Expert judgements and public values: preference heterogeneity for protecting ecology in the Swan River, Western Australia

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Expert judgements and public values: preference heterogeneity for protecting ecology in the Swan River, Western Australia

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Abstract

Western Australia's Swan River is a complex asset providing environmental, recreational and commercial benefits. Agencies responsible for its management rely extensively on advice from experts, whose preferences may or may not align with those of the community. Using a choice experiment, we compared public and expert preferences for managing the river's ecology. Modelling revealed heterogeneity in preferences, including within the experts sampled. Ecologists held similar preferences to the minority of public individuals who exhibited the strongest preferences for protecting river ecology. Planners were more similar to the public majority, whose preferences were moderated by the cost of ecological improvement.

Key words

Non-market valuation, choice experiment, public and expert preferences, willingness to pay, budget reallocation

JEL classifications

Q51 Valuation of Environmental Effects, Q58 Government Policy

1. Introduction

The management of iconic environmental assets is challenging, particularly when the asset is located close to a populated area. There are different and often conflicting uses to manage for, including recreational, commercial and environmental uses, and there are multiple stakeholder groups with varying preferences to consider. Governments often aim to manage for all of these preferences, and rely on expert advice on the most appropriate ways to do so.

The role of experts in providing technical advice is important and generally uncontroversial. However, experts are also often asked to judge which actions would be best from a wider perspective (Lynam et al. 2007; Martin et al. 2012). This expectation goes beyond technical expertise and into the realm of value judgements, and is usually justified as systematic and comprehensive consultation with the public (e.g. through detailed surveys) is too expensive to be practical for every policy decision (Adamowicz 2004; Rogers et al. 2013a). In effect, these experts are being used as low-cost substitutes for public consultation (Rogers 2013). However, reliance on experts to make value judgements may pose risks if these judgements diverge significantly from those of the public. Ideally, decision making should consider both the technical recommendations of experts to ensure feasibility, and the value judgements of the community to maximise welfare.

Discrete choice experiments have emerged as a convenient way to compare the value judgements of experts and the public. Carlsson et al. (2011) use a choice experiment to compare citizens' preferences with Environmental Protection Agency administrators in Sweden for valuations of a balanced marine environment and clean air. They found significant differences in willingness to pay, with values of environmental improvements tending to be higher for the experts. Rogers et al. (2013a) provide further evidence of differences existing between public and expert preferences in a choice experiment on biodiversity values in the Southwest Australia Ecoregion. In this case, they found that a sample of scientists had a statistically insignificant cost coefficient, but were not able to determine if it was because of (a) the level of cost being too small relative to what they would actually be willing to pay, (b) a strategic response to advocate for more environmental funding, (c) genuinely not caring about the costs of conservation, or (d) a small sample size. In an additional study, Rogers (2013) found evidence of both convergence and divergence between public and marine scientists' preferences in a choice experiment of ecological values for two marine reserves in Australia. For the Ningaloo Marine Park, which was associated with higher levels of public awareness and charismatic attributes, values converged. For the Ngari Capes Marine Park, which was associated with a lower public awareness, there was a divergence in values, particularly for attributes that were not charismatic.

In the existing examples, payment vehicle treatments have varied across the public and expert samples. Selecting an appropriate payment vehicle is important in terms of the incentive-compatible properties of the choice experiment: the payment should mimic how funds would actually be collected if the hypothetical policy was to be enacted, thus making the scenario appear more realistic (Carson and Groves 2007). Rogers (2013) and Rogers et al. (2013a) used an increase in taxes as the payment vehicle, and asked both the public and expert samples to respond with their personal preferences; that is, acting as private citizens who consider the tradeoffs implied by the policy cost with respect to their personal budget constraint. They recognise that this approach implicitly assumes there is an overlap between the experts' personal preferences and how they would actually act when making policy recommendations which may not always be true. However, the approach enables a direct comparison of the estimated public and expert values since the question being asked of each sample is identical. Carlsson et al. (2011) also used a tax-based payment vehicle for the public, but asked their expert sample to recommend which policy they would choose in their professional capacity (recognising the cost that an alternative would impose on the public), rather than act as a private citizen (as someone who would bear that cost). This choice provides a more accurate indication of the advice experts would offer when consulted on an environmental policy, but means that the comparison with public values is indirect: the experts are not bound by a private budget constraint in making their choices.

This study aims to contribute to the comparisons of public and expert values by providing further clarification of the suitability of expert judgement for reflecting community preferences. A choice experiment was used to measure and understand the differences between experts and the general public for the Swan Canning River System in Western Australia. This is an iconic river system that flows through the state capital of Perth, and is subject to multiple uses and complex management issues. The ecological health of the river is affected by a wide range of pressures including: nutrient and organic inputs, contaminants, foreshore degradation, invasive flora and fauna, decreased environmental water flows and climate change (e.g. Dollery 2013). In this study, a sample of the West Australian population was compared with two expert subsamples, namely ecologists and planners. Different types of experts were sampled to determine whether one type might better reflect public preferences than the other.

