Threatened Species Recovery Hub

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Using non-market valuation and cost-benefit analysis to prioritise introduced predator control strategies for threatened species' recovery

Vandana Subroy under the supervision of David Pannell, Abbie Rogers and Marit Kragt

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THE UNIVERSITY OF WESTERN AUSTRALIA

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Department of Biodiversity, Conservation and Attractions

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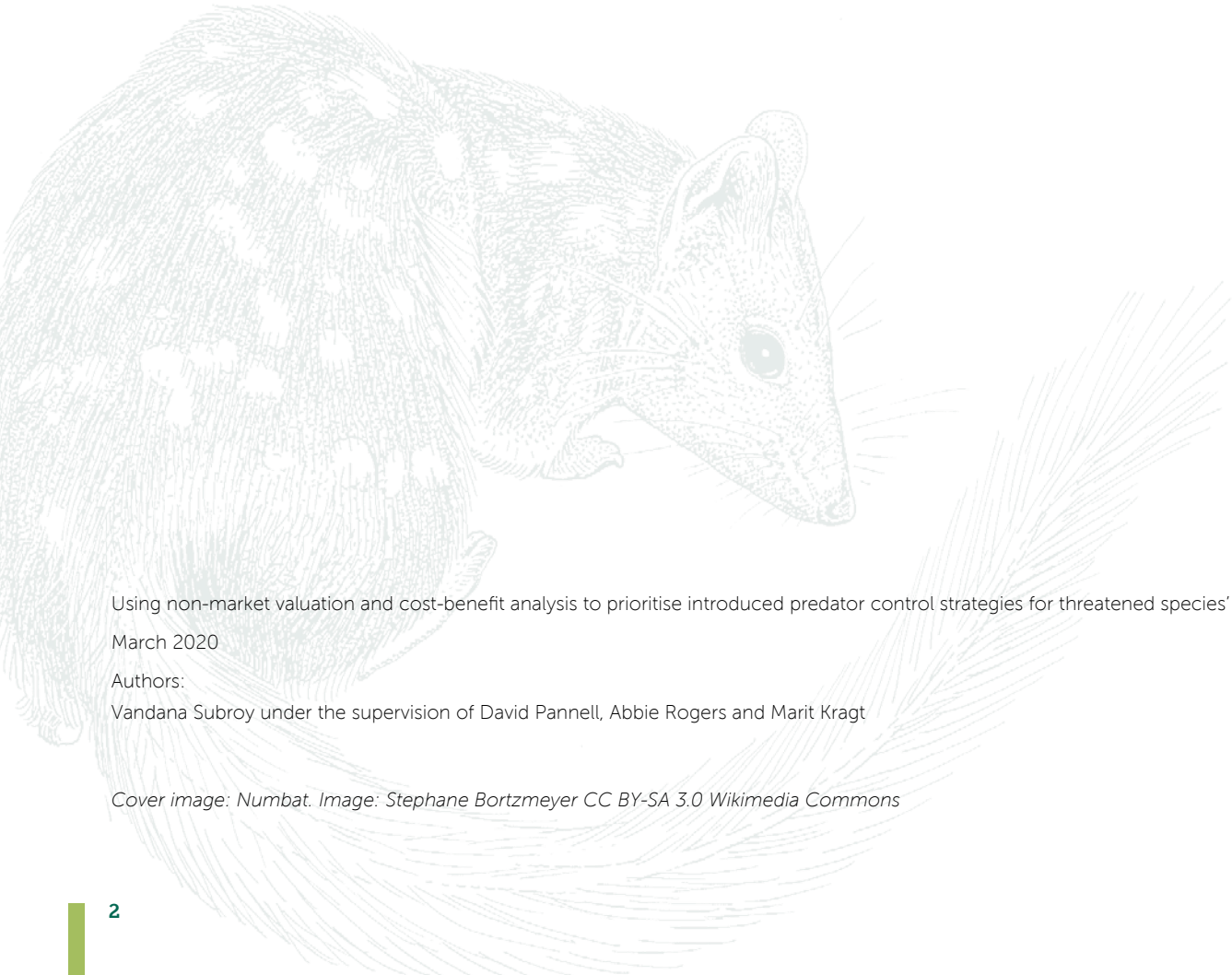

