Valuing threatened species, ecosystem types, and ecological communities for ecosystem accounts in the Gunbower-Koondrook-Perricoota (GKP) Forest Icon Site in the Murray-Darling Basin, Australia

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Abstract: Ecosystem Accounting (EA) involves tracking the extent, condition, and services provided by ecosystems and linking them to the economy under the international standard developed by the United Nations – System of Environmental-Economic Accounting. Ecosystem assets (species, ecosystems and ecological communities) provide use and non-use benefits to society. A key challenge is how to value non-market benefits that arise from these assets. This study aims to contribute to this challenge by estimating the marginal willingness to pay for key ecosystem assets in the Gunbower-Koondrook-Perricoota (GKP) Forest Icon Site in the Murray-Darling Basin of Australia, as a necessary precursor to identifying an exchange price, from which to derive exchange values. A discrete choice experiment with three types of ecosystem assets as attributes was designed and implemented among the Australian public in 2021. The ecosystem asset attributes were six threatened species (Australian bittern, Painted honeyeater, Superb parrot, Koala, Green-comb spider-orchid, Winged pepper-cress), three ecosystem types (River-swamp wallaby grass, River red gum, Black box) and two species groups or ecological communities (water birds and vascular plants). Collected data was analysed using a mixed-logit model. Findings suggest that the estimated marginal willingness-to-pay (WTP) for improvement in status (population or habitat condition index) of ecosystem assets vary from AU$14.60 per year per household for 20 years for water birds to AU$1.32 for Green-comb spider-orchid.

Key words: Ecological community, ecosystem account, habitat condition index , marginal willingness to pay, threatened species

JEL classifications: Q23, Q51, Q56, Q57

1. Introduction

Valuing natural capital to bring its value into economic decisions has been emphasized to halt decline of nature and biodiversity loss (IPBES, 2019, Pascual et al., 2023). To understand the interaction between ecosystems and the economy, and to integrate ecosystem values into economic decisions, the UN initiated Experimental Ecosystem Accounting in 2012 within the System of Environmental-Economic Accounting (SEEA) framework (United Nations et al., 2014). A detailed accounting guideline was developed and endorsed by the UN to consider Ecosystem Accounting (SEEA EA) as a regular account in 2021 (United Nations et al., 2024). Ecosystem accounts present environmental, social, cultural and economic information about ecosystems to aid decision making.

The SEEA EA provides a framework to quantify stocks of ecosystem assets, including biodiversity, and the flows of ecosystem services over an accounting period (United Nations et al., 2024). It is a spatially explicit framework. It consists of three stock accounts (extent, condition, and ecosystem assets - stocks and change in stock), and two flow accounts (physical and monetary ecosystem service -flow and use - accounts) (United Nations et al., 2024). The monetary accounts involve deriving monetary values of stocks and ecosystem service flows. Developing monetary accounts is still in its infancy and has operational challenges when it comes to non-use benefits such as ecosystem and species appreciation services provided by the ecosystem. In addition, SEEA EA uses exchange values rather than welfare values and lacks clear guidance on possible ways to estimate exchange values from welfare estimates for non-use benefits. However, it is worth noting that the ecosystem and species appreciation services provided by ecosystem assets are not fully appreciated by the SEEA EA to be included in the main supply and use tables due to lack of clear exchange prices (United Nations et al., 2024).

In 2018, Australian governments – federal, state and territories – developed a common national approach to apply SEEA to account for environmental assets, including ecosystems (Commonwealth of Australia, 2018). Australia started developing experimental ecosystem accounts across the country (such as Mitchell Catchment, Box-Gum Grassy Woodlands, Geographe Marine Park etc), including one for the Gunbower-Koondrook-Perricoota Forest Icon Site (GKP) in collaboration with the Murray-Darling Basin Authority, Commonwealth Scientific and Industrial Research Organisation (CSIRO), and private sector organisations (https://www.dcceew.gov.au/environment/environmental-information-data/natural-capital-accounts/past-work).

The GKP Forest Icon Site is located on the River Murray, north-west of Echuca on the border of Victoria and New South Wales. It covers an area of 56,020 hectares and it is one of the six icon sites that are regularly monitored for ecological health under The Living Murray program (McLeod et al., 2021). The site is a Ramsar-listed wetland that has the second largest extent of river red gum forests in Australia, and provides nesting sites for migratory waterbirds (McLeod et al., 2021). The priority ecosystem assets for ecosystem accounts of this site include threatened species, ecosystem types, and ecological communities: *threatened species* (Australian bittern, Painted honeyeater, Superb parrot, Koala, Green-comb spider-orchid, and Winged pepper-cress), *dominant species, hereafter referred to as 'ecosystem types'* (River-swamp wallaby grass[1], River red gum, and Black

[1] It is also a threatened species as the other six. However, it is measured in the habitat condition index rather than species population, thus it is considered as an ecosystem type for the purposes of the study.

box), and e*cological communities*[2] (water birds and vascular plants).

In developing the experimental ecosystem accounts of the GKP site, a range of assessments have been completed. For example, ecosystem extent (Richards et al., 2021), ecosystem condition (Harwood et al., 2021), and biodiversity assessment (Mokany et al., 2021) by CSIRO. The physical and monetary supply and use accounts for ecosystem and species appreciation services were also developed (McLeod et al., 2021). McLeod et al. (2021) provided an account of ecosystem and species appreciation services in terms of habitat provisions (measured as habitat hectares) for eight focal species of the GKP site for the year 2010 and 2015. However, they noted that the reliability of the monetary flow estimates for ecosystem and species appreciation services in their accounts lacks updated and relevant valuation data – a research gap which this study is aiming to fill.

To estimate ecosystem and species appreciation services with both use and non-use values, Discrete Choice Experiment (DCE) is arguably the preferred method as it allows trade-offs among attribute levels. There are a few DCE studies on threatened species and ecological communities in Australia (for example, Gunawardena et al., 2020, Zander et al., 2022), but they are primarily focused on understanding peoples' preferences for species and estimating welfare values.

In general, literature in estimating exchange values using DCE for ecosystem and species appreciation services are fairly limited. Some notable studies includes Campos et al. (2022) Campos et al. (2019) and La Notte et al. (2021). For example, Campos et al. (2019) used a DCE to estimate the exchange value of landscape and threatened biodiversity conservation in the Andalusian Forests of Spain. The exchange price was derived as the revenue maximising simulated price from an estimated mixed logit probability function. Similarly, La Notte et al. (2021) used a DCE study to estimate the exchange value of habitat and species maintenance ecosystem services at the European level with a study spanning four countries - Czech Republic, Germany, Ireland, and Italy, using a similar approach to that of Campos et al. (2019).

In this study, we estimate the willingness to pay (WTP) for 11 ecosystem assets (six threatened species, three ecosystem types, and two ecological communities) of the GKP Forest Icon Site to provide additional information on peoples' preferences and welfare values. How to translate these values into exchange values suitable for inclusion in EEA is outlined elsewhere (Scheufele et al., 2025).

Section 2 describes the materials and methods of our study, including the survey questionnaire, choice attributes, levels, design, and implementation. Section 3 presents the model used and describes the analysis carried out in this study. Section 4 presents the results and discussion. Finally, section 5 concludes the study.

2. Materials and methods

Survey questionnaire

The DCE questionnaire was developed and implemented in Qualtrics. The questionnaire consisted of five main sections (see **Appendix 1** for details). At the start of the questionnaire survey, a brief introduction to the survey is provided. Section 1 provides three screening questions about the respondents. Section 2 provides a brief description of choice options, information on payment

[2] Ecological communities are also referred *as 'species groups'*

method and explanation of the need for additional funding to conserve selected species, ecosystems, and ecological communities in the Murry-Darling Basin. Section 3 provides detailed information on species, ecosystems, and ecological communities separately in three sub-sections. Each sub-section consists of information on attribute (species, ecosystem types, and ecological community), attribute levels, choice options (status quo and management scenarios), and an example choice question for respondents to state their preferences. Section 4 has several follow-up questions to identify protestors, and section 5 provides questions on socio-economic information about respondents.

Attribute selection

The main ecosystem assets of the GKP site in the Murray-Darling Basin were considered in this study in consultation with CSIRO experts, the Threatened Species Commission, and the Commonwealth Government's Department of Agriculture, Water and Environment. A series of online meetings and discussions were held to identify the key attributes. These meetings and discussions resulted in 11 attributes that were considered important in developing ecosystem accounts of the site as well as from conservation and management perspectives. The attributes were divided into three types of ecosystem assets: six species of threatened flora and fauna, three dominant species or ecosystem types, and two ecological communities or species groups. Six threatened species included four fauna: Australian bittern, Painted honeyeater, Superb parrot, and Koala, and two flora: Green-comb spider-orchid and Winged pepper-cress. The three ecosystem types included River-swamp wallaby grass, River red gum, and Black box; and the two ecological communities were water birds and vascular plants. These were the prioritized threatened species, ecosystem types, and ecological communities by the Department to develop ecosystem accounts of the GKP site.

Background information on selected attributes, including threat status, extinction risk, and current population or habit condition index in the basin, is given in **Appendix 2**. For example, Australian bittern is an endangered bird found in Tasmania, and the south-east and south-west of Australia. Its population in the Murray-Darling Basin (MBD) was estimated at 1150, which represented approximately 88% of the total Australian population of the species. Similarly, River red gum is an endemic species to Australia; its current habit condition index is about 40 relative to its extent and condition in the MDB prior to European settlement (100). Habitat condition index is a composite measure of the extent and condition of the ecosystem or species habitat in an area (Mokany et al., 2022).

