CONTRIBUTED PAPER

Prioritising cat-owner behaviours for a campaign to reduce wildlife depredation

Linklater, W.L.[1, 2] *, Farnworth, M.J.[3], van Heezik, Y.[4], Stafford, K.J.[5], MacDonald, E.A.[6]

[1] Centre for Biodiversity and Restoration Ecology, School of Biological Sciences, Victoria University of Wellington, P.O. Box 600, Wellington 6140, New Zealand. Email: wayne.linklater@vuw.ac.nz. ORCID ID: 0000-0003-2627-693X

[2] Department of Environmental Science, Policy and Management, University of California – Berkeley, U.S.A. Email: waynelinklater@berkeley.edu.

[3] Animal, Rural and Environmental Sciences, Nottingham Trent University, Nottinghamshire, United Kingdom. Email: mark.farnworth@ntu.ac.uk.

[4] Department of Zoology, Otago University, Dunedin, New Zealand. Email: yolanda.vanheezik@otago.ac.nz.

[5] Institute of Veterinarian, Animal & Biomedical Sciences, Massey University, Palmerston North, New Zealand. Email: k.j.stafford@massey.ac.nz.

[6] Biodiversity Unit, Department of Conservation, Wellington, New Zealand. Email: emacdonald@doc.govt.nz.

* Corresponding author.

Running title: Prioritising cat-owner behaviors

Keywords: behaviour prioritisation, cat welfare, conservation behaviour, conservation campaign, domestic cat, *felis catus*, human behaviour change, veterinarian.

Target audience: The article is intended most for practitioners and researchers whose efficacy would benefit from human-behavior prioritisation to identify plausible best-targets for research and stakeholder community engagement.

Word count: 4302 (Abstract: 192). **References count:** 82. **Number of tables:** 2. **Number of figures:** 0.

Abstract

Behavior prioritisation is underutilised but critical to the success of conservation campaigns. It provides an understanding of the target audience's values to transcend conflict and informs the design of achievable and effective advocacy campaigns. Depredation by domestic cats may depress wildlife populations, leading to conflict between cat owners and conservationists. We surveyed veterinarians and cat owners at veterinary clinics to prioritise a list of nine cat-management behaviours. Cat-owner behaviours were ranked by their (i) likelihood of implementation and (ii) current adoption rate by cat owners, (iii) perceived effectiveness at reducing predation on wildlife, and (iv) veterinarians' opinions about their impact on cat welfare. Bringing cats in at night, from before dusk until after dawn, was revealed to be the behaviour most suited to a campaign to reduce cats' hunting. Behaviours ranked as more effective for conservation (e.g., 24-hour cat confinement) were unlikely to be adopted by cat owners or not supported by veterinarians, whose expert and normative support may be critical to a campaign. Although more conservation-effective behaviours received a lower priority, we discuss the repeated use of behaviour prioritisation to achieve incremental reductions in cat depredation by engaging with cat owners.

Introduction

44

The primary causes of environmental and biodiversity decline are anthropogenic: habitat
46 destruction, pollution, over-population, and over-harvesting (Wilson 2003). Addressing the root causes of these problems requires that human behaviours change (Schultz 2011).
48 Changing peoples' behaviour is challenging but the application of social science to conservation problems might mitigate human-caused biodiversity decline (Bennett et al.
50 2017a). Attempts to change behaviour should be guided by theoretical frameworks drawn from social marketing (Weinreich 1999; Kotler et al. 2002; McKenzie-Mohr et al. 2012,
52 Michie et al. 2014), social psychology (Ajzen & Driver, 1992; Fishbein & Cappella 2006), and integrated systems for knowledge management (Allen *et al.* 1998). The body of literature
54 where these concepts and methods have been applied to conservation challenges is growing but still small (Schultz 2014, Bennett et al. 2017b).

56 Fundamental to successful behaviour change is first identifying what behaviours (actions) to advocate to the target audience (e.g., the wider public). To conservationists the
58 mitigation actions required can appear obvious (e.g., buying products sold with less packaging or reducing cats' opportunities to hunt wildlife). However, a trade-off often exists
60 between an action's conservation impact and the likelihood that the target audience will implement the behaviour. Behaviours most likely advocated by conservationists are not
62 necessarily those most likely to be widely adopted. An empirical and evidential strategy called behaviour prioritisation has been developed to resolve this trade-off (Schultz 2011). It
64 should be the first stage of campaigns to change behaviour (McKenzie-Mohr et al. 2012).

Behavioural prioritisation is founded on the principle of engaging with the target
66 audience before, not after, mitigating actions are decided. Early engagement with the target audience helps to define the full spectrum of possible mitigation actions from the myriad

68 possible. It also quantifies which actions the target audience do not currently perform but are, nonetheless, able and most likely to adopt and implement. This information, when combined
70 with information about the behaviours of conservation benefit, contributes to ranking behaviours and deciding which should be advocated (McKenzie-Mohr 2000). Behaviours that
72 have a low likelihood of adoption, even though they may have a high conservation impact, will receive a low ranking. Advocacy campaigns, instead, prioritise behaviours that are likely
74 to have a conservation impact and high likelihood of adoption, although those behaviours are currently uncommon (Hine et al. 2015). Following this process avoids wasting time and
76 resources on behaviours that will not be adopted (Hine et al. 2015).

