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To Bait or Not to Bait: A Discrete Choice Experiment on Public Preferences for Native Wildlife and Conservation Management in Western Australia

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ABSTRACT

Foxes and feral cats are invasive predators threating biodiversity in many places around the world. Managing these predators to protect threatened species should involve careful consideration of biological, geographic, economic, and social aspects to ensure informed and effective decision-making. This study investigates people's preferences for the ways in which foxes and feral cats are managed at a conservation site in Western Australia using a discrete choice experiment. We further aim to quantify the non-market values of two native threatened species protected by management; Numbats and Woylies. The attributes evaluated in the survey included: increased populations of Numbats and Woylies, cost of management, and a range of invasive feral predator management strategies (1080 baiting, fencing, trapping, and community engagement). Results show that respondents prefer a combination of management strategies over the strategy of 1080 baiting that is currently being implemented, particularly combinations that include trapping and community engagement. There is also strong public support for increased Numbat and Woylie populations. Willingness to pay was, on average, $21.76 for 100 Numbats and $7.95 for 1000 Woylies. Including images of the threatened species in the choice sets does not influence willingness-to-pay estimates. We further discuss how familiarity with the species influences value. Our results feed into the conservation decision making process about feral species management in the region.

1. Introduction

Invasive feral predator management is crucial to ensure the survival of many native species. Invasive predators such as European red foxes (*Vulpes vulpes*) (hereafter, foxes) and feral cats (*Felis catus*) seriously threaten biodiversity in many parts of the world and are listed among the world's worst invasive species (Lowe et al., 2000). In Australia, predation by foxes and feral cats were listed as key threatening processes in the Federal Environment Protection and Biodiversity Conservation (EPBC) Act (DoE, 2013; DoE, 2015a; DoE, 2015b). Feral cats and foxes are opportunistic predators with a wide dietary range. Their adaptability allowed them to exploit diverse habitats and rapidly colonize the Australian mainland after being introduced by Europeans in the 19th century (Denny and Dickman, 2010; Saunders et al., 2010). Feral cats prey on 400 Australian vertebrate species including 28 IUCN-listed threatened species (Doherty et al., 2015), and have been linked to the early extinctions of seven mammalian species (Denny and Dickman, 2010). Foxes and feral cats are currently a predatory threat to 103 and 142 EPBC-listed threatened species, respectively (DoE, 2013; DoE, 2015a; DoE, 2015b).

Controlling invasive feral predator populations is imperative to increasing native species' populations (Friend, 1994; Kinnear et al., 2010). In many cases, protection or reintroduction of native wildlife is much more successful if invasive feral predators are managed concurrently e.g., Sharp et al. (2014), Short et al. (1992).

Management strategies for fox and feral cat populations have commonly focused on lethal methods like poison baiting, shooting, and trapping with soft-jaw or cage-style traps, and non-lethal methods like predator-exclusion fencing (DEWHA, 2008; DoE, 2015a). Poisoned meat baits are often used when managing large sites, and when primary food sources (rabbits, mice, native species) are absent or in low numbers (DoE, 2015a). Shooting and trapping are more labor intensive and expensive and are generally not preferred for broad-scale control but are effective in smaller areas (DoE, 2015a; Saunders et al., 2010). Other fox management techniques focus on den fumigation, den destruction, and fertility control (Saunders et al., 2010), while those for cats have also included the use of specially trained dogs and the introduction of *feline panleucopaenia* (Denny and Dickman, 2010).

The complete eradication of foxes and feral cats at a conservation site using lethal techniques is near impossible (unless the site is a small

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island), because they disperse over large areas and can reappear after predator management been carried out—unless management is implemented periodically (Moseby et al., 2009). In such cases, exclusion-fencing can be an effective strategy to mitigate threats to native species, and is being favored in many regions including Australia, New Zealand, and southern Africa (Hayward and Kerley, 2009). Once feral predators and other invasive species within the enclosure have been eradicated, fencing creates feral-free 'islands' allowing native species to thrive. Exclusion fences, however, have high installation costs, are not 100% effective at preventing predator incursions, and require frequent maintenance which can be time-consuming and labor- and cost-intensive. Ecological costs such as inbreeding and poorly developed threat-defense mechanisms can result from preventing the movement of animals (Hayward and Kerley, 2009). Fences are also not independent of other management strategies since predators within the enclosure need to be eradicated anyway (Long and Robley, 2004).

Although the aim of invasive feral predator management is to safeguard threatened species and increase their survivability, it is not simply the end result that matters. Management takes place in a social context that needs to consider community preferences for different management strategies. It is likely that people have preferences for the *means* of achieving conservation outcomes as well as for the outcomes themselves. This has been shown by, for example, Johnston and Duke (2007), who found that respondents significantly preferred state conservation easements over other techniques that can be used to preserve agricultural lands. Similarly, in a study on marine ecology conservation in Western Australia, Rogers (2013b) found that utility for the same conservation outcomes differed depending on the management process specified: respondents typically preferred processes that were less restrictive in terms of human use of the marine reserve. More recently, Sheremet et al. (2017) also concluded that public support (for forest disease control) is conditional on the type of control measures used. On the other hand, Hanley et al. (2010) found that respondents were largely indifferent to how conservation objectives (for raptors in Scottish moorlands) were achieved, implying that the benefits are roughly equal across management alternatives if the same level of environmental protection is achieved. Our study contributes to this literature by assessing whether people have different preferences for different methods to manage invasive species.