Attribute levels

The attribute levels in designing the DCE were defined differently for the three types of ecosystem assets – species, ecosystem, and ecological community. A 20-year period into the future was considered to describe the changes in attributes. For all threatened species, the percentage change in species' current population 20 years from 2021 was considered. Similarly, for all three ecosystem types, the habitat condition index that captures both the extent (area) and condition (quality) of the habitat was considered, and for the ecological communities, mean species richness per hectare (water birds) and the habitat condition index (vascular plants) were considered. **Table 1** provides an overview of the attributes and their levels considered for use in the DCE design, based on review of the literature and consultations with experts.

Table 1. Attributes and levels used in the DCE experimental design

Attribute	Measure of attribute level	Level under status quo management *(In 20 years without additional management*)	Other levels presented in the discrete choice experiment *(In 20 years with one of the proposed management options)*
*Threatened species**			
Australian bittern	% Change in population	-30	-20, -10, 0, +10, +20
Painted honeyeater	% Change in population	0	+5, +10, +15, +20
Superb parrot	% Change in population	0	+5, +10, +15, +20
Koala	% Change in population	-30	-20, -10, 0, +10, +20
Green-comb spider-orchid	% Change in population	-50	-30, -10, 0, +10, +30
Winged pepper-cress	% Change in population	-15	-10, -5, 0, +5, +10
Cost	AU$/year	$0	$75, $150, $225, $300, $375
Ecosystem types[$]			
River-swamp wallaby grass	Condition index	30	35, 40, **45**, 50, 55
River red gum	Condition index	25	30, 35, **40**, 45, 50
Black box	Condition index	40	45, 50, **55**, 60. 65
Cost	AU$/year	$0	$75, $150, $225, $300, $375
Ecological communities[@]			
Water birds	Species richness (Spp. #/ha)	9	10, 11, **12**, 13, 14
Vascular plants	Condition index	48	51, 54, **57**, 60, 63
Cost	AU$/year	$0	$75, $150, $225, $300, $375

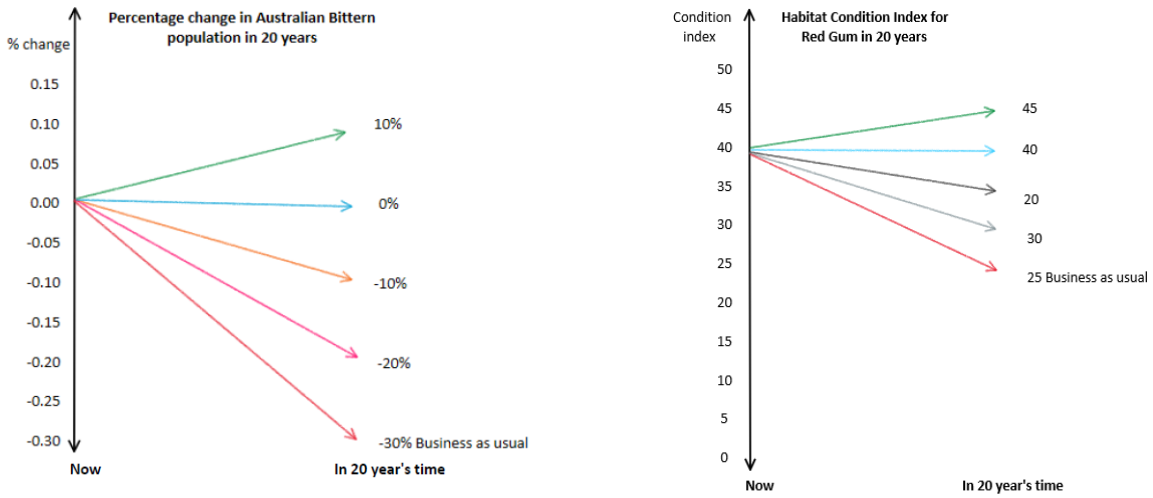
[*] For threatened species, the measure is 1% change in the population in 20 years' time. Thus, the current level for threatened species is 1% of its current population at the time of survey (see **Appendix 2** for details).

[$] For ecosystem types, the current levels of habitat condition indices considered were the mid-point levels under the management options (in bold).

[@] For water birds, the current level of species richness considered was 12 per ha. For vascular plants, the current level of the habitat condition index was 57.

Figure 1 depicts how attribute levels were represented for a threatened species (Australian bittern) and ecosystem (River red gum) using the percentage change in species population and the habitat condition index in 20 years' time. For other attributes, the attribute levels were described in one of these two ways – the percentage change in the population or the habitat condition index, except for water birds. For water birds, mean species richness per hectare in 20 years' time was used. To

establish the plausible levels for each attribute, several consultation meetings were held with the Department and CSIRO experts working in the GKP site in developing experimental ecosystem accounts.



a) Threatened species: Australian bittern b) Ecosystem type: River red gum

Figure 1. Diagrammatic representation of attribute levels for a) threatened species (% change in population) and b) ecosystem type (changes in habitat condition index) in 20 years

Choice options

Based on past experience with using discrete choice experiments to value threatened species in Australia (Zander et al., 2022, Gunawardena et al., 2020), we limited the choice options to three: status quo, management option 1, and management option 2. The status quo option represented the business-as-usual outcome for species, ecosystem types, and ecological communities in 20 years' time under the current mode of funding and management activities. Management options 1 and 2 represented the improved status of species, ecosystem types, and ecological communities relative to the status quo situation in 20 years' time with financial contributions from respondents. This financial contribution would help to fund additional conservation and management activities to improve the status of species, ecosystem types, and ecological communities in the GKP site and in the MDB. It is worth mentioning that even to maintain the population or condition of the habitats as of 2021 in 20 years' time (2041), some additional management activities would be necessary.

Below is an example of a species description included in the survey questionnaire on what would happen to the species in 20 years' time under different management options.

> **Australian bittern** is currently endangered and only 1150 birds are found in the Murray Darling Basin. According to experts there will be only 800 birds available in 20 years' time. Therefore, the percentage change in species population under business as usual is -30% (see Graph 1). In this example, we provide you two management options that are aiming to increase species population in 20 years. For example, if we do nothing the change is -30 %, that is, the population of Bittern declines (to 805). Option 1 helps to keep Bittern population at current level (1150) that means the percentage change in 20 years from the current level is 0%. Please note that even 0% change is an improvement when considering the threats over the next 20 years. The option 2 will increase the Bittern's population by 10% from the current level in 20 years (to 1265).

		Percentage change of species population in Murray Darling Basin in 20 years		
		(Business as usual)	Option 1	Option 2
Australian Bittern (Endangered)		-30%	0%	+10%

Experimental design and choice sets

Three experimental designs were considered for the DCE survey, one each for threatened species, ecosystem type, and ecological community with seven, four, and three attributes, respectively, including the cost as one attribute in each design.

Given the number of attributes and levels (four or five, see **Table 1**), a full factorial design including all possible combinations of attributes and their levels was not feasible. Therefore, three D-efficient experimental designs were generated using Ngene (ChoiceMetrics, 2018). The D-efficient design maximizes statistical efficiency of the model while minimizing the parameter standard errors. The threatened species design (D-error: 0.000292, S-estimate: 14.38) consisted of nine blocks of four choice sets, the ecosystem type-specific design (D-error: 0.001852, S-estimate: 250.34) consisted of eight blocks of three choice sets, and the ecological community-specific design (D-error: 0.001852, S-estimate: 247.23) consisted of five blocks of three choice sets.

Using the experimental design, the choice sets were developed. We also included photographs of the species or ecological community in the choice sets to add visual clarity for the attribute and to reduce the cognitive burden to respondents. **Figures** 2, 3, and 4 present example choice sets for threatened species, ecosystem types, and ecological communities, respectively. These choice sets were presented to respondents in a single DCE survey with three different choice sections.

Survey implementation

A survey instrument that consists of choice sets and other relevant questions was developed and submitted to UWA's Human Ethics Review committee for approval (see **Appendix 1**). The approved survey instrument (Approval reference number: RA/4/20/5471) was first piloted with 100 respondents. Based on evaluation of responses from pilot surveys, it was determined that there was no need to update the original design. The survey was administered by an online survey company (dynata.com) in March 2021 through Qualtrics. Quota were set in Qualtrics to secure representative sample of the Australian public (age, gender and state).

In implementing the survey questionnaire, each respondent was first offered four threatened species choice questions, followed by three ecosystem type-specific choice questions, and finally three ecological community-specific choice questions. In total, each respondent was asked to answer 10 choice questions, resulting in 30 observations from a single response. Given the experimental design, each choice task had three choice options. This design generated 12 threatened species-specific observations (4 choice occasions x 3 options), nine ecosystem type-specific observations (3 choice occasions x 3 options), and nine ecological community-specific observations (3 choice occasions x 3 options) from one completed response.

