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RESEARCH ARTICLE

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# Observations at backyard bird feeders influence the emotions and actions of people that feed birds

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## Abstract

1. Backyard bird feeding is one of the most common ways people engage with wildlife in many parts of the world. Given its scale, it can have profound consequences for the ecology of feeder birds and their behaviour. While previous work has primarily explored socio-demographic factors associated with bird feeding, how observations of nature at backyard feeders (e.g. changes in feeder bird abundance, interaction with natural enemies and weather) influence people's propensity to feed birds remain largely unknown.
2. We examined the association between peoples' observations at their backyard feeders and their emotions and behaviours related to providing food to birds. We conducted an online survey of a subset of United States participants in Project FeederWatch, a large-scale citizen science project.
3. Overwhelmingly, respondents ($n$ = 1,176) reported taking actions, such as managing predators or maintaining feeders, in response to observable natural factors (e.g. increased incidence of disease, the presence of predators, increased bird abundance). Additionally, respondents described a variety of emotional responses to the scenarios of depredation or disease at their feeders, some of which (particularly anger) had a small association with whether a respondent would take action in response. Respondents generally believed that their bird feeding benefits backyard birds (e.g. by improving overwinter survival and overall health), and indicated that natural factors (e.g. bird abundance, disease prevalence) and abiotic factors (i.e. cold temperature) had more of an influence on how much they feed birds than internal constraints such as time and money.
4. These findings suggest that human behaviour with respect to bird feeding is coupled to observations of nature, which could lead to feedbacks between provisioning intensity and ecological dynamics. Overall, our results have important implications for bird conservation and for understanding the potential benefits that humans receive from provisioning birds.

**KEYWORDS**
bird feeding, citizen science, emotions, human behaviour, human–wildlife interactions, resource provisioning

## 1 | INTRODUCTION

Backyard bird feeding is a popular form of human–wildlife interaction in certain regions of the northern and southern hemisphere including North America, Europe, Australia and New Zealand (Cox & Gaston, 2018; Jones, 2018; Reynolds, Galbraith, Smith, & Jones, 2017). With increasing urbanization, feeding wild birds is one of the few remaining ways in which many humans can readily connect with nature and experience the benefits of direct interaction with wildlife (Cox & Gaston, 2018; Cox et al., 2017). Although most forms of intentional feeding of wildlife are actively discouraged, backyard bird feeding is viewed positively in most countries and is implicitly or explicitly encouraged by a diversity of bird organizations (Jones, 2011). Overall, the enormous popularity of backyard bird feeding in countries such as the United States, with over 57 million households feeding backyard birds and spending over $4 billion annually on bird food (U.S. Department of the Interior, U.S. Fish and Wildlife Service, U.S. Department of Commerce and U.S. Census Bureau, 2018), suggests that people in many parts of the world have a strong connection with wild bird feeding.

This unprecedented scale of wildlife provisioning has been shown to have significant and diverse ecological impacts on bird populations. Backyard bird feeding can result in positive effects on some bird species, such as improved overwinter survival (Jansson, Ekman, & von Bromssen, 1981), increased population sizes (e.g. Fischer & Miller, 2015; Fuller, Irvine KN, & Armsworth PR, 2012; Fuller, Warren, Armsworth, Barbosa, & Gaston, 2008) or geographic range expansion (e.g. Greig, Wood, & Bonter, 2017; Job & Bednekoff, 2011). However, recent studies have also highlighted potential negative effects of feeding on wild birds, such as increased risk of depredation (Hanmer, Thomas, & Fellowes, 2016; Malpass, Rodewald, & Matthews, 2017) and disease spread (Adelman, Moyers, Farine, & Hawley, 2015; Galbraith, Stanley, Jones, & Beggs, 2017; Lawson et al., 2012; Wilcoxen et al., 2015). Many of these potential positive or negative effects of feeding are directly visible to backyard bird watchers. For example, those who feed birds can readily observe changes in bird abundance at their feeders, the presence of predators at or near feeders and in some cases, predator- or pathogen-induced mortality (Brittingham & Temple, 1986; Dunn & Tessaglia, 1994). In terms of disease, bird watchers can observe birds with severe lethargy, swollen eyes or tumour-like lesions at their feeders (Dhondt, Tessaglia, & Slothower, 1998; Lawson et al., 2018). However, the degree to which people observe and respond to these potential positive or negative effects of feeding currently remains unknown.

The human dimensions underlying provisioning of wild birds have been increasingly studied in the past decade, providing some insight into the reasons why people feed wild birds, sometimes at considerable financial cost (Fuller et al., 2008; U.S. Department of the Interior, U.S. Fish and Wildlife Service, U.S. Department of Commerce and U.S. Census Bureau, 2018). Research to date has often focused on socio-demographics as factors influencing the decisions of people regarding bird feeding (e.g. Davies, Fuller, Dallimer, Loram, & Gaston, 2012). However, research in a variety of settings indicates that socio-demographic factors are often inconsistent predictors of human behaviours, compared to social psychological variables such as attitudes and motivations (e.g. Dietz, Stern, & Guagnano, 1998; Schultz, Oskamp, & Mainieri, 1995; Straughan & Roberts, 1999). A key impetus of bird feeding appears to be the psychological benefits of direct human–wildlife interaction, including senses of pleasure or relaxation, feelings of usefulness and an increased connection to nature (e.g. Cox & Gaston, 2016; Dubois & Fraser, 2013; Galbraith et al., 2014; Goddard, Dougill, & Benton, 2013). A desire to enhance bird welfare is also commonly cited by those who feed wildlife (e.g. Goddard et al., 2013), including a desire to help wildlife or 'assist them through hard times' (e.g. Cox & Gaston, 2016; Galbraith et al., 2014). Indeed, bird feeding tends to be most prominent in seasons when natural food is perceived to be limited (e.g. Galbraith et al., 2014), suggesting a role of this desire to help wildlife. Intriguingly, the desire to help wildlife through feeding is sufficiently strong that it does not appear to differ even in countries where feeding is actively discouraged, such as Australia (Reynolds et al., 2017).

Given the apparent psychological benefits and drivers of bird feeding, we expect that emotions play an important role in the degree to which people provision birds. Emotions have been linked to human decision-making as it relates to wildlife more broadly (Hudenko, 2012; Larson, Cooper, & Hauber, 2016; Manfredo, 2008). Emotional responses are likely to be shaped by situational specifics (e.g. how many birds are present at the feeders, the presence of a cat) and distinct goals (e.g. attracting as many birds as possible, helping birds survive harsh winter temperatures, keeping birds healthy and free of disease; Manfredo, 2008). For example, Cox and Gaston (2015) found that increased species richness at feeders is associated with well-being benefits, which are likely tied to positive emotional responses. We expect that decisions related to bird feeding may thus be a result of emotional responses to observations at feeders (Jacobs, 2009; Larson et al., 2016), although this has not been previously explored.