Wildlife policies to increase populations of threatened and endangered species should involve careful consideration of biological, geographic, economic, and social aspects to ensure informed and inclusive decision-making and, ultimately, policy success (Rogers, 2013b). Understanding the socio-economic impact of conservation decisions enables a more efficient use of limited resources available for the task. Economic research can guide policy decision-making by analyzing the cost-effectiveness of conservation actions e.g. Busch and Cullen (2009), Helmstedt et al. (2014). Of interest to the current study are the socio-economic (non-market) *benefits* that different eradication strategies may generate. Quantifying the non-market benefits of conservation actions, as well as the values of the species being protected, allows these benefits to be included in a benefit-cost analysis to assess which conservation policy options will be optimal from a social welfare perspective. While there exist a small number of non-market valuation studies for threatened species in Australia (Jakobsson and Dragun, 2001; Tisdell and Nantha, 2007; Wilson and Tisdell, 2007; Zander et al., 2014) there are, to the best of our knowledge, no studies quantifying the social welfare impacts of fox and feral cat management. There are some studies that estimate households' willingness to pay (WTP) for the management of other invasive species in other parts of the world. For example, Florida residents' WTP to control invasive plants in state Parks (Adams et al., 2011); French households' WTP to reduce nuisance from invasive Asian ladybirds (Chakir et al., 2016); and UK households' WTP for tree disease control programs in UK forests (Sheremet et al., 2017).

We focus on the socio-economics of fox and feral cat management at a fragmented conservation site in southwest Western Australia (WA); Dryandra Woodland, to ensure the survival of two of the state's threatened species at the site; the endangered Numbat (*Myrmecobius fasciatus*) and the critically endangered Woylie (*Bettongia penicillata ogilbyi*). The site has a high concentration of feral cats and foxes. The objectives of this paper are (i) to determine people's preferences for different strategies to manage fox and feral cat populations in Dryandra Woodland, and (ii) to quantify the non-market values of Numbats and Woylies in monetary terms.

We use a discrete choice experiment (DCE) to estimate non-market vales associated with fox and feral cat management for Numbat and Woylie conservation. The DCE was carried out in collaboration with the Department of Biodiversity, Conservation and Attractions (DBCA), Western Australia. Results of this survey may be used to inform conservation policies for invasive feral predator management in Western Australia.

2. Methodology

2.1. Conservation Site

Dryandra Woodland is a conservation site about 160 km south-east of Perth, WA (Fig. 1). It exists as 17 discrete fragments scattered across 50 km with a total area of 28,066 ha with blocks ranging from 87 to 12,283 ha (DEC, 2011). It is surrounded by farmland and has a high concentration of feral cats and foxes. Being extremely fragmented, it has a high perimeter to area ratio which makes the implementation of invasive feral predator management challenging. Apart from supporting the largest area of remnant vegetation in the region, the Woodland has high conservation value as it is home to several threatened species of flora and fauna (DEC, 2011). It is one of two sites with original populations of the endangered Numbat, and one of three sites supporting original populations of the critically-endangered Woylie (de Tores and Marlow, 2012), and is the only conservation site with original populations of both Numbats and Woylies—the species of interest in our study. Along with biodiversity conservation, the Woodland is used for recreation, timber production, and Aboriginal land use (DEC, 2011). The importance of the Woodland for conservation and cultural uses mean that its management is also likely to be of interest to the broader WA community.

Both Numbats and Woylies were widely distributed prior to European arrival in Australia, with Woylies distributed across the continent south of the tropics (Fig. 2). The population of Numbats in Dryandra Woodland declined from about 800 mature individuals in 1992 to about 80 at present (M. Page, DBCA, pers. comm.). The population of Woylies in the Woodland declined from about 30,000 mature individuals in 2001 to about 2000 at present (M. Page, DBCA, pers.

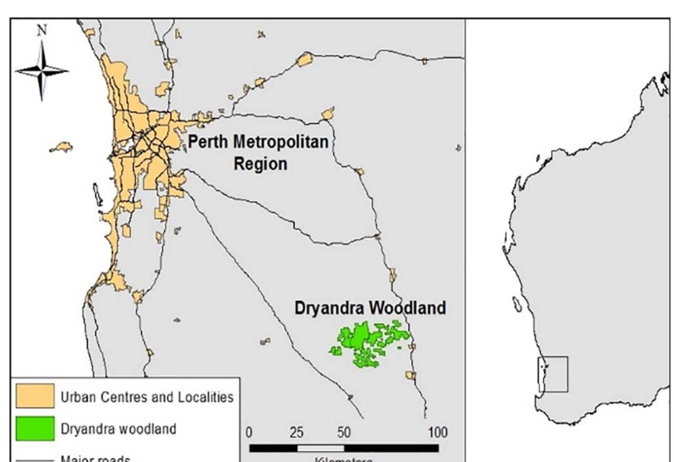

Fig. 1. Location of Dryandra Woodland Relative to Perth and Western Australia.

