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Research Article

What motivates the masses: Understanding why people contribute to conservation citizen science projects

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ABSTRACT

Participation in conservation citizen science projects is growing rapidly and approaches to project design are diversifying. There has been a recent shift towards projects characterised by contributors collecting data in isolation and submitting findings online, with little training or opportunities for direct social interaction with other citizen scientists. While research is emerging on developing citizen science projects by optimising technological modalities, little consideration has been given to understanding what motivates individuals to voluntarily contribute data. Here, we use the Volunteer Functions Inventory, combined with open-ended questions, to demonstrate that the two strongest motivations underpinning participation, for both individuals who contribute data systematically (regularly; $n = 177$) and opportunistically (ad hoc basis; $n = 218$), are 'Values' and 'Understanding'. People take part in such projects because they have an intrinsic value for the environment and want to support research efforts (representing 'Values'), as well as wanting to learn and gain knowledge (signifying 'Understanding'). Unlike more traditional citizen science projects that involve specific training and considerable time investments, contributors to these newer types of project are not motivated by the potential to develop their career or opportunities for social interaction. The person-level characteristics of contributors considered in this study did not reliably forecast levels of motivation, suggesting that predicting high levels of motivation is inherently more complex than is often speculated. We recommend avenues for future research that may further enhance our understanding of contributor motivations and the characteristics that may underpin levels of motivation.

1. Introduction

The scale and complexity of the current environmental crisis poses a considerable challenge to conservationists around the world. Effective conservation strategies rely on extensive knowledge of the natural world, yet in a time of limited funding, time and resources, this is often unachievable. Recruiting the public as citizen scientists has proven to be a powerful tool (Ellwood et al., 2017; McKinley et al., 2017). Although observations by non-experts have been appreciated as a source of scientific knowledge for centuries, participation in conservation citizen science projects, defined as organised activities run by scientists where the public help gather or analyse data, has grown rapidly over the last decade (Pocock et al., 2017). The proliferation of citizen science projects has been motivated by an increasing appreciation of the value of such programmes by the scientific community (van der Velde et al., 2017; Horns et al., 2018). Citizen scientists contribute towards conservation efforts, natural resource management and environmental protection via two primary pathways (McKinley et al., 2017). Firstly, understanding conservation challenges and designing effective strategies often requires longitudinal data collected over a large geographical scale. Citizen scientists play a critical role in building these datasets, especially where funding and other practical constraints would otherwise make this unachievable. Indeed, data from citizen scientists has been used to successfully predict national-scale population trends for a range of taxa (Outhwaite et al., 2020), including butterflies (Dennis et al., 2017) and birds (Horns et al., 2018), assess the effectiveness of conservation management strategies (Jordan et al., 2016) and monitor the spread of invasive species (Roy et al., 2012). Secondly, public

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engagement with conservation can indirectly contribute to environmental protection (McKinley et al., 2017). For instance, citizen scientists may share information within their communities and thereby motivate new individuals to participate in conservation actions.

Traditionally, conservation citizen science projects have involved people actively collecting and submitting samples/observations to a central administering organisation (Haklay, 2013). Projects typically require individuals to invest significant amounts of time on a regular basis, primarily outdoors and frequently as part of a team. The participants also often require some form of training or support to gain the skills needed to complete the data collection task (e.g. OPAL, http://www.opalexplorenature.org/aboutopal; Butterfly Conservation Europe Monitoring Programme, www.bc-europe.eu/index.php?id=339). Project formats are, however, beginning to diversify. There has been a notable shift towards people collecting and contributing data on their own, with limited training and little/no direct social interaction with either experts or other citizen scientists, before submitting it via an online reporting platform (e.g. Garden BirdWatch, https://www.bto.org/our-science/projects/gbw; Bug Count, https://www.opalexplorenature.org/bugscount; Marine Debris Tracker, http://marinedebris.engr.uga.edu/). This has been driven, in part, by the rapid development of the Internet, both in terms of ease of accessibility/use and data capacity/processing capability, which has allowed mass participation via online reporting platforms to become common (Higgins et al., 2016; Pocock et al., 2017; Luna et al., 2018).

To date, we have a limited understanding of why individuals choose to engage in these large-scale citizen science projects with online reporting elements, often leaving project managers within conservation organisations reliant on anecdotal evidence. Knowing why people are motivated to take part could inform project design and efficiency, increasing the likelihood of collecting accurate, long-term data to inform robust conservation decisions and improving the recruitment/retention of contributors (Sutherland et al., 2015; West and Pateman, 2016). Indeed, citizen science contributors are more likely to remain engaged and committed if they perceive their motivations for contributing are being met by the project (Jacobson et al., 2012; Domroese and Johnson, 2017). Despite these facts being widely acknowledged, Follett and Strezov (2015) reviewed the literature and found that just 3% of citizen science papers consider contributor motivations. Previously, Bruyere and Rappe (2007) examined field-based environmental volunteers and identified the key motivations to be learning new knowledge, socialising, congruence between the activity and individual values, and self-esteem. Raddick et al. (2010) found that learning and fun were important to citizen 'cyberscientists'. More recently, a study of the Great Pollinator Project (http://greatpollinatorproject.org/) reported that a desire to help the environment and learn about bees were the most cited reasons for participant involvement in conservation citizen science (Domroese and Johnson, 2017). Here, we examine why individuals are motivated to engage in large-scale citizen science projects with an online reporting component, where training or social interaction opportunities are limited. We also explore the extent to which assumed motivations and anecdotal evidence collated by citizen science project managers resonate with contributors more broadly. Finally, we determine whether person-level characteristics can be used to predict high levels of motivation.

