*The Australian Journal of Agricultural and Resource Economics*, 48:4, pp. 591–611

# Valuing New South Wales rivers for use in benefit transfer

Mark Morrison and Jeff Bennett[†]

The results from seven choice modelling applications designed to value improved river health in New South Wales are reported. These applications were designed to provide value estimates that could be used, through benefit transfer, to value improvements in the health of other rivers within the state. Because of limitations on the number of rivers that could be valued and populations sampled, a pooled model for use in benefit transfer was also estimated. The results indicate that both use and non-use values were found to exist for all catchments. In addition, value estimates were found to differ across catchments when populations resident within catchments were sampled. However, when populations resident outside catchments were sampled for two of these catchments, value estimates were found to be statistically similar. This indicates the importance of valuing improved river health in specific catchments by sampling populations within catchments. Yet, it also indicates that it is less critical to conduct multiple surveys of residents outside catchments to value improved river health.

## 1. Introduction

Benefit transfer refers to the extrapolation of non-market value estimates generated at a source site to a second target site. Benefit transfer is particularly popular with policy makers and consultants providing advice to policy makers, because value estimates so derived are relatively cheap and easy to obtain. However, there is a tension between these advantages and the greater potential inaccuracy that results from using benefit transfer rather than generating original estimates. One possible strategy for dealing with this implicit trade-off is to recognise that some decisions require less accurate value estimates (Brookshire and Neil 1992). For these sorts of analyses, the use of benefit transfer may be acceptable. For instance, threshold value analysis (e.g., Bennett 1999) may require value estimates that are sufficiently robust to indicate an order of magnitude difference between benefits and costs. An alternative response is to consider the development of methods to

[†] Mark Morrison is Senior Lecturer in the School of Marketing and Management, Charles Sturt University, Bathurst, Australia and Jeff Bennett is Professor of Environmental Management, National Centre for Development Studies, Australian National University, Canberra, Australia.

improve the accuracy of benefit transfer, so that it can be used more widely.

Benefit transfer can be undertaken with varying levels of sophistication. At its most basic level, analysts attempt to use mean household or unit day value estimates. For instance, a value might be established for a day of recreation and this estimate combined with estimates of the number of recreators at various sites to estimate the recreation value of each site. This approach was widely used by the US Corps of Engineers to value recreation sites in the USA (Loomis 1992). The advantage of this approach is that it is straightforward for analysts to use and intuitive to most stakeholders. However, its limitation is that there may be differences in the preferences of the populations at each of the sites, as well in the biophysical characteristics of the sites, both of which may affect value estimates.

Because of these limitations, various researchers have advocated the transfer of demand functions when using benefit transfer (e.g., Desvousges *et al*. 1992). Initially, these transfers involved the use of value functions derived from the travel cost and contingent valuation methods. Analysts altered the mean values for the sociodemographic variables within the value function so that they reflected the characteristics of the relevant population (e.g., Loomis 1992). Later studies also included variations in site characteristics when conducting benefit transfer (Morrison *et al*. 2002). These studies made use of multiattribute stated preference techniques, such as discrete choice modelling. They allowed the analyst to adjust for different changes in environmental quality across sites. That is, if a small change in environmental quality is occurring at the target site, then a corresponding small value estimate can be extrapolated, rather than simply extrapolating the value for the environmental change that occurred at the source site.

While the use of value functions is likely to improve the rigour of benefit transfer, the benefit transfer process may still yield inaccuracies. Differences in sites are not likely to be completely captured by adjusting the change in environmental quality across sites. This is because sites differ in several respects including: (i) the base level of environmental quality; (ii) the range of improvements that might occur; and (iii) the community's perceptions of the importance of the site and of improvements at the site. In addition, differences in populations may not be completely accounted for by the standard sociodemographic variables included in demand functions (e.g., income, age, education, gender and work status). Differences in values may be more closely related to factors such as whether a population is urban or rural, or lives in proximity or remote to the site of interest. The development of methodologies to account for these sorts of factors may lead to more accurate benefit transfer estimates, and a greater range of acceptable applications for benefit transfer.

The present paper has two main objectives. The first is to present the results from a series of choice modelling applications designed to value improved health of rivers across New South Wales (NSW). Because of the large number of rivers in the state and a budget constraint, it was only feasible to value a subset of these rivers. Five catchments were selected for valuation (Gwydir River, Murrumbidgee River, Clarence River, Bega River and Georges River), because they were seen to be representative of catchments within New South Wales. To value the remaining rivers in the state, it was planned to make use of benefit transfer. However, as discussed above, benefit transfer may be subject to additional error if the base level of environmental quality, the range of improvements or the preferences of the population are different. Therefore, the second objective of the current paper is to present the results of a pooled model that can be used to remedy some of these deficiencies. We believe this to be an innovation in the use of benefit transfer.

Discrete choice modelling is the technique used in the present study to derive value estimates of improved river health. Choice Modelling is a multiattribute technique in which estimates of the value of changes in the attributes of a good are derived (Bennett and Blamey 2000; Louviere *et al*. 2000).