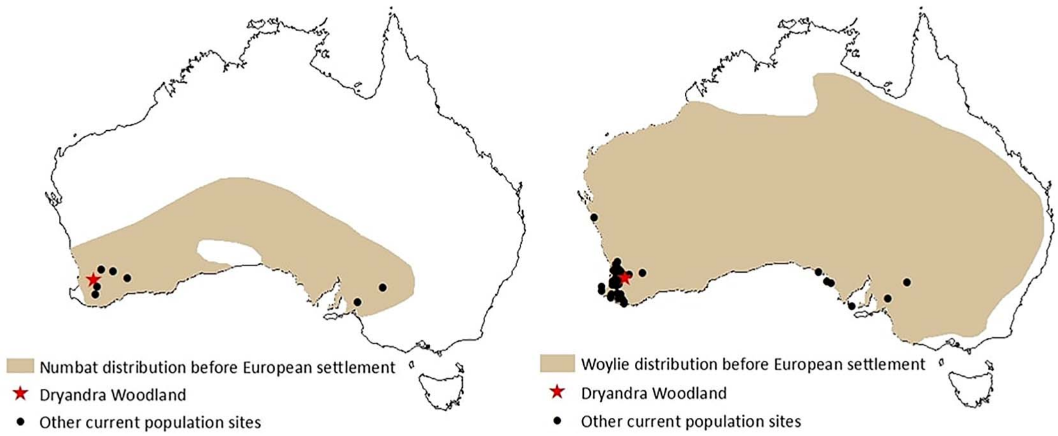

Fig. 2. Past and current Numbat and Woylie distribution sites in Australia. Numbat and Woylie distribution maps adapted from Cooper (2011), and Yeatman and Groom (2012), respectively.

comm.). Natural native predators of Numbats and Woylies include the western quoll (*Dasyurus geoffroii*), Carpet Pythons, and raptors. Along with land clearing, predation by foxes and feral cats remain key processes that threaten the survival of both species (Yeatman and Groom, 2012; DPaW, 2015). Numbats are listed as *Endangered* (Woinarski and Burbidge, 2016b) since their population is small and declining, with less than 1000 mature adults currently present in the wild including the 80 at Dryandra Woodland. Woylies are listed as *Critically Endangered* (Woinarski and Burbidge, 2016a) since their population declined by over 90% since 1999, with about 15,000 mature adults currently present in the wild including the 2000 at Dryandra Woodland. Currently, translocations of Numbats bred in captivity at Perth zoo, and translocations of Woylies from natural populations at the Upper Warren region in WA, are carried out to augment their wild populations at Dryandra Woodland and to increase their genetic diversity (Friend, 2014; Wayne and Wnuk, 2015).

2.2. Management Strategies for Foxes and Feral Cats in Dryandra Woodland

Lethal baiting using the poison sodium monofluoroacetate (compound 1080) encapsulated in dried meat is the primary strategy to manage invasive feral predators in Dryandra Woodland. 1080 is a pesticide widely used in many countries for the control of invasive vertebrate species (Littin et al., 2009). 1080 baiting has by far been the most effective technique in reducing fox and feral cat populations on Australian islands and in reserve sites across mainland Australia (Algar et al., 2002; Twyford et al., 2000; Moseby and Hill, 2011; Saunders et al., 2010). 1080-poisoned meat baits work very well in a WA context because non-native species including foxes and feral cats that are highly susceptible as well as intolerant to the poison. Native species of southwest WA have coexisted with fluoroacetate-bearing native plants for several thousand years and are therefore highly tolerant to the poison (King et al., 1978; Twigg and King, 1991). Baited areas are regularly checked to remove the carcasses of invasive predators. Currently, the baits for foxes, called Probait®, are salami-like sausages injected with 1080 and then dried to make them hard and less appetizing for native species. The baits for feral cats, called Eradicat®, are smaller and moister 1080-infused sausages. Although monthly fox baiting with 1080-poisoned meat baits has been ongoing since 1989 at Dryandra Woodland, a simultaneous feral cat baiting program was not carried out until 2015.

Other strategies that are being carried out by DBCA on a smaller-scale, or being considered for implementation at Dryandra Woodland, include *trapping*, *fencing* and *community engagement*. Trapping using padded leg-hold or cage traps is carried out occasionally in certain sections of the Woodland but not on a broad-scale. Fencing parts of the Woodland is also being considered. The size and the number of fenced areas are under consideration but fenced areas may be as large as 12,500 ha. Since foxes and feral cats can move between surrounding private land and the Woodland, it makes sense to also implement feral predator management on surrounding private land. The community engagement strategy, therefore, encourages fox and feral cat management by the landholders on surrounding private agricultural land. It involves providing equipment and training to landholders about fox and feral cat management and may potentially involve funding for surrounding landholders to cover costs of carrying out fox and feral cat management on their property.

2.3. Attribute Selection for the Discrete Choice Experiment

Discrete choice experiments (DCEs) are a well-established method that can be used to measure the social welfare impacts of a change in (environmental) policy. They provide a framework to help guide decision-making by revealing which aspects of the policy are most preferred by people. DCEs have been used to determine non-market values for many species around the world (Boxall et al., 2012; Decker and Watson, 2016; Jin et al., 2010; Langford et al., 2001; Loomis and Ekstrand, 1997). They have also been used to measure social welfare for various conservation processes (Johnston and Duke, 2007; Hanley et al., 2010; Rogers, 2013b).