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Map of the study location (Dryandra Woodland)

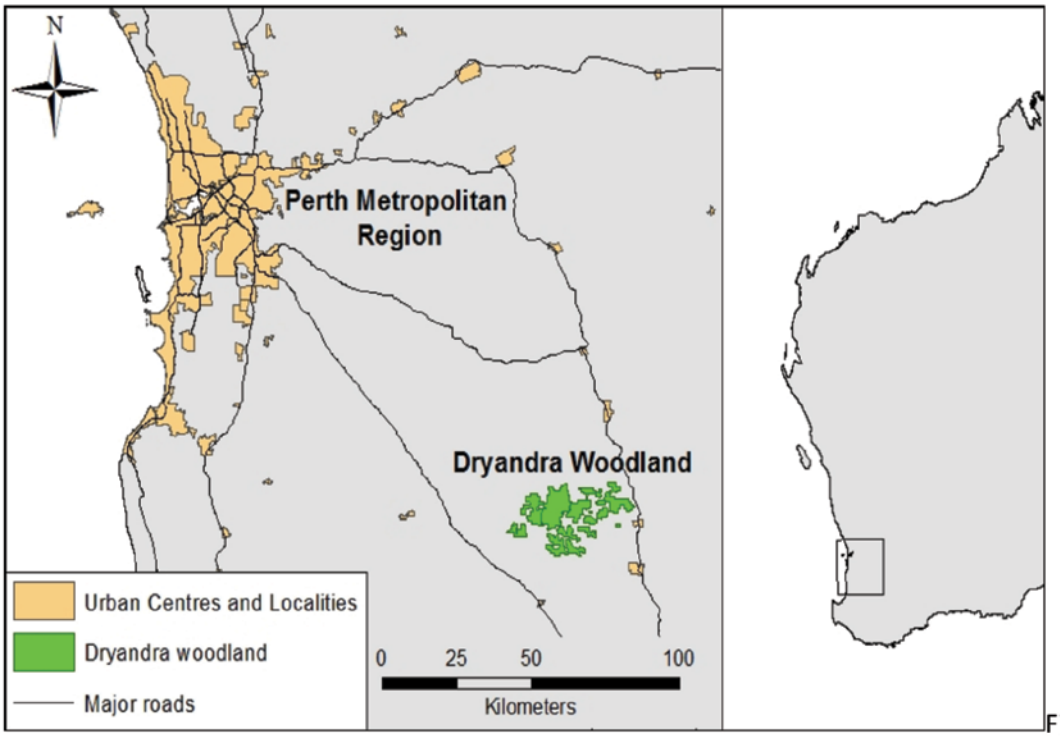

Figure 1: Location of Dryandra woodland relative to Perth and Western Australia

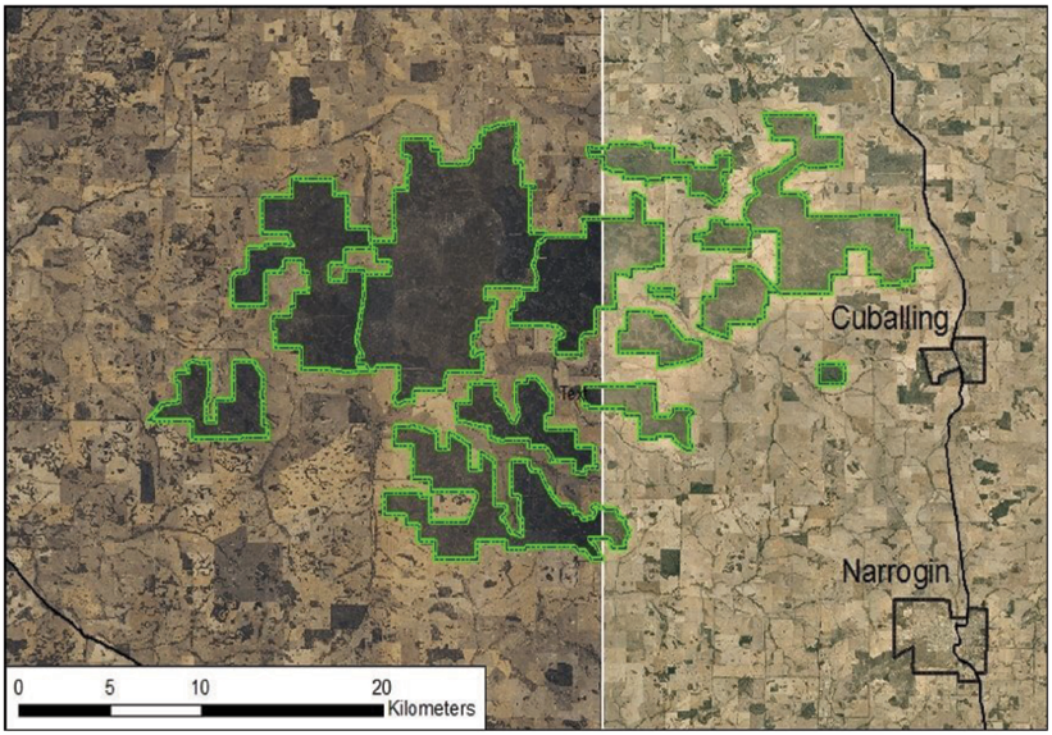

Figure 2: Close-up of Dryandra Woodland showing its fragmented nature

Executive summary

Foxes (*Vulpes vulpes*) and feral cats (*Felis catus*) seriously threaten the survival of many native Australian fauna. Policies to control populations of these introduced invasive predators have multiple aspects—ecological, geographic, economic and social—which must be considered during decision-making to select projects that deliver the greatest net benefits.

This PhD project examined various aspects of the economics of the conservation of two endangered marsupials—numbats (*Myrmecobius fasciatus*) and woylies (*Bettongia penicillata ogilbyi*) through fox and feral cat control in an ecologically important conservation site in Western Australia—Dryandra Woodland, near the town of Narrogin, chosen as the case-study site. The project comprised three research questions:

Research question 1 sought to understand the economic values of threatened species and the factors affecting the general public's willingness to pay (WTP) for threatened species conservation. This was statistically determined through a meta-analysis of non-market valuation studies of threatened species conducted globally over the last 34 years. Average total WTP was $414/household[1] but there was large variation in reported values depending on the species and survey context. WTP was found to be significantly higher for charismatic and threatened species, but was not affected by a country's development status, respondent's income, or using coloured photographs of species in the survey. However, available literature was limited—most studies were from developed countries on charismatic mammals, several lacked a baseline or counterfactual to the scenario being valued, and many did not report WTP or demographic statistics. Given these limitations, dedicated primary valuation studies are recommended if time and budgets permit.

Research question 2 sought to examine the economic values of numbats and woylies and of the various strategies used to control foxes and feral cats in Dryandra Woodland. It also examined whether preferences of different stakeholders differ for numbats, woylies and for various fox and feral cat control strategies through a discrete-choice experiment, which was administered to a sample of the Western Australian general public, conservation experts, landholders directly bordering the Woodland, and the wider local community surrounding it. Results showed that people significantly valued increased populations of numbats and woylies, albeit with a diminishing marginal utility, as the population size increased. WTP was species-dependent. The type of invasive predator control strategy employed also mattered. There was a segment of the population that was averse to the status quo strategy of 1080 baiting, and one unwilling to pay anything for species conservation.