The present paper proceeds in the following way. In Section 2, the case study used for the present paper is reviewed, in Section 3 the questionnaire design is described and in Section 4 survey logistics are discussed. In Section 5 the choice models estimated for the five catchments are presented and in Section 6 the results for the pooled model are presented. Finally, in Section 7, implications of the results are discussed.

## 2. Case studies

Within New South Wales, reform of the water allocation process is being undertaken to achieve a more appropriate balance between consumptive and environmental uses. As part of the reform process, the State Government established Water Management Committees (WMC) to provide advice regarding the allocation of water resources. To fulfil their goals, the WMC required information relating to the biophysical consequences of alternative water-sharing arrangements. For instance, predictions of the impacts on the number of fish species present in a river and the quantities of irrigated crops harvested given increased allocations of water to agriculture were relevant. However, biophysical predictions alone are no indication of the relative values of alternative water-sharing regimes. To consider the impact on the community of changes in fish species numbers and tonnes of crops harvested, the values held by the community for these changes also had to be established.

To provide these value estimates, five rivers from within different geographical regions of NSW were selected for valuation. These representative rivers were selected after consultation with ecologists and river managers, because they were representative of the main types of rivers within NSW. The rivers were the Bega River, the Clarence River, the Murrumbidgee River, the Gwydir River and the Georges River.

The current conditions of the rivers and their catchments are summarised in table 1. This information and other information presented in the questionnaires was collected through an extensive review of published literature, with much of the information provided by NSW Fisheries, the NSW Environment Protection Authority, NSW Department of Land and Water Conservation, NSW National Parks and Wildlife Service and the Healthy Rivers Commission (see Bennett and Morrison 2001 for further details). The Georges River is the only urban catchment, and both the Georges River and the Bega River are relatively small in size compared to the other three rivers. Three of the rivers are coastal (Georges, Clarence and Bega) and the other two (Murrumbidgee and Gwydir) are inland rivers. In terms of irrigated agriculture, the Murrumbidgee and Gwydir Rivers provide the greatest value. For the environmental attributes, the Bega and Clarence Rivers have the highest percentages of healthy riverside vegetation and wetlands. For recreational uses, none of the rivers are particularly well suited for fishing: of all sites monitored, more than 50 per cent are of inadequate quality for this recreational use (more than 50 per cent of the time). For swimming, only the Georges and Bega Rivers had more than 50 per cent of sites being good enough for swimming (more than 50 per cent of the time). All rivers, apart from the Clarence and Bega, have lost more than 50 per cent of their native fish species.

## 3. Questionnaire design

Discrete choice modelling (CM) was employed to estimate the value of improvements in river health in NSW. In environmental choice modelling questionnaires there are several well-defined elements. These include: (i) a description of the environmental issue; (ii) a description of possible solutions to the problems faced; (iii) a description of the payment scenario, including the payment vehicle; and (iv) choice sets. These elements are now described to provide contextual information for the value estimates that have been generated.

### 3.1 The environmental issue

For each of the rivers, the issue of declining river health was initially described. Within the questionnaire, the information was described as shown in table 2 (for the Bega River). Respondents were told that there had been falls in the main environmental attributes of concern, and what had led to these declines. The actual decline in the four environmental attributes

**Table 1** Past and current characteristics of the five rivers

| | Bega | Clarence | Georges | Gwydir | Murrumbidgee |
|---|---|---|---|---|---|
| Location | Southern, coastal | Northern, coastal | Central, coastal | Northern, inland | Southern, inland |
| Urban/rural | Rural | Rural | Urban | Rural | Rural |
| Population in catchment | 5000 | 55 000 | 800 000 | 30 000 | 400 000 |
| Area of catchment (km$^2$) | 2000 | 23 000 | 960 | 26 000 | 84 000 |
| Length of river (km) | 50 | 390 | 96 | 330 | 1 690 |
| Value of irrigated agricultural production ($Amillion) | 55 | 78 | NA | 240 | 410 |
| Attribute 1: Current percentage healthy vegetation and wetlands | 30 | 40 | 20 | 10 | 10 |
| Attribute 2: Percentage of sites not good enough for: | | | | | |
| Fishing | 75 | 100 | 87 | 67 | 62 |
| Swimming[†] | 25 | 79 | 33 | 86 | 95 |
| Attribute 3: Native fish species: | | | | | |
| Past level | 25 | 35 | 25 | 25 | 25 |
| Current level | 15 | 22 | 12 | 10 | 8 |
| Attribute 4: Waterbirds and other fauna (number of species): | | | | | |
| Past level | 88 | 95 | 102 | 79 | 85 |
| Current level | 48 | 67 | 65 | 45 | 60 |

[†]More than 50 per cent of the time. NA, not applicable.

