ISSN 1835-9728

Environmental Economics Research Hub

Research Reports

# Comparing Scientist and Public Preferences for Conserving Environmental Systems:

## A Case of the Kimberley's Tropical Waterways and Wetlands

Abbie Rogers and Jonelle Cleland

**Research Report No. 80**

**December 2010**

**About the authors**

Abbie Rogers (nee McCartney) and Dr Jonelle Cleland are Research Associates at the School of Agricultural and Resource Economics, University of Western Australia.

This research is part of the Environmental Economics Research Hub Project 8: Divergence between public and expert valuation of environmental assets, which is funded by the Australian Commonwealth Environmental Research Facilities (CERF) program.

The authors would like to thank: (1) Ruth O'Connor, Knowledge and Adoption Coordinator for TRaCK, for her assistance in organising the Kimberley expert consultation, (2) the scientists who kindly gave up their time to participate in the expert survey, and (3) Professor Michael Burton for his comments on this manuscript.

**Environmental Economics Research Hub Research Reports** are published by The Crawford School of Economics and Government, Australian National University, Canberra 0200 Australia.

These Reports present work in progress being undertaken by project teams within the Environmental Economics Research Hub (EERH). The EERH is funded by the Department of Environment and Water Heritage and the Arts under the Commonwealth Environment Research Facility.

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## Abstract

This study uses choice modelling to investigate public and expert preference divergence through a valuation of the Kimberley's tropical waterways and wetlands in Western Australia. A sample of Australian tropical river scientists participated in an identical survey to the West Australian public. Within the public sample, a split survey design is utilised to examine the effects of information on preferences – a low information version provided sufficient information for respondents to participate in the survey, while a high information version provided a more thorough and detailed description of the attributes. Divergent preferences are apparent between the public and scientist samples. This is illustrated through two key results: first, an attempt to merge the data for each of the samples is rejected; and second, there are differences in conservation preferences. The scientists had stronger preferences to protect system based attributes and threatened species, and were generally not willing to pay to protect iconic attributes. The public, on the other hand, held positive and more evenly spread values for all attributes. Information had an impact on public preferences, particularly through the rejection of a combined low/high information model, but also with respect to the iconic species attribute, where there is a pattern of decreasing willingness to pay as information level increases.

# 1. Introduction

An understanding of both public preferences and expert advice are of upmost importance in guiding policy decisions. Under the tenets of a democratic society, decision-makers require information about community values, preferences and attitudes to appropriately inform policy (Lengwiler 2008). Likewise, expert advice is required to inform decision-makers of risks, feasibility of actions, and other technical aspects of a proposed policy (e.g. see Pannell and Roberts 2009). Often expert advice is sought for matters that reach beyond the technical aspects of a policy or decision. In such cases, it is generally assumed that experts capture the sentiments of the wider community and can be relied upon to be the 'voice' of the community. From a transaction cost perspective, relying on the advice of experts is a cost-effective alternative to implementing a community consultation program.

The classical model of expert-informed decision making has come under scrutiny in more recent times (Pellizoni 2003). This has raised an important question: do expert values reflect the value-judgements of the public? If expert advice adequately represents public preference, then relying solely on experts to guide policy is not an issue. However, if divergence is found to exist between public and expert values, then public consultation would become an essential component of decision making to ensure community values are sufficiently addressed in policy.

To date, there has been limited research investigating the potential for public and expert preference divergence. One of the problems that exist in comparing expert and public preferences is that different approaches are typically used to capture their preferences, thus they aren't directly comparable(e.g. Colombo *et al*. 2009). Choice modelling (CM) offers a solution to this problem. CM is a non-market valuation technique, commonly used in environmental valuations to estimate public values, although it can effectively be applied to estimate both public and expert values (see McCartney 2010). A CM survey works by asking respondents to make trade-offs between various components of an environmental system. The trade-offs are then analysed to estimate marginal values for the various components. This trade-off scenario appeals to the expert way of thinking, in the sense that environmental problems often require a certain amount of trading off between competing outcomes, rather than an 'all or nothing' solution.

This study uses CM to address the question of whether expert and public preferences diverge, based on samples of Australian scientists and the general West Australian community. The Kimberley's tropical waterways and wetlands are employed as a case study to investigate potential divergence.

It is acknowledged that the public may value the environment differently to experts because they lack understanding of environmental complexity. As such, within the case studies a number of public knowledge factors are considered to determine whether they impact on preferences, including personal experience with the environmental assets considered in the studies and the amount of information provided in the survey describing the environmental assets.

The following section provides further background on the issues of public/expert preference comparisons and describes the CM technique in more detail before introducing the case study. Section 3 provides an overview of the survey methodology and Section 4 presents and discusses the results. The paper then concludes with a summary of public and scientist preference divergence.

## 2. Background

This section provides a review of the existing literature concerned with the comparison of public and expert preferences (Section 2.1). Following this, Section 2.2 offers a brief account of CM methodology. Section 2.3 then introduces the case study – the Kimberley's tropical waterways and wetlands.

### 2.1 Public and expert preference comparisons

The assertion that public preferences are an essential component of policy and decision making can be validated on both political and economic grounds. First, it is the responsibility of a democratic society to ensure that public interests are upheld in all matters, not least of all the management of public assets (Hansen 1998). Second, if an individual suffers a loss of welfare from a particular change, that individual is considered to have economic standing (Kontoleon *et al*. 2002). The individual is then entitled to be included in the aggregate population that may possibly influence the decision process regarding that change. In an environmental context, this circumstance could occur frequently – environmental externalities can affect members of the public, thus they have economic standing in any decisions relating to environmental change.

Having justified the importance of considering public preferences in policy changes, particularly environmental policy, we now turn to examine past efforts to compare public and expert preferences. There is a substantial body of research that has collected information about either public or expert preferences, however, as seen in Table 1, one of the biggest issues is that different preference elicitation techniques tend to be used between the two groups (e.g. see Colombo *et al.* 2009, Johnston *et al*. 2002, Kenyon and Edwards-Jones 1998). This discrepancy results in preferences that cannot be systematically compared between the public and experts – the preferences have been captured in different metrics and they may not be preferences for an identical item. That is, the different elicitation techniques may mean that a different question has been asked of the participants, thus the preferences being captured are not explicitly for the same thing.

To our knowledge, only a small number of cases exist where the same quantitative elicitation technique has been used to capture preferences of both public and experts, providing the potential for a direct comparison. In all cases CM was selected as the elicitation technique. Araña *et al*. (2006) use CM to directly compare the preferences of medical practitioners and undergraduate social science students for cervical cancer screening. They found congruence in the values of the practitioners and students. However, it is possible that the result may be different in an environmental context.

**Table 1:** Main approaches for capturing the preferences of scientists and the public (table adapted from Kontoleon *et al*. 2002).

| **Approach** | **Political** | **Participatory** | **Stated preference** | **Multi-criteria analysis** | **Expert panels** |
|---|---|---|---|---|---|
| **Examples** | * Voting<br>* Referenda<br>* Polls | * Citizen juries<br>* Focus groups<br>* Town meetings | * Contingent valuation<br>* Choice experiments | * Analytic Hierarchy Process | * Delphi<br>* Task forces |
| **Theoretical basis of the approach** | Social democracy | Deliberative democracy | Welfare economics | Grounded in operations research | Participatory learning |
| **Whose preferences are captured?** | Public, independently | Public, collectively | Public, independently | Experts, independently or collectively | Experts, collectively |
| **Are preferences budget-constrained?** | Generally, no | Generally, no | Yes | Generally, no | Generally, no |

Carlsson *et al*. (2008) use CM to compare the preferences of the Swedish community with Environmental Protection Agency administrators for two case studies: a marine environment and clean air. They find significant differences between the two samples, with the administrators tending to have higher values. However, the CM questions presented to the public and administrators were slightly different: the public were asked to choose their most preferred conservation programs in the CM survey, and the choices made were constrained by their personal budget as each program had an associated cost (see below for a more detailed description of the CM technique and how options are presented); the administrators were asked to *recommend* programs that should be implemented. On the one hand, this is an appropriate question to ask of the administrators – this is similar to the actual role that they perform. On the other hand, though, removing the personal budget constraint may violate the incentive compatible properties of a well designed CM study[1]. It also means that preferences are not (truly) directly comparable between the public and administrators – there is no way to be certain that any differences in the values estimated are a result of actual preference divergence or a reaction to the difference in the survey instrument.

McCartney (2010) used an identical CM survey instrument to sample the West Australian community and marine scientists in a valuation exercise for the Ningaloo Marine Park and proposed Ngari Capes Marine Park in Western Australia (WA). With respect to the Ningaloo valuation, some divergence was evident in terms of the probability of selecting conservation programs as opposed to maintaining the current situation, with the public typically opting to conserve more than the scientists. However, there was a convergence of values between the public and scientists for each of the attributes considered in the study. For the Capes Marine Park, divergence was found to exist between public and scientist values.

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[1] Readers are directed to EERH Research Report No.76 (McCartney and Cleland 2010) for a more thorough discussion of incentive compatibility in CM.

It is thought that public knowledge and awareness factors played a role in the convergence of values for Ningaloo (McCartney 2010). The Ningaloo Marine Park is the iconic marine park of WA, and receives much public attention. However, given the inconsistency between the Ningaloo and Capes valuations, the results of the McCartney (2010) study suggest that further investigation of public and expert preferences is warranted to establish under what particular contexts preferences are likely to diverge.

## 2.2 Choice modelling methodology

The aim of CM is to estimate how much people are willing to pay to change, improve or conserve particular attributes of the good in question. In a CM survey, respondents are faced with a number of questions called choice scenarios (see Figure 3 for an example of the choice scenarios used in the Kimberley survey). Each scenario is comprised of a number of hypothetical options, or alternatives (e.g. different conservation programs or policies), and the alternatives comprise of a list of attributes describing the good. The amount of each attribute offered varies across the alternatives. One of the attributes included is usually a cost associated with implementing the program, and a status quo or 'choose none' type alternative is usually included in each choice scenario (Bennett and Blamey 2001).