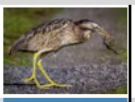
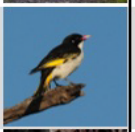
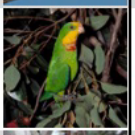
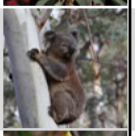
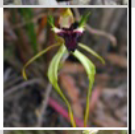
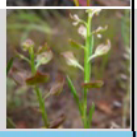
Name of the species (Current threat status)	Percentage change of species population in Murray Darling Basin in 20 years		
	Current Management (Business as usual)	Management Option 1	Management Option 2
Australian Bittern (Endangered) 	-30%	0%	+10%
Painted honeyeater (Vulnerable) 	0%	+10%	+20%
Superb parrot (Vulnerable) 	0%	+20%	+30%
Koala (Vulnerable) 	-30%	-20%	0%
Green-comb spider-orchid (Vulnerable) 	-50%	0%	+20%
Winged pepper-cress (Endangered) 	-15%	-5%	+10%
Additional cost to your household per year (in AUD)	$0	$225	$375
Which option would prefer?	☐	☐	☐

Figure 2. Example choice question for threatened species

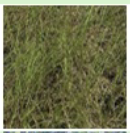
Dominant plant species (Ecosystem)	Habitat condition index of dominant plant species in Murray Darling basin in 20 years		
	Current Management (Business as usual)	Management Option 1	Management Option 2
River-swamp wallaby grass 	30	45	55
River red gum 	25	40	50
Black box 	40	55	65
Additional cost to your household per year (in AUD)	$0	$225	$375
Which option would prefer?	☐	☐	☐

Figure 3. An example choice question for ecosystem types

Ecological community	Type of index	Index of ecological communities in Murray Darling Basin in 20 years		
		Current Management (Business as usual)	Management Option 1	Management Option 2
Waterbirds 	Species richness (number of species per ha)	9	11	14
Vascular plants 	Habitat condition	48	57	63
Additional cost to your household per year (in AUD)		$0	$225	$300
Which option would prefer?		☐	☐	☐

Figure 4. An example choice question for ecological communities

3. Model and analysis

Model

We used conditional logit and mixed logit versions of the limited-dependent variable model[3] to analyse the choice data (Long and Freese, 2006, Hensher et al., 2005, Train, 2009) for each ecosystem asset-specific DCE (threatened species, ecosystem types, and ecological communities). These models are consistent with the random utility theory (McFadden, 1974), which assumes that when faced with two or more alternative choices, individuals will choose the utility maximising alternative. In other words, random utility theory assumes that individuals make rational choices. These models relate the probability of choice among the alternatives presented in each choice occasion to the characteristics of the attribute levels that define those alternatives. Under the assumption that the standard deviation of the parameter estimate in the sample is zero, the conditional logit model is a special case of the mixed-logit model. Therefore, we specify the mixed-logit model specification in this section (Hensher et al., 2005, Train, 2009).

Following random utility theory, the utility associated with an alternative is assumed to be a function of observed characteristics (deterministic component) and unobserved characteristics (error component) of the choice alternatives. We assume that the utility (U_{ijk}) received by individual i from available choice option j in choice set k is expressed as:

$$U_{ijk} = V_{ijk} + \varepsilon_{ijk} \qquad [1]$$

where V_{ijk} is the deterministic component and ε_{ijk} is the random error component of the utility function. The random error is assumed to be independently and identically distributed following a

[3] The fundamental difference between the two models is in the model assumptions. Conditional logit model assumes that respondents have the same preference for attribute levels across the sample and estimates only a set of coefficients representing the mean preference weights (Hensher et al., 2005; Train, 2009). The mixed-logit (also classed random-parameter logit) model assumes that respondents' preferences could vary across the sample, thus estimates a set of coefficients representing mean effect (preference weights) and standard deviation of effects across the sample (Hensher et al., 2005; Train, 2009).

Gumbel distribution (Hensher et al., 2005, Train, 2009). The deterministic component of the utility function is further decomposed into alternative-specific constant and choice attributes as:

$$U_{ijk} = \alpha_{ij} + \boldsymbol{\beta}_i \boldsymbol{X}_{ijk} + \varepsilon_{ijk} \quad [2]$$

where α_{ij} is an alternative specific constant characterising intrinsic preferences for a specific alternative (status quo, management option 1 or management option 2), $\boldsymbol{X}_{ijk}$ is a vector of choice attributes (threatened species, ecosystem types or ecological communities), and $\boldsymbol{\beta}_i$ is a vector associated with attribute parameter estimates.

Given that utility has a random error component, the analyst can only predict the probability that alternative *j* will be selected if the probability that the utility from option *j* is greater than that of another option *t*, across all alternatives.

$$\Pr(Choice_i = j|k) = \Pr\left(V_{ijk} + \varepsilon_{ijk}\right) > \Pr(V_{itk} + \varepsilon_{itk}), \forall\, j \neq t \quad [3]$$

Then, the choice probability of an alternative in a mixed-logit model becomes:

$$\Pr\left(Choice_i = j|k\right) = \frac{exp^{V_{ijk}}}{\sum_j exp^{V_{ijk}}} = \frac{exp^{(\alpha_{ij} + \beta_i X_{ijk})}}{\sum_j exp^{(\alpha_{ij} + \beta_i X_{ijk})}} \quad [4]$$

We modelled choice behaviour of respondents for three sets of DCEs for three ecosystem assets (threatened species, ecosystem type, and ecological community) separately. In total, individual respondents answered four choice sets for threatened species, three for ecosystem types, and three for ecological community, each with three choice alternatives – status quo, management option 1, and management option 2.

In the modelling, we allowed the status quo option to behave randomly to capture preference heterogeneity associated with it. The status quo parameter (associated with a dummy variable which is equal to one if the alternative is status quo or business as usual and zero otherwise) is specified as a normally distributed random parameter. This parameter identifies any utility level that is associated with the status quo option over and above what would be expected from the level of attributes in the status quo option. We also allowed non-linearity in the attribute levels to evaluate alternative model specifications for each ecosystem asset-specific DCE. We estimated the mixed-logit model and alternative models using STATA 17 to identify the parameters that best explain the choices made by the survey respondents across the three types of DCEs. We only report the preferred model results, that is, simple mixed-logit model results with the random status quo option in the results section. For completeness, we present other model results in the Appendix (see **Appendix 3**).

A total of 1756 responses were obtained from the survey. A close examination of the survey responses revealed that 144 respondents missed answering the Likert scale survey question "*I do things without thinking"*, and an additional 192 respondents finished the survey in less than five minutes, which was considered unreasonably quick. These responses were dropped from further analysis, because either they did not respond to all the questions, including the key filter question, or they finished the survey without considering all the information provided. Once these two sets of responses were dropped, only 1420 responses remained for further analysis.

Marginal WTP or partworth

The model results were used to calculate marginal willingness to pay for the sample respondents. The marginal willingness to pay or partworth is defined as the maximum amount that an individual would be prepared to pay to gain a unit change in an attribute that they value. Algebraically, the marginal WTP for attribute x can be calculated as:

$$Marginal\ WTP = -\frac{\beta_x}{\beta_c} \quad [5]$$

where β_x is the parameter estimate (coefficient) associated with the attribute x, and β_c is the parameter estimate of the cost attribute in the choice sets.

4. Results and discussion

Sample characteristics: Socio-demographics of the sample

Summary statistics of survey respondents for gender, age, education, state or territory are reported in **Table 2**. The last column in **Table 2** provides the percentage of the Australian population, according to the 2021 Census, for the socio-demographic variables. The survey sample was representative of the Australian population for gender (49.3% male, 50.7% female). The median age of the sample (45-54 years) was slightly higher than the median age of the Australian population (38 years), which is expected as the survey sample consists of only the respondents aged 18 years and over. All samples were somewhat biased towards higher education levels (undergraduate degree and above) which is common for online surveys (Dillman et al., 2014, p. 61). The distribution of survey respondents across the Australian states and territories followed the actual population distribution (**Table 2**).

Additional information on socio-economic characteristics of the survey sample is provided in **Appendix 4**. The sample included a larger percentage of high-income earners and a slightly higher percentage of retired respondents. In terms of sample identity, there were 19 identity groups, and about 2/3^{rds} of the sample identified themselves as Australian followed by about 13% Anglo-Saxon (for details, see **Appendix 4**).

Table 2. Sample characteristics of the respondents by gender, age, education, and state or territory (n = 1420)

Sample characteristics	Frequ -ency	Percent -age	Cumula -tive	% Australian population in 2021*[$]
Gender:				
Male	687	48.38	48.38	49.3
Female	730	51.41	99.79	50.7
Others	3	0.21	100	
Age:				
18-24 years	89	6.27	6.27	6.2[@]
25-34 years	204	14.37	20.63	14.7
35-44 years	244	17.18	37.82	13.7
45-54 years	232	16.34	54.15	12.7
55-64 years	349	24.58	78.73	11.9
>64 years	302	21.27	100.00	17.2
Highest level of education:				
Year 11 or below	202	14.23	14.23	21.9
Year 12	228	16.06	30.28	14.9
Certificate III/IV	254	17.89	48.17	16.1
Advanced Diploma and Diploma	185	13.03	61.2	9.4
University Undergraduate or above	551	38.8	100.00	26.3
Australian state or territory:				
ACT	22	1.55	90.77	1.8
Northern Territory	8	0.56	89.23	1.0
NSW	450	31.69	31.69	31.4
Queensland	298	20.99	52.68	20.4
South Australia	113	7.96	60.63	7.0
Tasmania	35	2.46	63.1	2.2
Victoria	363	25.56	88.66	25.5
Western Australia	131	9.23	100.00	10.7

* Australia 2021 Census All persons QuickStats available at: https://www.abs.gov.au/census/find-census-data/quickstats/2021/AUS

[@] This figure is for age 20-24 years.