An alternative payment vehicle was used in contrast to those used in previous public/expert comparisons. The choice experiment was framed for the public and expert samples using a budget reallocation payment, as opposed to a personal increased cost payment. The opportunity costs of the reallocation were demonstrated to respondents in terms of money being drawn away from other Government portfolios, which deliver services they value. The advantage of this approach was our ability to ask the expert sample to make professional recommendations rather than personal choices, in line with Carlsson et al. (2011), while still viewing the cost of the trade-off scenario as binding due to the broader applicability of the reallocation. This allowed a direct comparison of public and expert values in line with Rogers (2013) and Rogers et al. (2013a).

Another point of departure from the existing literature was our modelling approach. Carlsson et al. (2011), Rogers (2013), and Rogers et al. (2013a) tested for equivalency of parameters between public and expert samples; that is, the different samples were pooled and likelihood ratio tests were used to determine whether the hypothesis of equal parameters could be rejected. While this approach offers a direct test of whether public and expert preferences are statistically equivalent, it assumes *a priori* that the separate samples (public or expert) are relatively homogeneous, notwithstanding heterogeneity explained through random parameters or the inclusion of explanatory sociodemographic variables. We instead used a latent-class model. This approach provides greater flexibility by allowing for heterogeneous preferences both within and between the public and expert samples. The analysis is able to separate respondents into different classes, and membership of individuals within those classes can be identified. If the public and experts have different preferences, they will separate into different classes. Alternatively, there could be an overlap in preferences between the public and experts, in which case the classes will contain individuals from each.

2. Methodology

The Swan and Canning rivers formed the case study area. These rivers form a single drainage system that collects water across the Perth metropolitan region in Western Australia and large sections of its semi-rural surrounds. This study focussed on the ecological values of the river system. A related study also measured preferences for the recreational values of the rivers (Rogers et al. 2013b). A choice experiment was designed to evaluate the preferences of both experts and the general public for the rivers.

Choice experiments are a survey-based technique used to investigate the trade-offs that people are prepared to make between different goods or policy outcomes. Respondents are presented with hypothetical choice scenarios, from which they must select their preferred outcomes. Conditional logit models are used to quantify the trade-offs between attributes that are implied by the choices made. One of the attributes that respondents are asked to consider is the cost required to achieve a particular outcome. The inclusion of this cost allows calculation of how much people are willing to pay for the various outcomes about which they are asked. Choice experiments are well-established and widely applied as an economic tool to estimate values for environmental assets (Bennett and Blamey 2001, Bateman et al. 2002). Many rivers and wetlands have been valued in the past using this method, with Rolfe and Brouwer (2013) identifying 145 separate choice modelling studies valuing river protection in Australia, and Brouwer (2009) identifying a further 20 experiments in Australia valuing wetlands protection.

2.1 Attribute selection

The selection of attributes for the choice experiment was informed by: a literature review on the ecological characteristics of the rivers; information gathered from observing focus group discussions with 143 river stakeholders (including community members, recreational users, and government representatives) on the topic of river health and use, undertaken as part of a separate project; and, participatory workshops with the senior management of the Swan River Trust (the governing body for the rivers), to ensure the attributes were meaningful for decision making.

Three ecological attributes were selected based on their relevance as either an indicator of river health or iconic status within the community, the ability of the Swan River Trust to manage identified threats and pressures associated with the attribute, and the availability of information to define the attributes adequately. The attributes are described in Table 1 and include foreshore (riparian) vegetation, fish, and dolphins.

Foreshore vegetation is important for river health given its ability to reduce nutrient and sediment run-off into the rivers, serving to both benefit water quality and reduce erosion of the foreshore (Hancock et al. 1996). Foreshore vegetation also offers additional benefits to wildlife, particularly waterbirds who rely on the vegetation for habitat, shelter and food provision (Department of Water 2007). The fish populations, including for instance, the recreationally important black bream (*Acanthopagrus butcheri*) in the river also have important links to river health as they are sensitive to algal blooms that can result in fish-kill events (Borusk 2004; Zammit et al. 2005). Thus, these attributes are important indicators of river health and it was anticipated that they would be highly valued by ecologists. The broader community might also value the attributes for these reasons or for the amenity and recreational opportunities offered (e.g. natural scenery; recreational fishing).

Bottlenose dolphins (*Tursiops aduncus*) were included as an attribute primarily because of their iconic status amongst the Perth community. At the time of conducting the study, there was a small resident population of approximately 20-25 individuals (Holyoake et al. 2010). The ecological role of this small dolphin population is unknown: while the dolphins are likely to be dependent on the health of the river, the degree to which their presence contributes to river health remains unknown. Moreover, linkages between the Swan River dolphins and the much larger population of non-resident bottlenose dolphins outside the rivers are also unclear, with further research being required, particularly in terms of establishing dolphin demographic and ecological vulnerability (Holyoake et al. 2010). Therefore, it was hypothesised that dolphins may be valued highly by the community as an iconic species, but less so by ecologists who might focus on improving the vegetation and fish attributes which have better established links as indicators of river health.

Table 1. Ecological and cost attribute descriptions.

