

**To bait or not to bait: A discrete choice experiment on public preferences for native
wildlife and conservation management in Western Australia**

Vandana Subroy^{*,a,b}, Abbie A. Rogers^{#,a,b,c}, Marit E. Kragt^{\$.a,b}

^a UWA School of Agriculture and Environment, University of Western Australia, 35 Stirling
Highway, Crawley, WA 6009, Australia

^b Centre of Environmental Economics and Policy, University of Western Australia, 35 Stirling
Highway, Crawley, WA 6009, Australia

^c Centre of Excellence for Environmental Decisions, University of Western Australia, 35 Stirling
Highway, Crawley, WA 6009, Australia

*** Corresponding author:**

Ms. Vandana Subroy

M087 / 35 Stirling Highway

Crawley, WA 6009

AUSTRALIA

Ph: +61(0)8 6488 1495

E-mail: vandana.subroy@research.uwa.edu.au

Email: abbie.rogers@uwa.edu.au

\$ Email: marit.kragt@uwa.edu.au

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1 **Abstract**

2 Foxes and feral cats are invasive predators threatening biodiversity in many places around the
3 world. Managing these predators to protect threatened species should involve careful
4 consideration of biological, geographic, economic, and social aspects to ensure informed and
5 effective decision-making. This study investigates people’s preferences for the ways in which
6 foxes and feral cats are managed at a conservation site in Western Australia using a discrete
7 choice experiment. We further aim to quantify the non-market values of two native threatened
8 species protected by management; Numbats and Woylies. The attributes evaluated in the
9 survey included: increased populations of Numbats and Woylies, cost of management, and a
10 range of invasive feral predator management strategies (1080 baiting, fencing, trapping, and
11 community engagement). Results show that respondents prefer a combination of management
12 strategies over the strategy of 1080 baiting that is currently being implemented, particularly
13 combinations that include trapping and community engagement. There is also strong public
14 support for increased Numbat and Woylie populations. Willingness to pay was, on average,
15 \$21.76 for 100 Numbats and \$7.95 for 1,000 Woylies. Including images of the threatened
16 species in the choice sets does not influence willingness-to-pay estimates. We further discuss
17 how familiarity with the species influences value. Our results feed into the conservation decision
18 making process about feral species management in the region.

19 **Keywords**

- 20 · Threatened species
- 21 · Invasive feral predator management
- 22 · Willingness to pay
- 23 · 1080 baiting
- 24 · Non-market valuation

25 **1. Introduction**

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

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

43 Management strategies for fox and feral cat populations have commonly focused on
44 lethal methods like poison baiting, shooting, and trapping with soft-jaw or cage-style traps, and
45 non-lethal methods like predator-exclusion fencing (DEWHA, 2008a, DoE, 2015a). Poisoned
46 meat baits are often used when managing large sites, and when primary food sources (rabbits,
47 mice, native species) are absent or in low numbers (DoE, 2015a). Shooting and trapping are
48 more labor intensive and expensive and are generally not preferred for broad-scale control but
49 are effective in smaller areas (DoE, 2015a, Saunders et al., 2010). Other fox management
50 techniques focus on den fumigation, den destruction, and fertility control (Saunders et al., 2010),

51 while those for cats have also included the use of specially trained dogs and the introduction of
52 *feline panleucopaenia* (Denny and Dickman, 2010).

53 The complete eradication of foxes and feral cats at a conservation site using lethal
54 techniques is near impossible (unless the site is a small island), because they disperse over
55 large areas and can reappear after predator management been carried out—unless
56 management is implemented periodically (Moseby et al., 2009). In such cases, exclusion-
57 fencing can be an effective strategy to mitigate threats to native species, and is being favored in
58 many regions including Australia, New Zealand, and southern Africa (Hayward and Kerley,
59 2009). Once feral predators and other invasive species within the enclosure have been
60 eradicated, fencing creates feral-free ‘islands’ allowing native species to thrive. Exclusion
61 fences, however, have high installation costs, are not 100% effective at preventing predator
62 incursions, and require frequent maintenance which can be time-consuming and labor- and
63 cost-intensive. Ecological costs such as inbreeding and poorly developed threat-defense
64 mechanisms can result from preventing the movement of animals (Hayward and Kerley, 2009).
65 Fences are also not independent of other management strategies since predators within the
66 enclosure need to be eradicated anyway (Long and Robley, 2004).