[$] The % Australian population in 2021 is from https://www.abs.gov.au/statistics/people/population/national-state-and-territory-population/dec-2021#data-downloads-data-cubes

Protest responses

There were a number of protest responses in the sample. Such responses were identified by examining two conditions which need to be fulfilled to consider a response as protest response. First, protest responses were those with the status quo option in all choice tasks for each ecosystem asset-specific choice question. Second, such responses had other reasons than the two expected responses to the debriefing question. The two expected responses were: *I preferred this option to all others*, and *I could not afford an additional tax*. **Table 3** summarises the protest responses for three different sets of valuation tasks. There were about 5.5%, 8%, and 8.9% of protest responses in the species, ecosystem type, and ecological community-specific DCE surveys, respectively. Detailed profiles of the protest responses to choice tasks by ecosystem asset are provided in **Appendix 5**. High protest responses could skew the WTP estimates and need to be carefully considered. Despite

the protest response rate being relatively low, we dropped these responses from further analysis. The model results presented next are based only on the valid responses.

Table 3. Number of protest responses by type of ecosystem asset

Ecosystem asset type	Protest responses	Valid responses for further analysis
Threatened species	78 (5.5%)	1342
Ecosystem types	113 (8%)	1307
Ecological community	127 (8.9%)	1293

Model results

Table 4 reports the estimated results for the mixed-logit model for each ecosystem asset type in the GKP Forest Icon Site in the MDB. The parameter coefficients represent the utility weights associated with ecosystem asset-specific attributes. For example, a respondent's utility is significantly and positively influenced by a 1% increase of threatened species, habitat condition index of dominant species or ecosystem type and vascular plants, and mean species richness per hectare for waterbirds. The disutility associated with increased cost across ecosystem asset types is significant, as expected. The status quo mean effect is negative and significant for ecosystem types and ecological communities, but insignificant for threatened species choice options. Overall, these results are consistent with expectations.

Other results based on conditional logit models and non-linearity in attribute specifications (i.e., including a square term of the attribute in the model) are given in **Appendix 3** for each of the ecosystem assets. The non-linear terms are significant for the ecological communities, but are not significant for threatened species models - except for Winged pepper-cress, and ecosystem models - except for River-swamp wallaby grass (see **Appendix 3** for details).

Marginal WTP or partworth estimates

Based on the mixed-logit model results, the marginal willingness to pay for threatened species, ecosystem types, and ecological communities is reported in **Table 5**.

The marginal WTP estimates indicate that WTP varies by ecosystem asset and even within the same asset type between attributes. Across the ecosystem assets, the marginal WTP tends to be higher for ecological communities compared to threatened species and ecosystem types. For example, the marginal WTP is highest for water birds (AU$14.6 per year per household for 20-year), an ecological community, and lowest for Green-comb spider-orchid (AU$1.32 per year per household for 20-year), a threatened species. The WTP for water birds is associated with marginal improvement in mean species richness per hectare, whereas it is associated with a 1% increase in species population for Green-comb spider-orchid. Among the threatened species, the highest marginal WTP is for a 1% increase in the Koala population in 20 years' time (AU$3.22 per year per household for 20 years). Similarly, the marginal WTP for ecosystem types ranged between an estimated AU$1.5 to AU$3.3 for Black box and River red gum per year per household, respectively, for a 1-unit increase in the habitat condition index in 20 years.

Table 4. Mixed logit model results by ecosystem asset

Choice attribute	Coefficient	Std. err.	z	P>z	[95% conf.	interval]
Threatened species:						
Australian bittern	0.0126	0.0016	8.02	0.000	0.0095	0.0157
Painted honeyeater	0.0147	0.0030	4.92	0.000	0.0088	0.0205
Superb parrot	0.0155	0.0030	5.13	0.000	0.0096	0.0214
Koala	0.0156	0.0016	9.79	0.000	0.0125	0.0187
Green-comb spider-orchid	0.0064	0.0015	4.23	0.000	0.0034	0.0094
Winged pepper-cress	0.0129	0.0025	5.13	0.000	0.0080	0.0179
Cost1	-0.0049	0.0004	-11.40	0.000	-0.0057	-0.0040
Status quo (Mean)	-0.1981	0.1772	-1.12	0.264	-0.5455	0.1492
Status quo (Std. dev.)	1.8888	0.4197	4.50	0.000	1.0662	2.7114
Number of observations	16,104					
Log likelihood	-5655.25					
Ecosystem types:						
River-swamp wallaby grass	0.0169	0.0030	5.54	0.000	0.0109	0.0229
River red gum	0.0230	0.0031	7.45	0.000	0.0169	0.0290
Black box	0.0105	0.0030	3.48	0.001	0.0046	0.0164
Cost2	-0.0071	0.0004	-16.54	0.000	-0.0079	-0.0062
Status quo (Mean)	-1.4665	0.2277	-6.44	0.000	-1.9128	-1.0203
Status quo (Std. dev.)	2.8565	0.4651	6.14	0.000	1.9450	3.7681
Number of observations	11,763					
Log likelihood	-4082.25					
Ecological communities:						
Water birds	0.1074	0.0154	6.96	0.000	0.0771	0.1376
Vascular plants	0.0242	0.0051	4.69	0.000	0.0141	0.0342
Cost3	-0.0074	0.0004	-19.77	0.000	-0.0081	-0.0066
Status quo (Mean)	-1.5789	0.1895	-8.33	0.000	-1.9504	-1.2075
Status quo (Std. dev.)	2.5955	0.4021	6.45	0.000	1.8074	3.3836
Number of observations	11,637					
Log likelihood	-3942.39					

Table 5. WTP estimates to achieve marginal improvement in ecosystem asset (species, ecosystem type or ecological community) in 20 years' time (AUD/year/household for 20 years)

Choice attribute	WTP estimate	Std. err.	z	P>z	WTP [95% CI]	
Threatened species:						
Australian bittern	2.60	0.248	10.48	0.000	2.11	3.09
Painted honeyeater	3.02	0.601	5.04	0.000	1.85	4.20
Superb parrot	3.19	0.608	5.25	0.000	2.00	4.39
Koala	3.22	0.271	11.85	0.000	2.68	3.75
Green-comb spider-orchid	1.32	0.238	5.56	0.000	0.86	1.79
Winged pepper-cress	2.66	0.480	5.54	0.000	1.72	3.60
Ecosystem types:						
River-swamp wallaby grass	2.39	0.429	5.59	0.000	1.56	3.23
River red gum	3.26	0.434	7.50	0.000	2.41	4.11
Black box	1.49	0.422	3.52	0.000	0.66	2.31
Ecological communities:						
Water birds	14.60	2.056	7.10	0.000	10.57	18.63
Vascular plants	3.28	0.679	4.84	0.000	1.95	4.62

The extrapolation of welfare estimates based on the findings (**Table 5**, **Column 1**) to the entire Australian population is possible, given there were 9.275 million households in Australia in 2021 (Australian Bureau of Statistics, 2021). However, direct comparison of all our findings with previous DCE studies is not possible for several reasons. First, relevant studies covering all the ecosystem assets in our study do not exist. Second, while a few studies exist (Zander et al., 2022, Gunawardena et al., 2020) that consider some of the ecosystem assets, the framing of the valuation questions were different. For example, the framing of the valuation questions in our study provide WTP estimates for a 1% increase in the population of threatened species in 20 years for threatened species, a 1-unit increase in the habitat condition index in 20 years for ecosystem types and vascular plants, and a 1-unit increase in mean species richness per ha in 20 years for water birds. The framing of the valuation questions in Zander et al. (2022) and Gunawardena et al. (2020) were percentage reduction in the risk of extinction for the species from its current risk level in 20 years.

Gunawardena et al. (2020) estimated the WTP among the Australian public for Australian bittern with a focus on reducing the risk of extinction for this species, even though the time period considered is the same (20 years). Their framing of the valuation question provides WTP estimates of AU$1.12 [95% CI: $0.57 to $1.67] for one percentage point improvement in the extinction risk status of Australian bittern. Australian bittern is classified as a critically endangered bird (very high risk of extinction). To reduce the risk of extinction from very high to the lowest level, the estimated WTP was about AU$84 per year per household for 20 years (Gunawardena et al., 2020). Similarly, Zander et al. (2022) estimated the WTP per year for 20 years among the Australian public for Australian bittern with a focus on reducing extinction risks from certain to extinct to lower levels. They found that the WTP for reducing the risk of extinction from certain to extinct to high risk of extinction (endangered) was AU$56 [95% CI: $22 to $91], to moderate risk of extinction (vulnerable) was AU$102 [95% CI: 60 to 143], and low risk of extinction (near threatened) was AU$117 [$71 to $163]. On the other hand, our estimated WTP of AU$2.60 per year per household

is for a 1% increase in the population of Australian bittern at the GKP site in the MDB in 20 years. This raises a question about context-specificity of valuation tasks and the importance of the framing of valuation questions in DCE studies.

At the national level, Australia has been developing experimental ecosystem accounts following the SEEA – EA Framework of the United Nations. This effort is being led by the Australian Bureau of Statistics (ABS) and the Department of Climate Change, Energy, the Environment, and Water (DCCEEW). In collaboration with CSIRO, they have recently released the first national ecosystem accounts estimates (Australian Bureau of Statistics, 2020-21) and noted that the value of five ecosystem services (carbon storage, water supply, coastal protection, wild fish provisions, and forage provisions or grazed biomass) provided by the ecosystems generated at least AU$85 billion of value to support the economy and wellbeing. Regarding biodiversity assets, it provided threatened species status over the years, and indicated an increasing trend in the number of threatened species. For example, the total number of threatened species listed under the EPBC Act were 1772 in 2015 (including 1293 plants, 147 birds and 130 mammals), which increased to 1898 species in 2020 (including 1380 plants, 157 birds and 135 mammals) (Australian Bureau of Statistics, 2020-21). Given that it was the first national-level ecosystem accounts site, specific details are very limited. It provided some information on the extent, condition, physical and monetary flow of ecosystem services, and the change in stock accounts. Details required to make decisions at local levels are obviously missing. Importantly, it recognises that these accounts will be further developed in coming years. The value of ecosystem assets that provide non-use benefits to society such as ecosystem and species appreciation services are possibly a long way away from appearing in the national accounts, given the lack of micro-level data on values across the ecosystem assets (species, ecosystem types, and ecological communities.