Attribute	Description of current status	Attribute levels	Coding[a]
Foreshore vegetation in good condition	In 2008, a foreshore assessment report of the Swan and Canning rivers showed that about 20% of the foreshore vegetation was in good condition, 50% in moderate condition, and the remaining 30% in poor condition	20% (500 hectares) in good condition*; 40% (1000 hectares) in good condition; 60% (1500 hectares) in good condition	baseline veg40 veg60
Average frequency of significant fish kill events	Over the past decade, there has been an average of 2 significant fish kill events in the rivers each year, where more than 1000 fish have been killed each time	2 events each year*; 1 event each year	baseline fish1
Health of dolphin population	In 2009, about 75% of the river dolphins were in good health, in terms of being free from known entanglements and not showing any obvious signs of impairment	75% (17 dolphins) in good health*; 85% (19 dolphins) in good health; 95% (21 dolphins) in good health	baseline dolphin85 dolphin95
Budget-reallocation: reallocation amount each year from the State Government budget, for the next 10 years	Revenue sourced by reallocation of shifting money within the current State Government budget, meaning that money will be taken away from other State Government sectors	$0*; $50million total (average of $50 per tax payer); $100million total (average of $100 per tax payer); $150million total (average of $150 per tax payer); $200million total (average of $200 per tax payer); $250million total (average of $250 per tax payer); $300million total (average of $300 per tax payer)	continuous

Notes:

*Indicates the status quo level for each attribute

[a]Unless coded as continuous, variables are dummy coded and = 1 if present, or = 0 otherwise. For dummy coded variables, the baseline is the omitted attribute level in the analysis (i.e. the status quo level).

2.2 Payment vehicle

A budget-reallocation payment vehicle was used in this survey due to its relevance for the expert sample, relative to a traditional coercive payment vehicle. In the latter case, the respondent is (hypothetically) asked to pay from their own pocket to achieve some beneficial change in the attributes they value. However, there are arguments against using these traditional coercive payment vehicles (Morrison and Hatton MacDonald 2011). First, it may not be equitable: low income earners, if adhering to the incentive compatible properties of the choice experiment, would often be forced to select a status quo (zero cost) option as they have low disposable income and are unable to exhibit preferences for conservation or recreation benefits. Second, environmental programs are often funded by a reallocation of an existing budget, rather than by increasing costs. Third, and most pertinent to this study, an increased-cost payment vehicle may not be appropriate for an expert sample, particularly if the experts are being asked to select options based on the advice and recommendations they would give in their professional role[1].

Budget-reallocations have emerged as a way to deal with equity issues and provide a more realistic payment scenario (Bergstrom et al. 2004; Morrison and Hatton MacDonald 2011; Nunes and Travisi 2009; Swallow and McGonagle 2006), and are appropriate for experts to consider in making recommendations as it enforces a limited budget. The use of a budget-reallocation cost has implications for the incentive compatibility of the survey instrument. Stated preference surveys should be designed in a manner that is "consequential" to the respondent in a way that means they have an incentive to truthfully reveal their preferences when making their responses (Carson and Groves 2007). Increased-cost payment vehicles have been favoured in this regard to ensure that there is an opportunity cost to the respondent, in terms of trading off their disposable income (at least hypothetically). Accordingly, for a budget-reallocation it is important to define the reallocation explicitly with respect to where money is being reallocated from, so that the respondent realises there is still an opportunity cost to him or her in that less money would be available for other things that they value. That is, the bundle of goods from which the money is reallocated should be relevant to the respondent.

We defined the budget-reallocation as a reallocation of the State Government budget (Table 1). Specifically, respondents were advised that, under the survey's hypothetical scenario, any additional costs of managing the rivers would be met through reallocating funds evenly from the main State Government sectors: (1) education; (2) health; (3) community amenities, safety and welfare; and (4) transport, communication, recreation, energy and other affairs. These four sector groupings each comprised of roughly one quarter of the WA budget in 2011-2012, meaning that an even reallocation would see equal amounts of money being taken from the four sectors.

In the public survey, a survey treatment was also included where a set of choice questions were completed using an increased-cost (i.e. personal cost) payment vehicle. Only the budget-reallocation data, which applied to both public and expert subsamples, was used for the estimation of public and expert willingness to pay in the present article. However, the supplementary information reports a

[1] An increased-cost payment vehicle may be appropriate for an expert sample if the experts are being asked to respond with their own personal preferences (Rogers 2013).

comparison of results using the increased-cost and budget-reallocation data for the public sample, showing that results are statistically similar (Appendix 1). This suggests that the opportunity costs were recognised by respondents in the budget-reallocation choice experiment, and validates its use in our public-expert model.

2.3 Survey design and administration

The choice scenarios were designed with three options: a status quo option and two others (Figure 1). The experimental designs for the surveys were prepared using NGene (Rose et al. 2008). Bayesian d-efficient designs (see Scarpa and Rose 2008) were generated for the public and expert surveys. For the public survey, the same design was used for both budget-reallocation and increased-cost versions of the experiment, with 24 choice scenarios blocked into six groups of four. The design had a D-error of 0.22. The expert design also comprised of 24 scenarios, but was blocked by a factor of two, with a D-error of 0.22.

Conservation scenario 1: Consider the following options. Assuming these are the only options available to you, which one would you choose? Remember to keep in mind that by spending more money on the river system there will be less funding available for other things.

