

1 **Running Title: Attitudes towards the control of non-native mammals in New**
2 **Zealand**

3

4 **Understanding attitudes towards the control of non-native wild and feral**
5 **mammals: Similarities and differences in the opinions of the general public,**
6 **animal protectionists and conservationists in New Zealand (Aotearoa).**

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13

14 **Abstract**

15 Lethal control is used extensively in New Zealand to control non-native non-human
16 mammals. Respondents were surveyed about eight mammal groups considered to be
17 pests and their attitudes towards their control and pest status. They also identified
18 their most appropriate method of control for the eight different mammals. Information
19 was gathered from three groups of respondents: animal protectionists, conservationists
20 and the general public. Conservationists routinely rated all animal groups as more
21 severe pests than the general public or animal protectionists, who provided the lowest
22 scores. Rats, stoats, brushtail possums and rabbits were identified as the four most
23 serious pests by all three groups. Conservationists were 5.7 and 2.6 times more likely

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24 to prefer a lethal method of control than protectionists and the general public
25 respectively. For all three groups an increase in pest score for a given animal saw a
26 decline in importance placed upon its welfare. This relationship was strong for the
27 general public but weak for conservationists and animal protectionists. Understanding
28 aspects of potentially opposing viewpoints may be invaluable in supporting the
29 development of new welfare-focused control methods.

30

31 **Key words** *Animal welfare, conservation, feral, introduced mammal, lethal control,*
32 *non-lethal control, pest*

33

34 **Introduction**

35 The distinctive elements of New Zealand ecosystems evolved in the absence of
36 mammalian predators (Holdaway, 1989; White & King, 2006). The introduction of
37 various non-human non-native mammals by Māori and non-Māori settlers had
38 significant impacts on components of these ecosystems (Clout & Saunders, 1995;
39 Craig & et al. 2000). In addition, some of these mammals act as vectors for disease
40 (e.g. Ryan & et al. 2006) with potential for substantial economic costs to New
41 Zealand's primary agricultural industries (Clout & Veitch, 2002; Warburton &
42 Norton, 2009). Consequently both governmental and non-governmental organizations
43 are engaged in major pest control programs to reduce or mitigate these impacts.

44 The control of non-native mammals in New Zealand predominantly involves
45 lethal methods (Warburton & Norton, 2009) and includes trapping, poisoning,
46 shooting, and the introduction of disease (Clout & Veitch, 2002). Non-lethal control
47 methods include the use of cage trapping and release, repellents and predator
48 exclusion fences. (Scofield, Cullen & Wang, 2011). Reproductive control is currently

49 under investigation (Holland, Cowan, Gleeson & Chamley, 2008). Different methods
50 of control have the potential to inflict varying degrees of pain, distress and suffering
51 dependent upon the duration of effect and mode of action (Littin, 2010).

52 Public awareness of animal welfare is increasing (Eggleston, Rixecker &
53 Hickling, 2003; Jordan, 2005; Meerburg, Brom & Kijlstra, 2008). The acceptability of
54 the impacts of a range of control methods on the welfare of the target species may
55 vary dependent upon the perceived damage caused by (and economic value of) the
56 species concerned (Littin & Mellor, 2005). The need to assess the acceptability of
57 control programs on wild animals among the general public and special interest
58 groups has been noted (Bremner & Park, 2007, Decker, Brown & Siemer, 2001).
59 However, studies have largely focused on those groups that manage wildlife (e.g.
60 Miller & Jones 2005, 2006). There is a relative paucity of information on those who
61 may traditionally oppose lethal animal control measures.

62 Both ecological and economic objectives inform decisions around the most
63 appropriate means of pest control (Littin, Mellor, Warburton & Eason, 2004; Sharp &
64 Saunders, 2008). Increasingly, the impacts of particular pest management protocols on
65 animal welfare are also becoming an integral component of the decision making
66 process. The relative importance of welfare impacts (encompassing mental and
67 physical wellbeing) of control measures on both pest and non-target animals (Duncan,
68 1996) will be affected by local social and cultural values (Sharp & Saunders, 2008).

69

70 The extent to which a range of introduced animals are considered pests by the general
71 public in New Zealand has been addressed (e.g. Fraser, 2001). The current study
72 extends this work to consider the extent to which welfare concerns associated with
73 possible control options, for both target and non-target animals, may vary among

74 different interest groups. It also considers how these differ among a range on non-
75 native mammal groups. We hypothesized that the degree to which welfare concern, in
76 respect of both target and non-target animals, dictates the choice of control will be
77 influenced by the extent to which the target animal group is consider a pest. Littin &
78 Mellor (2005) have suggested that the acceptability of control methods, related to the
79 possible impact on the welfare of a target pest species, may be dictated in part by
80 perceived damage caused by the species concerned.

81

82 **Materials and Methods**

83

84 Attitudes towards the control of non-native feral or wild animal groups were
85 investigated by means of a survey. Responses were gathered on eight different non-
86 native animal groups present within New Zealand namely brushtail possums
87 (*Trichosurus vulpecular*), cats (*Felis catus*), rabbits (*Oryctolagus cuniculus*), deer
88 (*Cervus spp.*), horses (*Equus caballus*), rats (*Rattus spp.*), stoats (*Mustela erminea*)
89 and dogs (*Canis familiaris*). The group ‘deer’ represents seven species and the group
90 ‘rats’ three species. This approach was taken as it simplified the questionnaire and
91 there may be little awareness of the species differences amongst the general public
92 (see Fraser 2001) particularly as it relates to control and pest status. It was assumed
93 that respondents with an interest in conservation are likely to appreciate the ecological
94 and behavioral differences between deer and rat species. For example, the Polynesian
95 rat or kiore (*Rattus exulans*) has cultural significance for Māori and is potentially less
96 damaging to some but not all native fauna than the two other species of rats (Hoosen
97 & Jamieson, 2003, Towns, Dougherty & Cree, 2001). The potential ambiguity that
98 this may cause in categorizing the pest status of these multispecies groups may be

99 partially offset by the common use of rodenticides and kill traps for all species of rats
100 (Gillies 2002) and shooting for all species of deer (Husheer, Coomes, & Robertson
101 2003).