The Volunteer Functions Inventory (VFI) framework is a validated psychological scale (Clary et al., 1998) that is based on functional theory (Katz, 1960). It encapsulates the complexity and diversity of potential intrinsic and extrinsic motivations more effectively than alternative quantitative psychological frameworks (Okun et al., 1998) and allows relative comparisons to be made between different motivations. There are six motivations included in the VFI: 'Understanding', 'Social', 'Values', 'Protective', 'Career' and 'Enhancement' (Clary et al., 1998). 'Understanding' relates to activities permitting new learning experiences and an opportunity to exercise knowledge, skills and abilities. This is pertinent for citizen science projects as a contributor's desire to learn about issues directly relevant to projects, is a commonly referenced motivation (e.g. Bruyere and Rappe, 2007; Domroese and Johnson, 2017). 'Social' describes motivations which centre on developing and strengthening social ties and skills, either by being with friends or engaging in an activity viewed favourably by important others. We anticipated that this would be less of a driver to engage in large-scale citizen science projects with online reporting platforms, as data collection and submission are often conducted without direct interaction with other contributors. 'Values' encompasses the ability to express altruistic and humanitarian values. We expected this to be an important motivation for people involved in any conservation-focused citizen science projects, because the outputs from the vast majority of these initiatives are used to inform species/habitat management. 'Protective' is ego-centric and examines how volunteering can protect an individual's ego from the difficulties experienced in wider life. For instance, activities that reduce feelings of guilt around being more fortunate than others. We had no a priori reason to believe that this would be relevant to people contributing data to citizen science projects. 'Career' embodies the possibility that volunteering may improve present/future career prospects. We deemed this to be most relevant to more traditional style citizen science schemes, which include a training or skilled component (e.g. sampling species using transect methods). For large-scale projects where contributors simply submit observations/data via online reporting platforms, this would be less likely to be a strong motivator. Finally, 'Enhancement' reflects the opportunity to increase positive affect. This may be relevant to contributors who gain a sense of personal development or heightened self-esteem by contributing data.

Additionally, conservation organisations may wish to segment the population and promote participation in their citizen science projects to particular sociodemographic sectors of society. Such targeting has been proposed to increase household engagement in supplementary bird feeding (Davies et al., 2012), improve conservation outcomes by encouraging youth-focused citizen science projects (Ballard et al., 2017), and target specific audiences for effective social marketing campaigns that benefit conservation (Wright et al., 2015). Nevertheless, there remains a paucity of knowledge regarding whether or not person-level characteristics can be used to predict high levels of motivation to engage in conservation citizen science projects.

2. Methods

2.1. Study system

We use Garden Wildlife Health (GWH; www.gardenwildlifehealth.org) as a case study large-scale citizen science project where contributors collect data, predominantly on their own, and submit their observations using an online reporting platform. Emerging wildlife infectious diseases are one of the most challenging threats to biodiversity (Canessa et al., 2020), with pathogens causing population declines due to mass mortality (e.g. Daszak & Cunningham, 2000; Smith et al., 2009; Lawson et al., 2018). The chytridiomycosis panzootic is one of the most dramatic examples of biodiversity loss at a global scale due to disease. The pathogen *Batrachochytrium dendrobatidis* was first discovered in amphibian populations over two decades ago and has since caused the decline of 501 species, including 90 presumed extinctions (Scheele et al., 2019). After invading new areas, pathogens are normally impossible to eradicate in free-living wildlife, making effective surveillance programmes and rapid responses to outbreaks essential to mitigate against biodiversity loss (Canessa et al., 2020). Structured citizen science schemes offer a means to conduct wildlife disease surveillance that would be practically and financially impossible without the public's assistance (Lawson et al., 2015). GWH, which was launched in July 2013, is used to investigate infectious/non-infectious threats to the health of British garden wildlife (comprising amphibians, reptiles, garden birds and hedgehogs). Contributors to GWH have enabled identification and ongoing surveillance of several emerging infectious diseases of conservation concern (e.g. Franklinos et al., 2017). GWH

disseminates science-based best practice guidance for habitat management and biosecurity to citizen scientists, helping prevent and control disease outbreaks and safeguard wildlife health thereby promoting practical conservation. While there are social media groups associated with the GWH project, these are largely used to disseminate advice from the project managers, rather than facilitate social interaction between contributors.

