	559	627	620	692	3148
Incorrect addresses	52	20	46	25	51	194
Response rate (%)	48.2	57.0	54.3	63.6	51.3	54.2

Table 3 Socio-demographic and attitudinal characteristics of the samples (available ABS values)

	NSW	ACT	VIC	SA	Rest of Australia
Household income under $52,000*	53.8% (47.3%)	32.4% (31.4%)	51.1% (47.9%)	60.1% (54.1%)	55.8% (48.1%)
Age	47.6 (39.2)	47.9 (37.6)	44.7 (39.0)	47.9 (40.0)	48.2 (38.9)
Gender (female = 1)	55.3% (50.7%)	51.9% (50.7%)	56.5% (50.9%)	54.6% (50.8%)	56.9% (50.7%)
Have children under 18	33.7%	33.3%	36.4%	33.9%	35.2%
Self-identifies as being pro-environment†	48.6%	44.9%	42.8%	48.6%	44.9%
Self-identifies as being pro-development	2.5%	2.0%	3.4%	3.5%	3.1%
Member of an environmental group	4.2%	7.7%	5.4%	5.1%	5.5%
Family member associated with farming	18.0%	26.7%	23.0%	26.9%	28.0%

*Source: Australian Bureau of Statistics (2007, 2009) is the most recent household income data and ABS (2009) for age and gender. †Three binary variables are used to capture attitudes about development vs. the environment: When there is a conflict between development and environment, have you tended to: (i) favour environment; (ii) favour development (iii) neither favour environment nor development.

compared with the proportion of population. Among the State-based samples, all the States are similar with respect to households having children under 18. The Victorian sample has a lower proportion of respondents self-identifying as pro-environment. The lowest proportion of respondents with family members in farming is the NSW sample.

5. Modelling approach

A panel multinomial logit error components (EC) model is specified and employed as a means of controlling for scale differences across samples collected from States and the ACT. The use of EC models is fairly common in the environmental economics literature where they have been used to test differences in error variances across subsets of alternatives (see Scarpa *et al.* 2008 for details of this approach). We use this modelling approach to control for error variance differences (i.e. scale) across samples from different geographic regions of Australia, similar to how the Nested Logit (NL) has been used to combine multiple datasets after accounting for scale differences (see Hensher *et al.* (2008), for a discussion of this issue). We have not estimated random parameters because this complicates hypothesis testing, which is a goal of this paper. We estimate separate error components by allowing different dummy variables to exist for each State dataset, thus approximating the commonly used NL model approach typically used to combine data sets (Train 2010). The advantage of using the EC model as opposed to the NL model is that the log-likelihood function of the NL model precludes the model from directly accounting for the pseudo-panel nature typical of most choice experiment data. Failure to account for repeated choices and the panel nature of the data not only impacts upon the standard errors (and hence any hypothesis testing that might be performed) but also affects parameter estimates. Thus, this approach represents one of the best available, though we note the caveat that future advances in econometric techniques may have an impact on welfare estimates.

5.1. Experimental design

Underlying the choice questions shown to respondents is a D_b-efficient design (Bliemer and Rose 2006; Bliemer *et al.* 2009). Rather than assume precise knowledge of the population parameter estimates, D_b-efficient designs utilise distributions of likely parameter estimates in the design construction process. The priors used in generating the final design were drawn from Bayesian multivariate normal distributions.[3] The resulting design had 32 choice sets with a D_b-error of 0.10004. Rather than have each respondent answer all 32 choice

[3] Available from the authors.

sets, the design was further blocked into eight groups of four choice sets (or questions) each.

6. Results

The EC models were estimated with socio-demographic and attitudinal variables. The data are weighted by age and gender population proportions across States/Territories (ABS 2007, 2009).[4] The model contains an alternative specific constant (SQ constant) for the status quo alternative and an alternative specific constant (SP1 constant) for the middle alternative in the choice set to capture middle alternative effects. This is commonly done in transportation choice modelling studies (e.g. Hess and Rose 2009). In Table 4, models for samples from NSW, ACT, SA, Victoria, and the rest of Australia were estimated jointly using Nlogit 4.0, avoiding the need to correct for scale differences when testing for differences between parameters (Swait and Louviere 1993).

