Domestic carnivore interactions with wildlife in the Cape Horn Biosphere Reserve, Chile: husbandry and perceptions of impacts from a community perspective

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Background. Hundreds of millions of domestic carnivores worldwide have diverse positive affiliations with humans, but can provoke serious socio-ecological impacts when free-roaming. Unconfined dogs (*Canis familiaris*) and cats (*Felis catus*) interact with wildlife as predators, competitors, and disease-transmitters; their access to wildlife depends on husbandry, perceptions, attitudes, and behaviors of pet owners and non-owners.

Methods. To better understand husbandry and perceptions of impacts by unconfined, domestic carnivores, we administered questionnaires (n=244) to pet owners and non-owners living in one of the last wilderness areas of the world, the Cape Horn Biosphere Reserve, located in southern Chile. We used descriptive statistics to provide demographic pet and husbandry information, quantify free-roaming dogs and cats, map their sightings in nature, and report experiences and perceptions of the impact of free-roaming dogs and cats on wildlife. We corroborated our results with an analysis of prey remains in dog feces (n=53). With generalized linear models, we examined which factors (i.e., food provisioning, reproductive state, rural/village households, sex, and size) predicted that owned dogs and cats bring wildlife prey home.

Results. Thirty-one percent of village dogs (n=121) and 60% of dogs in rural areas (n=47) roamed freely day and/or night. Free-roaming dog packs were frequently observed (64% of participants) in the wild, including a feral dog population on Navarino Island. Dogs (31 of 168) brought home invasive muskrats (*Ondatra zibethicus*) and avian prey, and over half of all cats (27 of 51) brought home mainly avian prey. Birds were also the most harassed wildlife category, affected by one third of all dogs and cats. Nevertheless, dog-wildlife conflicts were hardly recognized (<9% of observed conflicts and suspected problems), and only 34% of the participants thought that cats might impact birds. Diet analysis revealed that dogs consumed livestock (64% of 59 prey occurrences), beavers (*Castor canadensis*, 14%), and birds (10%). The probability that dogs brought prey to owners' homes was higher in rural locations and with larger dogs. There was also evidence that cats from rural households and with an inadequate food supply brought more prey home than village cats.

Discussion. Although muskrat, beavers, and birds were brought home, harassed, or found in dog feces, free-roaming dogs and, to a lesser extent, cats are perceived predominantly in an anthropogenic context

(i.e., as pets) and not as carnivores interacting with wildlife. Therefore, technical and legal measures should be applied to encourage neutering, increase confinement, particularly in rural areas, and stimulate social change via environmental education that draws attention to the possibility and consequences of unconfined pet interaction with wildlife in the southernmost protected forest ecoregion of the globe.

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19 **Abstract**

20 **Background.** Hundreds of millions of domestic carnivores worldwide have diverse positive

21 affiliations with humans, but can provoke serious socio-ecological impacts when free-roaming.

22 Unconfined dogs (*Canis familiaris*) and cats (*Felis catus*) interact with wildlife as predators,

23 competitors, and disease-transmitters; their access to wildlife depends on husbandry, perceptions,

24 attitudes, and behaviors of pet owners and non-owners.

25 **Methods.** To better understand husbandry and perceptions of impacts by unconfined, domestic

26 carnivores, we administered questionnaires (n=244) to pet owners and non-owners living in one

27 of the last wilderness areas of the world, the Cape Horn Biosphere Reserve, located in southern

28 Chile. We used descriptive statistics to provide demographic pet and husbandry information,

29 quantify free-roaming dogs and cats, map their sightings in nature, and report experiences and

30 perceptions of the impact of free-roaming dogs and cats on wildlife. We corroborated our results

31 with an analysis of prey remains in dog feces (n=53). With generalized linear models, we examined

32 which factors (i.e., food provisioning, reproductive state, rural/village households, sex, and size)

33 predicted that owned dogs and cats bring wildlife prey home.

34 **Results.** Thirty-one percent of village dogs (n=121) and 60% of dogs in rural areas (n=47) roamed

35 freely day and/or night. Free-roaming dog packs were frequently observed (64% of participants)

36 in the wild, including a feral dog population on Navarino Island. Dogs (31 of 168) brought home

37 invasive muskrats (*Ondatra zibethicus*) and avian prey, and over half of all cats (27 of 51) brought

38 home mainly avian prey. Birds were also the most harassed wildlife category, affected by one third

39 of all dogs and cats. Nevertheless, dog-wildlife conflicts were hardly recognized (<9% of observed

40 conflicts and suspected problems), and only 34% of the participants thought that cats might impact

41 birds. Diet analysis revealed that dogs consumed livestock (64% of 59 prey occurrences), beavers

42 (*Castor canadensis*, 14%), and birds (10%). The probability that dogs brought prey to owners'

43 homes was higher in rural locations and with larger dogs. There was also evidence that cats from

44 rural households and with an inadequate food supply brought more prey home than village cats.

45 **Discussion.** Although muskrat, beavers, and birds were brought home, harassed, or found in dog

46 feces, free-roaming dogs and, to a lesser extent, cats are perceived predominantly in an

47 anthropogenic context (i.e., as pets) and not as carnivores interacting with wildlife. Therefore,

48 technical and legal measures should be applied to encourage neutering, increase confinement,

49 particularly in rural areas, and stimulate social change via environmental education that draws

50   attention to the possibility and consequences of unconfined pet interaction with wildlife in the

51   southernmost protected forest ecoregion of the globe.

52

53   **Introduction**

54   In parallel with human population growth, the number of companion animals is constantly

55   increasing. Pet and feral dogs (*Canis familiaris*) have reached an estimated population of 900

56   million while cat (*Felis catus*) populations are estimated at 600 million (O'Brien & Johnson, 2007;

57   Gompper, 2014a), existing on all continents except Antarctica (Hughes et al., 2015). Since their

58   domestication thousands of years ago, domestic dogs have had profound roles in human lives.

59   These include companionship, livestock guarding, rescue, hunting, tourism, service animals, and

60   wildlife management (Hart & Yamamoto, 2017). As dogs are part of a diversity of human cultures,

61   their various roles, husbandry, and people's attitudes towards them have different implications for

62   human-dog-wildlife interactions (Miller, Ritchie & Weston, 2014).

63   The potential for interactions with wildlife depends on dogs' and cats' husbandry,

64   particularly on their confinement. This ranges from complete mobility restriction, for leashed

65   and/or indoor dogs and cats, to feral domestic carnivores that survive independently of

66   supplemental provisioning from humans (Kays & DeWan, 2004; Vanak & Gompper, 2009).

67   Between these extremes, there exists a range of free-roaming animals that are owned or unowned

68   and are, to some extent, subsidized by humans. As subsidized predators, domestic carnivores can

69   reach higher population densities than wild carnivore populations (Gompper, 2014b), leading to

70   complex socio-ecological consequences.

71   The impacts of free-roaming subsidized and feral domestic dogs include loss of livestock

72   (Baker et al., 2008; Echegaray & Vilà, 2010), aggression towards humans (Schalamon et al., 2006),

73   disease transmission (Matter & Daniels, 2010), and wildlife interference (reviewed in Young et

74   al., 2011; Hughes & Macdonald, 2013; Doherty et al., 2017). Dogs prey upon (Butler, du Toit &

75   Bingham, 2004; Manor & Saltz, 2004), compete with (Mitchell & Banks, 2005; Vanak, Thaker &

76   Gompper, 2009), infect (Acosta-Jamett, 2009), and disturb (Silva-Rodríguez, Ortega-Solís &

77   Jiménez, 2010; Silva-Rodríguez & Sieving, 2012) wild animals. Suburban cats are successful

78   small vertebrate predators (Woods, McDonald & Harris, 2003; Loyd et al., 2013). On islands,

79   Medina et al. (2011) demonstrated that feral cats were responsible for at least 14% of global avian,

80   mammalian, and reptilian extinctions (see also Nogales et al., 2013). Finally, both dogs and cats

81   may hybridize with their wild relatives (Randi, 2008).

82   While the biology of domestic carnivore-wildlife interactions is often the focus of research,

83   studies on social dimensions are still in their infancy (Miller, Ritchie & Weston, 2014).

84   Understanding the perceptions of free-roaming pet carnivores is indispensable to inform

85   conservation action, because the causes and solutions to this problem directly depend upon the

86   nature of relationships between humans and their domestic pets (Gramza et al., 2016). Conflicts

87   between dogs/cats and wildlife could thus be minimized by a better understanding of how

88   husbandry, attitudes, and behaviors of pet owners influence dogs and cats in their access to and

89   interaction with wild prey or carnivores, particularly when close to protected areas. For example,

90   dog owners felt more obliged to leash their dogs when they thought their dog would harm beach-

91   nesting birds or people (Williams et al., 2009). Recent studies have shown that a more adequate

92   diet (i.e., commercial or prepared food instead of e.g., household scraps) for dogs and cats

93   decreases the probability of preying upon wild animals (Silva-Rodríguez & Sieving 2012,

94   Sepúlveda et al., 2014). Additionally, in the absence of biological data or for logistical and cost

95   reasons, a community-based assessment may provide suitable information on the impact of

96   particular species on other species (White et al., 2005).

97   Here, we focus on understanding the interactions with wildlife by populations of free-

98   roaming dogs and cats in a sensitive conservation area of southern Chile, the Cape Horn Biosphere

99   Reserve, from a community perspective. To date, the only substantial human impacts in the

100   biosphere reserve are biological invasions, particularly of wild and domestic exotic mammals that

101   outnumber their native counterparts (Anderson et al., 2006). Additionally, native terrestrial

102   predators are absent on many of the islands of the reserve, including Navarino Island, where the

103   only village of the reserve is located (Anderson et al., 2006). Thus, introduced predators may cause

104   extensive population reductions on native and often naïve prey (discussed in Sih et al., 2010).

105   Although free-roaming and feral dogs are commonly observed by locals on Navarino Island, there

106   are few observations of their impacts. Dogs have been reported to prey upon the southernmost

107   population of guanacos (*Lama guanicoe*), which is virtually unstudied and considered in danger

108   of local extinction (Cunazza, 1991; Gónzalez, 2005). Evidence also exists of dogs preying upon

109   nests of solitary nesting waterfowl, such as the Flightless Steamer Duck (*Tachyeres pteneres*), a

110 species endemic to Patagonia, and nesting colonies of the South American Tern (*Sterna*
111 *hirundinacea*, Schüttler et al., 2009). There are no published accounts of local cat impacts.
112   We administered questionnaires to pet owners and non-owners to address the following
113 objectives: (1) provide demographic and husbandry information relevant for future dog and cat
114 management in one of the last wilderness areas of the globe, (2) quantify free-roaming dogs and
115 cats and map their locations in nature, (3) examine experiences and perceptions of the impact of
116 free-roaming dogs and cats on wildlife and corroborate those with an analysis of prey remains of
117 dog feces, and (4) predict which factors best explain when owned dogs and cats bring wildlife prey
118 home. With regard to the paucity of ecological data on domestic carnivore-wildlife interactions in
119 this sub-Antarctic wilderness area, this study allows a first insight into this conservation problem.
120

121 **Materials & Methods**

122

123 **Ethics statement**

124   We obtained prior informed consent from each participant by reading a printed statement
125 explaining the project aims, the lack of risks in participating, the possibility of omitting questions,
126 information about use of and access to the results, and that the interview was anonymous and
127 voluntary. The participants agreed to participate by signing a copy of the informed consent; they
128 were also given a copy. Paper and digital questionnaires were stored anonymously. The Scientific
129 Ethical Committee of the University of Magallanes, Chile, certified ethical approval of the
130 instrument.