5. Conclusions

We implemented a DCE study to estimate the Australian public's willingness to pay for key ecosystem assets at the GKP site in the Murray-Darling Basin. A total of six threatened species, three ecosystem types, and two ecological communities or species groups were considered as key ecosystem assets of the GKP site. Improvement in the percentage of species population and the health and extent of ecosystems, represented by the habitat condition index, 20 years into the future were used as measures of attributes in the valuation tasks.

The WTP estimates obtained from a mixed-logit model suggests that the marginal WTP is highest for water birds (AU$14.60 per year per household for 20 years) and lowest for Green-comb spider-orchid (AU$1.32 per year per household for 20 years). The marginal willingness to pay is generally higher for ecological communities than individual threatened species and ecosystem types in the GKP Forest Icon Site.

We acknowledge the fact that we implemented three different DCE studies for threatened species, ecosystem types, and ecological communities in a single survey. This approach may have implications on the WTP estimates that we obtained. It is recommended to compare the estimates obtained from a single survey for a single set of ecosystem assets with a single survey for multiple sets of ecosystem assets within the DCE framework. Also, we have limited our analysis to a simple model, without interactions of socio-demographic characteristics of respondents with the attributes.

The next important step is to use the values identified here to generate exchange prices and exchange values for these environmental assets. This is not undertaken here, but the theoretical basis for undertaking this is reported in Scheufele et al. (2025).

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Appendix 1. Questionnaire or survey instrument

Social preferences for conserving threatened species

You are invited to participate this online survey that seek your preferences conserving multiple species. The survey will take about 15-20 minutes to complete.

What is the project about?
The aim of the study is to understand preferences of Australian public for conserving multiple threatened species (animals, plants and ecological communities). The study will estimate the dollar values that people will place on protecting different types of species that are facing different levels of extinction risk.

What does participation involve?
The participation of the survey means that you have to answer an online survey. You will be provided with information of multiple species that are facing risk of extinction at different levels. Then you will be asked make choices of protection programs that involve reducing the risk of extinction of combination of species.

Voluntary Participation and Withdrawal from the Study
Your participation will be on a voluntary basis and you can withdraw your participation at any stage of research without prejudice. However, your participation will prove important to complete this research.

Your privacy
Your information will be anonymously stored on the questionnaire forms initially and later on the researcher's laptop and finally in University of Western Australia (UWA) data backup system for at least seven years. This information will be kept strictly confidential and will not be made available to other people.

Possible Benefits
This research project will estimate the monetary benefits of protecting threatened species. Benefits (values) of threatened species are not currently available for most species listed in the Australian Government's Threatened Species Strategy (TSS). Decisions on program funding at Commonwealth and state levels rest on sound understanding of the values of threatened species. Selection of projects for species management are improved, through identifying projects that provide that best value for money.
By answering these questions, you will have the opportunity to express your opinions in protecting Australia's threatened animals and plants and ecological communities.

Possible Risks and Risk Management Plan
There are no foreseeable risks and potential harm associated on providing personal information and opinions. If any aspects of this research project distresses you, you can contact me at the above address or the UWA Human Research Ethics office at the below address.

Contacts
If you have any questions with any aspects of this interview, please feel free to contact either at my work phone number (+61864881353) or on my mobile phone number (+610422185791).

Sincerely,
Dr. Ram Pandit, Chief Investigator

Approval to conduct this research has been provided by The University of Western Australia (ethics reference number: RA/4/20/5471), in accordance with its ethics review and approval procedures. Any person considering participation in this research project, or agreeing to participate, may raise any questions or issues with the researchers at any time. In addition, any person not satisfied with the response of researchers may raise ethics issues or concerns, and may make any complaints about this research project by contacting the Human Ethics office at UWA on (08) 6488 4703 or by emailing to humanethics@uwa.edu.au.

All research participants are entitled to retain a copy of any Participant Information Form and/or Participant Consent Form relating to this research project.

1. A few questions about you

1.1 Please enter your postcode

1.2 Could you please indicate your age group?

- ☐ Less than 18 years
- ☐ 18-24 years
- ☐ 25-34 years
- ☐ 35-44 years
- ☐ 45-54 years
- ☐ 55-64 years
- ☐ >64 years

1.3. State the highest level of education level you have completed so far

- ☐ Year 11 or below
- ☐ Year 12
- ☐ Certificate III/IV
- ☐ Advanced Diploma and Diploma
- ☐ University Undergraduate/ Bachelor Degree
- ☐ Post Graduate Degree (Masters or PhD)

If less than 18 years, then the system should take them to a "Thank you page".

2. Managing the protection of threatened species in the Murray Darling Basin (MDB)

In this survey, we are aiming to value your preferences to conserve threatened species, ecosystems (ecosystems dominated by two eucalyptus species) and ecological communities in the MDB.

Below we describe species, ecological communities, and dominant habitats considered. We also present levels of possible changes for each of species, ecological community, and habitat type in the next 20 years under three management scenarios – business as usual, option 1 and option 2. Business as usual mean nothing different than the current practice, while the option 1 and option 2 are improved management scenarios with changes in levels of different attributes (species, communities, habitat and cost contributions). If more funding is allocated to conservation then we can implement management options (option 1 or option 2). In the survey questions we will be asking whether you would be willing to contribute personal funds for this to happen.

Additional funding for Conservation

In the survey questions we will be asking whether you would be willing to contribute personal funds for this to happen. The extra funds would be collected through an additional tax for the next 20 years, and would be used to create a special "Threatened Species Conservation Fund" that would be used solely for conserving threatened species and ecological communities. However, it is not always possible to allocate enough funds to protect all species.

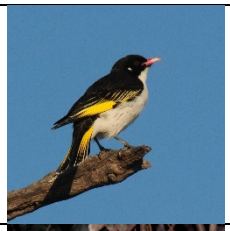
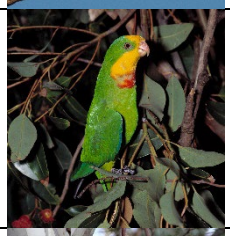
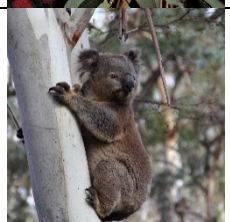
3. Species information

In this survey, we ask your preferences for conserving three types of species in three sections

1. Individual species (animals and plants)
2. Ecosystems with dominant species
3. Ecological communities

Section 1: Individual species (animals and plants)

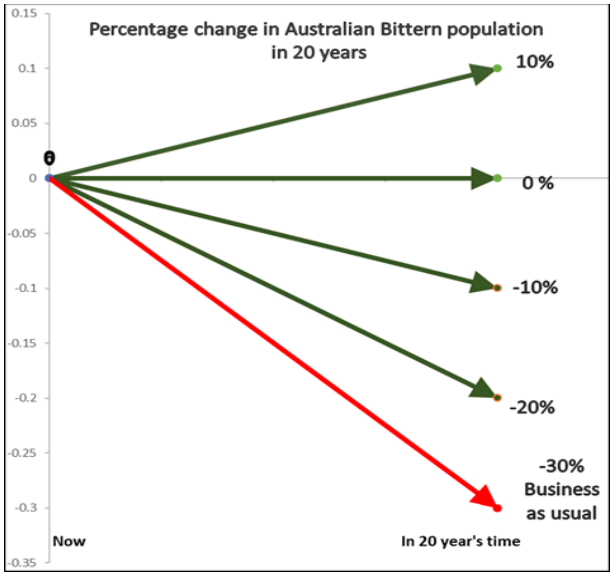
Here, we will be considering 4 different animals and 2 plants. The Table below provides information on species' current extinction risk levels, where they are found in, and their current population in the Murray Darling Basin.

Species name		Current risk of extinction at local level	Found in	Number of individuals in the Murray Darling Basin (MDB)	Percentage of individuals in the MDB out of total individuals in Australia
1. Australian Bittern		Endangered	South-eastern and South-western Australia , and Tasmania	1150	88%
2. Painted honeyeater		Vulnerable (Endemic to Australia)	Queensland, New South Wales Northern Victoria. Northern Territory , South Australia	7000	80%
3. Superb parrot		Vulnerable (Endemic to Australia)	New South Wales and Victoria	20,000	100%
4. Koala		Vulnerable	Queensland, New South Wales, Victoria and South Australia	29,990	10%
5. Green-comb spider-orchid		Vulnerable	Victoria, South Australia	4500	100%
6. Winged pepper-cress		Endangered	New South Wales, Victoria, South Australia	3000	50%

Here is an example for Australian Bittern on what will happen to this species in 20 years' time under different situations.

Australian Bittern is currently endangered and only 1150 birds are found in the Murray Darling Basin. According to experts there will be only 800 birds available in 20 years' time. Therefore, the percentage change in species population under business as usual is -30% (See Graph 1). In this example, we provide you two management options that are aiming to increase species population in 20 years. For example, if we do nothing the change is -30 %, that is, the population of Bittern declines (to 805). Option 1 helps to keep Bittern population at current level (1150) that mean percentage change in 20 years from the current level is 0%. Please note that even 0% change is an improvement when considering the threats over the next 20 years. The option 2 will increase the Bittern's population by 10% from the current level in 20 years (to 1265).