The respondents' choices are analysed according to Random Utility Theory (RUT) (Bateman *et al*. 2002). RUT defines utility held by individual *n* over alternative *i* ($U_{in}$) as a function of a vector of *k* attributes ($X_{ik}$), the parameters ($\beta_k$) and an unobservable utility component ($\varepsilon_i$):

$$U_{in} \quad = \sum_{k=1}^{K} \beta_k X_{ik} + \varepsilon_{in}$$

Equation 1

where $x_i$ is a vector of attributes. Following Morrison *et al*. (1996), an individual (*n*) will choose alternative *i* over alternative *j* if the individual's utility for *i* exceeds that for *j*:

$$P\left({}^{i}/_{i}\,, j\epsilon J\right) = P\left[\left(V_i + \varepsilon_{in}\right) > \left(V_j + \varepsilon_{jn}\right)\right], \forall\, j \mid i \qquad \text{Equation 2}$$

where *V* represents the deterministic utility $\beta' x_i$. This implies that if the combined deterministic and unobservable utility is greater for *i* than it is for *j*, individual *n* will choose alternative *i* over *j*. By rearranging Equation 2, one can then show that the probability of choosing *i* over *j* is equal to the probability that the difference in deterministic utilities of the alternatives is greater than the difference in unobservable utilities:

$$, \forall\, j \mid i \qquad \text{Equation 3}$$

Because the error term is unobservable, an assumption must be made about its distribution. Usually it is assumed that the error terms are independently and identically distributed (IID), taking on the form of a Gumbel distribution. This leads to the estimation of probabilities through the Multinomial Logit Model (MNL) (Train 2009). As described by Train (2009), in the MNL the probability of an alternative (*i*) being chosen by an individual increases as the number or level of preferred attributes increases and undesirable attributes decrease in *i* in comparison to alternative *j*:

$$P_{in} = \frac{e^{\lambda\beta' x_{in}}}{\sum_j e^{\lambda\beta' x_{jn}}} \qquad \text{Equation 4}$$

where $\lambda$ is a scale parameter that is inversely proportional to the standard deviation of the distribution of the error term. The scale and beta parameters are not independently identifiable (unless imposing a normalisation rule), so estimated parameters are interpreted as scaled marginal utilities. This assumes that error variance is constant across individuals. However, it is possible to allow scale to vary across individuals by assuming a parametric relationship between the variance of the error term and exogenous characteristics that vary across a sample, thereby identifying changes in the relative value of the error variance.

When a cost attribute is included, we are able to estimate how much people are willing to pay to receive one unit more of a particular (non-monetary) attribute. Dollar value estimates, or partworths, are retrieved by taking the negative ratio of the coefficient for the non-monetary coefficient ($\beta_a$) to that of the cost coefficient ($\beta_b$) (Bennett and Blamey 2001):

$$Partwort\mathbf{I} = \mathbf{I}\frac{\beta_a}{\beta_b} \qquad \text{Equation 5}$$

The MNL model assumes that the marginal utilities are constant across all individuals within the sample, that is, the betas are considered as constants. However, it is now well recognised in the literature that there is often heterogeneity in individuals' preferences (e.g. see Train 2009, Hensher *et al*. 2005, Louviere *et al*. 2000). To capture this heterogeneity, one can model marginal utility as a function of individual characteristics, in the form of socio-economic variables (e.g. age, gender, etc.) (see Equation 7).

An alternative means of capturing heterogeneity, which can be used in conjunction with the inclusion of socio-demographic modifiers, is to assume that there is a distribution of marginal utilities across the sample, and that distribution is treated as a random variable, with the analyst estimating its meta parameters (e.g. mean and variance). This leads to the now frequently applied Mixed Multinomial Logit (ML) model.

Following Hensher et al (2005), one can re-specify Equation 1 making the marginal utilities individual specific:

$$U_{in} = \sum_{k=1}^{K} \beta_{nk} X_{ik} + \varepsilon_{in}$$ Equation 6

$\beta_{nk}$ can then be specified as:

$$\beta_{nk} = \beta_k + \delta'_k z_n + \eta_{nk}$$ Equation 7

where $\delta$ represents the impact of individual characteristics ($z_n$) on marginal utility, and $\eta_{nk}$ is a random term representing the distribution across individuals according to an underlying functional form. This specification incorporates heterogeneity from both random effects and individual specific shifters in the mean of their distribution. Normal and lognormal distributions are commonly applied to $\eta$, and there can be correlation between random parameters.

It is important to recognise that individuals often provide information over a series of choices, so the random parameter for any particular individual is constant across all repeated choices that are observed. Thus with $t$ repeated choice scenarios being answered by an individual the utility function becomes:

$$U_{itn} = \sum_{k=1}^{K} \beta_{nk} X_{itk} + \varepsilon_{itn}$$ Equation 8

Determining which attributes should be specified as having random parameters is not clear cut. There are tests available to *a priori* establish the selection of random parameters (McFadden and Train 2000). However, as Hensher *et al*. (2005, p.612) note, such tests can be "very demanding for a large number of explanatory variables and might be problematic in establishing the model". Thus, it is often necessary for the researcher to make *ex ante* assumptions about which parameters should be treated as random.

## 2.3 Case study – Kimberley's tropical waterways and wetlands

Building upon the Ningaloo and Capes case studies considered in McCartney (2010), the case study selected for this investigation explores preference divergence over a different scale and setting. The Kimberley's tropical waterways and wetlands reflect a broad scale system, consisting of numerous water catchments, situated in a remote part of Western Australia (Figure 1).

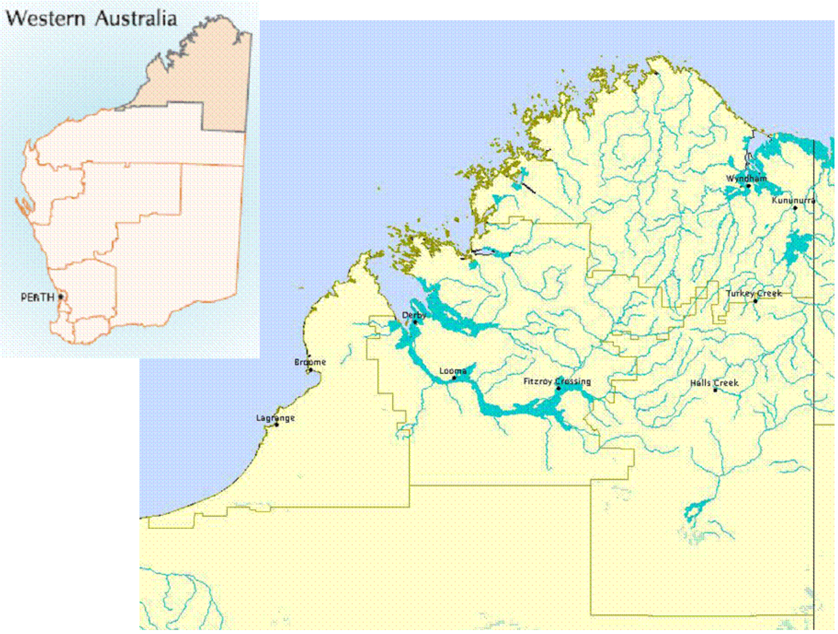

**Figure 1:** The Kimberley region of Western Australia showing major waterways and wetlands (map adapted from ANRA 2009 and DOIR 2005).

The Kimberley region is characterised by a tropical monsoon climate with the majority of its rainfall received during a wet season that typically runs from November to April. Cyclones are common and the region's rivers periodically flood during the wet season. Conservation priorities for the Kimberley's waterways must be managed in conjunction with pressures to utilise this vast water resource. In the past, these competing interests have lead to widespread debate and political controversy (e.g. the Kimberley pipeline proposal was a focal point of the 2005 WA state election campaign).

The WA State Government has recently announced the Kimberley Wilderness Parks plan[2], which aims to add to the conservation estate in the Kimberley and deliver a 'landscape approach' to conservation across the region, including the waterways and wetlands. A valuation of public preferences would be timely to offer insights into the conservation plans, and provide an understanding of community values in the event of future debate over the water resources.

Further, the Kimberley waterways and wetlands offer an ideal setting for a comparison of public and expert preferences. The remote location and notions of wilderness associated with the Kimberley mean that it is likely to be of value not only to locals and visitors, but also to non-users who may consider it important in terms of its pure existence values. Thus, it would be appropriate to draw a public sample from the broader West Australian community. A consortium of tropical river scientists also exists, in the

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[2] http://www.dec.wa.gov.au/content/view/6171/2183/

form of the Tropical Rivers and Coastal Knowledge (TRaCK) research hub[3], therefore providing an established expert sample.

## 3. Survey Methodology

This section begins with an overview of the process of attribute selection. The approach used to define attributes is introduced, as are the split-samples used in the survey design (Section 3.1). Next, the different information versions applied to the public samples are described (Section 3.2). The survey design is then discussed in detail in terms of choice scenario and experimental design (Section 3.3). Finally, the survey administration procedure is described in Section 3.4.

### 3.1 Attribute selection

The waterways and wetlands were defined in the survey as including a broad set of water bodies (i.e. rivers, streams, water supply dams, floodplains, lakes, swamps, billabongs, waterfalls, gorges, etc.) as well as the vegetation and animals living in, or alongside, these water bodies. Estuaries and the marine/coastal environment were not included.

Attributes were selected to represent the different knowledge bases associated with the Kimberley's waterways and wetlands (Table 2). In this context, a knowledge base is the particular 'lens' through which a shared understanding of a topic is gained and, if appropriate, used for a specific purpose. The knowledge base approach to attribute selection is explained in more detail in EERH Research Report No.79 (Cleland and Rogers 2010), but essentially it involves a review of prevailing knowledge bases in conservation and policy settings associated with the good in question (e.g. expert, activist, user, indigenous knowledge bases etc.).

The knowledge bases associated with the Kimberley's waterways and wetlands included: wild rivers; iconic places; representative ecosystems; threatened species; iconic species; functional ecological species and communities; and indigenous natural and cultural areas. Expert knowledge bases are represented by attributes such as 'rare and/or threatened ecological communities and species'. The knowledge bases of non-experts are represented by attributes such as 'iconic species' and 'iconic places'. These knowledge bases form the attributes for the survey (see Table 2).

Note that the indigenous knowledge base is not represented as an independent attribute within the survey. Although it is recognised as an important potential attribute (see Cleland and Rogers 2010), for the purposes of the survey it was difficult to explicitly define as an independent attribute. The indigenous knowledge base is potentially captured within other attributes, for example, iconic attributes are relevant to indigenous knowledge bases through both present and historical associations with traditional owners.

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[3] http://www.track.gov.au/

In the case of iconic and threatened species, three different attribute framings were selected for each. This approach was adopted for these two attributes to explore the hypothesis that the public may place different weights on the conservation of species that represent different biological classes (i.e. mammals, birds, reptiles, fish, etc.). The bird, fish and plant classes were selected for the survey given that it was possible to identify species from each of these classes that were specifically associated with water bodies in the Kimberley, and information about current conservation status was readily available.

It was not thought possible to include each of the bird/plant/fish species permutations for the iconic and threatened species attributes in the one public survey[4]. Thus, a split design was employed where respondents were presented with fixed attributes representing the wild rivers, iconic places and representative ecosystems, and two attributes that were either bird, fish *or* plant based to reflect the threatened species and iconic species. Figure 2a presents the various splits in the survey design, including those for information level which is discussed in further detail in Section 3.2 below.

Given that the scientist sample size was expected to be small, only one species was considered for the comparison of public and expert preferences. The fish species was selected as the most relevant because (1) the migratory ability of fish in the Kimberley is a politically relevant issue[5], and (2) fish migration is a scientifically complex matter. Hence, all further discussion is focussed on the versions of the survey that included the *fish attributes only* (identified in Figure 2b)[6].