Results from the discrete-choice experiment were used to answer **research question 3**: which fox and feral cat control strategy or strategies for Dryandra Woodland would provide the largest net benefits. This question compared the prioritisation of projects using Cost-Effectiveness Analyses and Benefit-Cost Analyses including Benefit-Cost Analyses with and without social values for strategies to control foxes and feral cats. All seven alternative projects that could be realistically implemented were found to be attractive, with robust net benefits, and benefits exceeding costs, on average, by a factor of 700. The ranking of projects, including the top-ranked project, was altered when using a Cost-Effectiveness analysis compared to a Benefit-Cost Analysis. The rankings of projects also differed depending on whether the analysis accounted for the fact that people preferred some predator control strategies over others, independent of the actual effect on animal populations. Accounting for the risks of project failure also made a difference to the ranking of projects.

Introduction

Foxes and feral cats threaten the survival of many faunal species globally, including in Australia, where they have been listed as "Key Threatening Processes" under the federal *Environment Protection and Biodiversity Conservation Act (1999)*. Reintroductions of native species to reserves and conservation sites in Australia have often failed on account of predation by foxes and feral cats (Fancourt, 2014; Saunders et al., 2010; Short et al., 1992; Sinclair et al., 1998), making it important to control populations of these introduced predators (Friend, 1994; Kinnear et al., 2010; Marlow et al., 2015).

Common strategies to control foxes and feral cats in Australia have included lethal baiting using the compound 1080 (sodium monofluoroacetate) incorporated in dried or fresh meat, exclusion-fencing, shooting and trapping using cage-style or padded leg-hold traps (DEWHA, 2008a; DoE, 2015a). Other strategies can include den fumigation with carbon monoxide and den destruction for foxes (Saunders and McLeod, 2007), grooming traps[2] (Read et al., 2014), and canid pest ejectors (ACTA, 2015). Each strategy has benefits and disadvantages. They vary in effectiveness at reducing predator populations, and in suitability for application, depending on the area to be managed, and the type and density of introduced predators, non-target species and threatened species on site.

[1] In 2016 US dollars.

[2] Still in the development stage. See (Read et al., 2014) for more details.

Conservation, however, takes place in a social context. Government conservation schemes are largely funded by public tax revenue. It is therefore important to understand the preferences of stakeholders such as the general public or the community living in proximity with the conservation site along with the advice of conservation experts to ensure that policies are supported by people and will eventually be successful.

The selection of a decision-making framework, which considers these ecological, geographical, economic and social aspects, is equally vital to prioritise limited conservation funding. Although Cost-Effectiveness Analyses are often used to guide decision-making for threatened species' recovery (Bode et al., 2012; Busch and Cullen, 2009; Campos et al., 2017; Clapperton and Day, 2001), they usually omit consideration of the way that the community prefers some conservation management actions over others, independent of their outcomes (Rogers, 2013; Sheremet et al., 2017)).

A Benefit-Cost Analysis systematically compares the costs and benefits of a project (quantified in monetary-equivalent terms) to select projects that provide the greatest net benefits for the allocated budget, making it a more appropriate tool to prioritise conservation investment. The benefits of threatened species' recovery programs largely exist in the form of the intangible (non-market) values attached to the species being protected. There exist well-established non-market valuation techniques[3] to monetarily quantify these socio-economic values.

Non-market values have been incorporated into benefit-cost analyses to demonstrate the value of greater protection for species as opposed to development (Jin et al., 2008; Solomon et al., 2004) and to economically justify the eradication of invasive species (Mwebaze et al., 2010). However, there are no benefit-cost analyses studies to guide the prioritisation of alternative management strategies for threatened species' recovery programs.

A conservation site in Western Australia, Dryandra Woodland, was used a a case study to understand how the prioritisation of conservation projects is affected by the inclusion of diverse aspects- economic, social and ecological in decision-making. Dryandra Woodland was chosen as it is an ecologically important conservation site, which not only supports the largest area of remnant native vegetation in the Wheatbelt region of Western Australia, but is also home[4] to over 200 native vertebrate species including numbats (*Myrmecobius fasciatus*) and woylies (*Bettongia penicillata ogilbyi*)—the focal species at the site and the species of interest in this research.

