ISSN 1835-9728

Environmental Economics Research Hub

Research Reports

Conserving biodiversity in the Southwest Australia Ecoregion: the policy implications of scientist and community values

Abbie Rogers and Jonelle Cleland

Research Report No. 91

November 2011

About the authors

Dr Abbie Rogers (nee McCartney) and Dr Jonelle Cleland are Research Associates at the Centre for Environmental Economics and Policy, 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) Danielle Whitham, project leader for the Southwest Australia Ecoregion Initiative for involving us in planning workshops, facilitating access to experts and data sources, and commenting on our survey, (2) the respondents who kindly gave up their time to participate in the 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.

The views and interpretations expressed in these Reports are those of the author(s) and should not be attributed to any organisation associated with the EERH.

Because these reports present the results of work in progress, they should not be reproduced in part or in whole without the authorisation of the EERH Director, Professor Jeff Bennett (jeff.bennett@anu.edu.au)

Crawford School of Economics and Government

THE AUSTRALIAN NATIONAL UNIVERSITY

http://www.crawford.anu.edu.au

Table of Contents

Abstract

The Southwest Australian Ecoregion Initiative presented an opportunity to examine whether an expert-driven, systematic conservation planning process, was likely to reflect public values for biodiversity. The planning process – carried out at a strategic, whole of ecoregion scale to identify 'Zones for Conservation Action' – did not involve the public in establishing conservation priorities. During this period of time, we conducted a discrete choice experiment, administered to both scientists and the public, which demonstrated that preferences for a set of key conservation features were in fact divergent. With this finding in mind, we have outlined a way to incorporate public values, derived from a choice experiment, into a systematic conservation planning framework. This novel approach offers an way to explicitly consider social welfare benefits for biodiversity conservation.

1. Introduction

For a policy to be deemed successful, an overall net benefit to society must be demonstrated. To guide policy formation, the relevant community is often consulted. This can be in one of two ways (or both): (1) public consultation can be undertaken ex ante of policy development, to gain an understanding of community preferences, and this information can be used to inform the decision making process; or (2) public consultation can be used ex post of policy development to educate and increase the likelihood of public buy-in. However, there are costs involved in undertaking public consultation, and the exercise is often fraught because it isn't always broadly representative of the relevant community[1] (e.g. individuals and groups with a vested interest may dominate meetings, forums, etc.). As such, experts are often used as the voice of reason in conservation policy and decision making.

There is a limited understanding of whether expert advice is a suitable substitute for public opinion. If public and expert preferences are similar then expert guidance alone offers a suitable and cost-effective alternative to public consultation – the decisions made should be 'close enough' to what the community prefers. However, if divergent preferences are held, public consultation may be required (in addition to the technical advice of experts) to appropriately understand the social welfare impacts of proposed policies, and therefore aid successful policy implementation.

Systematic conservation planning is an example of an expert-driven process which is increasingly being relied upon to inform decisions regarding the protection of biodiversity through the establishment of conservation reserves. Whilst the process can be designed to consider financial constraints, such as the budget available for acquiring new reserves and the opportunity costs associated with converting different land uses, it typically does not incorporate the broader costs and benefits to society. Social welfare considerations could be built in to systematic conservation methodologies to provide a more complete picture of optimal conservation strategies.

Non-market valuation offers a means for doing this. That is, similar to its use in a benefit-cost analysis (e.g. Hanley and Spash 1993), a non-market valuation can generate the social values associated with biodiversity conservation. These can be built into systematic conservation planning tools, so that there is a social weighting on different conservation outcomes.

This paper reveals the values that scientists and the Western Australian community place on different conservation features in the context of them being used for expanding the reserve system in the Southwest Australia Ecoregion (SWAE). Identifying that divergence exists between the public and scientists, the paper then considers how the public values may be utilised in a systematic conservation planning context to aid policy development. The paper contributes to an ongoing program of research that is using discrete choice experiments to discern whether experts and members of the public place different priorities on key components of the Australian environment.

[1] The relevant community, in the case of biodiversity conservation, may extend far beyond the geographical boundaries of that which is being conserved. For instance, people may hold existence values for biodiversity.

This paper is divided into a number of sections that will: provide the reader with a brief overview of systematic conservation planning (Section 2) and its application in the SWAE (Section 3); outline the conceptual framework utilised in the study, including the choice experiment, selection of conservation features and survey design constructs (Section 4); report and discuss results (Section 5); and summarise key findings and areas warranting further investigation (Section 6).

2. A move toward systematic conservation planning

A cornerstone of environmental conservation strategies throughout the world is to set aside natural areas so that they can be better protected from threatening processes. Such areas, generally referred to as 'protected areas' or 'reserves', represent a legacy of values. Indeed, it is a legacy due to the long history of reserve establishment and the particular conservation priorities that have come to bear over time. For example, the wilderness movement saw large areas of land set aside to protect scenic and recreational values (Lewis 2007), whilst concerns over the deteriorating quality of many domestic water supplies saw areas set aside to protect ecosystem services such as the provision of clean water (Dudley and Stolton 2003).

Increasingly, reserves are being established for the protection of biodiversity. At its broadest level of conception, reserves established to protect biodiversity 'should sample or represent the biodiversity of each region and they should separate this biodiversity from processes that threaten its persistence' (Margules and Pressey 2000, p. 243). However, difficulties arise from the fact that areas are generally protected one at time rather than as a system, driven by factors such as incomplete knowledge, political expediency and budget realities. It has been argued that such a 'scattergun' approach to conservation compromises biodiversity values (Myers *et al*. 2000, p. 858).

This has seen a call for prioritisation of candidate reserves based on the notion that (1) not all biodiversity elements have the same conservation needs, nor do they provide the same contribution to the conservation goals of a region, and (2) resources available for conservation are scarce and any effort needs to make the greatest contribution to preserving the biodiversity of a region (Pressey *et al.* 1993). Reserve selection algorithms were the beginning of an explicit, structured approach to setting conservation priorities (Pressey 1999). For example, achieving a desired representation in a minimum number of places or maximal representation in a fixed number of places can be computed using a variety of heuristic or optimising selection algorithms (Pressey *et al*. 2004). However, reserve selection algorithms remain largely unused by conservationists and land use planners (Hajkowicz *et al*. 2007; Prendergast *et al*. 1999). This has seen the emergence of *systematic conservation planning* and a number of associated decision support tools (e.g. Marxan[2]; C-Plan[3]).

Approaches falling under the banner of systematic conservation planning are generally characterised as being: data driven; goal-directed; efficient; repeatable; and flexible (Pressey 1999). They purport to

[2] http://www.uq.edu.au/marxan/
[3] http://www.uq.edu.au/ecology/index.html?page=101951

reveal conservation urgency by combining the concepts of irreplaceability and vulnerability, whilst considering concepts such as complementarity, persistence and opportunity costs. At an operational level, there are two decision points that, whilst being explicit, can involve a considerable amount of subjectivity in their formulation.

First, difficult choices need to be made about the conservation features to be used as surrogates for overall biodiversity in the planning process.

Second, quantitative targets need to be set for the selected features.

Conservation features need to be measurable and a spatially definable part of the biodiversity that is to be conserved within a reserve network. They can be defined at different levels of ecological scale, such as species, communities, habitat type, populations and genetic sub-types. In a typical analysis, each conservation feature is given a target which is the amount of that particular feature to be included within the reserve network (WWF-Australia 2010). However, due to issues of uncertainty and incomplete information, it has been noted that there is 'no best surrogate' and that target setting can be 'problematic' (Margules and Pressey 2000, p. 246).

Decisions about conservation features and targets have generally been left to those researchers responsible for carrying out the systematic conservation planning exercise. To date, public preferences regarding the appropriateness of specific conservation features and targets have not been factored into the approach. That is, while there may be some amount of stakeholder engagement (e.g. with landholders or the local community in the planning area) to gain an understanding of attitudes towards the conservation plan (e.g. see Pressey and Bottrill 2008), there is typically no broad elicitation of public preferences directly related to the setting of features and targets. Whilst it could be argued that the public are not sufficiently informed or skilled to connect conservation features and targets to biodiversity outputs, they do have a stake in the biodiversity outcomes that systematic conservation planning delivers (if taken up by government administrators).

Recent research suggests that, in the case of environmental management, preference divergence between public and expert communities is context specific (e.g. see Carlsson *et al*. 2011; McCartney 2011; Rogers and Cleland 2010). This study explores the issue of preference divergence in the context of systematic conservation planning, with the SWAE used as the case study area.

3. Systematic conservation planning in the Southwest Australia Ecoregion

In Australia the reserve system is considered the 'nation's premier investment in biodiversity conservation' (NRSTG 2009, p. 7). By 2030, the federal government has set the challenge to achieve 'a truly effective national reserve system that secures Australia's biodiversity assets in their landscape setting and ensures they are effectively managed' (NRSTG 2009, p. 8). This goal acknowledges the understanding that many elements of Australia's biodiversity are not adequately represented in the reserve system and that many elements face extinction due to threatening processes (Biodiversity Assessment Working Group, 2009).

Fifteen 'national biodiversity hotspots' have been identified by the Australian Government's Threatened Species Scientific Committee[4]. Five of these hotspots occur within the boundaries of the SWAE (see Figure 1), which also has international recognition as:

- one of 34 global biodiversity hotspots (as defined by Conservation International)
- one of five Mediterranean-climate ecosystems that are globally significant (as defined by WWF[5] and IUCN[6])
- a Centre for Plant Diversity (as defined by WWF and IUCN)
- an Endemic Bird Area (as defined by Birds International)

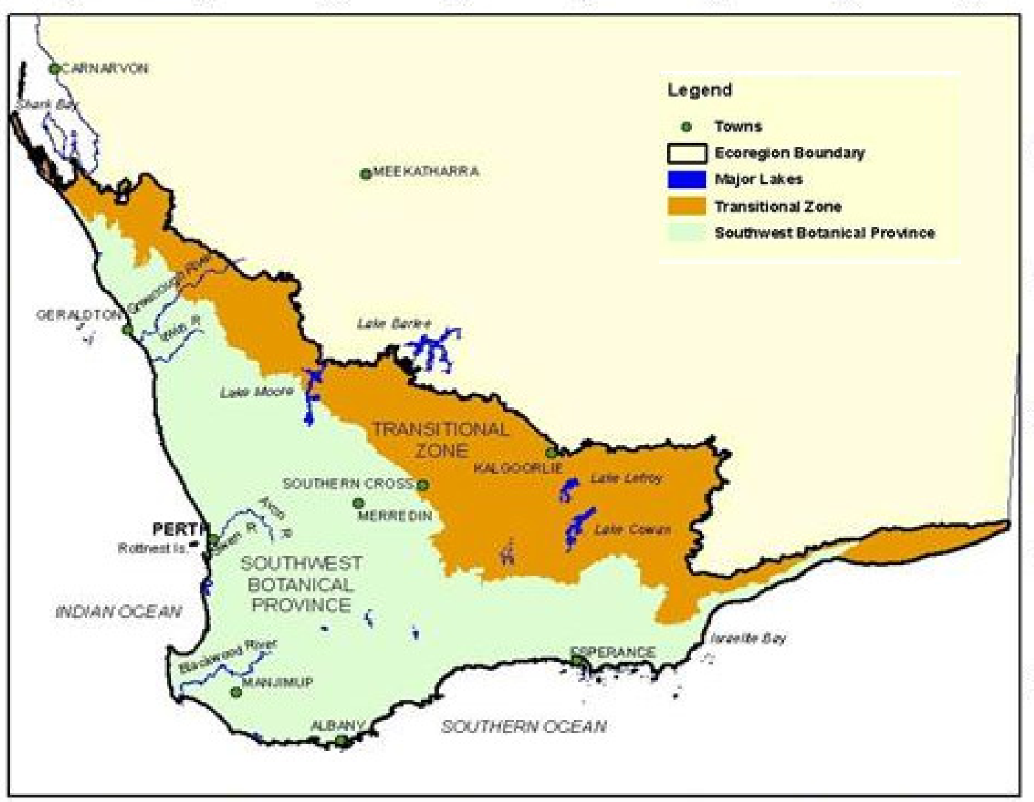

Figure 1: The Southwest Australia Ecoregion (Gole 2006).