**Table 2** Description of the environmental issues facing the Bega River

| |
|---|
| Scientists agree that the quality of many parts of the Bega River and its tributaries has declined over time. There have been falls in: |
| the number of native fish species |
| the amount of healthy riverside vegetation and wetlands |
| the number of water bird and other fauna species |
| recreation opportunities such as fishing and swimming |
| *Please read carefully the information in the fold-out cover. It gives some details about these changes.* |
| Various factors have contributed to this: |
| use of water for irrigation has reduced the amount of water in the river |
| treated water from sewage treatment flowing into the river |
| polluted run-off from urban areas, especially during wet weather (Run-off is water that runs off the land into streams and rivers.) |
| land clearing which has increased erosion and the depositing of sediment in the river |
| erosion of river banks because of stock grazing and walking down to the river to drink |
| farmland run-off containing fertilisers and pesticide |
| non-native fish species and weeds (such as willow trees) |

used to describe the condition of the rivers was specified in detail in the fold-out cover of the questionnaire, as shown in table 1.

### 3.2 Description of possible solutions

After describing the environmental problem, several alternative ways of improving river health were described. These alternatives included: improving water use efficiency, construction work to reduce erosion, fencing to protect riverside vegetation and control of feral species. In addition to a verbal description, a photo of each of these alternatives was included in the questionnaire.

### 3.3 Payment scenario

Payment scenarios are important in all stated preference applications as they specify the method and timing of payment, both of which have been demonstrated to affect value estimates (Stevens *et al*. 1994; Morrison *et al*. 2000). In the questionnaires for this project, as shown in table 3, respondents were told that adopting the alternative river management strategies would be expensive and that it would be necessary to collect a one-off levy on water rates.

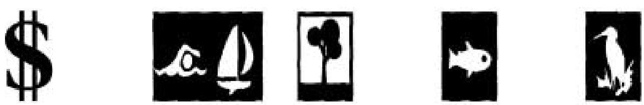
### 3.4 Choice sets

An example of a choice set from the Bega River case study is shown in figure 1. In each questionnaire, respondents answered five of these questions.

**Table 3** The payment scenario

| How this could affect you? |
|---|
| These projects would improve the quality of the Bega River but they would be expensive. One possibility for funding this scheme is for the State Government to collect a one-off levy on water rates for all households in the Bega River catchment during the year 2001. If your household does not pay water rates, an alternative way of collecting the levy would be arranged. This money would be used for projects like the ones described above.<br>The size of the levy and the environmental improvements achieved would depend on which projects were chosen. |

**Question 7:** Carefully consider each of the following three options for the Bega River. Suppose Options A, D and E were the ONLY ones available, which one would you choose?



| | Levy on water rates (one-off) | Recreational uses | Healthy riverside vegetation and wetlands | Native fish | Waterbirds and other fauna |
|---|---|---|---|---|---|
| **Option A** (Current situation) | no extra cost | ✓Picnics<br>✓Boating<br>✗Fishing<br>✗Swimming | Along 30% of river | 15 native species present | 48 species present |
| **Option D** | $ 50 | ✓Picnics<br>✓Boating<br>✗Fishing<br>✗Swimming | Along 80% of river | 21 native species present | 59 species present |
| **Option E** | $ 50 | ✓Picnics<br>✓Boating<br>✗Fishing<br>✗Swimming | Along 80% of river | 25 native species present | 88 species present |

Which of these options would you choose?

☐ I would choose Option A

☐ I would choose Option D

☐ I would choose Option E

☐ Not sure

**Figure 1** Example of a choice set from the Bega River questionnaire.

The experimental design, which was an orthogonal design selected from Hahn and Shapiro (1966), had a total of 25 alternatives. Therefore, there were five versions of the questionnaire for each catchment.

The attributes in the choice sets were selected after a review of published literature, a survey of experts and through the use of four focus groups (Bennett *et al*. 2000). In the expert survey, 23 industry experts were asked to list: (i) up to ten indicators of river health; and (ii) the five most important indicators. Slightly different procedures were used in the focus groups. In the first two focus groups, participants were asked to indicate what attributes of river health they would like to know about if they were to evaluate whether a project improving river health should proceed. In the second set of two focus groups, respondents were shown a list of the attributes identified by the survey of ecologists and river managers and asked to add any other attributes that they considered to be important.

Five main attributes were identified using this methodology. These were flow, fish, vegetation, water quality and water dependent fauna. For the choice modelling questionnaire, flow was excluded as an attribute because increases in flow was believed to be one of the main causes of change in the remaining attributes. There were also concerns that water quality would be seen to be a causally prior attribute to the other attributes (Blamey *et al*. 2002). Therefore, water quality was instead given the descriptor ‘recreational use’. Therefore, the attributes employed in the CM application were recreational use, healthy riverside vegetation and wetlands, native fish species, and waterbirds and other fauna species. Three of these variables are normally associated with existence values (healthy riverside vegetation and wetlands, native fish species, and waterbirds and other fauna species); although in some cases they can be use values. However, the remaining variable (recreational use) is clearly a use value. An additional attribute, a tax on water rates, was used as a payment vehicle.

