The inclusion of non-market values in systematic conservation planning to enhance policy relevance

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Abstract

The use of systematic conservation planning to establish conservation priorities will not necessarily attract sufficient public and policy support if the process does not explicitly consider public preferences. The Southwest Australia Ecoregion Initiative presented an opportunity to examine whether an expert-driven, systematic conservation planning process was likely to reflect public preferences for biodiversity conservation. Specifically, a discrete choice experiment was administered to both scientists and the public to generate non-market values for protecting a set of key conservation features, relevant to the planning exercise. The study demonstrates that conservation preferences differ between scientists and the public.

With this finding in mind, a novel approach is outlined for incorporating non-market values – derived from a choice experiment – into a systematic conservation planning framework.

Key words: choice experiment; non-market valuation; policy; public and expert preferences; social benefits; systematic conservation planning

1. Introduction

Systematic conservation planning (SCP) has been acknowledged for its effectiveness and efficiency in reserve network design (Margules and Pressey, 2000; Wilson et al., 2005; Wilson et al., 2009). It offers a structured approach that yields conservation priorities by combining the concepts of irreplaceability and vulnerability, whilst also considering complementarity, persistence and socio-economic constraints (e.g. Pressey and Taffs, 2001). Nonetheless, the widespread integration of SCP into planning policy and practice is yet to be realised (Prendergast et al., 1999; Knight, 2006).

Uptake may be adversely affected by a range of perceived limitations. Factors acknowledged to be genuine limitations on the broad application of SCP include: difficulties with the selection of conservation features and the setting of targets (Margules and Pressey, 2000; Smith et al., 2006); the need for better consideration of the costs of conservation (Hermoso et al., 2010); and the need for greater involvement of stakeholders, particularly in the early stages of the planning process (Pierce et al., 2005; Smith et al., 2006; Maiorano et al., 2008).

The last two of these limitations begin to address the issue of accounting for public preferences and social costs – issues that are of paramount concern to policy makers and administrators who must make decisions about whether conservation investments deliver outputs that offer good returns for taxpayers. In considering policies and investments, those responsible are likely to also be concerned about whether the expected outcomes are highly

valued by the community. However, the typical expert-driven approach to SCP is founded on judgements made by scientists about what is important and valuable. The judgements and preferences of these scientists may or may not align with those of the broader community. To the extent that they do not, public support for suggested investments may be inhibited.

Our objectives here were: first, to estimate the extent to which expert and public preferences for conservation outcomes are aligned, and, second, to demonstrate a novel method by which quantitative estimates of public values for conservation can be included in a SCP framework. To investigate these objectives we used a discrete choice experiment (DCE). A DCE is a form of non-market valuation, which is an economic approach for quantitatively valuing assets that are not embedded in a traditional market; such is the case for many conservation features.

The Southwest Australia Ecoregion (SWAE), which was involved in a SCP process, was selected as the case study area for the application of the DCE. By comparing the non-market values for a set of key conservation features in the SWAE, we were able to detect whether the expert-driven SCP process represents public preferences for conservation. We find evidence of divergence in preferences, suggesting that integration of non-market values in SCP could be beneficial. In the case of the SWAE, this could be achieved via reweighting the targets for conservation features in the SCP: conservation targets are set by a series of expert-derived formulae, which could be subsequently adjusted to recognise the public utility of achieving each target. An underlying objective of this research is to contribute to efforts to mainstream SCP.

This paper first presents an overview of the methodology, including: the logic for integrating public preferences in SCP; an introduction to the SWAE case study and the SCP process applied therein; DCE methodology; and a description of the DCE application including

attribute definition, survey design and administration. The results that follow describe the outcome of the DCE and the application of non-market values in the SCP process. Finally, the implications of this research for SCP are discussed.

2. Methodology

2.1 Public preferences and systematic conservation planning

While Pressey and Bottrill (2008) recommend the inclusion of stakeholders at an early stage in SCP, such involvement is typically characterised by qualitative discussion (and subsequent involvement once on-ground work begins post-SCP process), rather than a formalisation of stakeholder preferences within the SCP process itself. At a more generic level, Reed (2008) provides a review of stakeholder engagement in environmental management, concluding that involvement should occur early in the process and be carried out systematically. Reed (2008, p. 2418) defines stakeholders ‘as those who are affected by or can affect a decision’. It is subsequently documented that conservationists generally restrict engagement to local stakeholders rather than the broader public. This observation presents an issue: in the case of biodiversity conservation, the broader public does hold a stake in conservation decisions – even individuals who do not directly engage with the environment being conserved may hold values for the existence and protection of that environment (Bennett and Blamey, 2001). Therefore, their welfare (in terms of net benefits or costs to society) can be affected by decisions based on a SCP process. It follows that broad public consultation should be considered in the early stages of SCP processes, in addition to existing strategies for local stakeholder engagement.

Systematic and explicit representation of (broad) public preferences in SCP is only necessary if the typical expert-driven process does not adequately represent the values that the public

hold for conservation. Indeed, it would be an unnecessary waste of resources to elicit public preferences if they were adequately represented by experts. It is hoped that with an emerging body of research on public and expert preferences (Carlsson et al., 2011; Rogers, in press; and others), it will be possible to develop a better understanding of the specific contexts under which preferences are likely to align or diverge. We would anticipate that such knowledge could lead to ‘rules of thumb’ as to when divergence is likely, and extra resources should be expended to elicit public preferences.

Until such time, it will be necessary to first establish whether the expert judgements used in SCP align with public preferences. To do this we need a methodology capable of directly and systematically comparing public and expert values. A DCE is such a methodology: its ability to estimate values in a quantitative metric, which can be applied to both a public and expert sample, can provide us with directly comparable public/expert values for environmental assets (e.g. Carlsson et al., 2011; Rogers, in press; Rogers and Cleland, 2010). These non-market values can then provide guidance as to whether public and expert preferences for conservation align. Where they do not, they present a case for explicit representation of public preferences in SCP.