Direct observations of nature and the subsequently evoked emotions can, in turn, alter human behaviours (Hudenko, 2012). For example, a study of nest box management behaviour found that citizen scientists pay close attention to the birds in their yard, respond emotionally to non-native species using their nest boxes and take direct action to manage them (Larson et al., 2016). Likewise, research has documented emotional responses to predators in other settings and associated emotions with support for management of predators (e.g. Jacobs, Vaske, Dubois, & Fehres, 2014), as well as emotional responses to wildlife disease (e.g. Evensen, 2011). The observations made at feeders and subsequent emotions experienced by those who feed birds may similarly influence the extent to which people provision birds and manage their backyard feeders. While internal factors (e.g. the ability to pay for bird seed; Jones, 2011) might also limit how much people feed birds, money and time may not be as important in provisioning food as previously thought (Cox & Gaston, 2016).

Here we explore how observations of nature at backyard feeders impact people's emotions and decisions related to bird feeding. Because we are specifically interested in whether people observe and respond to components of nature that potentially relate to their feeding, we focus on understanding the role of wild bird predators or predation events, diseased birds, changes in bird abundance and ambient temperature. We use surveys of citizen scientists who feed birds to examine associations between observations of potential impacts of bird feeding (i.e. predators, disease, changes in abundance) at backyard feeders and human emotions and behaviour. Because citizen scientists with backyard feeders have been critical for understanding the potential ecological effects of bird feeding on wild birds (e.g. Dunn & Tessaglia, 1994; Lawson et al., 2018; Reynolds et al., 2017), they represent an ideal starting point for examining the interplay between human thought and behaviour and wildlife population dynamics.

Our study addresses the following questions:

1. Do people who feed birds observe components of nature potentially related to bird feeding in their backyards, and do they report taking action in response to these observations?
2. What, if any, emotional responses to observations of predators and/or disease at their feeders do people report, and are these emotions associated with their intentions to take action (e.g. feeder maintenance or predator management)?
3. What factors are most important in people's decisions about how much to feed birds?
4. How do people who engage in feeding wild birds perceive the impact of their actions on the health of wild birds, the local abundance and diversity of species, and the risk of predation?

## 2 | MATERIALS AND METHODS

### 2.1 | Survey participant selection

From 21 July to 14 August 2017, we conducted an online survey via Qualtrics (www.qualtrics.com) of citizen scientists who feed birds in their backyard. Citizen scientists are non-professionals who voluntarily engage in research projects, often following a specific protocol and submitting data collected based on that protocol (Dickinson, Zuckerberg, & Bonter, 2010; Dickinson et al., 2012). The sampling frame was drawn from participants in Project FeederWatch (www.projectfeederwatch.org), a large-scale citizen science project run by the Cornell Lab of Ornithology. Project FeederWatch began across the United States in the winter of 1987–1988 and currently gathers data from over 11,000 participants each winter. Annually, between early November and early April, participants count the maximum numbers of birds of each species that they see simultaneously in their feeder areas over 2-day observation periods.

Due to our interest in responses to specific types of observations at bird feeders, including birds with visible disease, we targeted citizen scientists who had observed House Finches (*Haemorhous mexicanus*). This common feeder species has been subject to regular epidemics of the visible disease mycoplasmal conjunctivitis since the mid-1990s (Dhondt et al., 1998). All participants in our sampling frame of 2,048 Project FeederWatch participants had reported at least one House Finch at their feeders in the preceding FeederWatch season (November 2016–April 2017). Furthermore, half of those respondents had reported a House Finch with visible signs of eye disease (a question Project FeederWatch participants are asked when they submit results; a hyperlink with information about how to identify eye disease is provided during data submission). House Finches are one of the most common feeder birds in the United States, being reported at over 70% of all feeders in every region during the 2016–2017 Project FeederWatch season. Thus, no single region in the contiguous United States was biased in selection.

All members of the sampling frame were sent an email solicitation from the Cornell Lab of Ornithology with an individualized link to the survey. These email addresses are part of the database for Project FeederWatch participants; however, the survey was conducted outside of the Project FeederWatch season and survey responses were not connected in any way to Project FeederWatch data entry. We sent the initial survey on 21 July 2017. Three reminder emails were sent to those who had not finished or initiated the survey in intervals of approximately 1 week, over the 3 weeks following the initial invitation. We closed the survey on 14 August 2017.

This research was conducted with approval from, and in accordance with, the Cornell University Institutional Review Board for Human Participants (Protocol #1706007274). Virginia Tech Institutional Review Board relied on Cornell University's review and exemption decision. Consent to voluntarily participate and confirmation that participants were at least 18 years old were obtained on the first page of the online survey.

### 2.2 | Survey design

The survey was developed following a review of the scientific literature of bird feeding and bird watchers. Our survey development team included experts in conservation social science, citizen science project evaluation, avian disease ecology and ornithology. Members of the team also had extensive personal experience in backyard bird feeding and working with Project FeederWatch participants and other bird watchers. The survey was also pre-tested, with a follow-up interview about her experience, by one participant of Project FeederWatch who was not part of the research team.

While the survey contained 21 items in total (see Dayer et al., 2019), only items directly relevant to the research questions are described here. The relevant items included a set of potential responses to observations at backyard feeders; emotions in response to seeing various events at their feeders; the factors most important to respondents when deciding to feed birds; and the perceived effects of feeding on wild birds in the immediate area. For actual text of the items, which did not include these terms, see below. Most of the items, with the exception of those related to participants' feelings, were closed-ended.

#### 2.2.1 | Observations of nature and actions (research question 1)

To understand whether respondents observed components of nature that are potentially related to the provisioning of food for birds, we presented five scenarios and respondents indicated whether they had or had not observed those scenarios at or near (in the case of predators) their feeders. The five examined scenarios included a notable increase in the total number of birds at their feeder, a notable decrease in the total numbers of birds, the presence of a diseased bird at the feeder or the presence of a native (i.e. hawk) or introduced (i.e. cat) predator near their feeder. For depredation, we focused on observations of hawks and domestic cats, which together are responsible for 80% of observed predation events on wild birds near feeders (Dunn & Tessaglia, 1994). Specifically, with observations of diseased birds, we asked respondents how they determined that a bird was diseased, and we allowed participants to choose from predetermined options. We then asked respondents what types of actions (if any) they would take in response to each of the five scenarios. In each case, we presented a list of potential responses, and respondents could check all that applied.

#### 2.2.2 | Relationship of emotional connections to scenarios at feeders and taking action (research question 2)

In order to assess emotional responses to three of the five potential scenarios at feeders, we asked respondents to answer three open-ended questions: 'How do you feel when you see a diseased bird at your feeders?'; 'How would you feel if you saw a cat take a bird at your feeder?'; and 'How would you feel if you saw a hawk take a bird at your feeder?'. All responses were coded in the dataset with a '0' (not expressing theme) or '1' (expressing theme) by a single person (co-author CR) for consistency. Because responses often indicated multiple emotions and/or other themes, a participant's response could have '1' values for multiple themes. Coding followed a codebook with definitions for themes (Table 1). Emotion themes included anger, sadness, enjoyment and interest, which came from previously established lists of emotions (see e.g. Eckman, 1984; Izard, 1977). Additionally, themes included the emotions of worry and annoyance, which emerged from the research. We also coded the statements for emergent themes beyond the expected emotion themes, which included the emergent attributions themes (described in Section 3 and Table 1).

