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Community acceptance of biodiversity offsets: evidence from a choice experiment*

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This study of the community's acceptance of biodiversity offsets in Australia provides insights relevant to future revisions of offset policies of both State and Commonwealth Governments. A choice experiment was used to measure preferences for the general acceptability of offsetting, and for a number of attributes that define how an offset can be implemented. Based on a sample of 204 respondents from Perth, WA, we found that the majority of respondents did not object to the practice of biodiversity offsetting in general. A minority of respondents preferred that offset actions be direct, but most accepted a combination of direct and indirect actions. Individuals generally preferred that the offset be located near the site of impact, and it became more unacceptable the further away that it was located. However, there was heterogeneity in preferences for protecting the impacted species or a more endangered one.

Key words: biodiversity offsets, choice experiment, migratory birds.

1. Introduction

Biodiversity offsets are used to account for environmental damages caused by development. In a review of offset frameworks, McKenney and Kiesecker (2010) identify a degree of consensus on the objectives of offset policy internationally, although the details of implementation differ. There is an interest in offsets by governments, international agencies, NGOs and companies as they represent opportunities to balance development with environmental objectives, but if they are poorly designed they run the risk of promising environmental protection, but not delivering it (Treweek *et al.* 2009; ICMM IUCN, 2012; Temple *et al.* 2012; Dickie *et al.* 2013; Quétier *et al.* 2014). In Australia, there are offset policies operating at the State and Commonwealth Government levels. An offset policy becomes relevant when residual environmental damages are likely to result from a proposed development; that is, when damages are likely to remain after all avoidance and mitigation measures have been undertaken. In such a case, the proponent must propose to offset the residual damages by protecting or improving equivalent environmental matter elsewhere. In theory, the offset should result

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in no net loss to the environment. If the proponent can reasonably show that the proposed offset will avoid a net loss, then the development may be considered for approval.

The offset policy we are concerned with here relates to *ex ante* consideration of damage, rather than remediation that may arise as a result of accidental damages. These policies typically require resource-to-resource or service-to service equivalence (Shaw and Wlodarz 2013; Gastineau and Taugourdeau 2014) in restoration, although as noted by Flores and Thacher (2002), this may not be sufficient to achieve full compensation in welfare terms because of heterogeneity in preferences and distributional effects. Although in some jurisdictions, value-based equivalency methods are allowed (e.g. see Martin-Ortega *et al*. 2011, for a discussion of the European Directive on environmental liability), here the focus is on community preferences for the means of achieving ecological no net loss, as that is the Australian policy context.

The relevant State offset policy applies to any residual environmental damages resulting from development (Government of Western Australia 2011). In addition, if a 'matter of national environmental significance' is affected, the Commonwealth's Environmental Protection and Biodiversity Conservation (EPBC) Act Offset Policy also applies (Australian Government 2012). Matters of national environmental significance include species listed as threatened or migratory under the EPBC Act.

While there is research that focuses on the design and implementation of offsets from an ecological perspective (ten Kate *et al*. 2004; Hayes and Morrison-Saunders 2007; Madsen *et al*. 2010; Middle and Middle 2010; Department of Environment and Conservation NSW 2011; Quétier and Lavorel 2011; Dickie *et al*. 2013), there is little in the literature which addresses the question of public attitudes towards the acceptability of offsets (an exception is Bougherara *et al*. 2013; who look at the acceptability of firms 'making' offsets versus 'buying' offsets in the context of production attributes of milk in France). If offsets are to become common practice in environmental management and policy, it is important that they are designed in a way that satisfies ecological, economic and social dimensions. Current policy in Australia is relatively restrictive in terms of methods, location and substitution possibilities. Although those restrictions might be relaxed in order to achieve ecological or economic objectives, if there is social resistance to change then developers may not be willing to exploit them (Richert *et al*. 2015). The objective of this paper is to evaluate the extent to which the public is willing to accept changes in the design of ecological offsets. It is important to note that the interest is primarily in the mechanism by which no net loss is achieved, rather than requiring respondents to make judgements about whether, ecologically, it is achieved.

This study examined the preferences of a sample (n = 204) of the West Australian community with respect to whether the practice of biodiversity offsets is considered acceptable, and how the offsets could be implemented.

Preferences for biodiversity offsets were examined in the context of a hypothetical marine development, a gas plant that has artificial lighting and an increase in the number of people using a beach, which will cause residual impacts on a species of migratory shorebird. A discrete choice experiment (CE) was used to elicit preferences for how an outcome of no net loss in ecological function might be achieved.