The same non-market values that are used to establish cases where divergence in preferences exists can then be utilised to explicitly incorporate public preferences in SCP. This paper addresses the issue of representing the broader public’s conservation preferences in SCP by first establishing whether it is necessary to explicitly consider such preferences, and then exploring a method to do this. The basis for integration of DCE and SCP methodologies is conceptualised in Figure 1.

In the integration of DCE and SCP methodologies, the expert non-market values are used only for the purpose of establishing whether expert and public preferences align. Generally, it

is not appropriate to incorporate expert non-market values in adjustments of the SCP targets as it may create problems with double counting. That is, SCP targets are already based on expert judgement, for example, through the consensus of multiple experts and scientific data (where it exists).

2.2 The Southwest Australia Ecoregion

The SWAE covers 48.9 million hectares of land (Gole, 2006), and is recognised as: one of 34 global biodiversity hotspots, of which it is one of only five Mediterranean-type ecosystems that are globally significant (Myers et al., 2000); a global conservation priority through the Global 200 Ecoregions listing (Olson and Dinerstein, 1997); a Centre for Plant Diversity (WWF and IUCN, 1995); and an Endemic Bird Area (Stattersfield et al., 1998). The ecoregion also contains five of Australia's 15 national biodiversity hotspots (Environment Australia, 2011).

In light of the region's conservation status, the Southwest Australia Ecoregion Initiative (SWAEI) was formally established in 2003. In 2007 the SWAEI adopted SCP to underpin the development of a conservation strategy for the region (WWF-Australia, 2010). Promotional material for the project indicated that conservation planning would enable 'smarter decisions' about protecting the SWAE, and emphasised that future generations will 'look back and judge' how well the job has been done (Pressey, quoted in WWF-Australia, 2009). The latter statement suggests that the importance of public preferences regarding the outcomes of the planning process was acknowledged. However, 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 associated targets. This included a series of eight target setting workshops with over 60 experts involved, and a 'stakeholder' reference group of 15 experts that met monthly.

The SWAEI anticipates that the actual conservation of priority areas will, in many instances, involve negotiation with individual landholders, presenting opportunities for establishing partnerships with local government and stakeholder groups (WWF-Australia, 2012). While this approach offers some potential to account for the conservation preferences of local landholders, they are not considered in the SCP analysis that identifies regional priorities. Further, and crucially, the approach does not capture conservation preferences held by the broader public.

2.3 Systematic conservation planning in the Ecoregion

The SCP process applied by the SWAEI involves several stages: (1) data collation; (2) software selection (i.e. Marxan, Ball et al., 2009); (3) setting the planning units' size and shape; (4) identifying conservation features; (5) setting targets for the conservation features; (6) adding layers (e.g. threat, feasibility or boundary length layers) to weight the 'cost' of protecting particular planning units; and (7) investigating optimal solutions using the planning software (WWF-Australia, 2010). Stage (5) is critical: Pressey et al. (2003) acknowledge that one of the main aspects of SCP is its use of explicit targets for conservation features.

The targets, ideally, should be defined to represent a quantity of the conservation features that will be protected under the conservation plan (Margules and Pressey, 2000). In the case of the SWAE, the targets represented a percentage of a spatial area to protect (WWF-Australia, 2010). At an operational level, this meant that the SWAE had to be divided into planning units that could be individually categorised according to the occurrence and extent of the conservation features they contained. This process was achieved using a geographic information system that divided the area into 266 821 hexagons and overlaid it with many layers of data sourced from various government agencies. Thus, using the planning unit data,

one can determine the spatial extent of a particular conservation feature over the whole planning region. Optimisation algorithms are then used to generate efficient ‘solutions’ that protect the target amounts of multiple conservation features at a minimum cost, where cost is a function of the number of planning units selected, the length of planning unit boundaries, and threat ratings (i.e. cost increases if threats are present).

The targets for conservation features were set using three different formulae (WWF-Australia, 2010). Each formula related to a broad category of conservation features, specifically: single features, surrogates for biodiversity, and vegetation complexes. All formulae were similarly defined using a number of criteria: (1) a ‘base’ criterion that applied to all conservation features; and (2) additional scientific criteria dependent on the characteristics of the particular conservation feature such as rarity, life history, functional importance, and exposure to threats. Adding (1) and (2) together provides the target, which is the percentage of the identified spatial extent of the feature that should be protected. The formulae were designed so that a target for a particular feature could never reach 100% protection as this would mean that most of the landscape would be included in the conservation solutions generated, rather than being able to identify plausible solutions.

An example of a formula used by the SWAEI is provided in Figure 2. It captures features that are a surrogate for biodiversity and that can be categorised as an inland water body (more generally known as wetlands). According to the formula, such inland water body features are ascribed a base criterion amount of 30%, and therefore, at the barest minimum, will have a conservation target of 30% protection of their spatial extent. On the other hand, if a particular inland water feature is considered to be threatened and functionally important, its conservation target is 60% (WWF-Australia, 2010).

2.4 Discrete choice experiments

A DCE estimates how individuals make trade-offs between different features, or attributes, of a good. They are often used to retrieve measures of how much individuals are willing to pay to change, improve or conserve different environmental assets. A DCE is particularly useful in an environmental setting because of its ability to quantify non-use or passive values (e.g. intangible existence values), and its ability to estimate these values, in relative terms, simultaneously for a set of different attributes (Bennett and Blamey, 2001).

In a DCE survey, respondents are (typically) faced with a sequence of hypothetical questions called choice scenarios. 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, which 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 scenario, providing 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):

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

Common estimation approaches include the multinomial logit and mixed multinomial logit models (for an overview of methods see Hensher et al. 2005; Train, 2009).