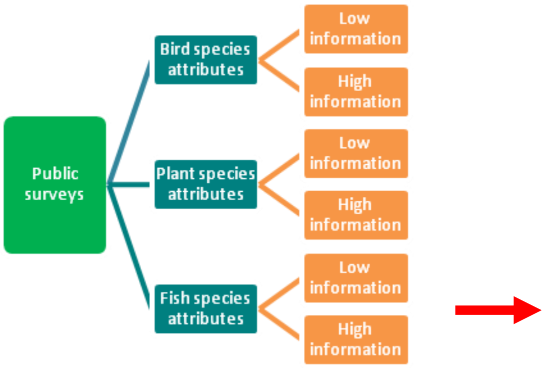

**Figure 2a:** Public survey splits for the Kimberley case study according to species class and information level.

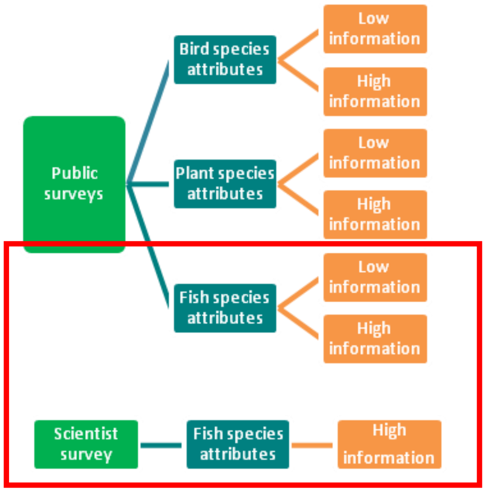

**Figure 2b:** Box identifying the public and scientists fish species samples considered in the present paper.

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[4] Error variance can increase along with number of attributes, expectedly due to enhanced cognitive burden on respondents (e.g. see Caussade *et al*. 2005, DeShazo and Firmo 2002).

[5] There have been appraisals for installing fishways on the Ord and Fitzroy Rivers to aid the migration of certain fish species, and there has been rallying to implement the proposals (e.g. see FRDC 2008, http://www.environskimberley.org.au/wp-content/uploads/2011/01/2009_06-Bull-50.pdf).

[6] Results relating to all three species splits for the public samples can be found in EERH Research Report No.60 (McCartney *et al*. 2010).

The attributes that are the focus of this study are defined in Table 2. The Freshwater Sawfish and Barramundi were selected for the threatened and iconic species attributes, based on migratory similarities of the two species. Each benefits from the freedom to migrate up and downstream for different stages of its life cycle (e.g. Thorburn *et al*. 2004a). During the dry season, barriers such as dams and barrages can block their migratory abilities. For the endangered sawfish, this threatens population sustainability, while the widespread Barramundi appears capable of surviving this threat at a population level. The Fitzroy River is a particularly important nursery habitat for sawfish (Thorburn *et al*. 2004b). Barramundi are common across much of the Kimberley, but no longer occur upstream of the Ord River diversion dam (FRDC 2008).

The representative ecosystems attribute was based on the current national government policy to increase the reserve area to at least 10% in all bioregions across Australia (Table 2). Bioregions are geographically distinct areas formed by the Interim Biogeographic Regionalisation for Australia (IBRA) scheme. The IBRA scheme divides Australia into bioregions according to various characteristics such as climate, geology, landforms, vegetation and animals), effectively making each bioregion a representative ecosystem (DEWHA 2009). Currently, only two of the five bioregions in the Kimberley have at least 10% of their area under reserve.

Wild rivers in WA are defined as “those rivers which are undisturbed by the impacts of a modern technological society. They remain undammed, and exist in catchments where biological and hydrological processes continue without significant disturbance. They occur in a variety of landscapes, and may be permanent, seasonal or dry watercourses that flow or only flow occasionally” (Department of Water 2009, p.1). In the Kimberley, there are 17 pristine (Priority 1) wild rivers. A further 18 are in a near-pristine (Priority2) condition and, with adequate rehabilitation, could be returned to a pristine status (Water and Rivers Commission 1997). As such, the wild rivers attribute was focussed on returning the Priority 2 rivers to a Priority 1 status (Table 2).

Iconic places associated with the Kimberley’s waterways and wetlands are generally associated with notions of remoteness and naturalness, with waterfalls and gorges typically being attractions. However, their popularity tends to result in considerably disturbed environments. Human activity can result in trampling and disturbance of native vegetation, which is successively replaced by weeds. Hence, the iconic place attribute was defined according to the extent of rehabilitation of native vegetation at iconic locations (Table 2).

The payment vehicle, or cost attribute, was defined as: “a hypothetical cost collected through increased taxes, user fees associated with recreation sites in the Kimberley, higher prices associated with goods and services of the Kimberley, or some combination of these”. The attribute took on levels of $0, $50, $100, and $150, and were specified as a per year amount to be collected over a five year period. The $0 level only applied to the status quo option, as all other options involved some level of conservation improvement which realistically would come at some cost.

**Table 2:** Attributes selected using a knowledge base approach.

| **Knowledge Base Attribute** | **Attribute frame** | **Attribute Reference**[a] | **Attribute Levels**[b] |
|---|---|---|---|
| Rare and/or threatened ecological communities and species | Upstream migration of Freshwater Sawfish in the Fitzroy River during dry season | Sawfish | Restricted, Unrestricted |
| Iconic species | Upstream migration of Barramundi in the Ord River during dry season | Barra | Restricted, Unrestricted |
| Representative ecosystems and assemblages of ecological communities | Number of bioregions with at least 10% protected by reserves | Reco | 2, 3, 4 |
| Wild rivers | Number of Priority 1 wild rivers | Wild | 17, 26, 35 |
| Iconic places | Percentage area of native vegetation in good condition at iconic sites | Icon | 80%, 89%, 98% |

[a] The attribute references are used in the regression tables in Section 4. Attributes are dummy coded, with the first level representing the baseline. Sawfish and Barra are referenced as 0,1 (i.e. Sawfish1 = unrestricted), while the others are referenced according to level (i.e. Reco3 = 3 bioregions protected).

[b] The first level in each instance represents the status quo.

### 3.2 Information versions

Low and high information versions were included to determine if enhanced public knowledge impacts on preferences. The differences in information were nested within the text describing the Kimberley waterways and wetlands and the associated attribute definitions. The low information version provided the essential information required to prime respondents for the choice exercise. For example, information included:

- A description of the attribute and threat abatement mechanism used to achieve the conservation outcome (required to deem the improvements in attribute levels plausible in the choice scenarios)
- Photographs of the attribute
- A description of the current state of the attribute (i.e. the status quo)

The high information version provided more detail on all aspects of this information, but particularly focussed on providing a more encompassing description of the environmental system and greater scientific detail. Specifically, the high information version included information on (1) a discussion of the threats and pressures faced by both the attributes and the broader ecological system, and (2) the ecology and management actions appropriate for conservation of the attributes. The primary areas of difference in information are outlined in Table 3.

**Table 3:** Differences in information versions used in the public sample survey splits.

| Area of divergence | Low information | High information |
|---|---|---|
| Attribute definition | Basic (one sentence) | Detailed (descriptive paragraph) |
| Informational diagrams (e.g. maps) included (where relevant) | No | Yes |
| Discussion of threats and pressures | No | Yes |

By providing a holistic view of the system and identifying the relative risks associated with particular attributes it was hypothesised that respondents would apportion more weight to attributes that were suffering from greater threats and pressures. For example, Barramundi are widespread so there is little pressure on populations, while the Freshwater Sawfish faces many threats to population sustainability. Thus, when faced with additional information to depict each fish species' conservation status, individuals may prefer to conserve the endangered sawfish rather than the common Barramundi.

## 3.3 Survey design

The survey was divided into three sections[7]:

1) Background information and experience questions: this section contained a description of the Kimberley waterways and wetlands, and the attributes, and included questions relating to an individual's experience with the Kimberley and various features of the waterways and wetlands.
2) Choice scenarios: a series of choice questions were presented to respondents, followed by debriefing questions relating to certainty of choices and believability of the survey.
3) Socio-demographic questions.

*Choice Scenarios*

The choice scenarios were designed with three alternatives – two conservation options plus a status quo (Figure 3). The literature suggests that three or four alternatives are optimal for reducing error variance (e.g. see Caussade *et al*. 2005, DeShazo and Firmo 2002). Given that this survey involved a complex issue, the lower end of this range was considered appropriate.

Members of the public each received nine choice scenarios. Nine scenarios were considered appropriate based on comments from an undergraduate student focus group (11 participants) and a public survey pretest (20 individuals). The scientists received 15 choice scenarios as it was necessary to generate extra observations per individual because of the limited sample size. It was assumed that 15 scenarios would be acceptable for scientists based on their assumed cognitive abilities.

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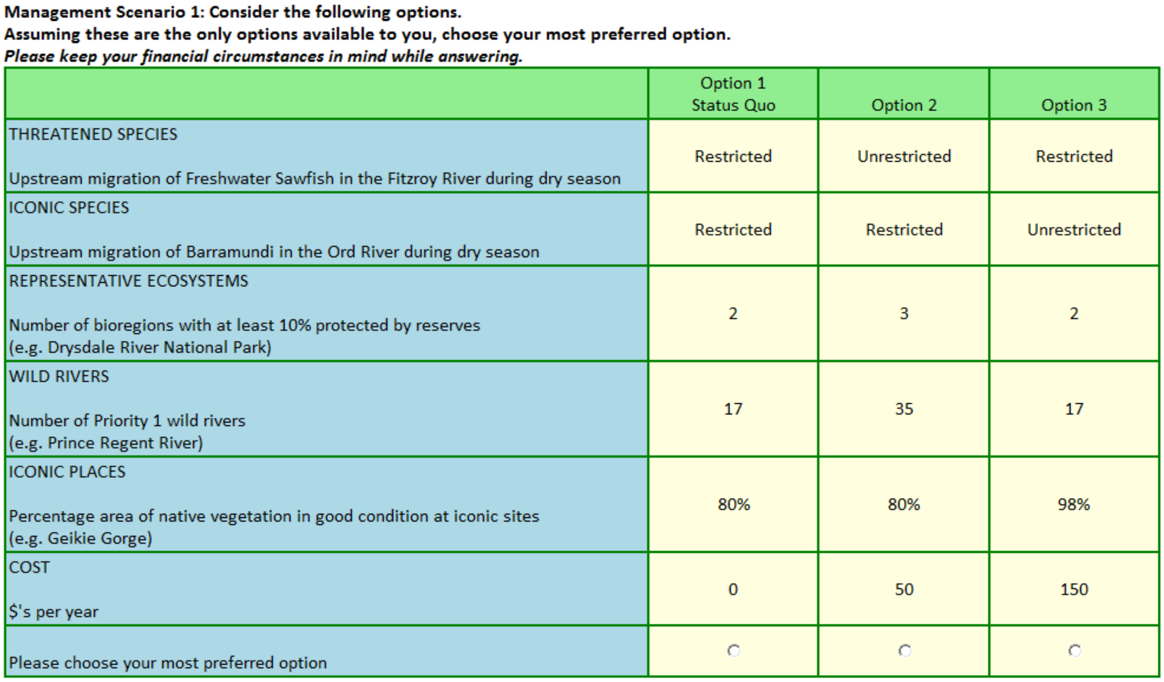
[7] An example of the questionnaire (the bird species - high information version from Figure 2a) can be viewed in McCartney *et al*. 2010).



