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Analysis

An economic assessment of the value of tropical river ecosystem services: Heterogeneous preferences among Aboriginal and non-Aboriginal Australians

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ABSTRACT

There is a current debate about development of the river and wetland systems of tropical Australia. Aboriginal and non-Aboriginal residents of tropical river catchment areas have complex values for these systems which are difficult for decision-makers to accommodate. Aboriginal Australians are a large and growing proportion of the population and are also significant landowners, yet there is little information about the impacts of potential development scenarios on the welfare of Aboriginal Australians that can be used in benefit–cost analyses. This paper reports the application of a choice experiment to assess the potential impact of development/management strategies for three tropical rivers in Australia, and explores the differences between the preferences of Aboriginal and non-Aboriginal Australians living in the catchment areas. Most respondents preferred healthy river systems that are managed under conservation schemes even if this comes at a private cost. The willingness-to-pay of Aboriginal Australians was significantly higher than that of non-Aboriginal Australians for some river attributes, particularly those related to cultural values. Aboriginal respondents were also indifferent towards the extraction of water for irrigated agriculture while non-Aboriginal respondents preferred moderate rather than large or small scale use.

1. Introduction

Policy-makers for Australian tropical rivers situated in the northern part of the continent are incorporating a wide range of values into their decision frameworks. Diverse values for the functions and services of tropical rivers are held by a range of stakeholders with multiple and sometimes conflicting priorities and aspirations. Development of river systems to date has largely occurred in southern Australia, whereas tropical rivers in the north still have potential for further development. Attention is shifting to potential development opportunities in the tropical rivers region due to increasing awareness of the value of water worldwide and an ongoing drought in southern Australia. This potential is based on the fact that the tropical rivers and groundwater systems of this area contain approximately 70% of Australia's freshwater resources (Hamilton and Gehrke, 2005). Tropical rivers are essential for irrigated agriculture, mining, tourism, recreational and commercial fishing and pastoralism, key industries in the tropical rivers region, but they also provide many other services for the environment, lifestyles and culture.

Many Australians have different values for tropical rivers, including non-use values such as existence and bequest values, and unpriced use values, such as aesthetic and cultural values. Monetary use values of tropical rivers mainly concern the direct extraction of water for industry and people who live in close proximity. The total economic value (TEV) of a tropical river is complex and difficult to separate into its component parts. This is particularly the case for Aboriginal Australians because these component parts are inextricably linked (Strang, 1997). Aboriginal Australians are closely connected to the rivers and the water for a number of reasons. They depend on healthy rivers for food, including fish, freshwater turtles, and waterbirds like magpie geese, and for the provision of fresh, clean water for daily use. Water is also of cultural significance as an integral part of songs, ceremonies, hunting and collecting, and other activities that bind people to their country (Toussaint et al., 2005; Jackson et al., 2005, 2008). The tendency for the western scientific paradigm to dominate Indigenous systems of knowledge and the marginalisation of Aboriginal Australians means that the continued influence of Aboriginal values and systems of knowledge on the ways in which tropical rivers are viewed and managed is also marginalised (Jackson et al., 2005).

The need for information on the potential impacts of alternative development scenarios on Aboriginal Australians is becoming more and more pressing, especially given the detrimental impacts of the historical lack of consideration of Aboriginal values, aspirations and knowledge systems in much decision-making in Australia. Aboriginal Australians are a large and growing proportion of the population of northern Australia and are also significant landowners, yet very little is known about their preferences for the future development of rivers in the region.

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We hypothesise that the preferences of Aboriginal Australians will be different to those of non-Aboriginals. The importance of ethical beliefs, perspectives and cultural practices in influencing preferences and welfare estimates has been highlighted by many scientists (e.g. Fuller and Parker, 2002; Hoyos et al., 2009) but the empirical evidence of this for Aboriginal societies in Australia is very limited. The only study known to us is one by Rolfe and Windle (2003). While economic valuation will not provide information about the full range of values or impacts of potential developments on Aboriginal Australians, the welfare estimates calculated in this study help to provide indicators of value and impact that were not previously available to decision-makers. These welfare estimates can help to translate at least some of what is important to Aboriginal Australians into terms that can be more readily understood by decision-makers and more readily incorporated into decision-making frameworks such as benefit–cost analyses.

This study provides an application of a choice experiment (CE) to assess the values of three tropical rivers in Australia (the Mitchell, Fitzroy and Daly Rivers) from the perspectives of local users who live within the catchment areas. The aims are to 1) assess the value of tropical river ecosystem services to catchment residents and 2) explore differences in responses for the three rivers as well as between different groups of individuals, in particular between Aboriginal and non-Aboriginal Australians.

2. Study Site

Australia's tropical rivers region stretches across approximately 1.3 million km^2 of the northern part of the continent, including parts of Western Australia, the Northern Territory and Queensland (Fig. 1). Australia's tropical river systems are comprised of waterways, wetlands, aquifers, riparian vegetation, groundwater dependent ecosystems, and aquatic communities and species, some of which are endemic to the region and/or rare, threatened and endangered. The three river systems included in this study all fit within the tropical rivers region and were chosen based on discussions with Commonwealth, State and Territory Government staff, other stakeholder groups and other researchers working in the region.

The Mitchell River region covers about 73,000 km^2 in northern Queensland. About 3700 people live in the region, mainly in the towns of Mareeba, Dimbulah and Chillagoe. The region is home to about 1000 Aboriginal Australians (just a quarter of the population). The Daly River region covers about 53,000 km^2 in the north-west of the Northern Territory. About 14,000 people live in the region, mainly in the town of Katherine. Aboriginal Australians make up about a quarter of the population. Eleven different Aboriginal language groups have traditional lands in the region. The Fitzroy River region covers about 96,000 km^2 in the north-west of Western Australia. About 13,000 people live in the region, mainly in the towns of Derby and Fitzroy Crossing. Aboriginal Australians make up more than half of the population.

The major economic activities that take place in all three regions are irrigated and dryland agriculture, cattle grazing, mining, tourism and commercial fishing. All three catchment regions are popular for recreational fishing. While further development of water resources is currently limited by caps on extraction in each catchment, issues relating to the negative impacts of some land and water uses (for example, over grazing, land clearing, erosion, habitat destruction, and declines in water quality) are evident and affect the functions of all three tropical rivers (Finlayson et al., 2005).