102 With the exception of dogs, all animal groups are officially listed as ‘pests’
103 within New Zealand (Littin & et al. 2004). Some are common pest species within
104 New Zealand and are frequently reported as such within the media and popular
105 literature (e.g. brushtail possums: Potts, 2009). Others represent companion animals
106 that may be strongly associated with human habitation in New Zealand (Aguilar &
107 Farnworth 2012; Aguilar & Farnworth 2013) but may also be socially problematic
108 (e.g. domestic cats: Farnworth, Dye & Keown, 2010) with a potential to impact upon
109 native fauna if not controlled. Finally some have the potential to be perceived as
110 commercial and recreational hunting resources (e.g. deer: Fraser, 2001) as well as
111 pests.

112

113 *Sampling*

114 Three different respondent groups were selected on the basis they were likely to have
115 different views towards management of vertebrate pests (Littin, 2010). The groups
116 were: general public (group 1), protectionist (group 2) and conservationist (group 3).
117 Protectionists were identified as those individuals that belonged to, were employed by
118 or volunteered for an animal protection or animal welfare charity or were currently
119 studying a curriculum at a tertiary institution which contained courses with titles that
120 included the term ‘animal welfare’. Conservationists were defined on the basis of
121 similar associations to conservation organizations or tertiary-based study of the
122 discipline. Individuals were canvassed at tertiary institutes, an annual national
123 conference for animal welfare charities and their volunteers, meetings of conservation

124 charities and their members and agencies concerned with the enforcement or
125 dissemination of welfare and/or conservation based information. The survey and its
126 method of dissemination were approved by the Unitec Research Ethics Committee. It
127 was assumed that responses reflected the opinions of the individuals that completed
128 them and we did not differentiate among the particular organizations with which they
129 were associated.

130 A total of 150 surveys were distributed to each of the three target groups between
131 April 2009 and June 2010. A total of 263 were returned. For both the protectionist
132 (n=91) and conservation groups (n=81), surveys were handed out with a freepost
133 return address in places (universities, tertiary education providers and professional or
134 charitable organizations) or during events (conferences, volunteer days or society
135 meetings) appropriate to the particular group. Responses from the general public
136 (n=91) were gathered within Auckland. Greater Auckland is New Zealand's largest
137 urban center containing a third of the national population (Statistics New Zealand,
138 2011). Every third individual in the central business district or transport hubs passing
139 the researcher was invited to complete the survey and return it directly. If a given
140 individual declined then the next available individual was approached until an answer
141 was obtained. Members of this group were not vetted as to their interest in
142 conservation or animal welfare issues. An information sheet provided definitions of
143 the terms 'welfare': "encompassing mental and physical wellbeing" (Duncan, 1996)
144 of both pest and non-target animals, 'pest': "an animal that poses a threat towards
145 humans, other species of animals or causes detrimental impacts on the environment"
146 (Littin & Mellor, 2005); 'wild': "those in their original natural state, not
147 domesticated" (Department of Conservation, 2006) and 'feral': "those that live as

148 self-sustaining populations following a history of domestication” (International Union
149 for the Conservation of Nature, 1989).

150 The only demographic detail requested of respondents was gender. The survey
151 consisted of a series of questions concerning the eight mammal groups. The questions
152 were identical for all animals. An example for brushtail possums is provided in
153 Appendix 1. For most questions the response was scored by use of a single mark
154 through a linear rating scale which ranged from ‘not a pest’ (0 mm) to ‘extreme pest’
155 (100 mm). This methodology was adapted from Wemelsfelder, Hunter, Mendl &
156 Lawrence (2001) where it was used to rate perceptions of an animal’s behavior.

157 The second question asked respondents to circle which method of control they
158 deemed most appropriate for the animal in question. There was no option for
159 respondents to select that the animal should not be subjected to control. In the final
160 section respondents were required to identify the important criteria for determining
161 the method of control.

162

163 *Statistical Analysis*

164 Data on the pest status score of eight animal groups were highly skewed.
165 Consequently differences among the three respondent groups were tested using non-
166 parametric protocols. Tests were restricted to pest scores combined for all animal
167 groups or all respondent groups, as appropriate. This avoided the problem of inflated
168 Type I error rates that would have resulted if multiple tests had been completed by
169 analyzing each possible combination of animal and respondent groups separately.

170 Whether the frequencies at which lethal or non-lethal methods of control were
171 selected were independent of respondent group and animal group were tested using

172 three-way log linear modeling. This procedure was followed with separate chi-
173 squared tests to examine two-way interactions as appropriate.

174 The importance of welfare (target and non-target organisms) and conservation
175 considerations (for non-target organisms) in influencing the choice of the preferred
176 control methods for each animal and respondent group were explored using mixed
177 factorial ANOVA after reducing the number of potentially interrelated dependent
178 variables using a Principal Component Analysis (PCA). Survey participants were
179 required to score the importance of seven different criteria or variables (see above) in
180 determining the method of pest control for each animal group. The PCA were used
181 with a varimax rotation to reduce these potentially interrelated variables to a smaller
182 set of factors. Sampling adequacy was assessed using the Kaiser-Meyer-Olkin
183 measure. Whether correlations between items were sufficiently large for PCA were
184 tested using Barlett's test of sphericity.