2.5 Conservation features used as attributes for the choice experiment

A key stage in designing a DCE is the selection of a set of attributes that will appear in the choice scenarios. In economic terms, attributes are selected for inclusion in a DCE because it is known or hypothesised that they play a major role in the choice behaviour of interest (Louviere, 2001). Ideally, a given set of attributes should reflect public interests, have a sound scientific basis, and provide useful information to end-users. Full consideration was given to each component in the design of this DCE. However, we note that some concessions were necessary when addressing all components in the one DCE.

As we discuss later in Section 3.3, for the purpose of integrating NMVs in SCP, it would be ideal to select attributes that are in full alignment with the expert-defined categories of conservation features used in the SCP target-setting process. However, it is conceivable that the public do not interpret environmental assets in the same way as they are defined in a scientific process such as SCP (Cleland and Rogers, 2010). Thus, a broader aim of this research was to not only identify the extent of divergence for a given set of attributes through the DCE, but also whether public and expert groups would propose different sets of attributes in the first place. Towards this end, a number of processes were used to inform the selection of attributes for the DCE, summarised below (or see Cleland and McCartney, 2010, for detailed notes).

First, as part of the SCP process, a series of expert workshops, with over 60 participants, were hosted by the SWAEI to assist with the identification of conservation features and the

definition of associated targets. The dialogue from these workshops was captured and used to identify a list of high priority attributes (Appendix Table A1).

Second, two public focus groups were conducted to describe and prioritise conservation features of public importance. Each group was provided the opportunity to brainstorm what they considered to be important environmental assets to conserve in the SWAE. After deriving a comprehensive list of assets, the group was prompted to prioritise the assets to create a suitable number of attributes for a DCE. In the prioritisation process, the group was given the freedom to either select particular assets from the list, or to group them into broader categorisations of assets. Across the focus groups there was a high degree of overlap in the asset lists, and there tended to be a preference to group assets broadly, with the resulting attributes presented in Appendix Table A1.

Third, a mediation process with members of the SWAEI Working Group (including Federal, State, Local and non government representatives) was conducted to consider conservation features identified through the expert workshops and public focus groups. This was necessary given that the set of public and expert attributes differed. The mediation process consolidated the lists of public and expert defined attributes, providing a short-list of conservation features deemed relevant to both populations (Appendix Table A1).

The list of conservation features derived through the mediator process was then altered slightly, on the basis of data availability, to arrive at a final set of attributes (Table 1) (see Appendix B for data sources). The conservation features were all defined according to their current representation within the reserve system (see second column in Table 1). This was consistent with the objective of defining attributes in a policy relevant manner, that is, policies for protection of biodiversity are commonly implemented through expansion of the reserve system. Note that the nature of the reserve system and mechanisms for expansion

were explained to respondents in the survey, providing the context that different areas could be selected to achieve different bundles of the attributes (and their levels). Where available, the absolute figure for the proportion of the attribute that was contained in the reserve system was used (i.e. for wetlands and estuaries). In some cases, absolute figures for the status quo were not available (i.e. for critical vegetation associations, threatened species and endemic species). In these cases, an indication of the full extent of the attribute was provided, along with a percentage estimate of the proportion contained in reserves (based on data sources listed in Appendix B).

The final set of attributes is the product of an inclusive process, of both experts and the public, which improves the broader relevance of the DCE. However, improving relevance may prompt some criticism in terms of interaction effects between attributes. Specifically, it has been suggested that each attribute in environmental DCE applications should be the final ecological outcome, and that attributes should not be interdependent or causally related (Blamey et al., 2002). However, participants in focus group sessions will often bring order to a complex environmental setting by lumping features together to create an attribute that they perceive to represent a certain outcome (e.g. water quality is often selected to represent fish health, waterbird health, etc.) (Blamey et al., 2002; Cleland and Rogers, 2010). Reducing a complex environmental problem to a set of representative attributes can be important in controlling cognitive burden on respondents: as the number of attributes and levels under consideration increases, respondents are placed under increasing cognitive burden, which can lead to increased variance in the parameter estimates, or biased responses due to coping strategies (Caussade et al., 2005; DeShazo and Fermo, 2002). Thus, from a practical viewpoint, it is not always possible to avoid interaction effects. Taking the recommendation of Blamey et al. (2002), we have opted to deal with this issue through an advanced

experimental design that models attribute interactions (where we have deemed them to a potential issue, see Section 2.6).

A cost attribute was also included in the DCE. It was defined as an additional environmental tax, to be collected through annual tax payments, and charged until 2030. The timeframe given was in line with the Australia's Biodiversity Conservation Strategy from 2010-2030 (NRMMC, 2010). Information was included about current expenditure on conservation in Western Australia, and that additional funds would be required for further conservation efforts. Such efforts are commonly funded through tax revenue in Australia; thus, this payment vehicle was considered appropriate. Whilst the literature notes that there can be objection to this form of payment vehicle (Morrison and Hatton MacDonald, 2011), no protest evidence was revealed through focus group testing in this application.

2.6 Survey design and administration

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 DCE followed, along with debriefing questions relating to certainty of choices and believability of the survey; and (3) socio-demographic questions were asked. The survey was informed by four public focus groups, involving 25 participants, at two stages: gauging community understanding of the geographical boundaries of the Ecoregion and attribute definition (discussed above); and piloting of the drafted survey. Members of the mediator group (see Section 2.5) provided iterative comment on the survey draft from the perspective of expert comprehension.

The choice scenarios contained four alternatives – three conservation options and a status quo. Members of the public received eight choice scenarios in total, while the experts received 15 (the larger number of choice scenarios was necessary based on the smaller expert sample size, and considered appropriate based on their cognitive capacity). With the exception of the number of choice scenarios, the public and expert surveys were identical in terms of framing of the DCE.