In DCEs, respondents are presented with choice sets that describe the impacts of two or more hypothetical policy alternatives on a set of characteristics (called attributes). These attributes capture the outcomes of each policy alternative. One of the attributes included is typically the cost of the policy to the respondent. The attributes are ascribed different levels which vary between the alternatives. Respondents are asked to select their most preferred alternative from the ones in a choice set, implicitly making tradeoffs between the levels of the various attributes.

The attributes and levels for our choice experiment (Table 1) were decided after extensive consultations with the DBCA. Since the aim of invasive feral predator management in our study was to increase the survivability of Numbats and Woylies at Dryandra Woodland, Numbat and Woylie populations were included as attributes in the choice experiment along with strategies to manage fox and feral populations and cost.[1]

[1] A reviewer suggested that management strategies could also have been used as labels in the DCE. We included the management strategies as attributes because we are explicitly interested in people's preferences for different management actions, and in their trade-offs between attributes. It has been shown that unlabelled DCEs are more suitable to investigate trade-offs between attributes than labeled experiments (de Bekker-Grob et al.,

Table 1
Attributes and levels used in the choice experiment.

Attribute	Description	Levels	Variable name
Management strategy	Strategy to manage fox and feral cat populations in Dryandra Woodland	1080 baiting	1080 (current strategy)
		Trapping	TRAP
		Fencing	FENCE
		Community engagement	CE
		+ combinations of the above (11 levels in total)	
Numbat	Numbat population in 5 years' time in Dryandra Woodland	100	NUM100 (status quo)
		250	NUM250
		400	NUM400
Woylie	Woylie population in 5 years' time in Dryandra Woodland	2500	WOY2500 (status quo)
		5000	WOY5000
		7500	WOY7500
Cost[a]	Annual cost to West Australian households each year for the next 5 years	$0, $20, $50, $100, $150, $250, $400	COST

Notes: Variables are dummy coded where they = 1 if selected; 0 otherwise.
[a] Cost modelled as a continuous variable with $0 representing the status quo.

The levels for Numbats and Woylies represented a low (status quo), medium, or high increase in the populations of mature adults in five years' time. Estimates were provided by conservation experts at the DBCA. A low, medium, and high increase for Numbats was defined as 100, 250, and 400 mature individuals respectively (from the current level of 80), and 2500, 5000 and 7500 mature individuals for Woylies (from the current level of 2000). The status quo option in our DCE was the continuation of DBCA's current 1080 baiting program in Dryandra Woodland. This is expected to lead to a low increase in Numbat and Woylie populations (to 100 and 2500 individuals respectively) at zero cost.

The management strategies included every combination of the following four strategies, which were selected by the DBCA as the most feasible to implement in the Woodland: 1080 baiting, fencing, trapping, and community engagement. It was implicit that management effort would be increased to improve the conservation outcome (higher Numbat and Woylie numbers).

Focus group testing was carried out in August 2016 with two focus groups of ten participants each. The focus groups tested the survey questionnaire for clarity of the wording, the number of choice questions considered suitable to answer before mental fatigue set in, and the number of alternatives deemed adequate for each choice question. We also tested the appropriateness of the pictures included in the survey. Participants were shown pictures related to foxes and feral cats preying on native species, the management strategies (including images of animals caught in traps), and of Numbats and Woylies. The images that were included in the survey were those that participants considered to be a realistic representation of what is happening in the area, and that did not induce an emotive response (e.g. warm and cuddly towards the native species).

Following Rolfe and Windle (2012), we used a combination of increased taxes, increased council rates, and increased prices of certain goods and services as the payment vehicle in order to avoid a protest response relating to any particular payment vehicle. This mix of payment vehicles also ensured that it would be applicable to the broader population that we were sampling to include those who do not pay taxes but for whom higher prices of goods might be a more realistic payment (Johnston et al., 2017). Respondents were told that higher Numbat and Woylie numbers could be achieved by increasing fox and feral cat management using a combination of management strategies. However, funds from all WA households would need to be collected to implement management. Payment was stated to be annually for the next five years. The maximum levels of the cost attribute were based on the focus group discussions, with bids ranging from $0 – $500.[2]

(*footnote continued*)
2010; Chakir et al., 2016).
[2] All $ expressed in 2016 Australian dollars.

2.4. Survey Design

The survey was designed in Ngene (Choice Metrics Pty. Ltd.) using a D-efficient main effects design. The priors for management were set to zero because there was no consistent evidence about whether preferences would be positive or negative towards the different strategies. The priors for Numbat and Woylie conservation were kept positive and that for cost was kept negative. The design included 24 choice scenarios divided into four blocks of six choice questions each. Each respondent was randomly allocated one of the blocks. Each question had four unlabeled alternatives (A, B, C and D). Alternative A was the status quo with 1080 baiting as current management strategy, a low improvement in Numbat and Woylie numbers (100 and 2500, respectively), and no additional annual cost to respondents. The other three alternatives presented additional management strategies (alone or in combination) and potential improvements in Numbat and Woylie numbers, at a cost to the respondent.

