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Perceptions of Veterinarians in British Columbia of Cat Management Strategies to Reduce Cat Overpopulation and Impacts on Wildlife Populations

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ABSTRACT Free-roaming cats present a multidisciplinary challenge for wildlife conservation and feline welfare. Veterinary professionals are critical stakeholders in the issue of free-roaming cats, making it imperative that their attitudes and perspectives are well understood. In this study, we conducted an electronic survey of veterinarians practicing across British Columbia to evaluate their perceptions of 1) whether cat overpopulation is a concern, 2) the impacts of cats on wildlife, and 3) alternative management strategies for dealing with cat overpopulation. Of the 389 respondents, 56% agreed that cat overpopulation was a local problem, and 91% agreed that veterinarians play a role in reducing cat overpopulation. Veterinarians in rural communities had a greater involvement in cat overpopulation and perceived it as more problematic than their urban colleagues. The majority (70%) of veterinarians reported that they performed early-age sterilization, supported the principle of low-cost spay-neuter services (67%), and 65% of them were involved in these services. Just over half (54%) of respondents reported that they provide permanent identification to cats, typically offering both microchips and tattoos. Veterinarians were less cohesive on their perceptions of the impact of

free-roaming cats on wildlife: 53% agreed that after habitat loss cats are one of the most significant, direct causes of bird and wildlife mortality, while 30% were neutral and 17% disagreed. Fifty-six percent of veterinarians felt that keeping cats indoors would be one of the most effective strategies to reduce cat impacts on wildlife, but they also felt that public education programs and low-cost spay-neuter programs would be effective and more popular with cat owners. Most veterinarians (79%) recommended against unsupervised outdoor access, citing safety and disease risks. Rodent control was the most common reason for not recommending an indoor lifestyle. Overall, our survey results suggest that veterinarians are committed participants in the prevention of cat overpopulation. Conservationists need to focus on increased engagement with veterinarians regarding the impact of cats on wildlife.

Keywords: free-roaming cats, human–animal interaction, veterinarian, wildlife conservation



Due to their popularity as a companion animal, and their substantial reproductive capacity, domestic cats (*Felis domesticus*) are distributed nearly globally, with a population estimate of 600 million individuals (Peterson, Hartis, Rodriguez, Green, & Lepczyk, 2012). Free-roaming cats exist along a continuum, ranging from owned family pets roaming unsupervised off the owner's property to unowned feral cats and managed feral cat colonies. There are 94.2 million owned cats in the United States (US) (American Pet Products Association, 2017) and 8.8 million in Canada (Canadian Animal Health Institute, 2016), and an estimated 40–70% of these are free-roaming (Blancher, 2013; Loss, Will, & Marra, 2013). The actual number of feral cats in North America is unknown, but available estimates in the US range from “tens of millions” (Levy & Crawford, 2004) to 60–100 million (Jessup, 2004). In Canada, it is estimated that there are from 1.4 to 4.2 million feral cats (Blancher, 2013).

Non-native mammalian species have had devastating impacts on biodiversity, with cats and introduced rodents having the greatest detrimental effects (Doherty, Glen, Nimmo, Ritchie, & Dickman, 2016). Worldwide, cat predation is the primary threat for 38 critically endangered species, has caused the extinction of 63 species (Doherty et al., 2016), and has had significant impacts on native wildlife in mainland regions (Lepczyk, Mertig, & Liu, 2004; Loss & Marra, 2017; Woinarski et al., 2017). Each year, free-roaming cats kill an estimated 1.3–4.0 billion birds and 6.3–22.3 billion mammals in the US (Loss et al., 2013) and an estimated 100–350 million birds in Canada (Blancher, 2013). Unfortunately, cats are not just depredating animals that would have died from other sources, but instead serve as an added source of mortality (van Heezik, Smyth, Adams, & Gordon, 2010). Given these enormous mortality estimates, free-roaming cats have obvious impacts on the welfare and conservation of wildlife, but there are also significant welfare implications for free-roaming cats, especially feral cats, who suffer from trauma, extreme temperatures, starvation, dehydration, and disease (Jessup, 2004; Nutter, Levine, & Stoskopf, 2004).

The suitability of various management and mitigation strategies for managing free-roaming cats differs between unowned and owned cats. Populations of feral cats can be reduced by removing individuals through adoption, sanctuary transfers, or euthanasia, reducing reproduction through trap-neuter-return (TNR) programs, and restricting the free-roaming of owned cats so that they do not contribute to the existing feral population. With the exception of very small, isolated feral populations, trap-neuter-release programs when used as a sole strategy are ineffective at reducing feral cat populations over reasonable time frames (Boone, 2015; Longcore, Rich, & Sullivan, 2009; Loyd & DeVore, 2010; Miller et al., 2014). Individual removals are more effective (Andersen, Martin, & Roemer, 2004; Longcore et al., 2009; Loyd & DeVore, 2010), so any management program should implement some degree of high-volume

adoptions, sanctuary transfers, and humane euthanasia. Large-scale TNR projects documenting population-level impacts, removed approximately half of the individuals primarily through adoptions (Levy, Gale, & Gale, 2003; Levy, Isaza, & Scott, 2014).