Domestic cats (*Felis catus*) may pose a significant risk as predators to the
78 conservation of wildlife in many parts of the world, particularly if they stray and re-wild to become feral (Brickner-Braun et al. 2007, Loss et al. 2013; Liberg, 1984; Blancher 2013,
80 Dickman 2014, Loyd et al. 2013). While the hunting by feral cats is known to cause population declines in wildlife, it is not clear that pet cats are also so ubiquitously
82 detrimental. The evidence is mixed (Barratt 1997, Barratt 1998, Sims et al. 2008, van Heezik et al. 2010, Calver et al. 2011, Kikillus et al. 2016). The impact of pet cats might be small or
84 idiosyncratic in space, time and among prey species. Nonetheless, it is certain that they kill wildlife which conflicts with growing efforts to improve the biodiversity value of
86 anthropogenic landscapes (i.e. reconciliation ecology) or ecological restoration projects around and within them (Hanmer 2017). Areas of high ecological value and biodiversity
88 habitat are often, and increasingly, found adjacent or within urban landscapes, especially because they are supported by nature-loving urbanites (Aguilar et al. 2012). Yet, pet
90 ownership, particularly of cats, is on the rise, and especially high in cities (Pet Food Manufacturers Association 2018; American Pet Products Association 2018). There has
92 emerged, therefore, a growing and high-profile conflict between cat ownership and

biodiversity conservation (Loss et al. 2018; Walker et al. 2017). A precautionary approach to managing cat predation may be warranted.

In New Zealand, cats are a particularly serious biodiversity threat because much of its native fauna (i.e., birds and reptiles) evolved without mammalian predators (McCarthy 2005; McLennan et al. 1996; van Heezik et al. 2010). In New Zealand's cities around 35% of households have at least one cat – a rate similar to, or higher than, estimates from other countries (summarised and compared in van Heezik et al. 2010; see also Baldock et al. 2003 for Australia, 25%; Downes et al. 2009 for Ireland, 10.4%; and Murray et al. 2010 for the United Kingdom, 26%). Public opinions where biodiversity conservation and cat ownership and welfare intersect vary dramatically depending on both the beliefs and attitudes of the respondent (Farnworth et al. 2014; Peterson et al. 2012) and the lifestyle of the cat (i.e. companion, stray or feral; Farnworth et al. 2011; Walker et al. 2017). In New Zealand, like in other countries, there is a robust, ongoing and emotional debate about mitigating the biodiversity impact of domestic cats (Morgan Foundation 2013; Walker et al. 2017).

Research on the challenge cats pose to biodiversity conservation has, until now, largely focussed on understanding cat habitat-use and depredation (e.g. in New Zealand: Aguilar et al. 2015; Kikillus et al. 2016; UK: Hanmer et al. 2017; USA: Loyd et al. 2013; Australia: Lilith et al. 2008). Research dedicated to the human dimension of changing cat owner behaviour is comparatively uncommon but important (e.g., Gramza et al. 2016; McDonald et al. in press; McLeod et al. 2015; McLeod et al. 2017a; Peterson et al. 2012; Walker et al. 2017). Proposed solutions have largely focussed on changes to law and governance, gradually imposing greater constraints and obligations on cat ownership (Walker et al. 2017). However, these solutions do not resolve the conflict with cat owners, the risk of widespread non-compliance, and the costs of enforcement. More research to understand how

to engage with cat owners is required to resolve the conflict and mitigate cats' predatory
118 impacts in ways that are motivated by, and motivating to, cat-owners (McLeod et al. 2017a).

The aim of our study was to identify and prioritise cat-owner behaviours for a future
120 advocacy campaign that is effective amongst cat owners. Our objective is to evaluate what cat-owner behaviours are most likely to be adopted as well as reduce domestic cats'
122 depredation of wildlife. Our expectation is that a behaviour's conservation benefit will need to be traded-off against its likelihood of adoption, especially perceptions about its negative
124 consequences for cat welfare.

126

Methods

128

Behaviours and behavioural prioritisation

130 Cat owners could take numerous actions to mitigate the impact of their cat on native wildlife, e.g., keep their cats inside, restrict them to an outdoor enclosure, or make them wear a collar
132 with a bell. We selected nine behaviours that cat owners could implement to mitigate the impact of their domestic cat's predation on native species. The behaviours were selected
134 based on a literature review (Table 1) and on the authors' knowledge of existing and potential behaviours that would limit cat wandering and hunting.

136 We adopted McKenzie-Mohr's (2000) formula for behavioural prioritisation that numerates the conservation gain of the behaviour, the current penetration rate of each
138 behaviour, and the probability of each behaviour being adopted by the target audience (cat owners). Specific to our context and problem, we modified McKenzie-Mohr's (2000)
140 formula by adding a fourth variable: veterinarians' ranking of the impact of the behaviour on cat welfare, because we were interested in delivering our future advocacy campaign from

142 veterinary clinics. Veterinarians have a strong expert and normative influence over cat owners, particularly with respect to animal welfare (MacDonald et al. 2015; Harrod et al.
144 2016). Veterinarians have been successful advocates in previous owner-behaviour change initiatives (e.g., Byers et al. 2014 for improving owner and dog health) and could also be an
146 important influence on cat owners. Thus, we wanted to ensure they would also support the prioritised behaviour. The likely effectiveness of a behaviour was calculated using the
148 augmented prioritisation formula:

150 Effectiveness = Conservation Impact * Likelihood of Adoption * (1-Current Penetration Rate) * Cat Welfare.

152

Conservation Impact is represented by the average score between 1 and 10. Likelihood of
154 Adoption and Cat Welfare (based on veterinarians' opinions about the actions' impact) were an average Likert score (range 1 to 7). Current Penetration Rate was represented as a
156 proportion of survey respondents (ranging from 0 to 1). Behaviours were then ranked based on their Effectiveness with higher scores being judged better subjects for an advocacy
158 campaign.