[4] Biodiversity hotspots are areas that support natural ecosystems that are largely intact and where native species and communities associated with these ecosystems are well represented. They are also areas with a high diversity of locally endemic species. The current, planned or potential management activities in hotspots place the natural values at risk, and it is likely this risk will increase in the future in the absence of active conservation management (definition sourced from Environment Australia 2011).

[5] World Wildlife Fund

[6] International Union for Conservation of Nature

In light of the region's conservation status the Southwest Australia Ecoregion Initiative (SWAEI) was formalised in 2003. The SWAEI recognised that there was 'no systematically planned, coordinated or prioritised conservation strategy to ensure the long-term sustainability and biodiversity of the entire Southwest Australia Ecoregion, which is subject to ad hoc planning and prioritisation across a variety of jurisdictions' (SWAEI n.d.). With representatives from a consortium of agencies, non-governmental organisations, research centres and other groups, SWAEI activities have included various bioregional planning exercises. In 2007 the SWAEI adopted systematic conservation planning to underpin the development of a conservation strategy for the region (WWF-Australia 2010).

The SWAEI's expectations of what systematic conservation planning would deliver were high, particularly in terms of improving efficiency in the use of limited resources and conserving the crown jewels of the SWAE. With funding sourced from the Australian Government (under the Caring for Country initiative) leading conservation planner Professor Bob Pressey was engaged to guide the project. In promotional material Pressey affirms that conservation planning will enable 'smarter decisions' about saving the treasures of the Southwest (WWF-Australia 2009). Pressey also emphasises that future generations will 'look back and judge' how well the job has been done (WWF-Australia 2009).

The latter statement suggests that the importance of public preferences regarding the outcomes of the planning process is acknowledged by Pressey. This recognition can also be extended to the SWAEI executives who provided in-kind support for the research project 'Divergence between public and expert valuation of environmental assets', within which the SWAE was one of a number of case studies[7]. However, to date, the planning process has been primarily expert driven, drawing on a large number of scientists from government agencies and research institutions to identify conservation features and establish targets[8]. This assertion is supported by a statement made by former project manager, Danielle Witham:

> Scientific knowledge has underpinned the Systematic Conservation Planning project to determine the priorities for biodiversity conservation. It is hoped that the transfer of the knowledge that has gone into this process will better inform and focus management decisions for both on-ground implementation and by statutory protection mechanisms (*pers. comm.* 2011)

The SWAEI does anticipate that the actual conservation of priority areas (known as Zones for Conservation Action[9]) will, in many instances, involve negotiation with individual landholders and

---

[7] See the Environmental Economics Research Hub website for project details (i.e. <http://www.crawford.anu.edu.au/research_units/eerh/projects/project8.php>)

[8] This included a series of eight target setting workshops with over 60 experts in attendance, and a stakeholder reference group of 15 experts that met on a monthly basis.

[9] The Zones for Conservation Action are determined by systematic conservation planning techniques. A Zone for Conservation Action is a regional-scale area that can be defined as a cluster of highly desirable planning units that contribute to achieving the targets set for the 1,391 conservation features across the SWAE in the most efficient manner.

present the opportunity for establishing partnerships with local government and stakeholder groups (WWF-Australia, in print). This approach is problematic in that a locally driven process is likely to underplay the importance of existence or non-use values of biodiversity. Indeed, it is noted in the SWAEI's regional framework that:

> The Ecoregion's global and national recognition does not always lead to actions that ensure the long term protection and management of its biodiversity. Too often, economic values take precedence over cultural, ecological and social values of biodiversity (WWF-Australia, in print, p. 9).

Incorporating a broader representation of the public in the roll-out of Zones for Conservation Action could be considered an option for overcoming divergent preferences. In the case of formal reservation, one mechanism that is already in place to gauge public sentiment is the release of documentation regarding proposed reserves and their indicative management, with the opportunity for the public to have their say. However, the majority of feedback comes from interest and lobby groups. Therefore, it is unlikely to draw out the preferences of the broader public.

Alternatively, a more encompassing deliberative process – one that establishes a dialogue with members of the broader public – could be put in place. In the case of the SWAE, such a process would require a large investment in awareness raising, engagement and consultation. It would likely be prohibitive in terms of costs and time delays.

Clearly, a mechanism is needed that can effectively elicit public preferences, and be easily incorporated into the existing expert-driven, systematic conservation planning process. With this in mind, the following paper demonstrates how the application of a discrete choice experiment can offer:

(1) A direct comparison of public and expert preferences;
(2) A broad elicitation of public preferences for biodiversity outcomes;
(3) Provision of public values suited for inclusion in a systematic conservation planning framework.

4. Conceptual framework for the study

A discrete choice experiment approach is used to estimate values for conserving biodiversity in the SWAE. Section 4.1 introduces the choice experiment as a technique used in non-market valuation, while Section 4.2 outlines its suitability for addressing the research problem. The set of conservation features identified for inclusion in the choice experiment are defined in Section 4.3. Section 4.4 outlines the survey methodology and experimental design. Finally, the survey administration process is discussed in Section 4.5.

4.1 Discrete choice experiments

Choice experiments estimate how much individuals are willing to pay to change, improve or conserve different characteristics, or attributes, of a good. They are particularly useful in an environmental setting based on their ability to quantify what we term non-use, or passive, values (e.g. intangible existence values). In a choice experiment survey, respondents are (typically) faced with a sequence of hypothetical questions called choice scenarios (see Figure 3 for an example of the choice scenarios used in the SWAE survey). Each choice scenario is comprised of a number of options, or alternatives, that describe, for example, different conservation programs or policies. The alternatives are made up of a set of attributes that describe the good, and these attributes can include intangible features of the good. The set of attributes is the same for each alternative in the scenario, but the level or amount of each attribute offered varies across the alternatives. A status quo option is often included in the choice scenario to provide respondents with an 'opt-out' alternative, and if the aim is to estimate dollar values then one of the attributes included is a cost associated with implementing the program (Bennett and Blamey 2001).

The choice data are analysed in accordance with Random Utility Theory, which defines utility held by individual *n* over alternative *i* (U_{in}) as a function of a vector of *k* attributes (X_{ik}), the parameters (β_k) and an unobservable utility component (ε_i) (Bateman *et al*. 2002):

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

Assumptions are made about the distribution of the unobservable error term. Typically it is assumed that it is independently and identically distributed in the form of a Gumbel distribution. Under this assumption, choice probabilities can be estimated using the multinomial logit (MNL) model (Train 2009). Following Train (2009), using MNL estimation 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*:

$$P_{in} = \frac{e^{\lambda\beta' x_{in}}}{\sum_j e^{\lambda\beta' x_{jn}}} \qquad \text{Equation 2}$$

The scale parameter, λ, is inversely proportional to the standard deviation of the distribution of the error term. It is not possible to independently identify the scale and beta parameters, so estimated parameters are interpreted as scaled marginal utilities. Here it is assumed that error variance is constant across individuals; however, if one assumes a parametric relationship between the variance of the error term and exogenous characteristics that vary across a sample, thus identifying changes in the relative value of the error variance, scale can be varied across individuals (Swait 2006).

We can estimate dollar values through the inclusion of the cost attribute. Dollar value estimates, or partworths, are retrieved by taking the negative ratio of a non-monetary attribute coefficient (β_a) to that of the cost coefficient (β_b) (Bennett and Blamey 2001):

$$Partworth = -\frac{\beta_a}{\beta_b} \quad \text{Equation 3}$$

In this manner, we can estimate how much people are willing to pay to receive one unit more of a particular (non-monetary) attribute.

MNL estimation makes the assumption that beta parameters, and marginal utilities, are constant across individuals within a sample. However, heterogeneity may exist in individuals' preferences (e.g. see Train 2009; Hensher *et al*. 2005; Louviere *et al*. 2000), and this can be captured by modelling marginal utility as a function of individual characteristics (i.e. socio-economic variables) (see Equation 5).

Alternatively, heterogeneity can be modelled by assuming a distribution of marginal utilities across the sample. The mixed multinomial logit (ML) model does this by treating the distribution as a random variable, with the meta-parameters (e.g. mean and variance) estimated by the analyst. This approach can be applied congruently with socio-economic modifiers as discussed above. For ML estimation, following Hensher *et al*. (2005), Equation 1 is re-specified to make the marginal utilities individual specific:

$$U_{in} = \sum_{k=1}^{K} \beta_{nk} X_{ik} + \varepsilon_{in} \quad \text{Equation 4}$$

β_{nk} can then be specified as:

$$\beta_{nk} = \beta_k + \delta'_k z_n + \eta_{nk} \quad \text{Equation 5}$$

where δ represents the impact of individual characteristics (z_n) on marginal utility, and η_{nk} is a random term representing a specified distribution (e.g. a normal or lognormal distribution) across individuals. Equations 4 and 5 allow for heterogeneity to be captured both through random effects and from individual specific shifters in the mean of parameter distributions.