67 Although the aim of invasive feral predator management is to safeguard threatened
68 species and increase their survivability, it is not simply the end result that matters. Management
69 takes place in a social context that needs to consider community preferences for different
70 management strategies. It is likely that people have preferences for the *means* of achieving
71 conservation outcomes as well as for the outcomes themselves. This has been shown by, for
72 example, Johnston and Duke (2007), who found that respondents significantly preferred state
73 conservation easements over other techniques that can be used to preserve agricultural lands.
74 Similarly, in a study on marine ecology conservation in Western Australia, Rogers (2013b) found
75 that utility for the same conservation outcomes differed depending on the management process
76 specified: respondents typically preferred processes that were less restrictive in terms of human

77 use of the marine reserve. More recently, Sheremet et al. (2017) also concluded that public
78 support (for forest disease control) is conditional on the type of control measures used. On the
79 other hand, Hanley et al. (2010) found that respondents were largely indifferent to how
80 conservation objectives (for raptors in Scottish moorlands) were achieved, implying that the
81 benefits are roughly equal across management alternatives if the same level of environmental
82 protection is achieved. Our study contributes to this literature by assessing whether people have
83 different preferences for different methods to manage invasive species.

84 Wildlife policies to increase populations of threatened and endangered species should
85 involve careful consideration of biological, geographic, economic, and social aspects to ensure
86 informed and inclusive decision-making and, ultimately, policy success (Rogers, 2013b).
87 Understanding the socio-economic impact of conservation decisions enables a more efficient
88 use of limited resources available for the task. Economic research can guide policy decision-
89 making by analyzing the cost-effectiveness of conservation actions e.g. Busch and Cullen
90 (2009), Helmstedt et al. (2014). Of interest to the current study are the socio-economic (non-
91 market) *benefits* that different eradication strategies may generate. Quantifying the non-market
92 benefits of conservation actions, as well as the values of the species being protected, allows
93 these benefits to be included in a benefit-cost analysis to assess which conservation policy
94 options will be optimal from a social welfare perspective. While there exist a small number of
95 non-market valuation studies for threatened species in Australia (Jakobsson and Dragun, 2001,
96 Tisdell and Nantha, 2007, Wilson and Tisdell, 2007, Zander et al., 2014) there are, to the best of
97 our knowledge, no studies quantifying the social welfare impacts of fox and feral cat
98 management. There are some studies that estimate households' willingness to pay (WTP) for
99 the management of other invasive species in other parts of the world. For example, Florida
100 residents' WTP to control invasive plants in state Parks (Adams et al., 2011); French
101 households' WTP to reduce nuisance from invasive Asian ladybirds (Chakir et al., 2016); and
102 UK households' WTP for tree disease control programs in UK forests (Sheremet et al., 2017).

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

111 We use a discrete choice experiment (DCE) to estimate non-market values associated with
112 fox and feral cat management for Numbat and Woylie conservation. The DCE was carried out in
113 collaboration with the Department of Parks and Wildlife (DPaW), Western Australia. Results of
114 this survey may be used to inform conservation policies for invasive feral predator management
115 in Western Australia.