Another important aspect of designing a choice modelling questionnaire is the selection of levels for attributes. Levels refer to the quantities or qualitative descriptors for each attribute. Identifying appropriate levels is arguably more difficult than selecting attributes, because there are often many ways to describe the same attribute. In the initial focus group, participants had difficulty in suggesting suitable descriptors for the attributes. Therefore, in the remaining focus groups, participants were shown a list of descriptors based on findings from the review of published literature and the survey of experts, and asked to indicate which descriptors they most preferred. This information was used as a basis for selecting the levels used in the questionnaires.

The levels for the attributes were catchment specific (apart from water rates and recreational uses), but an example is shown in figure 2 for the Bega River. The range for the attribute levels was chosen so that it would be as wide as possible, but so that plausibility would be maintained. Based

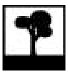
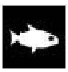
| Attribute | Symbol | Current | Level 1 | Level 2 | Level 3 |
|---|---|---|---|---|---|
| Water rates | $ | No extra cost | $50 | $100 | $200 |
| Recreational uses (across entire river) |  | Picnics Boating | Picnics Boating Fishing | Picnics Boating Fishing Swimming | |
| Health vegetation and wetlands |  | Along 30% of river | Along 40% of river | Along 60% of river | Along 80% of river |
| Native fish |  | 15 native species present | 18 native species present | 21 native species present | 25 native species present |
| Waterbirds and other fauna |  | 48 species present | 59 species present | 72 species present | 88 species present |

**Figure 2** Attribute levels for the Bega River case study.

on the recommendations of Pearmain *et al.* (1991), unequal increments were used to select attribute levels. Note that increased rates would only be associated with improvements in river health, never declines.

## 4. Survey logistics

Surveys were conducted in each of the five catchments (Bega, Clarence, Georges, Gwydir and Murrumbidgee). However, it is possible that people that reside outside of these five catchments will also value improved river health. Indeed, several previous studies have identified distance decay functions (e.g., Sutherland and Walsh 1985; Pate and Loomis 1997), implying that respondents who do not reside within a catchment may, nevertheless, value improved catchment quality. For instance, people in Sydney may be willing to pay for improved water quality in the Murrumbidgee River, located 500 km away. Therefore, there is a rationale for obtaining out-of-catchment samples in addition to those collected within-catchment. Resource constraints and funding requirements meant that out-of-catchment samples could only be collected for two of the rivers: the Gwydir and Murrumbidgee. These two catchments were selected because both were inland catchments. Testing in the present study would, therefore, indicate whether out-of-catchment values were equivalent for two relatively similar rivers. Testing in future studies could then be used to extend this testing and determine whether out-of-catchment values from more different rivers were also equivalent. Therefore, seven samples were collected: five within-catchment (Bega, Clarence, Georges, Gwydir and Murrumbidgee catchments) and two out-of-catchment (Gwydir and Murrumbidgee).

To implement this sampling plan, seven samples of 900 respondents were drawn from 'Australia on Disk', a listing of people based on the White Pages telephone directory. For the five local or within-catchment samples, respondents were selected at random on the basis of postcodes relating to the corresponding river catchments. For two of the catchments (Gwydir and Murrumbidgee) a further 900 respondents were drawn from outside of these catchments within the State of NSW.

A four-stage surveying process was employed. First, an introductory letter was dispatched, advising those drawn in the sample that they would shortly be receiving a questionnaire. Those receiving the letter were given the option of withdrawal. As well as heightening the significance of the survey, this preliminary letter was designed to filter out names and/or addresses from the sample that were redundant: such as people who had moved, were incapable of answering or who were deceased. The second stage of the survey involved the mailing of the questionnaire with an accompanying letter and a reply paid envelope. The number of successfully delivered surveys ranged from 703 to 763 across the seven surveys. A reminder card comprised the third stage and a re-mail of the questionnaire to those yet to respond completed the process. The overall response rate for the seven surveys was 39.6%, ranging from 30.4% to 45.9%. These response rates compare favourably with other mail surveys of this genre (Mitchell and Carson 1989).

The sociodemographics of the survey samples are shown in table 4. In general, respondents to the questionnaire self-selected to be older, better

**Table 4** Sociodemographics of the survey samples

| | Clarence | Bega | Georges | Murrumbidgee: within | Murrumbidgee: outside | Gwydir: within | Gwydir: outside |
|---|---|---|---|---|---|---|---|
| Age (year) | 55.9 | 52.6 | 51.1 | 50.5 | 52.9 | 51. 5 | 52.4 |
| Sex (% female) | 41 | 41 | 30 | 45 | 39 | 34 | 36 |
| Children (%) | 87 | 83 | 89 | 84 | 85 | 85 | 80 |
| Education† | 3.9 | 4.3 | 4.1 | 4.1 | 4.3 | 4.1 | 4.3 |
| Income ($A) | 32 256 | 38 899 | 46 069 | 50 548 | 50 251 | 43 517 | 47 989 |

†1: never went to school, 6: tertiary degree.

educated, and more affluent than the population they represent. Respondents were also more likely to be male.[1]

