Examining the public's awareness of bee (Hymenoptera: Apoidea: Anthophila) conservation in Canada

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Abstract
Understanding the general public's knowledge and perceptions of an issue can help drive action on the part of decision-makers. Such understanding is critical when decision-makers are faced with multiple stakeholders, which is the case with biodiversity conservation issues. We surveyed the Canadian general public using a telephone questionnaire to assess the level of knowledge and perceptions of native wild bee (Hymenoptera: Apoidea: Anthophila) health and conservation. We found that the general level of bee knowledge among participants was low. Half of participants named the non-native managed European honeybee (Apis mellifera Linnaeus 1758) as a wild bee, native to Canada. Over two-thirds of participants stated the provisioning of ecosystem services (ES) is the most important reason to conserve bees. Half of participants thought the Canadian federal and provincial government should be principally responsible for bee conservation. One-third of participants perceived no personal barriers to bee conservation and nearly one-quarter stated they did not know how to help bee conservation efforts. Our results highlight that scientific researchers can play an important role in outreach and education and environmental non-governmental organizations (ENGOs) can take an active lobbying role at the provincial and federal levels with respect to bee conservation.

KEYWORDS
bee, Canadian public, conservation, conservation policy, multinomial logistic regression, perceptions, pollinators, questionnaire

1 | INTRODUCTION

Pollinators, such as bees, flies, beetles, butterflies, and other animals are well known for their role in the reproduction of over 80% of all flowering plants (Ollerton, Winfree, & Tarrant, 2011) and 5–8% of global agricultural crops would be lost without pollination (Potts et al., 2016). In recent years, pollinator decline has become a subject of intense public support and policy development (Colla & MacIvor, 2017; Hall & Steiner, 2019; Neumann & Carreck, 2010; Ontario Ministry of Agriculture Food and Rural Affairs, 2016; Underwood, Darwin, & Gerritsen, 2017). Research has supported that many wild pollinator species and the pollination services they provide are in decline globally due to threats including pesticides, habitat loss or fragmentation, pathogens, competition with non-native...
and/or managed species and climate change (Biesmeijer et al., 2006; Burkle, Marlin, & Knight, 2013; Cameron et al., 2011; Cameron & Sadd, 2020; Kerr et al., 2015; Koh et al., 2016; Potts et al., 2010; Powney et al., 2019).

However, this is not the case of all pollinator species. In fact, many of the studies that show pollinator declines also show that some species remain common and are even increasing in relative abundance (e.g., for bumble bees Colla & Packer, 2008; Gritti, Wong, Cameron, & Favret, 2009; Colla, Gadallah, Richardson, Wagner, & Gall, 2012; Mathiasson & Rehan, 2019; Richardson, McFarland, Zahendra, & Hardy, 2019; Cameron & Sadd, 2020). In addition, often bee decline messaging in North America refers to the managed non-native honeybee (Apis mellifera Linnaeus 1758), though this species is not assessed to be in decline or at-risk of extinction (Aizen & Harder, 2009; Colla & MacIvor, 2017; Garibaldi et al., 2013; Geldmann & González-Varo, 2018; Ollerton et al., 2011). Given the public interest and subsequent resource availability to conserve pollinators, it is important to understand to what extent the public understands the situation. Misinformation on the topic has and could continue to lead to policies and management plans which do not conserve declining species (Alaux, Le Conte, & Decourtye, 2019; Cardoso & Gonçalves, 2018; Colla & MacIvor, 2017; Geldmann & González-Varo, 2018; Kleijn et al., 2015; Senapathi et al., 2015). When programs are not effective, there can also be an erosion of trust between the public and scientists, policy makers and environmental non-governmental organizations (ENGOs) (Horton, Peterson, Banerjee, & Peterson, 2016; Loss & Marra, 2018).