We categorized potential actions in response to three scenarios (observations of a hawk, cat or diseased bird near the feeder) as active or passive, similar to how Larson et al. (2016) classified actions related to nest box management. Active responses were characterized by attempted direct interaction with wildlife to address the issue, while passive responses did not require direct interaction with the wildlife. For the scenarios with cats and hawks, active actions were 'scare off the cat/hawk' and 'try to trap the cat/hawk', while passive actions were 'move feeders', 'provide shelter' and 'remove feeders'. With diseased birds, the only active action was 'attempt to catch the diseased bird and take it to a rehabilitator', while the passive actions were 'clean feeders more often', 'remove feeders', 'change type of feeder', 'keep feeders fuller', 'switch to a more expensive seed' and 'add more feeders'.

#### 2.2.3 | Self-reported factors important to feeding decisions (research question 3)

To determine which factors were most important to respondents when deciding how much to feed birds, we offered a list of several factors, including what we define as 'internal' factors (time and money) and what we define as 'natural' factors (e.g. the number of birds at feeders, the number of diseased birds at feeders, etc.). We asked respondents to select the level of importance for each factor when deciding how much to feed birds with five response options from 'not important at all' to 'very important'.

#### 2.2.4 | Perceived impacts of feeding on wild birds (research question 4)

We presented respondents with a range of potential impacts that feeding could have on wild birds in the immediate area around a participant's bird feeders. We asked them to indicate which potential impacts they believed to be a result of their bird feeding (multiple responses were possible).

### 2.3 | Response rate

Overall, 1180 citizen scientists engaging in Project FeederWatch of the 2,048 in our sampling frame responded to our survey. One individual who took the survey twice was removed from the sample, and three respondents under the age of 18 (based on age provided in the demographics section) were removed and coded in the response rate calculation as ineligible. After accounting for these ineligibles and 50 more undeliverable emails, the overall response rate was 59%. Further, due to an error in the online survey response settings in the first 18 hr of survey administration, the final sample size for three items ('How do you respond when you see cats near your feeders?'; 'How do you respond when you see

**TABLE 1** Themes used to code the emotions and attributions of answers to the open-ended questions, 'How do you feel when you see a diseased bird at your feeder?' and 'How would you feel if you saw a cat/hawk take a bird at your feeder?'

| Code and definition | Example quotes from respondents |
|---|---|
| Emotion codes | |
| Sad: feeling sad, unhappy, helpless or some similar emotion | 'Greatly saddened & helpless to do anything about it. Reality says things die' 'Sad that they are diseased and that they might spread the disease to other birds at the feeder' |
| Angry: feeling angry, upset or some similar emotion | 'Livid. I understand the "balance of nature" theory, but I don't want it in my yard' 'Angry. Cats in my neighbourhood are domestic, well fed, and only hunt to satisfy their prey instinct' |
| Annoyed: feeling annoyed, frustrated, or some similar emotion | 'Annoyed. Send the dog out to chase it off' 'Grossed out and annoyed with the hawk, but the circle of life means the hawk has to eat too' |
| Worried: feeling worried, concerned, stressed or some similar emotion | 'Concerned for the bird, other birds, wondering how did the bird get sick' 'Very stressed and I try and tell myself the hawks are only trying to survive' |
| Interested: feeling curious or interested by the observation | 'Interested and glad to have an opportunity to observe nature' 'Interested. Would be curious about disease and cause' |
| Enjoy: feeling enjoyment or being excited by the observation | 'Excited. Score one for the hawk. Hopefully it gets a European starling or Eurasian Collared Dove' 'Enjoy watching the hawk, it is a part of nature' |
| Neutral: feeling neutral or unconcerned | 'Neutral. We already interfere enough w/wildlife' 'Have seen only a few so no concern at this time' |
| Attribution codes | |
| Natural: attributes the event to some aspect of the natural world | 'A natural event. I like observing hawks and their activities' 'This is a natural process that some bird fall ill to, but I clean my feeders just in case' |
| Others: attributes the event to the actions of other people | 'I am irritated with my neighbours who let their cats run wild and I'm sad for our natural populations' 'When I see birds having convulsions and dying, I get upset at my neighbours who are using pesticides' |
| Self: attributes the event to the respondent him/herself | 'I am concerned that my feeder could have caused it' 'Worry I might have set up a bird buffet by putting feeders out' |

hawks near your feeders?'; 'Do you think your bird feeding has led to any of the following in your immediate areas?') was only 832 respondents. Based on this sample size and an overall population of 11,000 Project FeederWatch participants, the population estimates we present have at most a ±1.7% sampling error associated with them at the 95% confidence level (calculation based on Vaske, 2008).

### 2.4 | Statistical methods

Data (Dayer et al., 2019) were analysed using SPSS (version 25.0). To answer research questions 1, 3 and 4, we summarized the frequency of responses (percentages of respondents) to the survey questions. For research question 2, we calculated phi (Φ) coefficients as part of 2 × 2 Chi-square tests to measure the strength of association between independent variables of the qualitative emotion and attribution themes (coded as present or absent in the respondent's open-ended answer) and dependent variables of taking action in response to certain events (coded as took the action or not). To reduce the likelihood of a Type I error from multiple independent tests, we used Benjamini–Hochberg procedure (Benjamini & Hochberg, 1995) values to assess the significance of *p*-values with a false discovery rate of 5%.

## 3 | RESULTS

The majority of the respondents (72.3%) were female. The mean respondent age was 64 years old (range 18–96). Respondents indicated that, on average, they had been feeding birds for 25.4 years (range 1–80). The mean number of feeders a participant provisioned in winter was 6.1 (range 1–147), and in summer was 5.7 (range 0–444). The respondents' mailing addresses spanned all 48 contiguous states of the United States, as well as Washington, D.C.

### 3.1 | Observations of nature and actions (question 1)

Overwhelmingly, respondents reported that they observed facets of nature potentially related to bird feeding in the past year, including the presence of a hawk (88%) or cat (57%) near their feeder, a diseased bird at their feeder (62%) or increases (51%) or decreases (38%) in bird abundance within a season (Figure 1). For respondents who reported seeing a diseased bird, approximately 65% noticed that the bird had swollen eyes, 36% reported that the bird sat still for an abnormally long period of time, 21% reported other visible symptoms and 12% found a dead bird nearby.