2. Methodology

Discrete CEs are a survey-based approach, commonly used in the economic valuation of environmental assets. Extensive reviews of the theory and application of the technique can be found in the literature (McFadden 1974; Bateman *et al*. 2002; Bennett 2011; Rogers *et al*. 2015; Hensher *et al*. 2015) and a full exposition is not given here. Briefly, the environmental asset that is of interest is described by a number of attributes, and the attributes can take a number of levels. Formally, a respondent is assumed to evaluate the utility they obtain from the environmental asset, in a particular condition, by evaluating the levels of the attributes. Conventionally, a linear additive form is used such that the utility that individual i gains from alternative j is given by:

$$U_{ij} = \beta\mathbf{X}_j + \varepsilon_{ij}$$

where $\mathbf{X}$ is a vector of attributes describing alternative j, β the utility weights that apply to them, and ε_{ij} a random component unobservable to the analyst. By presenting respondents with ‘choice sets’ with N alternatives, and asking them to identify the best from the each set, it is possible to estimate the utility weights, and hence the relative values held for the attributes. A wide range of statistical models is available to estimate such discrete choice data, which typically differ in the way they consider heterogeneity in preferences in the sample. The discrete choice approach was considered appropriate to explore community preferences for biodiversity offsets because of its ability to investigate the trade-offs that people are prepared to make between different policy implementation methods. Migratory shorebirds provide a useful context for investigating extensions to offset policy in that there are threats throughout their flyways and offsets could be taken in the various geographical locations, and there are a number of alternative species with differing levels of threat that allow for consideration of ‘trading-up’ to more endangered species (Bamford *et al*. 2008; Australian Government, 2009; Murry *et al*. 2015).

Survey context and attribute descriptions

In designing the CE, one has to provide context and define the attributes of the environmental outcome that are going to change. Here, a hypothetical development was described where an oil and gas exploration and production company was planning to construct and operate a gas plant in the vicinity of a beach on the Kimberley coast, in the north of Western Australia (WA). The development would cause some environmental impacts that could be avoided or mitigated, but there would also be residual impacts on the use of the beach as a feeding ground by 1000 Ruddy Turnstones (*Arenaria interpres*). Ruddy Turnstones are a species of migratory shorebird, protected under the EPBC Act as a matter of national environmental significance. The developer would have to offset the residual impacts if the project was to go ahead, ensuring no net environmental loss.

For this experiment, the offset is defined in terms of three attributes: the proportion of direct offset, the species protected and the geographical location of the offset.

In defining a direct or indirect offset, it is important to acknowledge that the language associated with offsets varies across jurisdictions, and time. The EPBC Offset Policy defines a direct offset as one that provides a measurable conservation gain for the environmental matter that is affected (Australian Government 2012). The Policy differentiates between direct offsets and 'other compensatory measures' where 'other compensatory measures are those actions that do not directly offset the impacts on the protected matter, but are anticipated to lead to benefits for the impacted protected matter, for example funding for research or educational programs' (Australian Government 2012, p. 9). To simplify the language within the survey, and this paper, we used the terms 'direct' and 'indirect' offsets, with the latter being consistent with the definition of other compensatory measures. In the survey, specifically, the direct offset was defined as the identification of a substitute beach that would be fenced off so that the birds would not be disturbed. The indirect offset was defined as research to improve existing on-ground management of the birds. It was hypothesised that people would prefer a higher percentage of direct offsets because the conservation gain is more easily measured, relative to indirect. The proportion of direct to indirect offsets was varied from 50:50 through to 100:0, in multiples of 10. Current policy suggests that the minimum direct offset should be 90 per cent.

Because of the migratory nature of the birds considered, it is possible to benefit the species by interventions that are located anywhere within its flyway. In the CE, it was specified that the offset could be implemented a few kilometres away from the development site in WA. Alternatively, it could be located in the adjacent Northern Territory (NorthT.), also in Australia, or overseas in either New Zealand (NewZ.) or China. In each case, the relevant environment department (e.g. of the State or Territory Government) would be responsible for overseeing and implementing the offset. Such international offset trades are not yet allowed (Bull *et al.* 2014), and it was anticipated that people would have stronger preferences for the offset to be implemented closer to the site of the residual impact. This effect is something that the model can formally test for.

The third attribute was the species protected by the offset. The offset could be designed to protect the impacted Ruddy Turnstones, which, although protected under the EPBC Act, are classified as of 'Least Concern' by the IUCN (Birdlife International 2012a) or it could be used to protect a more endangered species of migratory shorebird – the Eastern Curlew (Numenius madagascariensis) which is classified as 'vulnerable' (Birdlife International 2012b). Different offset policies have established different rules regarding the potential to substitute protection between an impacted species and a different species. For example, in Australia, the EPBC Offset Policy requires the offset to protect the species affected, while the West Australian Offsets Policy opens up the possibility of some substitution between species (Government of Western Australia 2011, p. 3). What is of interest in this study is whether the public might accept offsets that protect another species, particularly if that species was more endangered than the one affected by the development (i.e. out-of-kind and trading-up: McKenney and Kiesecker 2010).