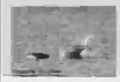
		Option 1 Current state	Option 2	Option 3
	Foreshore vegetation in good condition	20% (500 hectares) in good condition	20% (500 hectares) in good condition	20% (500 hectares) in good condition
	Average frequency of significant fish kill events	2 events each year	2 events each year	1 event each year
	Health of dolphin population	75% (17 dolphins) in good health	95% (21 dolphins) in good health	95% (21 dolphins) in good health
Reallocation amount each year from State Government budget, for the next 10 years		$0	$100 million total (average of $100 per tax payer)	$150 million total (average of $150 per tax payer)
Which one would you choose?		☐	☐	☐

Figure 1. Example choice scenario from ecological survey with budget-reallocation payment vehicle.

A split-design approach was used to compare public and expert preferences (Table 2 identifies subsample descriptions and names). Two public subsamples were collected to manage potential ordering effects related to the payment vehicles: Public1, where respondents were presented with four budget-reallocation scenarios, followed by four increased-cost scenarios; and, Public2, where the order was reversed. For the expert subsamples (Ecologists and Planners), only the budget-reallocation payment vehicle was used, and respondents each saw 12 choice scenarios (a higher cognitive capacity was assumed, such that experts could manage with this many choice scenarios).

Table 2. Survey versions and sample descriptions.

Sampled population	Payment vehicle	Number of choice scenarios	Number of choice blocks	Sample size	Subsample reference
Public – WA	Budget-reallocation / increased-cost	4 / 4	6	343	Public1
Public – WA	Increased-cost / budget-reallocation	4 / 4	6	321	Public2
Expert – ecologists	Budget-reallocation	12	2	36	Ecologists
Expert – planners	Budget-reallocation	12	2	16	Planners

In each survey, first, the purpose of the survey was defined. For the public surveys, the purpose was to identify the values that West Australians place on the ecological features of the rivers, and to communicate the key findings of the research to management bodies. Similarly, the experts were informed that the purpose was to identify their values, but they were also made aware that the results of their survey would be compared to those of the public surveys. In particular, experts were asked to complete the survey in a way that reflected the recommendations or advice that they would give based on their current position as an expert in the field (rather than as a general member of the Australian community).

Respondents were then asked about their past experiences with the rivers. This query was followed by information describing the relevant attributes in the choice experiment. A simple definition of each attribute was provided including a description of: the current condition of the attribute (see Table 1); the pressures or threats experienced by the attribute; and, examples of management approaches for dealing with the pressures. A description of the relevant payment vehicle was then given, and instructions on how to answer the choice scenarios. The choice experiment followed, along with debriefing questions and socio-demographics.

Before the full launch of the surveys, the public questionnaires were road tested across six focus groups consisting of 23 participants. The expert questionnaires were iteratively reviewed by Swan River Trust senior management. The full survey was administered online via The Online Research Unit, a market research company. For the public survey, members of the company's online panel were invited via email to participate in the survey, and offered a minor incentive for completion (entries into a prize draw). The sample was stratified based on the relevant population demographics for age and gender. Sampling was conducted in August 2012, with 664 respondents completing the two versions of the survey (Table 2).

Expert sampling took place between December 2012 and March 2013. The expert sample was constructed based on contacts provided by the Swan River Trust, with individuals identified as having specific expertise related to the Swan Canning River System. Experts were classified as "ecologists" if they had a background in environmental science or management, or as "planners" if they had a background in land use planning or recreational and community management. This sampling strategy was adopted so that we would be able to explore whether preferences of river experts were dependent upon typology as an ecologist or planner. Note that another survey on the recreational values of the rivers was being conducted in parallel to this survey, and the experts were invited to participate in both. They were allocated first to the survey that most closely matched their expertise (i.e. ecologists were invited to respond to this ecological value survey first), and then were given the option to complete the alternate survey. Consequently, planners had already completed the recreational value survey before they responded to this survey. A total of 36 ecologists and 16 planners responded to this survey, resulting in 52 completed questionnaires (Table 2).

2.4 Scale extended latent-class models

We analysed the data using a scale extended latent-class modelling approach which allows for heterogeneity in preferences and error variance. This provided flexibility in addressing the question of how public and expert preferences compare. If preferences are homogeneous between all subsamples, the model will select one preference class as the best fit; if preferences are heterogeneous, the model fit will improve with more preferences classes. In the latter case, individual specific characteristics can be used to explain class membership and identify whether members from a particular subsample are always likely to fall into a particular preference class. Thus, the model allows for the case where preferences are strictly homogeneous within a subsample (e.g. all ecologists have the same preferences), but subsamples differ. However, it also allows for the more general case, where there is heterogeneity in preferences, reflected in multiple classes, but knowledge about the subsample an individual is drawn from (Public, Ecologists, Planners) provides no information to differentiate between the probability of being in a particular preference class. That is, experts are indistinguishable in their heterogeneity from the public. The final possibility is the more nuanced case where experts may have an increased probability of being in certain classes, but there is an overlap in membership between them and the public.

A latent-class specification of a conditional logit model was used to analyse the data, using Latent Gold Choice 5.1 Syntax (Vermunt and Magidson 2013). The model assumes that a set number of classes of people exist. Each class of people have different preferences, and the distribution of those preferences is not imposed (Train 2009, Hess 2014). The model has been applied in a number of areas, including environmental and natural resource management (e.g. Thiene et al. 2012, 2015).