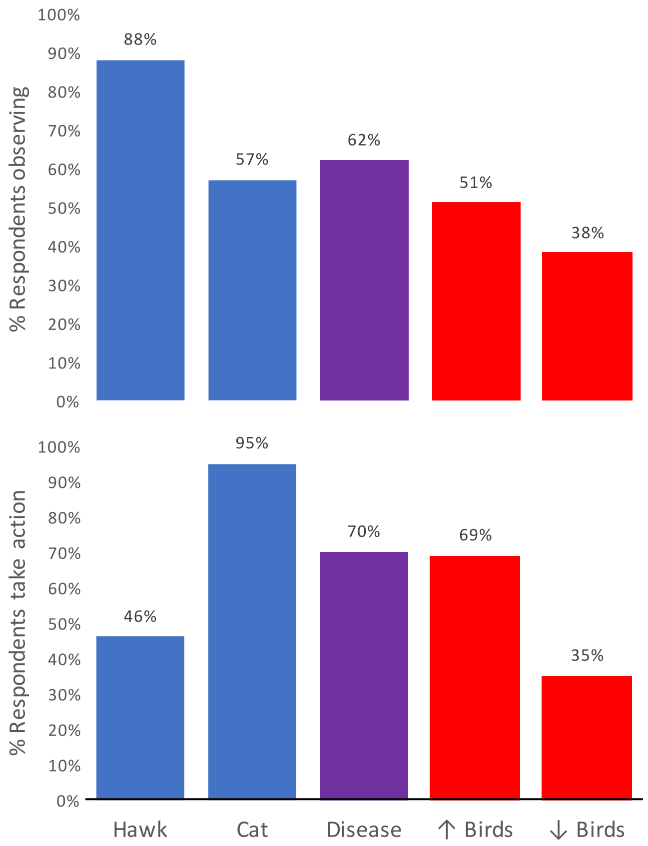


**FIGURE 1** Top: Percent of respondents who observed any of the following events at their feeders: the presence of a predator (blue), the presence of a diseased bird (purple), or a notable change in bird abundance (red). Bottom: Percent of respondents who have/would take action if they observed any of those scenarios at their feeders [Colour figure can be viewed at wileyonlinelibrary.com]

Many of the respondents reported that they have or would alter their feeding-related behaviours or take other actions as a result of observing the presence of predators or disease. However, the likelihood of taking action depended on the scenario presented (Figure 1). For the case of seeing a cat near the feeder, an overwhelming majority (95%) of respondents would take some kind of action. In terms of actions taken, most respondents indicated they would scare off the cat (84%; Table 2). In contrast, in response to seeing hawks (a native predator) near feeders, fewer respondents would take action (46%), with the most common responses being to provide shelter or protection for the smaller birds (35%) and to scare off the hawk (14%). With respect to observations of diseased birds at their feeders, the majority of respondents (70%) reported that they have or would take some sort of action. The most common reported action in response to disease was to clean feeders more often (67%). In response to seeing a notable increase in birds at their feeders, approximately 69% of respondents indicated they would make some change in their feeding-related behaviours, with the most common reported actions as keep feeders fuller (54%) and add more feeders (24%). In contrast, in response to seeing a notable decrease in birds at their feeders, only about 35% of respondents indicated they would take action. The two most common actions in response to decreases in birds at feeders were to remove some or all feeders (10%), and keep feeders fuller (9%).

## 3.2 | Relationship between emotional connections and attributions and taking action (question 2)

Respondents' descriptions of their feelings when they observed a depredation event by a cat or hawk or a diseased bird at their feeders reflected seven emotion themes (Figure 2; see Table 1 for sample quotes for each emotion). The expressed emotions were positive (e.g. enjoy, interested), negative (e.g. sad, angry) or neutral. In addition to finding emotions that were part of our initial coding scheme, we also found frequent reference to being 'worried' and 'annoyed'. For observations of diseased birds, approximately 20% of responses did not reflect an identifiable emotion in their response (and another 10% were left blank), 56% of responses expressed one emotion theme, while 14% expressed multiple emotion themes. Similarly, for observations of depredation by cats, 20% expressed no emotions (and another 4% were left blank), 70% expressed one emotion theme and 7% expressed multiple emotion themes. For observations of depredation by hawks, the distribution was 43% for no identifiable emotions (and another 3% were left blank), 50% for one emotion theme and 5% for multiple emotion themes.

Additionally, three emergent themes became apparent from the responses. Many of the statements reflected to whom/what respondents attributed the cause of the event (Figure 2). They were 'natural attribution' (used to represent responses that justified the event as part of some component of nature), 'self attribution' (believing the event at the feeders is the result of one's own actions) and 'others attribution' (blaming other people for the event) (see Table 1 for sample quotes). Unlike emotions, respondents who expressed an attribution usually expressed only one in their response. For observations of diseased birds, 17% of respondents expressed a single attribution theme, while less than 1% of respondents expressed multiple. For observations of depredation by cats, 30% expressed a single attribution theme, while only 2% expressed multiple. Finally, for observations of depredation by hawks, 69% expressed one attribution theme, while 1% expressed multiple.

The emotions reported by respondents varied depending on the type of scenario presented (Figure 2). While nearly half of the respondents (47%) felt angry in response to seeing a cat depredate a bird at their feeder, very few respondents felt angry in response to seeing a hawk depredate a bird (7%) or in response to seeing a diseased bird at their feeder (3%). Similarly, about 28% of respondents indicated that they would be worried if they saw a diseased bird at their feeder, while only 2% of respondents indicated being worried in response to an observed depredation event by a cat or hawk. Not all of the emotions that respondents felt in response to these events were negative. About 11% of respondents expressed some sort of enjoyment from seeing a hawk take a bird at their feeders, while nearly 0% felt this emotion in response to seeing a diseased bird or cat take a bird at their feeders.

There was also variation among the attributions reflected in response to the various scenarios (Figure 2). The most pronounced distinction was that 69% of respondents indicated that seeing a hawk take a bird at their feeders was natural, while only 10% and 11% mentioned that seeing a cat take a bird, or seeing a diseased bird,

**TABLE 2** Percent of respondents who reported they have or would take various actions (or none at all) in response to observations at or near feeders, including a notable increase or decrease in bird abundance, a diseased bird, domestic cat or hawk

| Actions | Experiences at feeders: Notable increase (*n* = 1,176) | Notable decrease (*n* = 1,148) | Diseased bird (*n* = 1,162) | Cat (*n* = 841) | Hawk (*n* = 835) |
|---|---|---|---|---|---|
| Add more feeders | 24.4% | 4.9% | 0.1% | – | – |
| Switch to a higher quality, more expensive feed | 1.9% | 7.3% | 0.3% | – | – |
| Switch to a less expensive feed | 1.0% | 0.5% | – | – | – |
| Keep feeders fuller | 53.7% | 9.2% | 0.3% | – | – |
| Remove some or all feeders | 2.2% | 10.2% | 9.1% | 1.3% | 2.2% |
| Change to a different type of feeder | – | – | 1.1% | – | – |
| Clean feeders more often | – | – | 66.7% | – | – |
| Attempt to catch the sick bird and take it to a wildlife rehab facility | – | – | 8.3% | – | – |
| Scare off cat/hawk | – | – | – | 83.7% | 14.0% |
| Try to remove/trap cat/hawk | – | – | – | 11.3% | 0.1% |
| Provide shelter or plants for protection for smaller birds | – | – | – | 31.9% | 35.3% |
| Relocate feeder(s) or make feeder less accessible for cats/hawks (e.g. remove shelter or perch for cats/hawks) | – | – | – | 31.6% | 7.8% |
| Other | 5.8% | 11.6% | 7.1% | 6.9% | 3.6% |
| I do not (or would not) make changes | 31.0% | 64.6% | 30.0% | 5.2% | 54.3% |

*Note*: Dashes indicate that a given action was not an option for that type of observation or scenario.

respectively, was natural. Another notable difference was that 19% of respondents attributed seeing a cat take a bird to other people (mostly blaming other people for letting their cats outside), while close to 0% attributed other people as the reason for seeing hawks take a bird, or diseased birds at their feeders.