As choice experiments often involve a sequence of choices, individuals may provide a number of choice observations. This should be recognised so that the random parameter for a given individual is held constant across the repeated choices. For *t* repeated choice scenarios being answered by an individual, the utility function becomes:

$$U_{itn} = \sum_{k=1}^{K} \beta_{nk} X_{itk} + \varepsilon_{itn} \quad \text{Equation 6}$$

Deciding upon which attribute parameters should be treated as random is not always easy. For smaller experimental designs (i.e. few attributes/levels), there are tests that can deduce a selection of random parameters (McFadden and Train 2000). However, for larger designs, Hensher *et al*. (2005, p. 612) note that such tests can be 'very demanding for a large number of explanatory variables and might be problematic in establishing the model'. Introduce the possibility of correlations between random parameters and this task can become even more demanding. In such cases, it may be necessary for the researcher to make prior assumptions about which parameters should be treated as random.

4.2 Suitability of the approach

This methodology offers a flexible framework that appeals to the three points of interest in this research, that are:

(1) A direct comparison of public and expert preferences;
(2) A broad elicitation of public preferences for biodiversity outcomes;
(3) Provision of public values suited for inclusion in a conservation planning framework.

First, choice experiments are considered an appropriate method for comparing public and expert preferences because of their ability to quantitatively estimate conservation values. That is, an identical choice experiment can be applied to both a public and expert sample and provide directly comparable dollar value estimates. Further, the choice experiment approach has been used in several other case studies aimed at comparing public and expert preferences for the environment. Australian studies include the Kimberley's tropical waterways and wetlands (Rogers and Cleland 2010), and the Ningaloo and proposed Ngari Capes marine parks (McCartney 2011). Internationally, Carlsson *et al*. (2011) also used choice experiments in a Swedish study comparing community and environmental administrator preferences for the marine environment and clean air. Thus, maintaining a consistent methodology for the SWAE comparison allows us to build upon these previous studies and catalogue instances of public/expert divergence over a range of environmental asset scales and settings.

Second, the questionnaire-based approach, which is commonly administered as a mail-out or web-based survey, can reach a broad audience. Large sample sizes and representative cross-sections of populations can be collected with comparatively less effort and cost than deliberative approaches, such as public meetings and focus group consultation. Perhaps more importantly, the attributes that are included in a choice experiment are defined in a recognisable, non-technical manner. That is, if we consider biodiversity conservation as an example, the environmental outcomes are described using a set of conservation features and classifications that are familiar to the public. By using common terms, the public can be reasonably expected to make decisions that reflect their preferences for different environmental outcomes.

Third, the ability of choice experiments to estimate marginal values for attributes lends itself to the target setting component of systematic conservation planning. According to Pressey *et al.* (2003), one of the main aspects of systematic conservation planning is its use of explicit targets for conservation features. These targets are often formulae that contain weighted arguments to place higher priority on characteristics relating to rarity, life history, functional importance, exposure to threats, etc. (Figure 2). The weightings placed on these characteristics are usually decided by expert judgement. As such, targets may appear to be set arbitrarily and may come under scrutiny. In contrast, the marginal values derived from choice experiments can offer quantitative 'weightings' (i.e. due to the fact that the value coefficients for a set of attributes are estimated relative to one another).

Conservation target for inland water body features

Target = Base 30% + Threats 15% + Functional importance 15%

Formula rationale:

- Base target of 30% water features to be protected
- An extra 15% if the features are considered to be threatened
- An extra 15% if the feature is identified by experts as being functionally important

Maximum target of 60% water features to be protected under the conservation plan

Figure 2: An example of a target formula used in the SWAEI conservation planning process (WWF-Australia 2010).

In this context, the marginal values derived from a choice experiment could be used to complement the expert-informed formulae. Most notably, the marginal values elicited from a choice experiment, administered to the public, could provide a useful means of explicitly incorporating a 'social value weighting' in the formulae (see Figure 4 in Section 6). In addition, the marginal values elicited from a choice experiment, administered to the relevant experts, could be used to validate the target or its components (see Appendix 1).

4.3 Conservation features used as attributes for the choice experiment

A key stage in designing a choice experiment is the selection of a set of attributes that will appear in the choice scenarios (Section 4.1). In economic terms, attributes are selected for inclusion in a choice experiment because it is known or hypothesised that they play a major role in the choice behaviour of interest (Louviere 2001). At a pragmatic level, a given set of attributes should (1) reflect public interests, (2) have a sound scientific basis, and (3) provide useful information to end-users.

For the purpose of this study, the attributes must be a set of conservation features located in the SWAE. Careful consideration must also be given to their scientific legitimacy, their relevance to the broader public, and their application to the systematic conservation planning process undertaken in the SWAE. Towards this end, a number of processes were used to inform the selection of attributes for the choice experiment. These included:

1. Expert workshops – as part of the systematic conservation planning process, a series of expert workshops were hosted by the SWAEI to assist with the identification of conservation features and the definition of associated targets. Each workshop had a different theme: these were based on asset classes (i.e. birds; vegetation; flora; inland water bodies; inland water species; mammals, reptiles and amphibians; invertebrates) and regional threats.
2. Public focus groups were conducted by Cleland and Rogers to describe and prioritise conservation features of public importance (Cleland and McCartney 2010).
3. A mediation process with members of the SWAEI Working Group was conducted by Cleland and Rogers to consider conservation features identified through the expert workshops and public focus groups (Cleland and McCartney 2010). This process lead to a short-list of conservation features.

Table 1: Definition of the conservation features that were selected as attributes for the SWAE choice experiment.

Conservation features selected as attributes	Description of attribute status quo in survey	Attribute representation in choice scenario	Attribute Reference	Attribute Levels*
Critical vegetation associations	Critical vegetation associations in the Ecoregion have 10% of their current extent contained within the reserve system	Percentage contained within reserves	Veg	10%, 30%, 50%
Threatened species	Representative threatened species in the Ecoregion have 50% of their known populations contained within the reserve system	Percentage of populations contained within reserves	Threat	50%, 60%, 70%
Endemic species	Representative endemic species in the Ecoregion have 50% of their known populations contained within the reserve system	Percentage of populations contained within reserves	End	50%, 60%, 70%
Wetlands	Of the Ecoregion's 65 nationally important wetlands, 20 are fully contained within the reserve system	Number of nationally important wetlands fully contained within reserves	Wet	20, 30, 40
Estuaries	Of the Ecoregion's 8 largely unmodified estuaries, 5 are fully contained within the reserve system	Number of largely unmodified estuaries fully contained within reserves	Est	5, 6, 7

*The first level in each case refers to the status quo or baseline level.

The list of attributes derived through the mediator process was then altered slightly, based on the availability of data required to sufficiently define attributes, with the final set of attributes listed in Table 1. The conservation features were all defined according to their current representation within the reserve system (i.e. see second column in Table 1). This is useful in the sense that it can provide input into decisions for expanding the reserve system.

4.4 Survey and experimental design

The survey contained three main sections: (1) respondents were given background information about the SWAE and its conservation status, asked questions regarding their familiarity with the ecoregion, and provided with the attribute descriptions; (2) the choice experiment followed, along with debriefing questions relating to certainty of choices and believability of the survey; and (3) socio-demographic questions were asked.

Within the public sample there was a split in the survey in terms of whether the attribute descriptions included information about scientific limitations. That is, for each of the attributes there are particular scientific uncertainties due to a lack of data or understanding, and this information may impact on an individual's choices. There is an emerging literature with respect to the certainty or risk associated with achieving a particular outcome in a choice experiment (e.g. see Rolfe and Windle 2010). There has been a tendency to model certainty explicitly by including it as an attribute. Here, we take the implicit approach of including uncertainty in the attribute description given that each attribute is unique in terms of its specific scientific uncertainties, making it difficult to treat the issue uniformly as an attribute. The sample was randomly split in half and directed to the attribute descriptions that did/did not include the scientific limitations information. The scientist sample received the survey version that included the scientific limitation descriptors as this was considered the most comprehensive version.

The choice scenarios contained four alternatives – three conservation options and a status quo (Figure 3). Members of the public received eight choice sets in total, while the scientists received 15 (the larger number of choice sets was necessary based on the smaller scientist sample size, and considered appropriate based on their cognitive capacity). The designs were generated in Ngene 1.0.1 (Rose *et al.* 2008). For the public, a 32 choice set Bayesian D-efficient design, blocked by a factor of four, was generated, with a D-efficiency of 80.38%. The scientist design was estimated to maximise S-efficiency (i.e. to minimise the required sample size) using a 30 choice set design, blocked by a factor of two (see Scarpa and Rose 2008 for a description of S-efficiency). It was estimated that 19 full replicates (38 individuals) would be required, with a D-efficiency of 64.18%.

Within the experimental designs a two-way interaction was specified between the threatened species and endemic species attributes. A large number of flora and fauna species within the ecoregion are both threatened and endemic to the region. Thus, it was anticipated that individuals may envisage a relationship between these two attributes, perhaps considering that by protecting one of them they are partially protecting the other.

Conservation Scenario 1: Consider the following options (looking down each column).
Assuming these are the only options available to you, choose your most preferred option.
Keep in mind what you can afford when weighing up the cost of each option.
Treat this scenario independently from any other scenarios you will consider on subsequent screens.

	Option 1 Status Quo	Option 2	Option 3	Option 4
CRITICAL VEGETATION ASSOCIATIONS Percentage contained within reserves	10%	50%	30%	10%
THREATENED SPECIES Percentage of populations contained within reserves	50%	60%	60%	50%
ENDEMIC SPECIES Percentage of populations contained within reserves	50%	60%	70%	50%
WETLANDS Number of nationally important wetlands fully contained within reserves	20	20	30	40
ESTUARIES Number of largely unmodified estuaries fully contained within reserves	5	5	7	6
COST $'s per year	0	$100	$150	$200
Please choose your most preferred option	○	○	○	○

Figure 3: An example of a choice scenario used in the SWAE survey.

4.5 Survey administration

The surveys were designed for web-based administration using the program Sensus 4.2 (Sawtooth Technologies 2006). The public survey was administered in November 2010 by a market research company, The Online Research Unit. A representative sample was drawn of the Western Australian (WA) community based on gender and age demographics by randomly inviting members of their online panel to participate in the survey. The invitation email stated that the survey was about a 'local issue' (rather than noting the SWAE subject) to minimise self-selection bias. Of 21,635 invitations sent, 901 individuals responded[10], with 528 completing the survey in full (59% completion rate).

The scientist sample was administered during November-December 2010. The scientist sample was established via web searches of relevant institutions (universities, government departments, etc.) for experts associated with the ecoregion, and through the participant list for the SWAEI target setting workshop. Of 140 invitations sent, 63 responded (response rate of 45%) and 49 of those completed the survey (completion rate of 78%).

[10] Note that although this appears to be a small response rate, it does not account for invitations that may have ended up in junk mail boxes, or invitations that were opened after the survey quota was already fulfilled (which typically happens within a couple of days).

5. Results

This section reports the choice experiment results. First, general sample statistics are provided; second, the modelling approach is discussed in terms of defining appropriate base models given the various experimental characteristics; and, third, the final models for the public and scientist samples are presented. The data were analysed using Stata 11 (StataCorp 2009).