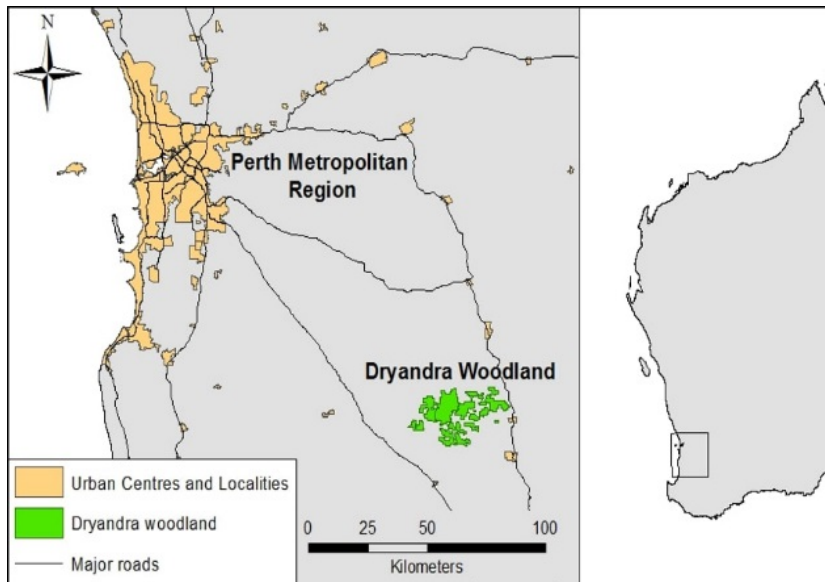
116

117 **2. Methodology**

118 **2.1. Conservation site**

119 Dryandra Woodland is a conservation site about 160 km south-east of Perth, WA
120 (Figure 1). It exists as 17 discrete fragments scattered across 50 km with a total area of 28,066
121 hectares with blocks ranging from 87 to 12,283 hectares (DEC, 2011). It is surrounded by
122 farmland and has a high concentration of feral cats and foxes. Being extremely fragmented, it
123 has a high perimeter to area ratio which makes the implementation of invasive feral predator
124 management challenging. Apart from supporting the largest area of remnant vegetation in the
125 region, the Woodland has high conservation value as it is home to several threatened species of
126 flora and fauna (DEC, 2011). It is one of two sites with original populations of the endangered
127 Numbat, and one of three sites supporting original populations of the critically-endangered
128 Woylie (de Tores and Marlow, 2012), and is the only conservation site with original populations

129 of both Numbats and Woylies—the species of interest in our study. Along with biodiversity
130 conservation, the Woodland is used for recreation, timber production, and Aboriginal land use
131 (DEC, 2011). The importance of the Woodland for conservation and cultural uses mean that its
132 management is also likely to be of interest to the broader WA community.



133

134 **Figure 1:** Location of Dryandra Woodland Relative to Perth and Western Australia

135

136 Both Numbats and Woylies were widely distributed prior to European arrival in Australia,
137 with Woylies distributed across the continent south of the tropics (Figure 2). The population of
138 Numbats in Dryandra Woodland declined from about 800 mature individuals in 1992 to about 80
139 at present (M. Page, DPaW, pers. comm.). The population of Woylies in the Woodland declined
140 from about 30 000 mature individuals in 2001 to about 2,000 at present (M. Page, DPaW, pers.
141 comm.). Natural native predators of Numbats and Woylies include the western quoll (*Dasyurus*
142 *geoffroii*), Carpet Pythons, and raptors. Along with land clearing, predation by foxes and feral
143 cats remain key processes that threaten the survival of both species (Yeatman and Groom,
144 2012, DPaW, 2015). Numbats are listed as *Endangered* (Woinarski and Burbidge, 2016b) since
145 their population is small and declining, with less than 1,000 mature adults currently present in
146 the wild including the 80 at Dryandra Woodland. Woylies are listed as *Critically Endangered*

147 (Woinarski and Burbidge, 2016a) since their population declined by over 90% since 1999, with
 148 about 15,000 mature adults currently present in the wild including the 2,000 at Dryandra
 149 Woodland. Currently, translocations of Numbats bred in captivity at Perth zoo, and
 150 translocations of Woylies from natural populations at the Upper Warren region in WA, are
 151 carried out to augment their wild populations at Dryandra Woodland and to increase their
 152 genetic diversity (Friend, 2014, Wayne and Wnuk, 2015).