**Management Scenario 1: Consider the following options.**
**Assuming these are the only options available to you, choose your most preferred option.**
***Please keep your financial circumstances in mind while answering.***

| | Option 1<br>Status Quo | Option 2 | Option 3 |
|---|---|---|---|
| THREATENED SPECIES<br>Upstream migration of Freshwater Sawfish in the Fitzroy River during dry season | Restricted | Unrestricted | Restricted |
| ICONIC SPECIES<br>Upstream migration of Barramundi in the Ord River during dry season | Restricted | Restricted | Unrestricted |
| REPRESENTATIVE ECOSYSTEMS<br>Number of bioregions with at least 10% protected by reserves<br>(e.g. Drysdale River National Park) | 2 | 3 | 2 |
| WILD RIVERS<br>Number of Priority 1 wild rivers<br>(e.g. Prince Regent River) | 17 | 35 | 17 |
| ICONIC PLACES<br>Percentage area of native vegetation in good condition at iconic sites<br>(e.g. Geikie Gorge) | 80% | 80% | 98% |
| COST<br>$'s per year | 0 | 50 | 150 |
| Please choose your most preferred option | ○ | ○ | ○ |

**Figure 3:** Example of the choice scenario presented to respondents.

*Experimental Design*

Two-way interactions were included when specifying the experimental design. *A priori* it was hypothesised that respondents would consider certain attributes to share a relationship, in the sense that the protection of one may in turn protect the other. This 'overlap' in protection, and values associated for that overlap, can be captured through interactions between attributes in the choice model. Specifically, it was anticipated that two-way interaction effects may be present between the threatened and iconic species attributes as the sawfish and Barramundi protection mechanisms were the same. The mechanisms were specified for different river systems in this case (i.e. Fitzroy River for sawfish; Ord River for Barramundi), but both fish species occur in each of those rivers to some extent, so both may benefit from the protection of one of the species.

A D-efficient design was generated for the public samples using the Ngene 1.0.1 software (Rose *et al*. 2008). Coefficients estimated from the public survey pre-test were used to inform the design, which resulted in 18 choice scenarios, blocked by a factor of two. The design was 70% efficient.

For the scientist sample, rather than optimising for D-efficiency, the design was optimised for S-efficiency. S-efficient designs are aimed at minimising the required sample size necessary to retrieve significant parameter estimates (Scarpa and Rose 2008). The unblocked, 15 choice scenario design was generated using prior coefficient estimates adapted from the public survey. The design had an S-estimate of 29 full replicates required, and a D-efficiency measure of 44%.

Based on the expectedly small sample size, a secondary design was generated, independently of the primary design, in the event that scientists were willing to complete an additional 15 choice scenarios. The secondary design had an S-estimate of 33, and a D-efficiency of 51%.

### 3.4 Survey administration

Using the Sensus 4.2 program (Sawtooth Technologies 2006), the surveys were designed for web-based administration. The WA general public sample surveys were administered during November 2009 by a market research company, The Online Research Unit (ORU). The ORU drew a representative sample[8] of the population based on gender and age demographics, randomly inviting members of their online panel (by email) to participate in the survey about 'a local issue' (the Kimberley topic was not specified to minimise self-selection bias). The 432 individuals (215 high information sample, 217 low information) who completed the survey received a $5 gift voucher and 20 entries into a prize draw as compensation for completing the lengthy questionnaire.

The scientist sample was collected during May-July 2010 via two methods: (1) at a meeting of tropical scientists in the TRaCK research hub, participants were provided with a web-link to the survey and invited to complete it on their portable computers; (2) other tropical scientists that were not present at the TRaCK meeting were identified through internet searches of relevant institutions and invited via email to participate. The same amount of introductory information was provided in each of the collection methods – this included some additional information that did not appear in the public survey, in terms of explaining that the research project aimed to compare public and expert preferences, and that the scientists should provide their own personal points of view (as opposed to the opinions of their organisational affiliations). In total 80 scientists were invited to participate, of which 43 responded and 33 completed the survey in full. Of the 33 that completed the survey, three also completed the secondary set of choice scenarios, providing 36 full replicates.

## 4. Results

This section presents the general sample statistics (Section 4.1). It is followed by a description of the modelling approach applied to the data (Section 4.2). The choice modelling results are then reported in Section 4.3. Here, statistics relating to model formation, as well as regression output and partworths, are presented. Discussion of the results is focused on how the public and scientist samples reacted to each attribute, along with scale insensitivity and heterogeneity of the ASC. Data were analysed using STATA (Statacorp 2009).

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[8] Concerns have been raised that web-based surveys are not entirely representative as they exclude members of the society without internet access. However, comparisons of mail and web-based surveys have found no significant differences (e.g. see Windle and Rolfe 2009, Olsen 2009), and internet access has steadily been on the increase in Australia with 72% of households having home internet access during 2008-09 (Australian Bureau of Statistics 2009).

## 4.1 General statistics

Some observational statistics are presented in this section, including choice frequency of alternatives in the choice scenarios and how respondents' reacted to the survey generally. The usable sample size was 211 for the public low information sample, 211 for public high information, and 33 for the scientists. Subjects that only partially completed the survey were removed from the sample, to ensure consistency across model estimations in terms of number of observations, as were a small number of subjects that had data recorded incorrectly (due to malfunctions within the Sensus software program).

Within the public survey there was a split relating to the type of information describing the attributes, that is, whether it was low/high information. The scientists received the most comprehensive version in the form of the high information. Respondents in each survey split were asked what they thought of the information provided.

Table 5 reports the responses to this question, and shows that overall there was very little difference in reaction to the survey information across the splits. A large majority in each survey split thought that the information provided was informative and accurate. Negative sentiments were likely to be more influenced by respondents wanting *more* information, than doubting the *accuracy* of the information (i.e. only 2-3% of the sample thought the descriptions were inaccurate). This is also supported by the observation that the high information samples were *less* inclined to want more information. It is reassuring to see that none of the scientists were confused by the information. Whilst some public individuals found the information confusing, a smaller percentage of the high information sample found it confusing suggesting that they were not overwhelmed by the additional content and complexity of the descriptions.

**Table 5:** Respondents thoughts regarding the information that was provided to describe the waterways and wetlands of the Kimberley.

| **Adequacy of information provided:** | **Public Low info** | **Public High info** | **Scientist High info** |
|---|---|---|---|
| Thought it was an informative and accurate description | 72% | 76% | 81% |
| Would have liked more information | 18% | 15% | 17% |
| Thought the descriptions were inaccurate | 2% | 2% | 3% |
| Thought it was confusing | 9% | 7% | 0% |

Respondents were asked whether or not they thought that public preferences were relevant in terms of conserving the Kimberley waterways and wetlands. The majority of respondents, both public and scientist, thought that the preferences of the community were indeed relevant (Table 6).

**Table 6:** Suitability of public respondents providing individual preferences for managing the waterways and wetlands of the Kimberley, rather than leaving these sorts of decisions to be made solely by experts and scientists.

| **Provision of individual preferences** | **Public Low info** | **Public High info** | **Scientist** |
|---|---|---|---|
| Thought public preferences were relevant | 74% | 65% | 86% |
| Thought these decisions should be dealt with by experts | 26% | 35% | 14% |

The choice frequencies across alternatives in the choice scenarios indicate that respondents preferred to choose programs with conservation benefits more often than the status quo (Table 7). The public sample selected the second alternative more frequently than the third, while the scientists had relatively even selection frequencies for the conservation alternatives. The disparity in the distribution of choice frequencies between the public and scientist samples, combined with the relatively uneven choice frequencies of alternatives 2 and 3 within the public sample, suggest that it is worth investigating the inclusion of a second ASC in the choice model, to identify if the public is reacting to the order of alternatives.

**Table 7:** Choice frequency of each alternative by case study and target population.

| **Alternative** | **Public Low info** | **Public High info** | **Scientist** |
|---|---|---|---|
| **1 (status quo)** | 20% | 29% | 11% |
| **2** | 44% | 41% | 45% |
| **3** | 36% | 30% | 44% |

## 4.2 Modelling approach

A multi-step procedure was followed to determine the most appropriate model form to generate the final models:

1) Likelihood ratio tests were performed to determine if one ASC (on the status quo option) or two ASC's (on the conservation program alternatives) were preferred. For the public models, two ASC's were preferred (See Appendix 1 for further discussion).
2) The two-way interaction terms specified in the experimental design were investigated with likelihood ratio testing to determine whether they were a significant inclusion in the model. In all cases, they were not (See Appendix 2).
3) MNL and ML models were compared to determine the preferred modelling approach. In the ML models the ASC's are specified as random parameters. In all cases, ML models were preferred (See Appendix 3).

4) Tests of preference homogeneity across public and scientist samples were performed. Likelihood ratio tests were used to determine if the samples could be combined. The results of these tests are presented in Section 4.3 below.
5) Socio-demographic variables were introduced in to the models to help explain preference heterogeneity. Appropriate inclusions were determined according to the following process:
    a. A list of potential interactions between socio-demographic and explanatory attribute variables was devised from all of the questions included in the survey.
    b. Each potential interaction was tested for significance in a basic MNL model that included the explanatory attribute variables and the socio-demographic variable of interest (there were a large number of potential interactions, thus the MNL was selected for expedient estimation).
    c. Once a short-list of the significant socio-demographic variables was defined, they were all included in one MNL model with the explanatory attribute variables. In this larger model, some socio-demographic variables became insignificant and were dropped from the model.
    d. The remaining significant socio-demographic variables from the MNL were then included in a ML model, and again any that became insignificant were dropped to define a parsimonious final model.
    e. Ultimately, the final model was compared against its basic counterpart (i.e. an equivalent model that only includes the ASC(s), attribute and cost parameters, and no socio-demographic interactions) to confirm that it was the preferred model.

The final resulting model from (d) and the tests against the basic counterparts from (e) are reported in Section 4.3 below.

A general utility function can be specified that applies to each of the models that follow. Utility (*U*) held by individual *n* over alternative *j* can be defined as (suppressing *j* subscript):

$$U_n = \beta_o' ASC + \sum_{k=1}^{K} (\beta_k + \delta_k z_{nk}) x_k + \varepsilon_n \qquad \text{Equation 9}$$

where:

$\beta_o'$ = ASC coefficient
$k$ = the attributes from the set $K$ {threatened species, iconic species, representative ecosystems, wild rivers, iconic places, cost}
$x_k$ = vector of attributes
$\beta_k$ = the vector of marginal utilities of the attributes, *x*
$\delta_k z_{nk}$ = impact ($\delta$ ) of socio-demographic variables ($z_{nk}$ ) on the marginal utility of the attributes, *x*
$\varepsilon_n$ = unobservable utility

The ASC can be further defined to include the impact of individual characteristics ($\delta' z_n$) and to be normally distributed ($\eta$ ):

$$\beta'_{on} = \beta_o + \delta' z_n + \eta \quad \text{Equation 10}$$

Note that in the public model results presented below, two ASC's are specified rather than one. Both ASC's can be represented by the specification in Equation 10.