The choice experiment survey was programmed online (Qualtrics LLC, Provo, UT, USA) with three sections. The first included background information on Dryandra Woodland, Numbats, Woylies, foxes and feral cats, and about the management strategies. Respondents were also asked about their familiarity with the conservation site, their prior knowledge of the threatened species, foxes, and feral cats. The second section described the need to improve Numbat and Woylie populations by implementing additional fox and feral cat management strategies and introduced the payment vehicle. It then described the outcomes of management on Numbat and Woylie populations (low, medium, and high population increases) and showed an example choice question. Respondents then answered six choice questions. The last part of the survey contained debriefing questions about the choice experiment, questions related to attribute nonattendance, on membership with conservation organizations, and on socio-demographics. Respondents who had selected the status quo (no-cost alternative) in all six choice questions were asked their reason for doing. This meant to ascertain whether the respondent holds a true-zero value for the attribute(s) or whether they 'protested' against the payment vehicle or against having to pay—in which case their true values may not be zero (Barrio and Loureiro, 2013).

Before being shown the choice questions, respondents were presented with a 'consequential script' similar to that described in Rogers (2013a), which stated that the findings of the study may be used to inform policies and practices for managing fox and feral cat populations at conservation sites in WA. Consequential statements are recommended to reduce hypothetical bias towards stated preference survey questions and encourage honest responses (Johnston et al., 2017).

We also tested the influence of photographs on willingness-to-pay (WTP) for improved conservation. The use of photographs in non-

	Option A (Primary management strategy)	Option B	Option C	Option D
Management strategy	1080 baiting	1080 baiting + Trapping	Fencing + Trapping + Community Engagement	Fencing
Numbat population in 5 years' time 	100	100	250	400
Woylie population in 5 years' time 	2,500	2,500	2,500	7,500
Annual cost to your household each year for the next 5 years	$0/year	$50/year	$400/year	$150/year

Fig. 3. Example choice question with images of the species. For respondents who were not shown images in their choice sets, the images of Numbats and Woylies were not included.

market valuation and their influence on WTP estimates has been unresolved since the NOAA Panel Report on Contingent Valuation by Arrow et al. (1993) (Shr and Ready, 2016). There are very few non-market valuation studies that test differences in people's WTP when they are shown photographs of the attributes in question. Labao et al. (2008) found colored photographs to be value-enhancing compared to black and white ones, while Shr and Ready (2016) concluded that respondents have a higher WTP when shown both images and text rather than only images or only text. This paper contributes to the discussion on the use of photographs in non-market valuation surveys. We explored whether showing respondents images of the threatened species (Numbats and Woylies) in the choice sets would influence their WTP for increasing populations of the species. A split-sample design was employed where half the respondents saw choice sets with attribute levels as text only, while the other half included photographs of Numbats and Woylies in the choice sets as well as the text (Fig. 3).

The survey was administered via an online internet panel managed by an online market research company to a sample of the WA population in December 2016. The sample was stratified to ensure that it was representative of the WA population in terms of age, gender and education. Respondents from the local area were not included in the analysis presented in this paper because their experiences and preferences are likely to be significantly different from the general WA population.[3]

2.5. Data Analysis

The survey data was analysed using Stata/IC 14 (Statacorp LLC, USA). Conditional logit and mixed logit models were estimated. In the initial models, all variables and interactions were considered, and these were refined step by step to arrive at the final model that includes only significant attribute level variables and interactions. The mixed logit model is used in our analysis, as this model can account for preference heterogeneity across respondents by estimating the coefficients as random parameters that follow a distribution specified by the researcher. Conditional logit models are detailed in McFadden (1974). Train (2009) and Hensher and Greene (2002) provide a comprehensive description of mixed logit models. Likelihood ratio tests were performed to determine models' goodness of fit. Insignificant variables and interactions were omitted from the final models. We estimated respondents' marginal willingness to pay (WTP), also called the implicit price or part-worth, for an attribute as:

$$WTP_k = \frac{-\beta_k}{\beta_C} \quad (1)$$

Where, β_k and β_C are the coefficients of the attribute k and cost C, respectively.

For the mixed logit models, we specified a normal distribution on all attributes except cost, which was kept fixed to avoid behaviorally implausible positive estimates on costs. An alternative specific constant (ASC) was included for the status quo alternative. The ASC measures the utility associated with the status quo alternative that cannot be explained by other variables included in the model. Two dummy variables (each) were used for the Numbat and Woylie attributes – one representing a medium level gain (250 and 5000, respectively) and the other representing the high level gain (400 and 7500, respectively) compared to their status quo levels. Wald tests[4] were used to determine whether the medium- and high-level coefficients for the species' attribute levels were significantly different from each other.

3. Results

We obtained 500 completed surveys from the West Australian population. Sample demographics were in line with WA demographics, with an almost equal number of females and males (Table 2) but slightly older and better educated respondents than the general population of WA.

One-fifth of all respondents knew about Dryandra Woodland as a conservation site prior to the survey (Table 2). Of the 100 people who knew the site, 65% had visited it, with 40% visiting it once in the past 5 years. A larger proportion of the sample (85.4%) had prior knowledge of Numbats than of Woylies (35.4%). Of the 427 respondents with prior knowledge of Numbats, 62.5% had seen a live Numbat either in the

[3] A sample was also drawn from the communities surrounding the conservation site. However, that analysis will be presented elsewhere.

[4] The Wald test evaluates the degree to which the explanatory power of the restricted model (where the coefficients of the attribute levels are confined to be equal to each other) would differ from the unrestricted model having no such limitations (Rogers, 2013b).

Table 2
Socio-demographic characteristics of respondents.