The experimental designs were generated in Ngene 1.0.1 (Rose et al., 2008). The scientist design was estimated to maximise S-efficiency (i.e. to minimise the required sample size), resulting in a 30 choice scenario design, blocked by a factor of two. It was estimated that 19 full replicates (38 individuals) would be required, with a D-efficiency of 64.18% (see Scarpa and Rose, 2008, for a description of S- and D-efficiency). For the public, a 32 choice scenario Bayesian D-efficient design, blocked by a factor of four, was generated, with a D-efficiency of 80.38%, and an S-efficiency measure estimating that 53 full replicates (212 individuals) were required.

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. Whilst it is possible there could have been further interactions between other attributes, the interactions were not as obvious, and accounting for all substantially reduced the efficiency of the design. Instead, framing of the survey conveyed independence of the attributes as far as possible. Further, Louviere et al. (2000) note that between 70 and 90% of explained preference variance is typically accounted for by the main effects of attributes.

Web-based surveys were administered during November-December 2010. Internet surveys offer a convenient alternative to traditional mail-out approaches, and recent studies have shown that there are no significant differences in welfare estimates between the two approaches (Olsen, 2009; Windle and Rolfe, 2011). The public survey was administered to an online panel by a market research company (The Online Research Unit), drawing a sample of the Western Australian community. The survey was completed in full by 528 individuals, resulting in 519 usable responses. Of the usable public responses, the sample is closely aligned with demographic statistics for gender and age of the Western Australian population (Table 2). For the expert data collection, a sample of 140 scientists with expertise relevant to the SWAE was established via web searches of relevant institutions, and through the participant list for the SWAEI target setting workshops. Of those, 49 completed the survey in full, all of which provided usable data.

3. Results

3.1 Discrete choice experiment results

In this section we present choice models for the purpose of comparing public and scientist preferences for conserving biodiversity in the SWAE. Mixed multinomial logit models were used for the analysis, with panel specification to account for repeated observations from individuals (McFadden and Train, 2000). In the initial estimation of the data, the models contained: the full set of attribute parameters; parameters to identify the two-way interaction term between the threatened and endemic species attributes; and, a random parameter specification on the status quo parameter – the alternative specific constant (ASC). The random parameter allows us to identify heterogeneity associated with preferences for conservation programs versus the current situation within each population, by estimating the

distribution of the ASC rather than just its mean (see Train 2009)¹. For the developmental models descriptive results are reported (statistical results available on request), with full regression output presented only for the models that are discussed in detail (see Table 3). A general utility function applicable to the models is specified in Appendix C. Data were analysed using Stata 11 (StataCorp 2009).

In the first instance, a test was conducted to determine whether the public and scientist samples had homogeneous preferences; that is, whether it was possible to pool the two data sets. A likelihood ratio test (i.e. $2 \times [\text{unrestricted log likelihood} - \text{restricted log likelihood}]$) was used to establish whether we could hold the utility parameters constant across the samples. The scale parameter was allowed to vary between the samples, following the grid search method (see Swait and Louviere, 1993), to account for differences in sample variance². The likelihood ratio test rejected the attempt to pool the data, implying heterogeneous preferences exist between the public and scientist samples.

Next, we considered the significance of the two-way interaction term between threatened and endemic species. For each of the public and scientist models a likelihood ratio test was conducted to establish whether we could apply a restriction that removed the two-way interaction parameters from the model. The restricted public model was rejected in favour of the model that included the two-way interaction parameters. In contrast, for the scientists we accepted the restricted model in favour of the model that included the two-way interaction parameters.

¹ Note that it is possible to identify further heterogeneity within samples, either by specification of additional random parameters, or by interacting individual characteristics with attribute parameters (e.g. Swait, 2006). However, as the significance of individual heterogeneity differs between the two samples, here we maintain a more simplistic model for the purposes of comparison between public and scientists.

² In multinomial logit estimation, the scale parameter is inversely proportional to the standard deviation of the distribution of the error term, or sample variance. It is not possible to independently identify the scale and beta parameters, so estimated parameters are interpreted as scaled marginal utilities. When pooling different samples, the grid search method allows for rescaling of the data to account for differences in variance.

This led us to two different model forms, where the two-way interaction between threatened and endemic species was a significant factor for the public sample, and not for the scientists (Table 3). Overall, the results indicated a positive preference for conserving biodiversity in the SWAE. This is explained in more detail below with respect to the ASC and particular attributes.

In both the public and scientist models, the ASC coefficient was significant and negative indicating a general preference for selecting the conservation alternatives over the status quo (Table 3). However, there is variability in this result with the significance of the standard deviation in each case. In particular, for the public the standard deviation of the ASC suggests that the individuals who were approximately one positive standard deviation from the mean had a preference for maintaining the current situation.

The critical vegetation associations attribute was, overall, the most highly valued attribute by both the public and the scientists, as seen by the weightings of the attribute coefficients (Table 3). The maximum level of wetland protection also received a relatively high attribute weighting for the scientists. The public valued wetlands positively, but not with the same emphasis as the scientists. Both the public and scientists had a positive preference for estuary conservation.

For threatened and endemic species, an interaction between the attributes exists in the public model, but was insignificant and excluded from the scientist model (Table 3). Indeed, for public individuals, the interaction between the two attributes was important in explaining preferences. It appears that the main driver for ascribing value to these attributes was for the threatened species attribute to be protected, as indicated by the insignificant endemic species parameters where threatened species protection is held at the status quo level. The scientists tended to focus on protecting only the maximum level of threatened or endemic species.