5.1 General Statistics

This section presents observational statistics, including choice frequency of alternatives in the choice scenarios and respondents' general reactions to the survey. The usable sample size, after removing subjects that only partially completed the survey and other anomalies, was 49 for the expert sample; 519 for the public sample – 252 in the version without scientific limitations described, and 267 in the version with scientific limitations included in the attribute descriptions (see Section 4.4).

Within the public survey there was a sample split dependent on whether respondents were presented with information about scientific limitations or not. The scientist sample received the most complete version of the survey that included the scientific limitation information. Respondents were asked what they thought about the information provided, with responses reported in Table 2. The responses show that the majority thought the survey was informative and accurate in terms of information content. Overall, there was very little difference in reaction to the survey across the sample splits.

Table 2: Respondents thoughts regarding the information that was provided to describe the biodiversity of the SWAE, by survey split.

Adequacy of information provided:	Public No Limitations	Public Limitations	Scientist Limitations
Thought it was an informative and accurate description	75%	69%	67%
Would have liked more information	15%	19%	22%
Thought the descriptions were inaccurate	2%	2%	6%
Thought it was confusing	8%	10%	4%

Respondents were asked to consider whether or not they thought that public preferences were relevant in terms of conserving biodiversity in the SWAE. Both the public and scientist samples, for the majority, thought that community preferences were relevant in helping to inform conservation decisions for the region, although the public sample exhibited this preference more strongly than the scientist sample (Table 3).

Table 3: Suitability of public respondents providing individual preferences for conserving biodiversity in the SWAE, rather than leaving these sorts of decisions to be made solely by experts.

Provision of individual preferences	Public	Scientist
Thought public preferences were relevant	81%	67%
Thought these decisions should be dealt with by experts	19%	33%

The choice frequencies across alternatives in the choice scenarios are indicative of respondents preferring to select programs with conservation benefits more often than opting for the status quo (Table 4). The scientists exhibited a strong inclination towards the conservation programs, only choosing the status quo option 2% of the time – a considerably lower frequency than the public's 17%. Choice frequencies were, relatively, more consistent between the public and scientists for alternatives two to four.

Table 4: Choice frequency of each alternative by target population.

Alternative	Public	Scientist
1 (status quo)	17%	2%
2	30%	36%
3	30%	32%
4	23%	30%

Approximately 10% of public respondents chose the status quo on *every* choice occasion. The scientists always chose conservation programs at least once. For those members of the public that always chose the status quo, the most common reason was because they could not afford to opt for the conservation programs (Table 5). Preferring the status quo option over others and believing the conservation funds should come from somewhere else were also common reasons.

Of respondents always choosing the status quo option, 4% indicated that the reason was because they did not believe that they should have to make these sorts of conservation choices (Table 5). Of these individuals, all had previously indicated that they thought experts should be making these kinds of decisions (Table 3 above), showing internal consistency of responses.

Table 5: Reasons for choosing the status quo option for those respondents that chose it on every occasion (n=52).

Reason for always choosing the status quo option	Percentage
Preferred the status quo to all others	19%
Could not afford the other options	33%
Believed funding to protect the waterways and wetlands of the Kimberley/biodiversity in the SWAE should come from somewhere other than their own pocket	31%
Did not think that the waterways and wetlands of the Kimberley/biodiversity in the SWAE needs further protection	8%
Did not believe they should have to make these choices	4%
Other	6%

5.2 Modelling approach

Before investigating whether socio-demographic factors are significant contributors in explaining preferences, a number of items in the experimental design must be addressed to determine the most appropriate 'base model' to which covariates can then be introduced. That is:

- The impact of the scientific limitation information in the public samples must be considered;
- The potential for heterogeneous preferences between the public and scientist samples must be investigated;
- The significance of the two-way interaction term imposed on the experimental design must be examined.

The following subsections address each of these issues in turn, resulting in appropriate base models that can then be defined further with the introduction of socio-demographic information. Note that the regression statistics for the various models discussed in this subsection are omitted in most cases (with the exception of log likelihood statistics) with reporting of more complete results reserved for the final models in Section 5.3. Also note that, for the ML models discussed, a random parameter is specified for the alternative specific constant (ASC) only. The ASC represents the marginal utility associated with the status quo option. Given the large experimental design, and the potential for correlations to exist between parameters (e.g. if an individual values one level of an attribute positively, they are also likely to value the other level(s) of the attribute positively), it was considered that the number of permutations possible would make a full random parameter model difficult to establish.

Scientific limitations

The first step in the analysis was to investigate whether the inclusion of scientific limitation information had an overall impact on public preferences. Using ML estimation, basic models were used to establish whether it was acceptable to pool the public split samples. The basic models included the attribute, cost, random ASC, and two-way interaction (i.e. between threatened and endemic species) parameters. A joint test restricting both utility parameters and the scale parameter was conducted. The likelihood ratio test statistic for the pooled versus separate samples is 22.76, accepting the restriction to pool the samples (Table 6). Thus, subsequent analysis of the results uses the full public sample dataset.

As noted in Section 4.4, an implicit approach was used to define scientific limitations within the attribute descriptions. Although this approach was justified given the uniqueness of limitations associated with each attribute, it is possible that this method is ineffective for delivering this type of information. Had it been possible to use an explicit approach, such as introducing a limitations attribute in the choice experiment, there may have been a significant reaction to the information.

Public and scientist preferences

The next step in the analysis was to consider whether preference heterogeneity existed between the public and scientist samples. Once more using ML basic models, a likelihood ratio test was used to determine whether the public and scientist samples could be pooled. A likelihood ratio test statistic of

107.60 rejects the restriction to pool the data (Table 6). However, this test assumes that the variance is equal across samples. To account for the possibility that preferences may be homogeneous once accounting for any differences in sample variance, the grid search method was used to allow the scale parameter to vary across samples (see Swait and Louviere 1993 for an explanation of the grid search method). For the public sample λ was held equal to one, and for the scientist sample an optimal fit was found with λ=1.09. Allowing for this difference in scale (i.e. by rescaling the scientist sample coefficients by 1.09), the likelihood ratio statistic is 106.60, once again suggesting that the public and scientist datasets cannot be pooled and heterogeneity in preferences exists (Table 6).

Table 6: Log likelihood ratio test statistics for the model formation tests on the public and scientist datasets.

Unrestricted log likelihood	Restricted log likelihood	Likelihood ratio*	Degrees of freedom; χ^2 critical value (p=0.05)	Outcome of restriction
Scientific limitations test				
Public without limitations LL + public with limitations LL: -4175.49	Pooled LL: -4186.87	22.76	17; 27.59	*Accept*
Public and scientist test				
Public LL + Scientist LL: -4894.01	Pooled LL: -4947.81	107.60	17; 27.59	Reject
Public and scientist test with public λ=1; scientist λ=1.09				
Public LL + Scientist LL: -4894.01	Pooled LL: -4947.31	106.60	16; 26.30	Reject
Public two-way interaction test				
With two-way LL: -4186.87	Without two-way LL: -4192.61	11.48	4; 9.49	Reject
Scientist two-way interaction test				
With two-way LL: -707.14	Without two-way LL: -708.23	2.18	4; 9.49	*Accept*
Public ML model with covariates (final model) and ML base model test				
ML with covariates LL: -4099.53	ML base LL: -4186.87	174.68	29; 42.56	Reject
Scientist ML model with covariates and ML base model test				
ML with covariates LL: -655.95	ML base LL: -708.23	104.56	21; 32.67	Reject
Scientist covariate models ML and MNL (final model) test				
ML LL: -655.95	MNL LL: -655.95	0.00	1; 3.84	*Accept*

*Likelihood ratio defined as 2(unrestricted log likelihood – restricted log likelihood).

Two-way interaction: threatened and endemic species

A two-way interaction term was included in the experimental design with the anticipation that individuals may have formed a relationship between the threatened and endemic species attributes given the similarities in the attributes' conservation approach as defined in the survey, and the real overlap between them[11]. To establish whether the interaction parameters significantly contributed to

[11] That is, a large proportion of endemic species are also listed as threatened species (D. Witham *pers. comm.* 2010).

explaining preferences for these attributes, models that included the attributes, cost, random ASC and two-way interaction parameters were compared to models that excluded the two-way interaction parameters (but were equivalent in all other respects). For the public, a ratio statistic of 11.48 suggests that the model cannot be restricted to exclude the interaction terms; for the scientists, a ratio statistic of 2.18 implies that the restriction is acceptable and the interaction term does not significantly explain preferences for the threatened and endemic species attributes (Table 6).

Resulting base models

The above investigations result in two ‘base models’. Each model contains the attribute and cost parameters, and a random ASC parameter. The public sample base model is further defined with two-way interaction parameters for the threatened and endemic species attributes, and pooled data for the split samples that did/did not include scientific limitation information. The scientist sample base model differs in that it does not include the two-way interaction between threatened and endemic species. The regression output for the public and scientist base models are presented in tables 8 and 9, respectively, and are developed further in the next section.

5.3 Final models

With the scientist and public base models defined, attention was turned towards establishing if any supporting questions in the survey helped to explain preference heterogeneity. For each base model, a number of steps were used to generate final models that included socio-demographic variables. First, the supporting questions from the survey were tested for correlations amongst each other – no strong correlations were found. Second, using MNL estimation for the base models (to allow for a more expedient estimation time) socio-demographic variables were introduced one at a time (and separately) into the models, interacted against parameters where it was *a priori* expected that they may have an impact on preferences. Third, for each of the scientist and public models, the covariates that were separately significant were then all included into the model together (again using MNL estimation), with those that became insignificant dropped from the model.

The resulting models were repeated using ML estimation, with any covariates that became insignificant dropped. A likelihood ratio test was then performed to confirm whether the ML model with covariates was the most appropriate model form, or if the base model was sufficient (see Table 6). In both cases, the base models were rejected in favour of the more explanatory ML models with covariates included. The public ML model with covariates is the final model for the public sample, with the regression output presented in Table 8.

For the scientist sample, the standard deviation of the ASC parameter in the ML model with covariates was not significant. It is possible that the covariates included as interaction terms on the ASC explain heterogeneity sufficiently within the sample, eliminating the need for the random ASC parameter. As such, another likelihood ratio test was performed between the ML model (with covariates) and an MNL model without the random ASC specification (but equivalent in all other respect). With a likelihood ratio test statistic of 0.00, the MNL restriction is accepted (Table 6). This provides the final model specification for the scientist sample, with the regression output reported in Table 9.