Citizen scientists are a valuable conservation resource. However, if programmes fail to engage or retain enough data contributors, they are unlikely to successfully meet their objectives (Sutherland et al., 2015). Currently, there are two distinct groups of GWH contributors: (a) *Systematic*, who observe wildlife in their garden and record either the presence/absence of sick or dead wildlife on a weekly basis, in conjunction with their contribution to the British Trust for Ornithology (BTO) Garden BirdWatch scheme, which is a long established and highly-subscribed citizen science project; and, (b) *Opportunistic*, who submit ad hoc sightings of sick or dead wildlife observations directly to GWH, independent of any other citizen science initiative. Both cohorts play an important role in wildlife disease surveillance. *Systematic* contributors enable conservationists to develop an evidence base of not only disease occurrence, but also absence. Overtime this can be used to deepen our understanding of epidemiological trends. On the other hand, engaging *Opportunistic* reporters offers the opportunity to maximise the number of reporters and increases the likelihood of recording novel incidents. To deliver the most effective disease surveillance scheme, understanding what motivates both these cohorts to continue their participation is essential (Lawson et al., 2015). This makes GWH a particularly interesting study system, as we can simultaneously examine synergies and divergences in findings for the two cohorts, which differ in regard to the amount of time they commit to observing wildlife in their gardens and submitting data online.

2.2. Questionnaire development

We used a mixed methods approach, combining a psychological framework and open-ended questions to develop a questionnaire that would allow us to examine: (a) what motivates individuals to contribute towards citizen science projects; (b) whether the existing validated Volunteer Functions Inventory (VFI) adequately captures the motivations for contributing to citizen science projects; and, (c) what person-level characteristics may predict high levels of motivation. Individuals were asked to answer questions based on their involvement with GWH, rather than any other citizen science projects to which they might also be contributing.

The VFI section of the questionnaire included thirty statements, five for each of the six motivations ('Understanding', 'Social', 'Values', 'Protective', 'Career' and 'Enhancement') described by Clary et al. (1998). Individuals indicate how accurate a series of statements are to them (e.g. '*I feel it is important to contribute towards this cause*') using a 7-point Likert scale (1 = not at all accurate; 7 = extremely accurate). After feedback obtained during piloting, we reduced the Likert scale from 7- to 5-points as participants experienced difficulty discriminating between points on the scale. The optimal number of points to use in Likert scale questions has been investigated in-depth and the general conclusion is that there is no discernable effect on the cognitive structure of the results if a 5- rather than a 7-point scale is used (Preston and Colman, 2000). This alteration will not, therefore, reduce the validity of the VFI. Indeed, 5-point scales have been used in other published studies which applied the VFI (e.g. Asah and Blahna, 2012; Horstmann et al., 2018).

To complement and triangulate the VFI framework we asked a single, neutrally worded open-ended qualitative question: '*What are the most important reasons underpinning your contribution to the Garden Wildlife Health Project?*' This was placed at the start of the questionnaire, with the rationale being to minimise the potential influence of subsequent closed-ended questions on responses.

To ascertain the extent to which assumed motivations and anecdotal evidence gathered by citizen science project managers resonate with contributors more broadly, the questionnaire also included a list of 11 motivation statements (Table A1; Fig. 1) provided by the GWH citizen science project managers. Questionnaire respondents were asked to identify up to five of the statements they felt best represented their motivations for contributing data to GWH.

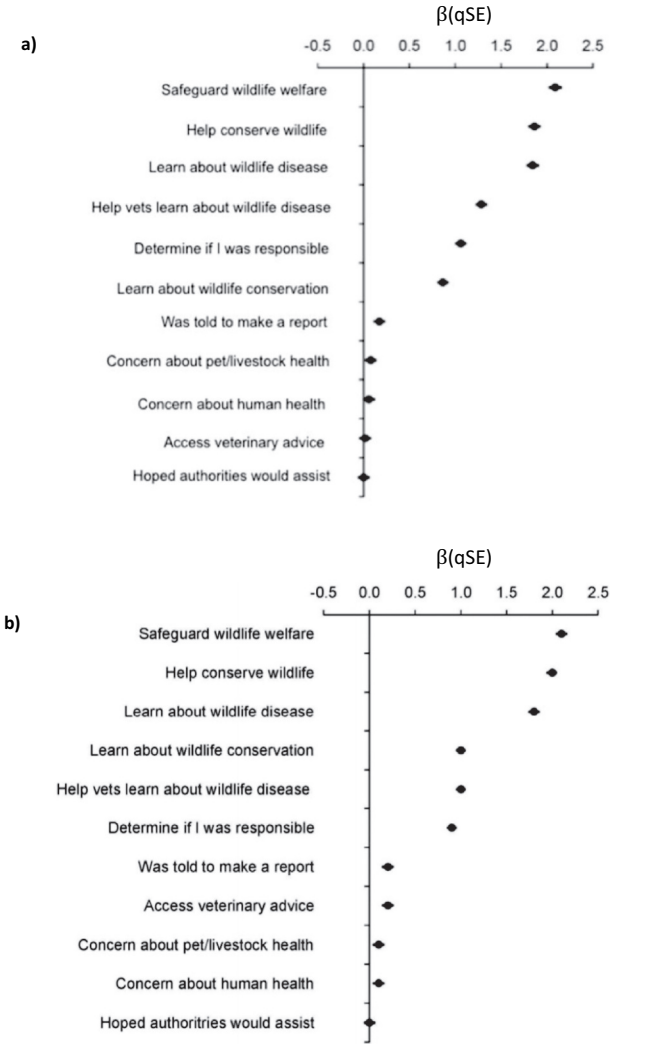

Fig. 1. Extent to which assumed motivations and anecdotal evidence gathered by citizen science project managers (Table A1) resonate with contributors more broadly as drivers for participating in Garden Wildlife Health for (a) *Systematic* (n = 177) and (b) *Opportunistic* (n = 218) data contributors. Values shown are β coefficients with quasi standard error bars (qSE).