185 Subject to the PCA protocol being deemed appropriate (see above), factor scores
186 based on components obtained from the PCA were then used in a two way mixed
187 factorial ANOVA to examine the effect of respondent group and animal group on
188 each of the retained components. It is recognized that this may increase the type 1
189 error rate however the use of PCA restricted the number of variables on which our
190 ANOVA protocols were run to acceptable limits. This also clarified interpretation of
191 the results.

192 The hypothesis that there may be a relationship between pest score and
193 importance of animal welfare when selecting a control method was tested for each
194 respondent group using simple correlation analyses. Each data point was generated by
195 randomly selecting, without replacement, a subsample of the total number of
196 respondents. Consequently each data point (see Figure 1) represented the mean

197 median pest score and welfare score of 10 to 11 individual respondents. This approach
198 avoided the potential problem of the lack of independence that would result from the
199 repeated use of the same individuals within a respondent group across all data points.

200

201 **Results**

202

203 *Gender distribution*

204 There were significant differences in the frequency of female and male respondents
205 amongst the three respondent groups (Percentage females: General public 53%,
206 Protectionist 85 %, Conservationist 62%, $\chi^2= 21.972$; $df=2$; $p<0.0001$).

207

208 *Pest Status*

209 The differences in median pest score among respondent groups and between animal
210 groups are described in terms of frequency, median and inter-quartile ranges as
211 appropriate (Table 1). Animal groups with higher pest scores (rats, stoats, possums)
212 tended to show right-handed skew whereas animals groups with lower pest scores
213 tended to show left-handed skew and hence these data are not amenable to
214 transformation.

215 Without exception, the conservationists rated all eight animal groups with a
216 higher median pest score than the general public who in turn rated all animal groups
217 with a higher median pest than the protectionists (Table 1). These differences were
218 significant (Kruskal Wallis test $\chi^2=201.46$; $df=2$; $p < 0.001$).

219 There was a large degree of agreement in the order in which the three respondent
220 groups ranked the extent to which a particular animal group was considered a pest.

221 Rats were ranked first by all three respondent groups and brushtail possums, stoats

222 and rabbits were all in the top four pests across all groups. Horses and dogs were the
223 lowest ranked (Table 1). The pest score for rats, brushtail possums and rabbits
224 provided by the general public was more closely aligned with that of the
225 conservationists whereas, for dogs, horses and cats it was closer to the score provided
226 by the welfarist group. The differences in pest scores among the eight animal groups
227 were significantly different (Friedman's test, $\chi^2=1035.29$; $df=7$; $p<0.001$).

228 _____

229 Table 1 here

230 _____

231

232 *Methods of control*

233 The dominant method of control selected by conservationists for all eight animal
234 groups was always a lethal one (poisoning, lethal-trapping, shooting, introduction of
235 disease) as opposed to the non-lethal options (TNR, contraception). Protectionists
236 selected lethal methods of control as the preferred method only for deer, rats and
237 stoats and had the lowest percentage selection for lethal control methods overall. The
238 general public only selected non-lethal control methods for cats and dogs (Table 2).

239 _____

240 Table 2 here

241 _____

242 We tested for statistical dependence of respondent group and animal on choice of
243 lethal or non-lethal control techniques using log linear analysis. The three-way log
244 linear analysis produced a final model that retained all two-way interactions i.e.
245 respondent group x animal group, respondent group x preferred control method and
246 animal group x preferred control method. Expected frequencies generated by the

247 model are not significantly different from the observed data and hence the model is a
248 good fit of the data (likelihood ratio analyses of this model: $\chi^2=15.856$; $df=14$;
249 $p=0.322$). The interaction respondent group x preferred control method was
250 significant ($\chi^2=259.134$; $df=2$; $p < 0.001$) indicating that the ratio of indicting a
251 preference for lethal versus non-lethal control measures was different across the three
252 respondent groups. Conservationists were 5.7 times more likely to prefer lethal
253 methods of control than protectionists but only 2.6 times more likely than the general
254 public group. Similarly the interaction between animal group and preferred control
255 method was significant ($\chi^2=368.196$; $df=7$; $p < 0.001$) indicating that the ratio of
256 indicting a preference for lethal versus non-lethal control measures was different
257 across the eight animal groups. The biggest difference occurred between rats and dogs
258 with participants in the survey 10.8 times more likely to prefer lethal methods of
259 control for rats than dogs. The significant interaction between animal group and
260 respondent group is a trivial result reflecting the different number of responses by the
261 respondent groups.

262 The median pest score for each animal was negatively correlated with the
263 corresponding median value for importance of animal welfare when selecting a
264 control method for each respondent group. This relationship was strong for the
265 general public ($r=-0.938$, $p=0.001$, $n=8$) but substantially weaker for both the
266 conservation group ($r=-0.385$, $n = 8$) and the animal protectionist group ($r=-0.219$,
267 $n=8$). This indicated that, particularly for the general public group, the greater the
268 degree to which an animal was considered a pest the lower the importance placed
269 upon its welfare (Fig. 1).

270 _____

271 Figure 1 here

272

273 *Impacts on target animals and non-target organism in influencing pest control*

274 *methods*

275 Principal component analyses were conducted on scores for the importance of seven
276 areas relevant to decisions around pest control methods for each animal group. The
277 Kaiser-Meyer-Olkin measure verified the sampling adequacy for the analysis (KMO
278 values for all individual items > 0.687). Barlett's tests of sphericity were significant
279 for all animal groups ($p < 0.001$) indicating correlations were sufficiently large for
280 PCA. Two components had eigen values over Kaiser's criteria of 1 and in
281 combination explained over 69 % of the variance for all animal groups. An example
282 of the factor loading after rotation for one of the animals (brushtail possum) is given
283 (Table 3). The first component clearly represented a measure of impact (suffering and
284 welfare) on the target animal. Factor 2 represented a measure of the impact on non-
285 target organisms (both welfare and biodiversity impacts) (Table 3). For the other
286 seven animals there were no major deviations in factor loadings for the components.