There are at least 855 species of bees known to be in Canada, with potentially another 110–135 currently undescribed species (Bennett, Sheffield, & deWaar, 2019; Sheffield et al., 2017). They occur in six families including the Andrenidae (mining bees), Apidae (honeybees, bumble bees), Colletidae (plasterer bees), Halictidae (sweat bees), Megachilidae (leaf cutter bees), and Melittidae (mellitid bees) (Bennett et al., 2019; Sheffield et al., 2017). Bees can be found in all of Canada’s terrestrial ecoregions, except for the northern parts of the Arctic (Bennett et al., 2019). Species distribution varies across the country with over 400 species in both British Columbia and Ontario and more than 300 in Alberta, while the three territories (Nunavut, Northwest Territories and Yukon Territory) and Newfoundland and Labrador all have less than 100 known species each (Sheffield et al., 2017). The conservation status of many species are unknown, but eight species or subspecies (one species has two at-risk sub-species) are considered by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) to be at-risk of extinction: three are considered Endangered, two are Threatened, and three are Special Concern (Committee on the Status of Endangered Wildlife in Canada, 2020). The International Union for the Conservation of Nature and Natural Resources (IUCN) Red List ranks approximately 20% of native bumblebees as at-risk of extinction (International Union for the Conservation of Nature and Natural Resources, 2020).

Relative to its land mass (10 million km²), Canada has a small population of 37.6 million people (Statistics Canada, 2019). Canada’s population is highly urbanized: over 70% of Canadians live in urban areas (Statistics Canada, 2019). The majority of the population live within 100 km of the southern border with the United States of America and within four provinces: Ontario (38.8%), Quebec (22.6%), British Columbia (13.5%), and Alberta (11.6%) (Statistics Canada, 2019).

Canada has a multiparty democracy consisting of five mainstream political parties: (a) the Progressive Conservative Party (PC), (b) the Liberal Party (LP), (c) the New Democratic Party (NDP), (d) the Bloc Québécois (PQ), and (e) the Green Party (GP). The Conservative party is considered politically to be right-of-center, while the Liberal party is politically left-of-center and the New Democrats are on the left (Cochrane, 2010; Walks, 2004). The ultimate goal of the Bloc Québécois is independence for the province of Quebec (Walks, 2004): it can be considered centrist. Camcastle (2007) describes the Canadian Green party as a centrist party compared to Green parties in Europe and Australia that are on the political left. Canadian Greens do share the same ideology of environmentalism and ecologism (non-human beings have intrinsic value) as their Australian and European counterparts (Camcastle, 2007). Compared to other democracies, Canadian politics are largely centrist, but within the Canadian political spectrum there exists distinct right/left ideologies (Cochrane, 2010).

Insect conservation does not happen in a vacuum: not only do researchers need to know information about species biology and abundance to make any conclusions, the general public, policymakers, and stakeholders need to be aware of their intrinsic and extrinsic value (e.g., relating to ecological services) and the threats they face (Cardoso & Gonçalves, 2018; Hall & Martins, 2020). The aims of this study were to assess Canadians’ (a) understanding of general bee knowledge, (b) level of concern for bee health, (c) perceptions of threats to bees, (d) attribution of responsibility for bee protection/conservation, and (e) perceptions of personal barriers to bee conservation.

2 | MATERIALS AND METHODS

We analyzed telephone survey data of Canadian residents, aged 18 years or older, that was conducted by the market research company Oraclepoll Research Ltd. This survey was commissioned by the environmental non-
TABLE 1 Questions posed to Canadian telephone respondents in May 2017, and the reason for the question