Strategies to reduce the number of unwanted cats in the owned population can be approached by increasing the number of animals sterilized through low-cost spay-neuter services, avoiding unwanted litters through early-age sterilization, and encouraging permanent identification to improve reclamation rates at shelters. Wildlife predation by owned cats can be prevented by discouraging owners from allowing their cats to roam unsupervised, or at the very least, it can be reduced to some degree by using anti-predation cat collars (Hall, Fontaine, Bryant, & Calver, 2015).

The management of free-roaming cats is a complex issue requiring the integrated cooperation of stakeholders with expertise in population ecology, animal welfare, feline behavior, social science, public health, and veterinary medicine. While perspectives on the free-roaming-cat issue have been assessed in surveys of the general public, conservationists, and cat colony caretakers (Dabritz, Atwill, Gardner, Miller, & Conrad, 2006; Lord, 2008; Peterson et al., 2012; Wald, Lohr, Lepczyk, Jacobson, & Cox, 2016), knowledge on the veterinary perspective is limited to a single survey of veterinary faculty in the US (Salo & Stone, 2015).

In this study, we surveyed veterinarians across British Columbia (BC) with the goal of understanding their perceptions of several aspects of the free-roaming-cat issue. Our first objective was to gather veterinarian attitudes of, and involvement in, initiatives toward increasing sterilization rates of the owned pet cat population and providing means for permanent identification. Our second objective was to examine veterinarian perceptions of the issue of cat overpopulation including the risks posed by free-roaming cats and perceptions of the efficacy and public popularity of different approaches and tools for managing cat overpopulation and cat predation. Direct interaction with cat owners and clinical experience provide veterinarians with a unique insight into cat owners' motivations and the ability to identify limiting factors of cat management techniques. An understanding of veterinary perspectives is essential toward developing effective management approaches and increasing the level of collaboration among conservationists, humane groups, and veterinarians on the free-roaming-cat issue.

Methods

Ethical Review Process

An ethics review was not required for this study conducted during an undergraduate co-operative education work term because the research was entirely under the control of an outside agency with no research affiliation with the university, the research was not supervised by university faculty or staff, the student did not use the specific research project for academic credit, the research did not use university resources, and finally, we did not make affiliations with the university in subsequent reporting (University of Victoria, 2018). Various protocols were used to ensure that participants were treated ethically: participation was voluntary, the questionnaire could be anonymous, and confidentiality was protected by removing any names from the dataset before analysis. We also did not exclude any persons, and there was no risk to participants.

Participants and Procedure

In March 2016, an online questionnaire was sent to 1,458 practicing or retired veterinarians registered with the College of Veterinarians of British Columbia. Eligible participants were given two weeks to complete the survey, with an email reminder sent three days before the deadline.

Table 1. Demographics of veterinarians participating in the web-based questionnaire investigating perceptions of cat overpopulation in British Columbia (BC).

Variable	Number (%) of Survey Respondents	Number (%) of Practicing BC Veterinarians
<i>Region</i>	387	1,389
Lower Mainland	180 (46.5)	731 (52.6)
Vancouver Island	112 (28.9)	348 (25.1)
Thompson/Okanagan	50 (12.9)	173 (12.5)
Northern British Columbia	22 (5.7)	67 (4.8)
Kootenays	18 (4.7)	49 (3.5)
Cariboo/Chilcotin	5 (1.3)	21 (1.5)
<i>City Population</i>	386	1,389
100–4,999	14 (3.6)	137 (9.9)
5,000–19,999	67 (17.4)	248 (17.9)
20,000–49,999	50 (13.0)	133 (9.6)
50,000–99,999	85 (22.0)	333 (24.0)
100,000 and more	170 (44.0)	538 (38.7)
<i>Gender</i>	356	1,153
Female	213 (59.8)	694 (60.2)
Male	132 (37.1)	459 (39.8)
Prefer not to answer	11 (3.1)	^a
<i>Age</i>	353	^a
20–29	22 (6.2)	^a
30–39	82 (23.2)	^a
40–49	78 (22.1)	^a
50–59	106 (30.0)	^a
60 or older	57 (16.2)	^a
Prefer not to answer	8 (2.3)	^a
<i>Number of Years in Practice</i>	355	^a
0–9	90 (25.4)	^a
10–14	31 (8.7)	^a
15–19	55 (15.5)	^a
20–24	42 (11.8)	^a
25–29	48 (13.5)	^a
30 or more	89 (25.1)	^a
<i>Number of Full-time Veterinarians</i>	332	^a
1	91 (27.4)	^a
2–3	147 (44.3)	^a
4–5	61 (18.4)	^a
6 or more	33 (9.9)	^a

^aData not available.