287

288 Table 3 here

289

290 There was a significant effect of respondent group on factor score 1 (impact on target
291 animal) ($F_{(2,260)}=25.24$; $P < 0.001$). Pairwise comparisons indicated that protectionists
292 had factor 1 scores significantly different from those of the general public and the
293 conservationists (both $P < 0.001$) but not between the general public and
294 conservationists ($P=0.713$). In particular, the protectionists routinely scored factor 1
295 (impact on the target species) consistently higher than that of the other two
296 respondent groups when considering the preferred or most acceptable pest control

297 measure (Fig. 2). Within respondent groups no effect of animal group was detected
298 nor was any interaction effect between animal and respondent group for factor 1 (P=1
299 and 0.06 respectively).

300 _____

301 Figure 2 here

302 _____

303 Similarly there was a significant effect of respondent group on factor 2 score (impact
304 on non-target organisms) ($F_{(2,260)}=6.754$; $P=0.001$). Differences between the general
305 public and the conservationists were significant ($P=0.001$). Differences between the
306 protectionists and conservationists bordered on significance ($P=0.052$) and there was
307 no significant difference between the general public and protectionists ($P=0.372$) (Fig
308 3). Similar to the case for factor 1, within respondent groups no effect of animal group
309 was detected nor was any interaction effect between animal and respondent group for
310 factor 2 ($P=1$ and 0.423 respectively).

311 _____

312 Figure 3 here

313 _____

314

315 Public acceptance of the control methods (Table 4 respondent group data are
316 combined for clarity) always scored lowest as a factor influencing the choice of
317 control measure for all animal groups (see Table 4). These differences were
318 significant among respondent groups (Friedman test, $\chi^2=1631.9$; $df=23$; $p<0.001$).

319 _____

320 **Table 4 here**

321 _____

322

323 **Discussion**

324

325 Our data show that conservationists scored the suite of eight animal groups more
326 severely as pests than the general public and protectionists. There was broad
327 agreement among respondent groups as to which were the most severe pests. Rats,
328 possums and stoats were identified as the most severe pests across all three respondent
329 groups. Lethal control was the preferred method of control for all animal groups for
330 conservationists. The general public held a similar view except for cats and dogs.
331 Protectionists accepted lethal methods of control as the most preferred option only for
332 rats, stoats and deer. In general the importance of impacts on animal welfare in
333 selecting a possible control measure declined the more severe the pest score of a
334 particular animal group became. This occurred across all respondent groups although
335 the relationship was weakest for the protectionists.

336 Women frequently differ from men in their attitudes towards animals and, for
337 example, show increased empathy and have a less utilitarian view (Miller & Jones
338 2006, Sanborn & Schmidt 1995). Accordingly differences in views among our
339 respondents groups may, at least, partly reflect the female bias in the protectionist and
340 conservationist respondent groups. Groups with a higher proportion of females may
341 be more likely to prefer pest control measures perceived to cause less suffering.
342 Notwithstanding, the female bias reported here is likely to be consistent with the
343 group population and therefore represent the view of this respondent population.
344 Evidence from elsewhere suggests that animal welfare or protection volunteer groups
345 are heavily dominated by females (e.g. Neumann, 2010). Groupings of
346 conservationists or wildlife managers may similarly have a female bias although

347 somewhat less marked than the previous group (Miller & Jones, 2006; Bonneau,
348 Darville, Legg, Haggert, & Wilkins, 2009)

349 The generally higher pest score for all animals reported by the conservation group
350 (Table 1) may reflect a more intimate knowledge of, and concern for, the impacts of
351 introduced mammals on New Zealand's ecosystems. The pest scores provided by
352 conservationists varied less than either of the other two groups, suggesting greater
353 consensus within this group.

354 Unsurprisingly concern for the welfare of pest animals as a factor influencing
355 choice of the control method was highest in the protectionist group. The similarity in
356 the level of concern expressed by the general public and conservationists may result
357 from a shared view that the impact of the pest groups supersedes, to a degree, welfare
358 concerns for them. However the generally lower concern of the general public for the
359 impact of control measures on non-target animals, compared to conservationists,
360 suggests that the largely urban general public may be less concerned with wild
361 animals as a whole.

362 For all three respondent groups the four animals with the highest pest ratings are
363 the same (rats, stoats, possums and rabbits). There is a wealth of evidence that rats,
364 possums and stoats are particularly damaging to New Zealand's natural ecosystems
365 compared to the other pest groups (Innes, Kelly, Overton, & Gillies 2010).

366 Rabbits and possums are significant pests in agricultural systems primarily
367 because they compete with domesticated livestock for pasture (e.g. rabbits: Norbury
368 & Norbury 1996) or act as vectors for disease in cattle or damage cash crops (e.g.
369 brushtail possums: Ryan & et al. 2006). Our results indicate this evidence is
370 effectively disseminated to the broader New Zealand society whether or not they have
371 a specific interest in conservation or agricultural issues. The lower absolute pest

372 scores for the other animal groups particularly among the general public and
373 protectionist group is likely to reflect a number of other factors. These include their
374 broader societal role as companion animals (Hazel, Signal & Taylor, 2011) and, in the
375 case of deer, their use as a hunting resource utilized by a substantial lobby group
376 (Nugent & Choquenot 2004; Nugent & Fraser, 1993) and greater levels of public
377 concern or value, placed on larger or charismatic mammals (Fraser, 2001; Nimmo,
378 Miller & Adams, 2007; Messmer, Brunson, Reiter, & Hewitt, 1999). Complicated
379 interactions between what constitutes pest, companion and production animals likely
380 exist for our respondent groups and influence the pest score provided, these should be
381 further explored.