The standard conditional logit specification of the latent-class model is given by the probability that individual *i* selects alternative *j* from the set of options *N*, in choice situation *t*, conditional upon being in preference class *c*:

$$P(y_{it} = j|c) = \frac{exp\left(\lambda\beta_{ck}X_{ijkt}\right)}{\sum_{n=1}^{N} exp(\lambda\beta_{ck}X_{inkt})} \quad (1)$$

where the attribute vector *X* and marginal utility parameters *β* form the systematic part of the utility, $\beta_{ck}X_{ijkt}$. The scale parameter *λ* can be defined by its relationship with the variance of the error term of the utility function:

$$\lambda^2 = \frac{\pi^2}{6\sigma^2} \quad (2)$$

The beta parameters are assumed to be class specific. An increasing number of classes *C* increases the flexibility of the latent-class framework. There are statistical limitations as to the number of classes that can be identified within a sample. However, the model is not limited by the distributional assumptions associated with other approaches such as random parameter models, where the heterogeneity in preferences is assumed to follow a specific distribution (e.g. normal).

The probability of individual *i* being a member of class *c*, for a given number of classes *C*, is given by S_{ic}. The unconditional probability of individual *i* making a sequence of choices across *T* choice scenarios is then:

$$P(y_i) = \sum_{c=1}^{C} S_{ic} \prod_{t=1}^{T} P(y_{it}|c) \tag{3}$$

The choice of *C* is typically empirical and requires a search across a range of values. The appropriate number of preference classes, *C*, is then identified using an information criteria. Although a number are available (including Akaike Information Criteria 3 (AIC3) and Consistent Akaike Information Criteria (CAIC), Nylund et al (2007) suggest that the Bayesian Information Criteria (BIC) is the most robust. One can use individual specific characteristics to estimate the probability that a specific individual will be a member of each class. Class membership of an individual is treated probabilistically, rather than imposed *ex ante*.

The scale extension accounts for error variance heterogeneity (Magidson and Vermunt 2007). If heterogeneity in error variance is ignored, it is possible that the preference class structure of the latent-class model will be misrepresented due to confounding of heterogeneity in preferences with heterogeneity in error variances (Louviere and Eagle 2006, Magidson and Vermunt 2007). That is, imagine a case where two groups exist: one with higher variance; one with lower variance. These two groups could emerge as two latent classes as their scaled marginal utilities would appear to be different, given that it is generally not possible to identify the scale parameter λ and the marginal utilities separately. By empirically allowing for *scale* latent classes as well as *preference* latent classes, one can avoid the potential for this confounding effect. Conditional upon being a member of latent preference class *c* and latent scale class *l*, the probability of selecting option j becomes:

$$P(y_{it} = j|c,l) = \frac{exp(\lambda_l\, \beta_{ck} X_{ijkt})}{\sum_{n=1}^{N} exp(\lambda_l\, \beta_{ck} X_{inkt})} \tag{4}$$

For identification, one scale factor has to be restricted to equal 1, and L-1 are freely estimated.

The scale extended model is implemented in a similar manner to the standard latent-class model, with the number of scale latent classes, L, selected *a priori* along with the number of preference classes, C, and individual specific characteristics can be used to explain the probabilities of scale class membership as well as preference class membership.

In our case, a search for the appropriate number of preference and scale classes was conducted using a modelling strategy where individual specific characteristics were used to explain preference class membership, but not heterogeneity in preferences within a class. They included: which subsample the respondent belonged to (*Public1, Public2, Ecologists, Planners*); the respondent's age (*age*); whether the respondent found the choice scenarios difficult or confusing to answer (*confused*); and, whether the respondent explicitly considered the cost attribute while making their choices (*considered cost*). Attendance to the cost attribute was of particular interest given the use of the reallocation payment mechanism instead of a traditional personal cost. An individual specific characteristic was also used to explain scale class membership (when there was more than one scale class): how certain respondents were of the choices they made in the choice experiment (*certain*; on a scale from 1-10, where 1 is very uncertain and 10 is very certain). The search ranged systematically over one to six preference classes, and one to three scale classes.

3. Results

The data contained four subsamples: Public1 who saw the set of reallocation choices first in order, Public2 who saw the reallocation choices second in order, Ecologists and Planners (Table 2). The BIC and CAIC measures for the search to determine the preferred model specification are presented in the supplementary information (Appendix 2). The preferred model was for three preference classes and two scale classes (BIC(LL) = 5491.62; CAIC(LL) = 5531.62).

The three preference class, two scale class model parameters were subsequently inspected. Within the class membership model we found that the parameters associated with the dummies for Planners was not significantly different from zero, that is, that class membership for planners was not statsitically different to that for the Public2 subsample (who were designated as the baseline cataegory). The Planner dummy variables were removed from the model implying that, conditional upon the other variables used to explain class membership, the distribution of preferences of the planning experts and this public subsample can be considered to be the same. This restricted model showed an improved model fit with a reduction in the BIC and CAIC values (to 5487.16 and 5525.16, respectively), relative to the unresticed model described above, and is the focus of the results discussion that follows (Table 3).

Individuals who belong to the three preference classes differed according to which attributes they considered to be important (Table 3). Individuals from Preference Class 1 had significant and positive preferences for improving the condition of foreshore vegetation and dolphin health, but not for reducing the number of fish kill events. The cost coefficient was significant and negative for these individuals. The ASC was also significant and negative, indicating individuals from this class were unlikely to prefer the status quo over an ecological improvement.