160 *Study population*

162 We quantified the variables for the behavioural prioritisation formula by surveying cat owners at 10 veterinary clinics and practices in three New Zealand cities: Wellington,
164 Dunedin, and Palmerston North. Wellington is the nation's capital city and its second-largest metropolitan area. Approximately 191,000 residents live within the 290 km^2 city limits and
166 an additional 280,000 residents live in the wider metropolitan area including smaller adjacent

cities. Dunedin has a population of 120,000 and Palmerston North 80,000 residents
168 (Department of Statistics, New Zealand 2016).

A list of all veterinary clinics and practices in the three New Zealand cities was
170 compiled from public listings. Clinics in each city were selected and contacted by telephone, informed of the study and its purpose, and asked if they would participate in the research.
172 Two attempts were made to contact the clinics and obtain participation. Two clinics in Palmerston North, three in Dunedin, and five in Wellington agreed and participated.

174

Surveying

176

During November and December 2014, customers in the 10 veterinary clinics were
178 approached by a research assistant after they had checked into reception and were waiting for their appointment. A script was prepared to ensure consistency in the recruitment process and
180 avoid bias. The research assistant identified themselves as being from the local university and conducting research on cat welfare. The customer was asked to self-complete a survey which
182 took approximately five minutes to complete (Supplementary File 1).

The survey asked respondents to quantify how likely they would engage in the nine
184 behaviours on a Likert scale from 1 to 7 (7 being highly likely). Respondents were also asked which of the nine behaviours they were already performing.

186 To calculate the conservation impact, we used a modified Delphi technique (Murry & Hammons 1995). This technique is used to develop consensus by a panel of experts on a
188 particular topic and is widely used in public health (DeVillers et al. 2005). The authors, all animal and conservation biologists, were asked in an open-ended fashion to provide their
190 input about the direct conservation impact of each owner behaviour based on the literature and their knowledge. A direct impact is one that reduces an individual and owned cat's ability

192 to hunt and kill native wildlife. Once this information was shared and discussed amongst them, all five authors individually ranked each behaviour on a scale of 1 to 10 (10 having the
194 greatest impact). The indirect impacts of an owner's behaviour were not considered (Dickman 2007; Lilith et al. 2006). For example, de-sexing (sterilisation) may reduce the cat
196 population over time to lower cats' hunting at a population level, but its impact is indirect because the de-sexed cat still hunts (Hall et al. 2016b). Furthermore, an owner's behaviour
198 may directly reduce a cat's hunting (the direct impact) but increase hunting by other smaller introduced mammalian predators such as rats (an indirect impact) (as speculated in Wood et
200 al. 2016). To date however, there have been few studies to look at the overall impact (cumulative effect of direct and indirect) of reduced cat predation on native species to inform
202 cat management practices. Hence, we adopted the precautionary approach (Calver et al. 2011; Grayson & Calver 2004; Lilith et al. 2006) by assuming that domestic cats pose a direct risk
204 to native wildlife (e.g., Morgan et al. 2009 found 11% of birds caught by cats were native and 18% of all prey species were skinks). However, it was accepted that the overall extent of the
206 impact is unknown (direct plus indirect). The authors, therefore, were instructed to base their ranking on the direct impact of an individual cat and not the population of cats. The average
208 ranking of each behaviour was shared with the group followed by a discussion until a consensus was reached.

210 The impact of behaviours on cat welfare was determined by surveying veterinarians. A link to an electronic survey was sent out via the New Zealand Veterinarian e-newsletter (25
212 Sept to 26 Oct 2014) with a follow-up reminder email sent ten days before the survey closed. In that survey veterinarians were asked to rate on a scale of 1 to 7 (7 being the greatest
214 positive impact) the impact of the nine behaviours on cat welfare (Supplementary Table 2). We also asked the veterinarians to rank the nine behaviours for their impact on wildlife on a
216 scale of 1 to 7 (7 having the greatest positive impact) so that we could compare with the

animal welfare ranking. Veterinarians were also asked: what their primary interest/practice type was (companion animal, equine, large animal/livestock, or wildlife).

Results

One-hundred and fifty-nine surveys were completed (no missing data) by customers at veterinary clinics and 173 veterinarians completed their survey over a four-week period. Ninety-seven percent of those veterinarians identified as companion, small animal veterinarians.

The authors ranked “cats inside 24 hours” as likely to cause a greater direct reduction in cat depredation than other actions, while cat registration, micro-chipping, de-sexing and limiting the number of cats that could be owned were thought most likely to have a trivial benefit (Table 2). Limiting the roaming of the household cat(s) by containing inside at night, fencing them into the property or an enclosure, were considered to have a moderate to high biodiversity conservation benefit. Collaring cats was thought to have a moderate benefit too. The behaviours most likely to be adopted in descending order were de-sexing cats, limiting the number of cats per household, microchipping cats, and bringing them inside all night (Table 2). Registering cats (as is the practice for dogs in New Zealand), or putting a collar on them, were less likely to be adopted. Containing cats to the property via a fence, keeping cats inside 24 hours a day, and restricting cats to a run, were the actions that cat-owners thought they were least likely to implement.

Ninety-six percent of cat owners currently had less than four cats in their household and 96% of respondents had de-sexed their cat(s). Sixty-four percent of cats were micro-chipped. Twenty-nine percent of respondents locked their cat inside at night every night.

242 Twenty-six percent of cat owners used a cat collar. The other cat-owner behaviours: “Cats in 24 hours a day”, “register cat like a dog”, “contain cat to property via a fence”, and “restrict
244 cats to a run”; had a current penetration rate of 1% or less.

The behaviours ranked by veterinarians with the greatest positive impact on cat
246 welfare was de-sexing, microchipping, limiting the number of cats per household, and cats kept inside at night, all having mean scores greater than five. “Registering a cat like a dog”
248 and “containing cats to property via fence” received intermediate scores. “Cats wearing a collar”, “restricting cats to a run”, and “keeping cats inside 24 hours” received considerably
250 lower scores for their positive impact on cat welfare.