Characteristic	Number of respondents (% of total surveyed)	WA population
Gender		
Males	256 (51.2%)	50.6 (%)
Females	244 (48.8%)	49.4 (%)
Region		
Perth Metropolitan Area	389 (77.8%)	78.3 (%)
Regional	111 (22.2%)	21.7 (%)
Average age of respondents	46.3	36[a]
Average annual income of respondents	93,989	69,056
Respondents with prior knowledge of		
Dryandra Woodland	100 (20.0%)	
Dryandra Woodland & who had visited the site	65 (13.0%)	
Numbats	427 (85.4%)	
Numbats had seen & a live Numbat	267 (53.4%)	
Numbats & aware of threat status	230 (46.0%)	
Woylies	177 (35.4%)	
Woylies & had seen a live Woylie	93 (18.6%)	
Woylies & aware of threat status	117 (23.4%)	
The threat of foxes to native species	409 (81.8%)	
The threat of feral cats to native species	410 (82.0%)	
Members of species' conservation organizations	147 (29.4%)	
Prior or current involvement in fox and/or feral cat management	79 (15.8%)	

[a] Median age.

wild or in the zoo and 54% were aware of their populations being in decline. Of the 177 respondents with prior knowledge of Woylies, 52.5% had seen a live Woylie either in the wild or in the zoo and 66% were aware of their populations being in decline. The majority of respondents were aware of the predatory threat of foxes (81.8%) and feral cats (82%).

There were 30 respondents who protested against having to pay (see Section 2.4). Most protesters (19) disagreed with paying for conservation and felt that it was the duty of the government to pay for it. Five respondents did not feel qualified to make the decisions and five did not want to make choices between the given options. Following regular practice in the DCE literature, these protest responses were removed from further analysis.

Interaction of the ASC with covariates such as age, gender, income, residence in the Perth Metropolitan Area, prior knowledge of Dryandra Woodland and predatory threat of foxes and feral cats, conservation organization membership or support, prior or current involvement in invasive feral predator management were not found to be significant. Only interacting the ASC with respondents who felt that their responses would influence future policy decisions (ASC × POLINF) was significant in the final model (Table 3). Respondents with prior experience with fox and/or feral cat management did not have significantly different preferences for management strategies compared to respondents with no previous experience. Therefore, prior experience with management was not included as a variable in the final model.

We tested the influence of including Numbat and Woylie images on the propensity to choose the status quo and on the WTP for increased Numbats or Woylie populations. None of these interactions were found to be significant and were therefore omitted from further analysis.

Likelihood ratio tests established that mixed logit models fit our data better than conditional logit models. We will therefore discuss the results of the final mixed logit model (Table 3). Respondents who believed that their choices would influence future conservation policies[5] were more likely to choose one of the conservation strategies over the status quo option, as indicated by the negative coefficient on ASC × POLINF.[6] Preference for the status quo itself was not significant (no significant coefficient on the ASC). However, the standard deviation on the ASC, which captures heterogeneity in respondents' preferences, was large (3.133), showing highly variable preferences for the status quo.

Table 3
Final mixed logit model with standard errors of the coefficients.

Variable	Coefficient	Standard error	Probability
COST[a]	− 0.007	0.001	0.000
ASC[b]	− 0.431	0.321	0.178
ASC × POLINF	− 1.023	0.363	0.005
NUM250 × DK	− 0.060	0.226	0.792
NUM400 × DK	− 0.241	0.283	0.395
NUM250 × KNOW	0.480	0.094	0.000
NUM400 × KNOW	0.488	0.123	0.000
WOY5000	0.476	0.086	0.000
WOY7500	0.297	0.113	0.009
TRAP	0.422	0.222	0.058
TR + CE	0.962	0.208	0.000
1080 + FE + TR	0.596	0.244	0.014
1080 + FE + CE	0.292	0.243	0.229
1080 + TR + CE	0.696	0.239	0.004
FE + TR + CE	0.749	0.255	0.003
FENCE	0.605	0.261	0.020
CE	− 0.656	0.391	0.093
1080 + FE	− 0.177	0.270	0.512
1080 + TR	0.233	0.207	0.261
1080 + CE	0.414	0.234	0.078
FE + TR	0.577	0.246	0.019
FE + CE	0.374	0.308	0.225
1080 + FE + TR + CE	0.674	0.262	0.010
Standard deviation			
ASC[b]	3.133	0.230	0.000
NUM250 × DK	0.756	0.336	0.024
NUM400 × DK	1.290	0.352	0.000
NUM250 × KNOW	0.351	0.272	0.196
NUM400 × KNOW	1.274	0.155	0.000
WOY5000	− 0.080	0.169	0.636
WOY7500	0.981	0.129	0.000
FENCE	1.635	0.309	0.000
CE	− 2.634	0.428	0.000
1080 + FE	1.688	0.352	0.000
1080 + TR	0.563	0.351	0.108
1080 + CE	0.905	0.265	0.001
FE + TR	1.268	0.298	0.000
FE + CE	− 1.502	0.348	0.000
1080 + FE + TR + CE	1.801	0.589	0.002
# of choice observations	11,280		
Log likelihood	− 3169.61		
AIC	6415.23		
BIC	6693.80		

[a] Annual for the next five years.
[b] Alternative specific constant = 1 for the status quo option.