## 4.3 Choice modelling results

*Preference homogeneity across Samples*

As noted above (Section 4.2, Step 4), one of the considerations in the analysis was to investigate whether or not various survey splits could be combined, implying that there are homogeneous preferences across the samples. A focus was maintained on whether or not information or understanding had an impact on preferences. That is, tests of preference homogeneity were performed on combinations of the public low and high information samples, and combinations involving the scientist sample. All permutations were considered: low+high+scientist; low+high; low+scientist; high+scientist.

Likelihood ratio tests were performed to determine whether the combined (constrained) samples were significantly different to the separate (unconstrained) samples, using the preferred ML model specification. Sample combinations were rejected for all permutations of the low/high/scientist samples (Table 8).

**Table 8:** Likelihood ratio tests for combining permutations of the public low information, high information and scientist samples.

| **Sample (all based on ASC2/3 models)**[a] | **Unconstrained log likelihood** | **Constrained log likelihood** | **Likelihood ratio** | **Degrees of freedom; critical $\chi^2$ value** | **Acceptance of restriction** |
|---|---|---|---|---|---|
| Low/high | -3117.69 | -3136.51 | 37.64 | 13; 22.362 | Reject |
| High/scientist | -2027.35 | -2073.74 | 92.78 | 13; 22.362 | Reject |
| Low/scientist | -2014.50 | -2065.17 | 101.34 | 13; 22.362 | Reject |
| Low/high/scientist | -3579.77 | -3654.73 | 149.90 | 26; 38.885 | Reject |

[a] See Appendix 1: although the preferred scientist model contains only one ASC (ASC1), given that the public models require two (ASC2, ASC3), the scientist model was also specified in this more flexible form for the purpose of considering sample combinations.

Although the combined models are all initially rejected, scale factors must be considered. That is, differences between the samples may be due to differences in variance across the samples. As such, it is important for one to test whether or not samples can then be combined by allowing the scale parameter to vary between samples. Although the scale parameter cannot be uniquely identified for a particular sample, it is possible to identify the relative difference in scale parameters between samples by setting the λ equal to one for the first sample and allowing λ to vary for the second sample.

For ML models, the relative value of λ for the second sample can be determined in STATA through the grid search method (it is directly estimable in STATA for a MNL model; however, the program is not capable of estimating models that include heterogeneity in random parameters and scale). The grid search approach fixes the scale for one sample, and iteratively varies the scale of the second sample over a range of values to search for the best fit, that is, the scale value with the maximum log likelihood.

Using the grid search method to determine the relative values of λ, the likelihood ratio tests for combining the various samples were then repeated, with variance now accounted for. As shown in Table 9, neither the low/high, high/expert or low/expert samples can be combined. Given that no two samples could be combined, testing to see if all three could be combined was not warranted. These results imply that heterogeneous preferences are present across the samples – scientists have distinctly different preferences to the public, and the information versions have had an effect on public preference formation.

**Table 9:** Grid search results – likelihood ratio tests for combining low/high/scientist samples while accounting for sample variance.

| **Sample (all based on ASC2/3 models)**[a] | **Relative values of λ** | **Unconstrained log likelihood** | **Constrained log likelihood** | **Likelihood ratio** | **Acceptance of restriction**[b] |
|---|---|---|---|---|---|
| Low/high | Low = 1<br>High = 1.02 | -3117.69 | -3136.46 | 37.53 | Reject |
| High/expert | Expert = 1<br>High = 1.19 | -2027.35 | -2072.50 | 90.30 | Reject |
| Low/expert | Low = 1<br>Expert = 0.79 | -2014.50 | -2063.01 | 97.01 | Reject |

[a] See Appendix 1: although the preferred scientist model contains only one ASC (ASC1), given that the public models require two (ASC2, ASC3), the scientist model was also specified in this more flexible form for the purpose of considering sample combinations.

[b] For 12 degrees of freedom; χ2 critical value (p=0.05) 12.03.

The outcomes of the preference homogeneity tests provide the foundation for three final models:

1) Public low information model: two ASC's included – one for each conservation alternative.
2) Public high information model: two ASC's included – one for each conservation alternative.
3) Scientist model: one ASC included for the status quo option.

*Final model results*

This section reports the choice modelling results for the public low information, public high information and scientist models as specified above, with the inclusion of socio-demographic interactions. The attribute parameters are dummy coded and referenced according to the labels in Table 2 (e.g. for wild rivers, the baseline level is 17, and the parameters associated with the levels of 26 and 35 are labelled as Wild26 and Wild35, respectively). The covariates that appear in the three models are described in Table 10, with mean values noted for relevant samples.

**Table 10:** Explanatory socio-demographic variable descriptions for covariates that appear across the low information, high information and scientist models. Mean values are noted for instances where the variable appears in the respective model.

| **Explanatory variable** | **Description** | **Mean**<br>**Low** | <br>**High** | <br>**Scientists** |
|---|---|---|---|---|
| *Covariates impacting on the ASC(s)* | | | | |
| Gender | 0 = female, 1 = male | 0.45 | | |
| Tax | Required to pay tax at least once during the last 5 years: 0 = no, 1 = yes | 0.89 | 0.90 | |
| Economic situation | Views about the current national economic situation[a] reduced willingness to pay: 0 = no, 1 = yes | 0.36 | 0.41 | |
| Inf | Inf1 = thought information describing the waterways and wetlands was informative and accurate | 0.72 | 0.76 | |
| | Inf2 = would have liked more information | 0.18 | 0.15 | |
| | Inf3 = though descriptions were inaccurate | 0.02 | 0.02 | |
| | Inf4 = thought information was confusing | 0.09 | 0.07 | |
| University education | 0 = no university degree, 1 = university degree | | 0.36 | |
| Preferences | Thought preferences of the public were relevant to inform management of the waterways and wetlands, rather than decisions being made solely by scientists and experts: 0 = no, 1 = yes | | 0.65 | |
| Confused | Thought the choice scenarios were confusing: 0 = no, 1 = yes | | | 0.42 |
| Ecological processes | Time allocation on breadth of environmental processes:<br>0 = 50% of time or less spent on ecological processes,<br>1 = greater than 50% of time spent on ecological processes | | | 0.44 |
| *Covariates impacting on attribute parameters* | | | | |
| Indigenous culture | Appreciated indigenous culture while visiting waterways or wetlands of the Kimberley: 0 = no, 1 = yes | 0.11 | | |
| Group | Belong to an environmental/conservation group: 0 = no, 1 = yes | | 0.08 | 0.36 |
| River | Rivers were a feature of interest while visiting the waterways or wetlands of the Kimberley: 0 = no, 1 = yes | 0.40 | | |
| Gorge | Gorges were a feature of interest while visiting the waterways or wetlands of the Kimberley: 0 = no, 1 = yes | 0.32 | 0.24 | 0.56 |
| Waterfall | Waterfalls were a feature of interest while visiting the waterways or wetlands of the Kimberley 0 = no, 1 = yes | 0.25 | 0.16 | |
| Dam | Dams were a feature of interest while visiting the waterways or wetlands of the Kimberley: 0 = no, 1 = yes | | | 0.24 |
| Fitzroy | Fitzroy River has been used as a case study in research: | | | 0.22 |

| | | |
|---|---|---|
| | 0 = no, 1 = yes | |

[a] The survey was administered during a period when people may have been feeling the effects of the 2008-09 Global Financial Crisis.

The regression output for each of the models is reported in tables 11, 12 and 13. Each table shows the accepted final model, with socio-demographic inclusions, and the equivalent base model with only the attribute parameters, cost and random ASC(s). Likelihood ratio tests were performed comparing the final and base model in each case, with the final models consistently offering the superior fit (Table 14). As such, the focus of the discussion is on the final model results.

**Table 11:** ML results for the public low information final model, with explanatory socio-demographic interactions, and base model.

| **VARIABLES** | **Final Model Mean (Standard Error)** | | **Base Model Mean (Standard Error)** | |
|---|---|---|---|---|
| ASC2 | 0.525* | (0.304) | 0.412*** | (0.137) |
| *ASC2 Standard Deviation* | *1.068**** | *(0.0929)* | *1.201**** | *(0.101)* |
| ASC3 | 0.0813 | (0.184) | 0.230** | (0.0963) |
| *ASC3 Standard Deviation* | *0.688**** | *(0.0639)* | *0.836**** | *(0.0697)* |
| asc2*gender | -1.179*** | (0.339) | | |
| asc2*tax | 1.024** | (0.490) | | |
| asc2*economic situation | -1.432*** | (0.346) | | |
| asc3*gender | -0.753** | (0.327) | | |
| asc3*tax | 1.617*** | (0.474) | | |
| asc3*economic situation | -1.642*** | (0.339) | | |
| Asc3*inf2 (more info) | 0.194 | (0.377) | | |
| Asc3*inf3 (inaccurate) | -3.380** | (1.413) | | |
| Asc3*inf4 (confusing) | -1.430** | (0.562) | | |
| Sawfish1 | 0.567*** | (0.0924) | 0.555*** | (0.0919) |
| Barra1 | 0.699*** | (0.103) | 0.746*** | (0.0996) |
| Barra1*indigenous culture | 0.600** | (0.254) | | |
| Reco3 | 0.307*** | (0.104) | 0.308*** | (0.104) |
| Reco4 | 0.204** | (0.103) | 0.201** | (0.102) |
| Wild26 | 0.199 | (0.121) | 0.372*** | (0.0967) |
| Wild35 | 0.328** | (0.139) | 0.533*** | (0.120) |
| Wild26*river | 0.818*** | (0.242) | | |
| Wild35*river | 0.367 | (0.257) | | |
| Wild26*gorge | -0.517** | (0.258) | | |
| Wild35*gorge | 0.203 | (0.271) | | |
| Icon89 | 0.232** | (0.109) | 0.324*** | (0.0967) |
| Icon98 | 0.542*** | (0.110) | 0.683*** | (0.0970) |
| Icon89*waterfall | 0.372* | (0.208) | | |
| Icon98*waterfall | 0.583*** | (0.208) | | |
| Cost | -0.0122*** | (0.00120) | -0.0122*** | (0.00119) |

Notes: ***p<0.01, **p<0.05, *, p<0.1; Standard errors in parentheses.
Number of observations = 1899; n=211.