3. Economic Framework

Because many environmental and cultural values have a mostly non-use, intangible nature they are often described in qualitative terms. This makes it difficult for policy-makers to compare them with other values. Comparing the values of rivers and costs to maintain them, however, is important in the evaluation of alternative development scenarios and often calls for tools such as benefit–cost analysis. While benefit–cost analysis is not the only tool available to help evaluate alternatives, some recourse to economic criteria is often made in order to assess trade-offs between strategies supporting conservation and strategies supporting development. The assessment of use values on the basis of market prices is relatively straightforward while the evaluation of unpriced and non-use values requires economic methods in which values are directly stated rather than revealed by market transactions. The existing techniques can be classified as either revealed preference or stated preference methods. Revealed preference methods are restricted to the measurement of use values only (Morrison et al., 1996) and only stated preference techniques can capture non-use values.

The two most commonly used stated preference valuation methods are contingent valuation (CV) and choice experiments (CE). A few studies in Australia have used CE in the evaluation of

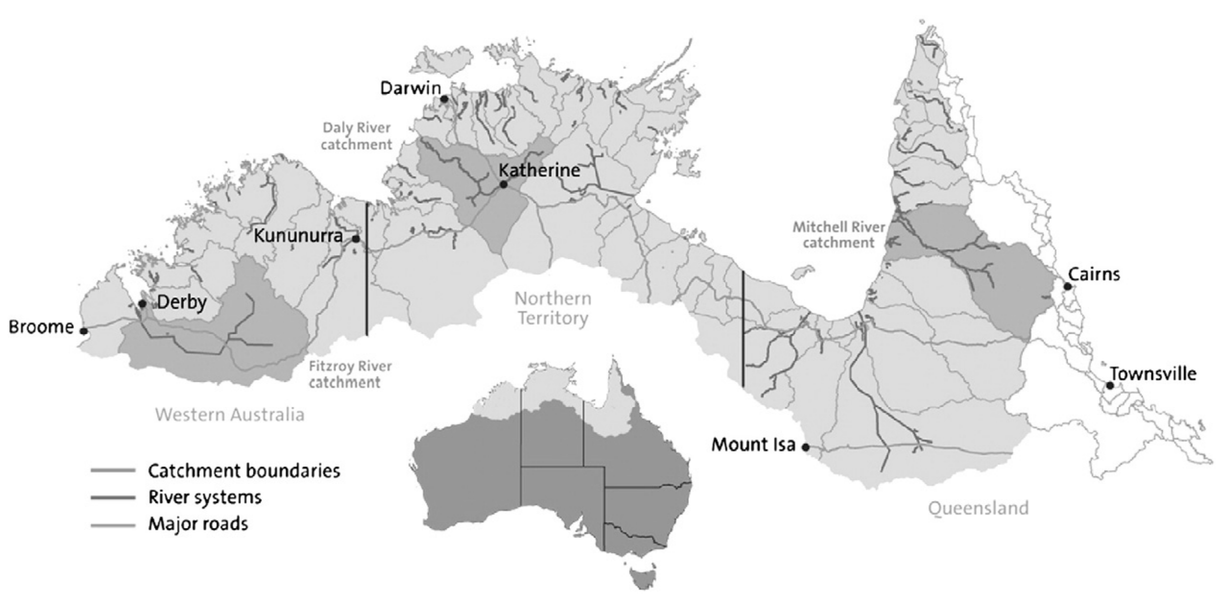

Fig. 1. Study site — Australian's tropical rivers and the three focal catchments.

river systems, water quality and other water services (e.g. Morrison and Bennett, 2004; Hensher et al., 2005a; Rolfe and Windle, 2005; Bennett et al., 2008) but exclusively from the perspective of non-Aboriginal people. A few studies aimed to value environmental and cultural goods for Indigenous people using stated preference methods (Murray et al., 1995 in Canada; Rolfe and Windle, 2003 in Australia; Tuan and Navrud, 2007 in Vietnam; Venn and Quiggin, 2007 in Australia; Hoyos et al., 2009 in the Basque country). The majority of the available studies assessing cultural values use CV and are from the view-point of non-Indigenous people (see Noonan, 2003 for a meta-analysis).

A CE uses a questionnaire format to set up a hypothetical market scenario, presenting respondents with several sets of options for the future of the river system. In this study the changes in welfare occur from hypothetical changes in management strategies for tropical rivers and the resulting changes in the quantity or quality of ecosystem services. By varying the outcomes of the management alternatives presented to the respondents in a CE, we can collect a wealth of information on the willingness of respondents to make trade-offs between the individual ecosystem services (attributes) and their likely responses to different river management strategies. The welfare estimates calculated through a CE can be used by decision-makers to help choose management or development strategies on the basis of the benefits and costs their choices will have on community welfare.

The CE is based on random utility theory. One common method to analyse choice data is the multinomial logit (MNL) model. This model has been recently superseded by the random parameter logit (RPL) model (Hensher et al., 2005c; Hoyos et al., 2009), the specifications of which can be found in Hensher et al. (2005c) or Train (2003), among others. We opted for an RPL model instead of an MNL model for three reasons: 1) it accounts for unobserved heterogeneity by allowing the parameters of the utility function to be random, 2) it considers that each respondent makes choices in more than one choice situation (panel data), and 3) it relaxes the assumption of the independence of irrelevant alternatives (Train, 1998). We believed a priori that preferences for river attributes vary across different groups of respondents, in particular between Aboriginal and non-Aboriginal Australians, and ignoring heterogeneity across individuals would lead to biased parameter estimates and failures in the calculation of welfare estimates (Breffle and Morey, 2000). In all our models we applied the panel data setting of the RPL model based on the sequential repetition of choice tasks per respondent.

4. Survey Procedure and Design

4.1. Sampling

Respondents from each of the three catchment areas (see Fig. 1) were selected for the survey. Catchment residents have intimate knowledge of their tropical rivers and freshwater systems. These peoples' lives often revolve around the river and rely on its multiple functions for drinking water, recreation, cultural activities and lifestyle, and also in some cases for employment and income generation. This knowledge is important for conducting any kind of evaluation exercise such as CE because it helps to provide a context for the experiment and indicate the perspective that respondents may take to the framing of the questionnaire and the environmental attributes.