Having prior knowledge of Numbats (yes/no) was interacted with the discrete Numbat attribute levels. Variables NUM250 × DK and NUM400 × DK capture the preferences of respondents without prior knowledge of Numbats for 250 and 400 Numbats respectively (relative to the status quo). NUM250 × KNOW and NUM400 × KNOW capture

[5] The variable 'POLINF' captures respondents' agreement to the question "How likely you think it is that the results of this study will influence future policy decisions about fox and feral cat management" measured as − 1 = very/somewhat unlikely, 0 = neither likely nor unlikely, and 1 = somewhat/very likely.

[6] A reviewer commented on this result, querying the consequentiality of the survey. This outcome does not necessarily suggest that respondents did not answer the questions honestly. Instead, it shows that some respondents have no faith that policy makers will listen to the results of this study. As one might expect, those respondents were more likely to choose the status quo where no policy changes would occur.

the preferences of respondents with prior knowledge of Numbats for 250 and 400 Numbats. Respondents without prior knowledge of Numbats were indifferent to population increases (NUM250 × DK and NUM400 × DK were not significant), whereas respondents with prior knowledge of Numbats significantly preferred higher Numbat populations than the status quo level (NUM250 × KNOW and NUM400 × KNOW both positive and significant,—Table 3). The coefficients on NUM400 × KNOW and NUM250 × KNOW were not significantly different from each other ($p = 0.952$). This suggests that, while respondents preferred an increase in population from the status quo, they are—on average—indifferent between increases to 250 or 400 Numbats.

Even The significant standard deviations on the NUM250 × DK and NUM400 × DK coefficients indicate that, among respondents without prior knowledge of Numbats, there was considerable preference heterogeneity for increasing Numbat populations to 250 or 400. Among those with prior knowledge, there was significant heterogeneity in preference for increasing Numbat populations to the highest level (400) as indicated by the significant standard deviation on NUM400 × KNOW.

Unlike Numbats, respondents' preferences for higher Woylie numbers (both 5000 and 7500) were not influenced by prior knowledge of the species. We therefore did not include prior knowledge of Woylies in the final model. Increases in Woylie populations over the status quo scenario (WOY5000 and WOY7500) were significantly different from zero (Table 3) which shows that people prefer a population increase over status quo levels. As with Numbats, there was significant heterogeneity in preference for increasing Woylie populations to the highest level (7500) as indicated by the significant standard deviation on WOY7500 (Table 3). The coefficients of WOY5000 and WOY7500 were significantly different from each-other ($p = 0.089$) indicating that respondents decidedly preferred a medium increase (5000 Woylies) over a high increase (7500 Woylies) (as shown by the smaller coefficient estimate for WOY7500).

Coefficients for all management strategies except two were positive and significant at the 90% level of confidence or above (Table 3). Trapping and fencing were preferred over the status quo strategy of 1080 baiting, while the coefficient on community engagement on its own was negative (respondents did not prefer this strategy over 1080 baiting). Combinations of strategies generally had the largest coefficient estimates, with the combination of trapping + community engagement (TR + CE) being the most preferred, followed by fencing + trapping + community engagement (FE + TR + CE) and 1080 baiting + trapping + community engagement (1080 + TR + CE). There was little preference heterogeneity towards trapping, trapping + community engagement, and combinations involving three strategies. Therefore, coefficients for these strategies were kept fixed in the final model. Respondents did show significant variation in preferences for some of the other management strategies. For example, even though 1080 baiting plus fencing (1080 + FE) was not significantly preferred over 1080 baiting alone, there was considerable heterogeneity in preference for these strategies as seen by their large standard deviations. There was considerable variation in preference for the combination of all four strategies in spite of it being significantly preferred over the status quo of 1080 baiting.

Marginal WTP (part-worths) were calculated for increases in Numbat and Woylie numbers using the '*nlcom*' command in STATA (Table 4). These confirm that respondents were indifferent to population increases in Numbats over the baseline, with WTP estimates for medium or high increases not being significantly different from each other. Respondents who have prior knowledge of Numbats are, on average, willing to pay $0.22 per Numbat (per year for five years) for an increase from the status quo of 100 to 400 Numbats, with WTP being $0.43 per Numbat for an increase from 100 to 250 Numbats, and only $0.007 per Numbat for an increase from 250 to 400 Numbats. In the case of Woylies, respondents have a higher WTP for a medium increase

Table 4
Annual marginal willingness to pay (MWTP) per household in 2016 Australian dollars, along with the standard error, and 95% confidence intervals (CI) for all significant attributes and levels above the status quo.