It is important to note that the cost coefficient in the scientist model was not significant (Table 3). This insignificance may be indicative of experts not reacting to the cost attribute, a result that could be explained due to either: the cost bids being too small to draw a reaction; strategically not reacting to cost as a means of encouraging more funding for experts' environmental programs and jobs; or simply not caring about the cost of conservation, for example, if they view the intrinsic benefits to be infinitely larger than any cost. It may be argued that the small sample size for scientists underlies this result; however, it is questionable given that the sample exceeds the estimated 38 individuals required to retrieve significant results ($n=49$), and the majority of the other attribute coefficients estimated were highly significant. The insignificance of the cost coefficient meant that the estimated partworths for the scientist model were not significant. A partworth is the negative ratio of a non-monetary attribute coefficient to that of the cost coefficient, and it provides the dollar value, or willingness to pay, estimates for an attribute. Reporting partworths can be useful for comparative purposes, but in our case, the difficulty in interpreting them meant it was not plausible to do so.

In summary, we have established that preferences for conservation of the SWAE are different for the public and scientists. We note divergence on a number of counts: (1) we are unable to pool the public and scientist models, indicating heterogeneous preferences; (2) the public and scientists react differently towards interactions between attributes, namely threatened and endemic species; and (3) attributes were weighted differently, in terms of how the public and scientists each prioritised the set of conservation features. Based on these collective differences, one might assume that the current, expert-driven SCP process does not adequately represent the preferences of the broader community.

3.2 Integration of non-market values in systematic conservation planning: when to adjust the SCP targets

Before adjusting the targets within a SCP process to account for public preferences, we need to ask whether it is necessary to do so, based on the results of the DCE. Such an adjustment is only required if we expect that it would make a difference to the final conservation solution of the SCP process. Therefore, we must establish whether public preferences are substantially divergent from expert preferences, in a way that could result in different conservation outcomes.

First, a simple likelihood ratio test can confirm whether or not the public and expert samples hold statistically different preferences (in general, across the full set of attributes considered). Second, if preferences are found to be divergent, the results of the DCE should be considered to determine whether the differences in marginal values between the samples could result in differences in conservation decisions. Two (related) aspects to consider are: (1) whether the significance of attributes varies between the public and expert models (including the significance of interactions between attributes), for example, if one sample does significantly value an attribute while the other doesn't; and (2) whether the conservation priorities differ between samples, as indicated by the relative attribute weightings within each sample. A case can be made for the inclusion of public preferences in SCP if evidence of these aspects is found.

3.3 Integration of non-market values in systematic conservation planning: how to adjust the SCP targets

Here, we propose a conceptual outline by which the targets for conservation features could be adjusted to account for public preferences by using the results of a DCE. The conservation

targets represent the maximum amount of a conservation feature to protect within the SCP solution. Once the targets are set for individual features, adjustments are often made prior to the optimisation process to account for details like threats, feasibility, boundary lengths, etc (e.g. WWF-Australia, 2010). These adjustments are typically applied to the planning units – for example, by weighting individual units according to whether they increase the cost of undertaking conservation action – rather than to the conservation features themselves. This means that in calculating the objective function in the SCP process, targets for different conservation features are treated as numerically equivalent. However, one could also reweight the final targets for individual conservation features, based on the relative public utility of each. This weighting would recognise the value of achieving the maximum target level of conservation for a particular feature within the conservation solution, according to the community. Particularly in the case where the SCP process is attempting to optimise the conservation solution subject to a budget constraint, changes in the weights applied to different targets will change the preferred outcome. The reweighting can be guided by using marginal rates of substitution (MRS) between the attributes valued in a DCE. There are a number of steps that are required to set up a DCE and estimate appropriate MRS that can then be used to make adjustments in the SCP process, outlined below.

Step one

A set of attributes should be selected that represent each conservation target, and each criterion within each target. This would allow for the estimation of MRS for every individual conservation feature considered in the SCP process, based on all permutations of targets and their criteria.

Whilst there are many individual conservation features included in a SCP process – 854 features in the case of the SWAE – it would be practically impossible to select an attribute to

represent each individual feature. Therefore, here we recommend selecting one attribute to represent each category of conservation features, rather than to represent each individual feature, and to apply the resulting MRS to all features that fall within that category (see Step Four).

To illustrate this, consider the SWAE SCP process. There were three different target formulae for the three different categories of conservation features: single features; surrogates for biodiversity; and vegetation. Within each of the three formulae, there was a base target for conservation, and several criteria that, if met, increased the target amount for conservation. Figure 2 shows the formula for the surrogate category, which included features such as inland water bodies (i.e. wetlands). To comprehensively estimate MRS to represent surrogates in the SCP process we would need, for example, a wetland attribute with (categorical) levels of: basic wetlands, to represent the base criterion in the formula; wetlands that are considered threatened, to represent the threat criterion; wetlands that are considered functionally important, to represent the functional criterion; and wetlands that are considered both threatened and functionally important, to represent the additive effect if all criteria in the formula are satisfied. We would also need to select attributes that can do the same for the other two formulae representing the single features and vegetation categories (and the criteria within each formula)³.

Step two

³ Using one attribute to represent each category of conservation features, and categorical attribute levels to represent the criteria within the target formulae for each category of features, is one approach. An alternative would be to define attributes more accurately based on the actual percentages specified by the criteria in the target formulae. For example, for wetlands, instead of one attribute, there would be several: an attribute representing basic wetlands, with attribute levels that capture the potential target percentage range between zero and 30% (based on the formula, see Figure 2); an attribute representing threatened wetlands, with levels ranging between zero and 45%; and so on. However, this would result in an even more complex design for the DCE which makes it less practical to apply.

Having selected attributes based on the expert-derived conservation target formulae, it will be necessary to pilot them with public focus groups. The language used to describe the attributes may need adjusting to make them comprehensible to the layman. This is common practice in conducting DCEs (e.g. Bennett et al., 2008; Rolfe and Windle, 2005).