| Question                                                                 | Testing                                                                 |
|-------------------------------------------------------------------------|-------------------------------------------------------------------------|
| Q1. Thinking of the many species of wild bees that are native to Canada, how many can you name? | An open-ended question to assess bee species recall ability. Multiple responses were accepted. |
| Q2. How concerned are you about the health of honeybees and the conservation of wild, native bees in Canada? Please use a scale from one not at all concerned to five very concerned. | Assesses the level of respondents’ concern for bee health using a five-point scale |
| Q3. Why (if at all) is it important that bees are protected? | An open-ended follow-up to Q2. One response was allowed. Assesses why it was important to conserve bees. |
| Q4. Which of the following do you think are the most important threats to wild, native bees in Canada? | Respondents were read a list of nine items and only one response was accepted. Assesses which entity has perceived most responsibility for bee protection. Item list: Agricultural industry, beekeepers, commercial operators, federal/provincial government, local government, homeowners, landowners, pesticide manufactures and do not know. |
| Q5. Which of the following do you feel should MOST take responsibility for the protection of wild native bees and their populations in Canada? | An open-ended follow-up to Q5. Assesses respondents’ perceived personal barriers to bee conservation. |
| Q6. What if anything is preventing you from doing more to help save bees? | An agreement statement on bee fact awareness |
| Q7. Honeybees can replace wild, native bees in pollinating crops and wild flowers. | An agreement statement on bee fact awareness |
| Q8. I think of wasps and bees as being the same. | An agreement statement on bee fact awareness |
| Q9. All bees nest in hives and make honey. | An agreement statement on bee fact awareness |
| Q10. All bees are endangered. | An agreement statement on bee fact awareness |
| Q11. All bees can sting. | An agreement statement on bee fact awareness |

governmental organization, Friends of the Earth (Canada). It was designed by Beatrice Olivastri and Dr. Paul Secaspina of Oraclepoll with substantial input from VM, SC, and others. The survey was designed to investigate the public’s perceptions of bees, threats to bee health and overall knowledge of bees. Survey questions analyzed are given in Table 1. Anonymized and aggregated information were provided to the authors by Oraclepoll.

2.1 Survey logistics & study sample

All surveys were administered using live operators. The survey was conducted using computer-assisted techniques interviewing (CATI) and random phone number selection. The database used was developed by Oraclepoll, included land-line and mobile phone numbers, and was inclusive of new numbers and private numbers. Interviews were conducted from May 14–24, 2017. Initial calls were made between the hours of 17:00 and 21:00 within each national time zone. Subsequent call backs of no-answers and busy numbers were made on a staggered, daily, rotating basis up to 5 times, during the hours of 10:00 to 21:00, until contact was made. In addition, telephone interview appointments were attempted with those respondents unable to complete the survey at the time of contact.

A total of n = 2,000 surveys were conducted. For question 2 a total of n = 31 observations were missing, representing 1.6% of the data; these respondents were completely removed from analyses related to this question. The total sample used for statistical modeling of question 2 was n = 1,969. The population surveyed was similar to that of Canadian population for each of the predictor variables (Table S1).

2.2 Statistical analysis

We conducted all statistical analyses using R v. 3.6.3 software (R Core Team, 2020). The Cumulative (Ordinal) Logit Models (CLMs) were built using the “ordinal” package (Christensen, 2019). The multinomial logistic regression models were built using the “nnet” package
(Venables & Ripley, 2002, 2016) and the “stargazer” package (Hlavac, 2018). Plots were made using the “ggplot2” and the “likert” packages (Bryer & Speerschneider, 2016; Wickham, 2016).

Question 1 was an open-ended question and therefore not suitable to further modeling. Descriptive statistics are presented (Table S2) using the complete \( n = 2,000 \) sample.

All six demographic variables (Area, Age, Gender, Income, Vote, and Rural/Urban) were tested for inter-correlation using Pearson’s \( r \) test. Pearson’s correlation coefficient \( (r) \) is a common diagnostic for collinearity; a threshold of \( r > 0.7 \) indicates high collinearity (Dormann et al., 2013). All demographic variables were weakly correlated. The strongest correlation was between area (the province where the respondents’ lived) and federal voting intent \( (r = 0.10) \).

For question 2, we tested for a significant difference in level of concern of bee health among the six demographic variables. We used CLMs with level of concern as the response and demographic variables as the predictors (Table S3). Significance of the predictors were tested using marginal fitting of terms based on a \( \chi^2 \) test. We did not include interactions because there was no a priori expectation of interactions among the demographic variables.

Item lists were consolidated for questions 3, 5, and 6 to allow for statistical analysis (Tables S4–S6). For questions 3, 5–11, responses were tested for significant differences using multinomial models that included all six demographic variables (Tables S7–S14).