The attributes of the offset and their levels are defined in Table 1. We did not include a price attribute in this CE as to do so would raise implausibilities for respondents: the offsets are required because of an impact on the environment that is caused by a private company undertaking a development. It is therefore the responsibility of the company, and not the general public, to cover the cost of any associated offset and there is no reasonable mechanism for delivering compensation. Brouwer and Martin-Ortega (2012) suggest that, applying a valuation study with a personal cost attribute where the polluter is known '... is expected to evoke protest that the polluter should pay' (p. 152). Evidence on the consequences of not having a price attribute in a CE is mixed: Carlsson *et al*. (2007) find differences in preferences, but suggest that in the case of a market good the presence of the price may lead to strategic behaviour in terms of avoiding future price increases, or that price is not weakly separable from the other attributes. Aravena *et al*. (2014) find no differences in marginal WTP, but some evidence of greater consistency in choices without a cost attribute, which they attribute to lower incentives for

Table 1 The offset policy attributes included in the choice experiment, with level specifications and variable labels

Attribute	Levels	Variable†
Species protected	1000 Ruddy Turnstones	Base level
	1000 Eastern Curlews	E.Curlew
Proportion of direct measures	50%, 60%, 70%, 80%, 90%, 100%	%direct
Location	Western Australia (Kimberly, site of development)	Base level (WA)
	Northern Territory	NorthT.
	New Zealand	NewZ.
	China	China

†For the purpose of estimation, %direct is a continuous variable and the other variables are dummy coded, where they are 1 = if present and 0 = otherwise.

strategic behaviour. Pedersen *et al.* (2011) do find effects on marginal rates of substitution among other attributes, but suggest that this is because the presence of a cost causes changes in decision rules, such as always selecting options with lowest costs.

Survey design and administration

Prior to the construction of the CE survey, two focus groups were held to test the language and concepts that would appear in the questionnaire. Recruitment to and facilitation of the focus groups was undertaken by a professional facilitator. Potential participants, who were members of the general Perth community, were asked to rank their level of interest and knowledge in environmental matters, and any who scored on the extremes of either scale were excluded. Participants were grouped by their level of self-reported knowledge, leading to seven people being in a 'medium knowledge' focus group, and nine in a 'high knowledge' focus group.

The survey consisted of five sections: background information on marine biodiversity offsets; description of the attributes (reported in the Supporting information) and CE questions; debriefing questions about the choice task; and finally socio-demographic information about the respondents and their attitudes towards the oil and gas industry. Some of the attitudinal questions were designed to measure the social license to operate (SLO) of the oil and gas industry in WA. A SLO is an implicit contract between a company and its stakeholders (Boutilier and Thomson 2011; Prno and Slocombe 2012). Two measures of SLO, which we describe here as 'economic legitimacy' (*Eco-legit)* and 'social legitimacy' (*Soc-legit*, in Table 2) are derived (see Richert *et al.* 2015, for more detail of the approach). Scores range from 0.75 to 5, with higher values implying higher levels of social license being awarded.

The choice scenarios were designed with three offset options plus a fourth option of 'no development', allowing respondents to opt-out of the offset going ahead and prevent development approval if that was their preference[1] (Figure 1). We anticipate that the SLO held by an individual will influence the tendency to select the opt-out option. The design involved 24 choice sets, blocked into four groups of six, with each respondent answering six choice scenarios. An S-efficient experimental design, using a Bayesian design employing priors from a small pre-test, was generated in Ngene to arrange the attributes and their levels in the choice scenarios (Rose *et al.* 2008; Scarpa and Rose 2008). S-efficiency is particularly useful in circumstances where sample size is limited, as it gives some reassurance that the design can retrieve priors with the available sample. Given the priors, the S-estimate for the chosen design was 134 for the fixed estimates, and 242 for the median of the Bayesian estimates. As there is no site of international significance for the

[1] The data analysed in this paper are part of a larger survey, where additional samples were collected varying the design of the choice scenarios (Rogers *et al.* 2014).