Step three

The DCE is undertaken, and following the data collection and estimation of results, the MRS for the attributes can be calculated using the formula:

$$MRS_{xy} = \frac{MU_x}{MU_y} \quad \text{Equation 2}$$

Where MU_x is the marginal utility of attribute parameter x , and MU_y is the marginal utility of attribute parameter y ⁴. One can select the attribute parameter with the highest marginal utility as y , effectively setting the weight of the associated target equal to one in the SCP process, and rescaling the weights of the other targets accordingly⁵. For example, Table 4 shows the MRS for the public DCE attributes in the SWAE, using the 50% level of the critical vegetation associations attribute as the denominator.

Step four

The MRS can be used to weight the maximum conservation targets for each individual feature.

⁴ The marginal utility of an attribute parameter is the coefficient estimated by the random utility model, for example, as per the coefficients reported in Table 3.

⁵ In theory, any attribute parameter could be selected as the denominator: the *absolute* values of the rescaled weights will vary depending on the selection; however, the *relative* values of the MRS, and their contribution to the planning objective function, will stay the same and lead to the same decision outcome.

For example, in the DCE for the SWAE, the wetlands attribute represented threatened and functionally important wetlands⁶. According to the formula for surrogates (Figure 2), the maximum target for conservation of such a wetland would be 60%. The MRS of a threatened and important wetland is 0.384 (for Wet40)⁷, when compared to critical vegetation associations with a MRS of 1 (for Veg50) (Table 4). Thus, to recognise that the public do not value wetlands as highly as vegetation, we would weight the maximum target of 60% by 0.384. This does not change the target to be achieved (i.e. 60%), but it does change the value of movements towards the target, and its impact on decisions will be analogous to the impact of heterogeneity in costs. This would mean, for example, if the SCP optimisation was limited by a budget constraint, achieving the conservation target for threatened and functionally important wetland features would only be 0.384 times as important as achieving the target specified for features relating to critical vegetation associations⁸.

In theory, this series of steps would acknowledge the differences in utility that the community holds for both different conservation features (e.g. vegetation versus wetlands), and different specifications of the same conservation feature (e.g. threatened versus non-threatened criteria). However, further investigation of the protocol is warranted to fully explore its underlying assumptions, and to overcome some potential obstacles from a practical viewpoint.

⁶ That is, the wetlands attribute was based on the categorisation for ‘nationally important’ wetlands (see Table 1), whereby the Australian Government selection is based on the wetland’s *functional (ecological or hydrological) importance*, and its association with *threatened* ecosystems (Environment Australia, 2001)

⁷ We have used the MRS for Wet40, rather than Wet30. As discussed later in this section, the attributes in the DCE did not align well with the definition of conservation features in the SWAE. However, Wet40 represents the protection of 40 out of 65 nationally important wetlands within the reserve system (Table 1), or 62% of nationally important reserves. This is approximately the equivalent of the maximum conservation target for threatened, important wetland features as per the formula in Figure 2, and is thus used to illustrate the application of the MRS weighting here.

⁸ That is, the maximum target for wetlands remains at 60%, and if the conservation budget is sufficiently large (infinite), this target might be achieved in the conservation solution. However, if the budget is restricted, the optimisation process would first try to achieve the target for critical vegetation associations, and then wetlands (subject to the costs of achieving the targets for each), given the relative social benefits for protecting each conservation feature are 1:0.384.

For example, the SWAE application revealed a number of practical challenges. Even after reducing the number of attributes to only include one to represent each category of conservation feature, there were still too many criteria within the target formulae for each category, to be able to design a suitable DCE. Indeed, the final selection of attributes did not account for all permutations of the targets and their criteria: for example, we only estimated the value of threatened and functionally important wetlands, and did not include attributes (or attribute levels) to measure utility for wetlands that were threatened only, functional only, or neither threatened or functional. However, this problem could be potentially be overcome by conducting several DCE studies, each containing a subset of the necessary attributes.

Furthermore, the DCE attributes did not align properly with every permutation of the SCP targets and their criteria. This posed difficulties in then applying the estimated MRS in Step Four, which has further implications: if attributes do not align properly with each permutation of the SCP targets and their criteria, it is not possible to weight every conservation feature that is included in the SCP scenario, which could introduce a degree of bias. This shortfall was a function of the research brief, in that we were also investigating the potential divergence in how experts and the public define attributes. As such, focus group participants were not asked to work on the comprehension of the actual conservation features, and associated targets, that were used in the SCP process (as recommended in Step Two); rather, they were given the opportunity to generate their own set of attributes without any reference points or expert guidance. Whilst the resulting non-alignment in attributes limits the SWAE application, it reinforces that Step Two is critical.

The treatment of non-positive MRS is also challenging. It is possible that some attribute parameters will result in zero MRS (i.e. actual zero value or a statistically insignificant value), or statistically significant negative MRS. This implies that the community doesn't value protecting the relevant conservation feature (in the zero MRS case), or that protecting

the feature would introduce a societal cost that is additional to the on-ground conservation costs (in the negative MRS case). In such cases, experts may argue that the feature is still worth protecting (e.g. from a functional perspective). This leads to a debate as to whether the public are knowledgeable enough about the environment to hold informed preferences about conservation (see Rogers 2013). This ongoing debate may eventually shed light as to the treatment of negative MRS, but for now we recommend that all conservation targets with zero or negative MRS are given a zero weighting. This would imply that there is no social benefit from their protection, but that, given an adequate budget, it is still possible for the features to be included in the conservation solution.

4. Discussion

This paper aimed to investigate whether public and expert preferences for biodiversity conservation in the SWAE were divergent through the use of a DCE, for the purpose of establishing whether there is a need to better integrate public preferences in SCP. Here, we discuss the key results of the DCE and their implications. We then comment on the proposed method by which non-market values, elicited from a DCE, can be incorporated into a SCP framework as a way to reflect public preferences.