There was a small incentive (the chance to win a donated case of Okanagan wine) for survey completion. After removal of duplicates and incomplete surveys ($n = 25$), we received 389 individual responses: a 26.7% response rate. The majority of respondents were female (59.8%), aged between 40 and 59 years of age (52.1%), and had been in practice for at least 10 years (75%). The full demographic characteristics of the respondents are summarized in Table 1. There were no significant differences between survey respondents and the overall population of veterinarians in BC (data obtained from the College of British Columbia Veterinarians, March 2017) in terms of gender ($\chi^2 = 0.08$, $df = 1$, $n = 1,509$, $p = 0.77$), geographic region in which veterinarians worked ($\chi^2 = 1.23$, $df = 5$, $n = 1,776$, $p = 0.94$), and municipal-population size ($\chi^2 = 3.37$, $df = 4$, $n = 1,775$, $p = 0.50$).

Questionnaire

The first section of the online questionnaire obtained information on region and community size served and then focused on veterinarians' perceptions of cat overpopulation, including whether or not cat overpopulation was a local issue. The second section contained questions regarding the veterinarians' involvement in and support for low-cost sterilization services and the type of permanent identification offered (if any) for owned cats. The third section of the questionnaire focused on the perceptions of veterinarians on the impact of free-roaming cats on wildlife and the efficacy, practicality, and popularity of different cat management and mitigation options. Veterinarians were then asked to provide their recommendations for indoor and outdoor access for owned cats and their rationale for them. The final section of the questionnaire obtained demographic information from each veterinarian, such as gender, age, years in practice, and clinic size.

For some questions, respondents were asked to describe their level of agreement using a 5-point Likert-scale (1 = "strongly agree," 3 = "neutral," and 5 = "strongly disagree"). Other questions required respondents to select from multiple options, choosing the top four answers, or all applicable answers with an option of writing in an additional answer. The full questionnaire is available as an online supplemental file. Some survey questions were omitted from discussion in this manuscript because of similarity to other questions or ambiguity.

Data Analysis

Descriptive analyses were performed on all quantitative variables and consisted of frequency counts and proportions of categorical and Likert-scale variables. Respondents' answers to open-ended questions were reviewed, categorized based on similarities, and tallied. Respondents were able to proceed through the survey without providing answers to all questions, resulting in variable sample sizes across questions.

Correlation coefficients between demographic variables were assessed using Cramer's V (Φ) if the variables were categorical or Kendall's tau if variables were ordinal. Univariate analyses were conducted between all predictor variables, with p -values of < 0.05 considered significant. A chi-square test (χ^2) was used for categorical variables if each cell in the contingency table had a value greater than five; otherwise, a two-sided Fisher's exact test (no test statistic or degrees of freedom reported) was used. Significant dichotomous variables ($p < 0.05$) were further evaluated using univariate logistic regression (z). Questions with Likert-scale responses were assumed to be ordinal variables and a non-parametric Kruskal-Wallis equality-of-populations rank test (χ^2) was used to compare each with the demographic variables. Significant variables ($p < 0.05$) were further evaluated using a Dunn test with a Bonferroni correction (z) to examine pairwise comparisons. Due to the large number of variables analyzed, only those deemed to be most relevant will be reported in the results. Analyses were completed using STATA IC13 (StataCorp LP 2013, College Station, TX).

Results

Perceptions of Cat Overpopulation

Overall, 91% (339/374) of the respondents felt that veterinarians have a role in controlling unowned cat populations, and just over half (56%; 215/387) reported that cat overpopulation was a concern in their community (Table 2). Veterinarians' perception of cat overpopulation was significantly associated with the population size of the city ($\chi^2 = 9.91$, $df = 4$, $n = 384$, $p < 0.001$) and region ($\chi^2 = 44.67$, $df = 5$, $n = 385$, $p < 0.001$). Specifically, veterinarians

Table 2. Descriptive statistics of veterinarians' perceptions of cat overpopulation and on contributions in controlling the stray and feral cat population.