The entire sample was derived from two independent surveys. The first survey was carried out in October–December 2008 through individual face-to-face interviews with Aboriginal Australians in Aboriginal communities in the catchment areas. Communities and households were selected by the Aboriginal co-researchers as randomly as possible given several constraints. First, some Aboriginal communities were undertaking cultural ceremonies at the time and could not be approached. Second, several cultural protocols needed to be respected, including the need to approach community elders and the inability of the Aboriginal co-researcher to approach certain people based on their kinship relationship. In all, 180 face-to-face interviews were carried out (Table 1).

The second survey was a mail-out survey aimed at non-Aboriginal residents. The mail-out survey followed a technique developed by Dillman (2007) and was undertaken in October 2008. Addresses were stratified into the main towns of each catchment and a sample then randomly selected from the Australian White Pages® for each region. The response rate for the mail-out survey was reasonable high at a mean of 29% for all three catchments, yielding 185 (Table 1) and a total of 365 for the two surveys.

The required sample size for a CE survey depends on the complexity of the experimental design as well as on the number of choice sets presented sequentially to each respondent (Bliemer and Rose, 2005). Our design (described in the next section) required a minimum sample size of 135, which we exceeded for both surveys.

4.2. Choice Experimental Design

4.2.1. Attributes Used in the Choice Experiment

Five attributes were used in the final design, each selected after a series of focus-group meetings with key stakeholders and reference groups for each river. The attributes can have different levels, in this study between three and four, as shown in Table 2. One of the five attributes is treated as a payment vehicle. In this study, it is described as the costs of the management strategy associated for certain outcomes. The other four attributes represent tropical river ecosystem services important to a range of stakeholders and industries, including recreational fishers, Aboriginal Australians, agriculturalists, pastoralists, tourism operators, and conservationists.

4.2.1.1. Area of Floodplain in Good Environmental Condition. This attribute is broadly representative of environmental values and also incorporates some elements of aesthetic value. A floodplain in good environmental condition is explained as having the necessary flow regime for supporting habitat for a diversity of native plants and animals and no weed cover. Without natural resource management, the area of floodplain in good environmental condition is expected to diminish by 10–50% (Begg et al., 2001). The levels were realistic numbers in km^2 and different for each of the three rivers and indicated in the maps shown to respondents. For the modelling process, the numbers in km^2 were translated into dummy variables of “small area in good environmental condition”, “medium-sized area” and “large area”.

Table 1
Sample size and response rates in catchment areas for both survey methods.

	Fitzroy		Daly		Mitchell		Total	
	Face-to-face survey	Mail-out survey	Face-to-face survey	Mail-out survey	Face-to-face survey	Mail-out survey	Face-to-face survey	Mail-out survey
Response rate	–	26%	–	27%	–	32%	–	29%
Number of questionnaires obtained	94	44	39	37	47	104	180	185

Table 2
Attributes and levels used in the choice experimental design.

Attribute	Number of levels	Management strategies 1 and 2	Status-quo strategy
Area of floodplain in good environmental condition	3	– Medium size (15% less than current level) – Large (current level)	– Small (25% less than current level)
Quality of the river for recreational fishing	3	– 3-star fishing – 4-star fishing	– 1-star fishing
Conditions of waterholes important to Aboriginal people	3	– OK – Good	– Poor
Income from irrigated agriculture	3	– Medium – Low	– High
Costs of strategy (in AUS$) as a one-off payment	4	– 10 – 50 – 100	– 0

4.2.1.2. Quality of Fishing. Fishing is important for recreation for tourists and residents as well as for the nutritional requirements, cultural practices and responsibilities of Aboriginal residents. In the choice sets, the fishing quality is measured using a star rating system. Without natural resource management, the quality would likely lead to a "1-star" fishing river with polluted water, less fish and modified scenery. A "4-star" river has mostly unmodified flows and unpolluted water offering abundant fishing opportunities in natural scenery. "3-star" fishing quality was explained as having reduced flows and slightly polluted water.

4.2.1.3. Condition of Waterholes Important for Aboriginal People. Waterholes are important places for Aboriginal Australians in undertaking activities such as hunting, teaching and carrying out traditional responsibilities to their country. Under unmanaged conditions, it is very likely that there will be fewer native plants and animals and less water flow. Weeds would make access to the waterholes difficult. With natural resource management strategies in place, waterholes can remain in "good" and "ok" conditions, meaning that there is a wide range of native plants and animals, that water sediments are unmodified, that there are no weeds and good access. For non-Aboriginal people this attribute has existence value where the benefit comes from knowing that the waterholes are in good condition for Aboriginal people.

4.2.1.4. Income from Irrigated Agriculture. While irrigated agriculture is not currently one of the largest industries in the tropical rivers region in terms of gross value of production, future development of this sector is highly likely. Higher incomes from irrigated agriculture are associated with an increase in water allocated to this purpose (within existing legislative constraints). This may lead to environmental degradation of the river system without expenditure to ensure potential impacts are managed, and may also provide jobs for people living in the catchment areas and other flow-on income and benefits. Couched here as an ecosystem service, we sought to explore people's preferences for seeing irrigated agriculture continue as a land use and possibly expand.

4.2.1.5. Cost of Management. The payment vehicle is a one-off contribution towards a certain management strategy for the river in question. It was explained to respondents that management strategies could include activities such as continued funding of government and non-government agencies to manage weeds on riverbanks, giving assistance to landowners to set aside land for animal habitat on their property, or awarding grants to people starting tourism or other businesses that don't use much water. The payments were listed as potentially being made through methods such as increased taxes, higher rate payments to local councils, and higher prices for goods and services as farmers and businesses meet higher environmental standards. No payment is needed for the status-quo alternative, because no additional management strategies are implemented under this option.