382 There was only a weak relationship between the degree to which an animal was
383 considered a pest and the degree to which this affected concern for its welfare and
384 choice of possible control measures for animal protectionists. This presumably
385 reflects a view among this group that welfare concerns are paramount irrespective of
386 the type of animal. An increasing body of literature evaluating the interaction
387 between conservation imperatives and animal welfare goals suggest recognition
388 among professional wildlife managers and conservationists of the importance of
389 considering the welfare impacts of pest management (e.g. Fitzgerald 2009; Littin
390 2010). However issues around effectiveness and cost effectiveness of particular
391 control measures are also likely to play a role with this group (Fitzgerald 2009; Barr
392 & et al. 2002). The strong negative correlation between pest score and welfare
393 concern as seen within the general public group suggests that the perceived degree of
394 impact of introduced vertebrates on New Zealand ecological and agricultural systems
395 may override welfare concerns.

396 The substantially higher effect of the impact on target animals as a factor
397 determining the primary method of control (see Fig 2.) for the protectionist group,
398 compared to the conservationist and general public, is consistent with the world view
399 of this group (see above) probably reinforced by the significant gender skew towards
400 females. Women are more likely than men to put greater value on compassion and
401 protection of individual animals (Miller & Jones, 2006). The low score on this factor
402 for the general public and conservationists is likely driven by recognition that lethal
403 poisoning, although likely to have substantial costs for animal welfare compared to
404 some other approaches, remains the only cost effective solution for landscape scale
405 pest control of three major pests (rats, stoats, possums) (PCE 2011). Negative
406 experiences and perceptions of animals among the general public may also increase
407 the likelihood that lethal control will be supported (e.g. feral cats: Lloyd & Miller,
408 2010) among this group.

409 The preferred method identified by groups for each animal was not necessarily
410 representative of current control practices (e.g. protectionists selected contraception
411 for rabbits, table 2). Protectionists routinely preferred non-lethal control methods
412 whereas conservationists unequivocally selected lethal methods. Although it has been
413 argued that instantaneous death does not constitute a welfare issue (Broom, 1998),
414 many lethal control methods are not instantaneous. In particular poisoning, which
415 although effective has the potential to cause substantial suffering for some toxins (e.g.
416 Eason & et al. 2010), is never selected by protectionists, despite its widespread usage
417 in pest control operations, particularly in New Zealand. There has been significant
418 focus on the improvement of toxins to reduce welfare compromise in recent years
419 (Littin, 2010). Dissemination of this information may reduce welfare-based opposition
420 to poisoning. The general public was also more likely to prefer lethal control methods

421 and, it could therefore be suggested, is less opposed to the killing of non-native
422 species in general. The general public only preferred non-lethal methods for feral cats
423 and feral dogs with Trap-Neuter-Release being the most preferred option. This is
424 consistent with animal protectionists. The status of dogs and cats as common
425 companion animals, probably impacts on attitudes to the acceptability of lethal
426 control. Lethal control of these species may not receive public support if not
427 appropriately justified and implemented. It also indicates that there may be little
428 difference between the general public's concerns for the two species despite only one
429 of the two being officially classified as a pest (i.e. the feral cat).

430 There was a strong acceptance for the lethal control of non-native species by the
431 general public and conservation groups including by poisoning. The identification of
432 poisoning as the most appropriate form of control of some species of pest animals by
433 the general public identified in this study, is in contrast to studies elsewhere (Barr &
434 et al. 2002) where concerns around welfare implications, poisoning of non-target
435 animals and potential risks to human health outweigh its acknowledged effectiveness.
436 (Barr & et al. 2002; Fitzgerald 2009). Despite mostly non-lethal control methods
437 being selected by the animal protection group there were two exceptions. For both rats
438 and stoats (ranked first and second respectively) lethal control methods (but not
439 poisoning) were indicated as preferred. The selection of lethal-trapping in both
440 instances suggests that protectionists do not oppose lethal control in some instances.
441 None of the groups for any animal group selected the introduction of disease as an
442 appropriate pest control measure (see also Fitzgerald & et al. 2005). Currently disease
443 is not widely or routinely used for the control of pest animals in New Zealand and this
444 is likely to influence the selection of this method. Disease use has also been identified
445 as having both safety and extensive regulatory requirements (Saunders, Cooke,

446 McColl, Shine & Peacock, 2010) which may influence its choice. The mode by which
447 many diseases cause death (e.g. myxomatosis) may be considered inhumane
448 (Henning, Heuer & Davies 2005) and this may also reduce the likelihood of selection
449 particularly by animal protectionists.

450 The importance of public opinion in dictating control measures for non-native
451 species was considered of only moderate importance by all three sample groups (see
452 table 4) and was the least important of all factors evaluated. Similarly, Reiter & et al.
453 (1999) established that residents in five Wildlife Services regions in the United States
454 considered public opinion the least important criteria in selection of control measures.
455 Notwithstanding Mason & Littin (2003) noted that public awareness of pest control
456 measures has previously resulted in the demand for increasingly humane methods to
457 be recognized. As public concern for the welfare of animals continues to grow
458 (Eggleston & et al. 2003; Jordan, 2005; Meerburg & et al. 2008), it becomes
459 increasingly important to develop and utilize control methods that take into account
460 the public's considerations with regards to welfare and the humane treatment of all
461 species; including pests (Coleman, 2003) whilst continuing to protect New Zealand's
462 ecosystems.