Effectiveness was calculated using the augmented behavioural prioritisation formula.
252 Behaviours were ranked based on their total score, with the greatest score aligning to the behaviour that should be the target of the future advocacy campaign (Table 2). “Keeping cats
254 inside at night, from before dusk until after dawn” had the highest score and thus received a behavioural prioritisation rank of 1. This behaviour also had the highest probability of
256 adoption, a moderate penetration rate, and a perceived robust impact on cat welfare and conservation outcomes (Table 2).

258

260 **Discussion**

262 Behavioural prioritisation techniques have been used much more widely and for substantially longer in fields such as public health (e.g., Booth 1992), but are under-utilised in biological
264 conservation (Schultz 2011). Our work contributes to a small but growing number of examples where behavioural prioritisation has been conducted as a guide to behavioural

change interventions for species management (Please et al. 2017; Skoien et al. 2016, Verbeek et al. 2014), including a recent example with domestic cats (McLeod 2017).

Advocacy campaigns have a history of omitting the behavioural prioritisation stage (Weinreich, 1999), especially in conservation (Johnson et al. 2007; McKenzie-Mohr 2000; Novacek 2008). Instead, conservation experts can be inflexible about the action the target audience should take and believe their opinions superior (expert righteousness). Experts can also assume they know what the target audience thinks about the problem and possible solution, believing that their own knowledge and beliefs are representative of the target population (expert naiveté). As a result, the behaviour that conservationists select and advocate to the public, while having the potential to achieve substantial conservation gains, nonetheless fails because the public do not implement it (McKenzie-Mohr et al. 2012; Eisenhauer & Nicholson 2005; Lorenzoni, Nicholson-Cole, & Whitmarsh 2007). Behavioural prioritisation (Schultz 2011) is a systematic approach to avoid this mistake.

In New Zealand, as has occurred in Australia (e.g. Department of Local Government 1994), the first proposals to reduce cats' hunting of wildlife have been to first regulate cat ownership and legislate for cat confinement. However, reliance on voluntary compliance and problems with enforcement often result in less-than-effective adoption than anticipated by government agencies (McLeod et al. 2015). While some changes can be achieved this way, a significant number of cat owners may not be swayed by new rules and passively, or actively, flout them, allowing their cats to roam. Non-compliance poses uncertainties about the usefulness of policies and risks encouraging opposition. An alternative, or reinforcing, strategy would be to understand cat owners' experience and beliefs about cat husbandry and their implications for animal welfare and biodiversity impacts (McLeod et al. 2017c). Then, those can be used to identify cat-owner behaviours with both benefits for biodiversity and a high likelihood of adoption.

Prioritising behaviours for a campaign

Identifying the values of cat owners and working within their current value system is essential for behaviour change, rather than implementing a top-down approach to change cat owner beliefs and values (Manfredo et al. 2017; McLeod et al. 2017b). By following the behavioural prioritisation process, we identified keeping cats inside at night as a behaviour for a future advocacy campaign. As expected, the prioritised behaviour was not the one with the greatest conservation value (i.e. maximum reduction in cat predation) nor did it have the greatest likelihood of adoption by cat owners. Instead, the behaviour identified optimises the trade-off between likely conservation impact and probability of adoption, with strong support from veterinarians.

Behavioural prioritisation, by integrating several critical considerations and viewpoints, and not exclusively the conservation benefit, also exposed and quantified particular values and beliefs that could significantly impact the success of a campaign. For example, 67% of veterinarians thought that keeping cats inside 24 hours a day would have a significant negative impact on cat welfare (a belief that might not be always true, e.g. Kasbaooui et al. 2016), although it would also reduce cats' hunting to zero. Moreover, 24-hour containment is a behaviour that cat owners identify as unlikely to be achievable. Thus, implementing an advocacy campaign for keeping cats inside 24 hours a day would more likely fail to motivate cat owners and lose the support of veterinarians who are a strong influence on cat owners.

While we have demonstrated the behaviour prioritisation process for the biodiversity conservation goal of reducing domestic cat depredation, it remains for us to demonstrate that the prioritised behaviour can be successfully advocated and adopted by the cat-owning

316 public. To achieve this, we need to understand (1) what values and beliefs drive cat owners when keeping their cat inside at night, (2) how to appeal to these drivers in an advocacy
318 campaign, and then (3) conduct and evaluate an advocacy campaign that is guided by these. For example, cat owners are less likely to believe that cats kill wildlife or they under-estimate
320 its magnitude. Thus, cat owners are less likely to be motivated to act to reduce cat depredation of wildlife (Lilith et al. 2006, MacDonald et al. 2015). Instead, cat owner's
322 willingness to keep cats in at night is better motivated by owners' perceptions that cats are more likely to be injured at night (e.g., cat fighting and traffic). It therefore follows that the
324 best course of action may be to appeal to cat owners to confine cats inside for their welfare (Toukhasti et al 2012). Campaigns around cat safety rather than their impact on wildlife may
326 be more effective (McLeod et al. 2017a). Discovering and applying these understandings should be the subject of future work.

328 Lastly, we confined our study to cat owners visiting veterinary clinics. Those surveyed are likely to be particularly responsible cat owners who are more responsive to
330 others', especially veterinarians', suggestions about how cats are cared for. Other cat owners who are less likely to seek the services, and act on the advice, of a veterinarian may behave
332 differently. Understanding those cat owners would require a different survey method and we would expect the behaviour prioritisation to yield different, perhaps very different, results.
334 Nonetheless, understanding and changing the behaviour of a community begins first with the people and actions that are most tractable and moves incrementally on to those that are more
336 difficult to implement and survey, in order to harness the potential for normative social expectations to generate a behaviour-change cascade.