Table 7 defines the covariates that appear in the final models. A general utility function can be specified for the models that follow. Utility (*U*) held by individual *n* over alternative *j* can be defined as (suppressing *j* subscript):

$$U_n = \beta_o ASC + \sum_{k=1}^{K} (\beta_k + \delta' z_n) x_k + \gamma x_2 x_3 + \beta_c COST + \varepsilon_n \qquad \text{Equation 7}$$

where:

β_o = ASC coefficient
k = the attributes from the set K{1=critical vegetation associations, 2=threatened species, 3=endemic species, 4=wetlands, 5=estuaries}
x_k = vector of attributes
β_k = the vector of marginal utilities of the attributes, x
$\delta' z_n$ = impact (δ') of socio-demographic variables (z_n) on the marginal utility of the attributes, x
$\gamma x_2 x_3$ = impact (γ) on the marginal utility of threatened species (x_2) and endemic species (x_3) as a result of the two-way interaction between them
β_c = marginal utility of the cost attribute
$COST$ = cost to respondent
ε_n = unobservable utility

The parameter associated with the ASC can be extended to include the impact of individual characteristics ($\delta' z_n$) and be normally distributed (η):

$$\beta_{on} = \beta_o + \delta' z_n + \eta \qquad \text{Equation 8}$$

Overall, the results indicate a positive preference for conserving biodiversity in the SWAE (tables 8 and 9). This is explained in more detail below with respect to the ASC and particular attributes. Experience related variables, such as activities undertaken and items reported to be of interest during visits to natural sites in the ecoregion, feature as important factors in explaining preference heterogeneity among both scientist and public individuals.

An interesting result is that in many cases significant positive preferences are only associated with the higher level of attribute conservation, when an attribute is not interacted with another variable (tables 8 and 9). This is true for both the public and scientist samples, with the exception of the endemic species attribute. This could indicate that the conservation targets in the study were not set high enough, or it may suggest a preference to protect all or nothing.

Table 7: Covariate descriptions for the public and scientist final models, with mean values noted where applicable.

Explanatory Variable	Description	Mean Public	Mean Scientist
Limitations	Limitations of the science described: 0=no; 1=yes	0.51	
Live	Live in ecoregion boundary: 0=no; 1=yes	0.92	
Ignore_$	Ignored the cost attribute while making choices: 0=no; 1=yes	0.30	
Certain	Certain of answers given in conservation scenarios: 0=no; 1=yes[a]	0.65	
Finance	Considered financial circumstances while making choices: 0=no; 1= yes	0.78	
Fund	Preferred method for funding protection of biodiversity in the ecoregion:		
	- Increase in taxes: baseline	0.17	
	- Reallocation from existing government budget: Fund_2	0.56	
	- Money collected from fundraising: Fund_3	0.08	
	- User fees for recreational sites in the south west: Fund_4	0.13	
	- Higher prices for goods and services associated with the south west: Fund_5	0.02	
	- Other: Fund_6	0.05	
Policy	Think results of study will influence policy: 0=no; 1=yes[a]	0.30	0.10
Scenic	Scenic vantage points were of interest during a visit[b]: 0=no; 1=yes	0.53	0.57
Bushwalk	Bushwalking was an activity undertaken during a visit[b]: 0=no; 1=yes	0.40	
Photography	Photography was an activity undertaken during a visit[b]: 0=no; 1=yes	0.34	
Relax	Relaxing and taking in the scenery was an activity undertaken during a visit: 0=no; 1=yes	0.69	0.69
Ignore_W	Ignored the wetlands attribute while making choices: 0=no; 1=yes	0.05	
Visit	Visited natural sites (beaches, nature reserves, bushland sites, estuaries, waterways or wetlands) within the ecoregion in the last 12 months: 0=no; 1=yes	0.82	
Wildflower	Wildflowers were of interest during a visit[b]: 0=no; 1=yes		0.57
Wildlife	Wildlife was of interest during a visit[b]: 0=no; 1=yes		0.65
Lake	Lakes or wetlands were of interest during a visit[b]: 0=no; 1=yes		0.45
Fishing	Fishing was an activity undertaken during a visit[b]: 0=no; 1=yes		0.18
Ecosystem	Spend 50% or more of time researching ecosystem processes: 0=no; 1=yes		0.41
Catchment	Spend 50% or more of time researching catchment processes: 0=no; 1=yes		0.33
Research	Research was an activity undertaken during a visit[b]: 0=no; 1=yes		0.59
Group	Belong to an environmental or conservation group: 0=no; 1=yes		0.59

[a]Based on an original scale of 1-10, where 10 is very certain. Responses of 1-6 were recoded as a no response, and 7-10 as a yes response.
[b]That is, a visit to beaches, nature reserves, bushland sites, estuaries, waterways or wetlands within the ecoregion in the last 12 months.

It is important to note that the cost coefficient in the scientist model is only weakly significant (at the 90% level of confidence) (Table 9). As a likely result of this, most of the scientist partworths are not significant, or at best are weakly significant (Table 10). This weak significance of the cost attribute may be reflective of the small sample size. However, it should be noted that in the McCartney (2011) study valuing the proposed Ngari Capes Marine Park, there was a larger expert sample size (n=89) of marine scientists and the cost coefficient was also only significant at the 90% level of confidence. Respecting the differences in design characteristics of the two studies, this may be indicative of experts not reacting to the cost attribute. This may be due to: (1) the bid amounts offered in the choice scenarios being too low in comparison to what scientists are actually willing to pay; (2) a lack of familiarity with the payment vehicle, given that scientists are more used to seeing environmental programs being funded through project budget allocations and other resources, rather than through private payments; or (3) the scientists were acting in a more familiar administrative role, and recommending conservation policies, rather than as a private individual (as they were instructed to in the survey).

For the purpose of comparing the public and scientist sample results, the regression output and partworths will be discussed in the context of each attribute, rather than by each model. To begin with, we discuss the general reaction towards biodiversity conservation with respect to the ASC.

Conservation preferences and the alternative specific constant

In both the public and scientist models, the ASC coefficient is significant and negative indicating a general preference for selecting the conservation alternatives over the status quo (tables 8 and 9). However, in the public ML model the significant standard deviation of the ASC suggests that the individuals who are approximately one positive standard deviation from the mean have a preference for maintaining the current situation. Noting that the MNL is an acceptable model form for the scientist data, it is possible that the scientists are less heterogeneous than the public with respect to their overall conservation preferences (although heterogeneity still exists with respect to particular attributes, as discussed below).

A number of interaction terms help to explain heterogeneity with respect to the ASC. Beginning with the public model (Table 8), we note that confidence factors played a role in explaining preferences. That is, individuals who were certain of the responses they gave in the choice scenarios, or believed the results of the study would influence policy, were more likely to select the conservation alternatives (*ceteris paribus*). It is likely that due to this confidence, in their own choices or the results having an impact, the respondents view the conservation options as being a realistic possibility and are thus more likely to select them over the status quo.

Noting that in Section 5.2 above, we discover that the inclusion of scientific limitations in the public sample did not result in significantly different models (implying homogeneous preferences); here we find a weakly significant impact of the limitations variable on the ASC (Table 8). Public individuals who were made aware of the scientific limitations associated with each attribute are more likely to opt for the status quo than other individuals (all else held constant). This result can be expected since these better-informed individuals may now view the conservation outcomes with less certainty.

Public individuals who live within the ecoregion prefer to conserve more than other individuals, all else held equal (Table 8). This could be because individuals living within the ecoregion hold both use and non-use values, making their aggregate preference for conservation greater, while individuals living outside of the ecoregion may only hold non-use values.

Table 8: ML results for the public final model, with covariates, and base model.

Variables	**Final model mean (standard error)**		**Base model mean (standard error)**	
ASC	-4.863***	(1.259)	-4.092***	(0.497)
ASC standard deviation	*5.313****	*(0.467)*	*-6.010****	*(0.535)*
ASC*limitations	1.036*	(0.587)		
ASC*live	-1.923**	(0.783)		
ASC*ignore_$	-1.727***	(0.656)		
ASC*certain	-2.407***	(0.660)		
ASC*finance	2.129***	(0.691)		
ASC*fund_2	3.207***	(0.905)		
ASC*fund_3	4.384***	(1.041)		
ASC*fund_4	2.825**	(1.110)		
ASC*fund_5	7.220***	(2.760)		
ASC*fund_6	2.923	(1.865)		
ASC*policy	-1.463**	(0.668)		
Veg30	0.341***	(0.0994)	0.775***	(0.0543)
Veg50	0.793***	(0.0962)	1.234***	(0.0528)
Veg30*scenic	-0.247*	(0.129)		
Veg50*scenic	-0.150	(0.124)		
Veg30*bushwalk	0.484***	(0.118)		
Veg50*bushwalk	0.413***	(0.113)		
Veg30*photography	0.267**	(0.121)		
Veg50*photography	0.308***	(0.116)		
Veg30*relax	0.422***	(0.131)		
Veg50*relax	0.372***	(0.126)		
Threat60	-0.0724	(0.118)	-0.0326	(0.112)
Threat70	0.290***	(0.0960)	0.408***	(0.0873)
End60	-0.199*	(0.121)	-0.111	(0.113)
End70	0.00487	(0.0970)	0.0906	(0.0866)
Threat60*End60	0.201**	(0.101)	0.447***	(0.163)
Threat70*End60	0.435***	(0.115)	0.349**	(0.155)
Threat60*End70	0.301***	(0.110)	0.351**	(0.154)
Threat70*End70	0.393***	(0.124)	0.0781	(0.123)
Threat60*photography	0.0394	(0.108)		
Threat70*photography	0.323***	(0.111)		
End60*bushwalk	0.213**	(0.101)		
End70*bushwalk	0.183*	(0.102)		
Wet30	0.103	(0.0727)	0.175***	(0.0498)
Wet40	0.550***	(0.0763)	0.474***	(0.0552)
Wet30*scenic	0.182*	(0.0939)		
Wet40*scenic	-0.0726	(0.0937)		
Wet30*ignore_W	-0.436**	(0.204)		
Wet40*ignore_W	-0.660***	(0.227)		
Est6	0.0895	(0.114)	0.149***	(0.0471)
Est7	0.486***	(0.121)	0.261***	(0.0528)
Est6*visit	0.0770	(0.124)		
Est7*visit	-0.276**	(0.131)		
Cost	-0.00767***	(0.000403)	-0.00753***	(0.000400)
Log likelihood	-4099.53		-4186.87	

Notes: n=519; number of observations = 4152. The ASC is the status quo parameter.
***, **, * denotes significance at the 99%, 95% and 90% level of confidence, respectively.

Table 9: MNL results for the scientist final model, with covariates, and ML base model.