The Woodland, which is located 160 km south-east of the Western Australian capital, Perth (Figure 1) is highly fragmented—it exists as 17 discrete segments scattered across a 50 km radius and is surrounded by farmland (Figure 2). Segments range in size from less than 1 km^2 to 125 km^2 with a total area of 280 km^2 (DEC, 2011). Feral cats and foxes can move easily between the site and the surrounding farms, which may offer additional food and shelter. The proximity of farmland means that carrying out fox and feral cat control will require an understanding of the preferences of the farmers directly bordering the Woodland and also the wider local community surrounding the site to increase the likelihood of their support for conservation programs.

Research Question 1:

What are: (a) the non-market values of threatened species, expressed in monetary terms as the community's willingness to pay (WTP) for their protection; and (b) what are the factors affecting willingness to pay for threatened species protection?

Research Question 2:

(a) What are the non-market values of numbats and woylies, expressed in monetary terms as the community's willingness to pay for their protection, and does the community have preferences for or against the various strategies used to control foxes and feral cats at Dryandra Woodland, above and beyond their impacts on feral-animal numbers?

(b) Do preferences of different stakeholders differ for numbats and woylies and for various fox and feral cat control strategies?

Research Question 3:

Which fox and feral cat control strategy(ies) for Dryandra Woodland would provide the largest net benefits when evaluated in terms of the community's willingness to pay for the outcomes?

[3] These techniques do not attempt to value environmental assets in terms of their non-anthropocentric intrinsic values.

[4] Dryandra Woodland is one of only two sites in Australia with original populations of the Endangered numbat, one of only three sites with original populations of the Critically Endangered woylie, and one of two sites with original populations of both species (de Tores and Marlow 2012).

Methodology

Non-market valuation studies of threatened species conducted globally over the past 34 years were systematically collated and statistically analysed through a meta-analysis to answer research question 1. Our refined dataset included 109 WTP estimates from 47 studies across 19 countries.

Research question 2 was addressed through a discrete-choice experiment survey that was administered to the stakeholders *(the general public of Western Australia, conservation experts across Australia, agricultural landholders directly bordering Dryandra Woodland, and the wider local community around the Woodland (i.e., within 50 km))*. The discrete choice experiment was developed after extensive consultations with the project's collaborator—the Western Australian Department of Biodiversity, Conservation and Attractions (DBCA).

To answer research question 3, we compared seven alternative projects that could be realistically implemented to control foxes and feral cats at Dryandra Woodland using Cost-Effectiveness Analysis and Benefit-Cost Analysis. The Benefit-Cost Analyses were conducted with and without inclusion of social preferences (non-market values) for threatened species and for strategies to control foxes and feral cats.

Findings

From our meta-analysis, we found the average total present value of WTP for threatened species to be $414/household (in 2016 USD). However, variation in reported values was large owing to variations in the survey context. WTP was significantly higher for charismatic and for threatened species. WTP was also higher for avoiding loss of a species' population compared to an equivalent-sized gain in population. A respondent's annual income or a country's development status or using coloured photographs of species in the survey did not significantly affect WTP.

From the discrete-choice experiment, we measured the monetary-equivalent value of the utility that people derived from increases in numbat or woylie populations. Respondents had a higher WTP[5] for numbats ($0.66/Numbat) than for woylies ($0.03/Woylie).

Looking at the various measures for controlling feral species, we found that people significantly preferred combinations of strategies over the current strategy of 1080 baiting at Dryandra Woodland. For example, on average, people preferred combinations that included trapping and community engagement[6] (Subroy et al., 2018). This preference is independent from and additional to people's preference to increase the population sizes for numbats and woylies.

WTP results were not uniform across the population. A segment of the respondents (17%) were found to be averse to 1080 baiting and had substantially higher WTP for strategies without 1080 baiting. A segment (17%) preferred the status quo of 1080 baiting and were unwilling to pay for improvements in numbat and woylie populations. These variations in preferences were not closely correlated with the stakeholder group to which they belonged to (general public, local farmers, local community, experts). Instead, an individual's characteristics had a significant effect on their preferences. Influential factors included their prior knowledge of fox and feral cat control strategies, and whether they supported an environmental or species' conservation organisation.