## 5. Results

The most common model used for analysing discrete choice data where there are multiple alternatives that can be chosen is the conditional logit model. With the conditional logit model, the probability of choosing an alternative is a function of the utility of the alternative relative to the utility of all alternatives. The error distribution of the conditional logit model is independently and identically distributed Gumbell, which leads to the independence from irrelevant alternatives (IIA) property. This implies that the probability of choosing one alternative over another is independent of the presence/absence of any other alternatives. In practice, violations of this property occur for many reasons, including the existence of heterogenous preferences. Therefore, it is becoming more common to use alternative models that either do not require this property or have less restrictive assumptions. In the present paper, each of the data sets have been analysed using a nested logit model, as violations of the IIA property were identified using the test recommended by Hausman and McFadden (1984). Unobserved components of utility are assumed to be shared between certain alternatives in the nested logit model; hence, the errors of the alternatives within branches are correlated and not independent. Therefore, this model is used to avoid problems associated with violations of the IIA property.

When using nested logit models, a tree-structure needs to be prespecified. Tree structures reflect the existence of homogenous sets of alternatives that have correlated errors. They can have multiple levels. All of the homogeneous alternatives are in the branches at the bottom of the structure. These alternatives are then grouped at the next level using the limbs of the tree. Following Kling and Thomson (1996), the nested logit model can be specified as follows. The probability of a particular alternative being chosen ($P_{jm}$) is equal to the probability that the limb that the alternative is in is chosen ($P(m)$) multiplied by the probability that the alternative is chosen from within the limb $P(j \mid m)$. That is:

$$P_{jm} = P(j \mid m) \cdot P(m) \tag{1}$$

[1] The self-selection bias evident in the sample is problematic only if the values estimated from the sample are extrapolated beyond the proportion of the population that responded to the questionnaire (see Morrison 2000).

where:

$$P(j|m) = \frac{\exp(V_{jm}|\alpha_m)}{\exp(I_m)} \tag{2}$$

$$P(m) = \frac{\exp(\alpha_m I_m)}{\sum_{k=1}^{M} \exp(\alpha_k I_k)} \tag{3}$$

$$I_m = \log\left[\sum_{i=1}^{J_m} \exp(V_{im}/\alpha_m)\right]. \tag{4}$$

In the above equations, $I_m$ is the inclusive value and is the sum of the utility of all of the alternatives. The model works by estimating the probability that an alternative is chosen within a limb, $P(j \mid m)$, and estimating the probability that a limb is chosen ($P(m)$).

The coefficients estimated using the nested logit model are used to derive estimates of the value of an environmental improvement. The focus of the present paper is on the estimation of implicit prices. These are point estimates of the value of a unit change in an attribute. They are useful for management decisions where information is required about the value of marginal changes in environmental quality, such as the value of an extra waterbird species preserved. They are also useful for identifying the relative importance people place on different attributes. Implicit prices are calculated as follows, if utility is a linear function of all attributes:

$$\text{IP} = \beta_{\text{A}}/\beta_{\text{M}} \tag{5}$$

where IP is the implicit price, $\beta_{\text{A}}$ represents the coefficient of the Ath non-monetary attribute, and $\beta_{\text{M}}$ represents the coefficient for the monetary attribute.

The variables used in the nested logit models (and in the pooled model presented in Section 6), and their expected signs, are presented in table 5. Note that for the sociodemographic variables, the expected signs are opposite to what would normally be expected as these variables have been interacted with the constant representing the 'continue the current situation' option. So, for example, you would expect the income variable to have a negative sign, because people with higher income would be expected to be less likely to choose to continue the current situation.

The nested logit models are presented in table 6. A single level nested logit model was estimated, as described in Greene (2002). The models were structured so that there were two branches (whether to improve river health

**Table 5** Variables used in the nested and conditional logit models

| Variable | Definition | Expected sign |
|---|---|---|
| *ASC1, 2* | Alternative Specific Constants | ? |
| *RATE* | Increase in water rates | – |
| *VEGET* | Percentage of healthy native riverside vegetation | + |
| *FISHSPEC* | Number of native species present | + |
| *FISHABLE* | Suitable for fishing | + |
| *SWIMABLE* | Suitable for swimming | + |
| *FAUNA* | Number of waterbirds and other fauna present | + |
| *PROGRE* | Progreen environmental orientation | – |
| *PRODEV* | Prodevelopment environmental orientation | + |
| *AGE* | Age (years) | + |
| *INCOME* | Income ($A) | – |
| *INCDUM* | Dummy variable that takes on a value of one if a respondent did not report their income | ? |
| *COASTAL* | Whether a catchment is inland or coastal (1: coastal, 0: inland) | ? |
| *NORTH* | Whether a catchment is in the north or south of New South Wales (1: north, 0: south) | ? |
| *LOCAL* | Whether a respondent resides within a catchment (1: resides inside catchment, 0-resides outside of catchment) | + |

or to continue the current situation), with the first of these branches having two twigs (which are the two options in each choice that improve river health: options D and E in the context of figure 1). Attributes for river health were defined for each of the three alternatives (options A, D and E).