For question 3, responses were coded by Oraclepoll into six categories: “Pollination,” “Honey,” “Endangered,” “Nature,” “Do not Care,” and “Do not Know.” We further consolidated this by grouping “Pollination” and “Honey” into Ecosystem Services (“ES”), while “Endangered” and “Nature” were grouped into pro-nature (“Eco”). “Do not Care” was renamed as “Indifferent” while “Do not Know” remained the same (Table S4).

For question 4, we tested for a significant difference in perceived threats to bees among all demographic variables using binary logistic regression models (Table S15).

In Question 5, respondents could only choose one answer from a nine-item list (Table S5). We consolidated this list into five categories: Agriculture, Government, Own (responsibility), Pesticide Manufacturers and Do not Know (Table S5).

Question 6 was an open-ended follow-up to Question 5. Oraclepoll consolidated the responses down to nine items, and we further consolidated this to five categories: No Barriers, Do not Know How to Help, Dislike/Fear Bees, Not a Priority and Lack of Resources (Table S6).

### 3 | RESULTS

The general level of bee awareness among participants was poor, for example 11.8 of respondents could not name a single wild native bee species and 51.4% named the non-native European honeybee \( (Apis mellifera \text{ L.}) \) as a native wild bee (Table S2). While 29.4% namedbumble bees, which is correct, 3% listed yellow jackets and 0.4% wasps, which are not. Moreover, a few respondents gave non-species as answers, 1.9% and 2% of respondents named “drone bee” and “queen bee” respectively as wild native bee species (Table S2). Neither of these are a species of any kind (rather a descriptor related to caste), indicating some lack of understanding of the concept of a species. Only 1 respondent (out of 2,000) named a solitary bee, “mason bee” as a native wild species (Table S2). Solitary bees comprise the majority of bee species in Canada (Bees Of Canada, 2020).

Two-thirds of respondents did not know if the honeybee can replace wild bees as crop pollinators (Figure 1). Nearly a quarter of participants agreed with the statement that all bees can sting (Figure 1) even though this is incorrect (Packer, 2010). Forty-two percent of participants thought all bee species were endangered (Figure 1). The top two ranked perceived threats to bees, as determined by 89% and 79% of participants respectively, were pesticide use and loss of floral resources (Figure 2). However, predictors for these items were non-significant (Table S15). Green Party and New Democratic Party voters were more likely to perceive factors such as climate change, disease, modern intensive agriculture and habitat loss as threats to bees than Conservative voters (-Table S15). Urbanites were more likely to perceive modern intensive agriculture as a threat to bees compared to rural dwellers (Table S15).

![FIGURE 1 | Summary of survey results.](image-url)
Federal voting intent, age and area (province) were found to significantly influence the level of bee health concern (Table S3). Respondents who identified themselves as Green Party voters were 3.78 times more likely to express the highest level of concern of bee health ("Very Concerned") compared with voters who identified themselves as Progressive Conservative voters (\(p < .001\)) (Table S3). Residents of British Columbia and Quebec were 1.63 times and 1.47 times more likely to express the highest level of bee concern respectively compared to residents of Alberta (\(p < .01\)) (Table S3).

Over two-thirds (68.3%) of participants stated the provision of ecosystem services was the most important reason to protect bees while under a quarter (24.2%) stated it was because of a pro-nature orientation (Ecological) (Figure 3). Half (50.1%) of participants thought that the Federal and Provincial Government should take the most responsibility for wild bee protection (Figure S1). Different demographics held different entities responsible for the protection of bees. Voters for the New Democratic Party (NDP) were 1.6 times (\(p < .05\)) more likely than Progressive Conservative (PC) voters to attribute responsibility for bee protection to the Government (Figure 4; Table S8) category. Participants from the Maritime provinces (New Brunswick, Nova Scotia, and Prince Edward Island) and British Columbia were 1.8 times and 1.7 times (\(p < 0.05\)), respectively, more likely to attribute responsibility for bee protection to the Government compared to respondents from Alberta. Respondents from Manitoba and Saskatchewan were 2.6 times (\(p < .05\)) more likely to attribute responsibility for bee protection to the agriculture sector and 2.4 times (\(p < .05\)) more likely to attribute responsibility for bee protection to the "Own" category (Figure 4 & Table S8) compared to voters from Alberta. Elderly people (71 years old and older) were 2.3 times (\(p < .05\)) more likely to not know whom to assign responsibility for the protection of bees compared to young people (18–35 years old).