Several emotions and attributions in response to the depredation and disease scenarios were significantly associated with whether respondents would take active or passive action in response to observations of predators or diseased birds at feeders (Table 3). With regard to diseased birds, significant phi associations were found between worried and passive action ($\Phi = 0.139$), neutral and passive action ($\Phi = -0.118$) and self attribution and passive action ($\Phi = 0.120$). Thus, respondents who felt worried by a diseased bird or attributed that observation to themselves were more likely to take a passive action, while those who felt neutral about diseased birds were less likely to take action. Similarly, with observations of cats, significant associations were found between angry and active action ($\Phi = 0.197$), neutral and active action ($\Phi = -0.172$) and self attribution and passive action ($\Phi = 0.091$). Finally, with regard to seeing a hawk, there were significant phi associations between sad and active action ($\Phi = 0.149$), angry and active action ($\Phi = 0.178$), angry and passive action ($\Phi = 0.107$), worried and active action ($\Phi = 0.120$), interested and active action ($\Phi = -0.088$), enjoy and active action ($\Phi = -0.093$) and natural attribution and active action ($\Phi = -0.127$). Notably, the last three phi associations were negative, indicating less likelihood to take action with the emotions of interested or enjoyment, or a natural attribution statement.

## 3.3 | Self-reported factors important to feeding decisions (question 3)

Respondents reported that observations of nature were more important in their decisions to feed birds than were internal constraints (time and money; Figure 3). The three most important factors (based on combined responses of 'very important' or 'important') for respondents' decisions about bird feeding were all components of nature: temperature (59%), followed by abundance of birds at feeders (39%) and the number of diseased birds seen at feeders (23%). The presence of predators near feeders was less important than these factors: 19% considered the presence of cats important, and 8% considered the presence of hawks important. In contrast to several of the natural factors, internal constraints were considered important by only a small proportion of respondents: only 13% considered money to be important, while 9% considered time to be important in determining how much they feed birds.

## 3.4 | Perceived impacts of feeding on wild birds (question 4)

Respondents largely perceived the impacts of their feeding on wild birds to be positive (Figure 4). Specifically, respondents believed their bird feeding increased the number of bird species in their feeding area (74%), the number of individual birds in their feeding area (75%), improved overwinter survival of birds (64%) and improved

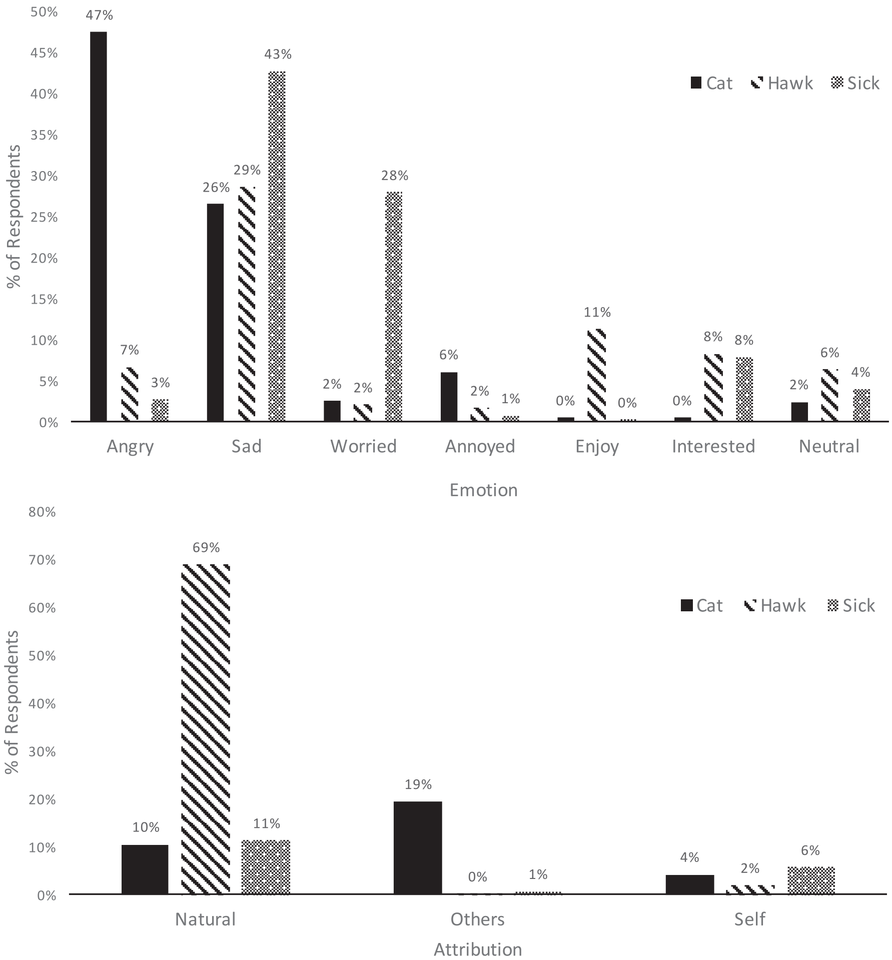


**FIGURE 2** Top: Emotions that respondents reported in response to scenarios of seeing a depredation event by a cat (solid black) or hawk (diagonal lines), or a diseased bird (dotted gray) at their feeders. Bottom: Attributions of respondents in response to those same observations

**TABLE 3** Phi coefficients for strength of association and *p*-values between emotions/attributions themes (coded as 0 or 1) in response to scenarios of cat or hawk depredation or diseased birds at feeders, and whether or not respondents would take an active or passive action (collapsed from a variety of actions and coded as 0 or 1) in response to observing a diseased bird, cat or hawk near their feeders. Bold denotes significant *p*-values with Benjamini–Hochberg correction procedure for multiple independent comparisons