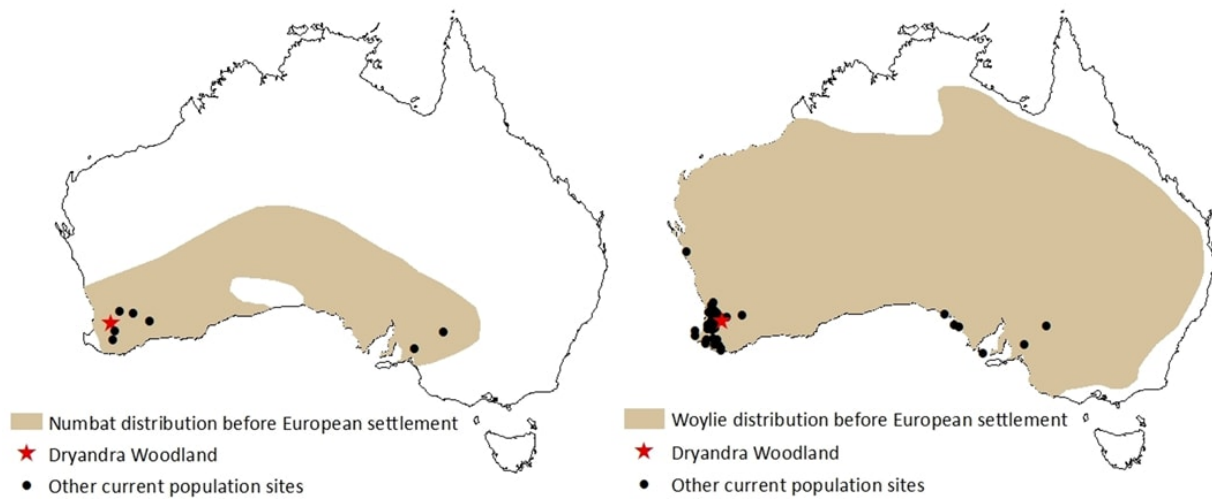


Figure 2: Past and current Numbat and Woylie distribution sites in Australia. Numbat and Woylie distribution maps adapted from Cooper (2011), and Yeatman and Groom (2012), respectively.

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

167 the poison. Native species of southwest WA have coexisted with fluoroacetate-bearing native
168 plants for several thousand years and are therefore highly tolerant to the poison (King et al.,
169 1978, Twigg and King, 1991). Baited areas are regularly checked to remove the carcasses of
170 invasive predators. Currently, the baits for foxes, called Probait®, are salami-like sausages
171 injected with 1080 and then dried to make them hard and less appetizing for native species. The
172 baits for feral cats, called Eradicat®, are smaller and moister 1080-infused sausages. Although
173 monthly fox baiting with 1080-poisoned meat baits has been ongoing since 1989 at Dryandra
174 Woodland, a simultaneous feral cat baiting program was not carried out until 2015.

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

187

188 **2.3. Attribute selection for the discrete choice experiment**

189 Discrete choice experiments (DCEs) are a well-established method that can be used to
190 measure the social welfare impacts of a change in (environmental) policy. They provide a
191 framework to help guide decision-making by revealing which aspects of the policy are most
192 preferred by people. DCEs have been used to determine non-market values for many species

193 around the world (Boxall et al., 2012, Decker and Watson, 2016, Jin et al., 2010, Langford et al.,
194 2001, Loomis and Ekstrand, 1997). They have also been used to measure social welfare for
195 various conservation processes (Johnston and Duke, 2007, Hanley et al., 2010, Rogers,
196 2013b).

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

204 The attributes and levels for our choice experiment (Table 1) were decided after
205 extensive consultations with the DPaW. Since the aim of invasive feral predator management in
206 our study was to increase the survivability of Numbats and Woylies at Dryandra Woodland,
207 Numbat and Woylie populations were included as attributes in the choice experiment along with
208 strategies to manage fox and feral populations and cost¹.

209 The levels for Numbats and Woylies represented a low (status quo), medium, or high
210 increase in the populations of mature adults in five years' time. Estimates were provided by
211 conservation experts at the DPaW. A low, medium, and high increase for Numbats was defined
212 as 100, 250, and 400 mature individuals respectively (from the current level of 80), and 2,500,
213 5,000 and 7,500 mature individuals for Woylies (from the current level of 2,000). The status quo
214 option in our DCE was the continuation of DPaW's current 1080 baiting program in Dryandra

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 labelled experiments (de Bekker-Grob et al., 2010; Chakir et al., 2016).