Respondents were asked questions regarding their personal-level characteristics (gender, age, ethnicity, household income [before tax], registered disability, employment status and education level), as these might predict levels of motivation. The categorical/nominal questions were aligned with those from the 2011 UK Census (Office for National Statistics, 2014), and figures on annual household income (before tax) from the Institute for Fiscal Studies (Brewer et al., 2007), thereby allowing comparisons to be made with the wider UK population. The degree to which an individual feels emotionally connected to the natural world has also been shown to be associated with the likelihood of engaging in pro-environmental behaviours (Barbaro and Pickett, 2016; Whitburn et al., 2018). We included the 'connectedness to nature scale' (CNS) in the questionnaire, which comprises fourteen statements to which participants indicate their degree of agreement on a 5-point Likert scale (1 = strongly disagree; 5 = strongly agree) (Mayer and Frantz, 2004). The CNS is a reliable scale which has been extensively tested (see e.g. Schultz et al., 2004).

2.3. Questionnaire delivery

An email invitation to participate in the research was sent to all GWH contributors with a link to the online questionnaire. The link was open for two weeks. A modified Dillman approach (Dillman, 2011) was used to maximise response rates, with a reminder email sent six days after the initial invitation. Before a contributor could begin the questionnaire, they were asked to provide informed consent. Data from the self-administered questionnaire were collected using Qualtrics (version 37,892). Ethical approval was received from Imperial College London Research Ethics Committee.

2.4. Data analysis

The quantitative analysis was carried out using RStudio (version 1.2.133; RStudioTeam, 2019). The *Systematic* and *Opportunistic* data cohorts were analysed separately. Cronbach's alpha was calculated to determine internal consistency for each VFI function using the R *psych* package (Revelle, 2019). Responses to the open-ended motivation question were qualitatively analysed using a thematic approach (Braun and Clarke, 2006), creating a qualitative index of coded categories that appropriately captured the meanings of each individual's response. Thematic analysis was undertaken using NVivo (version 12, QSR International). Identified categories were then mapped onto the VFI framework. The number of individuals discussing the theme as one of their two main reasons for contributing for both *Systematic* and *Opportunistic* contributors were compared using z-tests.

The extent to which assumed motivations and anecdotal evidence gathered by citizen science project managers resonated with contributors more broadly was assessed using the Bradley-Terry Model (BTm; Strobl et al., 2011), a form of logistic regression, for both the *Systematic* and *Opportunistic* contributors. Independent samples *t*-test analyses were undertaken to determine if differences were apparent in mean CNS scores between *Systematic* and *Opportunistic* contributors.

To establish which sociodemographic background characteristics, if any, were important predictors of strong motivations, we adopted a multiple regression approach. Ethnicity, registered disability and employment status (Table A2) were excluded from the modelling process after exploratory data analysis because the data did not meet statistical assumptions. Age, household income, education level, gender and CNS score were retained as possible explanatory variables. We used the Akaike Information Criterion (*AIC*) to compare all candidate models and to identify the most parsimonious solution (Burnham and Anderson, 2004). The dependent variable in each model set was the mean VFI score for a specific motivation. Any models with a delta AIC_c value of 2 or more were excluded (Mazerolle, 2006), with parameter estimates and r^2 values averaged across the $\Delta AIC_c < 2$ model set.

3. Results

A total of 723 GWH data contributors were invited to complete the questionnaire and the overall response rate was 54.6% ($n = 395$). This equated to 69.7% ($n = 177$ from $N = 254$) and 46.5% ($n = 218$ from $N = 469$) for the *Systematic* and *Opportunistic* cohorts respectively.

For both *Systematic* and *Opportunistic* contributors 'Values' was identified as the most important motivation (mean = 4.4, SE = 0.03 and mean = 4.43, SE = 0.04 respectively). This was followed closely by the desire to develop their 'Understanding' (*Systematic*: mean = 3.55, SE = 0.05; *Opportunistic*: mean = 4.03, SE = 0.05). The importance of these motivations was further evidenced by the number of related themes emerging from the qualitative open-ended question (Table 1). Wanting to 'contribute towards research efforts' was the most frequently mentioned theme, by 57.6% ($n = 102$) and 38.1% ($n = 83$) for the *Systematic* and *Opportunistic* data contributors respectively, which maps directly onto the VFI 'Understanding'. Wanting to 'learn why the disease had occurred' also mapped onto 'Understanding', and was mentioned by 26.6% ($n = 47$) of the *Systematic* and 24.5% ($n = 53$) of the *Opportunistic* contributors. Both *Systematic* and *Opportunistic* contributors (17.5% and 31.2% respectively) described their 'concern about wildlife health' as being their predominant reason for reporting to GWH, which is associated with 'Values'. 'Career' was the least important motivation (*Systematic*: mean = 1.27, SE = 0.03; *Opportunistic*: mean = 1.38; SE = 0.03). This was also reflected in the qualitative results, with no themes emerging related to career development. Likewise, 'Social' (*Systematic*: mean = 2.05, SE = 0.04; *Opportunistic*: mean = 2.13; SE = 0.04) and 'Protective' (*Systematic*: mean = 1.54, SE = 0.03; *Opportunistic*: mean = 1.49; SE = 0.03) were not seen as important motivators to contributors.