One-third of participants perceived no personal barriers to bee conservation (Figure S2). Nearly one-quarter (23.9%) did not know how they could personally help bee conservation and 19.4% stated bee conservation was not a personal priority (Figure S2). Urbanites were 2.76 times (\(p < .001\)) more likely to state lack of resources (Figure 5 & Table S9) as a barrier to bee conservation compared to rural dwellers. Urbanites were also 1.66 times (\(p < .05\)) more likely to state fear or dislike of bees as a barrier compared to rural dwellers. Left-wing voters were less likely to state “Not a Priority” as a perceived personal barrier to bee conservation compared to conservative voters (Table S9). People living in Quebec, Ontario, Manitoba, Saskatchewan and British Columbia were less likely to state “Not a Priority” as a barrier to bee conservation compared to people living in Alberta (Table S9). Therefore, conservative voters and residents of Alberta were
more likely to perceive bee conservation as not being a personal priority. Discussion.

We found that Canadians had a poor overall knowledge of native wild bees, although the majority thought bees should be protected, particularly for their ecosystem services (ES) provision. Our results are similar to Wilson, Forister, and Carril (2017) who found that although actual knowledge was low, there was widespread general interest in bee conservation among the public in the United States of America. They also found that survey participants greatly underestimated species richness and misidentified non-bees as bees in test photos (Wilson et al., 2017). In a survey of Louisiana, USA beekeepers and the general public, Penn, Hu, and Penn (2019) found that beekeepers were more likely to know European honeybees were non-native to North America than the general public. Interestingly, both beekeepers and the public tended to agree with the statement that European honeybee were more similar to wildlife than to livestock (Penn et al., 2019). While not related to pollinators specifically, a recent poll of Canadians (McCune et al., 2017) found that 89% of respondents also believed general species conservation was important, although that support dropped slightly depending on the potential economic impacts and limiting of individual property rights that would be involved. This clearly shows there is strong public support for further conservation work for all at-risk species, including pollinators.

In Canada over half of all land is publicly owned (Huque & Watton, 2010). In relation to environmental policy, Canada has one of the most decentralized frameworks for implementation in the world (Huque & Watton, 2010). Under Section 92A(1) of the Canadian Constitution, provincial legislatures have exclusive powers to create laws in relation to “(a) exploration for non-renewable natural resources in the province; (b) development, conservation and management of non-renewable natural resources and forestry resources in the province, including laws in relation to the rate of primary production therefrom” (Constitution Acts, 1867 to 1982, 1982). However, the Canadian Constitution does not assign specific responsibility for the environment and judication is shared between the federal and provincial governments (Office of the Auditor General of Ontario, 2019, p. 14). In addition, municipalities come under provincial legislative authority and have no separate constitutional powers, the provinces may delegate powers to them some environmental stewardship may be addressed at a local level (Office of the Auditor General of Ontario, 2019, p. 14). On environmental policy, the federal government takes a supportive role, such as with the coordination of standards and establishing broad guidelines (Huque & Watton, 2010). There is currently little legislation in Canada to support pollinators (Tang, Wice, Thomas, & Kevan, 2007); this is but one area that could be addressed. The majority of our respondents thought the federal and provincial governments should take the lead in protecting native wild bee populations in Canada. This was also seen by McCune et al. (2017) who found that 70% of Canadian respondents believed federal or provincial governments were primarily responsible for species conservation.