338

Incremental progress

340

Our research found that 30% of cat owners bring their cat inside at night but less than 1%
342 confined their cat inside or to their property 24 hours a day. This is a similar rate to Australians engaging in the same behaviour more than a decade ago (e.g., 34%, Van de Kuyt
344 2004; 38%, Lilith et al. 2006) at which time there was also very low support amongst Australian cat-owners for 24-hour confinement. In Australia, 24-hour cat confinement was
346 also not considered an essential component of responsible pet ownership with some viewing all-day confinement as cruel and 'unnatural' (McCarthy 2005; Rochlitz 2005, McLeod et al.
348 2015). Lilith et al. (2006) also found only 6% of cat owners confined their cats to their property via an enclosure, but there was greater acceptance and implementation of bringing
350 cats inside at night (Grayson & Calver 2004). However, starting in the late 1990s advocacy campaigns about cat owner behaviour began (McLeod et al 2015; Hall et al. 2016a) and many
352 Australian towns and states (e.g., Western Australia: Cat Act 2011) adopted cat-confinement legislation at small scales, but avoided all-day confinement due to the public backlash
354 (McCarthy 2005). As a result, cat owner behaviour changed over time. For example, more recently Toukhsati et al. (2012) found in the state of Victoria, Australia, 80% of cat owners
356 contained their cat to their property during the night and 41% during the day too (i.e., 24-hour confinement), with 26% of owners having an enclosed yard or run. And, in Tasmania, those
358 owners who were motivated to practice a nightly curfew became significantly more likely to state an intention to fully contain their cat(s) indoors (McLeod 2018).

360 The incremental changes in cat-owner behaviour that have occurred in Australia were preceded by a large amount of research to understand cat owners' propensity to adopt new
362 actions (Grayson & Calver 2004) that has led to successful government regulation of cats (Denny & Dickman 2010). Cat owner adoption of targeted behaviours (i.e., night time
364 confinement) led to greater support for other, originally more challenging, management behaviours (e.g., cats inside 24-hours a day or confined to property). Once the first prioritised

366 behaviour has been embedded in the target audience, i.e., the penetration has greatly increased, another behaviour that has greater conservation gains but requires greater cat-
368 owner commitment can be advocated (in our study this could be cats inside 24 hrs or confining cats to owners' property via fencing). Thus, asking people to keep cats inside at
370 night may prime cat owners to adopt a future behaviour that is a larger commitment, i.e., a foot-in-door technique. This step-wise approach over time appears to have been successful
372 because attitudes and beliefs among cat owners have shifted in Australia over the last decade (Toukhsati et al. 2012, Hall et al. 2016a).

374

Conclusions and recommendations

376

Aspiring immediately to behaviour-change goals with greatest conservation benefit, but with
378 little hope the targeted audience will adopt or engage in the behaviour, raises the risk of disengagement by cat owners. It may also polarise the debate, and even result in a reversal of
380 progress. Focussing, instead, on achievable, smaller behaviour changes in the short term raises the possibility of on-going incremental change. Over longer periods of time it is
382 possible to move towards other related behaviours and more aspirational goals, via the spill-over effect (Thøgersen & Crompton 2009) or foot-in-door technique (Burger 1999, Truelove
384 et al. 2014). By designing and implementing an advocacy campaign that focuses, first, on a behaviour acceptable to cat owners (i.e., bringing cats inside at night in New Zealand) over
386 time, there could be a more substantial shift in behaviour with greater conservation benefit. Although globally objectives may differ, we strongly suggest that engaging with cat-owners
388 in this way may enable substantial change. Incremental changes through behaviour prioritisation may deliver longer-term and sustained reductions in the impact of domestic cats
390 on native wildlife whilst not exacerbating conflicts and risks of non-compliance.

Acknowledgements and data

The New Zealand Companion Animals Trust funded this research. Thanks also to the New Zealand Veterinary Association and many staff at veterinary clinics for their assistance and participation in the study. Erin Willson, Julie Whitburn, Kate Irving, Kayla Griffin, Laura Harvey, Rosi Merz, Sarah Hight, Sarah Irvine, and Skyler Suhrer are thanked for their assistance surveying. The study was approved by the Victoria University of Wellington's Human Ethics Committee (#23123). The data are available via the following link to the data repository: www._____.

References

Aguilar, G. D., Farnworth, M. J., & Winder, L. (2015). Mapping the stray domestic cat (*Felis catus*) population in New Zealand: Species distribution modelling with a climate change scenario and implications for protected areas. *Applied Geography*, 63, 146-154.

Ajzen, I., & Driver, B. L. (1992). Application of the theory of planned behavior to leisure choice. *Journal of Leisure Research*, 24(3) 207-224.

Allen, W., Brown, K., Gloag, T., Morris, J., Simpson, K., Thomas, J., & Young, R. (1998). Building partnerships for conservation in the Waitaki/Mackenzie basins *Landcare research contract report* (pp. 1-14). Lincoln, New Zealand.

American Pet Products Association. (2018). National pet owners survey. Stamford, Connecticut, American Pet Products Association Inc.**:** 614.

Baldock, F. C., Alexander, L., & More, S.J. (2003). Estimated and predicted changes in the cat population of Australian households from 1979 to 2005. *Australian Veterinary Journal*, 81, 289-292.

Bennett, N. J., Roth, R., Klain, S. C., Chan, K. M. A., Christie, P., Clark, D. A., Cullman, G., Curran, D., Durbin, T. J., Epstein, G., Greenberg, A., Nelson, M. P., Sandlos, J., Stedman, R., Teel, T. L., Thomas, R. E., Verissimo, V., & Wyborn, C. (2017a). Conservation social science: Understanding and integrating human dimensions to improve conservation. *Biological Conservation* 205, 93-108.