Overall, the VFI framework encompassed the majority of motivations identified through the open-ended question (Table 1). Themes that could not be mapped onto the VFI, such as a desire to 'maintain garden environment' or 'influence policy' were mentioned infrequently (0.6% *Systematic* and 1.8% *Opportunistic*, and 0% *Systematic* and 0.5% *Opportunistic*, respectively).

Analysis of the statements derived from assumed motivations and anecdotal evidence gathered by project managers demonstrated that, for both cohorts, 'safeguard wildlife welfare' (*Systematic*: 84.7%, $n = 150$; *Opportunistic*: 89.8%, $n = 196$) was the most frequently identified motivation by data contributors (*Systematic*: $\beta = 2.09$, quasi standard error [qSE] = 0.06; *Opportunistic*: $\beta = 2.14$, qSE = 0.05; Fig. 1). Similarly, the two different cohorts were consistent in choosing 'conserve wildlife' (*Systematic*: 77.1%, $n = 136$, $\beta = 1.86$, qSE = 0.05; *Opportunistic*: 55.5%, $n = 177$, $\beta = 1.96$; qSE = 0.05) and 'learn about disease' (*Systematic*: 51.4%, $n = 90$, $\beta = 1.84$, qSE = 0.05; *Opportunistic*: 43.5%, $n = 87$, $\beta = 1.85$, qSE = 0.05) as the next two most frequently stated motivations. Generally, the majority of the assumed motivations and anecdotal evidence statements did resonate with contributors to some extent. However, this was not the case for 'hoping that authorities would assist with disposal of the animals' for either cohort (Fig. 1).

In each cohort, > 60% of the questionnaire respondents were women, which is over-representative of the UK population (Table A2). The age groups of the *Systematic* and *Opportunistic* data contributors were also skewed, with a higher proportion of older individuals than in the wider population, particularly among the *Systematic* contributors. An analogous pattern was observed for household income, with respondents typically having a higher income than the public in general. Employment status was most frequently described as retired for both cohorts, far exceeding the retired proportion of the UK population, particularly for the *Systematic* group. A further difference between both sets of data contributors and the general public was level of education, with a higher proportion of respondents having formal qualifications. The extent of connectedness to nature for both cohorts was comparable ($t = 0.352$, $df = 393$, $p = 0.730$), with *Systematic* and *Opportunistic* individuals scoring means of 3.79 (SE = 0.02) and 3.82 (SE = 0.02) respectively.

'Values' and 'Understanding' were the strongest motivations underpinning data contributions by both cohorts and were thus used as dependent variables in the regression analyses. The 'Values' motivation of *Systematic* cohort was predicted by age and CNS across the $\Delta AIC_c < 2$ model set, explaining 26% of the variation observed (Table 2). CNS was the only reliable predictor for the 'Understanding' motivation for *Systematic* contributors, explaining 23% of the variation observed (Table 2). For the *Opportunistic* cohort, 'Values' was be predicted by CNS and education. However, only 4% of the variation was explained (Table 2). Similarly, only 3% of the variation was explained for 'Understanding' for *Opportunistic* contributors, with education and gender being the only reliable predictors (Table 2).

4. Discussion

Citizen scientists are a valuable conservation resource. However, if programmes fail to engage or retain enough data contributors, they are unlikely to successfully meet their objectives (Sutherland et al., 2015).

Table 1

Motivations of *Systematic* (n = 177) and *Opportunistic* (n = 218) Garden Wildlife Health citizen science data contributors, framed according to the Volunteer Functions Inventory (VFI). VFI includes six motivations: 'Career' (improve present/future career prospects), 'Social' (develop/strengthen social ties), 'Values' (express altruistic/humanitarian values), 'Enhancement' (increase positive affect), 'Understanding' (permit new learning or exercise existing skills/knowledge) and 'Protective' (protect individual's ego). Chronbach's alpha (α) is reported, along with mean respondent values, for each VFI motivation. Themes identified after qualitative analysis of open-ended questions are mapped onto VFI motivations. Themes not associated with a VFI motivations are categorised as 'Other'. The number of *Systematic* and *Opportunistic* individuals discussing the theme as one of their two main reasons for contributing data to GHW is compared using z-tests.

