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

Understanding attitudes towards the 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).

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Abstract

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

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

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

Introduction

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

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

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

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

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

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

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

Materials and Methods

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

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

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

Sampling

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

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

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

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

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

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

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

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

Results

Gender distribution

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

Pest Status

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

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

There was a large degree of agreement in the order in which the three respondent groups ranked the extent to which a particular animal group was considered a pest. Rats were ranked first by all three respondent groups and brushtail possums, stoats

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

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Table 1 here

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Methods of control

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

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Table 2 here

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

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

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

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Figure 1 here

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

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

Table 3 here

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

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

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Figure 2 here

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

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Figure 3 here

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

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Table 4 here

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Discussion

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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References

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

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

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

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

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

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

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

Clout, M. N., & Saunders, A. J. (1995). Conservation and ecological restoration in 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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Statistics New Zealand 2011. Subnational Population Estimates: At 30 June 2011 http://www.stats.govt.nz/browse_for_stats/population/estimates_and_projections/SubnationalPopulationEstimates_HOTPJun11.aspx. Retrieved 30 August 2012.

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

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

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

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