Benefit-Cost Analysis was used to evaluate seven discrete projects selected by DBCA. The projects consisted of various combinations of the control strategies 1080 poison, fencing to exclude feral predators, integrated off-reserve management, and trapping. All seven projects were found to be highly attractive to implement from a Benefit-Cost Analysis perspective (i.e. their Net Present Value (NPV)>0 and the Benefit: Cost Ratio (BCR)>1). Indeed, the benefits were many times larger than the costs in all cases. In the most comprehensive versions of the Benefit-Cost Analyses, the Benefit-Cost Ratios ranged from 50:1 to 2,400:1.

We found that the rank of projects was altered depending on the decision criterion used (Benefit-Cost Analysis or Cost-Effectiveness Analysis), and also depending on whether socio-economic values and risk of project failure were included in the DBCA criterion. For example, a project that implemented the combination of 1080 baiting + trapping, was the most favourable when a cost-effectiveness framework was used, while a project involving fencing an 8,300 ha block of the Woodland, was the most favourable based on Benefit-Cost Analysis.

[5] Per household per year for five years in 2016 AUD. The difference in WTP for numbats and woylies could likely be because (1) a greater percentage of respondents had prior knowledge of numbats (89.5%) compared to woylies (50.8%)—the numbat being the faunal emblem of Western Australia, and the face of many conservation campaigns by government and private conservation agencies; or (2) respondents paid attention to the absolute numbers of the species' existing populations rather than their endangerment levels (i.e. 2,500 woylies versus 100 numbats).

[6] The community engagement strategy was stated to include providing equipment (traps) and training (for 1080 user permits) to surrounding farmers to control foxes and feral cats on their properties. It could also include monetary payment to the farmers for undertaking such actions.

Discussion

We found the available primary studies for the meta-analysis to be limited in the following ways: (1) studies were mostly from developed countries, valuing charismatic species, especially mammals, with some studies of birds and fish but very few on non-charismatic species or insects, reptiles, crustaceans or other species; (2) many studies did not report WTP statistics or demographic data making it difficult to include them in the meta-analysis or for future decision making; and (3) many studies did not specify a baseline or counterfactual for the policy scenario being valued, making it difficult to understand what exactly was being valued. Given these limitations, we recommend using unit transfers cautiously if the valuation contexts are similar but undertaking dedicated primary studies if time and budgets permit.

Results from the discrete-choice experiment show that there is heterogeneity in social preferences for conservation benefits and the strategies to achieve those benefits. Ideally, conservation decision-makers would account for this variation when planning programs of conservation investment. For example, this might mean weighting the WTP values of different population segments by their population sizes. This would allow a realistic estimation of the overall socioeconomic benefits of conservation, and an understanding of how the benefits are distributed within the community.

Our discrete-choice experiment estimated values for only the threatened focal species at Dryandra Woodland, and not for the other threatened and common fauna at the site that also benefit from fox and feral cat control. Thus, the benefits quantified here can be considered as a conservative estimate of the actual benefits of fox and feral cat control at Dryandra Woodland.

The most striking result is that, for all management strategies we analysed, and under all assumptions used, the benefits of feral-predator control for conservation of numbats and woylies at Dryandra Woodland far exceeded the costs. The strong message from the study is that investment in threatened species conservation can generate very large benefits for the community, relative to costs.

Applications of the research

This project was carried out in collaboration with the DBCA, Western Australia. The findings from this research may be used to inform policy and decision-making for threatened species conservation and fox and feral cat management in Dryandra Woodland, as well as other sites managed by the agency.

As foxes and feral cats pose a predatory threat to the survival of native species around the world, and because management strategies assessed in this study are also used in other parts of the world, our insights and our approach to the analysis of conservation actions will be applicable internationally.