131

132 **Study area**

133   We carried out this study in the Cape Horn Biosphere Reserve (CHBR) (19,172 km^2
134 terrestrial surface), Chile, located at the extreme southern tip of South America (Fig. 1). The
135 biosphere reserve exists within the Magellanic Sub-Antarctic forest ecoregion, one of the
136 remaining 24 wilderness areas of the world (Mittermeier et al., 2003). The dominant habitats
137 within this ecoregion are unfragmented evergreen and deciduous southern beech (*Nothofagus* spp.)
138 and Winter's bark (*Drimys winteri*) forests, Magellanic peat bogs (predominantly *Sphagnum* spp.),
139 high-Andean habitats, and glaciers (Pisano, 1977). The human population in the CHBR is of mixed
140 cultural and ethnic origin (i.e., Yaghan indigenous people, Chilean Navy, fishermen, and Chilean

141   and foreign short- and long-term settlers) and is concentrated in the only town within the reserve,

142   Puerto Williams (2,800 inhabitants) on Navarino Island. A small fishing village, Puerto Toro,

143   exists on the eastern coast of Navarino as well as eight rural farm settlements. In the remainder of

144   the biosphere reserve, there are only 11 Chilean Navy posts operated by a new family each year,

145   and one farm on Hoste Island (Fig. 1). The principal economic activities on Navarino Island

146   include fishing, tourism, and small-scale livestock farming. The infrastructure is limited to a dirt

147   road along the northern coast of Navarino; public maritime transport within the reserve does not

148   exist.

149

150   [please insert Figure 1 here]

151

152   **Survey**

153   From May 2015 to April 2016, we interviewed 215 households in Puerto Williams, seven

154   farm owners on Navarino Island, and 22 Chilean Navy families living for one year on the 11 Navy

155   posts on different islands in the CHBR (n=244 total interviews). To test the questionnaire design

156   and adapt the questions, we conducted a pilot study with four trial informants who were later

157   excluded from the dataset.

158   We calculated a representative 95% probability sample of 215 interviewees in Puerto

159   Williams based on a census of households conducted by ES in May 2015 (490 houses). We used

160   a confidence interval of 5% and applied the finite population correction for smaller populations

161   (Bernard, 2006: 183). We randomly chose 280 households from a map of numbered houses in

162   town (adding 30% to the sample size of 215 to correct for non-responses). When an adult was not

163   present, we left a written message explaining the motivation for our visit and our contact

164   information. We visited each household up to three times before it was replaced. The

165   questionnaires were administered at different times in a face-to-face interview at the participant's

166   home and took 10-30 min. Two interviewers conducted the interviews in Spanish (n=92 by ES and

167   n=152 by LSA).

168   To meet objective 1, we collected information on dog and cat demographics (i.e., number,

169   age, sex, origin, purpose of pets, number of pups/kittens in previous year, elimination, and

170   temporary and definite pet loss) as well as on pet care/husbandry (i.e., veterinary treatments, food

171   type, in how many households pets eat, and whether owned or unowned street dogs are fed). We

172   asked participants whether they restricted the movements of their dogs (i.e., day and/or night and
173   if free-ranging, why), whether they saw unaccompanied dogs and cats (adults, pups/kittens)
174   outside of town and from where they thought the animals came (objective 2). We asked participants
175   about their observations of problematic dog situations in and out of town, perceptions of possible
176   impacts of free-roaming dogs and cats, and their personal experiences regarding the pet's
177   interaction(s) with other animals (objective 3). To better understand predictors (i.e., food
178   provisioning, reproductive state, rural/village households, sex, size) of dog and cat interactions
179   with wildlife, we asked owners whether their pets brought wildlife prey home (objective 4). We
180   finished the questionnaire by asking for suggestions for reducing the number of free-roaming dogs,
181   personal data (i.e., age, sex, education, residence time), and the owner´s permission to take a photo
182   of their pet. From this photo, we then classified dog sizes (i.e., small, medium, large) and calculated
183   the mean of two independent estimations by ES and LSA. For farm owners, we added questions
184   on their experience with the loss of domestic animals such as cattle (*Bos taurus*) or sheep (*Ovis*
185   *aries*) to dog attacks. For participants without pets, non-relevant questions were not asked. Some
186   questions were focused only on dogs because dogs produce visible socio-ecological conflicts in
187   the study area.

188

189   **Dog diet**

190   Dog feces of owned and feral dogs (n=70) were opportunistically collected within one km
191   of the 11 Navy posts and during trekking events on Navarino Island (June 2015 to April 2016).
192   Each sample was dried, rehydrated, and degreased with detergent, and then grouped into hair,
193   bones, feathers, and rubbish. Using a microscope, we examined the medullary and cuticular
194   patterns of guard hairs to identify up to species level using gelatin as the printing medium (similar
195   to González-Esteban, Villate & Irizar,1996). As reference collections, we used those provided by
196   the Instituto de la Patagonia, Universidad de Magallanes, complemented by our own additions,
197   and local keys (Chehébar & Martín, 1989). Unfortunately, we could not find a major number of
198   cat feces from different individuals for a sound analysis of cat diet.

199

200   **Statistics**

201   We first calculated descriptive statistics to analyze basic demographic and husbandry
202   information from the interviews to quantify (i) the number of free-roaming dogs and cats, (ii)

203   problems associated with dogs, (iii) perceptions of the potential impact of free-roaming dogs and

204   cats on wildlife, (iv) occurrence of predation and harassment by dogs and cats, and (v) percentages

205   of different types of prey in dog feces. We then used generalized linear models (GLMs) to examine

206   predictors of interactions with wildlife of owned dogs and cats (Table 1). Our response variable

207   for the dog and the cat model was whether pets brought wildlife home, defined here as any exotic

208   or native wild mammal or bird (PREY). As covariates, we considered diet (dinner leftovers and/or

209   commercial pet food) provided by the animal's owner (FOOD), sex (SEX), sterility

210   (STERILIZED), owners' household location (LOCATION, rural or village), and pet size (SIZE,

211   only for dogs). We focused on those covariates as they might identify pet characteristics or levels

212   of care which can then inform recommendations for pet management for the benefit of wildlife.

213   The location was included because rural households are imbedded in wilderness settings and

214   access to wildlife is immediate. Response and predictor variables are explained in detail in Table

215   2.

216   As the response variable of the two models was binomial, we fitted generalized linear

217   models (GLMs) with binomial error structure and logit link. The models were parameterized with

218   all possible covariate combinations. Prior to analysis, we explored these data following Zuur et al.

219   (2010). Collinearity between ordinal covariates was assessed with Spearman correlation

220   coefficients (no coefficients were $>|0.4|$). We tested the independence of categorical variables

221   using contingency tables (Chi-square and Fisher's exact tests, $p < 0.05$). We removed SEX and

222   STERILIZED from the dog model for being significantly associated with LOCATION; similarly,

223   we removed STERILIZED from the cat model for being significantly associated with LOCATION

224   and SEX. FOOD was maintained here, despite its collinearity with LOCATION, to test the same

225   variables in the dog and cat models (the conclusions for models tested with and without FOOD

226   were identical, see Mundry, 2014, for treating collinearity). For model selection, we used Akaike's

227   Information Criterion corrected for small sample size (AIC_c). We tested for an interviewer effect

228   by including interviewer as a random effect in the models (generalized linear mixed models,

229   GLMMs), but did not detect any (AIC GLMMs >AIC GLMs of the global models, respectively).

230   We accounted for model selection uncertainty (model weights ω_i were <0.9) using full-model

231   averaging (Symonds & Moussalli, 2011). To rank predictor variables in terms of importance, we

232   summed Akaike weights for each model in which the variable under consideration appeared

233   (Burnham & Anderson, 2002). We explored the direction of predictor impacts on the response

234   variable by calculating log odds ratios of the averaged estimates with 95% confidence intervals.

235   Statistical modelling was conducted in R (R Core Team, 2016).

236

237   [Please insert Table 1 here]

238   [Please insert Table 2 here]

239

240   **Results**

241   We conducted 215 interviews in Puerto Williams, seven in rural households, and 22 with

242   Navy post families. Only five people in Puerto Williams refused to participate. Of the 244

243   participants, 61.5% were female, mean participant's age was 39.5 years (SD 11.6, range 18-76

244   years), and mean residence time in the biosphere reserve was 11.6 years (SD 14.2, range one

245   month-66 years).

246   The Puerto Williams participants owned 121 dogs and 36 cats, predominantly for

247   companionship. The seven farm households owned 30 dogs and 15 cats, mainly kept as working

248   dogs and for rodent control, respectively. The 22 Navy families owned 17 dogs primarily for

249   companionship and two cats for rodent control. Two dogs and two cats stayed at the Navy post

250   when families were exchanged after one year ("inherited animals"), the others left with their

251   families. Reproductive control was moderate to high in Puerto Williams (41.7% of dogs and 19.4%

252   of cats not sterilized), but almost absent in rural areas (83.3% dogs, 93.3% cats) and Navy posts

253   (86.7% dogs, 100% cats, but 9 of 17 dogs were ≤1-year, Table 3). Additionally, four participants

254   had eliminated unwanted dog pups.

255   In Puerto Williams, over half of the dogs and around one third of the cats were vaccinated

256   against rabies (55.4% and 33.3%, respectively) and treated for parasites (60.3% and 36.1%,

257   respectively). Pet owners in rural households did not vaccinate against rabies, but treated for

258   parasites (100% dogs, 40.0% cats). At Navy posts, only dogs were vaccinated and dewormed

259   (64.7%). Pets in Puerto Williams, rural dogs, and dogs at Navy posts were provided mainly with

260   commercial food and/or meat (>77.7%). However, 35 village dogs (28.9%) were fed in more than

261   one household, and 74 interviewees in town (34.4%) reported feeding street dogs on a regular basis

262   (71.8% at least once a week), mostly with leftovers (73.5% of 83 mentioned food items).

263   Sixty-five of 168 dogs (38.7%) roamed freely day or night and 39 dogs (23.2%) were

264   always unrestricted. Using an extrapolated number of dogs for the 490 households in Puerto

265   Williams (n=275.8 with 1.4 dogs/household), we estimate that 84 dogs (30.6%) roam freely in

266   town during day or night. The most common method of dog restriction (69.4% in town, 53.3%

267   rural, 17.6% Navy posts) was keeping dogs in the house (63.6% of 121 responses), fewer were

268   kept free in the yard (18.2%) or leashed (18.2%). Reasons mentioned for allowing unrestricted

269   movement of dogs in town and rural environments were (i) the owner claimed animal freedom,

270   (ii) leashing may increase aggressiveness, (iii) acclimation to free-roaming and releasing energy,

271   (iv) the dog is not dangerous, and (v) unsuitable facilities (together 77.2% of 70 explanations).

272   Also, 44.0% of 91 non-pet owners thought that street dogs enjoyed their freedom, and most dog

273   owners (87.2% of 86) thought that street dogs roamed into the forest. Finally, 22 of 168 dogs

274   (13.1%) went missing between 12-24 hours during the last year (2014/15), among which 13 dogs

275   had disappeared up to one week before returning home. Cats disappeared more frequently (n=18,

276   34.0%); 14 cats for 2-7 days. Over the last 10 years, 35 pets (23 dogs, 12 cats) never returned.