In Preference Class 2, individuals reacted as expected to the cost attribute, which was negative and significant (Table 3). However, with respect to ecological improvements, they only had positive and significant preferences for improving vegetation at its maximum level of 60% in good condition.

Preference Class 3 could be labelled as the ‘environmentalist’ class (Table 3). Individuals were unlikely to select the status quo option with a negative and significant ASC, and had positive and significant preferences to improve the condition of vegetation and dolphin health. As a point of divergence from the other classes, individuals in Preference Class 3 were the only class with a positive and significant preference to reduce fish kill events, and did not react to the cost attribute, which was negative but not significant.

Table 3. Scale extended latent-class model results.

	Preference Class 1			Preference Class 2			Preference Class 3		
	coefficient		z	coefficient		z	coefficient		z
Preference class utility function estimates									
Asc	-16.885	***	-3.41	-0.824		-0.50	-1.159	**	-1.98
Cost	-0.077	***	-3.22	-0.089	***	-3.02	-0.002		-1.59
veg40	5.697	***	3.10	1.668		1.35	1.835	***	7.57
veg60	6.095	***	2.75	3.123	**	2.44	3.286	***	10.70
Fish1	0.463		0.77	-0.383		-0.35	1.215	***	7.78
dolphin85	1.721	***	2.61	0.824		0.79	0.985	***	6.44
dolphin95	3.349	***	2.82	-0.335		-0.23	1.465	***	6.78
Preference class membership parameter estimates									
constant	0		n.a.	0.806		1.35	1.805	***	3.13
Public1	0		n.a.	-0.635	***	-2.78	-0.358		-1.46
Ecologists	0		n.a.	-0.369		-0.63	1.024	**	2.14
confused	0		n.a.	0.089		0.33	-0.978	**	-2.54
considered cost	0		n.a.	0.178		0.43	-0.920	**	-2.28
age	0		n.a.	-0.008		-1.15	0.014	*	1.77
	Scale Class 1			**Scale Class 2**					
	coefficient		z	coefficient		z			
Scale estimates									
scale	1		n.a.	0.148	***	3.66			
Scale class membership parameter estimates									
Constant	0		n.a.	3.435	***	<0.001			
Certain	0		n.a.	-0.263	***	<0.001			
Covariances									
				Scale Class 2					
				coefficient		z			
Preference Class 2				-1.374	***	3.23			
Preference Class 3				-4.121	***	3.21			
Number of individuals			716						
Number of choices			3280						
Log Likelihood			-2618.68						

Notes: *Public1, Ecologists, confused, considered cost* are dummy coded variables that = 1 if present, 0 otherwise; *age* and *certain* are continuous variables.

***, **, * indicates significance at the 99%, 95%, 90% levels of confidence, respectively.

Looking at the extent to which the preference classes exhibit responsiveness to the *degree* of environmental improvement for vegetation and dolphins (i.e. whether coefficients are significantly different between *veg40* and *veg60*, and between *dolphin85* and *dolphin95*), there was a clear difference between preference classes 1 and 3. For Preference Class 1, there was no significant difference in marginal utility for improvements in vegetation condition at 40 or 60% (p=0.600), and only a marginal difference for improving dolphin health from 85% to 95% (p=0.070). In Preference

Class 3 there was clear evidence that higher levels of vegetation and dolphin protection (*veg60, dolphin95*) are valued more than lower levels (*veg40, dolphin85*) (p=<0.001 and 0.002, respectively). In other words, most benefits for Preference Class 1 are gained from moderate levels of environmental improvement, whereas the benefits for Preference Class 3 are tied to achieving maximum levels of environmental improvement.

The variables explaining preference class membership show that respondents were less likely to be in Preference Class 3 than the other classes if they were confused about how to answer choice scenarios or if they considered the cost attribute (Table 3). This suggests the insignificance of the cost attribute for this class was likely due to individuals ignoring the cost of the policy options presented to them. Individuals were less likely to be in Preference Class 2 if they belonged to the Public1 subsample, and were more likely to be in Preference Class 3 if they are an ecologist. Age was also a predictor of class membership, with older respondents more likely to belong to Preference Class 3; however, this result was only statistically significant at the 90% level of confidence.

The conditional probabilities of class membership presented in Figure 2 shows the percentage of each subsample likely to belong to the three preference classes. Overall, Preference Class 1 had the largest class membership, followed by Preference Class 3 and Preference Class 2. The public subsamples follow this same pattern with respect to class size: public individuals were most likely to be represented in Preference Class 1 and least likely to be in Preference Class 2, especially if they were from the Public1 subsample. Planners showed a similar spread of probabilities as for the Public2 subsample, reflecting the ability to restrict the parameters of these subsamples to be equivalent. Ecologists had a 60% probability of being in Preference Class 3, indicating they were more likely to be in this class than planning experts or public individuals who have approximately a 1 in 3 chance of being in this class.