The summary statistics indicate that the EC model is robust. The ρ^2 (ASC) value for the model exceeds 0.20 when computed against a model with ASCs only. For the choice set attributes,[5] all coefficients have the expected signs and the *t*-statistics are all significant at the 1 per cent level. The SQ constant[6] is positive and significant for all the States and Territories. A right–left preference for the third alternative relative to the second is suggested, for NSW and marginally for the rest of Australia with SP1 constant being negative and significant.[7] In terms of the socio-demographic and attitudinal variables, income is significant in Victoria and SA. The propensity to favour development when development and the environment are in conflict is associated with an increased probability of selecting the status quo and is significant in all the samples except the ACT where there were too few respondents identifying as pro-development. When respondents identify as favouring the environment, there is an increased probability of choosing a nonstatus quo option.

Implicit prices for the choice set attributes are presented in Table 5. These are calculated by dividing the coefficient for a given attribute by the negative of the coefficient for the cost variable (e.g. implicit price for native

[4] The results of the unweighted models are available form the authors upon request.

[5] In response to queries from reviewers, two-way interaction terms between Waterbird Habitat in the Coorong and Waterbird Breeding along the River Murray are statistically insignificant.

[6] Constants technically include the mean of the errors, and therefore represent the non-attribute reasons for selecting an attribute. There is debate in the literature about whether to include these in value estimation, with most researchers choosing not to given concerns that they primarily capture either yea saying behaviour or status quo bias (e.g. Adamowicz *et al.* 1998).

[7] The reason for this variable being significant is unclear, thought it has often been found to be significant in transportation and marketing studies. One possibility is that people who learn to read right to left may have some right-left preference relative to the whole sample.

Table 4 Error Components Model for State-based Samples

	NSW	ACT	VIC	SA	Rest of Australia
SQ constant	0.237***	0.274***	0.088**	0.267***	0.211***
	(5.59)	(3.22)	(2.01)	(6.41)	(5.9)
SP1 constant	−2.947***	−0.350	−0.067	−0.924	−2.490*
	(−2.68)	(−0.05)	(−0.09)	(−1.03)	(−1.64)
Waterbird breeding† along the River Murray	−0.100***	−0.117***	−0.109***	−0.105***	−0.103***
	(−8.73)	(−4.85)	(−9.14)	(−9.16)	(−10.05)
Native fish in the River Murray	0.018***	0.026***	0.021***	0.014***	0.009***
	(5.52)	(3.98)	(6.52)	(4.28)	(3.3)
Healthy vegetation	0.021***	0.32	0.026***	0.025***	0.018***
	(8.25)	(6.43)	(9.89)	(10.07)	(7.97)
Waterbird habitat in Coorong	1.074***	1.444***	1.153***	1.111***	1.032***
	(11.33)	(8.16)	(12.4)	(12.07)	(13.41)
Household cost per year for 10 years	−0.007***	−0.007***	−0.009***	−−0.007***	−0.006***
	(−12.23)	(−7.58)	(−15.65)	(−10.94)	(−11.06)
Household income	−0.090	−1.53	−0.228***	−0.247***	−0.078
	(−1.13)	(−1.72)	(3.63)	(−2.79)	(−0.62)
Age of respondent	−0.036**	−0.136	−0.038***	−0.021	−0.083***
	(−2.29)	(−0.92)	(−2.94)	(−1.37)	(−3.17)
Gender (1 = Female)	1.299**	3.703	0.755 (1.63)	−0.789	0.519
	(2.16)	(0.75)		(−1.33)	(0.57)
Number of children	0.363	−3.105	0.340	0.479	1.327
	(0.57)	(−0.51)	(0.71)	(0.74)	(1.42)
Favour environment	−1.269**	−4.474−0.79	−1.388***	−1.442**	−2.660***
	(−2.14)		(−2.86)	(−2.43)	(−2.89)
Favour development	4.301***	n/a	1.814*	2.401*	4.449**
	(2.68)		(1.71)	(1.73)	(2.22)
Member of an environmental group	−0.737	1.184	−2.208*	−6.629**	−4.409**
	(−0.46)	(0.13)	(1.69)	(−2.25)	(−1.98)
Associated with farming	0.610	0.0646	0.497	0.714	−2.077*
	(0.79)	(0.01)	(0.94)	(1.04)	(−1.96)
Error component (Non SQ alternatives)	−5.036***	15.241***	4.132***	4.979***	7.969***
	(−10.53)	(3.17)	(11.18)	(9.75)	(9.17)
Summary statistics					
Log likelihood = −9163.740568					
Log likelihood(ASC only) = −11523.3759					
ρ^2(ASC) = 0.205; adj.ρ^2(ASC) = 0.200; N = 11644					