277

278   [Please insert Table 3 here]

279

280   Free-roaming dogs not accompanied by people outside of town were frequently observed

281   on Navarino Island (63.9% of 244 participants), whereas cat sightings in the wild were almost

282   absent (6.1%, Fig. 2). The greatest distance of sighted dogs and cats was 19.4 km and 5.2 km from

283   the northern settled coast, respectively. Neither dogs nor cats were seen roaming around Navy

284   posts, except near the two posts on Navarino Island. Dogs were mostly observed in packs, with a

285   median pack size of four dogs (mean 6.6, SD 7.5, range 2-60, n=172 sightings), while only 9.2%

286   of the sightings were single dogs. Dog pups (abandoned or feral) outside Puerto Williams were

287   sighted by 52 participants (21.3%) with a mean litter size of 4.0 (SD 2.3, range 1-12). Four

288   participants observed pups and kittens (n=17) abandoned in cardboard boxes outside town.

289   Apparently, the landfill, approximately 500 m from Puerto Williams, was a point of attraction for

290   dogs, as 12 participants observed dog packs with a median size of eight (mean 10.75, SD 8.0, range

291   1-25, Fig. 2) in this area.

292

293   [Please insert Figure 2 here]

294

295   Over half of the participants (55.9%, n=222) on Navarino Island had experienced problems
296   with dogs in Puerto Williams during 2009-2015 (83.9% had occurred during the last year,
297   2014/15), whereas 41 participants (18.5%) reported problems outside the town (61.4% during
298   2014/2015). Predominant dog problems in town were conflicts with people (biting, attacking,
299   frightening, disease transmitting, accidents, and stealing; 40.6% of 143 problems, 24.1%
300   concerned children) and free-ranging domestic animals (cows, horses, and their offspring) in town,
301   mostly foals (37.1%, Fig. 3). Outside of town, people experienced conflicts between dogs and
302   domestic animals, particularly involving cattle (77.3% of 44 problems), whereas only two people
303   saw dogs feeding on wildfowl eggs (4.5%).

304   Beyond personal experiences, most participants thought that free-roaming dogs caused
305   problems both in and outside of town (91.9% and 89.2%, respectively). In town, suspected dog
306   problems mainly involved people (68.8% of 221 problems), whereas outside of town concerns
307   involved domestic animals as well as people (Fig. 3). Dog-wildlife conflicts (e.g., involving
308   guanacos) were only mentioned 19 times (9.4% of 202 problems). However, when asked directly
309   whether feral dogs could have negative impacts on wildlife and what kind of wildlife could be
310   affected, most participants said yes (80.8%, n=239) regarding birds (67.3% of 349 problems).
311   Guanacos were only mentioned 16 times among the affected wildlife (4.6%).

312   Regarding suspected cat problems, only one third of participants (33.8% of 240) associated
313   problems with them outside of town, particularly with cats harassing and eating wild birds and
314   their eggs (67.5% of 77 problems, Fig. 3).

315   Five of seven farm owners reported losing domestic animals due to unrestricted dogs from
316   Puerto Williams or feral dogs during 2014/15. The estimated total loss during these events were
317   62 calves, 25 cows, and 30 sheep, while 30 sheep and 2 calves were injured. The losses on the five
318   farms corresponded to 3.3%, 11.5%, 16.7%, 18.8%, and 35.0% (cows), and 75.0% (sheep) of
319   owned livestock.

320

321   [Please insert Figure 3 here]

322

323   Thirty-one village and rural dogs (18.5%) brought prey home, mainly invasive muskrats
324   (32.5%) and birds (27.5%, Fig. 4). Among avian prey were songbirds (Austral Blackbird *Curaeus*
325   *curaeus*, Austral Thrush *Turdus falcklandii*, Rufous-collared Sparrow *Zonotrichia capensis*),

326   waterbirds (terns, Upland Goose *Chloephaga picta*), and raptors (Chimango Caracara *Milvago*
327   *chimango*). Over one third of all dogs (n=64) were observed harassing (but not killing) other
328   animals, particularly birds (38.0% of 79 items mentioned: Chimango Caracara, Patagonian Sierra-
329   Finch *Phrygilus patagonicus*, Upland Goose, and ducks such as Flightless Steamer Ducks), other
330   dogs (16.5%), and horses (15.2%); three dogs harassed native mammals (i.e., foxes and seals).
331   Over half of all village and rural cats (n=27) brought prey home (birds were 57.6% of 33
332   prey items): among songbirds, the Austral Thrush, Fired-eyed Diucon *Xolmis pyrope,* House
333   Sparrow *Passer domesticus*, Patagonian Sierra-Finch, and among waterbirds, ducks and terns.
334   Birds were also the most commonly harassed prey group (72.0%) by 18 cats (only one species
335   referred to here: Patagonian Sierra-Finch). The 244 participants mentioned diverse food items they
336   thought feral dogs would eat (Fig. 4). Domestic livestock was the most important group mentioned
337   (39.9%), whereas native birds and guanacos were less recognized (15.2% and 2.2%, respectively).
338
339   [Please insert Figure 4 here]
340
341   Of 70 fecal samples from owned and feral dogs in rural zones of the CHBR, we could not
342   identify prey remains in seven, and 10 feces were excluded for only containing dog hair. The
343   subsequent diet analysis revealed that the main food item (64.4% of 59 prey occurrences) found
344   in 53 feces was ungulates (i.e., horses and cows, which could not be distinguished here), followed
345   by beavers (13.6%), birds (10.2%), mice (5.1%), rubbish (5.1%), and Fuegian red fox
346   (*Pseudalopex culpaeus,* 1.7%).
347
348   Three models best explained whether dogs would bring prey home (Table 4). The most
349   important variable with the highest summed Akaike weights (ω, upper limit=1.0) was LOCATION
350   (ω=0.99); FOOD (ω=0.54) and SEX (ω=0.30) had less importance. The averaged estimates
351   indicated that dogs in rural areas were more likely to bring prey home (Fig. 5A), whereas an
352   adequate diet and the dog's sex had little influence (their confidence intervals overlapped the odds
353   ratio at one). LOCATION (ω=0.99) and FOOD (ω=0.99) were the most important variables in the
354   cat model, whereas sex played a minor role (ω=0.24, Table 4). Based on the averaged model
355   estimates (Fig. 5B), there is evidence that rural cats that received more leftovers brought more prey
356   home than village cats, whereas the cat´s sex was a poor predictor. From the collinear variables

357   removed before modelling, only SIZE had a significant association with LOCATION and PREY,

358   respectively (Fisher's exact tests, p <0.001), indicating that not only rural, but also larger dogs

359   were more prone to prey upon wildlife.

360

361   [Please insert Table 4 here]

362

363   [Please insert Figure 5 here]

364

365   Importantly, participants suggested several measures to diminish the number of street dogs,

366   including reproductive control (18.9%, n=534 suggestions), registration (14.6%), responsible pet

367   husbandry (11.2%), establishing an animal shelter (10.5%), education and adoption campaigns

368   (9.2%), controls and penalties (8.4%), movement restriction (8.1%), animal health (7.3%), limiting

369   the number of dogs per family or not abandoning dogs (7.1%), and euthanasia (4.7%).

370

371   **Discussion**

372   In the absence of biological studies, this survey provides a first understanding of the

373   interactions of domestic carnivores with wildlife in a sub-Antarctic wilderness setting. A

374   representative sample of the local population in the Cape Horn Biosphere Reserve gave insight

375   into pet husbandry and perceptions of impacts of free-roaming dogs and cats. We found that free-

376   roaming dog packs were frequently observed (64% of participants) in natural areas on Navarino

377   Island. Many of these individuals may be owned, as many participants indicated their dogs were

378   not confined (65 of 168 dogs roamed freely day or night, and 22 dogs had even disappeared for

379   24 h or more). Further, travel distances of free-roaming owned rural dogs vary, with reports of 4

380   km (Sepúlveda et al., 2015) or up to 8-30 km (Meek, 1999). However, such large foray distances

381   are an exception. Finding a village dog at a distance >1 km from its home had a 10% chance in a

382   study of dogs scavenging sea-turtle nests (Ruiz-Izaguirre et al., 2014), and most rural dogs even

383   spent 95% of their time <200 m from their households (Sepúlveda et al., 2015).

384   Our findings indicate that there is evidence of a feral dog population on Navarino Island.

385   The participants reported sightings of unaccompanied dog packs in remote parts of the island (up

386   to 19.4 km from the northern settled coast, Fig. 2) and sightings of dog pups (feral or abandoned)

387   outside town (52 participants). They identified 52% of the 172 sightings as feral dogs. This may

be an over-estimate, but given that free-roaming village dogs are easily recognized in the small town of Puerto Williams, it is likely that participants could distinguish between owned and feral dogs. However, it is not clear whether this presumably feral population has achieved long-term human independence, as for example the dogs eradicated from Isabela Island, Galápagos (Reponen et al., 2014). The reported population of abandoned dog pups and missing dogs may have been recruited into feral dog packs (e.g., Boitani et al., 2017). The importance of the local landfill (12 sightings of dog packs of 8-11 animals on average) as a food subsidy warrants further investigation, as these novel ecosystems can produce a variety of positive and negative impacts on vertebrate species exploiting them (Boitani et al., 2017; Plaza & Lambertucci, 2017). For cats, the few sightings (5% of participants) in natural areas were along the northern-settled coast, except for one cat sighted 5.2 km south of the coast. Further phenotypical, genetic, and ecological research is needed to better understand the feral dog and possible feral cat population and their impacts on Navarino Island.

Although there were 227 dog sightings during 2014/2015, dog-wildlife conflicts of free-roaming dogs were hardly recognized (4.5% of 44 observed problems, Fig. 3). The direct observation of dog-wildlife interactions is probably a rare situation, particularly with mammals, as the mammalian community on Navarino Island is limited (Anderson et al., 2006). Only five terrestrial native species exist: two species each of bats and mice, and the vulnerable guanaco. Among exotic mammals, there are three elusive wild species (North American beaver, American mink *Neovison vison*, and muskrat) and free-ranging domestic mammals such as cows, horses, sheep, and pigs. Dog interactions with exotic mammals may not have been considered as true wildlife-conflict by the participants as there was a general consensus in the community about the need for a population reduction of exotic mammals such as mink and beavers (Schüttler et al., 2011).

Guanacos have not been sighted along the northern coast for many years (González, Zapata & Marín, 2002), and their densities were as low as 0.14 individuals/km^2 on the northeastern coast of Navarino Island during 2002-2005 (González, 2005). Thus, it is almost impossible to see depredation or harassment of guanacos by dogs (one piece of photographic evidence was taken by Denis Chevallay in 2002). However, individual dog attacks on rare species may impact their persistence substantially (e.g., pudus, Silva-Rodríguez & Sieving, 2012; mountain gazelles

418   *Gazella gazella*, Manor & Saltz, 2004). Therefore, future studies on dog impacts on the
419   southernmost isolated population of guanacos are an urgent need.