Impact of the research

This research advances knowledge in the area of conservation policy decision-making by assessing how the inclusion of socio-economic considerations could better guide the spending of limited resources for conservation. By exploring determinants of WTP for threatened species, and estimating the non-market values of threatened species endemic to the southwest of Western Australia, and social value for strategies to control the populations of introduced predators, this research showed that conservation investment can be highly beneficial for the community.

Broader implications

Our findings have implications for conservation decision-making, particularly for the prioritisation of projects in order to allocate limited conservation budgets. Neglecting to consider the following aspects in conservation policy decision-making could lead to the selection of sub-optimal projects: (a) socioeconomic values for conservation benefits; (b) social preferences for the strategies used to achieve the conservation outcomes; (c) probabilities that the different projects will fail to deliver their intended benefits; or (d) use of an inappropriate decision rule (Cost-Effectiveness instead of Net Present Value) to select projects.

Future research priorities

Given gaps in the existing literature on non-market valuation of threatened species conservation, there is a need for new studies on the community's willingness to pay for conservation of non-charismatic species such as insects, reptiles, crustaceans, molluscs and amphibians, and species endemic to relatively narrow geographical locations.

An interesting focus for future research could be the inclusion of ethical values into mainstream non-market valuation. Ethical values have been found to play an important role in people's preferences for conservation policy outcomes—people have been found to select policies not because they maximised their utility but because they believed it was ethically the right thing to do. Disentangling ethical and efficiency concerns and including them in decision making will allow more ethically conscious conservation policies to be selected.

Data sets

Data for the meta-analysis can be accessed online at https://doi.org/10.1016/j.ecolecon.2019.106374

Data on social preferences for the threatened species and was collected and collated through a discrete choice experiment. However, as outlined the University of Western Australia Ethics application, and respecting the privacy of respondents, responses of the discrete choice experiment would only be accessible to the lead researchers of the project, and not publicly shared.

Conclusions

People in the Australian community care about conservation of threatened species. In this study, their willingness to pay for a set of strategies to conserve numbats and woylies, in aggregate, far exceeded the costs of those strategies. People also care about how conservation outcomes are achieved, not just whether they are achieved.

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Ethics statement:

The research involving human data reported in this thesis was assessed and approved by The University of Western Australia Human Research Ethics Committee. Approval #: RA/4/1/8443.

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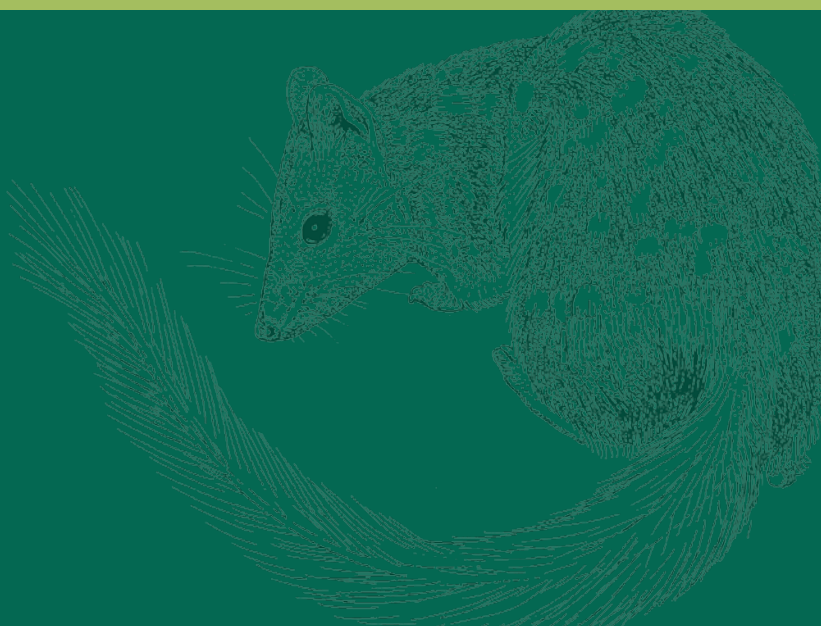

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