Variable	Number of Respondents	%
<i>Cat Overpopulation is a Problem in Your Community</i>		
Strongly agree	47	12.1
Agree	168	43.4
Neutral	86	22.2
Disagree	72	18.6
Strongly disagree	14	3.6
<i>If Agree or Strongly Agree to Above Question, in What Way is Cat Overpopulation a Problem</i>		
Shelters are overcapacity	191	88.8
Many stray and feral cats	178	82.8
Presence of community cat colonies	114	53.0
Cat fighting and antisocial behavior	78	36.3
Other	20	9.3
<i>Veterinarians Have a Role in Helping to Prevent and Control Stray and Feral Cat Populations</i>		
Strongly agree	119	31.8
Agree	220	58.8
Neutral	21	5.6
Disagree	7	1.9
Strongly disagree	7	1.9
<i>*What Are the Issues Faced by Veterinarians in Operating a Low-Cost Spay-Neuter Clinic or Having One in the Community? Please Choose All That Apply</i>		
Operating costs are too high for veterinary clinics to provide this service	31	8.0
It is difficult to prove low-income status of cat owners	26	6.7
It is difficult to provide the same standard of care in a low-cost spay-neuter clinic as for standard clients	26	6.7
Veterinary clinics lose critical revenue to low-cost spay-neuter clinics	16	4.1
Other	6	1.5
<i>Do you Provide Cats Under Your Care with Permanent Identification?</i>		
Only by request	138	37.9
Always (extra charge in addition to spay-neuter)	109	30.0
Always (included with spay-neuter)	87	23.9
Do not provide this service	30	8.2
<i>What Form Does the Permanent Identification Take?</i>		
Tattoo	270	69.4
Microchip	269	69.2
Ear tip	52	13.4
Other	12	3.1

*Multiple responses permitted.

working in smaller cities with populations less than 5,000 were significantly ($z = -3.14$, $df = 4$, $n = 14$, $p = 0.01$) more likely to agree that cat overpopulation was a concern compared with veterinarians working in cities with population sizes of 100,000 or more. Veterinarians practicing for less than ten years were more likely ($z = -2.69$, $df = 5$, $n = 90$, $p = 0.05$) to agree that cat overpopulation was a problem compared with veterinarians practicing for 30 or more years. Veterinarians believed that overpopulation was most problematic for shelter overcapacity and contributing to feral and stray populations (Table 2).

Early-Age Sterilization Surgeries

Seventy percent (255/367) of veterinarians reported performing early-age (< six months) surgical sterilization upon request. Veterinarians older than 50 years were significantly less likely to provide pediatric spays compared with veterinarians younger than 30 (Fisher's exact test, $n = 351$, $p = 0.02$). Additionally, veterinarians who stated they provide pediatric spay-neuter services were significantly more likely to agree that cat overpopulation was a problem in their community compared with those who did not provide such services ($\chi^2 = 9.21$, $df = 1$, $n = 351$, $p = 0.01$).

Low-Cost Spay and Neuter

The majority of respondents (65%; 238/365) stated that they provided support toward low-cost spay-neuter services, and of those who were not directly involved, 67% (89/132) supported the concept. Veterinarians in smaller cities were slightly more likely to provide support toward low-cost spay-neuter services (Fisher's exact test, $n = 386$, $p = 0.05$). Of the veterinarians who strongly agreed or agreed that overpopulation was a local issue, 80% (35/44) and 70% (142/202), respectively, reported that they supported low-cost services. Moreover, even among those veterinarians who were neutral or who did not perceive a local overpopulation issue, 64% (52/81) and 55% (38/69), respectively, were still involved in providing low-cost services. Veterinarians who did not support the principle of low-cost spay-neuter clinics were most concerned about maintaining standards of care in a low-cost clinic and the economic implications for their practice (Table 2).

Permanent Identification

Although there were some regional differences in the provision of permanent identification, over half of the respondents (54%; 196/364) reported that they provide cats with permanent identification, with the majority offering both microchips and tattoos (Table 2). Veterinarians located in larger cities were more likely to use microchips than were veterinarians working in cities with population sizes of less than 5,000 (Fisher's exact test, $n = 386$, $p = 0.03$).

Veterinary Attitudes to Cat Impact

When asked about their perception of whether cats had an impact on bird and other wildlife populations in Canada, 20% (76/368) of the respondents strongly agreed, 32.9% (121/368) agreed, 29.9% (110/368) were neutral, 13% (48/368) disagreed, and 3.5% (13/368) strongly disagreed. Veterinarians working in cities of fewer than 5,000 people were most likely to agree that cats were a significant source of bird and other wildlife mortality compared with cities with population sizes of 5,000 or more people. Veterinarians who agreed or strongly agreed that cat overpopulation was a problem in their community were also more likely to agree that cats were a significant source of bird and other wildlife mortality ($\chi^2 = 34.62$, $df = 4$, $n = 215$, $p < 0.001$).