| | Diseased bird (*n* = 1,162) | | Cat (*n* = 841) | | Hawk (*n* = 835) | |
|---|---|---|---|---|---|---|
| Variable | Active | Passive | Active | Passive | Active | Passive |
| Emotions | | | | | | |
| Sad | 0.004 (0.882) | 0.039 (0.189) | −0.039 (0.253) | 0.031 (0.369) | **0.149 (<0.001)** | 0.044 (0.199) |
| Angry | 0.028 (0.341) | 0.034 (0.242) | **0.197 (<0.001)** | 0.019 (0.583) | **0.178 (<0.001)** | **0.107 (0.002)** |
| Annoyed | 0.013 (0.662) | 0.035 (0.230) | 0.059 (0.089) | 0.023 (0.503) | 0.067 (0.052) | 0.069 (0.045) |
| Worried | 0.029 (0.325) | **0.139 (<0.001)** | 0.009 (0.791) | −0.028 (0.409) | **0.120 (0.001)** | 0.050 (0.145) |
| Interested | 0.016 (0.581) | −0.063 (0.031) | 0.027 (0.434) | 0.037 (0.288) | **−0.088 (0.011)** | 0.033 (0.344) |
| Enjoy | −0.012 (0.671) | −0.016 (0.591) | −0.024 (0.485) | 0.002 (0.952) | **−0.093 (0.008)** | −0.065 (0.059) |
| Neutral | −0.009 (0.755) | **−0.118 (<0.001)** | **−0.172 (<0.001)** | −0.002 (0.947) | −0.003 (0.941) | −0.044 (0.201) |
| Attributions | | | | | | |
| Natural | −0.068 (0.020) | −0.060 (0.040) | −0.056 (0.106) | 0.077 (0.025) | **−0.127 (<0.001)** | 0.025 (0.469) |
| Others | 0.017 (0.561) | −0.018 (0.548) | 0.056 (0.106) | 0.042 (0.227) | n/a | n/a |
| Self | 0.036 (0.223) | **0.120 (<0.001)** | −0.048 (0.167) | **0.091 (0.008)** | 0.005 (0.886) | 0.059 (0.088) |

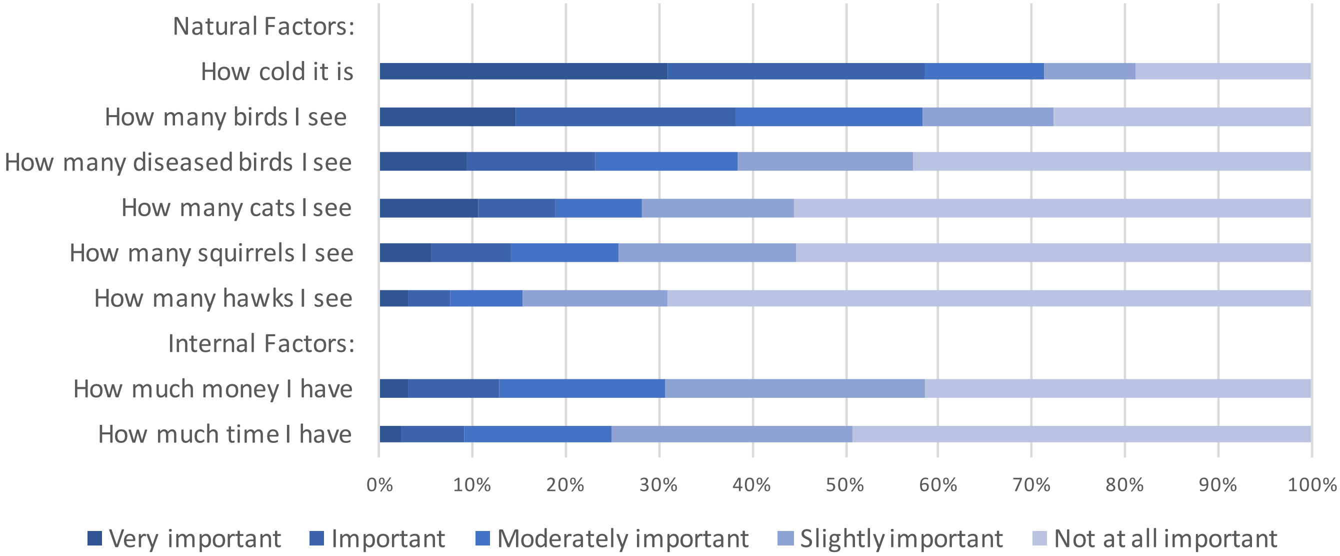


**FIGURE 3** Level of importance of various factors to percent of respondents (*n* = 1,151–1,163, depending on item) when deciding how much to feed birds [Colour figure can be viewed at wileyonlinelibrary.com]

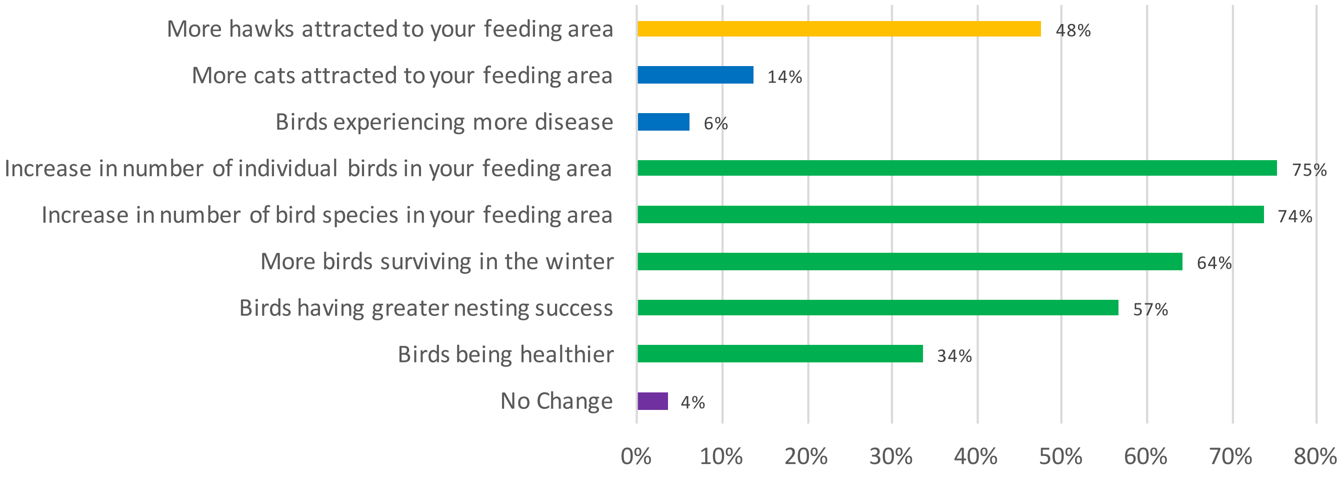


**FIGURE 4** Impacts of feeding wild bird populations in respondents' immediate area as perceived by percent of respondents (n = 839). Impacts likely to be perceived as positive are noted in green, while impacts likely to be perceived as negative are noted in blue. Due to mixed perceptions about hawks among respondents in our survey and in prior work by Cox and Gaston (2015), attracting more hawks was designated as neither positive or negative, and was given its own color, orange [Colour figure can be viewed at wileyonlinelibrary.com]

nesting success of birds (57%). Fewer respondents believed their feeding had adverse effects on birds, such as attracting more cats (14%) or exposing birds to more disease (6%).