215 Woodland. This is expected to lead to a low increase in Numbat and Woylie populations (to 100
216 and 2,500 individuals respectively) at zero cost.

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

Attribute	Description	Levels	Variable Name
Management strategy	Strategy to manage fox and feral cat populations in Dryandra Woodland	1080 baiting Trapping Fencing Community engagement + combinations of the above (11 levels in total)	1080 (current strategy) TRAP FENCE CE
Numbat	Numbat population in 5 years' time in Dryandra Woodland	100 250 400	NUM100 (status quo) NUM250 NUM400
Woylie	Woylie population in 5 years' time in Dryandra Woodland	2,500 5,000 7,500	WOY2500 (status quo) WOY5000 WOY7500
Cost ^a	Annual cost to West Australian households each year for the next 5 years	\$0, \$20, \$50, \$100, \$150, \$250, \$400	COST

221
222 Notes: Variables are dummy coded where they = 1 if selected; 0 otherwise; ^aCost modelled as a continuous variable with \$0
223 representing the status quo
224

225 **Table 1:** Attributes and levels used in the choice experiment
226

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

237 Following Rolfe and Windle (2012), we used a combination of increased taxes,
238 increased council rates, and increased prices of certain goods and services as the payment
239 vehicle in order to avoid a protest response relating to any particular payment vehicle. This mix
240 of payment vehicles also ensured that it would be applicable to the broader population that we

241 were sampling to include those who do not pay taxes but for whom higher prices of goods might
242 be a more realistic payment (Johnston et al., 2017). Respondents were told that higher Numbat
243 and Woylie numbers could be achieved by increasing fox and feral cat management using a
244 combination of management strategies. However, funds from all WA households would need to
245 be collected to implement management. Payment was stated to be annually for the next five
246 years. The maximum levels of the cost attribute were based on the focus group discussions,
247 with bids ranging from \$0 – \$500².

248

249 **2.4. Survey design**

250 The survey was designed in Ngene (Choice Metrics Pty. Ltd.) using a D-efficient main
251 effects design. The priors for management were set to zero because there was no consistent
252 evidence about whether preferences would be positive or negative toward the different
253 strategies. The priors for Numbat and Woylie conservation were kept positive and that for cost
254 was kept negative. The design included 24 choice scenarios divided into four blocks of six
255 choice questions each. Each respondent was randomly allocated one of the blocks. Each
256 question had four unlabeled alternatives (A, B, C and D). Alternative A was the status quo with
257 1080 baiting as current management strategy, a low improvement in Numbat and Woylie
258 numbers (100 and 2,500, respectively), and no additional annual cost to respondents. The other
259 three alternatives presented additional management strategies (alone or in combination) and
260 potential improvements in Numbat and Woylie numbers, at a cost to the respondent.

261 The choice experiment survey was programmed online (Qualtrics LLC, Provo, UT, USA)
262 with three sections. The first included background information on Dryandra Woodland,
263 Numbats, Woylies, foxes and feral cats, and about the management strategies. Respondents
264 were also asked about their familiarity with the conservation site, their prior knowledge of the



²² All \$ expressed in 2016 Australian dollars.

265 threatened species, foxes, and feral cats. The second section described the need to improve
266 Numbat and Woylie populations by implementing additional fox and feral cat management
267 strategies and introduced the payment vehicle. It then described the outcomes of management
268 on Numbat and Woylie populations (low, medium, and high population increases) and showed
269 an example choice question. Respondents then answered six choice questions. The last part of
270 the survey contained debriefing questions about the choice experiment, questions related to
271 attribute nonattendance, on membership with conservation organizations, and on socio-
272 demographics. Respondents who had selected the status quo (no-cost alternative) in all six
273 choice questions were asked their reason for doing. This meant to ascertain whether the
274 respondent holds a true-zero value for the attribute(s) or whether they 'protested' against the
275 payment vehicle or against having to pay—in which case their true values may not be zero
276 (Barrio and Loureiro, 2013).