Table 2 Scale extended latent class model results, with parameter restrictions imposed

	Class 1		Class 2		Class 3		Class 4	
	Coefficient	*P*-value	Coefficient	*P*-value	Coefficient	*P*-value	Coefficient	*P*-value
Part I. Preference class: utility function estimates								
Eastern Curlews	0	—	−1.44	<0.0001	0.77	0.0018	0	—
%direct	0	—	0	—	0	—	0.07	0.0005
China	0	—	−2.18	<0.0001	−14.08	<0.0001	−2.86	<0.0001
New Zealand	0	—	−2.18	<0.0001	−5.40	<0.0001	−2.86	<0.0001
Northern Territory	0	—	−0.84	0.046	−2.52	<0.0001	−2.86	<0.0001
Opt-out	16.06	0.0011	−11.96	0.0005	−16.13	<0.0001	5.64	0.0009
Part II. Preference class membership parameter estimates								
Constant	3.31	0.0004	−2.65	0.02	−1.60	0.08	0.94	0.29
Eco-legit†	−0.52	0.14	1.50	0.0002	0.07	0.79	−1.06	0.0015
Soc-legit	−0.95	0.028	−0.81	0.019	0.74	0.011	1.02	0.0055
Part III. Preference class marginal effects (derived from parameter estimates above)								
% change in class membership following a unit change in the variable								
Eco-legit	−0.05	0.066	0.40	0.001	−0.09	0.327	−0.27	0.0003
Soc-legit	−0.07	0.036	−0.32	0.001	0.23	0.012	0.16	0.028

	Class A		Class B	
	Coefficient	*z*	Coefficient	*z*
Part IV. Scale class: scale estimates	1		0.24	<0.0001

	Class A		Class B	
	Coefficient	*P*-value	Coefficient	*P*-value
Part V. Scale class membership estimates				
Constant	−2.34	0.0062	2.34	0.0062
Cert‡	0.46	0.0014	−0.46	0.0014

Table 2 (*Continued*)

		Coefficient	*P*-value
Part VI. Scale : Preference class correlation effects			
Scale (A)	Preference (1)	0.48	0.15
Scale (A)	Preference (2)	0.06	0.8
Scale (A)	Preference (3)	−0.55	0.015
Scale (A)	Preference (4)	0.01	0.98

Part VII. Summary statistics	Class 1	Class 2	Class 3	Class 4	
Probability of Class membership					
Scale Class A	0.04	0.17	0.10	0.08	**0.39**
Scale Class B	0.02	0.16	0.32	0.11	**0.61**
	0.06	**0.33**	**0.42**	**0.19**	

LL = −1162.85; BIC (LL) = 2474.61; CAIC (LL) = 2502.61; parameters = 28; df = 176; Number of individuals = 204; Number of choices = 1224.
†Eco-legit and Soc-legit are scored 0–5, with mean values of 3.7 and 3.0, respectively. Higher scores indicate higher levels of SLO.
‡Cert is scored 1 (‘not certain at all’) to 7 (‘very certain’), with a mean of 4.7.

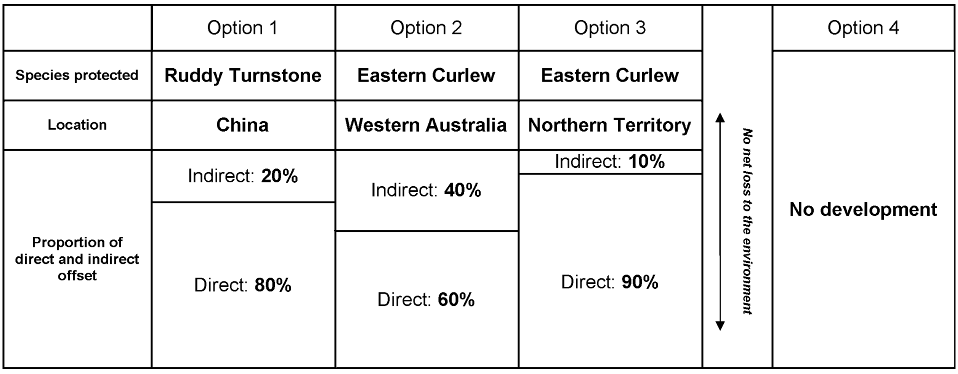

Figure 1 Example of a choice scenario, with three offset options and an opt-out.

Eastern Curlew in New Zealand, a constrained design was employed that ensured that this species and the New Zealand location were never associated together in an option.

Respondents were reminded to consider each choice set independently, and that the results of the study may influence offset policy in WA, to improve consequentiality (Carson and Groves 2007). There was no explicit 'cheap talk' script, as in the context it is difficult to be precise in what 'overstating' values might be, but respondents were reminded to choose their most preferred option based on the assumption that these are the only options available to them.