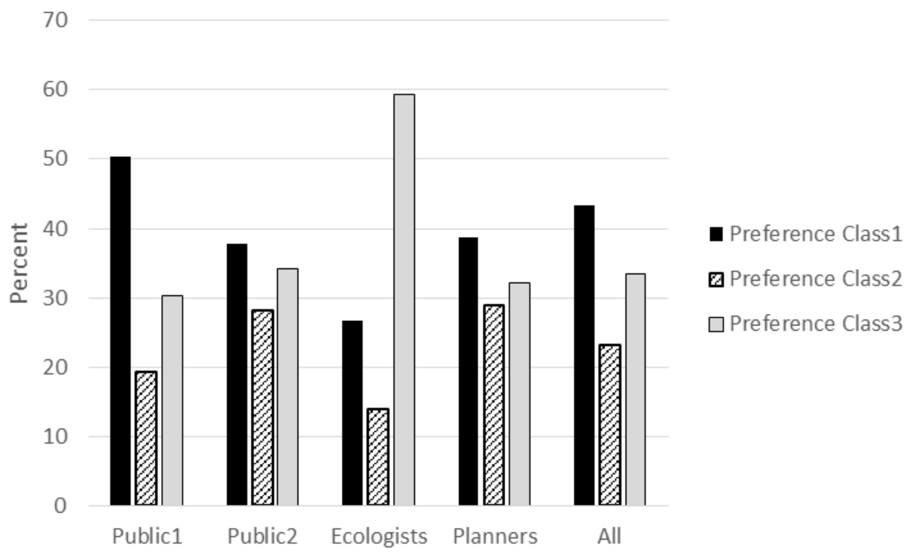


Figure 2. Conditional probabilities (%) of class membership, evaluated at total sample means of other modelled socio demographics.

Willingness to pay was calculated as the negative ratio of the attribute coefficient to the cost coefficient for each preference class (Table 5). In all classes, respondents were willing to pay to achieve the maximum level of foreshore vegetation in good condition, although this result was only weakly significant for Preference Class 3. Individuals in Preference Class 1 were also willing to pay almost the same amount for 40% vegetation in good condition as for 60% in good condition. These individuals were willing to pay almost twice as much to improve the dolphin population in good health from 75% to 95%, relative to 75% to 85%. Individuals in Preference Class 2 were only willing to pay for improving vegetation condition at its highest level. The willingness to pay estimates from Preference Class 3 were much larger than for the other classes; for Class 3, willingness to pay for the maximum levels of improvement for all three ecological attributes ranged from $544 million to $1471 million. However, these results were only significant at the 90% level of confidence due to the insignificance of the cost coefficient for this preference class, and the inflated willingness to pay values may not be robust.

Table 5. Willingness to pay estimates for the three preference classes, reported as the total budget reallocation per year, for the next 10 years.

	Preference Class 1		**Preference Class 2**		**Preference Class 3**	
	$million per year	(SE)	$million per year	(SE)	$million per year	(SE)
Improvement of foreshore vegetation in good condition:						
from 20% to 40%	74.43***	(7.22)	18.80	(13.97)	821.52	(518.89)
from 20% to 60%	79.63***	(9.21)	35.20**	(15.26)	1471.11*	(883.52)
Reduction in frequency of fish kill events each year:						
from 2 to 1 events	6.05	(-7.20)	-4.32	(-12.26)	544.08*	(-317.17)
Improvement of dolphin population in good health:						
from 75% to 85%	22.49***	(8.39)	9.28	(12.22)	440.88	(278.75)
from 75% to 95%	43.76***	(7.29)	-3.77	(16.57)	655.80*	(382.63)

Notes: ***, **, * indicates significance at the 99%, 95%, 90% levels of confidence, respectively.

4. Discussion

An important finding from these results was that the ecologist and planner experts were not found to be one homogenous group. As well, preference class membership showed that experts and the public did not separate neatly into different latent classes. Rather, expert and public individuals were found to be members of all three preference classes. This finding is consistent with the literature where it is widely acknowledged that the general public have heterogeneous value structures (Renn 2006), and there is some evidence of value heterogeneity among experts (Sandbrook et al. 2010). Comparisons of expert and public preferences for the environment find instances of both preference convergence (e.g. Colombo et al. 2009; Kenyon and Edwards-Jones 1998; Rogers 2013) and divergence (e.g. Carlsson et al. 2011; Decker and Bath 2010; Kenyon and Edwards-Jones 1998; Rogers 2013; Rogers et al. 2013a), supporting our discovery of multiple preference classes that each contain public and expert individuals.

The majority of ecologists (60%) belonged to Preference Class 3, where the cost coefficient was not significant. This lead to a very high (but marginally significant) willingness to pay for maximum levels of ecological improvement. Given that ecologists were most likely to belong to this group implies that they are likely to overstate how much the broader public are willing to pay for improvements in the river's ecology. The planning experts, on the other hand, had preferences that were statistically similar to one of the public subsamples, and were more likely to be in Preference Class 1 than the other classes. These results suggest that the preferences of the planners were more representative of public preferences than the ecologists. This could indicate that the particular area of expertise (i.e. specific training; in this case ecology or planning) is what distinguishes preferences, as opposed to just being a well-educated individual. In particular, planners have an incentive to try to reflect what the public wants, it is their disciplinary norm. The results could also indicate that 'green' people self-select themselves into ecology professions (e.g. Groom et al. 2007).