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

283 We also tested the influence of photographs on willingness-to-pay (WTP) for improved
284 conservation. The use of photographs in non-market valuation and their influence on WTP
285 estimates has been unresolved since the NOAA Panel Report on Contingent Valuation by Arrow
286 et al. (1993) (Shr and Ready, 2016). There are very few non-market valuation studies that test
287 differences in people's WTP when they are shown photographs of the attributes in question.
288 Labao et al. (2008) found colored photographs to be value-enhancing compared to black and
289 white ones, while Shr and Ready (2016) concluded that respondents have a higher WTP when
290 shown both images and text rather than only images or only text. This paper contributes to the

291 discussion on the use of photographs in non-market valuation surveys. We explored whether
 292 showing respondents images of the threatened species (Numbats and Woylies) in the choice
 293 sets would influence their WTP for increasing populations of the species. A split-sample design
 294 was employed where half the respondents saw choice sets with attribute levels as text only,
 295 while the other half included photographs of Numbats and Woylies in the choice sets as well as
 296 the text (Figure 3).

	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

297
 298 **Figure 3:** Example choice question with images of the species. For respondents who were not
 299 shown images in their choice sets, the images of Numbats and Woylies were not included.

300
 301 The survey was administered via an online internet panel managed by an online market
 302 research company to a sample of the WA population in December 2016. The sample was
 303 stratified to ensure that it was representative of the WA population in terms of age, gender and
 304 education. Respondents from the local area were not included in the analysis presented in this

305 paper because their experiences and preferences are likely to be significantly different from the
306 general WA population.³

307

308 **2.5. Data analysis**

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

320
$$WTP_k = \frac{-\beta_k}{\beta_C} \dots\dots\dots (3)$$

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

322 For the mixed logit models, we specified a normal distribution on all attributes except
323 cost, which was kept fixed to avoid behaviorally implausible positive estimates on costs. An
324 alternative specific constant (ASC) was included for the status quo alternative. The ASC
325 measures the utility associated with the status quo alternative that cannot be explained by other
326 variables included in the model. Two dummy variables (each) were used for the Numbat and
327 Woylie attributes – one representing a medium level gain (250 and 5,000, respectively) and the
328 other representing the high level gain (400 and 7,500, respectively) compared to their status

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

329 quo levels. Wald tests⁴ were used to determine whether the medium- and high-level coefficients
 330 for the species' attribute levels were significantly different from each other.

331

332 **3. Results**

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

337

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*
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%)	

338 * Median age

339 **Table 2:** Socio-demographic characteristics of respondents

340

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).

341 One-fifth of all respondents knew about Dryandra Woodland as a conservation site prior
342 to the survey (Table 2). Of the 100 people who knew the site, 65% had visited it, with 40%
343 visiting it once in the past 5 years. A larger proportion of the sample (85.4%) had prior
344 knowledge of Numbats than of Woylies (35.4%). Of the 427 respondents with prior knowledge
345 of Numbats, 62.5% had seen a live Numbat either in the wild or in the zoo and 54% were aware
346 of their populations being in decline. Of the 177 respondents with prior knowledge of Woylies,
347 52.5% had seen a live Woylie either in the wild or in the zoo and 66% were aware of their
348 populations being in decline. The majority of respondents were aware of the predatory threat of
349 foxes (81.8%) and feral cats (82%).

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

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

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

367 Likelihood ratio tests established that mixed logit models fit our data better than
368 conditional logit models. We will therefore discuss the results of the final mixed logit model
369 (Table 3). Respondents who believed that their choices would influence future conservation
370 policies⁵ were more likely to choose one of the conservation strategies over the status quo
371 option, as indicated by the negative coefficient on ASCxPOLINF⁶. Preference for the status quo
372 itself was not significant (no significant coefficient on the ASC). However, the standard deviation
373 on the ASC, which captures heterogeneity in respondents' preferences, was large (3.133),
374 showing highly variable preferences for the status quo.
375

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.