		Percentage change of species population in Murray Darling Basin in 20 years		
		(Business as usual)	Option 1	Option 2
Australian Bittern (Endangered)		-30%	0%	+10%



Graph 1: Population change of Australian Bittern in 20 years

We are going to consider improvements in species and the improvements will be shown as a percentage change in population of individual species.

We will show three options to choose from, with different levels of change for each species.

1. Business as usual – that means if funding and management of species continue as they are now.

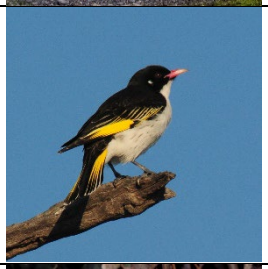
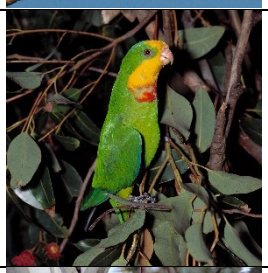
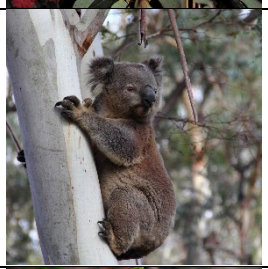
2. Management option 1

3. Management option 2

If more funding is allocated to conservation then we can implement management options (option 1 or option 2). In the survey questions we will be asking whether you would be willing to contribute personal funds for this to happen.

Example of a choice question in Section 1

In the questions that follow, we will show three options to choose from in order to make population changes of each species.Assuming that you have only these two options. Which option will you choose? Please bear in mind your financial situation when making a choice. Any amount collected as a tax will reduce the funds available for your household to spend on other things. Consider this question independent of the others.

		Percentage change of species population in Murray Darling Basin in 20 years		
		(Business as usual)	Option 1	Option 2
Australian Bittern (Endangered)		-30%	0	+10%
Painted honeyeater (Vulnerable)		0	+10%	+20%
Superb parrot (Vulnerable)		0	+20%	+30%
Koala (Vulnerable)		-30%	-20%	0
Green-comb spider-orchid (Vulnerable)		-50%	0	+20%

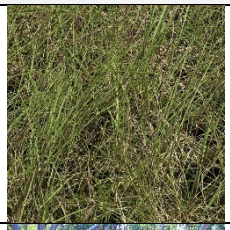
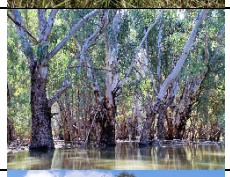
Winged pepper-cress (Endangered)		-15%	-5%	+10%
Additional Cost to you: $ per year		**0**	**225**	**375**
Which option would prefer?		☐	☐	☐

Section 2: Ecosystems with dominant species

In this section, we consider three ecosystems with dominant species in Australia. River-swamp wallaby grass is a grass and the River Red Gum and Black Box are dominant tree species that dominate that landscape in the Murray Darling Basin.

We are going to consider improvements in these three ecosystems using two management options and the improvements will be shown using habitat condition index (this is a measure that includes habitat area as well as the quality of the habitat)

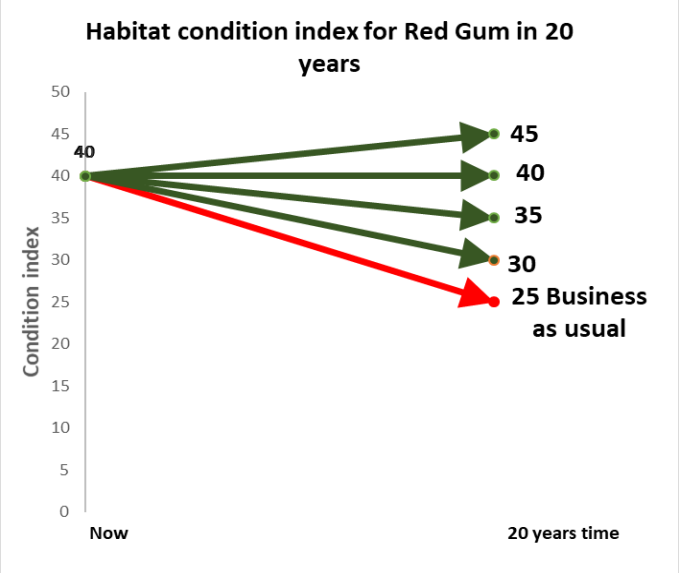
Here, we use the current habitat condition index considering the pre-European in the Murray Darling Basin as the baseline. In other words, we assume that pre-European habitat condition index as 100%. The last column of the table shows current habitat condition index relative to pre-European condition.

Ecosystem (species)		Current risk of extinction at local level	Found in	Habitat condition in Murray darling Basin (Expressed as habitat condition index)	
				Pre-European	Current
1. River-swamp wallaby grass		Vulnerable	Australia	100	45
2. River Red Gum		Endemic to Australia	Australia	100	40
3. Black Box		Endemic to Australia	Queensland, New South Wales, Victoria and South Australia	100	55

Here is an example to illustrate how condition index works.

		Habitat condition index in Murray Darling basin in 20 years		
		(Business as usual)	Option 1	Option 2
River Red Gum		25	30	50

As shown in the above Table current condition index is 40 for River Red Gum compared to the pre-European settlement state (=100, the maximum value for condition index). According to experts, If we continue business as usual the condition index would be 25 in 20 years. With new management options we can improve the condition index. For example under Option 1, the index would be 30 and under Option 2, it would further improve to 50 (see Graph 2).



Graph 2: Change in habitat condition index for River red gum in 20 years

We will show three options to choose from in order to make changes of each ecosystem

1. Business as usual – habitat condition index in 20 years if funding and management continue as they are now

2. Management option 1

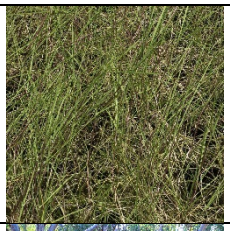
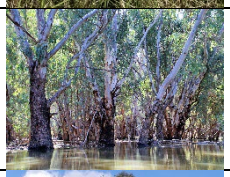
3. Management option 2

If more funding is allocated to conservation then we can implement management options (option 1 or option 2)

In the survey questions we will be asking whether you would be willing to contribute personal funds for this to happen.

Example of a choice question in Section 2

Consider the following two choice options assuming that you have only these two options. Which option will you choose? Please bear in mind your financial situation when making a choice. Any amount collected as a tax will reduce the funds available for your household to spend on other things. Consider this question independent of the others.

		Habitat condition index in Murray Darling basin in 20 years		
		(Business as usual)	Option 1	Option 2
River-swamp wallaby grass		35	45	55
River Red Gum Eucalyptus		30	40	50
Black Box Eucalyptus		45	55	65
Additional Cost to you: $ per year		**0**	**225**	**375**
Which option would prefer?		☐	☐	☐

Section 3: Ecological communities

In this section, we consider two unique ecological communities in Australia: water birds and vascular plants in Murray Darling Basin.

We are going to consider improvements in these communities using two management options and the improvements will be shown based on mean species richness for water birds and 'biodiversity retained' index for vascular plants. Biodiversity retained' is the expected percentage of species originally occurring within the reporting area that are expected to persist anywhere in their range, given changes in habitat condition across all south-east Australia.

Community		Type of index	Baseline	Current
Water birds		Mean species richness (number of waterbird species per ha)	12.56 (in 2010)	12
Vascular plants		Habitat Condition Index	100 (pre-European condition)	57

We will show three options to choose from in order to make changes of each community

1. Business as usual – habitat condition index in 20 years if funding and management continue as they are now

2. Management option 1

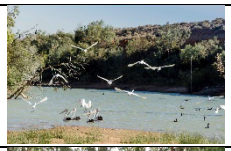
3. Management option 2

If more funding is allocated to conservation then we can implement management options (option 1 or option 2)

In the survey questions we will be asking whether you would be willing to contribute personal funds for this to happen.

In the questions that follow, we will show three options to choose from in order to make population changes of each species.

Assuming that you have only these two options. Which option will you choose? Please bear in mind your financial situation when making a choice. Any amount collected as a tax will reduce the funds available for your household to spend on other things. Consider this question independent of the others.

Community		Index of ecological communities in Murray Darling Basin in 20 years		
		Business as usual	Option 1	Option 2
Waterbirds		9	11	14
Vascular plants		48	57	63
Additional Cost to you: $ per year		**0**	**225**	**300**
Which option would prefer?		☐	☐	☐

4. Follow up questions

4.1 To what extent did you understand the questions in the previous section?
Please select one answer

☐ Fully understood the questions
☐ Partially understood the questions
☐ Did not understand the questions at all

4.2 How certain are you that you would be requested to pay the stated annual additional tax for threatened species conservation if asked in real life?

☐ Very certain
☐ Certain
☐ Uncertain
☐ Very uncertain

4.3 Did you consider all 3 features (Cost, Species, and measures of species persistence – proportion of population change or condition index or mean species richness where appropriate) when you answered the choice questions?