4.2.2. Creation of Choice Experimental Design

Given the number of attributes and levels we selected for the choice sets, the full set of possible combinations are far too many to present in the questionnaires. Respondents can only be presented with a fraction of these possibilities because too many choices can lead to boredom, confusion and inconsistencies (Holmes and Boyle, 2005). Experimental design is concerned with how to create the choice sets in an efficient way, i.e. to maximize efficiency criteria or equivalently minimise error criteria (Campbell, 2007).

We used the software package Ngene, (Collins et al., 2007) to create 48 unlabeled alternatives which were blocked into pairs. We used a Bayesian procedure (see e.g. Sándor and Wedel, 2002). The information about the necessary priors was taken from a literature search on similar choice model studies (for example, Rolfe et al., 2000; Birol et al., 2006; Rolfe and Prayaga, 2007). We compared different designs and chose the one with the smallest D-error. To each block of two we added a status-quo alternative which was always the same. These three alternatives together were called a choice set of which we created 24. Our final design of these 24 choice sets was highly efficient with a D-error of 0.00066 (see Ferrini and Scarpa, 2007 or Bliemer and Rose, 2005 for more details on efficient designs). Nevertheless, one of the choice sets was unrealistic and removed. The remaining 23 choice sets were blocked into three versions (A, B or C) containing seven (version C) or eight (versions A and B) choice sets. Only one of the versions was included in each questionnaire. Fig. 2 shows an example of a choice set.

4.3. Data Collection

All questionnaires were made up of the same questions, divided into three parts: first, attitudinal questions about tropical rivers and other environmental concerns, second, a CE with some follow-up questions, and third, household related questions. The questionnaires for mailing out were self-explanatory and contained more information, while the questionnaires for the face-to-face interviews were in language modified by professional linguists. The face-to-face interviews were mainly carried out by Aboriginal co-researchers to bridge the cultural gap, to share knowledge by better engaging with respondents (Garnett et al., 2009) and when there was a language barrier. The face-to-face setting allowed the Aboriginal co-researchers to convey all necessary information in a narrative way. The verbal transmission was supported by a compiled fact sheet for the Aboriginal respondents to keep. Loomis et al. (2006) concluded that language rather than ethnicity could influence the results of WTP/WTA in valuation surveys and by employing Aboriginal co-researchers we aimed to alleviate this problem.

Respondents were presented sequentially with seven or eight choice sets, depending on the version of the choice sets (see Section 4.2.2). For each choice set, respondents were asked to choose between the three options, two of which described a future scenario with some management and an associated management cost, and the status-quo alternative, involving maximum development (within existing legislative constraints) and minimal management (hence no associated management cost). Respondents were further reminded to be mindful of their household budget and all of the other things they could spend their

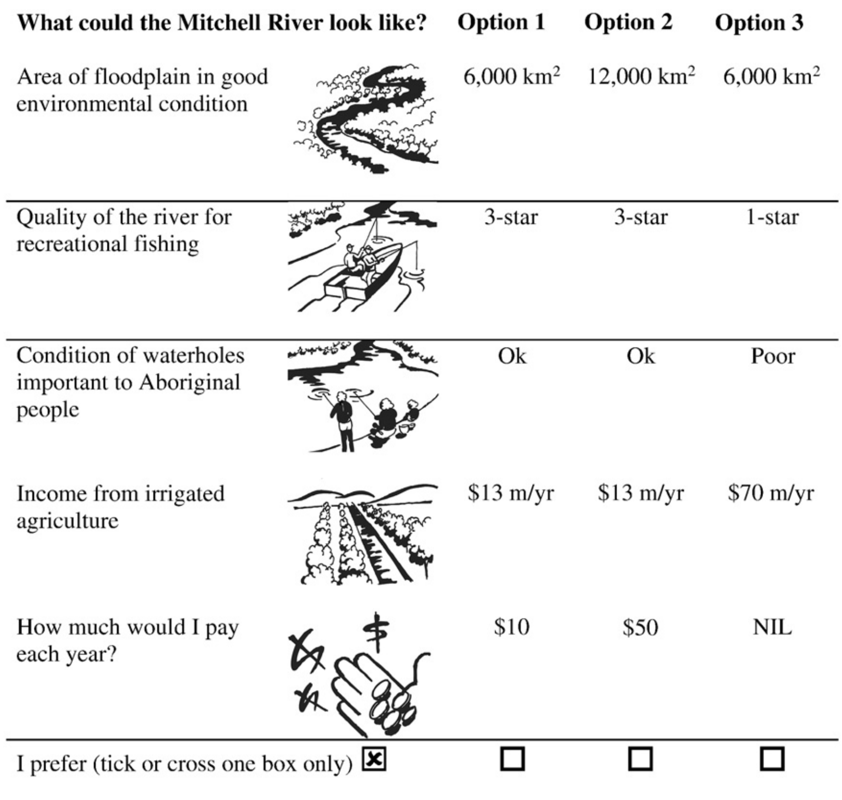

Fig. 2. Example of a choice set for the Mitchell River catchment.

money on. The attributes were described in words and using a visual icon to convey the complexity of information (see Fig. 2). In addition, maps of the relevant river catchment areas were shown to respondents.

5. Results

Limdep 9.0 Nlogit 4.0 was used to estimate the choice models. A few questionnaires had to be dismissed because respondents either skipped the choice tasks altogether or had ticked that they did not understand the CE. This left the final data set at 340 individuals (from 365 collected questionnaires): 171 from the mail-out survey and 169 from face-to-face interviews. Not all of the 340 individuals made a choice for all of the eight presented choice sets (in the mail-out survey, some people seemed to have accidentally skipped a page or two), and therefore the total number of choices is 2579. One hundred respondents answered version A (choice sets 1–8), 139 version B (choice sets 9–16) and 101 version C. Only a few respondents (8%) chose the status-quo option i.e. the majority of respondents were willing to spend some money on management strategies to maintain the quantity and quality of most tropical river ecosystem services. We hence did not include an alternative-specific constant for the status-quo in our models. It also seemed that these opt-out choices were protest choices because these few respondents chose the status-quo in all of the presented choice sets.

5.1. Characteristics of the Respondents

Table 3 shows differences in the demographic and socio-economic characteristics of respondents between the three river catchments and between the Aboriginal and non-Aboriginal samples. Eleven people (6%) who received the mail-out survey identified themselves as Aboriginal or Torres Strait Islander. The level of income was only

Table 3
Respondents' characteristics.