Variable	Coefficient	Standard Error	Probability
COST ^a	-0.007	0.001	0.000
ASC ^b	-0.431	0.321	0.178
ASCxPOLINF	-1.023	0.363	0.005
NUM250xDK	-0.060	0.226	0.792
NUM400xDK	-0.241	0.283	0.395
NUM250xKNOW	0.480	0.094	0.000
NUM400xKNOW	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
<i>Standard deviation</i>			
ASC ^b	3.133	0.230	0.000
NUM250xDK	0.756	0.336	0.024
NUM400xDK	1.290	0.352	0.000
NUM250xKNOW	0.351	0.272	0.196
NUM400xKNOW	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		

377 Notes: ^aAnnual for the next five years; ^b Alternative specific constant = 1 for the status quo option;

378

379 **Table 3:** Final Mixed logit model with standard errors of the coefficients

380

381 Having prior knowledge of Numbats (yes/no) was interacted with the discrete Numbat
382 attribute levels. Variables NUM250xDK and NUM400xDK capture the preferences of
383 respondents without prior knowledge of Numbats for 250 and 400 Numbats respectively
384 (relative to the status quo). NUM250xKNOW and NUM400xKNOW capture the preferences of
385 respondents with prior knowledge of Numbats for 250 and 400 Numbats. Respondents without
386 prior knowledge of Numbats were indifferent to population increases (NUM250xDK and
387 NUM400xDK were not significant), whereas respondents with prior knowledge of Numbats
388 significantly preferred higher Numbat populations than the status quo level (NUM250xKNOW
389 and NUM400xKNOW both positive and significant,—Table 3). The coefficients on
390 NUM400xKNOW and NUM250xKNOW were not significantly different from each other ($p=$
391 0.952). This suggests that, while respondents preferred an increase in population from the
392 status quo, they are—on average—indifferent between increases to 250 or 400 Numbats.

393 Even the significant standard deviations on the NUM250xDK and NUM400xDK
394 coefficients indicate that, among respondents without prior knowledge of Numbats, there was
395 considerable preference heterogeneity for increasing Numbat populations to 250 or 400. .
396 Among those with prior knowledge, there was significant heterogeneity in preference for
397 increasing Numbat populations to the highest level (400) as indicated by the significant standard
398 deviation on NUM400xKNOW.

399 Unlike Numbats, respondents' preferences for higher Woylie numbers (both 5,000 and
400 7,500) were not influenced by prior knowledge of the species. We therefore did not include prior
401 knowledge of Woylies in the final model. Increases in Woylie populations over the status quo
402 scenario (WOY5000 and WOY7500) were significantly different from zero (Table 3) which
403 shows that people prefer a population increase over status quo levels. As with Numbats, there

404 was significant heterogeneity in preference for increasing Woylie populations to the highest level
405 (7,500) as indicated by the significant standard deviation on WOY7500 (Table 3). The
406 coefficients of WOY5000 and WOY7500 were significantly different from each-other ($p= 0.089$)
407 indicating that respondents decidedly preferred a medium increase (5,000 Woylies) over a high
408 increase (7,500 Woylies) (as shown by the smaller coefficient estimate for WOY7500).

409 Coefficients for all management strategies except two were positive and significant at
410 the 90% level of confidence or above (Table 3). Trapping and fencing were preferred over the
411 status quo strategy of 1080 baiting, while the coefficient on community engagement on its own
412 was negative (respondents did not prefer this strategy over 1080 baiting). Combinations of
413 strategies generally had the largest coefficient estimates, with the combination of trapping +
414 community engagement (TR+CE) being the most preferred, followed by fencing + trapping +
415 community engagement (FE+TR+CE) and 1080 baiting + trapping + community engagement
416 (1080+TR+CE). There was little preference heterogeneity towards trapping, trapping +
417 community engagement, and combinations involving three strategies. Therefore, coefficients for
418 these strategies were kept fixed in the final model. Respondents did show significant variation in
419 preferences for some of the other management strategies. For example, even though 1080
420 baiting plus fencing (1080+FE) was not significantly preferred over 1080 baiting alone, there
421 was considerable heterogeneity in preference for these strategies as seen by their large
422 standard deviations. There was considerable variation in preference for the combination of all
423 four strategies in spite of it being significantly preferred over the status quo of 1080 baiting.