An identical DCE was applied to a sample of scientists and a sample of the Western Australian community. A notable result was that the test to pool the two datasets was rejected, implying a clear divergence in preferences between the two samples. Further differences between the samples were 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 the attribute definition process undertaken for this study, it was also found that the public tends to lump species into one category, whilst experts treat threatened and endemic species differently (Appendix A). Further confirmation for the expert result can be found in the SWAEI conservation planning process: for single-species conservation targets there are separate criteria 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, the consistency of the expert result across different forums is also useful for validating the DCE results.

Preference divergence between the public and scientists was also noted with respect to the marginal values of the various attributes. Although both samples valued critical vegetation associations highly, public individuals held a more even spread of preferences for conserving the remaining attributes. Scientists, on the other hand, valued 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 attributes. That is, vegetation is important for provision of habitat and connectivity; wetlands are an important form of refugia for biodiversity (Environmental Protection Authority, 2001).

The DCE results indicate a clear divergence in preferences between the public and experts with respect to biodiversity conservation in the SWAE. In this context, expert advice will not necessarily reflect the value judgements of the public, and the decisions made may result in conservation plans that do not maximise net benefits to the community. Therefore, expert-driven SCP processes may require complementary public consultation measures if they are to meet the desires of policy makers to reflect the conservation preferences of the broader community, rather than solely those of scientific experts. We demonstrate that the non-market values derived from DCEs could be incorporated into the SCP process, and offer a protocol

for doing so, as a way to reflect public preferences. This reduces the risk of conservation plans being rejected by policy makers and managers as unsuitable.

We conclude that scientists and the Western Australian community hold divergent preferences for biodiversity conservation in the SWAE. The implications of this finding are that SCP processes may benefit in terms of public and policy acceptance if they consider public preferences, rather than relying solely on the technical advice of experts. A DCE offers a means by which we can do this.

The DCE in this study elicits values for conservation features in the SWAE. We propose a novel approach for applying the resulting non-market values within a SCP framework, by weighting conservation targets based on the public utility for achieving the 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.

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Table 1. Definition of the conservation features that were selected as attributes for the Southwest Australia Ecoregion discrete 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 (i.e. vegetation associations with less than 30% of their pre-European extent remaining)	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. All attributes are 0,1 dummies.

Table 2. Gender and age distributions of public and scientist samples, and Western Australian population (WA).

Demographic category	Public sample	Scientist sample	WA population (2006)*
Gender			
Male	49%	59%	50%
Female	51%	41%	50%
Age			
18-30 yrs	16%	12%	23%
31-45 yrs	25%	51%	30%
46-60 yrs	27%	20%	27%
61-75 yrs	27%	14%	14%
Over 75 yrs	4%	2%	7%

*Data collected in the 2006 Census survey of Australian households (Australian Bureau of Statistics 2006).

Table 3. Mixed logit regression results for the public and scientist choice models.

Variables	Public model mean (standard error) ^a		Scientist model mean (standard error) ^b	
ASC ^c	-4.092*** ^d	(0.497)	-3.486***	(1.261)
<i>ASC standard deviation</i>	6.010***	(0.535)	2.393***	(0.719)
Veg30	0.775***	(0.0543)	0.991***	(0.147)
Veg50	1.234***	(0.0528)	1.615***	(0.132)
Threat60	-0.0326	(0.112)	0.269*	(0.147)
Threat70	0.408***	(0.0873)	0.331**	(0.144)
End60	-0.111	(0.113)	0.100	(0.144)
End70	0.0906	(0.0866)	0.259**	(0.130)
Threat60*End60	0.447***	(0.163)		
Threat70*End60	0.349**	(0.155)		
Threat60*End70	0.351**	(0.154)		
Threat70*End70	0.0781	(0.123)		
Wet30	0.175***	(0.0498)	0.314**	(0.145)
Wet40	0.474***	(0.0552)	0.905***	(0.128)
Est6	0.149***	(0.0471)	0.268**	(0.134)
Est7	0.261***	(0.0528)	0.424***	(0.123)
Cost	-0.00753***	(0.000400)	-0.00168	(0.00118)
Log likelihood	-4186.87		-708.23	

^a Public n=519; number of observations = 4152.

^b Scientist n=49; number of observations = 735.

^c The alternative specific constant (ASC) is the status quo parameter.

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

Table 4. Marginal rates of substitution: the value of protecting the SWAE attributes relative to the protection of 50% of critical vegetation associations.

Variables	MRS
Veg30	0.628***
Veg50	1
Threat60	-0.026
Threat70	0.330***
End60	-0.090
End70	0.073
Threat60*End60	0.246***
Threat70*End60	0.523***
Threat60*End70	0.332***
Threat70*End70	0.467***
Wet30	0.142***
Wet40	0.384***
Est6	0.121***
Est7	0.211***

Notes: for the interactions between threatened and endemic species, the values shown are the absolute MRS (i.e. after accounting for the marginal utility of the attributes independently, and the additional utility of the interaction term).

	Discrete choice experiment	Systematic conservation planning
<i>Key questions addressed by the methodology</i>	<ul style="list-style-type: none"> ▪ What importance does the public assign to a set of conservation features? ▪ Is this different to the importance assigned by experts? 	<ul style="list-style-type: none"> ▪ What priority should be placed on a range of conservation features? ▪ What spatial configuration of conservation areas will best protect these features?
<i>How is it evaluated?</i>	Non-market values of the conservation features	Targets for protecting conservation features (e.g. percentage of a spatial area to protect) are set using formulae with a number of scientific criteria; targets are used to produce optimal conservation plans
<i>Issues</i>	Non-market values are not readily transferred into scientific decision frameworks	Due to a lack of appropriate information, SCP targets are typically established by scientists and do not incorporate the importance the public places on conservation features
<i>Novel integration of methodologies</i>	<p>Determine whether there is a divergence between public and expert preferences for a representative set of conservation features</p> <p style="text-align: center;">↓</p> <p>If divergence is detected mount argument for inclusion of public preferences in scientific decision frameworks</p> <p style="text-align: right;">→ Use public non-market values to include an additional criterion in SCP targets to account for public preferences</p>	

Figure 1. Overview of discrete choice experiments and systematic conservation planning:

their purpose, issues and novel integration.