Note: N/A – this coefficient could not be estimated because of responses to this question in ACT. †The estimated coefficient on waterbird breeding was hypothesised to be negative because of the direction of the variable (decreasing in frequency from the status quo level of every 10 years to the highest level of every year). *t*-statistics are in brackets, * significant at 10%,** significant at 5%, *** significant at 1%.

fish = $\beta_{\text{native fish}}/-\beta_{\text{cost}}$). Willingness to pay to increase the frequency of waterbird breeding along the Murray by 1 year ranges from \$12.00 to \$18.64 per year for 10 years, while willingness to pay for an increase in frequency from once every 10 years to every year (the maximum improvement possible) is \$107.97–\$167.80 per year for 10 years. Willingness to pay for a 1 per cent increase in native fish populations in the River Murray ranges from \$1.71 to \$3.58 per year for 10 years. Willingness to pay for a one percentage increase

Table 5 Implicit prices – household willingness to pay each year for 10 years

	NSW	ACT	Victoria	South Australia	Rest of Australia
Waterbird breeding*	$13.64 ($10.95–$16.47)	$15.99 ($10.49–$21.89)	$12.00 ($7.52–$16.43)	$15.96 ($13.02–$19.28)	$18.64 ($15.40–$19.28)
Native fish	$2.50 ($1.77–$3.16)	$3.58 ($2.05–$5.05)	$2.28 ($0.97–$3.44)	$2.15 ($1.31–$2.88)	$1.71 ($0.78–$2.50)
Healthy vegetation	$2.88 ($2.27–$3.54)	$4.42 ($3.21–$5.91)	$2.87 ($1.91–$3.86)	$3.88 ($3.13–$4.78)	$3.31 ($2.53–$4.78)
Waterbird habitat in Coorong	$146.48 ($130.04–$164.25)	$198.15 ($163.73–$242.50)	$126.63 (99.03–$153.76)	$169.18 ($148.80–$193.24)	$187.09 ($164.37–$214.68)

Note: Lower and upper 95% Krinsky-Robb error bounds in parentheses. *The negative sign on the implicit price for increasing the frequency of waterbird breeding is suppressed.

in healthy vegetation along the River Murray is from $2.87 to $4.42 per year for 10 years. Willingness to pay to improve waterbird habitat in the Coorong is on the upper end of the bid distribution and ranges from $126.63 in Victoria to $198.15 in the ACT.

There is some spatial heterogeneity in willingness to pay. The rest of Australia has a higher willingness to pay with respect to frequency of waterbird breeding along the River Murray. With the exception of the frequency of bird breeding along the River Murray, respondents from the ACT have the highest willingness to pay for choice set attributes. Generally, respondents from Victoria are willing to pay less for environmental attributes.

Distributions of implicit prices were estimated using the Krinksy-Robb procedure, and differences between these distributions were tested using the method suggested by Poe *et al*. (2005). The results indicate that rest of Australia is different from NSW, and Victoria is different from ACT, SA and rest of Australia with respect to frequency of bird breeding along the River

Table 6 *P*-values for tests of difference between implicit prices

Samples compared		Waterbird breeding along river	Native fish	Native vegetation	Waterbird habitat in Coorong
NSW	ACT	0.23	0.09*	0.01***	0.01***
NSW	VIC	0.18	0.32	0.49	0.03**
NSW	SA	0.18	0.32	0.05**	0.03**
NSW	RoA	0.01***	0.07*	0.32	0.00***
ACT	VIC	0.09*	0.06*	0.00***	0.00***
ACT	SA	0.50	0.02**	0.12	0.09*
ACT	RoA	0.19	0.39	0.01***	0.32
VIC	SA	0.02**	0.13	0.00***	0.00***
VIC	RoA	0.00***	0.13	0.18	0.00***
SA	RoA	0.13	0.23	0.05*	0.14

Note: RoA, rest of Australia sample. *Significant at 10%, **Significant at 5%, ***significant at 1% level.