The Canadian provinces are slow to implement environmental policies because they do not wish to alienate extractive industries (Huque & Watton, 2010) from which they receive royalties. In Alberta the oil industry dominates the landscape and provincial governments stay in power for long periods of time (Timoney & Lee, 2001). The Progressive Conservatives were the governing party in Alberta for 44 years (1971–2015) consecutively (Legislative Assembly of Alberta, 2020). Timoney and Lee (2001) are critical of Alberta’s “stable” governance that prioritizes the interests of multinational corporations over biodiversity conservation. Other provinces also lag when it comes to implementing biodiversity measures despite calls from multiple organizations to do so, such as with the Ontario government not having a robust plan, and with its multiple ministries being unaware of their responsibilities or having confusion over who is responsible for acting (Environmental Commissioner of Ontario, 2012).

Environmental organizations should bring the shown desire for governments to take action to the attention of relevant politicians and government employees as part of a push for increased action for bee conservation, including policy and funding. They also need to continue educating these decision makers, as well as other influential groups including the media, about the issues and steps that need to be taken to ensure success (Bickford, Posa, Qie, Campos-Arceiz, & Kudavidanage, 2012).
We found that two-thirds of participants value bees for what they provide for people. It is hard to quantify the services bees provide, and limited information exists for Canadian systems, but values are likely in the $4–5.5 billion/year range for Canadian crops for European honeybees alone (Mukezangano & Page, 2017). Indeed, for the Credit River watershed in Ontario, Canada, the valuation of pollination services was found to be $5/household/year or $4 million/year (Kennedy & Wilson, 2009), while the Greenbelt area of Ontario had the value of wild pollination services (excluding European honeybees) estimated to be $48 million/year. Globally, the value has been estimated at €153 billion/year for crop pollination by insects (Vaissière et al., 2008). These values are high and give the added economic incentive for conservation to occur even without the consideration of the values to natural systems.

At-risk insects tend to receive less funding than other at-risk species: Cardoso and Gonçalves (2018) found European arthropods received 1,000 times less funding than mammals. Current funding for all types of endangered species in Canada is about $2/person, although there is a willingness to pay a median of $5/person (McCune et al., 2017). In the UK, the mean willingness to pay for bee protection policy was found to be approximately £43 per household per year (Mwebaze et al., 2018). The valuation of wild bees, both perception by the public and calculated ecosystem service values, should be investigated further.

Pesticides and loss of floral resources were ranked highly as threats to bees by most participants, with all demographic predictors being non-significant: this suggests that these threats are perceived equally by all respondents. In the case of pesticides in particular, this may be because it has been a highly publicized threat, receiving media coverage through efforts by environmental organizations and governments to limit the use of specific types of agrochemicals like neonicotinoid pesticides (Ontario Ministry of Agriculture Food and Rural Affairs, 2016; Health Canada, 2016). However, published scientific literature on the decline of wild, native Canadian bees includes pathogen spillover from managed bees and climate change as the top threats (Colla, 2016; Colla et al., 2012; Kerr et al., 2015; Szabo, Colla, Wagner, Gall, & Kerr, 2012). Indeed, public awareness and government policies have increased thanks to these types of discussions (Colla, 2016; Colla & MacIvor, 2017; Hall & Steiner, 2019; Underwood et al., 2017).

Nearly one-fifth of participants stated bee conservation was not a personal priority, which is likely because they want their governments to assume a leading role in native wild bee conservation; indeed, the participants that stated responsibility for bee conservation should be at the individual level were more likely to state bee conservation was a personal priority. Residents of Manitoba and Saskatchewan were more likely to attribute personal responsibility for bee protection and that bee conservation was a personal priority; these provinces could be specifically targeted with resources providing ways individuals can help. In an online survey of residents of Connecticut, USA, the major barriers to purchasing pollinator-friendly plants were lack of labeling (cited by 34% of participants) and high cost of plants (cited by 28% of participants) (Campbell, Khachatryan, & Rihm, 2017). Retailers can facilitate the purchase of pollinator-friendly plants by providing their customers with trusted information sources in their marketing/messaging (Campbell et al., 2017).