Barratt, D.G. (1997). Predation by house cats *Felis catus* (L) in Canberra, Australia. I. Prey composition and preference. *Wildlife Research*, 24, 263-277.

Barratt, D.G. (1998). Predation by house cats *Felis catus* (L) in Canberra, Australia. II. Factors affecting the amount of prey caught and estimates of the impact on wildlife. *Wildlife Research*, 25, 475-487.

Bennett, N. J., Roth, R., Klain, S. C., Chan, K. M. A., Clark, D. A., Cullman, G., Epstein, G.
426 Nelson, M. P., Stedman, R., Teel, T. L., Thomas, R. E., Wyborn, C., Curran, D.,
Greenberg, A., Sandlos, J., & Verissimo, V. (2017b). Mainstreaming the social
428 sciences in conservation. *Conservation Biology*, 31(1), 56-66.

Blancher, P. (2013). Estimated number of birds killed by house cats (*Felis catus*) in Canada.
430 *Avian Conservation and Ecology, 8(2).* DOI: 10.5751/ACE-00557-080203.

Brickner-Braun, L., Geffen, E.L.I., Yom-Tov, Y. 2007. The domestic cat as a predator of
432 Isreali wildlife. *Isreali Journal of Evolutionary Ecology* 53, 129-142.

Burger, J. M. (1999). The foot-in-the-door compliance procedure: A multiple-process
434 analysis and review. *Personality and Social Psychology Review*, 3(4), 303-325.

Byers, C.G., Wilson, C.C., Stephens, M.B., Goodie, J.L., Netting, F.E., Olsen, C.H. 2014.
436 Owners and pets exercising together: Canine response to veterinarian-prescribed
physical activity. *Anthrozoos*, 27, 325-333.

438 Calver, M. C., Grayson, J., Lilith, M., & Dickman, C. R. (2011). Applying the precautionary
principle to the issue of impacts by pet cats on urban wildlife. *Biological*
440 *Conservation*, 144(6), 1895-1901.

Denny, E. A., & Dickman, C. R. (2010). Review of cat ecology and management strategies in
442 Australia. *Invasive Animals Cooperative Research Centre, Canberra*.

Department of Local Government, (1994). Proposals for the development of cat control
444 legislation in Western Australia. Department of Local Government, Perth.

Department of Statistics, New Zealand (2016). http://www.stats.govt.nz/Census/2013-
446 census/profile-and-summary-reports.aspx Retrieved 20 march 2017.

DeVillers, M., DeVillers, P., & Kent, A. (2005). The Delphi technique in health science
448 education research. *Medical Teacher, 27*(7), 639-643.

Dickman, C. R. (2007). The complex pest: interaction webs between pests and native species. *Pest or Guest: the zoology of overabundance* 208-215.

Dickman, C. R. (2014). Measuring and managing the impacts of cats. In A. S. Glen & C. R. Dickman (Eds.), *Carnivores of Australia: Past, present and future* (pp. 173–196). Melbourne: CSIRO Publishing.

Downes, M., Canty, M. J., & More, S. J. (2009). Estimated and predicted changes in the cat population of Australian households from 1979 to 2005. *Preventive Veterinary Medicine*, 92, 140-149.

Farnworth, M. J., Campbell, J., & Adams, N. J. (2011). What's in a name? Perceptions of stray and feral cat welfare and control in Aotearoa New Zealand. *Journal of Applied Animal Welfare Science*, 14, 59-74.

Farnworth, M. J., Watson, H., & Adams, N. J. (2014). Understanding control of non-native wild and feral mammals: Similarities and differences in the opinions of the general public, animal protectionists and conservationists in New Zealand (Aotearoa). *Journal of Applied Animal Welfare Science*, 17, 1-17.

Fishbein, M., & Cappella, J. N. (2006). The role of theory in developing effective health communication. *Journal of Communication*, 56(s1), s1-s17.

Gordon, J. K., Matthaei, C., & van Heezik, Y. (2010). Belled collars reduce catch of domestic cats in New Zealand by half. *Wildlife Research*, 37(5), 372-378.

Gramza, A., Teel, T., VandeWoude, S., & Crooks, K. (2016). Understanding public perceptions of risk regarding outdoor pet cats to inform conservation action. *Conservation Biology*, 30(2), 276-286.

Grayson, J., & Calver, M. C. (2004). Regulation of domestic cat ownership to protect urban wildlife: a justification based on the precautionary principle. In: Lunney,

D. and Burgin, S., (eds.) *Urban wildlife: more than meets the eye*. Royal Zoological Society of New South Wales, Mosman, pp. 169-178.

Hall, C. (2016). *Mitigating the impacts of pet cats (*Felis catus*) on urban wildlife* (Doctoral dissertation, Murdoch University).

Hall, C. M., Adams, N. A., Bradley, J. S., Bryant, K. A., Davis, A. A., Dickman, C. R., Tsumugi, F., Kobayashi, S., Lepczyk, C.A., McBride, E. A., Pollock, K. H., Styles, I. M., van Heezik, Y., Wang, F., & Calver, M. C. (2016a). Community attitudes and practices of urban residents regarding predation by pet cats on wildlife: An international comparison. *Public Library of Science (PLoS)- One*, 11(4), e0151962.

Hall, C. M., Bryant, K. A., Haskard, K., Major, T., Bruce, S., & Calver, M. C. (2016b). Factors determining the home ranges of pet cats: A meta-analysis. *Biological Conservation* 203, 313-320.