Variables	Final model mean (standard error)		Base model mean (standard error)	
ASC	-4.744***	(1.195)	-3.486***	(1.261)
ASC standard deviation			*2.393****	*(0.719)*
ASC*policy	2.094**	(0.929)		
ASC*ecosystem	2.571***	(0.842)		
ASC*catchment	3.032***	(0.897)		
Veg 30	0.416	(0.261)	0.991***	(0.147)
Veg 50	0.459**	(0.224)	1.615***	(0.132)
Veg30*scenic	0.0553	(0.299)		
Veg50*scenic	0.888***	(0.263)		
Veg30*relax	0.954***	(0.307)		
Veg50*relax	1.198***	(0.267)		
Threat 60	0.163	(0.291)	0.269*	(0.147)
Threat 70	0.852***	(0.289)	0.331**	(0.144)
Threat 60*wildflower	-0.191	(0.245)		
Threat70*wildflower	-0.650**	(0.257)		
Threat60*research	-0.181	(0.247)		
Threat70*research	-0.892***	(0.263)		
Threat60*group	0.552**	(0.248)		
Threat70*group	0.636**	(0.262)		
End 60	-0.341	(0.220)	0.100	(0.144)
End 70	-0.0372	(0.207)	0.259**	(0.130)
End60*wildlife	0.707***	(0.253)		
End70*wildlife	0.502**	(0.249)		
Wet30	0.180	(0.185)	0.314**	(0.145)
Wet40	0.716***	(0.161)	0.905***	(0.128)
Wet30*lake	0.455*	(0.272)		
Wet40*lake	0.627***	(0.239)		
Est6	0.295	(0.179)	0.268**	(0.134)
Est7	0.345**	(0.163)	0.424***	(0.123)
Est6*lake	0.321	(0.277)		
Est7*lake	0.518**	(0.239)		
Est6*fishing	-0.671*	(0.350)		
Est7*fishing	-0.546*	(0.305)		
Cost	-0.00202*	(0.00122)	-0.00168	(0.00118)
Log likelihood	-655.95		-708.23	

Notes: n=49; number of observations = 735. The ASC is the status quo parameter.
***, **, * denotes significance at the 99%, 95% and 90% level of confidence, respectively.

Respondents in the public sample who ignored the cost attribute (i.e. a case of self-reported attribute non-attendance) held stronger preferences for conservation programs than other respondents, while those who considered their financial circumstances were more likely to opt for maintaining the current situation (*ceteris paribus*) (Table 8). These results are intuitive, in that those individuals not paying attention to the cost attribute are not bound by a budget constraint and therefore have the freedom to select conservation programs with no personal financial consequence. On the other hand, individuals considering their personal finances are more likely to pay attention to the payment amounts and may be more likely to select the status quo when the conservation options are costly.

Following the choice task, respondents were asked what their preferred method for funding biodiversity conservation improvements in the SWAE would be. Public individuals who preferred funding methods other than an increase in income taxes (which was the payment vehicle specified in the choice experiment) held stronger preferences for maintaining the current situation than other individuals, all else held equal (Table 8). Thus, individuals who object to the payment vehicle act accordingly by opting out of conservation programs.

In the scientist model, three interaction terms were significant in explaining preference heterogeneity associated with the status quo (Table 9). Individuals who believe the results of the study will influence policy are more likely to select the status quo than other individuals (*ceteris paribus*). Individuals were also more likely to prefer the current situation over conservation improvements if they spend more than half of their time researching either ecosystem or catchment processes (Table 9).

Critical vegetation associations

The critical vegetation associations attribute was, overall, the most highly valued attribute by both the public and the scientists, as seen by the attribute weightings (tables 8 and 9) and the WTP values for the public (Table 10). For the scientists, this result is rationalised by the likelihood that attributes, such as critical vegetation associations, would be preferred based on their ecosystem functionality, for example, provision of habitat and connectivity. For public individuals, their alignment with the scientists for this attribute could be due to recognition of the attribute's functionality, or it could be an association with images of a 'leafy environment' that is driving preferences. For example, increasingly retirees are moving away from major cities for a 'tree change'.

Several significant covariates explain preference heterogeneity associated with critical vegetation associations. In both the public and scientist models, a significant interaction occurred if scenic vantage points were of interest to individuals during a visit to the SWAE (tables 8 and 9). However, the reaction was not the same between the samples. At a level of 50% protection of critical vegetation associations, scientists who were interested in scenic vantage points tended to view vegetation conservation more positively than other individuals, while public individuals who were interested in scenic vantage points held weaker conservation preferences for critical vegetation associations at the 30% protection level (*ceteris paribus*). One can assume that, in the scientists' case, the interest in scenic vantage points from which vegetation can be viewed enhances their value for the attribute. However, for the public the result is not easy to understand. It is possible that the 'coastal-centricity' of the WA community is responsible for this result. That is, since most activity occurs along the coastal regions of the State, vantage points may be associated with the coastal sand dunes and scrubby vegetation (e.g. Banksia woodland), as opposed to the more vibrant inland forests (e.g. Karri forests).

If individuals enjoyed relaxing and taking in the scenery during a visit to the SWAE, their preferences for conserving critical vegetation associations were more positive than other individuals, all else held equal (tables 8 and 9). This is true for both public and scientist individuals. This result suggests that experience related factors result in individuals valuing attributes more highly. This theme is continued for public respondents if bushwalking or photography were activities undertaken during a visit to the SWAE, where WTP for critical vegetation associations was higher than for other individuals (Table 10). For critical vegetation associations, the bushwalking individuals had higher WTP values relative to all other public WTP values.

Table 10: Partworths (dollars per year) for the public and scientist final models.

Attribute	Public $'s		Scientist $'s	
Critical vegetation associations - % contained within reserves	**30%**	**50%**	**30%**	**50%**
Willingness to pay	45***	103***	206	228
- If scenic vantage points were of interest during visit	12	84***	234	668
- If bushwalking was undertaken during visit	108***	157***		
- If photography was undertaken during visit	79***	144***		
- If relaxing and taking in the scenery was undertaken during visit	100***	152***	678	822
Threatened species - % of populations contained within reserves	**60%**	**70%**	**60%**	**70%**
Willingness to pay	-9	38***	81	422
- If wildflowers were of interest during visit			-14	100
- If photography was undertaken during visit	-4	80***		
- If research was undertaken during visit			-9	-20
- If belong to an environmental/conservation group			355	738*
Endemic species - % of populations contained within reserves	**60%**	**70%**	**60%**	**70%**
Willingness to pay	-26*	1	-169	-18
- If wildlife was of interest during visit			181	230*
- If bushwalking was undertaken during visit	2	25*		
Wetlands - number of nationally important wetlands fully contained within reserves	**30**	**40**	**30**	**40**
Willingness to pay	13	72***	89	355*
- If scenic vantage points were of interest during visit	37***	62***		
- If lakes or wetlands were of interest during visit			314*	666*
- If ignored the wetland attribute	-43	-14		
Estuaries - number of largely unmodified estuaries fully contained within reserves	**6**	**7**	**6**	**7**
Willingness to pay	12	63***	146	171
- If visited natural sites in the last 12 months	22***	27***		
- If lakes or wetlands were of interest during visit			305	428
- If fishing was undertaken during visit			-187	-99

Note: ***, **, * denotes significance at the 99%, 95% and 90% level of confidence, respectively.

Threatened and endemic species

Although threatened and endemic species are separate attributes, it was anticipated that there may be an interaction between them and hence they are discussed jointly. Indeed, for public individuals, the interaction between the two attributes explains preferences to a large extent. The results are perhaps most easily interpreted by the partworths (Table 11). Focussing on instances where there are no socio-demographic variables involved, it appears that the main driver for ascribing value to these attributes is for the threatened species attribute to be conserved at its highest level (70%). All WTP values are significant at this level, regardless of the level of endemic species. In fact, respondents are only willing to pay to protect threatened species at its maximum conservation level, so it is a case of protecting all or nothing. Public individuals still react to the endemic species attribute to an extent, as can be observed by the WTP amounts increasing as endemic species protection increases beyond the status quo level (whilst holding threatened species protection constant at the 70% conservation level).

Table 11: Partworths (dollars per year) for the public final model two-way interaction between the threatened and endemic species attributes.

Endemic Species **Threatened Species**	**50%**	**60%**	**70%**
50%	n/a	-26*	1
60%	-9	-9	4
70%	38***	95***	90***

Note: ***, **, * denotes significance at the 99%, 95% and 90% level of confidence, respectively.

For the scientists, the two-way interaction between the threatened and endemic species attributes is not a significant explanatory factor and is excluded from the model (see Section 5.2). It is worth relating this result to the investigation into public and expert attribute definition, discussed in Cleland and McCartney (2010). In this linked qualitative study, we had a matching focus on conserving biodiversity in the SWAE. The experts in the study defined separate attributes to describe threatened and endemic species (e.g. rare and threatened species versus centres of endemism and short-range endemics), while the public focussed on a broader categorisation of 'native animals and plants'. This definition process is reflective of what the results show here: the public see a relationship between the two categories, as recognised by the importance of the two-way interaction coefficients; the experts see the two categories as separate. It is possible that the public are unable to discern between the threatened and endemic species, either due to a lack of information or understanding, or because they have a true preference to conserve all concerned species.

Not only is the two-way interaction redundant for scientists, but there is no significant preference for conserving the endemic species attribute, if wildlife was not a point of interest during a visit, or the 60% level of threatened species, unless they belong to an environmental group (Table 9). Here, the preference to only conserve threatened species (i.e. at the 70% level of protection) may relate to the principle that conservation efforts should be focussed, in the first instance, on attributes that are most at risk (Cleland 2008). Threatened species, by definition are at a disproportionate risk to loss in the future (Bonn *et al.* 2002)[12]. This worst-first approach has dominated responses to river restoration and salinisation in Australia, replaced only in recent times by responses with a greater focus on feasibility and cost-effectiveness (Cleland 2008). It could also be that the scientists are reacting emotively, with a preference to conserve threatened species before they are lost forever. A general lack of scientific knowledge regarding endemics in Western Australia could also be a contributing factor for apportioning more weight to threatened species protection.

For the public sample, experience related variables once again played a role in explaining preference heterogeneity (Table 8). Individuals who undertake photography in the ecoregion hold stronger preferences for protecting threatened species at the maximum level of conservation, and individuals who bushwalk in the ecoregion hold stronger preferences for endemic species conservation (all else the same). For the scientist sample, a similar positive influence on preferences for conserving endemic species is seen with respect to individuals who noted wildlife as being a point of interest during a visit to the SWAE (Table 9).

Scientists also hold stronger positive preferences for conserving threatened species if they belong to an environmental or conservation group (*ceteris paribus*) (Table 9). This result is to be expected given that such individuals are likely to have a stronger set of pro-conservation attitudes than other individuals. Indeed, one of the few (weakly) significant, and the largest, WTP values at $738 is associated with scientists belonging to environmental/conservation groups for the maximum level of threatened species protection (Table 10).