Unlike the other classes, Preference Class 3 tended to value protection of the ecology without worrying about the cost. This is a similar result to Rogers et al. (2013a) where their scientist sample had an insignificant response to cost, but in our study the sample size was much larger and the payment vehicle was more appropriately framed for the inclusion of an expert sample. This would suggest that Preference Class 3 was considering but not responding to the cost, possibly because they believe that conservation of the rivers should be funded at some higher amount than the options presented to them in the choice experiment. Strategic overbidding has been shown to occur in cases where subjects believe that a good will be provided if their willingness to pay is greater than the cost of provision (Posavac 1998).

Aside from the response to cost, Preference Class 3 showed sensitivity to scale in their preferences for the ecological attributes. They valued maximum improvements in vegetation condition and dolphin health, they were the only class willing to pay for a reduction in the frequency of fish kill events, and also the only class that responded consistently to changes in the degree of environmental improvement with a preference for more of everything.

Overall, the results support the findings of Carlsson et al. (2011), Rogers (2013) and Rogers et al. (2013a), who each present examples where preferences diverge between the public and experts. However, the results also show that preferences can be divergent among different types of experts, and *within* types of experts. This increases the challenges for government policy makers; not only may ecological experts not reflect public values, but they differ from other experts. However these challenges are to some extent ameliorated by our other important finding that the preference of some experts (planners) are broadly consistent with those of the public. We caution though that the extent to which this is consistent across other contexts remains to be tested. This finding offers an insight into the possible reasons for public and expert preference divergence cited in Rogers 2013. The ability of planning experts, who are highly knowledgeable about the river system, to reflect public preferences lends support to the idea that a divergence in preferences between public and scientific (ecologist) experts could reflect a true divergence in values, rather than being due to a lack of public awareness and understanding.

The emergence of three distinct preference classes means that optimal management of the river system is not straightforward – any given policy decision is likely to affect groups of individuals differently. However, management of public environmental assets inevitably involves trade-offs between competing interests and alternative value sets. What this study emphasises is that the diversity in preferences cuts across all groups, both public and different types of experts, and that identifying preferences of the public for the management of resources for which they hold use and existence values is still required, even if there are expert groups providing input. On the other hand, studies like this may help to identify outcomes that are beneficial to all or most groups in a community, as we found in the case of foreshore vegetation, for which we found consistently positive valuations.

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Appendix 1

The broader study collected public sample data with two different payment vehicles: the budget-reallocation and an increased-cost. We compared whether the use of the different payment vehicles lead to different results by pooling data from the two public subsamples (Public1 and Public2). Three multinomial logit models were estimated for the increased-cost data only, the budget-reallocation data only, and a choice model that included data for both payment vehicles. A likelihood ratio test confirms that the combined payment vehicle model is not statistically different to the separate models, with a Chi-squared statistic of 10.46 and 7 degrees of freedom. The ability to pool the data in this manner suggests that respondents' preferences for the ecological attributes were consistent across both payment vehicles.

Table A1. Multinomial logit results for the public samples comparing the increased-cost model, budget-reallocation model, and combined payment vehicle model.

	Increased-cost coefficient	Budget-reallocation coefficient	Combined payment coefficient
asc	-0.301***	-0.512***	-0.406***
cost	-0.006***	-0.006***	-0.006***
veg40	0.795***	0.704***	0.750***
veg60	0.990***	0.874***	0.935***
fish1	0.281***	0.187***	0.235***
dolphin85	0.251***	0.300***	0.276***
dolphin95	0.591***	0.467***	0.529***
Observations	*2656*	*2656*	*5312*
Log likelihood	*-2825.835*	*-2808.965*	*-5640.029*

Notes: ***, **, * indicates significance at the 99%, 95%, 90% levels of confidence, respectively.

Appendix 2

Table S1 reports the BIC and CAIC measures as one searchers over the class structure. This indicates that the prefered structure is one that has 3 preference classes and 2 scale classes.

Table A2. Results of the scale and preference class specification search.

Scale classes: preference classes	LL	BIC(LL)	CAIC(LL)	Number of parameters
sc1:pc1	-3393.06	6832.126	6839.126	7
sc1:pc2	-2804.76	5747.570	5768.570	21
sc1:pc3	-2643.03	5516.133	5551.133	35
sc1:pc4	-2603.89	5529.896	5578.896	49
sc1:pc5	-2568.25	5550.639	5613.639	63
sc1:pc6	-2541.27	5588.719	5665.719	77
sc2:pc1	-3099.78	6258.717	6267.717	9
sc2:pc2	-2753.57	5671.489	5696.489	25
sc2:pc3	**-2614.34**	**5491.624**	**5531.624**	**40**
sc2:pc4	-2575.3	5512.156	5567.156	55
sc2:pc5	-2541.88	5543.927	5613.927	70
sc2:pc6	-2515.21	5589.175	5674.175	85
sc3:pc1	-2865.15	5815.749	5828.749	13
sc3:pc2	-2681.96	5554.547	5583.547	29
sc3:pc3	-2601.17	5498.148	5543.148	45
sc3:pc4	-2559.43	5519.862	5580.862	61
sc3:pc5	-2524.98	5556.139	5633.139	77
sc3:pc6	-2497.32	5605.988	5698.988	93