420   The likelihood of interactions among dogs and avian species has the potential to be much
421   higher, as birds, among them many seabirds, are the most diverse and abundant group among
422   vertebrates in the CHBR (Rozzi et al., 2006). Indeed, eleven dogs brought bird prey home, and 30
423   dogs were observed by their owners to harass birds (songbirds, waterbirds, and raptors, Fig. 4).
424   However, these experiences were not translated into the context of a possible "dog-wildlife"
425   conflict: only 9% of 202 suspected dog problems outside town were dog-wildlife problems (Fig.
426   3); most were dog-domestic animal (54%) or dog-people conflicts (35%). On the one hand, this
427   may be due to a lack of knowledge of the local fauna by short-term residents; further, Cape Horn
428   biocultural identity is missing in the classrooms. Rozzi et al. (2008) reported an absence of native
429   fauna in the minds of local short-term residents who primarily mentioned cosmopolitan roses and
430   apple trees as local plant species. On the other hand, the absence of dog-wildlife interactions in the
431   participants' minds might indicate that dogs are mainly perceived as domestic animals that act in
432   a human-dominated context and not as carnivores in a natural ecosystem. Personal safety was also
433   the most common public concern regarding free-roaming dogs and cats in central Italy (Slater et
434   al., 2008). This perception may be attributed to the historical attachment bonding between the dog-
435   human dyad believed to be similar to a child-parent relationship (review in Payne, Bennett &
436   McGreevy, 2015).

437   For cats, awareness of possible cat-wildlife problems, particularly with birds, was higher
438   (68% of 77 problems, Fig. 3). On the one hand, these problems might be more visible, at least for
439   cat owners, whose cats brought birds home (37% of cats in this study, Fig. 4). This number,
440   however, probably clearly underestimates true capture rates, as Loyd et al. (2013) demonstrated
441   with animal-borne video cameras worn by urban cats in the United States (see also Kays & DeWan,
442   2004). On the other hand, Arahori et al. (2017) showed that owners' views of their cats and dogs
443   differed; for example, cat owners had a weaker tendency to regard their pets as family members
444   than dog owners. This perception may also influence their view on how cats behave outside their
445   homes (i.e., as carnivorous species).

446   Besides prey brought home by dogs and cats, our diet analysis of dog feces showed that
447   dogs indeed preyed upon domestic animals such as cows and horses (64%); but beavers (14%) and
448   birds (10%) were present in feces as well. This finding is consistent with cow losses reported by

449   Navarino's farm owners. However, part of the diet might also be a result of scavenging animals

450   that died from other causes, such as disease (e.g., Butler & du Toit, 2002). More biological

451   methods, such as analyzing cat diet or observations of what free-roaming dogs and cats actually

452   do, are needed to further validate and complement the self-reported observations on wildlife-

453   interactions in this survey.

454   Finally, with GLMs, we showed that rural provenance, large dog size, and an adequately

455   food supply for cats played a significant role as predictors for bringing wildlife prey home. When

456   rural households are imbedded in wilderness settings and spatial and behavioral barriers between

457   domestic and wild animals lacking, the apparent consequence are higher depredation rates of

458   (larger) dogs and cats on wildlife. Increasing the confinement of those pets should thus be part of

459   management strategies. Unlike other studies, an inadequate food supply (i.e., higher percentage of

460   leftovers) was not associated with dogs preying upon wildlife. This may be due to methodological

461   differences. Silva-Rodríguez & Sieving (2011) and Ruiz-Izaguirre et al. (2014) considered body

462   condition score and metabolic energy intake, whereas we only relied on the participants'

463   statements. To some extent, the social desirability bias (where the participants wish to appear

464   socially or morally worthy, Maccoby & Maccoby, 1954) might underlie these differences by

465   biasing results toward more frequent feeding with a commercial food diet. While restricting

466   boundaries for farm dogs and cats is probably a difficult task due to their roles as working dogs or

467   for rodent control, the necessity of improving nutrition could be more acceptable to owners, not

468   only for lowering wildlife depredation, but also for pet welfare. In general, where pet owners are

469   less susceptible to arguments based on wildlife protection, welfare-based arguments (such as

470   reducing risks of road accidents by confinement) could represent an alternative approach to

471   enhance pet husbandry (Hall et al., 2006).

472

473   **Conclusions**

474   Unconfined dogs and cats in the Cape Horn Biosphere Reserve interact with wildlife,

475   although this is almost unrecognized by the local community, particularly with dogs. To guarantee

476   the future intactness of this wilderness area, it is essential to put the possible impacts of free-

477   roaming pet carnivores on wildlife into perspective. This should be done using an integrative

478   approach that respects the many dimensions of pet carnivores in their beneficial and problematic

479   interactions with their human, conspecific, and natural environment: (1) Although over half of pets

480   in Puerto Williams were sterilized, encouraging neutering, particularly in rural areas, could reduce

481   pet density and avoid elimination or abandonment of unwanted pups/kittens. Moreover, sterilized

482   dogs were described to show lower rates of escaping from home and less roaming behavior

483   (Neilson, Eckstein & Hart, 1997; Spain, Scarlett & Houpt, 2004, but see Garde et al., 2015), which

484   might lower their access to wildlife. (2) Despite its probable unpopularity (e.g., Grayson, Calver

485   & Styles, 2002), we recommend that dog and cat ownership should be completely banned in

486   families living in Navy posts, as they are located within wild insular environments (some in

487   National Parks) where pet interactions with wildlife can be particularly severe (Medina et al., 2011)

488   and pets can become feral. (3) The evidence of a feral population of dogs on Navarino Island

489   (where native predators are absent) urgently needs biological methods of confirmation such as

490   GPS monitoring (Young et al., 2011) and an assessment of its impacts. Feral dogs are still poorly

491   investigated (Boitani et al., 2017), and management implications for feral dogs are challenging

492   (i.e., they may include the removal of dogs) due to their avoidance of human contact (Boitani &

493   Ciucci, 1995) and restriction to natural habitats. (4) Increasing dog and cat confinement is

494   beneficial to prevent not only pet-wildlife interactions, but also many socio-economic problems.

495   In-house/yard confinement largely depends upon cultural settings (Hsu, Severinghaus & Serpell,

496   2003; Jackman & Rowan, 2007) and is low in many countries in Africa, Asia, and South America

497   (Reece, 2005), including Chile, which has high percentages of free-roaming dogs in rural settings

498   (67%, Acosta-Jamett et al., 2010; 84-91% Silva-Rodríguez & Sieving, 2012; 92% Sepúlveda et

499   al., 2014). A new Chilean law promoting responsible pet ownership was recently enacted (Ley

500   21.020, 2017) and could be a first step towards regulating confinement by national legislation

501   which was considered far from sufficient in 2014 by Bonacic & Abarca (2014). Meanwhile, bells,

502   electronic alarms, or colorful collar covers are an option for free-roaming cats to reduce

503   depredation rates on wildlife (Gordon, Matthaei & Van Heezik, 2010; Calver & Thomas, 2011;

504   Willson, Okunlola & Navak, 2015), as well as advice on environmental enrichment techniques for

505   indoor cats (Rochlitz, 2005), outdoor enclosures, and leash training (Hall et al., 2016). (5) Finally,

506   an instrument such as this survey can reveal what problems with free-roaming pets exist; thus, it

507   provides insight into impacts in the absence of biological studies or complementary to them (e.g.,

508   dogs interacting with rare and endemic mammals were only detected through interviews in Silva-

509   Rodríguez & Sieving, 2011). Owners' and non-owners' suggestions can also contribute to creating

510   acceptable measures towards responsible pet ownership (Calver et al., 2011). For the CHBR, in

511   addition to the above mentioned technical and legal solutions, social change to improve pet

512   management for wildlife benefits could be stimulated through education about the vulnerability of

513   native fauna to dogs and cats, attractive education material such as puppet videos, documentaries,

514   or animal-borne films for school pupils, and action days such as walking with leashed dogs or

515   breakfasts with dog owners (further examples in Miller, Ritchie & Weston, 2014).

516

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527

528   **References**

529   Acosta-Jamett G. 2009. The role of domestic dogs in diseases of significance to humans and

530   wildlife health in central Chile. D. Phil. Thesis, University of Edinburgh.

531   Acosta-Jamett G, Cleaveland S, Cunningham AA, Bronsvoort BM deC. 2010. Demography of

532   domestic dogs in rural and urban areas of the Coquimbo region of Chile and implications for

533   disease transmission. *Preventive Veterinary Medicine* 94:272-281.

534   Anderson CB, Rozzi R, Torres-Mura JC, McGehee SM, Sherriffs MF, Schüttler E, Rosemond AD.

535   2006. Exotic vertebrate fauna in the remote and pristine sub-Antarctic Cape Horn Archipelago,

536   Chile. *Biodiversity and Conservation* 15:3295-3313.

537   Arahori M, Kuroshimaa H, Horia Y, Takagia S, Chijiiwa H, Fujita K. 2017. Owners' view of their

538   pets' emotions, intellect, and mutual relationship: Cats and dogs compared. *Behavioural*

539   *Processes*. http://dx.doi.org/10.1016/j.beproc.2017.02.007.

540   Baker PJ, Boitani L, Harris S, Saunders G, White PCL. 2008. Terrestrial carnivores and human

541   food production: Impact and management. *Mammal Review* 38:123-166.

542 Bernard HR. 2006. Research methods in Anthropology. Qualitative and quantitative approaches.
543   Oxford: Altamira Press.

544 Boitani L, Ciucci P. 1995. Comparative social ecology of feral dogs and wolves. *Ethology Ecology*
545   *& Evolution* 7: 49-72.

546 Boitani L, Francisci F, Ciucci P, Andreoli G. 2017. The ecology and behavior of feral dogs: A case
547   study from central Italy. In: Serpell J, ed. The domestic dog. Its evolution, behavior and
548   interactions with people. Cambridge: Cambridge University Press, 342-368.

549 Bonacic C, Abarca K. 2014. Hacia una política y legislación para el control de poblaciones de
550   cánidos y calidad de vida de las personas: un enfoque multidisciplinario hacia una política y
551   legislación para el control de poblaciones de cánidos y calidad de vida de las personas. *Centro*
552   *de Políticas Públicas UC* 65:1-13.

553 Burnham KP, Anderson DR. 2002. Model selection and multimodel inference. A practical
554   information-theoretic approach. New York: Springer.

555 Butler JRA, du Toit JT. 2002. Diet of free-ranging domestic dogs (*Canis familiaris*) in rural
556   Zimbabwe: implications for wild scavengers on the periphery of wildlife reserves. *Animal*
557   *Conservation* 5:29-37.

558 Butler JRA, du Toit JT, Bingham J. 2004. Free-ranging domestic dogs *Canis familiaris* as
559   predators and prey in rural Zimbabwe: threats of competition and disease to large wild
560   carnivores. *Biological Conservation* 115:369-378.

561 Calver MC, Grayson J, Lilith M, Dickman CR. 2011. Applying the precautionary principle to the
562   issue of impacts by pet cats on urban wildlife. *Biological Conservation* 144:1895-1901.

563 Calver MC, Thomas S. 2011. Effectiveness of the Liberator™ in reducing predation on wildlife
564   by domestic cats. *Pacific Conservation Biology* 16:244-250.

565 Chehébar C, Martín S. 1989. Guía para el reconocimiento microscópico de los pelos de los
566   mamíferos de la Patagonia. *Doñana Acta Vertebrata* 16:247-291.

567 Cunazza C. 1991. El guanaco, una especie de fauna silvestre con futuro. Corporación Nacional
568   Forestal, Report Gerencia Técnica, Santiago, Chile.