## 4 | DISCUSSION

Feeding birds is a widespread interaction between humans and nature, with likely far-reaching ecological consequences (Jones, 2018). However, many of the drivers and consequences of bird feeding remain poorly understood. Cox and Gaston (2018) recently proposed that people's experiences related to bird feeding are likely to feed back in either positive or negative ways to alter their degree of provisioning. However, to date, there have been no empirical tests of whether people who feed birds observe and respond to components of nature that are potentially related to their actions in feeding wild birds.

Here, we report evidence that people observe several components of nature that are potentially linked to their bird feeding behaviour, and further, the majority have or would take action in response to these observations. Over two-thirds of respondents indicated that they would alter their provisioning behaviour in response to increases in the number of birds in their yard, such as changing the number of feeders they have up or keeping feeders fuller. This suggests that bird feeding can, in some cases, lead to positive feedback loops similar to those proposed by Cox and Gaston (2018). In these cases, more feeding leads to more backyard birds, which then leads to more feeding. The positive feedback loops proposed by Cox and Gaston (2018) arise from the documented health and well-being benefits associated with bird feeding (Cox et al., 2017).

However, other mechanisms such as the perceived need for greater food provisions when more birds are present, can similarly lead to positive feedback loops between human experiences and the degree of provisioning. These feedbacks, in turn, could have important ecological consequences in localized areas because dense aggregations of feeder birds at predictable sites could attract predators and non-target taxa (Reed & Bonter, 2018), or increase infection risk (Murray, Becker, Hall, & Hernandez, 2016). Our survey intentionally used broad language to assess actions in response to observable changes in bird numbers (e.g. 'When you notice notable increases in the total number of birds coming to your feeder, do you…'). Thus, we are unable to separate out the potential contributions of increases in the number of species vs. increases in the total number of birds of one species on the likelihood of action. Because prior work by Cox and Gaston (2015) found that those who feed birds prefer species richness over abundance, future work should explore the role of species richness, in particular, in driving changes in people's provisioning behaviour. Future work should also examine the extent to which the well-being benefits associated with seeing higher numbers of birds at feeders (i.e. Cox et al., 2017) drive the degree to which people are willing to alter their provisioning behaviour in response to changes in abundance.

The three scenarios that represented potential negative effects of feeding (i.e. the presence of a cat, hawk, or diseased birds) varied in the degree to which they evoked likelihood of action in our respondents. The scenario of seeing a cat near feeders elicited the most widespread response, with 95% of respondents saying they did or would take action. This finding has important conservation implications, as bird mortality due to cats far exceeds any other source of anthropogenic mortality (Loss, Will, & Marra, 2013). We find that people are taking (or are willing to take) action at the local scale to attempt to prevent cat depredation at their feeders. In contrast, while more respondents had recent experience observing a hawk (a native predator) near their feeders compared to a cat (88% in the past year vs. 57%), only 46% of respondents reported that they would take some action in response to the hawk. For hawks, emotions were also less likely to be reflected in statements (43% of respondents had no identifiable emotion), and the majority of respondents (69%) referred to the taking of birds by hawks as natural. Thus, similar to the results of Larson et al. (2016) in their study of nest box management, people responded more strongly and negatively to the presence of a non-native species that has documented negative effects on wild birds. Our results also indicate some mixed responses to the presence of hawks, which is consistent with past work by Cox and Gaston (2015) showing that likeability of hawks is variable amongst those who watch birds.

Our results also show that respondents' emotional responses to the hypothetical scenarios of witnessing cat or hawk depredation, as well as diseased birds at their feeders, are often linked to whether they reported taking action in response to observations of cats, hawks or diseased birds near their feeders. In all three scenarios, at least one emotion (angry, worried or sad) was positively associated with taking action. In contrast, a neutral emotion or natural attribution was often negatively associated with action, suggesting that those who feel unconcerned or a lack of direct responsibility are less likely to be spurred to take action. This result confirms Larson et al.'s (2016) finding that emotions have a role in influencing human behaviour as it relates to birds. Research by Lerner and Tiedens (2006) suggested that anger, in particular, has a strong influence on the decision-making process, which is consistent with our results, as the strongest associations between emotion and action involved the emotion of anger. However, even the strongest associations we measured between emotions and action were of relatively small magnitude (Cohen (1988) defines 0.1 as a small association and 0.3 as medium association for phi). The small magnitude of associations we detected may result from the high variability inherent in human behavioural studies (Cohen, 1988), additional noise associated with thematic coding of open-ended survey responses (rather than close-ended selections for various emotions) or differences in the way that our emotion and action variables were surveyed. We surveyed emotions in response to actual depredation events, whereas actions were surveyed in response to the presence of a predator alone, rather than an actual depredation event. Thus, the presence of even small associations for the predator scenarios suggests that visual observations of predators alone can elicit actions that relate in part to the type of emotions evoked by scenarios of actual depredation events. Further study is needed to better understand how much of the variation in behaviour that emotions can explain and to determine whether this is a causal relationship.

Although our results suggest that emotions play some role in people's provisioning behaviour, we expect that future research would find better predictive power for when people would take actions in response to scenarios at their feeders with additional information about respondents' wildlife value orientations (Manfredo, Teel, & Henry, 2009). Wildlife value orientations are basic beliefs that shape people's attitudes, and thereby behaviours, towards wildlife (Teel, Manfredo, & Stinchfield, 2007). As suggested by Manfredo et al. (2009), we expect that people who feed birds are more likely to hold a mutualism value orientation, which involves caring about wildlife and social affiliation with it (Teel et al., 2007). Past research has suggested that value orientations are related to emotional responses to wildlife, and act together to influence human behaviour related to wildlife (Dayer, Stinchfield, & Manfredo, 2007; Larson et al., 2016). Thus, future work should examine relationships between emotions, wildlife value orientations and observations at backyard bird feeders to better elucidate the way in which those who feed birds respond to natural events in their backyards.

When we asked respondents which factors were most important in determining how much they feed birds, we found that internal factors (i.e. time and money) were not considered very important in influencing a respondent's decision to feed birds. Because bird feeding can be an expensive activity (Davies et al., 2012), it is particularly interesting that money does not appear to be a limiting factor in the degree to which our respondents feed birds. Our sample of participants in Project FeederWatch may be less likely to experience internal constraints, as they have been feeding birds for a long time, demonstrating their commitment to the activity. However, when surveying a random sample of individuals in the UK who were not citizen scientists, Cox and Gaston (2016) similarly found income to be unimportant regarding individuals' decisions to feed birds or not. Thus, the lack of importance of internal constraints in our study may not be a result of the study population. Instead, observations of nature were most important in our respondents' decisions about feeding birds, with ambient temperature ranked as most important. As Galbraith et al. (2014) found, provisioning activity tends to be greatest in seasons during which there is a perceived limitation of food, which often directly correlates with low temperatures. Thus, a perception of birds needing help may explain the strong importance of temperature in the extent of provisioning by our respondents. The next two factors ranked most frequently as being important (i.e. number of birds and number of diseased birds) indicate that direct observations of birds influence the rate of provisioning, as opposed to environmental conditions alone. This suggests that observations of wildlife can directly feedback to influence provisioning decisions by humans, leading to positive or negative feedback loops in some cases.