Characteristic	All	Daly	Mitchell	Fitzroy	Aboriginal	Non-Aboriginal
Number of valid responses						
Total	340	71	140	129	180	160
Face-to-face survey	169 (50%)	37 (52%)	42 (30%)	90 (70%)	169 (94%)	0 (0%)
Mail-out survey	171 (50%)	34 (48%)	98 (70%)	39 (30%)	11 (6%)	160 (100%)
1) Age						
Mean	48	44	49	48	44	52
Std. deviation	14	14	15	14	14	13
Range	16–86	16–76	17–82	20–86	16–83	21–86
2) Gender of respondents						
Females (%)	54%	60%	45%	61%	59%	48%
Males (%)	46%	40%	55%	39%	41%	52%
3) Respondents with children	87%	78%	87%	92%	91%	84%
4) Respondents with very high interest in tropical rivers	64%	68%	71%	53%	74%	54%
5) Respondents in favour of development of rivers	6%	4%	7%	7%	6%	7%
6) Respondents in favour of conservation of rivers	40%	41%	38%	43%	41%	39%

stated by 30% of the respondents and hence not further taken into account in the data analysis and choice modelling.

5.2. Estimation Results

The cost attribute (the management cost of an alternative) entered the models as the levels shown in the choice sets (Table 2). All other attributes are treated as discrete variables. Therefore, for each attribute with L levels we created L-1 discrete variables in order to avoid perfect multicollinearity. The omitted level of each attribute was considered the base level, chosen here to be the medium level of each attribute: “medium size of floodplains in good condition”, “3-star fishing quality”, “ok condition of waterholes” and “medium income from agriculture”. For eight respondents (2% of sample) missing observations for “age” were replaced by the mean age.

We present the results of a series of RPL models in Table 4. All panel-RPL models (Models 1–4) were estimated from normal distributions drawn from 150 Halton draws and under panel data conditions. The coefficient for the cost attribute was specified to be fixed in all models so as to facilitate the estimation of distributions of WTP/WTA (Hensher et al., 2005a). The models showed good levels of parametric fit with ρ^2 values around 0.3 to 0.4, indicting extremely good fit (Hensher and Johnson, 1981 comment that values of ρ^2 between 0.2 and 0.4 are considered extremely good fits).

In all models, the coefficients of all significant attributes accorded with a priori expectation. The cost coefficient was found to be negative, confirming that a river management strategy is less likely to be selected if more expensive. This result confirmed an important assumption for further welfare calculations. The coefficients for “small area of floodplains in good condition”, “1-star fishing quality”, “poor condition of waterholes” and “low income from irrigated agriculture” were negative, indicating that they were not preferred to the base (medium) levels. Attributes with positive coefficients were preferred over the base levels, for example, waterholes in “good” condition were preferred over waterholes in “ok” condition. The parameter standard deviations of all attributes were highly significant in all models. The two attributes “4-star fishing quality” and “high income from irrigated agriculture” were statistically not significant at a 5% level and were dropped from the estimation. A log-likelihood ratio test was carried out between an unrestricted model with all attributes and the final Model 1, confirming that Model 1 was statistically better.

For the first model we specified a panel-RPL model including significant attributes only and did not allow for observed variance heterogeneity. The second model is a panel-RPL model with interactions between a dummy variable for Aboriginal respondents, attributes and other socio-economic characteristics of respondents (“Aboriginal”: coded as 1 if respondents identified as Aboriginal, 0 if not). Including these interaction terms provided information on observed heterogeneity in addition to unobserved heterogeneity implied by the RPL model. Only significant interactions were included in the final Model 2.

Model 2 had a higher level of model fit than Model 1. The ρ^2 has slightly increased and the log-likelihood value has improved. In Model 2, four of the seven significant attributes seemed to be influenced by the parameter “Aboriginal”. Aboriginal respondents tended to choose the management strategies/future scenario with low income from irrigated agriculture and a higher cost. This confirmed that compared with non-Aboriginal respondents in the catchment areas, Aboriginal respondents were willing to pay more for natural resource management activities and also value irrigated agriculture less. Aboriginal respondents further

Table 4
Model results (standard errors in parentheses).

Attribute	Model 1	Model 2	Model 3	Model 4
	Pooled sample		Aboriginal sample	Non-Aboriginal sample
	Panel-RPL	Panel-RPL with interactions	Panel-RPL	Panel-RPL
Small floodplains (Std Error)	−0.861*** (0.154)	−0.861*** (0.158)	−0.856*** (0.177)	−0.789*** (0.225)
Large floodplains	0.732*** (0.179)	0.673*** (0.178)	Not significant	0.826*** (0.217)
1-star fishing	−1.826*** (0.150)	−2.233*** (0.477)	−1.755*** (0.186)	−1.717*** (0.227)
Poor waterholes	−1.137*** (0.196)	−1.287*** (0.205)	−1.286*** (0.287)	−1.214*** (0.283)
Good waterholes	0.784*** (0.234)	0.696*** (0.232)	1.723*** (0.233)	0.863*** (0.248)
Low income from agriculture	−0.639*** (0.166)	−0.670*** (0.169)	Not significant	−0.778*** (0.200)
Cost of management	−0.010*** (0.002)	−0.012*** (0.002)	−0.003** (0.001)	−0.010*** (0.002)
Interactions				
Large floodplains*Aboriginal	–	−0.597** (0.241)	–	–
Good waterholes*Aboriginal	–	1.337*** (0.268)	–	–
Low income from agriculture*Aboriginal	–	0.733*** (0.231)	–	–
Cost*Aboriginal	–	0.006** (0.003)	–	–
Cost*Mitchell river	–	0.004* (0.002)	–	–
Poor waterholes*favour of development	–	1.479*** (0.469)	–	–
Cost*favour of development	–	0.012*** (0.004)	–	–
1–star fishing*children	–	−0.923*** (0.336)	–	–
1-star fishing*age	–	0.025*** (0.009)	–	–
Standard deviations (all normal distributed)				
Small floodplains	1.503*** (0.197)	1.593*** (0.210)	1.350*** (0.248)	1.561*** (0.257)
Large floodplains	1.013*** (0.154)	0.991*** (0.150)	–	1.428*** (0.215)
1-star fishing	1.734*** (0.147)	1.772*** (0.156)	1.733*** (0.216)	2.187*** (0.271)
Poor waterholes	1.521*** (0.181)	1.543*** (0.190)	1.488*** (0.338)	1.905*** (0.248)
Good waterholes	1.296*** (0.186)	1.311*** (0.215)	1.705*** (0.246)	0.029 (0.417)
Low income from agriculture	1.182*** (0.154)	1.194*** (0.154)	–	1.374*** (0.206)
Model fit				
Log-likelihood function	−1755.37	−1740.87	−868.13	−875.24
Number of choices	2579	2579	1369	1210
ρ^2	0.378	0.383	0.421	0.338
Halton draws	150	150	150	150
Number of respondents	340	340	180	160