Participants were recruited from an actively managed online research panel maintained by a market research company (The Online Research Unit), during July–August 2013. Comparisons of internet panels with other survey modes suggest that similar estimates of preferences are identified, with no systematic biases (Lindhjem and Navrud 2011). A sample of 204 individuals from the Perth metropolitan area was collected. Both age and gender distributions matched Australian Bureau of Statistics distributions for Perth: differences in the distributions were not statistically significant, with *P*-values from the Pearson Chi-squared test of 0.98 and 0.62, respectively. Summary socio-demographic data are given in the Supporting information (Table S1).

Scale extended latent class models

To account for heterogeneity in preferences, a latent class specification of a conditional logit model was implemented to analyse the data. The latent class specification assumes that there are a finite number of classes of people, each with different preferences. The distribution those preferences may take within the sample is not imposed (Train 2009; Hess 2014). It is well known that discrete choice models confound estimates of model parameters with error variance (Louviere and Eagle 2006), and hence confound heterogeneity in preferences with heterogeneity in error variances (Swait and Louviere 1993).

This issue extends to latent class models, where the standard implementation may lead to a misrepresentation of preference class structure if one ignores the possibility that there is heterogeneity in the error variance as well. We therefore implement a scale extended latent class model (Magidson and Vermunt 2007) to investigate whether there is error variance scale heterogeneity in our data. The model has been widely reported elsewhere (Tapsuwan *et al*. 2014; Thiene *et al*. 2015) and full details of the specification are given in the Supporting information. All estimation reported here used Latent GOLD Choice 5.0 Syntax (Vermunt and Magidson 2013).

3. Results

Modelling strategy

We did not exclude any 'protest' respondents from the sample, as the latent class specification allows one to endogenously identify this form of behaviour (e.g. repeated selection of the opt-out) without imposing any *ad hoc* definitions (Meyerhoff *et al*. 2012).

The modelling strategy adopted was to include the attributes of the CE design within the utility function, and allowed individual specific characteristics to explain preference class membership. The only two significant variables that were found to explain preference class membership are the measures of SLO held by respondents for the oil and gas industry (*Eco-legit and Soc-legit*).

In the scale extended latent class model, it is also possible to model membership of the scale classes. The only variable tested in this aspect of the model is the respondents' self-reported measure of certainty of the answers they gave (*Cert*, see Table 2). This question was asked once; after all choice sets were completed. In a review of how certainty measures may be employed in choice models, Beck *et al*. (2013) note that '…there is a consensus that using such techniques generates a model which [is] more behaviourally representative of the choice process' (p. 92), and the results here conform to *a priori* expectations and the results in Beck *et al*. (2013): those with lower self-reported levels of certainty are associated with higher error variance in choices. Similar effects have been found elsewhere (Tapsuwan *et al*. 2014; Burton *et al*. 2015).

An extensive search over class structure was conducted with preference classes ranging from 1 to 6 combined with scale classes of 1, 2 and 3. The associated summary data are reported in Table S2 in the Supporting information, which show that a 4 preference class, 2 scale class model was preferred based on the BIC values (Nylund *et al*. 2007). *Ex post* inspection of the estimated parameters of the model suggested that a number of restrictions (11) could be imposed, to provide a more parsimonious representation of preferences. The restrictions included setting some parameters to zero within a class (where they were not significantly different from zero), and constraining some to be equal within a class (e.g. restricting all non-WA location effects to be equal within Class 4). The log likelihood (LL) test statistic for these restrictions was 16.7, which is smaller than the critical value $\chi_{(11,0.05)}$ of 19.7, meaning the restricted model was accepted.

Choice model

Table 2 reports the results of the final four preference classes, two scale class model. Preference class marginal utilities, scale and class membership parameters are estimated simultaneously: Table 2 is split into sections to aid discussion. Each Preference Class can be characterised in general terms as follows (Table 2, Part I).[2]

Class 1: the restriction of the attribute parameters to zero, and the positive coefficient on the alternative specific constant (ASC) for the opt-out alternative imply this group will have a high probability of selecting the opt-out alternative in all occasions. This behaviour is consistent with some form of protest behaviour, rejecting the acceptability of the offset package at all and preferring to see the development not occurring.

Class 2: has a negative preference for protecting the Eastern Curlew rather than the Ruddy Turnstone. Compared to a WA location (the baseline), utility falls (equally) if the offset is located in China or NZ. Northern Territory is also viewed negatively relative to WA, but not as much as the international locations. The substantial negative ASC implies that the opt-out alternative will seldom be selected. The percentage of direct offset in the policy package does not affect choices.

Class 3: has a positive preference for protecting the Eastern Curlew rather than the Ruddy Turnstone. Compared to a WA location (the baseline), utility falls much more as the offset location becomes more distant (the ratio of effects for China to New Zealand. is 5.6, compared to 2.6 for Class 2). The substantial negative ASC implies that the opt-out alternative will seldom be selected. The percentage of direct offset in the policy package does not affect choices.