Murray (see Table 6). For native fish and vegetation, significant differences occur for four of ten and six of ten pairwise comparisons of implicit prices, respectively. For the Coorong, there are eight of ten significant differences.

7. Discussion

We present the results of our multistate choice modelling study that can be used to assist in setting priorities for water use by quantifying community willingness to pay for attributes associated with the River Murray and the Coorong. Our findings indicate that respondents are willing to pay substantial amounts to increase environmental flows and improve the quality of the Murray River and Coorong. The aggregate values are summarised in Table 7 using different assumptions about preferences of the population and discount rates. A standard discount rate of 5 per cent and an assumption that non-respondents have zero willingness to pay are presented in Table 7 as a conservative benchmark. As an alternative, using empirical evidence based on follow-up surveys conducted by Morrison (2000), 30 per cent of nonrespondents are assumed to have preferences similar to the sample. In addition, to facilitate comparison with one-shot payments used in other studies, a 28 per cent personal discount rate has also been presented. This provides flexibility for analysts when using the results in benefit-cost analyses. Several studies have shown that respondents may have quite high rates of time preference when faced with one-off and multiyear payment schedules in both field studies and experimental settings (Harrison *et al.* 2002; Kovacs and Larson 2008; Bond *et al.* 2009). While a rate of time preference of 28 per cent may appear large, it is the mid-point of the range provided by Harrison *et al.* (2002) and it is commensurate with rates found in time preference experiments (Frederick *et al.* 2002).

In Table 8, Morrison *et al.* (2002) found households were willing to pay a one-off amount of \$9.81 (\$1997) or \$13.71 in \$2009 to increase the frequency of waterbird breeding in the Macquarie by 1 year. When we aggregate values over the timeframe of the payment vehicle, for example, using a 28 per cent discount rate to facilitate comparison with a one-off payment, households are willing to pay between \$57 and \$78 \$2009 to increase the frequency of waterbird breeding by a year along the River Murray. As another example, it was found in this study that household willingness to pay for a 1 per cent increase in the area of healthy vegetation is \$2.87–\$4.42 per year for 10 years or present value of \$12–\$18. This substantially exceeds the value in Table 8 for Morrison and Bennett (2004) for rivers in NSW which ranged from \$1.46 to \$2.33 (one-off payment \$2001) or \$1.83–\$2.92 in \$2009. Willingness to pay for the Coorong ranges from \$530 per household in Victoria to \$829 per household in the ACT. This exceeds the estimates from the Bennett *et al.* (1998) contingent valuation study in Table 8.

Total willingness to pay for different packages of improvements is useful for policy analysis and can be compiled as required using Table 7. Total

Table 7 Aggregate values for each attribute by state using different discount rates over the 10 years

	NSW	ACT	Victoria	South Australia	Rest of Australia
5% discount rate, extrapolation based on response rate					
Increase waterbird breeding by 1 year	$146,903,684	$10,050,008	$111,214,437	$51,579,272	$234,436,295
Increase native fish by 1% of original	$26,925,162	$2,250,096	$21,130,743	$6,948,336	$21,506,763
Increase healthy vegetation by 1%	$31,017,787	$2,778,051	$26,598,786	$12,539,322	$41,630,050
Improve Coorong from poor to good habitat	$1,577,599,098	$124,540,908	$1,173,590,350	$546,753,210	$2,353,041,114
5% discount rate,–30% of nonrespondents having similar preferences					
Increase waterbird breeding by 1 year	$194,266,408	$12,324,484	$139,294,547	$60,435,336	$293,867,193
Increase native fish by 1% of original	$35,606,013	$2,759,328	$26,465,964	$8,141,352	$26,958,847
Increase healthy vegetation by 1%	$41,018,127	$3,406,768	$33,314,612	$14,692,300	$52,183,498
Improve Coorong from poor to good habitat	$2,086,227,520	$152,726,482	$1,469,905,704	$640,629,704	$2,949,550,060
28% discount rate –30% of nonrespondents having similar preferences					
Increase waterbird breeding by 1 year	$100,255,304	$6,360,311	$71,885,908	$31,188,938	$151,656,404
Increase native fish by 1% of original	$18,375,239	$1,424,010	$13,658,323	$4,201,517	$13,912,685
Increase healthy vegetation by 1%	$21,168,275	$1,758,135	$17,192,713	$7,582,273	$26,930,402
Improve Coorong from poor to good habitat	$1,076,642,004	$78,817,744	$758,576,045	$330,610,560	$1,522,177,929