☐ Yes
☐ No

4.4a Please indicate the features that you ***ignored*** in answering choice questions in Section 1 – **Individual species** (Tick all that apply)

☐ Costs (the additional annual tax)
☐ Species to be protected
☐ Level of change in species population
☐ All of them

4.4b Please indicate the features that you ***ignored*** in answering choice questions in Section 2 – **Ecosystems with dominant species** (Tick all that apply)

☐ Costs (the additional annual tax)
☐ Species to be protected
☐ Level of habitat condition index
☐ All of them

4.4c Please indicate the features that you ***ignored*** in answering choice questions in Section 3 – **Ecological communities** (Tick all that apply)

☐ Costs (the additional annual tax)
☐ Ecological communities to be protected
☐ Level of mean species richness for waterbirds and habitat condition index for vascular plants
☐ All of them

4.5 Tick the reason if you always selected zero cost option (no additional protection) for all the choices

- ☐ I preferred this option to all others
- ☐ I could not afford the other options
- ☐ I believe funding to manage endangered species and ecological communities should come from somewhere other than my own pocket
- ☐ I believe funding to manage endangered species and ecological communities should be collected by some other means than a State tax
- ☐ I don't trust that the funds would be used to manage endangered species and ecological communities
- ☐ I don't believe that there will be any impacts on the extinction of species during this time period (next 20 years)
- ☐ I don't believe I should have to make these choices
- ☐ Other

4.6 Tick the reason if you always selected the option with additional protection for all the choices

- ☐ I preferred these options to all others
- ☐ I was happy to make the payment asked, given the change in species population, habitat condition index or species richness (for waterbirds)
- ☐ I ignored the cost of the option
- ☐ I believe you should protect all species and ecological communities irrespective of any cost
- ☐ I didn't think I would ever be asked to make the payments
- ☐ Other

5. Information about you

5.1 What is your gender? Please select one answer☐ Male

- ☐ Female
- ☐ Non-binary ---------- (please specify)
- ☐ Prefer not to say

5.2. Number of people live in your household

- ☐ Adults --------
- ☐ Children <5 years ---------
- ☐ Children >5 years and <18 years ---------

5.3 Do you identify yourself as one of the following group?

- ☐ European
- ☐ Asian
- ☐ Aboriginal or Torres Strait Islander
- ☐ South-American
- ☐ Middle-eastern
- ☐ North American
- ☐ Prefer not to say
- ☐ Others, please specific …….

5.4 Please indicate your current annual household income (i.e. before tax and including all people living in your household)

☐ Negative income
☐ Nil income
☐ $1- $7,799 per year
☐ $7,800 - $15,599 per year
☐ $15,600 - $20,799 per year
☐ $20,800 - $25,999 per year
☐ $26,000 - $33,799 per year
☐ $33,800 - $41,599 per year
☐ $41,600 - $51,999 per year
☐ $52,000 - $64,999 per year
☐ $65,000 - $77,999 per year
☐ $78,000 - $90,999 per year
☐ $91,000 - $103,999 per year
☐ $104,000 - $155,999 per year
☐ $156,000 or more per year

5.5 What is your current employment status?

☐ Employed full time (40 or more hours per week)
☐ Employed part time (less than 40 hours per week)
☐ Unemployed and currently looking for work
☐ Unemployed and not currently looking for work
☐ Student
☐ Retired
☐ Homemaker (manages a home and family)
☐ Self-employed
☐ Unable to work

5.6 Did your household pay any taxes last year?

☐ Yes
☐ No

5.7 Do you actively support (financial donations or volunteering your time) any environmental groups or organizations associated with conservation of Australian Species?

☐ Yes
☐ No

5.8 Are you currently engaged or have you ever been engaged in species or ecological community conservation related work

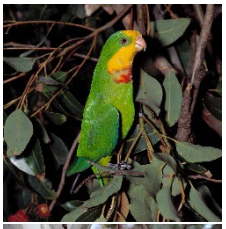
☐ Yes
☐ No

5.9 Do you have any comments about the survey?

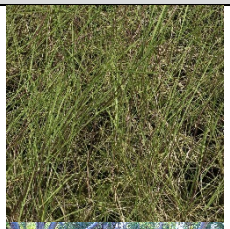
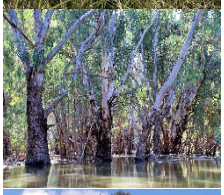
Thank you for your contribution.

Appendix 2. Background description of the attribute used in the study

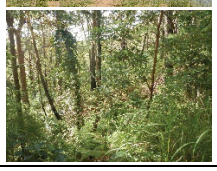
Annex-2a. Background information on six threatened species

Threatened species name		Current risk of extinction at local level	Found in	Number of individuals in the Murray Darling Basin (MDB)	Percentage of individuals in the MDB out of total species in Australia
Australian Bittern		Endangered	South-eastern and South-western Australia, and Tasmania	1150	88%
Painted honeyeater		Vulnerable (Endemic to Australia)	Queensland, New South Wales Northern Victoria. Northern Territory, South Australia	7000	80%
Superb parrot		Vulnerable (Endemic to Australia)	New South Wales and Victoria	20,000	100%
Koala		Vulnerable	Queensland, New South Wales, Victoria and South Australia	29,990	10%
Green-comb spider-orchid		Vulnerable	Victoria, South Australia	4500	100%
Winged pepper-cress		Endangered	New South Wales, Victoria, South Australia	3000	50%

Annex-2b. Background information on three ecosystems/dominant species

Ecosystem (dominant species)		Current risk of extinction at local level	Found in	Habitat condition in Murray darling Basin (Expressed as habitat condition index)	
				Pre-European	**Current**
River-swamp wallaby grass		Vulnerable	Australia	100	45
River Red Gum		Endemic to Australia	Australia	100	40
Black Box		Endemic to Australia	Queensland, New South Wales, Victoria and South Australia	100	55

Annex- 2c. Background information on ecological communities

Ecological community		Type of index	Baseline	Current
Water birds		Mean species richness (number of waterbird species per ha)	12.56 (in 2010)	12
Vascular plants		Habitat Condition Index	100 (pre-European condition)	57

Appendix 3. Alternative model specification and results for each ecosystem asset

1. Conditional (fixed effect) logit model results: Threatened species

Choice attribute	Coefficient	Std. err.	z	P>z	[95% conf.	interval]
Australian bittern (ab)	0.0095	0.0012	7.890	0.000	0.0071	0.0119
Painted honeyeater (ph)	0.0122	0.0029	4.280	0.000	0.0066	0.0178
Superb parrot (sp)	0.0128	0.0029	4.490	0.000	0.0072	0.0184
Koala (kl)	0.0124	0.0012	10.170	0.000	0.0100	0.0148
Green-comb spider-orchid (gso)	0.0029	0.0010	2.940	0.003	0.0010	0.0048
Winged pepper-cress (wpc)	0.0101	0.0023	4.400	0.000	0.0056	0.0146
Cost (c)	-0.0037	0.0002	-16.890	0.000	-0.0041	-0.0033
Status quo (sq)	0.1412	0.1049	1.350	0.178	-0.0644	0.3468
Number of observations	16,104					
Log likelihood	-5660.35					

2. Conditional (fixed effect) logit model results with non-linearity in choice attributes: Threatened species

Choice attribute	Coefficient	Std. err.	z	P>z	[95% conf.	interval]
ab	0.0121	0.0020	6.170	0.000	0.0082	0.0159
ab^2	-0.0002	0.0002	-0.740	0.461	-0.0007	0.0003
Ph	-0.0949	0.0776	-1.220	0.221	-0.2469	0.0571
ph^2	0.0044	0.0031	1.420	0.154	-0.0017	0.0105
Sp	0.1210	0.0792	1.530	0.126	-0.0341	0.2762
sp^2	-0.0042	0.0031	-1.340	0.181	-0.0104	0.0020
Kl	0.0155	0.0021	7.480	0.000	0.0114	0.0196
kl^2	-0.0002	0.0002	-0.940	0.349	-0.0006	0.0002
gso	0.0069	0.0020	3.370	0.001	0.0029	0.0109
gso^2	0.0000	0.0001	0.400	0.688	-0.0001	0.0001
wpc	0.0110	0.0025	4.330	0.000	0.0060	0.0160
wpc^2	-0.0036	0.0012	-3.020	0.003	-0.0059	-0.0013
c	-0.0049	0.0006	-7.940	0.000	-0.0061	-0.0037
sq	1.1404	0.5675	2.010	0.044	0.0280	2.2527
Number of observations	16,104					
Log likelihood	-5653.44					

3. Mixed logit model results with non-linearity in attributes: Threatened species

Choice attribute	Coefficient	Std. err.	z	P>z	[95% conf.	interval]
ab	0.0182	0.0026	6.940	0.000	0.0131	0.0234
ab2	0.0000	0.0003	0.030	0.978	-0.0006	0.0006
ph	-0.1239	0.1241	-1.000	0.318	-0.3672	0.1193
ph2	0.0058	0.0050	1.160	0.245	-0.0040	0.0155
sp	0.1895	0.1275	1.490	0.137	-0.0603	0.4393
sp2	-0.0068	0.0051	-1.330	0.183	-0.0167	0.0032
kl	0.0215	0.0027	7.900	0.000	0.0161	0.0268
kl2	-0.0003	0.0002	-1.410	0.158	-0.0008	0.0001
gso	0.0139	0.0029	4.880	0.000	0.0083	0.0195
gso2	0.0000	0.0001	0.390	0.697	-0.0001	0.0001
wpc	0.0163	0.0030	5.530	0.000	0.0105	0.0221
wpc2	-0.0056	0.0015	-3.650	0.000	-0.0087	-0.0026
c	-0.0070	0.0009	-8.100	0.000	-0.0087	-0.0053
sq (mean)	1.3122	0.6875	1.910	0.056	-0.0354	2.6597
sq (std. dev.)	2.2730	0.4386	5.180	0.000	1.4135	3.1326
Number of observations	16,104					
Log likelihood	-5644.92					