463 There is already some understanding within New Zealand as to how the general
464 public views the development of new control techniques and the importance of
465 concern for public health and animal welfare (Fisher, 2010). In addition to general
466 concerns, understanding in more detail a range of opinions and how they converge
467 and diverge is important when the objective (the control of non-native species) may
468 be contentious. This should be further explored as part of pest control programs in
469 order to improve effectiveness with support from all sectors of the animal industries.
470 Also by gaining a full understanding and, as here, representing the median opinion, it

471 allows extreme points of view (e.g. ‘no animal should be killed’ or ‘cats and dogs
472 should be banned in New Zealand’) to be acknowledged but placed in the context of a
473 full range of views. ‘Policy Delphi Analysis’ is one such method of focusing
474 discussions to ensure that outcomes address concerns of all parties whilst allowing
475 identification of areas of agreement. It has previously been used to address welfare
476 issues for horses in Ireland using a focus group of individuals that are traditionally
477 opposed or reluctant to engage with one another (Collins, Hanlon, More, Wall &
478 Duggan, 2009; Collins & et al. 2010). Further research on the topic of attitudes
479 towards the control of non-native animals should look to use this methodology and, as
480 per this research, should consider areas which we suggest may provide consensus.
481 This may include for example: how best to control rats, stoats and possums as major
482 pests; how to protect the welfare of non-target species; how to improve acceptance of
483 lethal control methods or the promotion of non-lethal control measures for cats.
484 Future research should also integrate wider opinion possibly drawing from other
485 groups with vested (but potentially contrasting) interests in this area (e.g. farmers,
486 hunters and animal rights advocates).

487

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489

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496 **References**

497

498 Aguilar, G.D. & Farnworth, M.J. (2012). Stray cats in Auckland, New Zealand:
499 Discovering geographic information for exploratory spatial analysis. *Journal of*
500 *Applied Geography*, 34, 230-238.

501 Aguilar, G.D. & Farnworth, M.J. (2013). Distribution characteristics of unmanaged
502 cat colonies over a 20 year period in Auckland, New Zealand. *Journal of Applied*
503 *Geography*, 37, 160-167.

504 Barr, J.J.F., Lurz, P.W.W., Shirley, M.D.F., & Rushton, S.P. (2002). Evaluation of
505 immunocontraception as a publically acceptable form of vertebrate pest species
506 control: the introduced grey squirrel in Britain as an example. *Environmental*
507 *Management* 30, 342-351.

508 Bonneau, L., Darville, R., Legg, M., Haggert, M., & Wilkins, R.N. (2009). Changes
509 in volunteer knowledge and attitudes as a result of Texas Master Naturalist
510 Training. *Human Dimensions of Wildlife*, 14, 157-172.

511 Bremner, A. & Park, K. (2007). Public attitudes to the management of invasive non-
512 native species in Scotland. *Biological Conservation* 139, 306-314.

513 Broom, D. M. (1998). The scientific assessment of animal welfare. *Applied Animal*
514 *Behaviour Science*, 20, 5-19.

515 Clout, M.N. (2001). Biodiversity conservation and the management of invasive
516 animals in New Zealand. In: Sandlund, O. T., Schei, P. J., & Viken, Å. (Eds.).
517 *Invasive species and biodiversity management* (Vol. 24). Springer. 24, 349- 362.

518 Clout, M. N., & Saunders, A. J. (1995). Conservation and ecological restoration in
519 New Zealand. *Pacific Conservation Biology*, 2, 91-98.

520 Clout, M. N., & Veitch, C. R. (2002). *Turning the tide of biological invasion: the*
521 *potential for eradicating invasive species*. In ‘Proceedings of the International
522 Conference on Eradication of Island Invasives’ Occasional Paper of the IUCN
523 Species Survival Commission No. 27. (Eds. Veitch, C. R. & Clout, M.N.) pp. 1-3.
524 (Gland, Switzerland and Cambridge, UK: IUCN Species Specialist Group).

525 Coleman, G. (2003). Assessing public attitudes to vertebrate pest control. In
526 ‘Proceedings of the Royal Society for the Prevention of Cruelty to Animals
527 (RSPCA) Australia Scientific seminar, Solutions for achieving humane vertebrate
528 pest control’ (Ed, B. Jones.) pp. 38-43. (Canberra, Australia.)

529 Collins, J., Hanlon, A., More, S. J., Wall, P. G., & Duggan, V. (2009). Policy delphi
530 with vignette methodology as a tool to evaluate the perception of equine welfare.
531 *Veterinary Journal*, 181(1), 63-69.

532 Collins, J. A., Hanlon, A., More, S. J., Wall, P. G., Kennedy, J., & Duggan, V. (2010).
533 Evaluation of current equine welfare issues in Ireland: Causes, desirability,
534 feasibility and means of raising standards. *Equine Veterinary Journal*, 42(2), 105-
535 113.

536 Craig, J., Anderson, S., Clout, M., Creese, B., Mitchell, N., Odgen, J., Roberts, M. &
537 Ussher, G. (2000). Conservation issues in New Zealand. *Annual Review of*
538 *Ecology and Systematics*, 31, 61-78.

539 Decker, D. J., Brown, T.L., & Siemer, W.F. (2001). *Human Dimensions of Wildlife in*
540 *North America*. The Wildlife Society, Bethesda, Maryland, USA.

541 Department of Conservation (2006). Kaimanawa Wild Horses Plan. Department of
542 Conservation, Wanganui, New Zealand

543 Diamond, J. M., & Veitch, C. R. (1981). Extinctions and introductions in the New
544 Zealand avifauna: cause and effect? *Science*, 211, 499-501.

545 Dowding, J. E., & Murphy, E. C. (2001). The impact of predation by introduced
546 mammals on endemic shorebirds in New Zealand: a conservation perspective.
547 *Biological Conservation*, 99, 47-64.

548 Duncan, I. J. H. (1996). Animal welfare defined in terms of feeling. *Acta Agriculturae*
549 *Scandinavica, Section A, Animal Science supplement*, 27, 29-36.

550 Eason, C. T., Shapiro, L., Adams, P., Hix, S., Cunningham, C., MacMorran, D.,
551 Statham, M., & Statham, H. (2010). Advancing a humane alternative to sodium
552 fluoroacetate (1080) for wildlife management- welfare and wallaby control.
553 *Wildlife Research*, 37, 497-503.