For most participants in our survey, the European honeybee is the bee species, which helps to confirm that misinformation about native pollinators is widespread in Canada. It is not surprising that the honeybee is foremost in people’s mind given its prominence in Western mass media. In a 1 year study of media coverage of pollinators in the United Kingdom, Ollerton et al. (2012) found the European honeybee comprised 40% of articles compared to bumblebees that had only 10% of coverage. In a study of Australian pollinator media coverage (2006–2015) the European honeybee comprised 50% of all coverage, whereas native bees received 15% of all coverage (Smith & Saunders, 2016). Indeed, the extensive publicity around Colony Collapse Disorder of managed honeybee hives (Neumann & Carreck, 2010) served to fuel intense scientific research and to promote increased public awareness of threats to bee health. When misinformation is spread that implies that honeybees are a native pollinator that need saving, federal and provincial policies are adopted that focus on helping this species, which can be to the detriment (directly or indirectly) to native bees (Colla & MacIvor, 2017; Geldmann & González-Varo, 2018). Additionally, private companies and even non-governmental organizations are routinely using honeybees to drive their campaigns and to increase their profits under the guise of “#savethebees” (Colla & MacIvor, 2017; Geldmann & González-Varo, 2018) (see also https://www.bee-washing.com/, run by University of Toronto PhD Candidate Charlotte De Kezyer).

While one-third of participants perceived no personal barriers to assisting in bee conservation efforts, nearly a quarter of participants stated they did not know how to personally help. This group represents an opportunity for education and outreach: indeed, communicating (marketing) the plight of pollinators and providing the public with relevant information can help conservation efforts (Bickford et al., 2012; Cardoso & Gonçalves, 2018). Avenues include traditional media, but also other platforms
such as social media, websites, blogs, documentaries, movies, science magazines, photography exhibitions, music and arts broadly, faith groups, and more (Bickford et al., 2012; Bubela et al., 2009; Cardoso & Gonçalves, 2018; Nisbet & Scheufele, 2009).

Although urbanites were more likely to state a fear or dislike of bees as a barrier to bee conservation as compared to rural dwellers, this did not rank among the top 3 perceived personal barriers (Figure 5). This may be surprising as typically the general public views invertebrates, particularly arthropods, with fear and disgust (Kellert, 1993). However, Sieg, Teibtner, and Dreesmann (2018) found that although general knowledge of bumblebees amongst German secondary students was relatively low, their attitudes were generally positive. O’Hara (2012) found that both the majority of residents of a neighborhood in Guelph, Ontario and participants in gardening and pollinator-themed organizations in that same city felt that there were no (63% and 61%) or only slight (37% for both) threats from bees, and that bees were extremely (83% and 77%) or very important (10% and 17%) to humans, respectively.

The fear of bees may be mitigated using their perceived value as pollinators (Cho & Lee, 2018). O’Hara (2012) notes that the word “bee” causes fear in some people and could be alleviated by using the word pollinator. Although the value of pollination services is a common message in pollinator protection, it is unemotional: a greater impact may be made by establishing an emotional connection with the public, such as by referring to pollinators as “creative connecters, emblematic of the interconnected and interdependent nature of ecosystems”, and building on pre-existing social and cultural values (Christmas et al., 2018).

In general, the demographic variable with the strongest predictive power was stated federal voting intent. Voters align with political parties on a collection of issues and importantly the symbolic values those issues represent. We found that the Green and NDP party supporters had the most support by those passionate about pollinators, but neither 2019 federal election platforms addressed pollinator conservation in any detail (Thompson, 2019). Interestingly, there was no difference among Green party voters between valuing bee protection for ecosystem services (extrinsic motivation) and ecological (intrinsic motivation) categories (Table S7). Given Green party supporters hold values of ecologism (Camcastle, 2007), one would expect Greens to state ecological values as the reason for bee conservation.

National NDP and Green parties could incorporate pollinator protection policy into their platforms that can serve as guidance for their provincial counterparts. We strongly encourage elected officials, policy makers, and public servants to work to better reflect public interest in this area, which developing evidence-based policy to protect these small insects.