Hanmer, H. J. (2017). *Unintended consequences: how human intervention affects the ecology of urban birds* (Doctoral dissertation, University of Reading).

Hanmer, H. J., Thomas, R. L., & Fellowes, M. D. (2017). Urbanisation influences range size of the domestic cat (*Felis catus*): consequences for conservation. *Journal of Urban Ecology*, 3(1), jux014.

Harrod, M., Keown, A. J., & Farnworth, M. J. (2016). Use and perception of collars for companion cats in New Zealand. *New Zealand Veterinary Journal*, 64(2), 121-124.

Hine, D. W., Please, P. M., McLeod, L., & Driver, A. B. (2015). *Behaviourally effective communications for invasive animal management: a practical guide*. Armidale: Invasive Animals Cooperative Research Centre.

Kasbaoui, N., Cooper, J., Mills, D. S., & Burman, O. (2016). Effects of long-term exposure to an electronic containment system on the behaviour and welfare of domestic cats. *Public Library of Science (PLoS)- One*, 11(9), e0162073.

498 Kays, R. W., & DeWan, A. A. (2004). Ecological impact of inside/outside house cats around a suburban nature preserve. *Animal Conservation*, 7(3), 273-283.

500 Kikillus, K. H., Chambers, G. K., Farnworth, M. J., & Hare, K. M. (2016). Research challenges and conservation implications for urban cat management in New Zealand. 502 *Pacific Conservation Biology*, 23(1) 15-24.

Kotler, P., Roberto, N., & Lee, N. (2002). *Social Marketing Improving the Quality of Life* 504 (2nd ed.). Thousand Oaks: SAGE Publications.

Johnson, M., Kazakov, D., & Lynch, C. (2007). *Public and staff conservation values* 506 Department of Conservation, Wellington, New Zealand: Research New Zealand.

Liberg, O. (1984). Food habits and prey impact by feral and house-based domestic cats in a 508 rural area in southern Sweden. *Journal of Mammalogy*, 65(3), 424-432.

Lilith, M., Calver, M., Styles, I., & Garkaklis, M. (2006). Protecting wildlife from predation 510 by owned domestic cats: application of a precautionary approach to the acceptability of proposed cat regulations. *Austral Ecology*, 31(2), 176-189.

512 Lilith, M., Calver, M., & Garkaklis, M. (2008). Roaming habits of pet cats on the suburban fringe in Perth, Western Australia: what size buffer zone is needed to protect wildlife 514 in reserves? in *Too close for comfort: contentious issues in human-wildlife encounters*. Eds, Lunney, D., Munn, A., & Meikle, W. Royal Zoological Society of 516 New South Wales, Mosman, NSW, Australia. Pp 65-72.

Loss, S. R., Will, T., Longcore, T., & Marra, P.P. (2018). Responding to misinformation and 518 criticisms regarding United States cat predation estimates. *Biological Invasions*, doi: 10.1007/s10530-018-1796-y

520 Loss, S. R., Will, T., & Marra, P. P. (2013). The impact of free-ranging domestic cats on wildlife of the United States. *Nature Communications*, 4, 1396.

522 Loyd K.-A.T., Hernandez, S.M., Carroll, J.P., Abernathy, K.J., Marshall, G.J., (2013). Quantifying free-roaming domestic cat predation using animal-borne video cameras. 524 *Biological Conservation*, 160, 183-189.

MacDonald, E., Milfont, T., & Gavin, M. (2015). What drives cat-owner behaviour? First 526 steps towards limiting domestic-cat impacts on native wildlife. *Wildlife Research*, 42(3), 257-265.

528 McDonald, J.L., Farnworth, M.J., & Clements, J. (2018). Integrating trap-neuter-return campaigns into a social framework: Developing long-term positive behaviour change 530 towards unowned cats in urban areas. *Frontiers in Veterinary Science* in press, doi: 10.3389/fvets.2018.00258.

532 Manfredo, M. J., Bruskotter, J. T., Teel, T. L., Fulton, D., Schwartz, S. H., Arlinghaus, R., Oishi, S., Uskul, A. K., Redford, K., Kitayama, S., & Sullivan, L. (2017). Why social 534 values cannot be changed for the sake of conservation. *Conservation Biology*, 31 (4), 772–780.

536 McCarthy, S. (2005). Managing impacts of domestic cats in peri-urban reserves. In *Urban Animal Management Conference Proceedings* (pp. 103-109).

538 McDonald, J. L., MacLean, M., Evans, M. R., & Hodgson, D. J. (2015). Reconciling actual and perceived rates of predation by domestic cats. *Ecology and Evolution*, 15 (14), 540 2745-2753.

McKenzie-Mohr, D. (2000). Fostering sustainable behavior through community-based social 542 marketing. *American Psychologist*, 55(5), 531-537.

McKenzie-Mohr, D., Lee, N. R., Schultz, P. W., & Kotler, P. (2012). Social marketing to 544 protect the environment: What works. Thousand Oaks, California: SAGE Publications, Inc.

546 McLennan, J. A., Potter, M. A., Robertson, H. A., Wake, G. C., Colbourne, R., Dew, L., Joyce, L., McCann, A. J., Miles, J., Miller, P. J., & Reid, J. (1996). Role of predation 548 in the decline of kiwi, *Apteryx* spp., in New Zealand. *New Zealand Journal of Ecology*, 27-35.

550 McLeod LJ (2017, September) Using behavioural science to improve the management of invasive animals: A domestic cat case study. Doctoral Thesis, University of New 552 England, Armidale, NSW, Australia.

McLeod, L (2018). Designing effective behaviour change interventions for cat management; 554 a practical guide' presented at the NZ Companion Animal Conference (Human Behaviour Change for Animals); Auckland, New Zealand.