554 Eggleston, J. E., Rixecker, S. S., & Hickling, G. J. (2003). The role of ethics in the
555 management of New Zealand's wild animals. *New Zealand Journal of Zoology*,
556 30, 361-376.

557 Farnworth, M. J., Dye, N. G., & Keown, N. (2010). The legal status of cats in New
558 Zealand: A perspective on the welfare of companion, stray and feral domestic
559 cats (*Felis catus*). *Journal of Applied Animal Welfare Science*, 13, 180-188.

560 Fisher, M. (2010) A method for considering the acceptability of novel biotechnologies
561 for the control of brushtail possums. *Kōtuitui*, 5, 41-52.

562 Fitzgerald, G. (2009). Public attitudes to current and proposed forms of pest animal
563 control. Invasive Animals Cooperation Research Centre, Canberra.

564 Fitzgerald, G., Fitzgerald, N., & Wilkinson, R. (2005). Social acceptability of stoats
565 and stoat control measures: a survey of the New Zealand public. *Science for*
566 *Conservation*, 253, 5-40

567 Fraser, K. W. (2001). Introduced wildlife in New Zealand: A survey of general public
568 views. *Landcare Research Science Series*, 23, Manaaki Whenua Press
569 (Wellington, New Zealand).

570 Gillies, C. 2001. Managing rodents on the New Zealand mainland-what options are
571 currently available? *DOC Science Internal Series 47. Department of*
572 *Conservation, Wellington* 20p.

573 Hazel, S. J., Signal, T. D., & Taylor, N. (2011). Can teaching veterinary and animal-
574 science students about animal welfare affect their attitude toward animals and
575 human-related empathy? *Journal of Veterinary Medical Education*, 38, 74-83.

576 Henning, J., Heuer, C., & Davies, P. R. (2005). Attitudes of New Zealand farmers to
577 methods used to control wild rabbits. *Preventive veterinary medicine*, 67(2), 171-
578 194.

579 Hill, N. J., Carbery, K. A., & Deane, E. M. (2007) Human-possum conflict in urban
580 Sydney, Australia: Public perceptions and implications for species management.
581 *Human Dimensions of Wildlife*, 12, 101-113.

582 Holdaway, R. N. (1989). New Zealand's pre-human avifauna and its vulnerability.
583 *New Zealand Journal of Ecology*, 12, 11-25.

584 Holland, O. J., Cowan, P. E., Gleeson, D. M., & Chamley, L. W. (2008) High
585 variability in the MHC class II DA beta chain of the brushtail possum
586 (*Trichosurus vulpecula*). *Immunogenetics*, 60, 775-781.

587 Hooson, S. & Jamison, I.G. (2003). The distribution and current status of New
588 Zealand Saddleback *Philesturnus carunculatus*. *Bird Conservation International*
589 13, 79–95.

590 Husheer, S. W., Coomes, D.A. & Robertson., A.W. (2003) Long-term influences of
591 introduced deer on the composition and structure of New Zealand *Nothofagus*
592 forests. *Forest ecology and Management* 181, 99-117.

593 Innes, J., Kelly, D., Overton, J. M., & Gillies, C. (2010). Predation and other factors
594 currently limiting New Zealand forest birds. *New Zealand Journal of Ecology*,
595 34(1), 86-114.

596 International Union for Conservation of Nature (1997) Position Statements of the
597 International Union for Conservation of Nature Caprinae Specialist Group (1989)
598 In Shackleton, D.M. (Ed.). *Wild Sheep and Goats and their Relatives: Status*
599 *Survey and Conservation Action Plan for Caprinae*. Gland, Switzerland.

600 Jacobs, M. A. (2009) Why do we like or dislike animals? *Human Dimensions of*
601 *Wildlife*, 14, 1-11.

602 Jordan, B. (2005) Science-based assessment of animal welfare: wild and captive
603 animals. *Revue Scientifique et Technique de l'Office International des*
604 *Epizooties*, 24, 518-528.

605 King, C. (1984). *Immigrant killers: introduced predators and the conservation of*
606 *birds in New Zealand*. Oxford University Press, Oxford, United Kingdom Pp 73.

607 Laven, R., Huxley, J., Whay, H., & Stafford, K. (2009). Results of a survey of
608 attitudes of dairy veterinarians in New Zealand regarding painful procedures and
609 conditions in cattle. *New Zealand Veterinary Journal*, 57(4), 215-220.

610 Levy, J. K., Gale, D. W., & Gale, L. A. (2003). Evaluation of the effect of a long-term
611 trap-neuter-return and adoption program on a free-roaming cat population.
612 *Journal of the American Veterinary Medical Association*, 222, 42-46.

613 Littin, K. E. (2010). Animal welfare and pest control: meeting both conservation and
614 animal welfare goals. *Animal Welfare*, 19, 171-176.

615 Littin, K. E., & Mellor, D. J. (2005). Strategic animal welfare issues: ethical and
616 animal welfare issues arising from the killing of wildlife for disease control and

617 environmental reasons. *Revue Scientifique et Technique de l'Office International*
618 *des Epizooties*, 24, 767-782.

619 Littin, K. E., Mellor, D. J., Warburton, B., & Eason, C. T. (2004). Animal welfare and
620 ethical issues relevant to the humane control of vertebrate pests. *New Zealand*
621 *Veterinary Journal*, 52, 1-10.

622 Lloyd, K. A. & Miller, C. A. (2010) Influence of demographics, experience and value
623 orientations on preferences for lethal management of feral cats. *Human*
624 *Dimensions of Wildlife*, 15, 262-273.