4 LIMITATIONS OF THE STUDY

Our sample of respondents does not completely match the demographics of the Canadian population according to the 2016 Census (Table S1). The variables of Age and Income have slightly different classes in our survey compared to the 2016 Census, making direct comparison difficult. Younger people had higher representation in our survey compared to their proportion of the general population (Table S1). Lower income earners (households making under $50,000 CND per year) were underrepresented whereas middle income earners (households making $50,000–$74,999 CND per year) were overrepresented in our survey (Table S1). Moreover, Statistics Canada does not collect information on federal voting intent. We choose to use 2019 federal election results as a proxy for comparison. At the 2019 federal election, voting turnout was 65.95% (CBC News, 2019) indicating nearly one-third of eligible voters in Canada did not vote. For example, it appears Conservative party voters are underrepresented in our sample (Table S1). However, the proportion of Conservation party voters in the 2019 federal elections results may be because more Conservative voters turned out to cast their ballots. The survey was also only conducted in English; although this is the most common language spoken in Canada, French is a second official language.

5 CONCLUSION

Conservation of wild native bees in Canada has broad public support. Although engaged with this issue, we found Canadians have limited general knowledge. An understanding of types of wild bees, what constituted wild native species vs. domestic non-native species, general ecology (fact awareness) and general classification knowledge (what a species is) was lacking. Green party voters expressed the highest level of concern for bee health yet were not more likely to express ecological (intrinsic) reasoning for bee conservation. A follow-up study could explore more explicitly the connection between political affiliation and salient motivations for bee conservation. We found broad consensus that pesticides and loss of floral resources were perceived as threats to bees. Scientists could play a role in science communication related to wild native bee fauna and the threats they face, such as climate change and pathogen spillover for non-native bees.
The majority of respondents want a top-down (government lead) approach to bee conservation. In Canada, the majority of the land is publicly owned and authority for environmental policy is delegated to the provinces. Policymakers at the provincial level could craft policies to suit their subnational context and the federal government could play an active supporting role providing standardized guidance at the national level. Respondents from Manitoba and Saskatchewan were more likely to attribute bee protection to the individual than the provinces. Provincial policymakers could design programs to enable individual stakeholder participation in bee protection and conservation. Nearly one-quarter of respondents identified not knowing how to help as a perceived personal barrier to bee conservation. This indicates a need for science communication and targeted programs emphasizing actions individual can take to promote bee conservation, that is, planting pollinator friendly garden plants.

Researchers and environmental non-governmental organizations can play a role in communication and education among the public and policymaker's understandings of the evidence and solutions around pollinator decline and conservation. We found Canadians want governments to take the lead in bee conservation: members of the public and those working in the conservation field can bring this to the attention of policy makers as a call to action.

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CONFLICT OF INTEREST
The authors declare not conflict of interest.

AUTHOR CONTRIBUTIONS
Nyssa van Vierssen Trip: Conceptualization, Methodology, Software, Validation, Formal Analysis, Data Curation, Writing -Original Draft, Writing- Review & Editing, Visualization. Victoria J. MacPhail: Conceptualization, Writing- Review & Editing. Sheila R. Colla: Conceptualization, Writing- Review & Editing, Supervision. Beatrice Olivastri: Conceptualization, Data Curation, Funding acquisition.

DATA AVAILABILITY STATEMENT
Data for this research are at available at Scholar Polar Dataverse https://doi.org/10.5683/SP2/TSDAHM. Please cite this dataset as van Vierssen Trip, Nyssa; MacPhail, Victoria J.; Colla, Sheila R.; Olivastri, Beatrice, 2020, “Replication Data for: Examining the public’s awareness of bee (Hymenoptera: Apoidea: Anthophila) conservation in Canada,” https://doi.org/10.5683/SP2/TSDAHM, Scholars Portal Dataverse. R language code to reproduce the analysis is available from the corresponding author upon reasonable request.

ETHICS STATEMENT
Data used for this research was collected by a market research company, Oraclepoll Research Ltd and commissioned by Friends of the Earth, Canada. Anonymized and aggregated information were provided to the authors by Oraclepoll Research Ltd. All potential identifying marks or sensitive information have been removed from the dataset and redacted from the codebook.

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**SUPPORTING INFORMATION**

Additional supporting information may be found online in the Supporting Information section at the end of this article.

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