VFI motivation	*Systematic*		*Opportunistic*		Qualitative theme	Example statement	*Systematic*		*Opportunistic*		z	p
	Mean (SE)	α	Mean (SE)	α			n	(%)	n	(%)		
Career	1.27 (± 0.03)	0.94	1.38 (± 0.03)	0.9	N/A	N/A	0	0	0	0	–	–
Social	2.05 (± 0.04)	0.81	2.13 (± 0.04)	0.83	Organisation requested I participate	BTO have previously asked if I could contribute disease sightings	14	7.9	0	0	4.23	< 0.001
Values	4.41 (± 0.03)	0.79	4.43 (± 0.04)	0.74	Prevent future diseases and outbreaks	It is important for us to be aware of possible disease outbreaks and prevent them where we can	17	9.6	24	11	−0.45	0.65
					Protect environment	Do my bit to protect our environment	1	0.6	2	0.9	−0.34	0.73
					Help conservation	I wanted to help the conservation process	2	1.1	5	2.3	−0.9	0.37
					Love for nature	I love nature and want to do all I can to help it	18	10.2	20	9.2	0.33	0.74
					Concern about chemicals	I am very worried about our use of chemicals in the UK and how this may contribute towards disease	0	0	1	0.5	−0.94	0.35
					Concern about bird population	I am concerned about decline in many species in recent years and hope that reporting may help curtail this	3	1.7	5	2.3	−0.42	0.67
					Concern about wildlife health	I am concerned about the decline in finches through disease	31	17.5	68	31.2	−3.1	0.00
					Concern about wider wildlife health problems	I was concerned because I have my horses in the field, I don't want the disease to spread to them	2	1.1	6	2.8	−1.19	0.23
					Reduce suffering	Because I don't like to see animals suffer	1	0.6	5	2.3	−1.37	0.17
					Help wildlife	I love all living creatures and just want to do my bit to help out wildlife	2	1.1	6	2.8	−1.19	0.23
					Preserve species	I was aware that diseases in wildlife could be reported and by doing this it may help to preserve species in the future	3	1.7	10	4.6	−1.6	0.11
Enhancement	1.79 (± 0.04)	0.82	1.62 (± 0.04)	0.84	Enjoyment	I enjoy helping schemes that help nature	23	13	3	1.4	−0.09	0.93
Understanding	3.55 (± 0.05)	0.8	4.03 (± 0.05)	0.74	Raise awareness	I hope the programme will use my report to raise awareness of wildlife disease spread	7	4	5	2.3	0.98	0.33
					To engage children	I want my children to understand and benefit as I have	0	0	1	0.5	−0.94	0.35
					Learn about why the disease occurred	Was so delighted to find that frogs lived in my garden. Was concerned when they started to die and wanted to know what was wrong with them.	47	26.6	53	24.3	0.52	0.60
					Seek advice	Noticed many sick and dead birds in garden, green finches, wanted advice on disease and advice on continuing bird care	24	13.6	17	7.8	1.88	0.06
					Contribute to research efforts	To help wildlife research, it needs all the help it can get	102	57.6	83	38.1	3.86	< 0.001
					Has a scientific background	As a scientist it is important to help where I can to further our understanding of these problems	14	7.9	6	2.8	2.29	0.02
					Interest in finding out more about wildlife	I'm interested in understanding more about the wildlife in my garden	16	9	19	8.7	0.1	0.92
Protective	1.54 (± 0.03)	0.84	1.49 (± 0.03)	0.85	Confirm the disease wasn't my fault	I was worried that I may be, in some way, responsible for passing on the disease - by not doing something that I should be.	10	5.6	7	3.2	1.17	0.24
					Moral responsibility	To help the greater good	12	6.8	5	2.3	2.19	0.03
					I have time available	I have free time so want to put it to something meaningful	7	4	0	0	2.98	0.01
Other					Influence policy	Maybe they can then persuade the Government to take a less cavalier attitude as they won't listen to me.	0	0	1	0.5	−0.94	0.35
					Concern about policy reports	I am concerned about the state of nature report and so I decided to "do something"	0	0	1	0.5	−0.94	0.35
					Importance of citizen science	Citizen science is becoming increasing important	2	1.1	10	4.6	−2.02	0.04
					Maintain garden environment	Monitor and maintain a good garden environment	1	0.6	4	1.8	−1.06	0.29

Table 2
The most parsimonious ($\Delta AIC_c < 2$) set of models, and model average, explaining variation in the Volunteer Function Inventory (VFI) 'Values' and 'Understanding' motivations for Garden Wildlife Health *Systematic* ($n = 177$) and *Opportunistic* ($n = 218$) citizen science data contributors. Parameter estimates are provided with standard errors.