569 Doherty TS, Dickman CR, Glen AS, Newsome TM, Nimmo DG, Ritchie EG, Vanak AT, Wirsing
570   AJ. 2017. The global impacts of domestic dogs on threatened vertebrates. *Biological*
571   *Conservation* 210:56-59.

572 Echegaray J, Vilà C. 2010. Noninvasive monitoring of wolves at the edge of their distribution and
573   the cost of their conservation. *Animal Conservation* 13:157-161.

574 Garde E, Pérez PE, Vanderstichel R, Dalla Villa PF, Serpell JA. 2015. Effects of surgical and
575   chemical sterilization on the behavior of free-roaming male dogs in Puerto Natales, Chile.
576   *Preventive Veterinary Medicine* 123:106-120.

577 Gompper ME. 2014a. The dog-human-wildlife interface: assessing the scope of the problem. In:
578   Gompper ME, ed. Free-ranging dogs and Wildlife Conservation. Oxford: Oxford University
579   Press, 9-54.

580 Gompper ME. 2014b. Introduction: outlining the ecological influences of a subsidized
581   domesticated predator. In: Gompper ME, ed. Free-ranging dogs and Wildlife Conservation.
582   Oxford: Oxford University Press, 1-8.

583 González-Esteban J, Villate I, Irizar I. 1996. Differentiating hair samples of the European mink
584   *(Mustela lutreola)*, the American mink *(Mustela vison)* and the European polecat *(Mustela
585   putorius)* using light microscopy. *Journal of Mammalogy* 270:458-461.

586 González BA. 2005. Informe sobre la situación de conservación de la población de guanacos
587   *(Lama guanicoe)* en la costa Noroeste de isla Navarino, XII Región de Chile. Report, Fundación
588   Biodiversitas, Chile.

589 González B, Zapata B, Marín JC. 2002. Situación de conservación y percepción local sobre la
590   población de guanacos más austral del mundo, Isla Navarino, XII Región de Chile. Report,
591   Pontificia Universidad Católica de Chile.

592 Gordon JK, Matthaei C, Van Heezik Y. 2010. Belled collars reduce catch of domestic cats in New
593   Zealand by half. *Wildlife Research* 37:372-378.

594 Gramza A, Teel T, VandeWoude S, Crooks K. 2016. Understanding public perceptions of risk
595   regarding outdoor pet cats to inform conservation action. *Conservation Biology* 30:276–286.

596 Grayson J, Calver MC, Styles I. 2002. Attitudes of suburban Western Australians to proposed cat
597   control legislation. *Australian Veterinary Journal* 80:536-543.

598 Hall CM, Adams NA, Bradley JS, Bryant KA, Davis AA, Dickman CR, Fjuita T, Kobayashi S,
599   Lepczyk CA, McBride EA, Pollock KH, Styles IM, van Heezik Y, Wang F, Calver MC. 2016.
600   Community attitudes and practices of urban residents regarding predation by pet cats on
601   wildlife: an international comparison. *PLoS ONE* 11(4): e0151962.

602 Hart LA, Yamamoto M. 2017. Dogs as helping partners and companions for humans. In: Serpell
603   J, ed. The domestic dog. Its evolution, behavior and interactions with people. Cambridge:
604   Cambridge University Press, 247-270.

605 Hsu Y, Severinghaus LL, Serpell JA. 2003. Dog keeping in Taiwan: its contribution to the problem
606   of free-roaming dogs. *Journal of Applied Animal Welfare Science* 6:1-23.

607 Hughes J, Macdonald DW. 2013. A review of the interactions between free-roaming domestic
608   dogs and wildlife. *Biological Conservation* 157:341-351.

609 Hughes KA, Pertierra LR, Molina-Montenegro MA, Convey P. 2015. Biological invasions in
610   terrestrial Antarctica: what is the current status and can we respond? *Biodiversity and*
611   *Conservation* 24:1031-1055.

612 Jackman J, Rowan A. 2007. Free-roaming dogs in developing countries: The benefits of capture,
613   neuter, and return programs. In: Salem DJ, Rowan AN, eds. The state of the animals.
614   Washington, DC: Humane Society Press, 55-78.

615 Kays RW, DeWan AA. 2004. Ecological impact of inside/outside house cats around a suburban
616   nature preserve. *Animal Conservation* 7:273-283.

617 Ley 21.020. 2017. Sobre tenencia responsable de mascotas y animales de compañía. Available at
618   https://www.leychile.cl/Navegar?idNorma=1106037&r=6 (accessed 15 September 2017).

619 Loyd KAT, Hernandez SM, Carroll JP, Abernathy KJ, Marshall GJ. 2013. Quantifying free-
620   roaming domestic cat predation using animal-borne video cameras. *Biological Conservation*
621   160:183-189.

622 Maccoby EE, Maccoby N. 1954. The interview: A tool of social science. In: Lindzey G, ed.
623   Handbook of Social Psychology. Cambridge: Addison-Wesley, 449-487.

624 Manor R, Saltz D. 2004. The impact of free-roaming dogs on gazelle kid/female ratio in a
625   fragmented area. *Biological Conservation* 119:231-236.

626 Matter HC, Daniels TJ. 2000. Dog ecology and population biology. In: Macpherson CNL, Meslin,
627   F, Wandeler AI, eds. Dogs, zoonoses and public health. Wallingford: CABI Publishing, 17-50.

628 Medina FM, Bonnaud E, Vidal E, Tershy BR, Zavaleta ES, Donlan CJ, Keitt BS, Le Corre M,
629   Horwath SV, Nogales M. 2011. A global review of the impacts of invasive cats on island
630   endangered vertebrates. *Global Change Biology* 17:3503-3510.

631 Meek PD. 1999. The movement, roaming behavior and home range of free-roaming domestic
632   dogs, *Canis lupus familiaris*, in coastal New South Wales. *Wildlife Research* 26:847-855.

633   Miller KK, Ritchie EG, Weston MA. 2014. The human dimensions of dog-wildlife interactions.
634   In: Gompper ME, ed. Free-ranging dogs and Wildlife Conservation. Oxford: Oxford University
635   Press, 286-304.

636   Mitchell BD, Banks PB. 2005. Do wild dogs exclude foxes? Evidence for competition from dietary
637   and spatial overlap. *Australian Ecology* 30:581-591.

638   Mittermeier RA, Mittermeier CG, Brooks TM, Pilgrim JD, Konstant WR, da Fonseca GAB,
639   Kormos C. 2003. Wilderness and biodiversity conservation. *Proceedings of the National*
640   *Academy of Sciences of the United States of America* 18:10309-10313.

641   Mundry R. 2014. Statistical issues and assumptions of phylogenetic generalized least squares. In:
642   Garamszegi L, ed. Modern phylogenetic comparative methods and their application in
643   Evolutionary Biology. Berlin, Heidelberg: Springer, 131-153.

644   Neilson JC, Eckstein RA, Hart BL. 1997. Effects of castration on problem behaviors in male dogs
645   with reference to age and duration of behavior. *Journal of the American Veterinary Medical*
646   *Association* 211:180-182.

647   Nogales M, Vidal E, Medina FM, Bonnaud E, Tershy BR, Campbell KJ, Zavaleta ES. 2013. Feral
648   cats and biodiversity conservation. The urgent prioritization of island management. *BioScience*
649   63:804-810.

650   O'Brien SJ, Johnson WE. 2007. The evolution of cats. *Scientific American* 297:68-75.

651   Payne E, Bennett PC, McGreevy PD. 2015. Current perspectives on attachment and bonding in
652   the dog-human dyad. *Psychology Research and Behaviour Management* 8:71-79.

653   Pisano E. 1977. Fitogeografía de Fuego-Patagonia chilena. I. Comunidades vegetales entre las
654   latitudes 52 y 56 S. *Anales del Instituto de la Patagonia* 8:121-250.

655   Plaza PI, Lambertucci SA. 2017. How are garbage dumps impacting vertebrate demography,
656   health, and conservation? *Global Ecology and Conservation* 12:9-20.Randi E. 2008. Detecting
657   hybridization between wild species and their domesticated relatives. *Molecular Ecology*
658   17:285-293.

659   R Core Team. 2016. R: A language and environment for statistical computing. R Foundation for
660   Statistical Computing, Vienna, Austria. Available at https://www.R-project.org/.

661   Reece JF. 2005. Dogs and dog control in developing countries. In: Salem DJ, Rowan AN, eds. The
662   state of the animals III, Washington, D.C.: Humane Society Press, 55-64.

663 Reponen SEM, Brown SK, Barnett BD, Sacks BN. 2014. Genetic and morphometric evidence on
664   a Galápagos Island exposes founder effects and diversification in the first-known (truly) feral
665   western dog population. *Molecular Ecology* 23:269-283.

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

668 Rozzi R, Massardo F, Berghöfer A, Anderson CB, Mansilla A, Mansilla M, Plana J, Berghöfer U,
669   Araya P, Barros E. 2006. Cape Horn Biosphere Reserve: Nomination document for the
670   incorporation of the Cape Horn Archipelago Territory into the Word Biosphere Reserve
671   Network. MaB Program – UNESCO. Punta Arenas: Ediciones de la Universidad de
672   Magallanes.

673 Rozzi R, Arango X, Massardo F, Anderson C, Heidinger K, Moses K. 2008. Field environmental
674   philosophy and biocultural conservation: The Omora Ethnobotanical Park Educational
675   Program. *Environmental Ethics* 30:325-336.

676 Ruiz-Izaguirre E, van Woersem A, Eilers K, van Wieren SE, Bosch G, van der Zijpp AJ, de Boer
677   IJM. 2014. Roaming characteristics and feeding practices of village dogs scavenging sea-turtle
678   nests. *Animal Conservation* 18:146-156.

679 Schalamon J, Ainoedhofer H, Singer G, Petnehazy T, Mayr J, Kiss K, Höllwarth ME. 2006.
680   Analysis of dog bites in children who are younger than 17 years. *Pediatrics* 117:e374-e379.

681 Schüttler E, Klenke R, McGehee S, Rozzi R, Jax K. 2009. Vulnerability of ground-nesting
682   waterbirds to predation by invasive American mink in the Cape Horn Biosphere Reserve, Chile.
683   *Biological Conservation* 142:1450-1460.

684 Schüttler E, Rozzi R, Jax K. 2011. Towards a societal discourse on invasive species management:
685   A case study of public perceptions of mink and beavers in Cape Horn. *Journal for Nature
686   Conservation* 19:175-184.

687 Sepúlveda MA, Singer RS, Silva-Rodríguez E, Stowhas P, Pelican K. 2014. Domestic dogs in
688   rural communities around protected areas: conservation problem or conflict solution? *PLoS
689   ONE* 9(1): e86152.

690 Sepúlveda MA, Pelican K, Cross P, Egurenc A, Singer R. 2015. Fine-scale movements of rural
691   free-ranging dogs in conservation areas in the temperate rainforest of the coastal range of
692   southern Chile. *Mammalian Biology* 80:290-297.