**Table 12:** ML results for the public high information final model, with explanatory socio-demographic interactions, and base model.

| **VARIABLES** | **Final Model**<br>**Mean (Standard Error)** | | **Base Model**<br>**Mean (Standard Error)** | |
|---|---|---|---|---|
| ASC2 | 0.176 | (0.196) | 0.211 | (0.139) |
| *ASC2 Standard Deviation* | *1.106**** | *(0.0940)* | *1.329**** | *(0.108)* |
| ASC3 | -0.603*** | (0.180) | 0.0265 | (0.0975) |
| *ASC3 Standard Deviation* | *0.801**** | *(0.0696)* | *0.878**** | *(0.0745)* |
| asc2*university education | 0.780** | (0.341) | | |
| asc2*economic situation | -1.210*** | (0.336) | | |
| asc2*preferences | 0.790** | (0.328) | | |
| Asc2*inf2 (more info) | -0.381 | (0.404) | | |
| Asc2*inf3(inaccurate) | 0.738 | (1.019) | | |
| Asc2*inf4(confusing) | -1.771*** | (0.667) | | |
| asc3*university education | 1.143*** | (0.349) | | |
| asc3*economic situation | -1.434*** | (0.340) | | |
| asc3*preferences | 1.424*** | (0.377) | | |
| asc3*tax | 1.008** | (0.468) | | |
| Sawfish1 | 0.581*** | (0.0979) | 0.578*** | (0.0978) |
| Barra1 | 0.344*** | (0.106) | 0.401*** | (0.103) |
| Barra1*group | 0.817** | (0.343) | | |
| Reco3 | 0.272** | (0.109) | 0.274** | (0.109) |
| Reco4 | 0.239** | (0.110) | 0.245** | (0.110) |
| Wild26 | 0.268** | (0.114) | 0.355*** | (0.103) |
| Wild35 | 0.546*** | (0.132) | 0.746*** | (0.124) |
| Wild26*waterfall | 0.252 | (0.257) | | |
| Wild35*waterfall | 0.791*** | (0.263) | | |
| Wild26*group | 0.623* | (0.347) | | |
| Wild35*group | 0.997** | (0.421) | | |
| Icon89 | 0.495*** | (0.116) | 0.606*** | (0.103) |
| Icon98 | 0.549*** | (0.116) | 0.694*** | (0.103) |
| Icon89*gorge | 0.406* | (0.219) | | |
| Icon98*gorge | 0.532** | (0.218) | | |
| Cost | -0.0136*** | (0.00126) | -0.0136*** | (0.00126) |

Notes: ***p<0.01, **p<0.05, *, p<0.1; Standard errors in parentheses.
Number of observations = 1899; n=211.

**Table 13:** ML results for the scientist final model, with explanatory socio-demographic interactions, and base model.

| **VARIABLES** | **Final Model<br>Mean (Standard Error)** | | **Base Model<br>Mean (Standard Error)** | |
|---|---|---|---|---|
| ASC1 | -0.644 | (0.800) | -3.492*** | (0.842) |
| *ASC1 Standard Deviation* | *2.066**** | *(0.461)* | *2.491**** | *(0.427)* |
| asc1*confused | -2.503** | (1.054) | | |
| asc1*ecological processes | -3.784*** | (1.211) | | |
| Sawfish1 | 1.161*** | (0.224) | 0.640*** | (0.163) |
| Sawfish1*dam | -1.011*** | (0.301) | | |
| Barra1 | -0.0348 | (0.158) | -0.0190 | (0.152) |
| Reco3 | 0.377 | (0.233) | 0.689*** | (0.198) |
| Reco4 | 0.493*** | (0.179) | 0.840*** | (0.147) |
| Reco3*group | 1.024*** | (0.374) | | |
| Reco4*group | 1.101*** | (0.288) | | |
| Wild26 | 0.920*** | (0.312) | 0.680*** | (0.218) |
| Wild35 | 1.559*** | (0.252) | 0.887*** | (0.153) |
| Wild26*gorge | -0.360 | (0.364) | | |
| Wild35*gorge | -1.032*** | (0.300) | | |
| Icon89 | 0.427* | (0.218) | 0.274 | (0.192) |
| Icon98 | 0.172 | (0.171) | 0.0709 | (0.146) |
| Icon89*Fitzroy | -0.634* | (0.376) | | |
| Icon98*Fitzroy | -0.302 | (0.336) | | |
| Cost | -0.00926*** | (0.00267) | -0.00901*** | (0.00260) |

Notes: ***p<0.01, **p<0.05, *, p<0.1; Standard errors in parentheses.

Number of observations = 540; n=33; number of full replicates = 36 (33 scientists completed the survey; three of those completed the secondary set of 15 choice scenarios, so there were 36 full replicates of the survey).

**Table 14:** Likelihood ratio tests for the final model, including socio-demographic interactions, and the equivalent base model, for each sample.

| **Sample** | **Unconstrained Log Likelihood (final model)** | **Constrained Log Likelihood (base model)** | **Likelihood Ratio** | **Acceptance of restriction** |
|---|---|---|---|---|
| Public Low Info | -1498.26 | -1552.42 | 108.32 | Reject[a] |
| Public High Info | -1518.87 | -1565.27 | 92.81 | Reject[b] |
| Scientists | -392.69 | -416.99 | 48.60 | Reject[c] |

[a] For 16 degrees of freedom, $\chi^2$ critical value (p=0.05) 26.30.

[b] For 17 degrees of freedom, $\chi^2$ critical value (p=0.05) 27.59.

[c] For 9 degrees of freedom, $\chi^2$ critical value (p=0.05) 16.92.

The first point to note across these models is that respondents typically held positive preferences towards the conservation of the various attributes. Some exceptions to this general observation are discussed below. As the purpose of this paper is a comparison of public and scientist preferences, the remainder of the results discussion focuses on how the various samples reacted to each attribute (i.e.

across models), rather than discussing each model in turn. To aid this process, the partworths are also presented by attribute for each sample (Tables 15-19).

- Threatened species

Individuals from all samples held significant positive preferences for the protection of the Freshwater Sawfish (Tables 11-13). A comparison of sample values for the sawfish is drawn from the partworths in Table 15. Partworths are not affected by sample variance and are thus directly comparable. The public low and high information samples were willing to pay positive amounts for sawfish protection, but considerably less than the scientists who were willing to pay $125 per annum. This is almost three times as much as the public. This is an intuitive result, as we would expect the scientists to have a better understanding of the importance of conserving threatened species, such as the sawfish, and thus be willing to pay more to protect them.

Scientists that considered dams as a site of interest during a visit to the Kimberley's waterways and wetlands present a unique case. They still have a positive inclination to protect sawfish, but less so than other scientists (*ceteris paribus*) (Table 13). They also have a willingness to pay (WTP) for sawfish conservation that is not significantly different to zero, while other scientists have a positive WTP (Table 15). It is difficult to interpret this result, as one would think that having seen the dam structures the scientists would have a better understanding of the need to aid migration for sawfish conservation. This result may be capturing uncertainty or disagreement with regards to the protection mechanism, that being fishways. For example, some scientists may believe installing fishways could damage the integrity of dam structures and thus, change the dynamics of upstream ecology. A number of dam structures in the Kimberley provide vital refuge habitat for wildlife despite their man-made fabrication. For example, Lakes Argyle and Kununurra on the Ord River are listed as RAMSAR wetlands.

**Table 15:** Threatened species attribute partworths for the public low information, public high information and scientist final models.

| ***Threatened species*** | **Public low info $** | **Public high info $** | **Scientist $** |
|---|---|---|---|
| Unrestricted sawfish migration | 47*** | 43*** | 125*** |
| Unrestricted sawfish migration + visited dam | | | 16 |

Notes: ***p<0.01, **p<0.05, *, p<0.1.

- Iconic species

The regression output provides an interesting comparison of the public and scientists for iconic species – both public samples hold significant and positive preferences for Barramundi conservation, while the scientists do not (Tables 11-13). This divergence is illustrated again in terms of partworths (Table 16). The insignificant coefficient and WTP for the scientists is unsurprising in this instance; Barramundi are common and widespread, and scientists will be aware that they don't require the same level of conservation investment as threatened species or ecosystems do.

There is another point of interest with respect to the Barramundi values in terms of information effects. Observing the partworths in Table 16, public individuals that received the higher amount of information are typically willing to pay less than those from the low information sample. Low information respondents that appreciated indigenous culture during a visit to the Kimberley are willing to pay as much as four times the amount of respondents in the high information sample. Also, the low information sample individuals that did not appreciate indigenous culture during a visit are willing to pay twice as much as high information individuals that don't belong to an environmental group. This indicates that the information level has had an impact on preferences. The better-informed high information respondents have a greater understanding of the Barramundi attribute and its present conservation status, which may therefore have reduced their WTP in comparison to the low information respondents.

We don't see this information effect on the other attributes in the study; however, it is likely that the impact of information was greatest on the Barramundi attribute. The fish attributes were particularly complex to describe, in terms of explaining the relevance of migration to their life cycle (and hence population sustainability), the barriers to migration during the dry season, and the use of fishways to aid migration. As such, we suspect that the 'difference' between the low and high information versions was greater for Barramundi and sawfish than for other attributes, and more likely to influence the understanding and preferences of individuals. Given that sawfish are threatened, this status may have been the focus and the information may not have changed people's preferences. On the other hand, for Barramundi the additional information allowed individuals to make more educated decisions that reflect the scientists' preferences more closely. That is, there appears to be a declining trend in WTP as information/knowledge increases.

There are two significant covariates for the Barramundi attribute: (1) appreciating indigenous culture during visits to the waterways and wetlands, for the low information sample (Table 11); and (2) belonging to an environmental group, for the high information sample (Table 12). In both cases, the individuals that belong to these groupings have stronger preferences for conserving Barramundi, and are willing to pay more for its protection (Table 16), than those who don't belong to these groups.

With respect to the appreciation of indigenous culture in the Kimberley, it is reasonable to assume that these individuals would be more knowledgeable about this issue than others. It would seem that these individuals have acknowledged the cultural importance associated with Barramundi and are thus willing to pay more for its protection than other individuals, all else held equal (Table 16).

It is not unusual for individuals belonging to environmental groups to have stronger pro-conservation preferences than others. However, it may seem odd that WTP increases for Barramundi in the high information sample when an individual belongs to an environmental group (Table 16), given the suggestion above that the information level reduces their WTP. There are three possible explanations for why WTP increases for these individuals (in comparison to other individuals in the high information sample) despite their better-informed placement in terms of the need (or lack thereof) to conserve Barramundi: (1) the pro-conservation attitude of these individuals may result in preferences to conserve the attribute even with the knowledge that populations are presently sustainable; (2) individuals that subscribe to environmental groups are more likely to have encountered lobbying material against recreational fishing activity that might influence their perception of how sustainable populations are; and (3) conservationists often turn to iconic symbols that can act as umbrella species to promote broader conservation of an area (e.g. see Entwistle and Dunstone 2000).

**Table 16:** Iconic species attribute partworths for the public low information, public high information and scientist final models.

| ***Iconic species*** | **Public low info $** | **Public high info $** | **Scientist $** |
|---|---|---|---|
| Unrestricted Barramundi migration | 57*** | 25*** | -4 |
| Unrestricted Barramundi migration + indigenous culture appreciation | 107*** | | |
| Unrestricted Barramundi migration + environmental group | | 85*** | |

Notes: ***p<0.01, **p<0.05, *, p<0.1.

- Representative ecosystems

The public samples each hold significant positive preferences for conserving representative ecosystems (Tables 11- 12). The scientists have strongly significant preferences (99% level of confidence) to conserve representative ecosystems when they belong to an environmental group. Scientists also have a positive preference to conserve the maximum level of the attribute (Reco4) when they do not belong to a group, but the same individuals are not significantly inclined to conserve when the level is Reco3 (Table 13).