*** = significant at the 0.1% level; ** = significant at the 1% level; and * = significant at the 5% level.

tended to choose the future scenario with waterholes in good condition more often, possibly driven by cultural considerations. Finally, Aboriginal respondents chose the future scenarios with large areas of floodplain in good environmental conditions less often. This emphasises the local aspect of the rivers. The probability of choosing management strategies with different levels of fishing quality was not affected by the parameter "Aboriginal", indicating that both groups had equal preferences for this attribute.

Also in Model 2, we tested the significance of interactions between dummy variables for characteristics such as education, age and attitudes/beliefs with all attributes. However, from all seven parameters reported in Table 3 and from a dummy variable for each of the three rivers only a few were found to be significant. Preferences did not strongly differ between the rivers. Respondents from the Mitchell catchment area chose the management strategies that have higher costs attached more often. Respondents who were in favour of development rather than conservation choose the management strategies leaving waterholes in poor condition more often. In addition, they tended to choose the strategies with the higher management costs, which is a rather unexpected result. Respondents with children choose the strategies with poor ("1-star") fishing quality less often. The older the respondents, the more likely were they to prefer "1-star" fishing quality over "3-star" fishing quality.

5.3. Differences between Aboriginal and Non-Aboriginal Respondents

Given the highly significant impact of the dummy variable "Aboriginal" on many of the attributes in the CE, we were motivated to run separate panel-RPL models for the datasets from the Aboriginal and the non-Aboriginal samples. The results are presented in Table 4; Model 3 (Aboriginal sample) and Model 4 (non-Aboriginal sample). The attribute "low income from irrigated agriculture" became insignificant for the dataset from the Aboriginal sample. This signifies that Aboriginal respondents did not reveal any significant preference for the income from irrigated agriculture, relative to the base level (medium income from irrigated agriculture). In addition, Aboriginal respondents also did not seem to have a significant preference for the attribute "large area of floodplain in good environmental condition".

5.4. Welfare Estimates

With respondents' preferences broken down into components associated with environmental attributes, it is possible to use CE results to investigate the relative importance of the various attributes and estimate the benefits associated with various combinations of attribute-levels. The formula $-\beta_j/\beta_{\text{cost}}$ was applied to calculate the part worth for each attribute. Welfare measures for all respondents in all three catchment areas, reported in Table 5, were identified for the significant attributes only. In addition to the mean values, we also report distributions of the part worths at a 95% confidence interval simulated with 1000 draws following the Krinsky and Robb (1986) procedure. The welfare change associated with a change in the area of floodplain in good environmental condition, for instance, was found to be a loss of between $41 and $128 per household for a change from small area to medium and a gain of between $28 and $92 per household from medium to large (based on Model 2).

The absolute values of all welfare estimates seemed to be larger for Aboriginal respondents than non-Aboriginal respondents (Table 5). The largest discrepancy was found for the attribute "condition of waterholes" where the difference equalled $437. Fig. 3 outlines the differences in welfare estimates between Aboriginal, non-Aboriginal respondents and the pooled sample (labelled "Unmodified").

5.5. Attribute Non-Attendance and the Cost Attribute

The survey questionnaires contained some follow-up questions to the CE, in which respondents were asked to indicate which attributes were important to them when making their choices and which ones weren't. This enabled testing of whether respondents consistently chose the alternative that was best with respect to one particular attribute, ignoring all other attributes, i.e. made lexicographic choices. By making lexicographic choices, respondents are driven by lexicographic preferences reflecting non-compensatory behaviour (Foster and Mourato, 2002), which is unwanted in a CE survey. Even if respondents look at a range of attributes, it is still problematic in deriving meaningful welfare estimates when trade-offs are not made between all the attributes in the choice task (Campbell, 2007). Hensher et al. (2005b) and Campbell (2007), for instance, found that respondents who ignored attributes have significantly lower valuation estimates than those who considered all the attributes.

Table 6 shows the percentage of individuals who considered each of the attributes when making the choices. The quality of recreational fishing and the size of floodplain in good environmental condition were mentioned by the majority of respondents, both Aboriginal and non-Aboriginal. Overall, the condition of waterholes was also mentioned as an important driving factor, but mainly by Aboriginal respondents. Income from irrigated agriculture and the costs of a management strategy were not as important when choosing an alternative, in particular for Aboriginal respondents.

Out of all the attributes, the management costs play the most crucial role because a cost attribute with varying levels is necessary for a sound welfare analysis (Carlsson et al., 2007). If respondents did not consider it, the assumption of continuously defined, differentiable and convex preferences in standard neoclassical theory would have been violated (Anderson, 1993). It is noteworthy that the majority of respondents who did not consider the costs were from the Aboriginal sample (Table 6). For Aboriginal Australians, non-market valuation based on neoclassical economic assumptions of exchange, tradability or commensurability between goods is challenging to apply (see Venn and Quiggin, 2007) and exploring cost attribute attendance could improve the choice model results and improve their reliability for Aboriginal respondents. There are different approaches for coping with attribute attendance, such as changing the scale parameters (as done in Campbell, 2007; Hensher et al., 2005b), applying external weighting factors, or completely eliminating/excluding the attributes that are not considered (as done in Hensher and Rose, 2009).