These models were estimated using LIMDEP 7.0. The choice set attributes are significant and correctly signed in all models, except for *FISHSPEC* (Clarence, Georges) and *FAUNA* (Georges and Gwydir out-of-catchment sample). *INCOME* is significant in five models, *AGE* is significant in five models, and *PROGRE* is significant in all seven models, providing evidence of theoretical validity. The explanatory power of the models is relatively high, with the adjusted rho-squared ranging from 0.21 to 0.41 (values greater than 0.2 indicate a robust model).

Implicit prices derived from these nested logit models are presented in table 7. The implicit prices were calculated using the formula presented in equation (5). For instance, the value for *VEGET* in the Bega catchment is 0.035/0.015 = 2.33. It is these estimates that can be used for valuing improved river health in each of the five catchments. These estimates may also be used to value river health in other similar catchments through benefit transfer.

Table 8 presents tests of differences between the implicit prices in table 7. So, for example, the value for *SWIMMABLE* was $A100.98 in the Bega River and $A72.77 in the Clarence River. The *p*-value of 0.00 indicates that

**Table 6** Nested logit models

| Variables | Bega | Clarence | Georges | Murrum: inside catchment | Murrum: outside catchment | Gwydir: inside catchment | Gwydir: outside catchment |
|---|---|---|---|---|---|---|---|
| *ASC1* | 0.22* | 0.17 | 0.22 | 0.20* | 0.15 | 0.24* | 0.12 |
| *RATE* | –0.15E-1** | –0.18E-1** | –0.16E-1** | –0.14E-1** | –0.13E-1** | –0.15E-1** | –0.13E-1** |
| *VEGET* | 0.35E-1** | 0.37E-1** | 0.24E-1** | 0.21E-1** | 0.28E-1** | 0.23E-1** | 0.26E-1** |
| *FISHSPEC* | 0.11** | –0.82E-3 | 0.28 | 0.39E-1** | 0.53** | 0.33** | 0.46E-1** |
| *SWIMABLE* | 0.77** | 0.65** | 0.58** | 0.54** | 0.57** | 0.80** | 0.39** |
| *FISHABLE* | 0.39** | 0.42** | 0.35** | 0.39** | 0.19** | 0.38** | 0.20** |
| *FAUNA* | 0.13E-1* | 0.34E-1* | 0.92E-3 | 0.25E-1** | 0.23E-1* | 0.27E-1** | 0.72E-2 |
| *ASC2* | –2.16** | –1.14 | 0.86 | –1.53** | –1.04 | –1.89** | –1.38** |
| *PROGRE* | –0.39** | –0.27** | –0.29** | –0.15* | –0.68** | –0.26** | –0.44** |
| *PRODEV* | 0.64** | 0.82** | –0.51E-1 | 0.30 | 0.42* | 0.22 | 0.22 |
| *AGE* | 0.26E-1** | 0.17E-1** | 0.11E-1* | 0.24E-1** | 0.63E-2 | 0.23E-1** | 0.47E-2 |
| *INCOME* | –0.42E-5 | –0.16E-4** | –0.22E-4** | –0.15E-4** | –0.21E-4** | –0.42E-5 | –0.15E-4** |
| *INCDUM* | 1.11** | 0.38* | –0.62* | –0.12 | –0.34 | 0.97** | –1.45** |
| *IV* | 0.42** | 0.39** | 0.39** | 0.45** | 0.30** | 0.27** | 0.43** |
| Summary statistics | | | | | | | |
| Log-likelihood | –1075.54 | –1049.94 | –728.62 | –875.39 | –758.47 | –896.27 | –708.16 |
| Adjusted rho-squared | 0.27 | 0.21 | 0.21 | 0.29 | 0.41 | 0.22 | 0.38 |
| N | 3855 | 3774 | 2481 | 3201 | 3120 | 3081 | 2760 |

**Significant at 1 per cent level; *significant at 5 per cent level.

**Table 7** Implicit prices

| | *VEGET* ($A) (per percentage of river covered with healthy native vegetation) | *FISHSPEC* ($A) (per species) | *SWIMABLE* ($A) (across river) | *FISHABLE* ($A) (across river) | *FAUNA* ($A) (per species) |
|---|---|---|---|---|---|
| Within-Catchment Estimates | | | | | |
| Bega | 2.33 | 7.23 | 100.98 | 51.33 | 0.88 |
| Clarence | 2.07 | −0.05* | 72.77 | 46.63 | 1.92 |
| Georges | 1.51 | 1.77* | 73.88 | 45.26 | 0.59* |
| Gwydir | 1.46 | 2.12 | 104.07 | 48.94 | 1.76 |
| Murrumbidgee | 1.46 | 2.77 | 75.24 | 54.16 | 1.73 |
| Outside Catchment Estimates | | | | | |
| Gwydir | 1.98 | 3.51 | 59.98 | 29.93 | 0.55* |
| Murrumbidgee | 2.15 | 4.05 | 86.46 | 28.75 | 1.79 |

*Insignificant coefficients in model.