Weaker preferences are noted for the 70% level of threatened species conservation for scientists that have undertaken research in the ecoregion, or noted wildflowers as a point of interest during a visit, all else held equal (Table 9). These individuals, with their combined scientific and ecoregion experiences, may be conveying that there is a ‘bigger picture’ in terms of protecting (or focussing on) more than just threatened species. Or, since these interactions are only significant on the maximum level of protection, they may be suggesting that this level of conservation is not as cost-effective. For example, Montgomery *et al*. (1994) find that the marginal cost of each additional unit of protection of the Northern Spotted Owl in the United States rises dramatically after a certain point.

Wetlands

Notably, the wetlands attribute retrieves three of the five (weakly) significant WTP values for the scientists (Table 10). Scientists are willing to protect wetlands at the maximum level of conservation (40 nationally important wetlands fully contained within reserves), and, intuitively, at both the maximum and lower level (30 wetlands contained) if lakes or wetlands were a feature of interest during a visit to the ecoregion. The importance of the wetlands attribute to scientists may be in recognition of the key role that these water bodies play in the dry WA climate, that is, wetlands are an important form of refugia for animal and plant biodiversity (Environmental Protection Authority 2001).

[12] Endemics species, which are commonly geographically restricted, may also be at risk from stochastic events (Bonn *et al.* 2002).

For the public, wetlands are again valued positively at their highest level, and at both levels of protection if scenic vantage points were of interest during a visit to the SWAE (Table 10). If individuals ignored the wetlands attribute (i.e. self-reported attribute non-attendance), they had significantly weaker preferences for conserving it, relative to other individuals, and were not willing to pay to protect it (tables 8 and 10).

Estuaries

Public individuals positively valued estuary conservation at its highest level (seven unmodified estuaries contained within reserves) (Table 8), and were willing to pay to protect estuaries at both the low and high level of conservation if they had visited natural sites within the ecoregion in the past 12 months (Table 10). However, WTP for the highest level of protection was lower if the individual had visited ecoregion sites (all else held equal). One can speculate that it is possible these individuals have visited popular estuary locations such as the Swan River estuary or the Peel-Harvey estuary, which are located close to Perth's main population base. Although in certain spots their appearance may be natural, these particular estuaries have been modified to a large extent, and as a result of anthropogenic influences they occasionally suffer from eutrophication and other associated problems (e.g. algal blooms) that detract from the estuary's overall appeal (e.g. the estuary may be closed off for a length of time, fish kills can result, the water may lack clarity, and it may smell pungent). If individuals are relating the condition of the popular modified estuaries near Perth to the unmodified estuaries within the ecoregion, then it may explain the weaker affinity for protecting them.

The scientists also exhibit a positive preference for conserving the maximum level of estuaries (Table 9). This effect is enhanced if the scientist noted that lakes or wetlands were of interest during a visit to the ecoregion, implying that these individuals consider water bodies to be of more value than the average individual. However, scientists that have undertaken recreational fishing activities within the SWAE have a weaker propensity to support estuary conservation than other individuals (all else the same). Interpreting this result is difficult as there are a variety of preferences tied up with recreational fishing that could be causing this outcome, for example, fishers may have different preferences for the quality/type of fish they like to catch; sheltered or open locations; boat or shore-based fishing; etc.

6. Key findings, implications and directions for further investigation

This paper aimed to investigate whether public and expert preferences for biodiversity conservation in the SWAE were divergent through the use of a choice experiment. We start by discussing the key results of the choice experiment and their implications. We then address the secondary purpose of the paper, that is, we propose a means by which public values elicited from a choice experiment can be incorporated into a systematic conservation planning framework, in the event that divergent preferences exist.

An identical choice experiment was applied to a sample of scientists and a sample of the WA community. A notable result was that the test to pool the two datasets was rejected, implying heterogeneity in preferences of the samples and clear evidence of divergence. Further differences between the samples are demonstrated through the two-way interaction term for the threatened and endemic species attributes. For the public sample, the two-way interaction was a significant specification in the choice model, while for the experts it was possible to remove the interaction term and treat threatened and endemic species as unrelated attributes. In an attribute definition exercise, Cleland and McCartney (2010) also find that the public tends to lump species into one category, whilst experts treat threatened and endemic species differently. Further confirmation for the expert result can be found in the SWAEI conservation planning exercise: for single species conservation targets there is a separate weighting in target formulae according to whether species are rare, threatened or endemic (WWF-Australia 2010, p. 21). As well as illustrating the differences between the public and experts, this consistency of the expert result across different forums is also useful in terms of validating the choice experiment results.

Preference divergence between the public and scientists is also noted with respect to the marginal values of the various attributes. Although both samples value critical vegetation associations highly, public individuals hold a more even spread of preferences for conserving the remaining attributes. Scientists, on the other hand, typically value both critical vegetation associations and wetlands more highly than the other attributes. This is likely due to the functional importance, from an ecosystem perspective, of these two particular attributes. This result is in line with the findings of Rogers and Cleland (2010) where scientists held stronger preferences for protecting the functional system-based attributes of the Kimberley's waterways and wetlands.

The SWAE case study results indicate a clear divergence in preferences between the public and experts with respect to biodiversity conservation. In this context, expert advice will not necessarily reflect the value judgements of the public, and the decisions made may result in conservation outcomes that do not optimise social welfare. As a result, expert-driven policy may require complementary public consultation measures if it is to be successful. For example, the non-market values derived from choice experiments could be incorporated into the systematic conservation planning process as a way to optimise social welfare.

Here, we offer an example of how the results from a choice experiment could be used to include a social value component in target setting formulae. We are not limited to assigning the same social value weighting to all conservation features; rather we can differentiate the weighting according to how the conservation features are valued relative to one another. We can do this by utilising the coefficients generated from the choice experiment that indicate the relative values of a set of conservation features.

Note that the conservation features selected as attributes for the choice experiment do not exactly mirror the conservation features used as measures of biodiversity within the SWAEI planning exercise[13]. However, there are some synergies that can be used here for the purpose of illustration. One of the SWAEI conservation features is 'inland water features', for which a target formula is provided that suggests the maximum target for protection is 60% of inland water features (see Figure 2). In the choice

[13] That is, the choice experiment conservation features were designed to consider both public and expert interests as discussed in Section 4.3, while the SWAEI conservation features were selected solely by experts.

experiment, the wetlands attribute is reflective of inland water features. In particular, the maximum level of the wetland attribute in the experiment is 40 out of 60 (or 67% of) nationally important wetlands fully contained within reserves. Thus, the percentage of wetlands protected under the choice experiment scenario is (closely) comparable to the 60% of inland water features protected under the target formula.

Now, consider the coefficient for this level of wetland protection in the choice experiment (referring to the public base model that is not complicated by covariate inclusions): 0.474 (Table 8). If we rescale all attribute coefficients within Table 8 so that they range from 0 to 1 (instead of from -0.111 to 1.234[14]), then the wetland coefficient takes on a rescaled value of 0.384. We then use this value as a multiplier in determining a social value weighting for the target formula.

First, we set a maximum for the social value component. We have arbitrarily selected 15% for illustration; however, this would require careful consideration in an actual application. Then we multiply the rescaled marginal value for wetlands against the 15%. The result is a social value weighting of 5.762%. Figure 4 presents this as a worked example.

Conclusion

This study demonstrates that scientists and the WA community hold divergent preferences for biodiversity conservation in the SWAE. The implications of this finding are that conservation policy would benefit from considering public preferences, rather than relying solely on the technical advice of experts. That is, policy implementation would be more successful if it delivers an improvement in social welfare, and the impact on social welfare can be better understood by undertaking broad and representative methods of public consultation. A choice experiment offers a means by which we can do this.

The choice experiment in this study elicits values for conservation features in the SWAE. We propose a novel approach for how the resulting non-market values can then be applied within a systematic conservation planning framework, by including a social value weighting in the formulae used to set conservation targets. This approach allows for explicit inclusion of a social welfare measure in conservation planning, which could ultimately lead to better decision making and policy. Refining this approach, and applying it empirically, is an area deserving of further research.

[14] Note that all insignificant coefficients are set equal to zero for the purpose of rescaling.

STEP 1: Expert derived conservation target for inland water features

Target for inland water features = Base 30% + Threats 15% + Functional importance 15%

Formula rationale:

- Base target of 30% water features to be protected
- An extra 15% if the features are considered to be threatened
- An extra 15% if the feature is identified by experts as being functionally important

Maximum target of 60% water features to be protected under the conservation plan

STEP 2: Estimate public value for inland water features via choice experiment

- Marginal value for (approximately) 60% protection of water features: 0.474
- Rescaled value for 60% protection of water features: 0.384

STEP 3: Add social value weighting to conservation target

- Set maximum social value weight: 15%
- Adjust social value weight: 15%*0.384 = 5.762%

Target for inland water features = Base 30% + Threats 15% + Functional importance 15% + ***Social value 5.762%***

Maximum target of 65.762% water features to be protected under the conservation plan

Figure 4: Worked example of how marginal values from a choice experiment can be included in the target setting process of systematic conservation plans to incorporate a social value component.

References

Bateman, IJ, Carson, RT, Day, D, Hanemann, M, Hanley, N, Hett, T, Jones-Lee, M, Loomes, G, Mourato, S, Özdemiroglu, E, Pearce, DW, Sugden, R and Swanson, J 2002, *Economic Valuation with Stated Preference Techniques: A Manual*, Edward Elgar, Cheltenham.

Biodiversity Assessment Working Group 2009, *Assessment of Australia's Terrestrial Biodiversity 2008*, report prepared by the Biodiversity Assessment Working Group of the National Land and Water Resources Audit for the Australian Government, Commonwealth of Australia, Canberra.

Bennett, J and Blamey, R (ed.) 2001, *The Choice Modelling Approach to Environmental Valuation*, Edward Elgar, Cheltenham.

Bonn, A, Rodrigues, ASL and Gaston, KJ 2002, 'Threatened and endemic species: are they good indicators of patterns of biodiversity on a national scale?', *Ecology Letters*, **5**: 733-741.

Carlsson, F, Kataria, M and Lampi, E 2008, ‘Do EPA Administrators Recommend Environmental Policies That Citizens Want?’, *Land Economics*, **87**(1): 60-74.

Cleland, JA 2008, *Western Australia’s Salinity Investment Framework: A Study of Priority Setting in Policy and Practice*, PhD thesis, University of Western Australia.

Cleland, J and McCartney, A 2010, ‘Putting the Spotlight on Attribute Definition: Divergence Between Experts and the Public’, *EERH Research Report*, **No. 77**, Environmental Economics Research Hub, Canberra.

Dudley, N and Stolton, S 2003, *Running Pure: The Importance of Forest Protected Areas to Drinking Water*, WWF, Glade.