Class 4: does not pay attention to the species being protected, but does prefer more direct offset in the design. All non-WA locations are viewed equally negatively compared to WA. The presence of a positive opt-out ASC suggests that there may be some combinations of offset attributes that may lead to the opt-out being the preferred option. This will be explored further below.

[2] As Davis *et al*. (2015) note, one has to be aware of the consequences of the estimated scale factors on the significance of the preference parameters. In this case, the inferences made about significance of the latter are not affected by the choice of base Scale class.

Membership of the preference classes is significantly influenced by the measures of SLO, in terms of economic (*Eco-legit*) and social legitimacy (*Soc-legit*). We report both the estimated parameter values from the multinomial logit model of class membership (Table 2, Part II) and the marginal effects that these imply (Table 2, Part III). The latter are more informative for the multinomial logit model. Of particular note is the result that the probability of being in Class 1 (those that always select the opt-out alternative) falls as the scores for economic and social legitimacy increase: or, conversely, those most likely to reject the use of offsets are those that have lower scores for SLO. For the other three classes, the direction of the effects are mixed: increased economic legitimacy increases the probability of being in Class 2, while increased social legitimacy reduces it: for Classes 3 and 4 the reverse is true. The magnitude of the changes is also large: a unit change in the SLO scores induces large changes in the probabilities compared to the mean values, given the SLO scores range from 0.75 to 5.

In terms of scale, the value for Scale Class A is normalised to equal unity, and scale for the Scale Class B is freely estimated (Table 2, Part IV). The value of 0.237 implies this latter class has a higher variance in the error terms.

The estimate of the effect of the variable *Cert* on scale class membership implies that those who are more certain (higher levels of *Cert*) are less likely to be members of this high variance class (Table 2, Part V: note that for identification parameters are constrained to sum to zero across the two classes). There is nothing in the model to explain why some people are more certain of their answers, but these results do provide some reassurance of the internal consistency of the estimated model.

Table 2, Part VI reports the correlation effects across scale and preference classes. The significance of a correlation effect implies that the distribution of the high variance individuals is not proportional across all preference classes, as seen in Table 2, Part VII: preference Class 3 has proportionally a larger number of Scale Class B, the class with a higher error variance.

The posterior probabilities of class membership give an indication of how prevalent each class is within the sample (Part VII). There are relatively few who continually opt-out from the provision of offsets (6 per cent), and hence we infer that our design does not have a major issue with protest behaviour. There are also relatively few (19 per cent) who are concerned about the level of direct offset in the offset design. The majority of the sample fall into Preference Classes 2 and 3, who are generally pro-offset, but differ in which species they wish to see protected, and the degree of their antagonism towards shifting the offset away from WA.

Probabilities of selecting offset packages

An issue with interpreting the policy implications of these results is that one cannot identify conventional marginal rates of substitution for Preference Classes 1, 2 or 3, because there are no significant continuous variables in the model that can be used as the denominator (using a binary attribute as the denominator leads to issues of interpretation). An alternative approach is to conduct the following thought experiment: if a set of four offsets were available, one in each location, plus the opt-out, what is the probability of a respondent of a particular class selecting each option? And, in addition, how do those probabilities change as one differentially changes the characteristics of the offsets? Note that this approach is not relevant for Preference Class 1, where individuals have a very high probability of selecting the opt-out, irrespective of attribute levels.

It is important to note that when dealing with probabilities, the estimate of the scale (or equivalently the variance) matters, which it does not when considering partworths. Higher variance leads to a higher entropy in the model: there is less discrimination between choices, and at the limit, the probability of selecting any outcome, *irrespective of attribute levels,* falls to 1/ n and choices are completely random. We report the results for Scale Class A here, and those of Scale Class B in the Supporting information.

This approach is illustrated by Table 3, for Preference Class 2, Scale Class A. In the initial row, the ‘species protected’ attribute was set to its least preferred setting which, for this class, was protecting the Eastern Curlew (for internal consistency in this simulation we set the New Zealand offset species to the Eastern Curlew, even if this is not ecologically plausible: this is because, in this experiment, we are interested in evaluating the strength of preferences, rather than a specific set of offsets). We do not consider the level of direct offset as this is not significant for this preference class. This generates a set of probabilities which reveal the strong preference for the offset based in WA (60 per cent) compared to a 27 per cent probability of selecting the Northern Territory offset, and 7 per cent for both China and New Zealand. In Row 2, the offset in China is modified to relate to the Ruddy Turnstone (which is the more preferred species), while maintaining the Eastern Curlew in all other regions.