GWH cohort	VFI motivation	Model	Intercept	Gender	Age	Education	CNS	Income	AICc	Akaike weight	r^2
Systematic	Values	1	3.12 ± 0.29	–	−0.08 ± 0.05	–	0.41 ± 0.05	–	241	0.285	0.26
		2	2.79 ± 0.21	–	–	–	0.42 ± 0.05	–	241.5	0.215	0.25
		3	3.2 ± 0.32	–	−0.07 ± 0.04	–	0.41 ± 0.05	0.01 ± 0.02	242.7	0.121	0.26
		Model average	3.01 ± 0.32	–	−0.08 ± 0.05	–	0.42 ± 0.05	0.01 ± 0.02			0.26
	Understanding	1	1.74 ± 0.26	–	–	–	0.48 ± 0.07	–	305.34	0.39	0.23
		2	1.62 ± 0.31	–	–	–	0.48 ± 0.07	0.02 ± 0.03	306.92	0.18	0.23
		3	1.81 ± 0.29	–	–	0.01 ± 0.02	0.47 ± 0.07	–	307.18	0.15	0.23
		4	1.65 ± 0.35	–	0.02 ± 0.05	–	0.48 ± 0.07	–	308.94	0.15	0.22
		Model average	1.71 ± 0.31	–	0.02 ± 0.05	0.01 ± 0.02	0.47 ± 0.07	0.02 ± 0.03			0.23
Opportunistic	Values	1	4.13 ± 0.33	–	–	−0.06 ± 0.03	0.16 ± 0.08	–	245.06	0.16	0.05
		2	4.31 ± 0.38	–	−0.06 ± 0.06	−0.06 ± 0.03	0.16 ± 0.08	–	246.27	0.09	0.06
		3	3.88 ± 0.31	–	–	–	0.16 ± 0.08	–	246.47	0.08	0.03
		4	4.21 ± 0.36	–	–	−0.06 ± 0.03	0.16 ± 0.08	−0.02 ± 0.04	246.91	0.06	0.05
		5	4.74 ± 0.14	–	–	−0.06 ± 0.03	–	–	247.03	0.06	0.02
		6	4.21 ± 0.39	−0.04 ± 0.1	–	−0.06 ± 0.03	0.16 ± 0.08	–	247.04	0.06	0.05
		Model average	4.28 ± 0.43	−0.04 ± 0.1	−0.06 ± 0.06	−0.06 ± 0.03	0.16 ± 0.08	−0.02 ± 0.04			0.04
	Understanding	1	4.85 ± 0.34	−0.27 ± 0.15	–	−0.08 ± 0.05	–	–	358.04	0.12	0.04
		2	4.48 ± 0.27	−0.25 ± 0.15	–	–	–	–	358.75	0.09	0.02
		3	4.35 ± 0.21	–	–	−0.08 ± 0.05	–	–	358.75	0.07	0.02
		4	4.43 ± 0.58	−0.26 ± 0.15	–	−0.08 ± 0.05	0.11 ± 0.12	–	359.38	0.06	0.04
		5	5.07 ± 0.43	−0.26 ± 0.15	−0.08 ± 0.09		–	–	359.42	0.06	0.04
		Model average	4.45 ± 0.57	−0.26 ± 0.15	−0.08 ± 0.09	−0.08 ± 0.05	0.11 ± 0.12	–			0.03

Understanding what underpins participation is therefore invaluable to citizen science project managers. This is particularly pertinent as programmes are diversifying away from traditional field-based conservation citizen science project formats. Increasingly, there is a shift towards individuals collecting and submitting data in isolation with limited training and no social interaction between contributors. This is the first study to investigate why individuals contribute towards such citizen science projects.

The design of Garden Wildlife Health has resulted in a dichotomy of contributors, characterised by the level of their reporting commitment. Both cohorts play a unique and important role in ensuring the effectiveness of the citizen science project (Lawson et al., 2015). As such, understanding each group's motivations, and the differences between them, is necessary to ensure the success of the project. We found that *Systematic* contributors – those who collect and submit data on a weekly basis – were predominantly older, retired, with a higher level of education and having a higher household income than is representative of the general public. This is perhaps unsurprising given the investment of time associated with their involvement. These characteristics observed in *Systematic* contributors have been previously noted in the broader volunteering literature (Bushway et al., 2011; Alender, 2016; Spiers et al., 2018; Davis et al., 2019). *Opportunistic* contributors report observations on an ad hoc basis, and showed a broader sociodemographic profile. This difference is likely a reflection of the fact that there is no regular commitment required for *Opportunistic* contributors (Davis et al., 2019).

Our findings, evidenced across multiple data sources in this study, revealed that *Systematic* and *Opportunistic* contributors were motivated primarily by reasons related to their intrinsic values and a desire to increase their knowledge (Table 1). Of these, an individual's intrinsic values were reported as the most important. In particular, data contributors expressed a concern about wildlife welfare and conservation. This reported concern for the environment has previously been attributed to a strong relationship with nature (Nisbet et al., 2009). Our results illustrate the importance of value-related motivations in driving engagement with citizen science projects, aligning closely with the motivations reported by contributors to more traditional conservation citizen science projects (Domroese and Johnson, 2017). Likewise, an ambition to understand more about issues related to the health of garden wildlife was an important motivation for both *Systematic* and *Opportunistic* contributors, reinforcing the need for citizen science projects to provide opportunities for information acquisition and learning (Rotman et al., 2012; Jennett et al., 2016; Domroese and Johnson, 2017). GWH contributors receive veterinary feedback after they submit a report, including information on wildlife disease and guidance on habitat management. Feedback and open lines of communication between the data contributors and the project administration team are critical to facilitate opportunities to fulfil both value- and understanding-related motivations (Rotman et al., 2012). The use of regular project updates and educational materials, advertising opportunities for contributors to increase their knowledge/understanding and highlighting how the project meets their intrinsic values, has been shown to maximise recruitment and retention (Lee et al., 2018).

The absence of career or social factors motivating participation in GWH is a notable finding in this study. It suggests that conclusions derived from previous studies focused on traditional citizen science schemes cannot be extrapolated to large-scale projects where skill development or social interaction is limited. Involvement in these large-scale projects with online reporting elements is often restricted to simple tasks, such as the submission of photographs or samples to experts. Opportunities to develop technical skills and engage in training, or other career-enhancing activities, are therefore rare. Additionally, data contributors have limited direct contact with project managers or other contributors. As such, these large-scale projects are distinctive from more traditional citizen science schemes, where building social bonds with other contributors or with project managers is an important motivation (Grese et al., 2000; Bell et al., 2008; August et al., 2019).