**Table 8** Probability values for tests of differences between implicit prices[†]

| | *VEGET* | *FISHSPEC* | *SWIMMABLE* | *FISHABLE* | *FAUNA* |
|---|---|---|---|---|---|
| Bega versus Clarence | 0.00*** | 0.00*** | 0.00*** | 0.01*** | 0.00*** |
| Bega versus Georges | 0.00*** | 0.00*** | 0.00*** | 0.01*** | 0.04** |
| Bega versus Murrumbidgee (within) | 0.00*** | 0.00*** | 0.00*** | 0.03** | 0.00*** |
| Bega versus Gwydir (within) | 0.00*** | 0.00*** | 0.42 | 0.54 | 0.07* |
| Clarence versus Georges | 0.00*** | 0.14 | 0.37 | 0.32 | 0.00*** |
| Clarence versus Murrumbidgee (within) | 0.00*** | 0.08* | 0.13 | 0.00*** | 0.23 |
| Clarence versus Gwydir (within) | 0.03 | 0.20 | 0.02** | 0.42 | 0.42 |
| Georges versus Murrumbidgee (within) | 0.19 | 0.01*** | 0.25 | 0.00*** | 0.00*** |
| Georges versus Gwydir (within) | 0.44 | 0.40 | 0.04** | 0.39 | 0.04** |
| Murrumbidgee (within) versus Murrumbidgee (outside) | 0.01*** | 0.13 | 0.25 | 0.04** | 0.44 |
| Murrumbidgee (within) versus Gwydir (within) | 0.49 | 0.29 | 0.04** | 0.61 | 0.48 |
| Murrumbidgee (outside) versus Gwydir (outside) | 0.30 | 0.34 | 0.06* | 0.46 | 0.07* |
| Gwydir (within) versus Gwydir (outside) | 0.05** | 0.15 | 0.01*** | 0.10* | 0.03** |

[†]Probability values are estimated using the approached described in Poe *et al*. (1994). ***Significant at 1 per cent level; **significant at 5 per cent level; *significant at 10 per cent level.

these two values are different at the $\alpha = 0.01$ significance level. Two main findings are evident from this testing. First, significant differences exist between the majority of implicit prices for the comparisons between the within-catchment samples. An implication of this finding is that it was appropriate to conduct valuation studies in multiple catchments, and not just rely on transferring the results from one or two studies, because the values generated are catchment specific. Second, all of the implicit prices are the same (at the 5 per cent significance level) when comparing the out-of-catchment samples (i.e., Murrumbidgee outside *vs* Gwydir outside). The implication of this finding is that it may be less critical to collect multiple out-of-catchment samples when using benefit transfer on a wide scale.

## 6. A pooled model for benefit transfer

A limitation of the results described in the previous section is that out-of-catchment estimates were not derived for the Bega, Clarence or Georges Rivers. Therefore, benefit transfer is likely to be subject to error when out-of-catchment estimates from the Murrumbidgee and Gwydir catchments are transferred to substantially different river catchments. Another limitation is that for several attributes (fish species in the Clarence and fauna species in the Gwydir Rivers) it was not possible to derive statistically significant value estimates.

A pooled benefit transfer model was estimated to remedy these limitations (see table 9). By pooling the data, it may be possible to identify systematic differences in value estimates as a result of catchment or sampling differences. This is especially important for identifying how value estimates differ when sampling is conducted outside of a catchment, instead of within a catchment, given that out-of-catchment sampling was only conducted for two catchments. In addition, the pooled model can be used to estimate values for attributes where they are found to be insignificant in individual models. By increasing the sample size, insignificance because of low statistical power will potentially be minimised.

The data from six samples were included in this model. The Georges River sample was excluded from the pooled model as it is an urban catchment and, hence, is unlike the other rural catchments for which benefit transfer estimates are sought.

Three dummy variables were interacted with each of the four environmental attributes to identify catchment specific values. These are whether: (i) the catchment is inland or coastal (*COASTAL*); (ii) the catchment is in the north or south of the state (*NORTH*); and (iii) the sample of respondents is located within or outside of the catchment (*LOCAL*). Only those variables that were significant were included in the model.

**Table 9** Pooled model

| Variables | Coefficients | *p*-values |
|---|---|---|
| *ASC1* | 0.574 | 0.000 |
| *ASC2* | 0.510 | 0.001 |
| *ASC * PROGRE* | 0.379 | 0.000 |
| *ASC * PRODEV* | −0.422 | 0.000 |
| *ASC * NORTH* | −0.240 | 0.002 |
| *ASC * LOCAL* | −0.790 | 0.000 |
| *ASC * COASTAL* | −0.534 | 0.001 |
| *RATE* | −0.854E-02 | 0.000 |
| *RATE * INCOME* | 0.514E-07 | 0.000 |
| *RATE * INCOME DUMMY* | −0.331E-02 | 0.000 |
| *RATE * AGE* | −0.783E-04 | 0.000 |
| *VEGETATION* | 0.216E-01 | 0.000 |
| *VEGETATION * LOCAL* | −0.742E-02 | 0.000 |
| *VEGETATION * COASTAL* | 0.807E-02 | 0.001 |
| *FISHABLE* | 0.171 | 0.000 |
| *FISHABLE * LOCAL* | 0.144 | 0.009 |
| *SWIMABLE* | 0.391 | 0.000 |
| *SWIMABLE * LOCAL* | 0.892E-01 | 0.112 |
| *FISH SPECIES* | 0.368E-01 | 0.000 |
| *FISH * COASTAL* | 0.343E-01 | 0.015 |
| *FISH * NORTH * COASTAL* | −0.482E-01 | 0.000 |
| *FAUNA SPECIES* | 0.986E-02 | 0.000 |
| Summary statistics | | |
| Log-likelihood | −5786.911 | |
| Adjusted rho-squared | 0.198 | |
| N | 6575 | |