Environment Australia 2011, Biodiversity Hotspots. Available from: <http://environment.gov.au/biodiversity/hotspots/index.html>. [13 November 2011].

Environmental Protection Authority 2001, *Environmental Protection of Wetlands, Position Statement No. 4*, Environmental Protection Authority, Perth.

Gole, C 2006, *The Southwest Australia Ecoregion Jewel of the Australian Continent*, Southwest Australia Ecoregion Initiative, Wembley.

Hajkowicz, SA, Higgins, A, Williams, K, Faith, DP and Burton, M 2007, ‘Optimisation and the selection of conservation contracts’, *The Australian Journal of Agricultural and Resource Economics*, **51**: 39-56.

Hanley, N and Spash, CL 1993, *Cost-Benefit Analysis and the Environment*, Edward Elgar, Cheltenham.

Hensher, DA, Rose, JM and Greene, WH 2005, *Applied Choice Analysis: A Primer*, Cambridge University Press, Cambridge.

Lewis, M 2007, *American Wilderness: A New History*, Oxford University Press, USA.

Louviere, JJ 2001, ‘Choice experiments: an overview of concepts and issues’, in *The Choice Modelling Approach to Environmental Evaluation*, eds J Bennett and R Blamey, Edward Elgar, Cheltenham, pp. 13-36.

Louviere, JJ, Hensher, DA and Swait, JD 2000, *Stated Choice Methods Analysis and Application*, Cambridge University Press, Cambridge.

Margules, CR and Pressey, RL 2000, ‘Systematic conservation planning’, *Nature,* **405**: 243-253.

McCartney, AA 2011, *The Policy Relevance of Choice Modelling: An Application to the Ningaloo and Proposed Capes Marine Parks*, PhD Thesis, University of Western Australia.

McFadden, D and Train, K 2000, ‘Mixed MNL Models for Discrete Response’, *Journal of Applied Econometrics*, **15**(5): 447-470.

Montgomery, CA, Brown, GM and Adams, DM 1994, ‘The Marginal Cost of Species Preservation: The Northern Spotted Owl’, *Journal of Environmental Economics and Management*, **26**: 111-128

Myers, N, Mittermeier, RA, Mittermeier, CG, da Fonseca, GA and Kent, J 2000, ‘Biodiversity hotspots for conservation priorities’, *Nature*, **403**(6772): 853-858.

NRSTG (National Reserve System Task Group) 2009, *Australia's Strategy for the National Reserve System 2009-2030*, Commonwealth of Australia, Canberra.

Prendergast, JR, Quinn, RM and Lawton, JH 1999, ‘The gaps between theory and practice in selecting nature reserves’, *Conservation Biology*, **13**(3): 484-492.

Pressey, RL 1999, ‘Editorial – systematic conservation planning for the real world’, *Parks*, **9**(1): 1-6.

Pressey, RL and Bottrill, MC 2008, ‘Opportunism, Threats, and the Evolution of Systematic Conservation Planning’, *Conservation Biology*, **22**(5): 1340-1345.

Pressey, RL, Cowling, RM and Rouget, M 2003, 'Formulating conservation targets for biodiversity pattern and process in the Cape Floristic Region, South Africa', *Biological Conservation*, **112**: 99 - 127.

Pressey, R L, Humphries, C J, Margules, C R, Vane- Wright, R I and Williams, P H 1993, ‘Beyond opportunism: key principles or systematic reserve selection’, *Trends in Ecology and Evolution,* **8***:* 124-8.

Pressey, RL, Watts, ME and Barrett, TW 2004, ‘Is maximizing protection the same as minimizing loss? Efficiency and retention as alternative measures of the effectiveness of proposed reserves’, *Ecology Letters*, **4**: 1035-1046.

Rogers, A and Cleland, J 2010, *‘*Comparing Scientist and Public Preferences for Conserving Environmental Systems: A Case of the Kimberley's Tropical Waterways and Wetlands’*, EERH Research Report*, **No. 80**, Environmental Economics Research Hub, Canberra.

Rolfe, J and Windle, J 2010, ‘Valuing protection of the Great Barrier Reef with choice modelling by management policy options’, *EERH Research Report*, **No. 57**, Environmental Economics Research Hub, Canberra.

Rose, JM, Collins, AT, Bliemer, MCJ and Hensher, DA 2008, *Ngene 1.0*, Statistical Software.

Sawtooth Technologies 2006, *Sensus 4.2*, Version 4.2.40, Questionnaire Authoring Software.

Scarpa, R and Rose, JM 2008, ‘Design efficiency for non-market valuation with choice modelling: how to measure it, what to report and why’, *Australian Journal of Agricultural and Resource Economics*, **52**(3): 253-282.

StataCorp 2009, *Stata*, Release 11, Statistical Software.

SWAEI, no date. *Conservation Planning Project: A Unique Approach*. Available from: <http://www.swaecoregion.org/conservation-planning-project>. [13 November 2011].

Swait, J 2006, ‘Advanced Choice Models’, in *Valuing Environmental Amenities Using Stated Choice Studies: A Common Sense Approach to Theory and Practice*, ed. BJ Kanninen, Springer, The Netherlands, pp. 111-133.

Swait, J and Louviere, J 1993, ‘The role of the Scale Parameter in the Estimation and Comparison of Multinomial Logit Models’, *Journal of Marketing Research*, **30**(3): 305-314.

Train, KE 2009, *Discrete Choice Methods with Simulation*, 2nd edn., Cambridge University Press, New York.

WWF-Australia, in print, *Regional Framework for the Conservation of Biodiversity in the Southwest Australia Ecoregion. Report A: For Decision-makers and Practitioners*, report prepared by WWF-Australia for submission to the Australian Government, Wembley.

WWF-Australia 2010, *A Strategic Regional Conservation Plan for Australia’s Global Biodiversity Hotspot: Phase 1 Report*, report prepared by WWF-Australia for submission to the Australian Government, Wembley.

WWF-Australia 2009, *Conservation Plan Aims to Save Australia’s Only Biodiversity Hotspot*. Available from: <http://www.wwf.org.au/news_resources/?1610/Conservation-plan-aims-to-save-Australias-only-biodiversity-hotspot>. [13 November 2011].

Appendix 1: Validating target setting with expert values

It is possible to design a choice experiment that would validate the target formulae used in systematic conservation planning. The experiment could validate (1) the maximum target values for a set of conservation features, and (2) the weightings of the components within the formulae.

See, for example, Figure A1 below illustrating the target formulae applied to two conservation features in the SWAEI conservation planning exercise: inland water features and granite outcrops. The same formula applies to each feature, indicating that the maximum target for conservation is equivalent, at 60%.

Conservation targets for inland water features and granite outcrops, with emphasis on maximum target value

Target for inland water features = Base 30% + Threats 15% + Functional importance 15%

Maximum target of 60%

Target for granite outcrops = Base 30% + Threats 15% + Functional importance 15%

Maximum target of 60%

Figure A1: Target formulae for inland water features and granite outcrops (WWF-Australia 2010).

The target formulae raise a number of important questions. First, should water features and granite outcrops have different maximum targets? In other words, is one considered more valuable to protect than the other? Second, should threatened and functionally important categories receive different weightings within the formula? That is, is a threatened feature more valuable than a functionally important one?

To validate the target formulae or attain information as to how they should be altered, a choice experiment using constructs similar to these could be designed:

- Attribute 1: conservation of inland water features; levels of 10%, 30%, 50%, 70% protected
- Attribute 2: conservation of granite outcrops; levels of 10%, 30%, 50%, 70% protected
- Attribute 3: threatened status for inland water features; levels of no, yes
- Attribute 4: threatened status for granite outcrops; levels of no, yes
- Attribute 5: functionally important status for inland water features; levels of no, yes
- Attribute 6: functionally important status for granite outcrops; levels of no, yes
- Design constructs: full factorial design allowing estimation of all interactions between attributes

With these attributes, we could estimate the marginal values at several points for inland water features and granite outcrops, enabling us to estimate a utility curve. By using a full factorial design, we can also establish how this curve may change depending on the status of the attribute (i.e. whether it is threatened, functionally important, or both). Figure A2 has been provided for further clarification, but it must be emphasised that it is for purely illustrative purposes. Here, we demonstrate that, although at the 30% level of protection the functionally important water feature has a higher value than granite outcrops, there is strong declining marginal utility associated with the former. This implies that at the 60% level of protection, granite outcrops are the more highly valued assets. In this example, we also see that water features have a higher value if they are threatened, than if they are functionally important. In such a case, equivalent weightings in the target formula would not reflect the actual values that experts assign at the margin.

Ideally, features should be protected such that, at the margin, marginal utilities are equalised. Outcomes from the proposed full factorial design would allow us to validate, or alter, the target formulae appropriately.

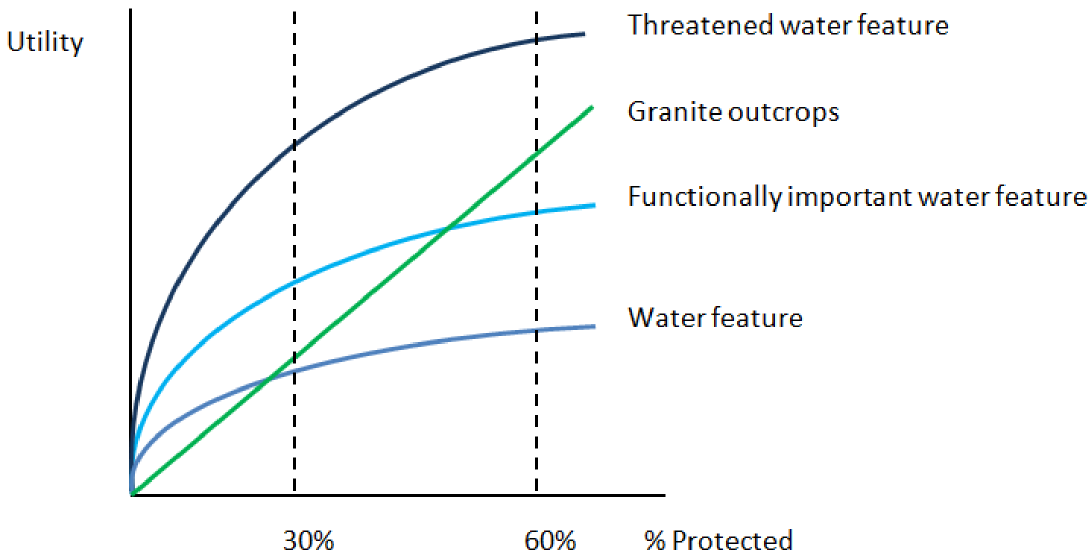

Figure A2: Illustrative example of relative marginal utilities for conservation features, which could be used in the setting of target formulae for conservation planning.