Veterinarians' Perceptions of Cat Management

To reduce cat impacts on wildlife, veterinarians generally believed that the top three most effective approaches to reducing the impact of cats on wildlife, in order of efficacy, would be to keep cats indoors (55.8%; 217/389), initiate public education campaigns (50.4%; 196/389), and encourage the use of outdoor enclosures (37.5%; 146/389). When asked about the practicality and popularity of these approaches, veterinarians felt that public education programs would be effective, practical, and popular (Table 3). Almost 40% of veterinarians (152/389) felt that bells or whistles would be popular with cat owners but neither effective (14.7%; 57/389) nor practical (20.8%; 81/389). Veterinarians perceived the

Table 3. The responses of British Columbia veterinarians on the effectiveness, practicality, and popularity of various management methods to reduce cat impacts on wildlife. The numbers of respondents are given, with the percentage of total respondents given in parentheses.

	Most Effective	Most Practical	Most Popular with Cat Owners
Keeping Cats Indoors	217 (55.8)	159 (40.9)	112 (28.8)
Public Education by Animal Welfare Groups and/or Local Government	196 (50.4)	194 (49.9)	184 (47.3)
Outdoor Enclosures	146 (37.5)	81 (20.8)	95 (24.4)
Education of Cat Owners by Veterinarians	133 (34.2)	144 (37)	135 (34.7)
No-Free-Roaming Municipal Bylaw	96 (24.7)	85 (21.9)	12 (3.1)
Bells or Whistles	57 (14.7)	81 (20.8)	152 (39.1)
Cat Licensing Municipal Bylaw	53 (13.6)	82 (21.1)	16 (4.1)
CatBibs or Birdsbesafe® Collars	49 (12.6)	56 (14.4)	131 (33.7)
Harnesses or Leashes	38 (9.8)	32 (8.2)	64 (16.5)
Other	13 (3.3)	3 (0.8)	12 (3.1)
Low-Cost Spay-Neuter	130 (33.4)	131 (33.7)	210 (54)
Trap, Neuter, Return	103 (26.5)	109 (28)	98 (25.2)
Trap, Neuter, Adopt	99 (25.5)	85 (21.9)	118 (30.3)
Trap, Euthanasia	55 (14.1)	50 (12.9)	5 (1.3)
Mandatory Spay-Neuter Municipal Bylaw	88 (22.6)	102 (26.2)	46 (11.8)

effectiveness, practicality, and popularity of CatBibs or Birdsbesafe® collars to be similar to bells and whistles (Table 3), and they ranked harnesses or leashes to be even lower in effectiveness (9.8%; 38/389), practicality (8.2%; 32/389), and popularity (16.5%; 64/389). Over half of veterinarians (54%; 210/389) felt that low-cost spay-neuter would be most popular with cat owners and that a no-free-roaming municipal bylaw would be least popular with cat owners as a management tool targeting owned cats (3.1%; 12/389). Overall, veterinarians held the perception that methods targeting unowned cat populations (e.g., trap-neuter-return, trap-euthanasia) to reduce impacts on birds and other wildlife would have lower effectiveness, practicality, and popularity (Table 3).

Indoor Access Recommendations

Most veterinarians (79%; 277/352) reported that they encourage their clients to keep cats indoors and cited that the top reason was for the health and safety of the cat (93%; 252/271). Twenty-one percent of veterinarians did not encourage their clients to keep their cats indoors, including 4% (15/352) that did not counsel clients either way, 6% (20/352) that cited an increased quality of life for the cat outdoors, and 4% (13/352) that stated outdoor cats were important for rodent control in barns. The tendency to recommend an indoor lifestyle was not influenced by the age or gender of the veterinarian nor the number of years in practice, but there were significant differences depending on city population size (Fisher's exact test, $n = 386$, $p < 0.001$). Veterinarians working in cities with population sizes of 100,000 or more were generally more likely to encourage clients to keep their cats indoors, particularly compared with veterinarians working in cities with population sizes of 5,000–19,999 ($z = -2.03$, $df = 4$, $n = 14$, $p = 0.04$) and 20,000–49,999 ($z = -3.93$, $df = 4$, $n = 50$, $p < 0.001$).

Discussion

Globally, cat overpopulation is a significant concern, and within North America there are tens of millions of unowned cats (Levy & Crawford, 2004). In our survey, 56% of BC veterinarians perceived an overpopulation issue within their communities, with a higher proportion of rural veterinarians reporting an issue. A 2012 survey from the Canadian Federation of Humane Societies reported that 42% of the surveyed BC veterinarians believed that there is a cat overpopulation problem, compared with 88% of respondents from BC shelters and rescue groups (Canadian Federation of Humane Societies, 2012). The extent to which a veterinarian perceives a cat overpopulation issue locally will likely depend on their direct experience, communication with humane societies, and exposure to informal and formal information sources on the subject. Rural communities often have fewer veterinary clinics, such that individual rural veterinarians would receive a greater number of requests from humane societies and rescue groups and would have more experience with cat overpopulation and cases of poor welfare experienced by free-roaming cats.