693   Sih A, Bolnick DI, Luttbeg B, Orrock JL, Peacor SD, Pintor LM, Preisser E, Rehage JS, Vonesh
694   JR. 2010. Predator-prey naïveté, antipredator behavior, and the ecology of predator invasions.
695   *Oikos* 119:610-621.
696   Silva-Rodríguez EA, Ortega-Solís GR, Jiménez JE. 2010. Conservation and ecological
697   implications of the use of space by chilla foxes and free-ranging dogs in a human-dominated
698   landscape in southern Chile. *Austral Ecology* 35:765-777.
699   Silva-Rodriguez EA, Sieving KE. 2011. Influence of care of domestic carnivores on their predation
700   on vertebrates. *Conservation Biology* 25:808-815.
701   Silva-Rodriguez EA, Sieving KE. 2012. Domestic dogs shape the landscape-scale distribution of
702   a threatened forest ungulate. *Biological Conservation* 150:103-110.
703   Slater MR, Di Nardo A, Pediconi O, Villa PD, Candeloro L, Alessandrini B, Del Papa S. 2008.
704   Free-roaming dogs and cats in central Italy: public perceptions of the problem. *Preventive*
705   *Veterinary Medicine* 84:27-47.
706   Spain CV, Scarlett JM, Houpt KA. 2004. Long-term risks and benefits of early-age gonadectomy
707   in dogs. *Journal of the American Veterinary Medical Association* 224:380-387.
708   Symonds MRE, Moussalli A. 2011. A brief guide to model selection, multimodel inference and
709   model averaging in behavioural ecology using Akaike's Information Criterion. *Behavioral*
710   *Ecology and Sociobiology* 65:13-21.
711   Vanak AT, Gompper ME. 2009. Dogs *Canis familiaris* as carnivores: their role and function in
712   intraguild competition. *Mammal Review* 39:265-283.
713   Vanak AT, Thaker M, Gompper ME. 2009. Experimental examination of behavioural interactions
714   between free-ranging wild and domestic canids. *Behavioral Ecology and Sociobiology* 64:279-
715   287.White PCL, Jennings NV, Renwick AR, Barker NHL. 2005. Questionnaires in ecology: a
716   review of past use and recommendations for best practice. *Journal of Applied Ecology* 42:421-
717   430.
718   Williams KJH, Weston MA, Henry S, Maguire GS. 2009. Birds and beaches, dogs and leashes:
719   Dog owners´ sense of obligation to leash dogs on beaches in Victoria, Australia. *Human*
720   *Dimensions of Wildlife* 14:89-101.
721   Willson SK, Okunlola IA, Novak JA. 2015. Birds be safe: Can a novel cat collar reduce avian
722   mortality by domestic cats (*Felis catus*)? *Global Ecology and Conservation* 3:359-366.Woods

723   M, McDonald RA, Harris S. 2003. Predation of wildlife by domestic cats *Felis catus* in Great

724   Britain. *Mammal Review* 33:174-188.

725 Young JK, Olson, KA, Reading RP, Amgalanbaatar S, Berger J. 2011. Is wildlife going to the

726   dogs? Impacts of feral and free-roaming dogs on wildlife populations. *BioScience* 61:125-132.

727 Zuur AF, Ieno EN, Elphick CS. 2010. A protocol of data exploration to avoid common statistical

728   problems. *Methods in Ecology & Evolution* 1:3-14.

729

Figure 1

Map of the Cape Horn Biosphere Reserve, southern Chile.

The Alberto de Agostini and Cape Horn National Parks are core areas of the CHBR and Yendegaia (in light grey) is a recently-created national park. The only large settlement (2,800 inhabitants) is Puerto Williams, on Navarino Island. Eleven Chilean Navy posts are located throughout the reserve on Tierra del Fuego Island (n=2), Navarino Island (n=2), and uninhabited islands (n=7); all are only accessible via maritime transport, except the western Navy post on Navarino Island.

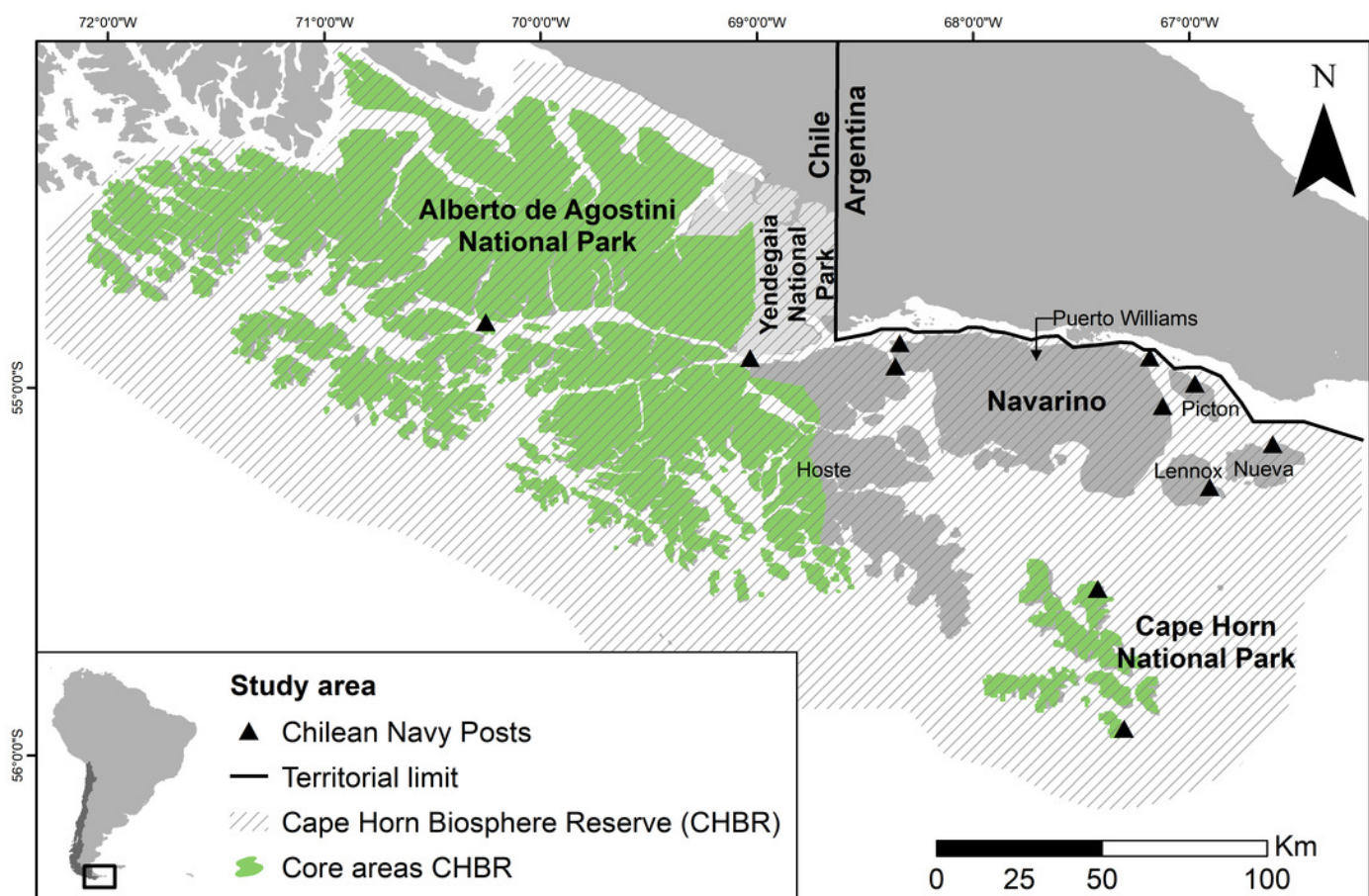



Figure 2

Free-roaming dog and cat sightings on Navarino Island, southern Chile.

Approximate sighting locations of unaccompanied adult dogs and cats, dog pups (abandoned or feral), and kittens (abandoned) from n=227 sightings by 143 participants during 2014/15. Dog sightings are shown in different classes of pack size.

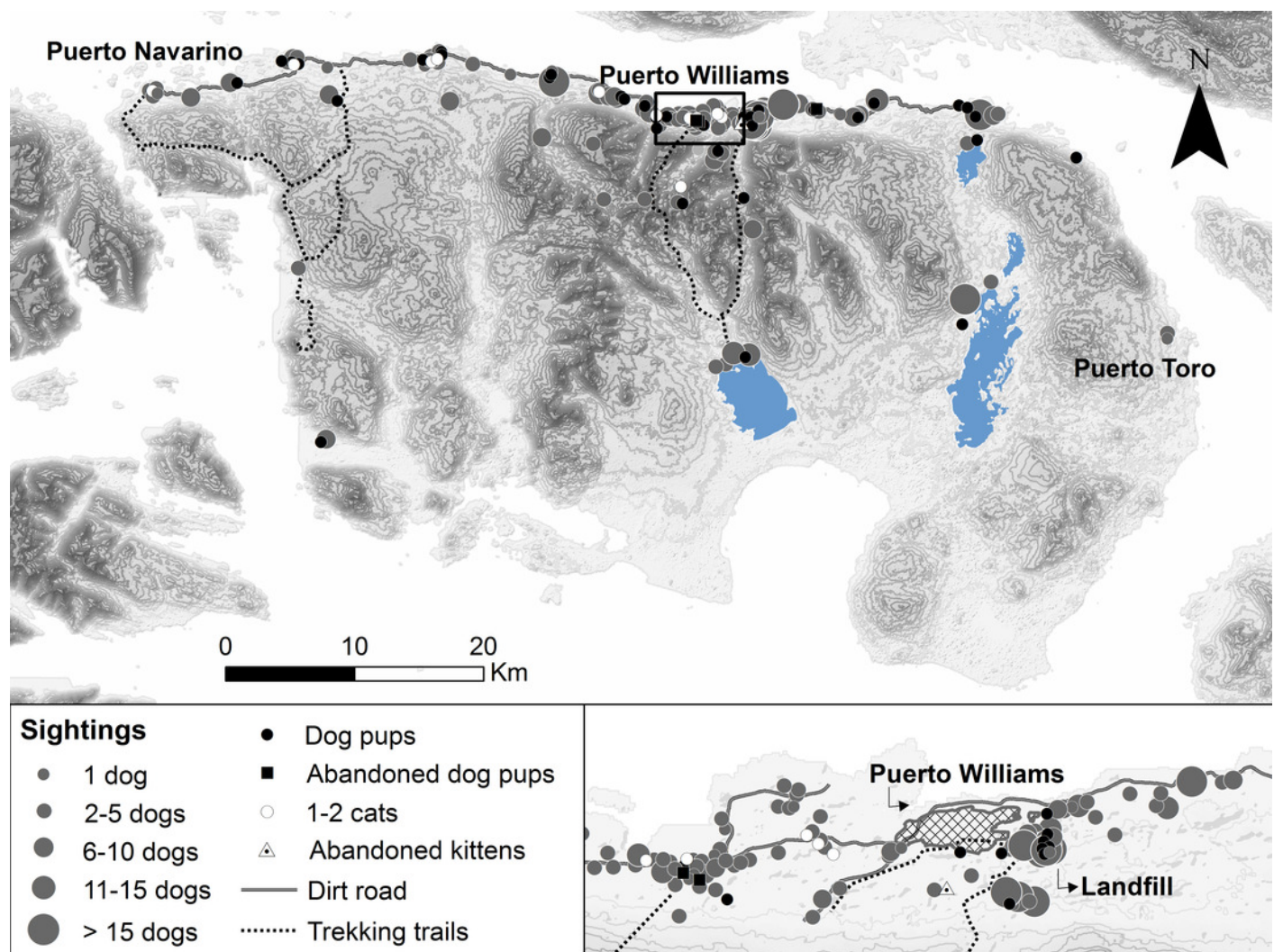



Figure 3

Experienced and suspected problems with dogs and cats in southern Chile.