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

430 per Numbat for an increase from 100 to 250 Numbats, and only \$0.007 per Numbat for an
431 increase from 250 to 400 Numbats. In the case of Woylies, respondents have a higher WTP for
432 a medium increase than for a high increase. Respondents are willing to pay, on average, \$0.008
433 per Woylie for an increase from 2,500 to 7,500 Woylies, with the WTP for the first increase from
434 2,500 to 5,000 Woylies being \$0.025 per Woylie. These numbers may appear small, but
435 remember that populations consist of several hundred Numbats and several thousand Woylies,
436 which means that an increase in Woylie population from 2,500 to 5,000 has a part-worth of
437 \$63.72 *ceterus paribus*.

438

Variable	MWTP	Standard Error	95% CI
NUM250xKNOW ^a	64.30	12.41***	(39.98 - 88.62)
NUM400xKNOW ^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)

440 Notes: ^a For respondents with prior knowledge of Numbats; *, **, *** denote significance at the 90%, 95% and 99% level of
441 confidence, respectively.

442

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

446

447 4. Discussions and Conclusions

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

456 In line with previous valuation studies on threatened species we find that WA community
457 members hold a positive value for an increase in Numbat and Woylie populations over their
458 status quo levels. Respondents are willing to pay \$0.22 per Numbat (per year for five years) for

459 an increase from 100 to 400 Numbats and \$0.008 per Woylie for an increase from 2,500 to
460 7,500 Woylies annually. It seems that Numbats are more highly valued, per individual, than
461 Woylies. This may be because a lot more respondents (about 85%) had prior knowledge of
462 Numbats compared to Woylies (about 35%). The familiarity of respondents with Numbats is due
463 to the Numbat being WA's faunal emblem. Indeed, previous studies (Metrick and Weitzman,
464 1996, Colleony et al., 2017, Morse-Jones et al., 2012) have found that the charisma of a
465 species is a significant determinant of willingness to pay. Additionally, there have been multiple
466 campaigns by the State Government and advocacy groups (for example, Project Numbat) to
467 educate the public about Numbat recovery. The same is not true for the Woylie, even though
468 the species' is *critically endangered*. Following these findings, conservation agencies could
469 consider using a charismatic species to obtain funding for conservation programs that also
470 target other species.

471 A further reason for the value difference between the two species lies in the absolute
472 numbers of the species' populations, rather than their threat status. Although respondents were
473 reminded about the *critically endangered* status of the Woylie, they may have thought that the
474 absolute number of 5,000 Woylies protected by the medium level increase is sufficiently high
475 simply because it is a large number (even though that number is only one-sixth of the 2001
476 Woylie population in Dryandra Woodland). Numbat populations, on the other hand, are much
477 lower with just 80 mature adults left in the Dryandra Woodland, which sounds more dramatic
478 and may have therefore attracted higher values.

479 For Numbats, there was no difference between the value estimates for 250 or 400
480 Numbats. This indicates that respondents want to see an improvement in Numbat populations
481 over the baseline, but are indifferent between a medium or a high increase. For Woylies, people
482 valued the first step increase in populations higher than the second (equal) step. This indicates
483 that, while they derive positive utility from an increase in Woylie population, that utility is lower
484 when the population increases are very high. Future choice experiment studies could use more

485 than three attribute levels to obtain more accurate information about the marginal utility that
486 people receive from different levels of threatened species' populations.

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

507 This study investigated people's preferences for fox and feral cat management
508 strategies to ensure the survival of native WA species, and aimed to estimate the values that
509 people place on two native threatened species: Numbats and Woylies. We found significant
510 support among the WA population for a medium increase in the species' numbers. Including

511 photographs of the species in the choice sets did not significantly affect people's WTP for
512 species' conservation. We recommend that conservation policy makers use a combination of
513 strategies to manage foxes and feral cats over the use of a single strategy to increase social
514 welfare and include trapping and community engagement in the combination.

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