Table 5
Welfare estimates for significant attributes (in AUS$) — mean and confidence intervals.

	Model 1	Model 2	Model 3	Model 4
	Pooled sample		Aboriginal sample	Non-Aboriginal sample
Attribute	Panel-RPL	Panel-RPL with interactions	Panel-RPL	Panel-RPL
Small floodplains (confidence interval)	−89 (−158 to −52)	−71 (−128 to −41)	−259 (−831 to −108)	−78 (−154 to −29)
Large floodplains (confidence interval)	76 (44 to 115)	55 (28 to 92)	Not significant	81 (44 to 130)
1-star fishing (confidence interval)	−189 (−280 to −137)	−184 (−335 to −102)	−531 (−1687 to −277)	−169 (−258 to −116)
Poor waterholes (confidence interval)	−118 (−197 to −73)	−106 (−169 to −68)	−389 (−1325 to −172)	−120 (−211 to −64)
Good waterholes (confidence interval)	81 (35 to 154)	57 (22 to 114)	522 (252 to 1751)	85 (34 to 163)
Low income from agriculture (confidence interval)	−66 (−132 to −29)	−55 (−111 to −26)	Not significant	−77 (−151 to −30)

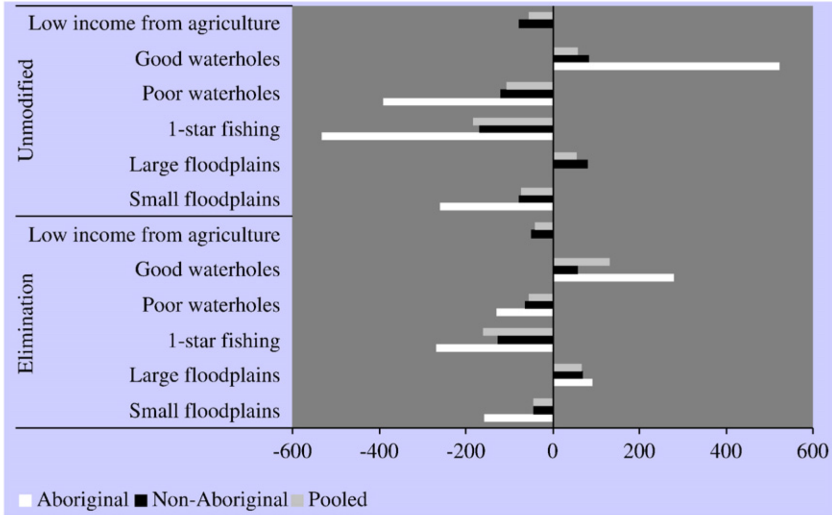

Fig. 3. Differences in welfare estimates (in AUS$) for Aboriginal and non-Aboriginal respondents.

We applied the latter approach and estimated a model in which we eliminated the responses from those respondents who did not consider the costs. The results for the pooled sample and for the Aboriginal and non-Aboriginal samples are reported in Table 1 in Appendix A: supplementary material. For the Aboriginal sample, the attribute "large healthy floodplains" became significant. A comparison of the welfare estimates from the modified models is compiled in Fig. 3 (labelled "Elimination"). The models yielded smaller absolute values than the welfare estimates from the unmodified models. This leads us to believe that the original welfare estimates were too high and eliminating those responses in which the cost attribute was neglected might provide less inflated and more realistic welfare estimates. The WTP of Aboriginal respondents for "good waterholes" compared to "ok waterholes" almost halved from $522 (Model 3) to $280. The welfare loss for Aboriginal respondents for a change to "1-star fishing quality" relative to "3-stars" dropped by $265 from $531 to $268 and by $259 from $389 to $130 for "poor waterholes" relative to "ok waterholes". As shown in Fig. 3, the welfare estimates for the non-Aboriginal sample did not change as much in absolute terms.

Table 6
Importance of attributes for making choices.

Importance of attribute	Pooled sample	Aboriginal (N = 170)	Non-Aboriginal (N = 170)
Management costs			
Yes (%)	110 (32%)	44 (26%)	66 (39%)
No (%)	224 (66%)	125 (74%)	99 (57%)
No answer (%)	6 (2%)	0 (0%)	6 (4%)
Fishing quality			
Yes (%)	241 (71%)	132 (78%)	109 (64%)
No (%)	94 (28%)	37 (22%)	57 (33%)
No answer (%)	5 (1%)	0 (0%)	5 (3%)
Size of good floodplains			
Yes (%)	235 (69%)	106 (63%)	129 (76%)
No (%)	100 (29%)	63 (37%)	37 (21%)
No answer (%)	5 (1%)	0 (0%)	5 (3%)
Conditions of waterholes			
Yes (%)	241 (71%)	156 (92%)	85 (49%)
No (%)	93 (27%)	13 (8%)	80 (47%)
No answer (%)	6 (2%)	0 (0%)	6 (4%)
Income from agriculture			
Yes (%)	130 (38%)	51 (30%)	79 (46%)
No (%)	204 (60%)	118 (70%)	86 (50%)
No answer (%)	6 (2%)	0 (0%)	6 (4%)

6. Discussion

The estimation of welfare estimates and the differences between estimates for Aboriginal and non-Aboriginal Australians can be useful to decision-makers by providing information about the welfare impacts of changes in tropical river systems where none was previously available. The results of the CE mostly accord with the expected signs. An unexpected result, however, was the non-significance of "4-star fishing quality". This result may be because respondents were content with "3-star fishing quality". The marginal improvement from three to four stars might have been not large enough and as long as people can fish (as long as it is better than "1-star fishing quality") they seem to be satisfied. In light of job creation and other public benefits, or the costs associated with additional water extraction and agricultural activity for the catchment areas, it was expected that respondents would have some preference for either high or low income from irrigated agriculture. However, respondents had no significant preference for "high income" compared to "medium income from irrigated agriculture", i.e. income from irrigated agriculture was not regarded positively for development in the catchment areas. Further, respondents valued "low income" negatively compared to "medium income", i.e. respondents preferred a balance of development and conservation outcomes, and conservation is only valued when some development for the catchment areas is provided. Aboriginal Australians seemed to be indifferent towards this production attribute altogether. Environmental, recreational and cultural attributes were clearly the main issue when Aboriginal respondents made their choices for future management strategies. These results comply with findings of other studies that have shown that similar values exist for people living outside the catchment areas (Zander et al., 2010).