The self-reported effects of providing supplemental food for birds suggest that people largely believe their feeding has a positive effect on birds. A majority of respondents believed bird feeding increased both the number of bird species (74%) and the number of individual birds (75%) in the immediate feeding area. Indeed, bird feeding has been associated with increased abundance or range expansions for certain bird species (e.g. Fischer & Miller, 2015; Fuller et al., 2008, 2012; Greig et al., 2017). In some cases, supplemental feeding has even been used as a conservation strategy for wild birds (e.g. Ewan, Walker, Canessa, & Groombridge, 2014). However, in areas where feeding is popular in the Southern Hemisphere, supplemental feeding may disproportionately benefit introduced bird species while leading to declines of native species, potentially due to heterospecific competition (Galbraith, Beggs, Jones, & Stanley, 2015). Thus, effects of feeders on bird abundance appear to be highly systems-specific (Reynolds et al., 2017) and species-specific (Fuller et al., 2008; Galbraith, Jones, Beggs, Parry, & Stanley, 2017), with overall effects on species richness either absent (Fuller et al., 2008) or only present for introduced bird species in some systems (Galbraith et al., 2015).

Further, while only 6% of our respondents believed their feeding was increasing the prevalence of disease, several recent studies have found that backyard bird feeding is associated with increased spread of disease for some species (reviewed in Lawson et al., 2018). Thus, respondents might not be fully aware of the potential adverse health effects their feeders can have on birds. This, in turn, could lead to a missing feedback loop similar to that proposed by Cox and Gaston (2018), in which people do not decrease feeding in response to negative impacts of their provisioning on wildlife. While Cox and Gaston (2018) proposed that this missing feedback loop could arise from people not experiencing the negative impacts of their feeding on wildlife, our study specifically targeted individuals for half of our sample who had seen a diseased bird in the last 4 months. Although 62% of the respondents in our study reported observing a potential negative impact of feeding on birds (i.e. a diseased bird in the last year), only 6% believed that their feeding was increasing the prevalence of disease. This suggests a disconnect, where an additional missing feedback loop arises from people observing but not recognizing the potential negative impacts of their feeding.

Relatedly, we found that only 6% of our respondents attributed the presence of a diseased bird at their feeder to their own role; yet, nearly twice as many respondents (11%) mentioned that there was a natural cause for this disease. While we did not specifically ask respondents to comment on the cause of diseased birds, these emergent findings are likely telling and should be explored with further research. We expect that many respondents hold strong beliefs that their feeding helps birds (in line with a mutualism value orientation [Manfredo et al., 2009]), which influences how they interpret their role in the impacts of feeding on birds. Such a mechanism could have important conservation implications because such beliefs might limit the utility of any educational messaging targeting people who feed birds, especially if those changes suggest reducing the amount of feeding in response to certain events. As we found, few respondents reported that they would limit their bird feeding activities in response to the five scenarios presented, while some bird conservation organizations suggest it may be advisable to reduce feeding in certain situations, such as during a disease outbreak. On the other hand, one key challenge with educational messaging about bird feeding is that further ecological work is sorely needed to determine the generality with which bird feeding has positive or negative overall impacts on bird populations (Reynolds et al., 2017). For example, theoretical studies suggest that if food supplementation, such as bird feeding, increases individual condition and thus the ability to resist disease, those positive effects of provisioning can in some cases outweigh the increased spread of disease by individuals aggregated at supplemental food sources (Becker & Hall, 2014). The likely complex impacts of feeding on wild birds and human perceptions of these impacts will require significant study before the overall implications for wild bird conservation and management can be fully elucidated.

While some key linkages between the biological and social aspects of bird feeding emerged through our work, we recommend further research to address the limitations of our study. One limitation is that we did not directly observe people, but instead relied on their accounts of their emotions in the past and their self-reported past or intended behaviour. We recommend future research to include measures of actual behaviour, such as the amount of food provisioned using a feeding log, and experimental assessments of emotions at the time of observations of events at a feeder. Additionally, our sample frame of citizen scientists, as opposed to the majority of non-citizen scientists who feeds birds, likely influenced our results. Citizen scientists likely pay closer attention to their feeders than non-citizen scientists, as they are primed to record data on bird presence at their feeders, and they are generally more experienced in feeding birds (our study population had an average of 25 years of feeding experience). Thus, they may also be more likely to notice changes in nature around their feeders. Further, Project FeederWatch participants are explicitly asked to make note of diseased birds and are given information about how to identify eye disease in finches. Finally, citizen scientists may be more likely to be aware of the high wild bird mortality rates associated with cat predation, which represents a particularly controversial issue for the general public (Marra & Santella, 2016). We recommend that future research on the human dimensions of bird feeding also include a sampling frame of non-citizen scientists who feed birds, allowing for comparisons to explicitly understand how feedbacks between humans and nature are influenced (or not) by participation in citizen science. Lastly, we suggest cross-cultural research, particularly in countries where feeding is discouraged (e.g. Australia) compared to those where it is largely encouraged (e.g. United States and the United Kingdom).

Overall, our results suggest that human thought and action related to bird feeding are directly coupled to observable components of nature, with important implications for conservation. Our findings indicate that people who observe potential problems in the environment directly, such as high rates of disease or cats at their feeders, may take action to combat those problems. Notably, the scenario of seeing a cat near a feeder was most likely to elicit a response and this response was associated with anger. Although the relationship between emotions and actions warrants more inquiry, these results tentatively suggest that people may be more likely to act in response to anthropogenic threats to birds or events that elicit anger-related emotions. Additionally, our results demonstrate that most people believe their feeding activities have a positive impact on birds; yet, the consequences of providing supplemental food may vary depending upon the species of interest and context (e.g. location, time of year, local predator community). Finally, further research is required on the linkages between the provisioning behaviour of humans and wildlife responses (e.g. individual bird fitness, population abundance) to improve our broader understanding of potential feedbacks between human thought, human behaviour and wildlife populations (Morzillo, de Beurs, & Martin-Mikle, 2014).

## CONFLICT OF INTEREST

Nothing to declare.

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## AUTHORS' CONTRIBUTIONS

A.D., D.H., D.B., R.H., W.H. and T.P. conceptualized the project; A.D. and D.H. designed the survey; H.F., D.B. and T.P. administered the survey; A.D. and C.R. analysed the data with support from W.H.; A.D., D.H. and C.R. led the writing of the manuscript. All authors contributed critically to the drafts and gave final approval for publication.

## DATA ACCESSIBILITY

Our de-identified survey data (Dayer et al., 2019), including thematic codes and computed variables used in this manuscript, are archived with VTechData, the data repository for Virginia Tech:

Dayer, A. A., Rosenblatt, C., Bonter, D. N., Faulker, H., Hall, R. J., Hochachka, W. M., Phillips, T. B., and Hawley, D. M. (2019). Observations at backyard bird feeders influence the emotions and actions of people that feed birds—Dataset. University Libraries, Virginia Tech. https://doi.org/10.7294/w4-rzs9-ht97

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