Although this increased the probability of selecting China, it was not sufficient to overcome the stronger preference for WA: for this group, the aversion to the offset being in China is sufficiently large that it cannot be

Table 3 Probability (%) of selecting an offset, by location, for Preference Class 2, Scale Class A

Row	China	New Zealand	Northern Territory	Western Australia	Opt-out
1. Protect Eastern Curlew everywhere	7	7	26	60	0
2. Protect Ruddy Turnstone in China†	24	6	21	49	0
3. Protect Ruddy Turnstone in Northern Territory	4	4	60	33	0
4. Protect Ruddy Turnstone in Western Australia	2	2	9	86	0

†The effects of having Ruddy Turnstone in New Zealand are equivalent to those of having them in China, and are not reported.

overcome by the preference for the Ruddy Turnstone. Row 3 repeats the same process for the Northern Territory, and as a consequence the offset with greatest support is changed: respondents were prepared to trade their preferred location of WA to the Northern Territory, if it meant the species protected was the Ruddy Turnstone and not the Eastern Curlew. What is notable is that the probability of selecting the opt-out is zero in all cases. If one presents Preference Class 2 with the choice of either an offset in China or to opt-out, they will still prefer the former. The implication of this analysis is that there is little likelihood of being able to generate an offset package in China (or New Zealand) that is more attractive than one in Australia, whatever the other characteristics of the offset. There is some possibility of seeing trade-offs across the Northern Territory and WA, depending on which species is being protected in each location.

Table 4 repeats the exercise for Preference Class 3, Scale Class A. Here, row 1 specifies that the Ruddy Turnstone is the species being protected everywhere, as this is the least preferred of the two species for Preference Class 3. The very strong spatial preference is revealed: if the same species is considered everywhere, there is a 92 per cent probability of selecting the WA offset. The consequences of this very strong preference for WA are revealed by the other rows: introducing the more preferred Eastern Curlew into any of the other regional offsets has negligible effects on their relative attraction. For this class, it is not possible to construct an offset in any other region that would be preferable to one in WA.

Table 5 repeats the process for Preference Class 4, Scale Class A. For this class, species is not significant, but the percentage of direct offset is. In row 1, the per cent of direct offset is set to 50 per cent, the lowest value used in the design, for all locations. At this level of direct offset, the probability of selecting the opt-out alternative was high, reflecting the positive ASC estimated (Table 2, Part I). The implication is that without a sufficiently high level of direct offset, this class would prefer to see the development not

Table 4 Probability (%) of selecting an offset, by location, for Preference Class 3, Scale Class A

Row	China	New Zealand	Northern Territory	Western Australia	Opt-out
1. Protect Ruddy Turnstone everywhere	0	0	7	92	0
2. Protect Eastern Curlew in China	0	0	7	92	0
3. Protect Eastern Curlew in New Zealand	0	1	7	92	0
4. Protect Eastern Curlew in Northern Territory	0	0	15	85	0
5. Protect Eastern Curlew in Western Australia	0	0	4	96	0

Table 5 Probability (%) of selecting an offset, by location, for Preference Class 4, Scale Class A

Row	China	New Zealand	Northern Territory	Western Australia	Opt-out
1. Direct offset = 50% everywhere	0	0	0	11	87
2. Direct offset = 100% in China	19	0	0	9	70
3. Direct offset = 100% in Western Australia	0	0	0	82	17

proceeding at all. If the direct offset was increased to 100 per cent for China, while remaining at 50 per cent elsewhere, the probability of picking the opt-out would fall, but it would still be the dominant strategy. Although this class favours higher levels of direct offset, it is not possible to counteract the negative sentiment towards China within the constraint of having an upper limit of 100 per cent direct offset. Given the equality of effects across non-WA locations, this result would be replicated for Northern Territory and New Zealand. If the direct offset was increased to 100 per cent in WA, then individuals in this class were prepared to accept an offset package rather than opt-out. If the percentage of direct offset in WA was 79 per cent, then members of Preference Class 4, Scale Class A were indifferent between the WA offset and opt-out.

The implications for this class is that offsets in non-WA locations are simply not feasible: they would prefer to see the development not take place rather than see an offset, even with 100 per cent direct action, in an non-WA location. Having the offset located in WA is not sufficient to guarantee acceptance: there has to be a minimum level of direct offset to make it acceptable.

4. Discussion

Both the Australian Government and the State Government of Western Australia consider biodiversity offsets as eligible to play a role in meeting economic and environmental objectives. While there is still uncertainty regarding the environmental outcomes of biodiversity offsets, the focus of this paper was to study their social acceptability.