The insignificant Reco3 coefficient is counterintuitive. One interpretation of this result is that the scientists did not feel that reserving 10% of land in only three bioregions was sufficient, and hence only supported conservation of the maximum amount (four bioregions). This interpretation is supported by literature noting that the IBRA scheme is designed for terrestrial conservation and may not be fully representative of aquatic systems (Kingsford and Nevill 2006). Therefore, the level Reco3 may not be considered adequate because the reserve area covered may not include important aquatic ecosystems. As the amount of reserve area increases to Reco4 (10% reserve area in four of the five Kimberley bioregions), it is likely that at least some representative aquatic ecosystems would be captured, even if by chance.

Scientists belonging to environmental groups may react similarly to public individuals that belong to environmental groups (such as those from the high information sample for Barramundi), with stronger conservation preferences than average, and are hence willing to protect either level of representative ecosystems. Or, perhaps because of their pro-conservation attitude they are less concerned by the technicalities of the aquatic representative arguments above, and are willing to protect any type of ecosystem, whether terrestrial or aquatic.

When comparing the partworths for representative ecosystems across samples, we see that the scientists are willing to pay more than the public (Table 17). Even the scientist WTP for conserving three bioregions is weakly significant (when not belonging to an environmental group), and their dollar values range from about two to ten times larger in magnitude than the public's dollar values. The highest dollar value of all the attributes and samples is recorded for conserving four bioregions if the scientist belongs to an environmental group ($172).

There are two potential interpretations for the divergence between public and scientist values that is seen here. First, scientists (particularly ecologists) are familiar with the 'comprehensive, adequate and representative' (CAR) approach to conservation[9]. CAR approaches are often used to incorporate land into the reserve system. Although the argument exists that the bioregionalisation may not accurately represent aquatic systems, the IBRA scheme and associated policy statements to reach 10% reserve area in each bioregion are congruent with a CAR approach. Given that scientists are familiar with this, and generally have a desire to add to the reserve system rather than not, it is not surprising that they value this attribute highly.

Second, the public may have reacted to the level definitions used. The other attributes either use categorical levels with a distinct change (for fish migration), or numerical levels that are 'bigger numbers' than for representative ecosystems (26 and 35 wild rivers; 89% and 98% good vegetation). Specifying the representative ecosystem levels as three or four (bioregions with 10% area under reserve) may have sounded small in comparison to the other attributes for the public respondents (one would expect the scientists to be able to interpret the levels more accurately). There is an indication of this being an issue through evidence of insensitivity to scale, discussed further below. An alternative considered in defining this attribute was to specify the hectares of reserve area in bioregions, but this was overly complicated given the different sizes of the bioregions (meaning 10% in one region would yield a different amount of hectares in another region), and calculation of current reserve areas that may occur across jurisdictional borders.

**Table 17:** Representative ecosystems attribute partworths for the public low information, public high information and scientist final models.

| ***Representative ecosystems*** | **Public low info $** | **Public high info $** | **Scientist $** |
|---|---|---|---|
| 3 bioregions | 25*** | 20** | 41* |
| 3 bioregions + environmental group | | | 151*** |
| 4 bioregions | 17* | 18** | 53** |
| 4 bioregions + environmental group | | | 172*** |

Notes: ***p<0.01, **p<0.05, *, p<0.1.

- Wild rivers

Several interaction terms help to explain preferences for the wild rivers attribute across samples. However, the coefficients are not always significant for both level parameters. The interaction terms

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[9] http://www.environment.gov.au/parks/nrs/science/scientific-framework.html

include experience related variables, such as rivers, gorges and waterfalls being sites of interest during visits to the Kimberley's waterways and wetlands, and belonging to environmental groups.

Gorges are a significant interaction term in both the public low information and scientist models, on Wild26 and Wild35 respectively, where they result in less positive preferences for wild river conservation, tending to negative preferences for the public individuals (*ceteris paribus*) (Tables 11 and 13). This result seems counter-intuitive – one would think that having experienced part of the Kimberley's waterways and wetlands, stronger connections would be felt towards wild rivers and preferences to conserve them would be more positive. It is possible that there is some form of option value tied up in this result – having already seen gorges, individuals have ticked them off the list of things to do and they are not as important to conserve as they are for individuals who have not seen them.

The remaining experience related variables impact preferences positively, as we would expect. Rivers being a site of interest results in a more positive orientation towards the Wild26 parameter for members of the public receiving low information (Table 11), and waterfalls being a site of interest results in a stronger tendency for conserving the Wild35 parameter for members of the public receiving high information (Table 12). Likewise, and following past trends in the results, individuals from the public high information sample belonging to environmental groups hold stronger conservation preferences for wild rivers (Table 12).

Comparing the partworths across samples, we see a similar pattern as for representative ecosystems where WTP is higher for scientists than for the public in comparable situations (Table 18). This includes the second highest dollar value across all attributes and samples ($168). In WA, wild rivers are clearly defined into categories that reflect the level of disturbance and condition of the rivers[10]. The strict definition holds scientific merit – wild rivers are an example of a natural pristine environment. A pristine river also has wider implications beyond its own banks. The hydrology of the river is likely to be unmodified, resulting in healthier catchments and benefits downstream. So it is intuitive that scientists would value this attribute highly.

Although the scientists are typically willing to pay more than the public, the public still have significant and positive WTP in most cases (Table 18). This preference likely captures broader preferences for conserving 'the Kimberley' in terms of it being the last 'wild frontier' in WA.

So it would appear that the wild and romantic notions, and the scientific merit, have resulted in an attribute that is valued positively by both the public and scientists. Wild rivers also obtain the highest WTP estimate for the public samples. Members of the public belonging to an environmental group in the high information sample are willing to pay $113 per annum to protect the highest level of wild

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[10] It was assumed that the contention surrounding wild rivers in Queensland would not play a significant role in the choices made by respondents in this study. There were was no qualitative evidence, in terms of additional comments provided by respondents, indicating that issues outside WA were influential.

rivers. These individuals are likely to have had more exposure to the concept of wild rivers (e.g. through WWF campaigns), and could be considered as 'super-informed' members of the public given their self-interest in environmental issues, resulting in a WTP more similar to that of the scientists.

**Table 18:** Wild rivers attribute partworths for the public low information, public high information and scientist final models.

| ***Wild rivers*** | **Public low info $** | **Public high info $** | **Scientist $** |
|---|---|---|---|
| 26 pristine | 16* | 20** | 99*** |
| 26 pristine + visited river | 84*** | | |
| 26 pristine + visited gorge | -26 | | 60** |
| 26 pristine + visited waterfall | | 38** | |
| 26 pristine + environmental group | | 65** | |
| 35 pristine | 27** | 40*** | 168*** |
| 35 pristine + visited river | 57** | | |
| 35 pristine + visited gorge | 44* | | 57** |
| 35 pristine + visited waterfall | | 98*** | |
| 35 pristine + environmental group | | 113*** | |

Notes: ***p<0.01, **p<0.05, *, p<0.1.

- Iconic places

A noticeable outcome of the iconic places regression is that the public have a significant preference to conserve such places, while the scientists only have a weakly significant preference to conserve the attribute in one instance (Tables 11-13). In fact, scientists have a (weakly) negative inclination to preserve iconic places if they have been involved in a case study on the Fitzroy River.

Scientists have a weak but positive preference to have 89% of native vegetation in good condition at iconic locations, such as Geikie Gorge on the Fitzroy River (Table 13). However, they do not place significant weight on preserving 98% of vegetation. It is possible that they believe 89% of vegetation is enough, or that 98% is an unrealistic goal. In any case, the weak significance for the Icon89 parameter, and lack thereof for Icon98, would suggest that scientists are not especially interested in conservation of iconic places. This should not come as a surprise; iconic locations are often disturbed and not as ecologically important as sites that are less accessible and in pristine condition. It is likely that the weakly positive significance is only registering because the attribute is framed around maintaining native vegetation, which at least has some ecological benefits.

For scientists that have been involved in research on the Fitzroy, the negative response to conserving iconic places is also understandable (Table 13). Many of these scientists will have experienced the disturbance at sites such as Geikie Gorge, and would likely want to place their conservation efforts elsewhere.

For the public, experience related variables once again played a role in explaining preferences (Tables 11 and 12). In the low information sample, individuals who noted waterfalls were a site of interest during a visit had a stronger orientation to preserve iconic places, as did individuals who considered gorges a site of interest for the high information sample. This continues the theme from wild rivers where individuals who have experience with landforms associated with attributes, and are therefore more knowledgeable and familiar with the attributes, want to protect them more so than other individuals (all else held equal). Experience related factors play a similar role in other studies of this nature (e.g. see McCartney 2010). Given that iconic places are often characterised as such due to appealing aesthetics, waterfalls and gorges may be associated with a more visually attractive landscape. Thus having seen these landforms, individuals place more value on protecting iconic sites.

The partworths for iconic places are reflective of the discussion above (Table 19). Scientists typically have a WTP that is not significantly different from zero, with the exception of being willing to pay $46 for 89% native vegetation in good condition. The public, on the other hand, have significant WTP values in all instances.

**Table 19:** Iconic place attribute partworths for the public low information, public high information and scientist final models.

| ***Iconic place*** | **Public low info $** | **Public high info $** | **Scientist $** |
|---|---|---|---|
| 89% good vegetation | 19** | 36*** | 46** |
| 89% good vegetation + visited waterfall | 50*** | | |
| 89% good vegetation + visited gorge | | 66*** | |
| 89% good vegetation + Fitzroy case study | | | -22 |
| 98% good vegetation | 44*** | 40*** | 19 |
| 98% good vegetation + visited waterfall | 92*** | | |
| 98% good vegetation + visited gorge | | 79*** | |
| 98% good vegetation + Fitzroy case study | | | -14 |

Notes: ***p<0.01, **p<0.05, *, p<0.1.

- Sensitivity to scale

There was an insensitivity to attribute level scale in many cases. That is, although there were generally significant differences between the status quo (baseline) level and some level of improvement in conservation, as shown in the regression output, there were often no significant differences between the conservation improvement levels themselves. One-tailed linear hypothesis tests were used to determine whether the coefficient for the second conservation improvement level (e.g. Reco4), was significantly more positive than the first conservation level coefficient (e.g. Reco3). These tests were irrelevant for the threatened and iconic species attributes where there was only one conservation improvement level, and so they were applied only to the representative ecosystems, wild rivers and iconic places attributes.

There was an insensitivity to scale in all cases for representative ecosystems, including when covariates were considered. This was likewise the case for the iconic place attribute in the public high information and scientist samples.

Sensitivity was expressed for the iconic place attribute in the public low information sample, both for individuals that had, and had not, noted waterfalls as a site of interest during a visit to the Kimberley. Most sensitivity to scale was associated with the wild rivers attribute. For this attribute, sensitivity is present for: members of the public receiving low information who noted gorges as a site of interest during a visit; members of the public receiving high information who did not belong to an environmental group (i.e. including those that did and did not note waterfalls as a site of interest); and scientists who did not note gorges as a site of interest.