It is very encouraging that the overwhelming majority of the respondents felt that they had an important role in reducing cat overpopulation, despite the fact that only a slight majority perceived a problem in their community. In North America, veterinarians are the only professionals licensed to perform surgical sterilization, making it a fundamental veterinary contribution to the cat overpopulation issue. An estimated 80–94% of owned cats are spayed or neutered in Canada (Canadian Federation of Humane Societies, 2017; Perrin, 2009), translating to potentially 0.5–1.7 million unsterilized owned cats (Canadian Animal Health Institute, 2016; Perrin, 2009).

Preventing unwanted litters requires that any financial barriers be removed such that owned animals are not only sterilized but sterilized at an age that precludes reproduction. In Canada, although cats are the most popular pet, they receive less veterinary care than dogs (Perrin, 2009), which may be related to the fact that cats are most often obtained opportunistically and from a free source (Canadian Federation of Humane Societies, 2017). Consequently, cat owners may delay or avoid surgical sterilization because they may be financially unable to cover the expense. For example, of the cats brought to low-cost sterilization services in Massachusetts and North Carolina, less than 7% of them had been purchased and 60–90% of them had never received any veterinary care (Benka & McCobb, 2016; Scarlett & Johnston, 2012). In North Carolina, 45% of the cat owners were unable to cover a \$10 charge (Scarlett & Johnston, 2012).

High-volume spay-neuter clinics subsidized by municipalities and humane groups can be cost-efficient and practical approaches for delivering low-cost sterilization options (Poss & Everett, 2006). The majority of BC veterinarians in our survey supported the concept of low-cost initiatives. Larger communities are more likely to have specialized spay-neuter clinics, creating less of a need for the involvement of urban veterinarians. Our results potentially reflect this variation because rural BC veterinarian respondents reported a greater involvement in low-cost options. The potential geographic disparity in the availability of high-volume sterilization services could present an opportunity for rural humane societies to collectively support mobile sterilization services.

Veterinarians who did not support the principle of low-cost services were most concerned about lost revenue, the difficulty in verifying low income, and the quality of low-cost services. Low-cost services could have a significant impact on veterinary practices that depend on revenue from spay-neuter surgeries. However, to avoid impacting local clinics and to be effective,

low-cost programs need to target low-income individuals who would not have sterilized their cat without a subsidized option; this would not represent lost income to local clinics. Frank and Carlisle-Frank (2007) found that as the number of low-cost surgeries performed increased, the number of non-subsidized surgeries also increased, which they attributed to effective public education campaigns that changed the public's perception of the importance of sterilization, suggesting that lost revenue could be replaced. The Association of Shelter Veterinarians has published standard-of-care guidelines for high quality, high volume spay-neuter programs (Griffin et al., 2016), which may address some concerns BC veterinarians have regarding the quality of care in these programs.

Even in the absence of financial barriers, unintended litters may arise because owners often do not realize that cats are able to reproduce from the age of four months (Welsh, Gruffydd-Jones, Roberts, & Murray, 2014). Among the cats brought to low-cost sterilization services in Massachusetts, less than 15% of animals were younger than six months, and 25% of owners were delaying the surgery based on an inaccurate belief of the appropriate age to sterilize their pet (Benka & McCobb, 2016). Early-age sterilization is advocated by the American Veterinary Medical Association (American Veterinary Medical Association, n.d.) and the Canadian Veterinary Medical Association (Canadian Veterinary Medical Association, n.d.), and the majority of our survey respondents were comfortable performing early-age surgeries when requested. Older BC veterinarians were slightly less likely to perform pediatric sterilization, which could be attributable to shifts in the veterinary curriculum. Veterinarians graduating in the last 20 years have been increasingly exposed to the field of Shelter Medicine and to research that documents the safety and benefits of early-age sterilization (Howe, 2015; Joyce & Yates, 2011; Porters et al., 2015; Spain, Scarlett, & Houpt, 2004).