Based on the welfare estimates calculated here, a more complete set of benefits and costs of development proposals for the tropical rivers region can be calculated by aggregating part worths over a proportion of the population of households on or to whom the costs and benefits confer (see Straton and Zander, 2009). The results could enable the incorporation of the impacts of development proposals or management strategies on Aboriginal and non-Aboriginal Australians into decision-making frameworks more readily. The welfare estimates can also help to give estimations of the worth of undertaking actions that may not have a tangible financial benefit, and yet have environmental, recreational or cultural benefits.

We applied a mixed-mode of data collection: mailing out questionnaires and individual face-to-face interviews. Differences in the welfare estimates could arise because of differences in the mode rather than differences in preferences and believe systems. However, we argue that while this possibility cannot be completely disregarded, it is minor for our results. First of all, there were also Aboriginal respondents among the sample which received the questionnaires by mail. Secondly, there is scientific evidence that the mode does not have a significant impact on the magnitude of welfare estimates. Although this evidence prevails for contingent valuation applications (Maguire, 2009) and also relates to other modes such as web surveys (Marta-Pedroso et al., 2007; Nielsen, 2010) we assume that the survey mode does not have relevant impact on welfare estimates from choice model application. However, more research is needed in the field of survey modes in CE applications.

The underlying assumption for each CE is that respondents have well defined and independent preferences for each of the attributes in the choice tasks. Violations of these assumptions have implications for the application of conventional welfare theory and the calculation of welfare estimates and hence on the usefulness of CE. We revealed that respondents, in particular Aboriginal, hardly took the management costs into account when making their choices. Our paper improved the choice model by eliminating responses in which the cost attribute was not considered. We thereby aimed to improve the applicability of the choice data for policy decisions and to obtain more reliable and realistic welfare estimates. As a result, the welfare estimates for the Aboriginal sample halved in their absolute values for many attributes.

The fact that the management cost was not cited as important for the choices of most Aboriginal respondents might indicate that they are unfamiliar with or did not find the idea of paying a levy very salient. This is not an unreasonable possibility given that the incomes of Aboriginal Australians living on remote communities are lower than for Australians generally (Steering Committee for the Review of Government Service Provision, 2005). It also raises the fact that there is a difference between WTP and ability to pay and that the assumption of equivalent marginal values of money across all respondents may not be realistic. Alternatively, the non-attendance of the cost attribute for Aboriginal respondents could be explained by the fact that improvements in environmental, recreational and cultural outcomes are "priceless" to them. Some values or ecosystem features related to connections to country are non-transferable and non-negotiable and cannot be valued within a scientific survey and analysis based on neoclassical economic assumption of utility maximisation. Fuller and Parker (2002) stated that many differences in economic behaviour between Aboriginal and non-Aboriginal Australians are due to cultural differences and our study presents another example of this in the context of valuing natural resources such as tropical rivers.

Bearing this in mind, it might be more appropriate to use non-monetary payment vehicles for the indirect calculation of welfare estimates (e.g. travel distance as payment vehicle). Completely dismissing the cost attribute from a CE design does not allow for the calculation of welfare estimates, as often desired by policy-makers, but preferences for attributes can still be ranked and scored. However, with this approach we would have again been left with the original problem of a lack of comparable measures of the impact of changes in the non-use values of tropical rivers on Aboriginal Australians' welfare. An all too often consequence of this is that these impacts are not incorporated into decision-making at all. Unless these impacts are to be accounted for in other ways, economic valuation may be the lesser of two evils. Holding the level of the cost attribute constant over all alternatives in the experimental design, as done in a study by Carlsson et al. (2007) does not seem to be appropriate in our case as well, as Aboriginal respondents hardly took it into account when making their choices. Based on our experiences from this study, we recommend the use of proxies for the cost attribute. Hanley et al. (2002) and Christie et al. (2007), for instance, use travel distance as proxy for the costs of travelling in research on recreational values. More research is needed on the application of different proxies.

While conducting the CE in Aboriginal communities with Aboriginal co-researchers is a novel and innovative approach, these issues suggest not only modifications to the CE design but also to the procedure to better suit the Aboriginal context of community relationships and kinship. For example, a better setting for a CE could be in a group setting in which family members can discuss the choice sets and make a communal choice. The drawback for this is the huge amount of groups and respondents that are needed to achieve statistical power and to fulfil sample size requirements for a specific CE design. Increasing the repetitions for each group and keeping the design as simple as possible can help to reduce the required number of group discussions.

7. Conclusions

This paper provides monetary values of three tropical Australian rivers from the perspective of local users: Aboriginal and non-Aboriginal Australians living in the catchment areas. The willingness-to-pay (WTP) for management policies that yield healthy river systems in the future is large, both for Aboriginal as well as for non-Aboriginal users. All respondents showed a high dislike for poor fishing quality, underpinning the high importance of all three river catchment areas for recreational fishing. The paper further revealed support for the hypothesis that the preferences of Aboriginal and non-Aboriginal water users for the same attributes are largely different. The difference in welfare estimates between Aboriginal and non-Aboriginal users was particularly large for the attribute "condition of waterholes important to Aboriginal people". While non-Aboriginal Australians supported some development of irrigated agriculture in tropical river areas providing jobs and income to the regions, Aboriginal Australians are indifferent towards development based on the extraction of tropical river water. These differences reveal different priorities for development or natural resource management that will need to be taken into consideration by decision-makers.

Responses to a question in the questionnaire about which attributes were important to respondents revealed attribute non-attendance. The welfare estimates for some of the attributes were reduced by almost half when eliminating respondents who did not consider the river management costs, in particular for the non-Aboriginal sample. The high rate of non-attendance of the cost attribute suggests that there is room for improvement of the design of CE, particularly in delivery with Aboriginal respondents. We raise the possibility of using non-monetary payment vehicles as cost attribute and/or delivering the questionnaires in groups to improve the realism and appeal for Aboriginal respondents.

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Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at doi:10.1016/j.ecolecon.2010.07.010.

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