The model specification has been kept simple because of the large number of variables in the model. A multinomial logit model has been used because of problems encountered with convergence of a pooled nested logit model; however, this change in model specification should not significantly affect implicit prices, which is the primary objective of this research (Hausman and Ruud 1987).

The coefficients for the variables in the model have expected signs and, importantly, almost all reported interactions are significant at the 1 per cent level, allowing estimation of values for catchments where attributes were insignificant in the models estimated using individual data sets. The model has an acceptable level of explanatory power, with an adjusted rho squared of 0.198.

The implicit prices estimated using the pooled model are presented in table 10. When calculating implicit prices, income and age were set at the mean value across the samples. The results from this model indicate that:

**Table 10** Attribute value estimates generated using the pooled model

| Catchment/sample | Vegetation ($A) | Fish species ($A) | Fauna species ($A)[†] | Boatable to fishable ($A) | Fishable to swimmable ($A) |
|---|---|---|---|---|---|
| Southern, coastal, within-catchment | 1.96 | 6.27 | 0.87 | 55.55 | 29.00 |
| Southern, coastal, out-of-catchment | 2.61 | 6.27 | 0.87 | 30.10 | 38.74 |
| Northern, coastal, within-catchment | 1.96 | 2.02 | 0.87 | 55.55 | 29.00 |
| Northern, coastal, out-of-catchment | 2.61 | 2.02 | 0.87 | 30.10 | 38.74 |
| Southern, inland, within-catchment | 1.25 | 3.25 | 0.87 | 55.55 | 29.00 |
| Southern, inland, out-of-catchment | 1.90 | 3.25 | 0.87 | 30.10 | 38.74 |
| Northern, inland, within-catchment | 1.25 | 3.25 | 0.87 | 55.55 | 29.00 |
| Northern, inland, out-of-catchment | 1.90 | 3.25 | 0.87 | 30.10 | 38.74 |

[†]The estimates of value for the fauna attribute are the same across all catchments/samples. This indicates that the pooled model did not detect any significant impact of catchment or respondent location on the value held for additional species of fauna.

- Use values are higher in the within-catchment samples
- Non-use values for vegetation are higher in coastal catchments, and lower for respondents living within a catchment
- Non-use values for fish species are higher for respondents living in a coastal catchment, but lower for respondents living in northern coastal catchments
- Non-use values for fauna species are not systematically affected by catchment characteristics (inland/coastal or north/south)
- Respondents to the inland, southern and out-of-catchment samples were more likely to choose an option to improve river health
- Respondent's environmental orientation (i.e., progreen or prodevelopment) influenced their likelihood of choosing an option to improve river health
- Willingness to pay is a function of sociodemographic characteristics (income and age).

## 7. Summary and implications

In the present paper, the methodology used for estimating implicit prices for river health in five catchments across NSW has been described. Implicit prices were estimated using choice modelling for four environmental attributes: recreational uses, fish species, health vegetation and wetlands, and waterbirds and other fauna. These attributes encompass both use and non-use values. Each of these values were found to exist for the majority of catchments. There was also evidence of theoretical validity, as shown by the existence of significant sociodemograhic variables such as income and environmental attitude. This is supportive of the use of choice modelling for the purpose of valuing improved river health.

It was found that significant differences exist between the majority of implicit prices for the within-catchment samples, indicating the necessity of undertaking multiple surveys so that benefit estimates are transferred only between similar rivers. That is, if value estimates are generated, say, for the Gwydir River, they should only be transferred to other similar northern inland rivers (e.g., the Namoi, Macquarie or Lachlan Rivers). However, the majority of implicit prices are the same when comparing the out-of-catchment samples, indicating that it may not be necessary to collect as many samples of this type. These findings may provide guidance about the appropriate selection of study sites and populations to sample when developing research designs for projects where the goal is the use of benefit transfer.

Finally, the results from a pooled model were presented. This represents one of the first attempts we are aware of to estimate a model where value estimates are a function of: (i) within-catchment site characteristics; (ii) catchment characteristics; and (iii) the location of respondents. The results of the model indicate that existence values tend to vary systematically across catchments, but values associated with recreation are relatively constant. In addition, whether a respondent is located within or outside of a catchment was found to systematically affect value estimates. We recommend the further use of pooled models in large-scale benefit transfer exercises where it is not possible to sample all relevant sites and populations within a research design.

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