In addition to low-cost spay-neuter, permanent identification may contribute to reducing the stray cat population and promoting responsible pet ownership. Stray cats constitute 49–68% of the animals entering North American shelters (American Society for the Prevention of Cruelty to Animals, 2018; Canadian Federation of Humane Societies, 2015), with only 2–11% being reclaimed by their owners (Canadian Federation of Humane Societies, 2015; Lord, Ingwersen, Gray, & Wintz, 2009). Cats with microchips have the potential for a 20-fold higher return-to-owner rate if the microchip registry contains current owner information (Lord et al., 2009). Fifty-four percent of the respondents in this study reported that they always offer permanent identification to cat owners, which will contribute toward increasing the 12% microchipping rate reported among Canadian cat owners (Perrin, 2009). By increasing the frequency that permanent identification is offered, BC veterinarians could contribute toward increasing the return-to-owner rate and reducing the stray and shelter population. However, given that 50–90% of the cat population does not see a veterinarian (Perrin, 2009; Benka & McCobb, 2016; Scarlett & Johnston, 2012), humane societies and municipalities have a valuable role in educating the public on the value of permanent identification and may achieve potentially higher microchipping rates through the sponsoring of low-cost microchip clinics (Lord, Griffin, Slater, & Levy, 2010).

Habitat loss and climate change are the leading risks to biodiversity (Sala et al., 2000), but additional sources of direct mortality (e.g., collisions, electrocutions, harvest, disease epidemics, and predation) can cumulatively destabilize wildlife populations. In Canada, free-roaming cats are estimated to be the largest direct mortality source for birds taking an estimated 100–350 million adults per year (Blancher, 2013), which is ten times the estimated mortality from sources such as collisions with power-lines, windows, and vehicles (Calvert

et al., 2013). Despite these estimates being available in an open-access journal (Blancher, 2013), only 20% of survey respondents strongly agreed, 33% agreed, and 30% were neutral regarding the statement that cats are one of the most significant direct sources of wildlife mortality. Therefore, only a slight majority of veterinarians have been exposed to and/or accept these published estimates.

Managing cat overpopulation and the associated impacts requires a combination of methods. Our survey revealed that BC veterinarian respondents tend to believe that effective approaches to reduce cat impacts on wildlife may not be the most popular with cat owners and vice versa. The respondents in our survey felt that low-cost sterilization would be the most popular approach with cat owners, but they ranked it lower when asked about the most effective ways to reduce the impacts of cats on wildlife. The effectiveness of subsidized sterilization programs has only been demonstrated in terms of shelter intake rates, which did decrease or slow after subsidized sterilization programs were introduced in North Carolina, New Hampshire, and Texas (Scarlett & Johnston, 2012; White, Jefferson, & Levy, 2010). In order for subsidized sterilization to reduce cat impacts on wildlife, these programs need to reduce the population of free-roaming cats; we are not aware of any studies demonstrating this. Free-roaming cats in rural areas are considered to have a greater impact on wildlife than urban cats (Blancher, 2013); therefore it could be more efficient to specifically target rural areas, especially given that the rural veterinarian respondents in our survey reported a higher issue of cat overpopulation.

Reducing the outdoor unowned cat population has been approached using TNR and removals (adoption or euthanasia). In our survey, BC veterinarian respondents believed that TNR and removals would only have moderate and low effectiveness, respectively, toward reducing cat impacts on wildlife. The overall perspective that TNR is impractical at the population level is supported by the literature (Longcore et al., 2009; Loyd & DeVore, 2010; Miller et al., 2014), and TNR may be only applicable at the colony level and only for colonies not receiving immigrants or abandoned animals nor in close proximity to sensitive ecological areas. Population models demonstrate that removals are more effective than TNR to reduce populations (Loyd & DeVore, 2010; McCarthy, Levine & Reed, 2013; Miller et al., 2014; Schmidt, Swannack, Lopez, & Slater, 2009); even TNR programs will adopt out animals to achieve population reductions (Levy, Isaza, & Scott, 2014). Veterinarians may have felt that the effectiveness of TNR and removals would be impacted by the large time investment required and low public support, respectively. Public attitudes toward cat management vary considerably, depending on geography, demographics, perception of risk, values, and knowledge (Ash & Adams, 2003; Gramza, Teel, VandeWoude, & Crooks, 2016; Hall et al., 2016; Loyd & Miller, 2010; Peterson et al., 2012), making simplistic generalizations difficult.

Veterinarians in this study felt that anti-predation devices such as bells or brightly colored collars would be popular, but ineffective. Studies in New Zealand and the United Kingdom reported cats with bells brought home roughly half the prey items compared with cats without bells (Gordon, Matthaei, & van Heezik, 2010; Ruxton, Thomas, & Wright, 2002). In Australia, colored collars did not reduce mammal predation by cats, but cats killed about 50% fewer birds and herpetofauna (Hall et al., 2015). It is unclear the extent to which return rates can be used as a proxy for actual kill rates because anti-predation devices may only affect the return rates, creating a false sense of effectiveness. Furthermore, even if wildlife are not immediately killed by a cat but sustain a bite or scratch, they will likely still die. Data from wildlife rehabilitation centers show that cat-related injuries still result in mortality rates upwards of 80% (Loyd,

Hernandez, & McRuer, 2017). Outdoor enclosures, colloquially termed “catios,” would prevent any physical contact and were viewed by the surveyed BC veterinarians to be an effective approach, but perhaps because of the investment required would be less popular. Although harnesses were not ranked highly by veterinarians in this survey, harness-training provides an attractive alternative for owners who value outdoor enrichment (e.g., Moss, 2017).