556 McLeod, L. J., Driver, A. B., Bengsen, A. J., & Hine, D. W. (2017b). Refining online communication strategies for domestic cat management. *Anthrozoös*, 30(4), 635-649.

558 McLeod, L. J., Hine, D. W., & Bengsen, A. J. (2015). Born to roam? Surveying cat owners in Tasmania, Australia, to identify the drivers and barriers to cat containment. *Preventive* 560 *Veterinary Medicine*, 122(3), 339-344.

McLeod, L. J., Hine, D. W., Bengsen, A. J., & Driver, A. B. (2017a). Assessing the impact of 562 different persuasive messages on the intentions and behaviour of cat owners: A randomised control trial. *Preventive Veterinary Medicine*, 146, 136-142.

564 Michie, S., Atkins, L., & West, R. (2014). *The behaviour change wheel. A guide to designing interventions.* Sutton: Silverback Publishing.

566 Morgan Foundation. (2013). Cat management: A new dawn? Retrieved from http://morganfoundation.org.nz/cats/

568 Morgan, S. A., Hansen, C. M., Ross, J. G., Hickling, G. J., Ogilvie, S. C., & Paterson, A. M. (2009). Urban cat (*Felis catus*) movement and predation activity associated with a 570 wetland reserve in New Zealand. *Wildlife Research*, 36(7), 574-580.

Murry, J. W., & Hammons, J. O. (1995). Delphi: A versatile methodology for conducting
572 qualitative research. *The Review of Higher Education*, 18(4), 423.

Murray, J. K., Browne, W. J., Roberts, M. A., Whitmarsh, A., & Gruffydd-Jones, T. J.
574 (2010). Number and ownership profiles of cats and dogs in the UK. *Veterinary Record*, 166, 163-168.

576 Novacek, M., J. (2008). Engaging the public in biodiversity issues. *Proceedings of the National Academy of Sciences, USA*, 105(1), 11571-11578.

578 Pet food Manufacturers Association (2018). Pet Data Annual Report. 6th Floor, 10 Bloomsbury Way, London, WC1A 2SL, Pet food Manufacturers Association**:** 17.

580 Peterson, M. N. et al.(2012). Opinions from the front lines of cat colony management conflict. *Plos One*, 7(9). 10.1371/journal.pone.0044616

582 Please, P. M., Hine, D. W., Skoien, P., Phillips, K. L., & Jamieson, I. (2017). Prioritizing community behaviors to improve wild dog management in peri-urban areas. *Human*
584 *Dimensions of Wildlife*, 23 (1), 39-53.

Robertson, I. D. (1998). Survey of predation by domestic cats. *Australian Veterinary Journal*,
586 76(8), 551-554.

Rochlitz, I. (2005). A review of the housing requirements of domestic cats (Felis silvestris
588 catus) kept in the home. *Applied Animal Behaviour Science*, 93(1), 97-109.

Sims, V., Evans, K.L., Newson, S.E., Tratalos, J.A., Gaston, K.J. (2008). Avian assemblage
590 structure and domestic cat densities in urban environments. *Diversity and Distributions*, 14, 387-399.

592 Skoien, P., Please, P. M., & Hine, D. W. (2016, November 7-10). Behavioural science and rural wild dog management. 5th Queensland Pest Animal Symposium, pp. 63–64.
594 Townsville, Australia.

Schultz, P. W. (2011). Conservation means behavior. *Conservation Biology*, 25(6), 1080-1083.

Schultz, P. W. (2014). Strategies for promoting proenvironmental behavior. *European Psychologist*, 19(2), 107–117.

Thøgersen, J., & Crompton, T. (2009). Simple and painless? The limitations of spillover in environmental campaigning. *Journal of Consumer Policy*, 32, 141–163.

Toukhsati, S. R., Young, E., Bennett, P. C., & Coleman, G. J. (2012). Wandering cats: attitudes and behaviors towards cat containment in Australia. *Anthrozoös*, 25(1), 61-74.

Truelove, H. B., Carrico, A. R., Weber, E. U., Raimi, K. T., & Vandenbergh, M. P. (2014). Positive and negative spillover of pro-environmental behavior: An integrative review and theoretical framework. *Global Environmental Change, 29*, 127-138.

Van de Kuyt, N. (2004, August). Turning research into reality: How councils can use findings from a survey to help manage pets in the community. In *Proceedings of the National Urban Animal Management Conference, Adelaide, Australia* (pp. 18-20).

van Heezik, Y., Smyth, A., Adams, A., & Gordon, J. (2010). Do domestic cats impose an unsustainable harvest on urban bird populations? *Biological Conservation*, 143(1), 121-130.

Verbeek, B., Van Oosterhout, E., & Grantley, J. (2014, September 1-4). Social science methods to improve community participation in weed management programs in New South Wales. Proceedings of the 19th Australasian Weeds Conference, (pp. 342–346). Hobart, Tasmania, Australia: Tasmanian Weed Society, Inc. Retrieved from http://www.caws.org.au/awc/2014/awc201413421.pdf

618 Walker JK, Bruce SJ, Dale AR. 2017. A survey of public opinion on cat (*Felis catus*) predation and the future direction of cat management in New Zealand. *Animals*, **7** 620 doi:10.3390/ani7070049.

Weinreich, N. K. (1999). *Hands-on social marketing a step-by-step guide*. Thousand Oaks, 622 Sage Publications, Inc.

Wilson, E. O. (2003). *The Future of Life*. Vintage Books. 229 pp.

624 Wood, V. et al.(2016). "Movement and diet of domestic cats on Stewart Island/Rakiura, New Zealand." *New Zealand Journal of Ecology*, 40(1), 186-190.