Problematic experiences with dogs during 2009-2015 A) inside (n=143) and B) outside (n=44) of Puerto Williams, suspected dog problems (first problem mentioned) C) inside (n=221) and D) outside of town (n=202), and suspected cat problems (first problem mentioned) E) outside of town (n=77). Conflicts with people included biting, attacking, frightening, disease transmitting, accidents, and stealing. Dog-domestic animal problems referred to killing, attacking, or feeding on free-ranging domestic animals such as cows, horses (*Equus caballus*), sheep, pigs (*Sus scrofa*), and cats, whereas cat-domestic animal problems referred to preying upon chickens (*Gallus gallus domesticus*). Conflicts with wildlife included killing wild animals such as birds and their eggs, North American beavers (*Castor canadensis*), and guanacos, or harming ecosystems. Conflicts with conspecifics were fights among dog packs or between cats, and disease transmission. Dog feces and waste dispersing were considered as hygienic problems. "Other" includes dog and cat overpopulation, bad image for tourists, and barking. Images of animals represent predominant animals involved in dog/cat problems.

Experienced dog problems (%)

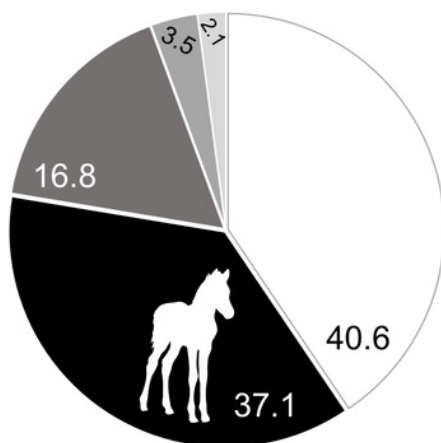
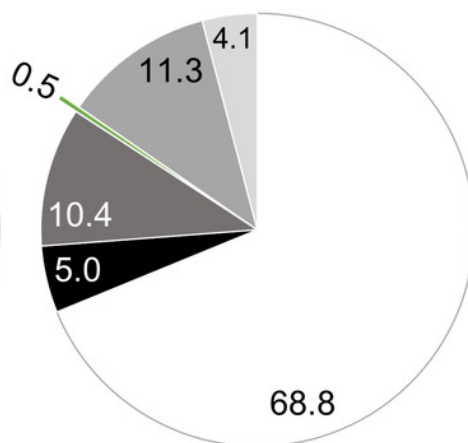
Suspected dog problems (%)

Suspected cat problems (%)

A Inside town

3.5 2.1
16.8
40.6
37.1

C Inside town

0.5
4.1
11.3
10.4
5.0
68.8

Problems with:

☐ People
■ Domestic animals
■ Conspecifics
■ Wildlife
■ Hygiene
☐ Other

B Outside town

4.5
6.8
11.4
77.3

D Outside town

0.5
9.4
1.5
35.1
53.5

E Outside town

Rest all 1.3
27.3
67.5

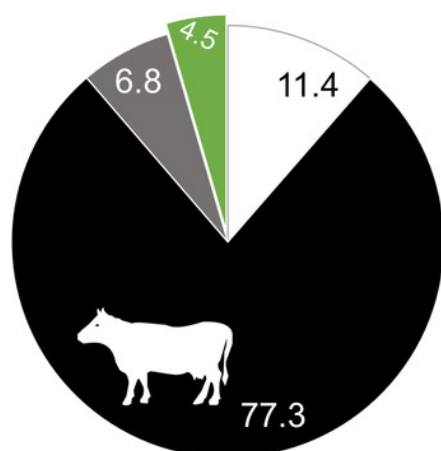
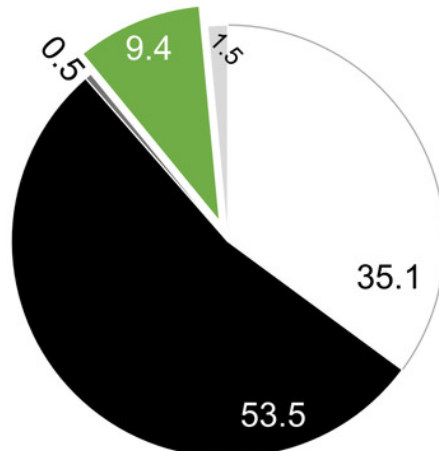
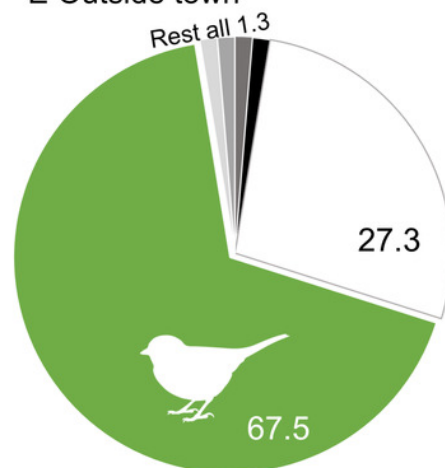



Figure 4

Preyed and harassed animals by dogs and cats, and suspected feral dog prey in southern Chile.

Prey brought to owners by 31 of 168 dogs (n=40 mentioned items), animals observed to be harassed by 64 dogs (n=79 items), prey brought to owners by 27 of 52 cats (n=33 items), animals observed to be harassed by 19 cats (n=25 items), and suspected prey of feral dogs (n=494 items) by 244 participants. "Other" includes fish (dog prey); fish, foxes, and seals, (harassed by dogs); bats (cat prey); and bird and horse feces, fish bait, foxes, seals, and vegetable material (suspected feral dog prey). "Small livestock" refer to chickens, pigs, and sheep. All bird species mentioned were native, except for the house sparrow, species mentioned among the cat prey.

Note: Auto Gamma Correction was used for the image. This only affects the reviewing manuscript. See original source image if needed for review.

		Dogs		**Cats**		**Feral dogs**
		Prey	Harassed	Prey	Harassed	Suspected prey
Natives	Birds	●	●	●	●	●
	Guanacos	○	○	○	○	●
Invasives	Beavers	○	○	○	○	●
	Mink	●	●	○	○	●
	Muskrats	●	○	○	○	●
Livestock	Cows	○	●	○	○	●
	Horses	●	●	○	○	●
	Small livestock	●	○	○	○	●
Pets	Cats	●	●	○	○	○
	Dogs	○	●	○	○	●
Other	Mice	●	●	●	●	●
	Carcasses					●
	Waste					●
	Other	○	○	●	○	●

Legend:

○ 0 %

● 1-20 %

● 21-40 %

● 41-60 %

● 61-80 %

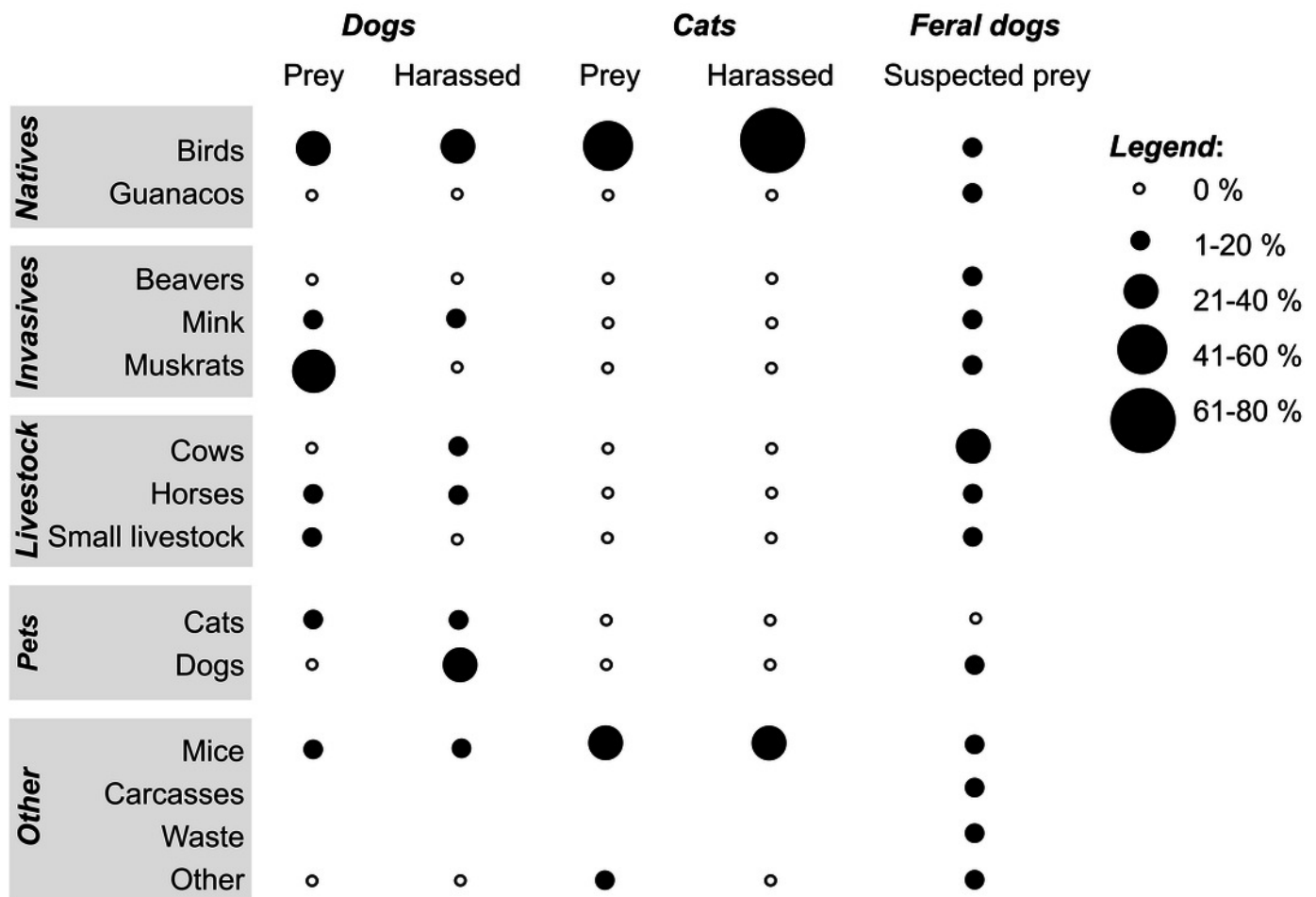
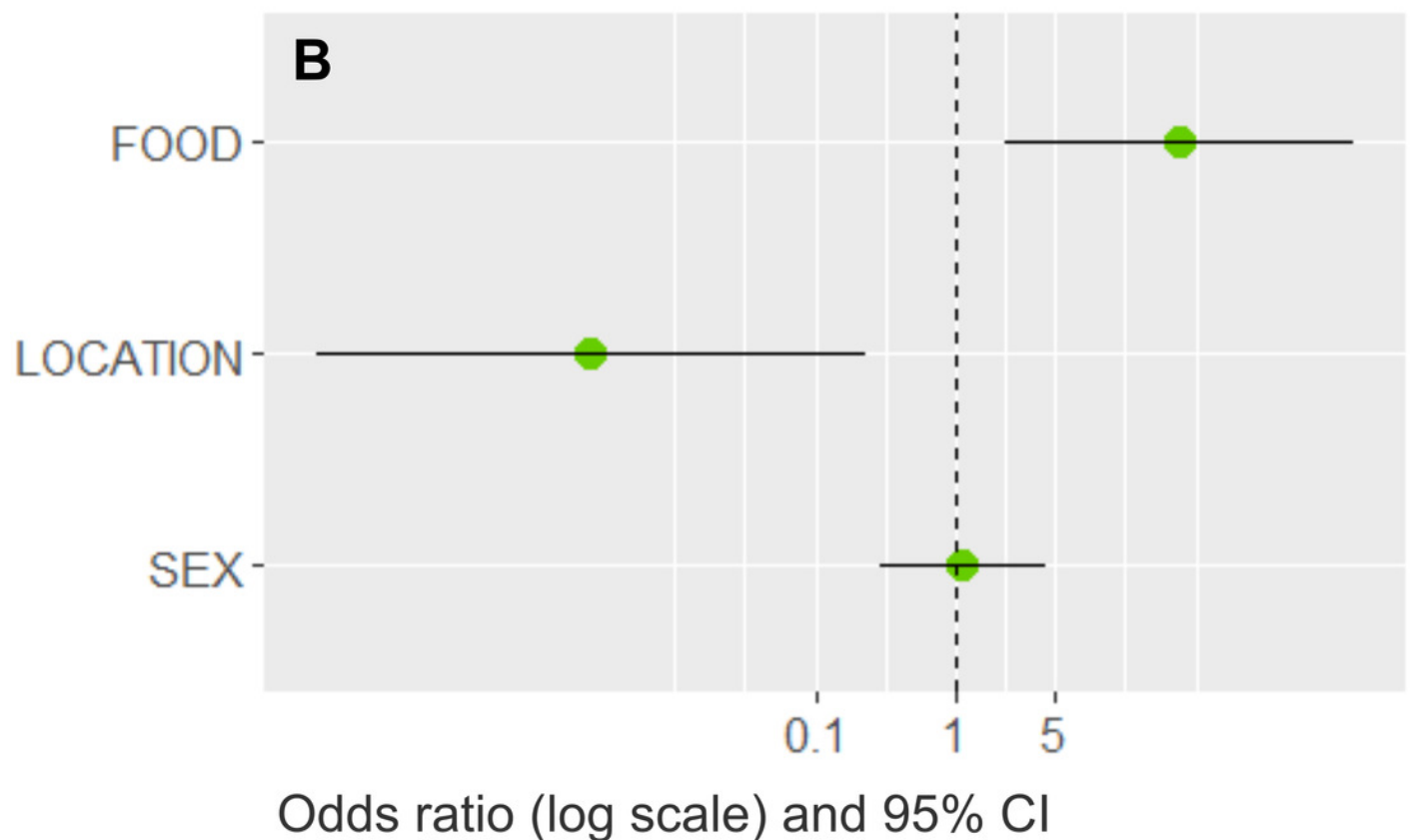
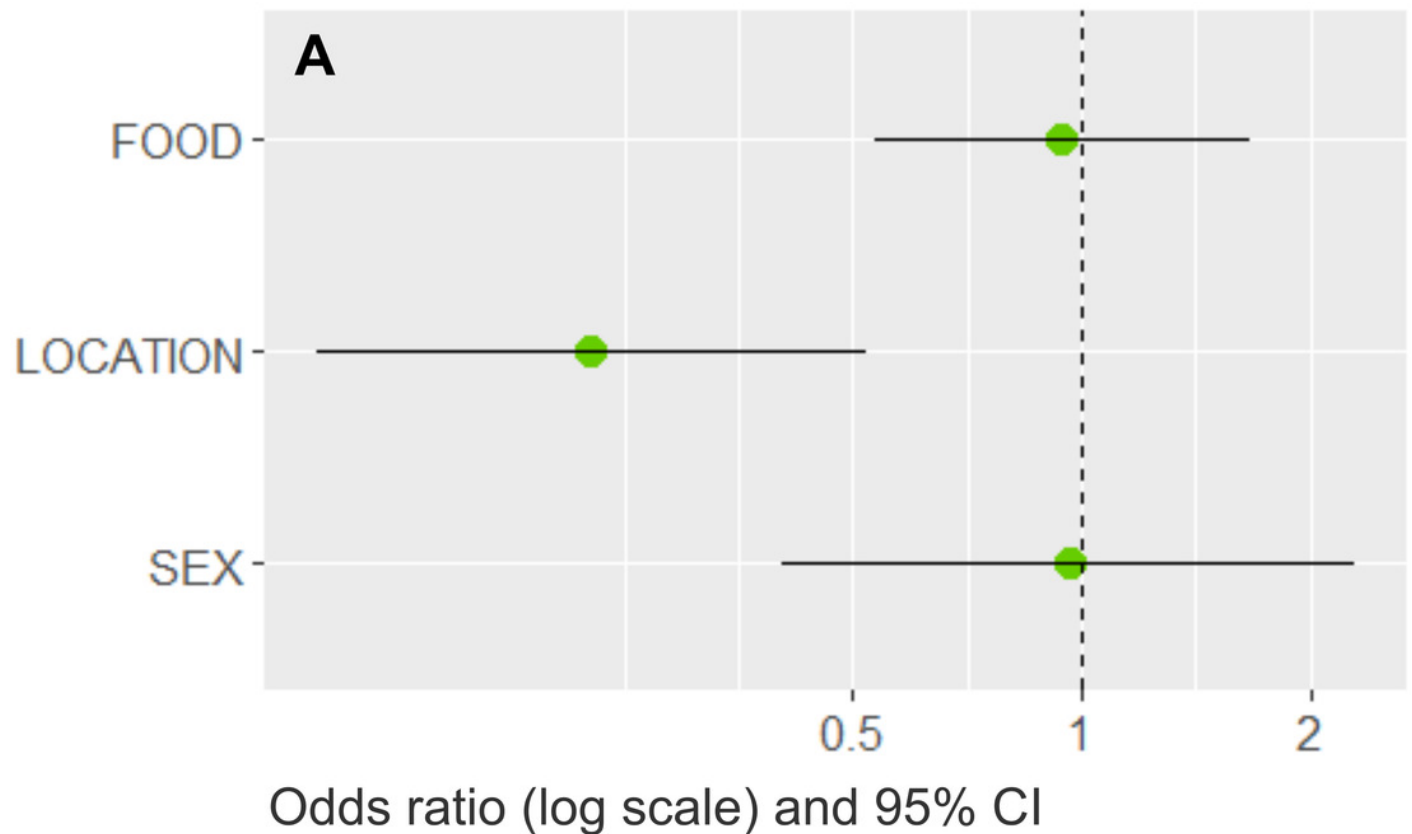



Figure 5

Model averaged odds ratios for models predicting dog and cat wildlife interactions in southern Chile.

Plots show the model averaged parameter estimates as odds ratios on a log scale with 95% confidence intervals (CI) for A) dog model and B) cat model, where LOCATION (dogs and cats) and FOOD (only cats) best predicted whether pets brought wildlife prey home. The other variables had confidence intervals that clearly overlapped the dashed line at 1, which implies that there is no direction of the parameter estimate.

Odds ratio (log scale) and 95% CI

Odds ratio (log scale) and 95% CI

Candidate models for predicting dog and cat wildlife interactions in southern Chile.

A detailed description of the response and predictor variables is provided in Table 2.

Candidate model sets	Response variable	Quantitative value of response variable	Predictor variables	n**
Dog model	PREY	19.0% of dogs brought prey home	FOOD+LOCATION+SEX SIZE* STERILIZED*	163
Cat model	PREY	51.9% of cats brought prey home	FOOD+LOCATION+SEX STERILIZED*	52

1   * Predictor variables not included in final model set due to collinearity

2   ** We deleted five missing observations from the dog model (3.0%) and one from the cat model (1.9%)

Variable description of candidate models for predicting dog and cat wildlife interactions in southern Chile.

The variable description refers to the questionnaire (see Supplementary Material S1).

Variable	Variable type	Variable description and question number	Categories
PREY	Response	Dog/cat brought wildlife prey home (Q25)	Yes/no
FOOD	Predictor	Feeding of participant's dog/cat with leftovers, commercial food/meat, or both (Q15)	0=leftovers 1=leftovers and commercial food/meat 2=commercial food/meat
LOCATION	Predictor	Dog/cat lives in rural environment (farm /Navy post) or in Puerto Williams	Rural/village
SEX	Predictor	Dog's/cat's sex (Q2)	F=Female, M=Male
SIZE*	Predictor	Dog's size (mean of two independent estimations by ES and LSA, Q42)	1=small, 1.5=small to medium-sized, 2=medium-sized, 2.5=medium-sized to large, 3=large
STERILIZED	Predictor	Dog/cat is sterilized (Q11)	0=not sterilized 1=pet's age<1 year 2=sterilized

1 * Variable only used in the dog model, not in the cat model

Demographic dog and cat data, and husbandry results from southern Chile.

We obtained data on owned dog and cat populations via questionnaires from households in Puerto Williams (n=215), accessible farm households on Navarino Island (n=7), and Navy families (n=22, data from two years) living on the 11 Navy posts on different islands within the CHBR.

	Town households (n=215)		Farm households (n=7)		Navy posts (n=22)	
	Dogs	*Cats*	*Dogs*	*Cats*	*Dogs*	*Cats*
Demographic data						
Households with pet ownership (%)	85 (39.5)	30 (14.0)	6 (85.7)	6 (85.7)	19 (86.4)	4 (18.2)
Mean pet number per household (SD)	1.4 (0.9)	1.2 (0.6)	5 (3.3)	2.5 (2.5)	1.3 (0.5)	1.0 (0.0)
Total pet number	121	36	30	15	17	2
Male:female ratio	1.3:1	0.7:1	2:1	0.3:1	0.7:1	0:1
Mean pet age (SD)	3.7 (3.8)	4.8 (4.1)	3.8 (4.6)	3.0 (3.0)	3.0 (3.7)	3.3 (1.1)
Number of offspring in previous year	16	0	21	7	9	0
Local origin (CHBR, %)	66.1	66.7	100	100	29.4	100
Reproductive control						
Females spayed; males neutered (%)	66.7; 52.2	71.4; 93.3	10.0; 20.0	8.3; 0.0	11.1; 16.7	0.0; 0.0
Health						
Vaccinated against rabies (%)	55.4	33.3	0.0	0.0	64.7	0.0
Treated for parasites (%)	60.3	36.1	100.0	40.0	64.7	50.0
Food provisioning						
Commercial food and/or meat (%)	77.7	94.4	86.7	20.0	82.3	50.0
Leftovers (%)	12.4	0.0	13.3	33.3	5.9	0.0
Mix of above (%)	9.9	5.6	0.0	46.7	11.8	50.0
Dog confinement						
Free-roaming during day or night (%)	30.6	-	46.7	-	82.4	-
24-h free-roaming (%)	19.0	-	30.0	-	41.2	-

Best-ranked generalized linear models for predicting dog and cat wildlife interactions in southern Chile.

Summary of model selection for models with ΔAIC_c <2. K indicates number of parameters per model, ΔAIC_c distance from lowest AIC_c, and ω_i model weight.

Model set	Competing models	k	AIC_c	ΔAIC_c	ω_i
Dog model	FOOD+LOCATION	3	150.72	0.00	0.37
	LOCATION	2	151.03	0.32	0.32
	FOOD+LOCATION+SEX	4	152.32	1.60	0.17
Cat model	FOOD+LOCATION	3	62.19	0.00	0.75