625 Mason, G., & Littin, K. E. (2003). The Humaneness of Rodent Pest Control. *Animal*
626 *Welfare*, 12, 1-38.

627 Meerburg, B. G., Brom, F. W. A., & Kijlstra, A. (2008). Perspective: The ethics of
628 rodent control. *Pest Management Science*, 64, 1205-1211.

629 Messmer, T. A., Brunson, M. W., Reiter, D., & Hewitt, D. G. (1999). United States
630 public attitudes regarding predators and their management to enhance avian
631 recruitment. *Wildlife Society Bulletin*, 22, 75-85.

632 Miller K.K., & Jones, D.N. (2005). Wildlife management in Australia: perceptions of
633 objectives and priorities. *Wildlife Research*, 32, 265-272.

634 Miller K.K., & Jones, D.N. (2006). Gender differences in the perceptions of wildlife
635 management objectives and priorities in Australia. *Wildlife Research*, 33, 155-
636 159.

637 Neumann, S. L. (2010) Animal welfare volunteers: Who are they and why do they do
638 what they do? *Anthrozoös*, 23, 351-364.

639 Nimmo, D. G., & Miller, K. K. (2007). Ecological and human dimensions of
640 management of feral horses in Australia: a review. *Wildlife research*, 34(5), 408-
641 417.

642 Nimmo, D. G., Miller, K. K., & Adams, R. (2007). Managing Feral Horses in
643 Victoria: A study of community attitudes and perceptions. *Ecological*
644 *management & restoration*, 8, 237-243.

645 Norbury, D. C., & Norbury, G. L. (1996). Short-term effects of rabbit grazing on a
646 degraded short-tussock grassland in Central Otago. *New Zealand Journal of*
647 *Ecology*, 20(2), 285-288.

648 Nugent, G., & Fraser, K. W. (1993). Pests or valued resources? Conflicts in
649 management of deer. *New Zealand Journal of Zoology*, 20, 361-366.

650 Nugent, G., & Choquenot, D. (2004). Comparing cost-effectiveness of commercial
651 harvesting, state-funded culling, and recreational deer hunting in New Zealand.
652 *Wildlife Society Bulletin*, 32, 481-492.

653 Nugent, G., Fraser, W., & Sweetapple, P. (2001). Top down or bottom up?
654 Comparing the impacts of introduced arboreal possums and 'terrestrial' ruminants
655 on native forests in New Zealand. *Biological Conservation*, 99, 65-79.

656 Paquet P. C., & Darimont, C. T. (2010). Wildlife conservation and animal welfare:
657 two sides of the same coin? *Animal Welfare*, 19, 177-190.

658 PCE 2011. *Evaluating the use of 1080: predators, poisons, and silent forests*.
659 Parliamentary Commissioner for the Environment, Wellington, New Zealand.

660 Potts, A. (2009). Kiwis Against Possums: A Critical Analysis of Anti-Possum
661 Rhetoric in Aotearoa New Zealand. *Society and Animals*, 17, 1-20.

662 Reiter, D. K., Brunson, M. W., & Schmidt, R. H. (1999). Public attitudes toward
663 wildlife damage management and policy. *Wildlife Society Bulletin*, 27, 746-758.

664 Ryan, T. J., Livingstone, P. G. Ramsey, D. S. L., de Lisle, G. W., Nugent, G., Collins,
665 D. M., & Buddle, B. M. (2006). Advances in understanding disease epidemiology

666 and implications for control and eradication of tuberculosis in livestock: The
667 experience from New Zealand. *Veterinary Microbiology*, 112, 211-219.

668 Sanborn, W.A., & Schmidt, R.H. (1995). Gender effects on views of wildlife
669 professionals about wildlife management. *Wildlife Society Bulletin*, 23, 583-587.

670 Saunders, G., Cooke, B., McColl, K., Shine, R., & Peacock, T. (2010). Modern
671 approaches for the biological control of vertebrate pests: An Australian
672 perspective. *Biological Control*, 52(3), 288-295.

673 Scofield, R.P., Cullen, R. & Wang, M. (2011). Are predator-proof fences the answer
674 to New Zealand's terrestrial faunal biodiversity crisis? *New Zealand Journal of*
675 *Ecology*, 35, 312-317

676 Sharp, T., & Saunders, G. (2008). *A model for assessing the relative humaneness of*
677 *pest control methods*. Canberra: Australian Government Department of
678 Agriculture, Fisheries and Forestry. Pp. 11-45. (Canberra, ACT).

679 Statistics New Zealand 2011. Subnational Population Estimates: At 30 June 2011
680 [http://www.stats.govt.nz/browse_for_stats/population/estimates_and_projections/](http://www.stats.govt.nz/browse_for_stats/population/estimates_and_projections/SubnationalPopulationEstimates_HOTPJun11.aspx)
681 [SubnationalPopulationEstimates_HOTPJun11.aspx](http://www.stats.govt.nz/browse_for_stats/population/estimates_and_projections/SubnationalPopulationEstimates_HOTPJun11.aspx). Retrieved 30 August 2012.

682 Towns D., Dougherty C. & Cree A. (2001) Raising the prospects for a forgotten
683 fauna: a review of 10 years of conservation effort for New Zealand reptiles.
684 *Biological Conservation*, 99, 3-16.

685 Warburton, B., & Norton, B. G. (2009). Towards a Knowledge-Based Ethic for Lethal
686 Control of Nuisance Wildlife. *Journal of Wildlife Management*, 73, 158-164.

687 Wemelsfelder, F., Hunter, E. A., Mendl, M. T., & Lawrence, A. (2001). Assessing the
688 'whole animal': a free-choice-profiling approach. *Animal Behaviour*, 62, 209-
689 220.

690 White, P. C. L., & King, C. M. (2006). Predation on native birds in New Zealand
691 beech forests: the role of functional relationships between Stoats (*Mustela*
692 *ermine*) and rodents. *Ibis*, 148, 765-771.