Ultimately, BC veterinarians felt that the most effective way to reduce cat impacts on birds was to keep cats indoors. Based on our survey data, the majority of BC veterinarian respondents reported that they recommend an indoor lifestyle, most commonly to avoid the increased risk of trauma and disease that occurs in free-roaming cats with unsupervised outdoor access (Hoopes et al., 2015; Norris et al., 2007). Veterinarians in this survey predicted that no-free-roaming bylaws would be unpopular with some cat owners, which has been shown elsewhere (Lilith, Calver, Styles, & Garkaklis, 2006; Lord, 2008; McDonald, Maclean, Evans, & Hodgson, 2015; Wald & Jacobson, 2013). However, when asked, the majority of cat owners in an Australian survey reported that they would comply with any compulsory no-free-roaming legislation (Lilith et al., 2006). In Canada, cat owners constitute only about one-third of the general public (Canadian Animal Health Institute, 2016), so the opinion of the remaining two-thirds of the public needs to be known. Some surveys of the general public have shown support for no-free-roaming bylaws (Grayson, Calver, & Styles, 2002; Lilith et al., 2006; Toukhsati, Young, Bennett, & Coleman, 2012).

The general public is often under-informed regarding the poor welfare of free-roaming cats and about the consequences for wildlife conservation and public health (Lloyd & Hernandez, 2012). Respondents in this study felt that education programs originating from humane societies, governments, and, to a lesser extent, from veterinarians could be effective approaches toward reducing the impact of cats on wildlife.

Knowledge is only one driver of behavior change (Grob, 1995; Kollmuss & Agyeman, 2002), especially within the free-roaming-cat issue where surveys have shown that an individual's values influence their assessment of risks to wildlife (Gramza et al., 2016; Peterson et al., 2012). The traditional veterinary communication style of providing objective information in a directive manner (Bard et al., 2017) may not be the most suitable approach for effectively discussing outdoor cat access with owners, compared with more collaborative styles. In surveys on cat containment in Australia, cat owners were motivated by both a cat-benefit and wildlife-protection rationale for restricting free-roaming, but altering owner behavior was limited by perceptions that they could not effectively contain their cat or that their cats required outdoor access for enrichment (McLeod, Hine, & Bengsen, 2015; McLeod, Hine, Bengsen, & Driver, 2017). Veterinarians may be able to remove these barriers by educating owners and suggesting effective enrichment techniques (Ellis, 2009; Herron & Buffington, 2010), which may motivate owners to turn intentions into actions (McLeod et al., 2015, 2017).

Conclusions

The overall goal of our survey was to determine the perspectives of veterinarians in BC on several aspects of the free-roaming-cat issue. Our survey sample appears to be representative of the demographics of licensed BC veterinarians; however, veterinarians with strong beliefs or interest in the subject of cat overpopulation may have been more likely to complete the survey. This potential self-selection bias prevents us from extrapolating these results to the entire population of BC veterinarians.

Veterinarians have a pivotal role in the free-roaming-cat issue by providing surgical sterilization services, counseling owners on responsible pet ownership and feline enrichment strategies, and by providing leadership on controversial welfare issues. The majority of veterinarians in this survey supported initiatives to reduce cat overpopulation, which is key to the successful implementation of these programs. It is important to recognize that veterinarians alone cannot solve the problem of cat overpopulation. Instead, this issue requires a paradigm shift as to what constitutes responsible cat ownership. The efforts of veterinarians need to be accompanied by effective education campaigns from humane societies and municipalities, aimed at increasing the public's compliance on spaying and neutering, as well as using permanent identification methods and preventing unsupervised outdoor access.

Our results also revealed that there are opportunities for conservationists to better engage veterinarians regarding the evidence of cat impacts on wildlife. Conservationists could address this discrepancy by increasing their publication efforts within the veterinary literature, publishing in open-access journals, and providing educational material and seminars at veterinary conferences and to veterinary schools and associations. During consultations with cat owners, veterinarians are in an influential position to help reduce the estimated 77 million birds that are killed annually by pet cats in Canada (Blancher, 2013). By advocating for a responsible pet ownership model that includes health and reproductive management and excludes unsupervised free-roaming, veterinarians could simultaneously contribute toward conservation and improvements in feline welfare.

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Conflicts of Interest

The authors state that there are no conflicts of interest.

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