Variable	MWTP	Standard error	95% CI
NUM250 × KNOW[a]	64.30	12.41***	(39.98–88.62)
NUM400 × KNOW[a]	65.29	15.66***	(34.60–95.99)
WOY5000	63.73	10.66***	(42.83–84.63)
WOY7500	39.75	14.20***	(11.93–67.58)
FENCE	80.98	34.92**	(12.55–149.42)
TRAP	56.45	29.20*	(− 0.78–113.68)
CE	− 87.86	52.64*	(− 191.03–15.31)
1080 + CE	55.37	31.05*	(− 5.48–116.22)
FE + TR	77.33	32.68**	(13.29–141.37)
TR + CE	128.76	27.49***	(74.88–182.64)
1080 + FE + TR	79.84	32.59**	(15.97–143.71)
1080 + TR + CE	93.20	31.73***	(31.01–155.40)
FE + TR + CE	100.34	33.73***	(34.23–166.46)
1080 + FE + TR + CE	90.25	35.57**	(20.54–159.96)

[a] For respondents with prior knowledge of Numbats.
* $p < 0.1$.
** $p < 0.05$.
*** $p < 0.01$.

than for a high increase. Respondents are willing to pay, on average, $0.008 per Woylie for an increase from 2500 to 7500 Woylies, with the WTP for the first increase from 2500 to 5000 Woylies being $0.025 per Woylie. These numbers may appear small, but remember that populations consist of several hundred Numbats and several thousand Woylies, which means that an increase in Woylie population from 2500 to 5000 has a part-worth of $63.72 *ceterus paribus*.

4. Discussions and Conclusions

This study seeks to determine preferences for, and quantify part of the benefits of, invasive feral predator management. To the best of our knowledge, there has been very little research in this area. Clapperton and Day (2001) performed a cost-effectiveness analysis on fencing versus lethal control for stoat management at a recovery site in New Zealand but did not account for social welfare impacts of these strategies. de Tores and Marlow (2012) investigated the relative merits of fencing versus fox-baiting, but treated benefits in a qualitative rather than quantitative manner. Including costs, benefits, and social preferences in an analysis provides valuable information for more efficient decision-making.

In line with previous valuation studies on threatened species we find that WA community members hold a positive value for an increase in Numbat and Woylie populations over their status quo levels. Respondents are willing to pay $0.22 per Numbat (per year for five years) for an increase from 100 to 400 Numbats and $0.008 per Woylie for an increase from 2500 to 7500 Woylies annually. It seems that Numbats are more highly valued, per individual, than Woylies. This may be because a lot more respondents (about 85%) had prior knowledge of Numbats compared to Woylies (about 35%). The familiarity of respondents with Numbats is due to the Numbat being WA's faunal emblem. Indeed, previous studies (Metrick and Weitzman, 1996; Colleony et al., 2017; Morse-Jones et al., 2012) have found that the charisma of a species is a significant determinant of willingness to pay. Additionally, there have been multiple campaigns by the State Government and advocacy groups (for example, Project Numbat) to educate the public about Numbat recovery. The same is not true for the Woylie, even though the species' is *critically endangered*. Following these findings, conservation agencies could consider using a charismatic species to obtain funding for conservation programs that also target other species.

A further reason for the value difference between the two species lies in the absolute numbers of the species' populations, rather than their threat status. Although respondents were reminded about the *critically endangered* status of the Woylie, they may have thought that the absolute number of 5000 Woylies protected by the medium level increase is sufficiently high simply because it is a large number (even though that number is only one-sixth of the 2001 Woylie population in Dryandra Woodland). Numbat populations, on the other hand, are much lower with just 80 mature adults left in the Dryandra Woodland, which sounds more dramatic and may have therefore attracted higher values.

For Numbats, there was no difference between the value estimates for 250 or 400 Numbats. This indicates that respondents want to see an improvement in Numbat populations over the baseline, but are indifferent between a medium or a high increase. For Woylies, people valued the first step increase in populations higher than the second (equal) step. This indicates that, while they derive positive utility from an increase in Woylie population, that utility is lower when the population increases are very high. Future choice experiment studies could use more than three attribute levels to obtain more accurate information about the marginal utility that people receive from different levels of threatened species' populations.

As far as management strategies are concerned there emerged no clear single 'winner'. With the exception of community engagement on its own, and 1080 baiting + fencing combined, all management strategies were preferred over the status quo strategy of 1080 baiting. The positive willingness to pay for most conservation strategies shows that respondents prefer those over the current program of 1080 baiting. It may be that respondents view strategies with 1080 baiting as cruel and are therefore not supportive of them. The use of 1080-poisoned meat baits is contentious owing to the perceived inhumaneness of the poison on pest animals and on unintended non-target species including pet dogs (Marks et al., 2004). The visible signs of fluoroacetate poisoning (see Sherley, 2007 may be distressing to onlookers and usually interpreted as the animal being in pain and distress (Marks et al., 2000). This means that conservation managers may need to consider alternative strategies to 1080 baiting if they wish to increase public support for feral predator management. Indeed, we show that the most preferred management strategies were those combinations that included trapping and community engagement (TR + CE, FE + TR + CE, 1080 + TR + CE, 1080 + FE + TR + CE). Combinations were potentially seen to be more effective than a single strategy at managing invasive feral predator populations, which is in line with findings from other studies, for example, Rolfe and Windle (2012). Our results provide a clear message for conservation managers that—if they wish to increase social welfare from their policies—they should (i) use multiple strategies instead of just one strategy, and (ii) include trapping and community engagement in the management package.

This study investigated people's preferences for fox and feral cat management strategies to ensure the survival of native WA species, and aimed to estimate the values that people place on two native threatened species: Numbats and Woylies. We found significant support among the WA population for a medium increase in the species' numbers. Including photographs of the species in the choice sets did not significantly affect people's WTP for species' conservation. We recommend that conservation policy makers use a combination of strategies to manage foxes and feral cats over the use of a single strategy to increase social welfare and include trapping and community engagement in the combination.

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