Conservation target for inland water body features

Target = Base (30%) + Threat (0 or 15%) + Functional (0 or 15%)

Formula criteria:

- **Base** all inland water body features are afforded a 30% base level of protection
- **Threat** features are afforded an additional 15% protection if they are considered threatened (i.e. associated with broad-scale or ongoing problems), or 0% otherwise
- **Functional** features are afforded an additional 15% protection if they are identified by experts as having an important functional, or pivotal, role in the ecosystem, or 0% otherwise

Target range:

Lowest possible target – 30% protection (base criterion only)

Highest possible target – 60% protection (if feature satisfies both threat and functional criteria)

Figure 2. An example of a target formula used in the Southwest Australia Ecoregion Initiative conservation planning process (WWF-Australia, 2010).

Appendix A: Attribute definition process

Appendix Table A1 reports the attributes defined through a number of processes: an expert workshop, public focus groups, and a mediation process (see Section 2.5 for details). The table is arranged to show first the consolidated list of attributes that resulted from the mediation process, which were used to inform the final set of attributes in the DCE (see Table 1). In subsequent columns, the attributes from the expert workshops and public focus groups are reported. They are arranged in a manner that shows which mediation attributes they helped to inform. Examples of the way that the attributes could be framed and measured in the context of the DCE were also captured within each forum, and are listed under the attribute headings. Readers are referred to Cleland and McCartney (2010) for a full overview of the attribute definition exercise.

Table A1. Attributes for the Southwest Australia Ecoregion, defined through a series of expert workshops, public focus groups and a mediation process.

Mediator attributes	Expert attributes	Public attributes
Coast/beaches - Proportion of beach formation types in various zones (i.e., conservation, recreation etc. - Proportion of vegetation cover on dunes	n/a (Experts were aware that the SWAE SCP process would not include the coastline)	Coast/beaches - formation types - level of disturbance
Estuaries, wetlands, rivers - Proportion of 'healthy' wetlands - Proportion of the catchment vegetated (as an indicator of disturbance to the water balance)	Wetlands - health of wetlands – water quality; proportion of catchment protected Catchment - Natural/modified - Level of protection - connectivity	Waterways - policing recreational use - pollution levels
Threatened species and ecological communities - Percentage protected in conservation estate	Rare/threatened species of flora and fauna - populations protected/extinctions prevented - population size/viability Species representation - IBRA subregions Declining wheatbelt birds not yet considered threatened - Habitat area protected	Native animals and plants - rare fauna and flora - endemics - persistence of species - old and regrowth forests
Flora and fauna habitat - Percentage of vegetation communities that are less than 30% of their original extent	Vegetation communities - representation in protected areas Representative landscapes containing >30% vegetation - area of remnant vegetation	Native animals and plants - rare fauna and flora - endemics - persistence of species - old and regrowth forests

	- level of protection	National parks - number of parks
Unique/rare species - Percentage protected in conservation estate	Centres of endemism for flora and fauna - proportion of species within group protected Species representation - IBRA subregions Short range endemic species - Habitat area protected - Species protected	Native animals and plants - rare fauna and flora - endemics - persistence of species - old and regrowth forests
Ecosystem processes/landscape function - Percentage of conservation estate linked to other reserves and/or remnant bushland	Catchment - Natural/modified - Level of protection - connectivity Functionality - orchid relationships with insects - birds – pollinators, nectavores, etc. Beta-diversity - representation across region	
Refugia - Percentage of granite outcrops, hilltops, ridges in conservation estate	Refugia - size of granite outcrops	

Appendix B: Data sources

Several data sources were used to define the final selection of attributes used in the DCE.

Statistics of a general nature:

- Environmental Protection Authority, 2008. Environmental Guidance for Planning and Development. Guidance Statement No. 33. Environmental Protection Authority, Perth.
- West Australian Department of Environment and Conservation's Florabase found at <<http://florabase.dec.wa.gov.au>>.

Data for 'critical vegetation associations', 'threatened species' and 'endemic species' was drawn, specifically for our purposes, from the GIS supporting the SWAEI SCP project; data source details in:

- WWF-Australia (World Wildlife Fund Australia), 2010. A Strategic Regional Conservation Plan for Australia's Global Biodiversity Hotspot: Phase 1 Report. Report to the Australian Government. WWF-Australia. Wembley.

Data for 'unique wetlands':

- Information sheets supporting the Directory of Important Wetlands found at <<http://www.environment.gov.au/water/publications/environmental/wetlands/directory.html>>.
- Information concerning tenure contained on the Conservation Commission of WA website found at <<http://www.conservation.wa.gov.au/document-centre.aspx>>

Data for 'largely unmodified estuaries':

- Information on condition taken from the Australian Natural Resources Atlas - Estuary Assessment 2000 found at <<http://www.anra/topics/coasts/estuaries/wa/index.html>>.
- Conservation of reserve boundaries taken from the West Australian Department of Environment and Conservation's park finder, found at <http://www.dec.wa.gov.au/component/option,com_hotproperty/Itemid,1584>; and, where unclear, verified with officers of the Department.

Appendix C: Utility function.

A general utility function can be specified for the models described. Utility (U) held by individual n over alternative j can be defined as (suppressing j subscript):

$$U_n = \beta_o ASC + \sum_{k=1}^K \beta_k x_k + \gamma x_2 x_3 + \beta_c COST + \varepsilon_n \quad \text{Equation C.1}$$

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

$\gamma x_2 x_3$ = 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 be normally distributed, η , according to:

$$\beta'_n = \beta_o + \eta \quad \text{Equation C.2}$$