Interpretation of why sensitivity to scale was present for some attributes/levels and not others is difficult. Possible reasons for scale insensitivity include: (1) the range of the attribute levels was too small for significant differences in scale to be detected; (2) the attribute levels were difficult to interpret; (3) individuals want to conserve some amount, but do not care about how much; (4) a strong diminishing marginal utility could be associated with an attribute if individuals believe that the lowest level of conservation improvement is sufficient to protect the attribute; or (5) some combination of these factors.

- Alternative specific constant

To interpret the ASC coefficients, we must remember that the scientists had one ASC specified on the status quo option, meaning a negative coefficient shows support for conservation programs, while the public samples had two ASC's specified for each of the conservation alternatives – so a positive coefficient is associated with support for conservation programs. The highly significant standard deviations for all ASC's show there is heterogeneity in the population with respect to probability of selecting conservation programs (Tables 11-13). For the scientists, the ASC coefficient is negative, but not significant. For the public low information sample, similar results are found – the ASC3 coefficient is positive but not significant, while the ASC2 coefficient is weakly positive, showing support for conservation options. The public high information sample again has one insignificant ASC, but there is a significant negative inclination associated with selecting alternative 3 (unless an individual is in the tail of the distribution that would result in a positive preference for alternative 3 according to the standard deviation). This does not necessarily imply that there is a negative preference for conservation, as individuals may be opting for the other conservation alternative.

Heterogeneity in the ASC's is partially explained by several significant socio-demographic interactions (Tables 11-13):

- *Gender:* in the low information sample, if an individual is male they are less likely to select the conservation options (*ceteris paribus*). Evidence of females exhibiting stronger conservation preferences has been found in similar studies (e.g. see McCartney 2010).
- *Tax:* in both of the public samples (for ASC3 only in high information), individuals who have had to pay income tax within the last five years are more likely to select conservation options than other individuals, all else held equal. This result is sensible if you consider that paying taxes is

evidence of earning an income, and thus reflective of having resources available to spend on conservation.

- *Economic situation:* in both public samples, for people who stated that their views of the recent global financial crisis reduced their WTP when making choices, the no cost status quo option was favoured over the conservation options (*ceteris paribus*). It is likely that this group was paying particular attention to, or currently experiencing, financial challenges and making decisions accordingly.
- *Information:* in the low information public sample, individuals who thought the attribute descriptions were inaccurate or confusing were less likely to opt for conservation alternative 3. In the high information sample, those who found the descriptions confusing were less likely to opt for conservation alternative 2. Thus, confusion factors may be associated with a smaller tendency to conserve, although there is no strict evidence of this given that significant effects are not found on both conservation options in each case.
- *University education:* in the high information public sample, respondents with a university degree were more likely to select the conservation alternatives, all other things being equal.
- *Preferences:* for the public high information sample, individuals that believed public preferences were relevant in guiding decisions to manage the Kimberley's waterways and wetlands were more likely to select conservation programs, all else held constant.
- *Confused:* Scientists who found the choice scenarios confusing were more likely to select conservation options (*ceteris paribus*). It is difficult to interpret this result without follow-up questions as to the source of their confusion.
- *Ecological processes:* Scientists were asked to note how much time they spent researching/working on various aspects of the system (specifically: species level, ecological processes, catchment processes and social/human impacts). For those that spend more than half of their time on ecological processes, the tendency to select conservation programs was stronger than for other scientists, all else held equal.

## 5. Summary

This choice experiment compares public and scientists preferences for conserving the Kimberley's tropical waterways and wetlands, using a unique 'knowledge base' approach to attribute definition. The knowledge base approach allowed for the inclusion of attributes relevant to both the community and experts. Divergence of preferences is evident between the public and scientists for various attributes in the study. This is first noted with respect to the model formation process – the public low information, public high information and scientist data could not be joined into one pooled model. This signifies that preferences for each sample are significantly different, and indicates that information plays a role in preference formation.

The scientists tended to prefer attributes that were system based, such as representative ecosystems and wild rivers, or where population sustainability was an issue as for threatened species. Their willingness to pay to protect these attributes was greater than that of the public for comparable situations. These results were anticipated – scientists tend to focus on the bigger picture, in terms of protecting broader catchment level attributes that have flow on effects to protect the components of the environment within them. Scientists also recognise the need to protect threatened species that require support to maintain sustainable populations. The removal of a keystone species from an ecosystem could affect its overall functionality.

The scientists did not place much weight on the protection of iconic attributes. This is intuitive given that these attributes are not as ecologically and functionally important, in the sense that the iconic species in this instance, Barramundi, is widespread and does not require support for sustainable populations, and iconic places are often disturbed environments. That is not to say that the protection of iconic places is not warranted in all cases – in certain circumstances (e.g. heavily populated areas) there may be few substitutes for an iconic (environmental) location making its conservation imperative. However, in the case of the Kimberley's waterways and wetlands, there are available substitutes where ecological integrity has remained more intact due to poor accessibility to humans and conservation may be more successful and valid.

The public tended to have their hands in all of the cookie jars, so to speak. They valued all attributes positively and were willing to pay to protect them under nearly all circumstances. There are not the same marked differences between attributes as there is for the scientists (who did not value iconic attributes, but valued other the attributes, and often more highly than the public). This 'even spread' of preferences to protect all attributes could be a strategy in the face of uncertainty – as the public are not as well informed as to which attributes require the most protection, they have opted to conserve them all to some extent.

There is some evidence to support this suggestion. The information versions imposed on public respondents had the desired effect of reducing willingness to pay for the Barramundi attribute as information level increased. We expected that the information provided would have the greatest impact on the Barramundi attribute, given the complex nature of the description, and that as the public gained a greater understanding of the attribute they would come to realise that it was not as important to conserve as other attributes.

Other information effects are picked up through covariates in the models. Generally, individuals that had experienced or were interested in particular aspects of the waterways and wetlands valued them more highly, as did individuals belonging to environmental groups. Individuals with experience or environmental self-interest are likely to be more knowledgeable about the waterways and wetlands, or the environment more generally, and this has resulted in stronger conservation preferences.

### *Conclusion*

In conclusion, divergence between public and scientist preferences was found with respect to conservation of the Kimberley's waterways and wetlands. The models for the public low information, public high information and scientist samples were all significantly different, indicating preference divergence. Scientists held stronger values for system based attributes and threatened species, and were not particularly interested in conserving iconic attributes. The public had an even spread of positive values for protecting all attributes. It is thought that information played a significant role in determining preferences. This is noted first in terms of the split public information models, and second with respect to the Barramundi attribute, where public preferences appeared to be on a pathway of convergence with scientist preferences as the information available to individuals increased.

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## Appendix 1: ASC Investigation

Following the outline in Section 4.2, the first step in the analysis was to investigate the inclusion of ASC's in the model. For each of the three data sets collected from the survey (i.e. the two public information splits, and the scientist sample), basic MNL models were estimated that contained the explanatory attribute variables. Likelihood ratio tests were performed on each of these data sets comparing a flexible model, with ASC's specified on each of the two conservation alternatives in the choice scenario, with a more restrictive model with one ASC specified for the status quo alternative.

Table A1 reports the results of the ratio testing. In the case of the public samples, the constrained model with one ASC is rejected. The scientist model allows the restriction to only one ASC, reflecting the choice frequencies observed in Table 7 where only the status quo option has a relatively different selection frequency to the other alternatives.

**Table A1:** Likelihood ratio tests for including two or one ASC's in the model, for each sample.

| **Sample** | **Unconstrained Log Likelihood (ASC2 & ASC3)** | **ConstrainedLog Likelihood (ASC1)** | **Likelihood Ratio** | **Acceptance of restriction**[a] |
|---|---|---|---|---|
| Public Low Info | -1762.16 | -1771.17 | 18.02 | Reject |
| Public High Info | -2407.18 | -2421.99 | 29.62 | Reject |
| Scientists | -473.85 | -474.04 | 0.39 | *Accept* |

[a] For 1 degree of freedom, $\chi^2$ critical value (p=0.05) 3.84.

Note that, for the purposes of considering the potential to combine samples (see Section 4.3), although the scientist model allowed the restriction to one ASC, it was pertinent to still consider the more flexible two-ASC version of the model in the event that it could be combined with the public samples. That is, any potential combination between the three samples would need to be made with the most flexible *common* model form in place. Since the public samples require the two-ASC specification, any pooling of the data sets should take this form. Therefore, the subsequent tests for two-way interaction inclusion and MNL/ML model specification were performed for both the one-ASC and two-ASC specifications for the scientists.

However, as reported in Section 4.3, the scientist and public samples cannot be combined. Therefore, we revert back to the preferred one-ASC model for the scientists. As such, the subsequent results reported for the interaction and model specification investigations report only on this particular model form for the scientists.

## Appendix 2: Two-way Interactions

The second step of model formation was to consider the relevance of the two-way interaction terms incorporated in the experimental design. Referring to Section 3.3, two-way interactions were designed for between the threatened and iconic species attributes.

As shown in Table A2, it was possible to constrain the survey samples to a model that excludes the two-way interaction terms, suggesting that respondents were not considering the underlying possibility of overlap between attribute conservation. It is interesting to note that this restriction was possible even for the scientist sample where one may have expected that more emphasis would have been placed on relationships between attributes.

**Table A2:** Likelihood ratio tests for including two-way interactions in the model, for each sample.

| **Sample** | **Unconstrained Log Likelihood (two-way interactions included)** | **Constrained Log Likelihood (no interactions)** | **Likelihood Ratio** | **Acceptance of restriction**[a] |
|---|---|---|---|---|
| Public Low Info (2*ASC) | -1762.16 | -1762.17 | 0.02 | *Accept* |
| Public High Info (2*ASC) | -1853.01 | -1853.24 | 0.46 | *Accept* |
| Scientists (1*ASC) | -474.04 | -474.35 | 0.61 | *Accept* |

[a] For 1 degree of freedom, $\chi^2$ critical value (p=0.05) 3.84.

## Appendix 3: MNL versus ML Models

As discussed in Section 2.2, the ML specification is a common extension to the basic MNL model. To determine the appropriate model form, likelihood ratio tests were performed on MNL and ML models for each of the sample splits. The ML model is the more flexible model specification, given that it allows for heterogeneity in random parameters. Table A3 reports the results of the likelihood ratio tests, showing that in all cases the ML is the preferred model form.

**Table A3:** Likelihood ratio tests for comparing ML and MNL models, for each sample.

| **Sample** | **Unconstrained Log Likelihood (ML)** | **Constrained Log Likelihood (MNL)** | **Likelihood Ratio** | **Acceptance of restriction**[a] |
|---|---|---|---|---|
| Public Low Info (2*ASC) | -1552.42 | -1762.17 | 419.5 | Reject |
| Public High Info (2*ASC) | -1565.27 | -1853.24 | 575.94 | Reject |
| Scientists (1*ASC) | -416.99 | -474.35 | 114.72 | Reject |

[a] For the public samples with two ASC's – 2 degrees of freedom, $\chi^2$ critical value (p=0.05) 5.99; for the scientist sample – 1 degree of freedom, $\chi^2$ critical value (p=0.05) 3.84.