The latent class model revealed a variety of preference structures within the sample. A relatively small number of individuals (6 per cent) belonged to a class that rejected offsets outright and preferred to see the development stopped. Membership of this class was linked with a low SLO for the oil and gas industry, and although the absolute percentage is small, a unit decline in SLO leads to significant increases in the probability of being in this class (Table 2, Part III). This meant that individuals who perceived that the industry provides a low economic or social benefit to the community were less likely to support offsets for an oil and gas development. The small number of individuals belonging to this class indicated that the majority of people were willing to accept the practice of using biodiversity offsets, suggesting offsets are a suitable tool to use in managing sustainable development in Australia.

The negative signs on all locations for all classes confirmed that people preferred offsets to be implemented in WA, rather than in the other proposed locations, and that overall they least liked offsets that take place in China. There are a number of possible explanations for this result. First, respondents may have held the view that the offset should take place as close to the development site as possible, for ecological reasons. Secondly, Perth respondents may have preferred the closest offset because it may enhance use values. Third, the general avoidance of offsetting in China could be explained by the fact that it is the most culturally and politically different location proposed in the choice scenarios, relative to WA. The strong preference for offsetting in WA indicates that offset policies should generally prescribe for offsets to be implemented as close to the impacted site as is practicably possible.

With respect to the species protected by an offset, 42 per cent of the sample (Class 2) were willing to give more support to offsets which protected a species that was more endangered (Eastern Curlew) than the species that was impacted by the proposed development (Ruddy Turnstone), suggesting they are prepared to allow for offsets to ‘trade-up’ for species at threat rather than to strictly compensate for a specific loss. However, Class 3, comprising 32 per cent of the sample preferred that the offset protected the impacted Ruddy Turnstone.

Only a minority of the sample (19 per cent: Class 4) preferred offsets that had a higher level of direct (on ground) activity. For this preference class, the level of direct offset was not only statistically significant, but could change the preferred outcome, from rejecting the development entirely to accepting a WA-based offset package when the ratio of direct to indirect offsets was high. Our prior expectation was that people would prefer direct offsets to indirect or compensatory actions, such as research. However, the fact that the percentage of direct offset was not a significant factor for the majority of the sample would suggest that offsets comprising a combination of direct and indirect activities are a suitable approach, as long as they deliver the required environmental benefits.

This analysis suggests that there are segments within the community who are prepared to accept relaxations in the current specification of offset design. However, an issue is that there is no attribute where there is agreement across the sample. Thus, although Class 2 and 3 are prepared to see complete flexibility in the use of indirect offsets (at least up to 50 per cent, which is the largest value in the design), Class 4 would find such a change utility reducing. Similarly, Class 3 and 4 would prefer/be indifferent to focusing on a more endangered species rather than the species at risk, but Class 2 would find this utility reducing. In particular, if one considers that the current policy requires that the offset target the Ruddy Turnstone in WA, Class 2 would find any shift away from this design as utility reducing, with no change attribute in attribute that could compensate for it. Thus, any changes in what is permitted in the offset design will meet with some opposition from some portion of the sample. What the study does confirm is that there is general aversion to moving the offset overseas, even though, ecologically, this may be appropriate. It should be noted that these conclusions are limited to this particular sample, and to the elements of offset design that have been included as attributes in this study. It may be possible to identify other attributes of an offset that would be valued by respondents, that would allow offset packages to be defined that were acceptable (e.g. by increasing the number of birds protected, to allow 'exchange rates' for the less acceptable attributes to be identified; Burton *et al*. 2012).

Finally, it is worth highlighting that community preferences may be based on limited scientific understanding. Designing offset policies that only consider community values could result in inefficient, or even negative, environmental outcomes. Therefore, the findings from this type of valuation study, that gauges public values for elements of offset design, should be used as an input into choosing the more socially acceptable offset strategy amongst an equivalently efficient set of offsets, or to adapt communication and education strategies about an offset when the best options in terms of environmental outcomes do not match the population's preferences.

There are a number of areas where this study could be extended. The sample used here is relatively small, and limited to Perth, WA, which may limit the precision of the estimates being generated, and the extent to which they may be generalised to a broader population. Given the focus on existence values, extension to a more representative national sample would be useful. More complete consideration of the issue of pure distance effects compared to trans-boundary jurisdiction effects would also be valuable. At a technical level, the implications of including a personal cost attribute could be examined: although our prior is that the inclusion of such an attribute would lead to higher levels of protest behaviour as respondents are asked to pay for an offset that is currently a legal requirement, it may also lead people to overstate values. If a cost attribute could be included, then it would also allow an estimate to be made of the value of the ecological outcomes of the offset.

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Supporting Information

Additional Supporting Information may be found in the online version of this article:

Appendix S1. Information on attributes provided in the online survey including Tables S1–S5.