Table 8 Current value of implicit prices from previous studies

Study	Location	Implicit price of attribute $2009			
		Waterbird breeding	Native fish	Native vegetation	Coorong
Bennett *et al.* (1998)	Coorong, SA				CVM median value of $280.12
Morrison *et al.* (2002)	Gwydir wetlands Macquarie Marshes, NSW	$13.71–$34.75 to increase breeding freq by 1 year			
Morrison and Bennett (2004)	Gwydir and Murrumbidgee Rivers, NSW		$2.65–$9.05 per species	$1.83–$2.92 for a 1% change	
Rolfe *et al.* (2006)	Comet, Nogoa, Mackenzie, Dawson, QLD			$1.43–$1.69 for a 1% increase	
Bennett *et al.* (2008)	Goulburn River, Victoria		$2.38–$6.05 for a 1% increase in pop levels	$6.05–$4.77 increase in % of bank with veg	

Note: All one-off payment vehicles are used in these studies. Reserve Bank of Australia inflation calculator used to inflate values to 2009. http://www.rba.gov.au/calculator/annualDecimal.html willingness to pay for improving the Coorong is A$5.8 billion. Total willingness to pay to increase the frequency of waterbird breeding from every 10 years to every 4 years, to increase native fish populations from 30 to 50 per cent of original levels, to increase the area of healthy native vegetation from 50 to 70 per cent and to improve waterbird habitat quality in the Coorong is equal to A$13 billion using a discount rate of 5 per cent. Owing to the unique nature of the River Murray and the Coorong, the use of these numbers for benefit transfer to other smaller wetlands or smaller rivers would not be appropriate given conditions for transferability (Johnston 2007).

The higher implicit prices and aggregate values in this study can be explained in part by three factors. First, is the unique ecological, historical and cultural importance of the River Murray and the Coorong for Australians. Second is the fact that most of the early CM studies in Table 8 have used one-off payment scenarios. In retrospect, the use of one-off payments is recognised in the literature as being a very conservative design feature (Whitehead and Blomquist 2006). The reason for this is that respondents are required to pay for an environmental improvement in 1 year only, whereas the benefits may be received over a much longer time period. Multiple year payments on the other hand may be more realistic and are consistent with examples of levies that occur over multiple years (e.g. South Australian Murray River improvement levy). Third, there has been a growing public awareness of the severe environmental degradation of the River Murray and Coorong.

8. Conclusions

In this study, we focus on attributes that can be used by policy analysts and environmental managers in the design and implementation of water buy-back programmes, investments in infrastructure and habitat rehabilitation. The values obtained for these attributes can be used in cost-benefit analysis to assist in choosing which alternatives will provide the greatest net-benefit to the community. With the next round of community consultation, negotiation and implementation of water sharing plans in the Murray-Darling Basin, State-level values from this study can be used in target setting and planning processes.

As this study was conducted towards the end of a period of prolonged drought, the results provide guidance about what the broader Australian society values during drier conditions, which is likely to be the norm given future climate change projections. Offsetting this, the survey was undertaken during the global financial crisis, which would have been likely to lead to lower values. It is possible that the results may have been different if the survey had been undertaken during a period of water abundance or not during an international financial crisis.

In this study, we estimated a willingness to pay of $13 billion for good-quality waterbird habitat in the Coorong and a medium to upper end set of improvements along the River Murray. However, further analysis of the full range of costs and benefits of the detailed projects using modelled ecological responses is required to ascertain the overall net benefit to society.

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