4. Conditional (fixed effect) logit model results: Ecosystem types

Choice attribute	Coefficient	Std. err.	z	P>z	[95% conf. interval]	
River-swamp wallaby grass (swg)	0.0135	0.0028	4.810	0.000	0.0080	0.0191
River red gum (rrg)	0.0188	0.0028	6.680	0.000	0.0133	0.0243
Black box (bb)	0.0081	0.0028	2.880	0.004	0.0026	0.0136
Cost (c)	-0.0050	0.0003	-19.100	0.000	-0.0055	-0.0045
Status quo (sq)	-0.4784	0.0930	-5.140	0.000	-0.6607	-0.2961
Number of observations	11,763					
Log likelihood	-4103.11					

5. Conditional (fixed effect) logit model results with non-linearity in attributes: Ecosystem types

Choice attribute	Coefficient	Std. err.	z	P>z	[95% conf. interval]	
swg	0.1853	0.1209	1.530	0.125	-0.0517	0.4224
Swg^2	-0.0019	0.0014	-1.400	0.163	-0.0045	0.0008
rrg	0.1389	0.0931	1.490	0.136	-0.0436	0.3214
rrg^2	-0.0015	0.0012	-1.260	0.209	-0.0038	0.0008
bb	0.1072	0.1644	0.650	0.514	-0.2150	0.4294
bb^2	-0.0009	0.0015	-0.590	0.554	-0.0038	0.0021
c	-0.0062	0.0005	-12.550	0.000	-0.0072	-0.0053
sq	0.0862	0.2242	0.380	0.700	-0.3531	0.5256
Number of observations	11,763					
Log likelihood	-4098.86					

6. Mixed logit model results with non-linearity in attributes: Ecosystem types

Choice attribute	Coefficient	Std. err.	z	P>z	[95% conf. interval]	
swg	0.3561	0.1550	2.300	0.022	0.0523	0.6600
swg^2	-0.0038	0.0017	-2.180	0.029	-0.0072	-0.0004
rrg	0.1577	0.1139	1.390	0.166	-0.0654	0.3809
rrg^2	-0.0017	0.0014	-1.180	0.236	-0.0045	0.0011
bb	-0.2357	0.2359	-1.000	0.318	-0.6982	0.2267
bb^2	0.0023	0.0022	1.050	0.293	-0.0020	0.0065
c	-0.0081	0.0007	-11.410	0.000	-0.0095	-0.0067
sq (Mean)	-1.1478	0.4311	-2.660	0.008	-1.9928	-0.3028
sq (Std. dev.)	2.9282	0.4910	5.960	0.000	1.9658	3.8906
Number of observations	11,763					
Log likelihood	-4078.79					

7. Conditional (fixed effect) logit model results: Ecological communities

Choice attribute	Coefficient	Std. err.	z	P>z	[95% conf.	interval]
Water birds (wb)	0.0873	0.0142	6.130	0.000	0.0594	0.1152
Vascular plants (vp)	0.0180	0.0048	3.780	0.000	0.0086	0.0273
Cost (c)	-0.0057	0.0002	-23.440	0.000	-0.0061	-0.0052
Status quo (sq)	-0.7590	0.0829	-9.150	0.000	-0.9215	-0.5965
Number of observations	11,637					
Log likelihood	-3965.20					

8. Conditional (fixed effect) logit model results with non-linearity in attributes: Ecological communities

Choice attribute	Coefficient	Std. err.	z	P>z	[95% conf.	interval]
wb	2.3581	0.5177	4.560	0.000	1.3435	3.3727
wb^2	-0.0944	0.0215	-4.390	0.000	-0.1367	-0.0522
vp	0.9320	0.2759	3.380	0.001	0.3912	1.4728
vp^2	-0.0080	0.0024	-3.330	0.001	-0.0128	-0.0033
c	-0.0067	0.0003	-22.310	0.000	-0.0073	-0.0061
sq	0.1877	0.1778	1.060	0.291	-0.1607	0.5362
Number of observations	11,637					
Log likelihood	-3946.82					

9. Mixed logit model results with non-linearity in attributes: Ecological communities

Choice attribute	Coefficient	Std. err.	z	P>z	[95% conf.	interval]
wb	2.1634	0.6976	3.100	0.002	0.7963	3.5306
wb^2	-0.0855	0.0291	-2.940	0.003	-0.1425	-0.0286
vp	1.1903	0.3842	3.100	0.002	0.4373	1.9433
vp^2	-0.0102	0.0034	-3.050	0.002	-0.0168	-0.0037
C	-0.0080	0.0004	-18.410	0.000	-0.0089	-0.0072
sq (mean)	-0.3530	0.2932	-1.200	0.229	-0.9277	0.2218
sq (Std. Dev.)	2.1651	0.3823	5.660	0.000	1.4157	2.9144
Number of observations	11,637					
Log likelihood	-3933.53					

Appendix 4. Socio-economic characteristics of the sample: identity, income, and employment

Sample characteristics	Freq.	Percent	Cum.
Identity group **(n=1420)*:***			
Aboriginal	12	0.85	0.85
Others, please specify	18	1.27	2.11
African	7	0.49	2.61
Anglo-Saxon	184	12.96	15.56
Asian / Asian American	35	2.46	18.03
Australian	885	62.32	80.35
Mixed descent (e.g. White & Asian, White & Black)	12	0.85	81.2
North African and Middle Eastern	12	0.85	82.04
North American	8	0.56	82.61
North East Asian (e.g. Chinese, Japanese, Korean)	30	2.11	84.72
North and West European (e.g. United Kingdom, France, Germany, Norway, Sweden)	56	3.94	88.66
Pacific Islander	5	0.35	89.01
South American	2	0.14	89.15
South and East European (e.g. Spain, Italy, Greece, Hungary, Romania, Ukraine)	49	3.45	92.61
Southern and Central Asian (e.g. Indian)	29	2.04	94.65
South East Asian (e.g. Vietnamese, Filipino, Indonesian)	39	2.75	97.39
Torres Strait Islander/ Indigenous Australian	4	0.28	97.68
Other Oceanian	12	0.85	98.52
Prefer not to answer	21	1.48	100

Sample characteristics	Freq.	Percent	Cum.
Current household income before tax (n=1417):			
Negative income	9	0.64	0.64
Nil income	41	2.89	3.53
$1- $7,799 per year	35	2.47	6
$7,800 - $15,599 per year	25	1.76	7.76
$15,600 - $20,799 per year	56	3.95	11.71
$20,800 - $25,999 per year	76	5.36	17.08
$26,000 - $33,799 per year	87	6.14	23.22
$33,800 - $41,599 per year	122	8.61	31.83
$41,600 - $51,999 per year	108	7.62	39.45
$52,000 - $64,999 per year	127	8.96	48.41
$65,000 - $77,999 per year	124	8.75	57.16
$78,000 - $90,999 per year	124	8.75	65.91
$91,000 - $103,999 per year	101	7.13	73.04
$104,000 - $155,999 per year	236	16.65	89.7
$156,000 or more per year	146	10.3	100
Current employment status (n=1392):			
Employed full time (35 or more hours per week)	481	34.55	34.55
Employed part time (less than 35 hours per week) /causal?	212	15.23	49.78
Unemployed and currently looking for work	85	6.11	55.89
Unemployed and not currently looking for work	22	1.58	57.47
Student	53	3.81	61.28
Retired	338	24.28	85.56
Homemaker (manages a home and family)	104	7.47	93.03
Self-employed	48	3.45	96.48
Unable to work	49	3.52	100

Appendix 5. Protest response profiles for species, ecosystem, and ecological community choice questions

The main reason respondents selected zero cost option (status quo or no additional protection)	Freq.*	Percent	Cum.
For six threatened species choice questions:			
I preferred this option to all others	19	12.03	12.03
I could not afford an additional tax	61	38.61	50.63
I believe funding to manage threatened species should come from somewhere other than my pocket	***24***	15.19	65.82
I believe funding to manage threatened species should be collected by some other means than annual household tax (a State tax)	***19***	12.03	77.85
I don't trust that the funds would be used to manage threatened species	***11***	6.96	84.81
I don't believe that there will any impacts on the extinction of threatened species during the next 20 years	***1***	0.63	85.44
I don't believe I should have to make these choices	***14***	8.86	94.3
Other	***9***	5.7	100
Total	158	100	
For three ecosystems or dominant species choice questions:			
I preferred this option to all others	21	10.1	10.1
I could not afford an additional tax	74	35.58	45.67
I believe funding to manage plant species should come from somewhere other than my pocket	***34***	16.35	62.02
I believe funding to manage plant species should be collected by some other means than annual household tax (a State tax)	***22***	10.58	72.6
I don't trust that the funds would be used to manage plant species	***15***	7.21	79.81
I don't believe that there will any impacts on the extinction of plant species during the next 20 years	***4***	1.92	81.73
I don't believe I should have to make these choices	***23***	11.06	92.79
Other	***15***	7.21	100
Total	208	100	
For two ecological community choice questions:			
I preferred this option to all others	26	10.97	10.97
I could not afford an additional tax	84	35.44	46.41
I believe funding to manage ecological communities should come from somewhere other than my pocket	***39***	16.46	62.87
I believe funding to manage ecological communities should be collected by some other means than annual household tax (a State tax)	***22***	9.28	72.15
I don't trust that the funds would be used to manage ecological communities	***13***	5.49	77.64
I don't believe that there will any impacts on the extinction of ecological communities during the next 20 years	***7***	2.95	80.59
I don't believe I should have to make these choices	***30***	12.66	93.25
Other	***16***	6.75	100
Total	237	100	

* Frequency or number of observations in bold and italic were treated as protest responses for each type of valuation tasks