While focusing on more prominent motivations is one option for large-scale citizen science project managers with online reporting elements wishing to grow their participant numbers, an alternative would be to consider enhancing the potential for social interaction or career building opportunities within projects. Social interactions could be integrated into large-scale projects through frequent communication

between citizen science data contributors through tools such as member forums. For example, iSpot, an online platform where the public can upload wildlife observations and identify species, encourages the use of online social media platforms to promote active dialogue between experts and project contributors (Snaddon et al., 2013). Citizen science projects that offer positive feedback and build a feeling of trust with contributors may yield higher levels of motivation (Tiago et al., 2017). Prospects for career-related motivations might also be provided by linking participation in citizen science projects to accredited courses such as university degrees (Mitchell et al., 2017).

Overall, many of the motivations suggested by citizen science project managers, derived from assumptions about motivations and anecdotal evidence, resonated with both *Systematic* and *Opportunistic* contributors. There were, however, several motivations identified by contributors that were not adequately captured within project managers' assumptions. These include participating due to enjoyment or because of a perceived moral responsibility.

It has been postulated that projects such as GWH, which raise the profile of wildlife diseases, promote anxiety over the potential human health implications (Joffe, 2011), thereby having a negative impact on human emotional wellbeing (Decker et al., 2010) and reducing public support for conservation (Vaske et al., 2009; Buttke et al., 2015). Our findings, however, indicate this is not the case. This could be related to the person-level characteristics of GWH citizen scientists, which is known to influence the risk perception of zoonotic diseases (Decker et al., 2010; Davis et al., 2017). Nonetheless, it is possible that perceived human health concerns act as a barrier to some members of the public engaging in the project. While investigating such deterrents was beyond the scope of this study, they are an important issue in the design and operation of any conservation citizen science scheme and warrant consideration (Conrad and Hilchey, 2011; Merenlender et al., 2016).

When attempting to increase participation in environmental activities, it has often been suggested that efforts should either be concentrated on individuals who are already highly connected to nature, or on improving the connection for those who are not (Liefländer et al., 2013; Zelenski et al., 2015; Rosa and Collado, 2019). When considering what person-level characteristics might underpin strong levels of motivation in contributors to citizen science programmes, the extent of connectedness to nature was a predictor for *Systematic* data contributors. In contrast, while levels of nature connectedness were similar for both *Systematic* and *Opportunistic* cohorts, it was not a predictor for the latter. Indeed, connection to nature did not explain a substantial amount variation in motivation for either cohort.

While our cohorts were older, with a higher level of education, and had higher incomes, these person-level characteristics did not predict high-levels of motivation well, suggesting that alternative factors may be driving individuals to contribute data. For example, August et al. (2019) explored whether external factors could be used to predict participation in citizen science programmes and identified levels of social engagement, training and the complexity of activities to be important predictors of motivation. Predicting high levels of motivation is thus inherently more complex than often speculated. In future work, applying conceptual frameworks, such as the theory of planned behaviour (TPB; Ajzen, 2011) might yield interesting results. The TPB predicts an individual's intention to engage in a behaviour at a specific time or place, based on attitudes towards the behaviour, social pressures and perceived behavioural control (the perceived ease of carrying out the activity). Previous studies have used this model successfully in relation to volunteering and charitable giving (e.g. Greenslade and White, 2005), although not in the context of schemes with an explicit conservation focus. Furthermore, personality might also underpin motivation as the interplay of traits such as 'agreeableness' and 'prosocial value' can significantly impact the likelihood that an individual will engage in volunteer activities (Carlo et al., 2005). It may also be valuable to look at other characteristics such as attitudes towards wildlife and pro-environmental values (Davis et al., 2019). Finally, it must be remembered there were two distinct groups of contributors in this study, characterised by the level of their reporting commitment. However, in other projects there might be a continuum of contributing effort, rather than a dichotomy, which may provide further insights into the motivations underpinning involvement.

Understanding and delivering what motivates data contributor participation (e.g. the ability to learn new knowledge) is fundamental to ensuring their long-term engagement and, consequently, the success of citizen science projects (Measham and Barnett, 2008; Rotman et al., 2012; August et al., 2019). Despite this being widely accepted, there remains a paucity of research on contributor motivations (Geoghegan et al., 2016). This is particularly true for projects which often lack the social and skill-building opportunities that support engagement in traditional citizen science projects. Our work demonstrates the importance of intrinsic values and a desire to further one's understanding as motivators for participation in this type of citizen science project.

With the rapid increase of citizen science projects, and their potential to make a significant contribution to conservation, motivating large numbers of people to contribute high-quality data is vital. Not only will this translate into data that may otherwise be unattainable, but also has the potential to engage the public in conservation actions and decision-making (McKinley et al., 2017). Managers of citizen science projects need to understand what motivates their contributors. Projects can then be designed to adequately fulfil these motivations, ensuring retention, satisfaction and high levels of involvement from participants. This approach will ultimately result in more sustainable projects creating a win-win scenario, both for the contributors and for biodiversity conservation.

CRediT authorship contribution statement

Phoebe R. Maund: Conceptualization, Data curation, Formal analysis, Methodology, Writing - original draft, Writing - review & editing. **Katherine N. Irvine:** Conceptualization, Writing - original draft, Writing - review & editing. **Becki Lawson:** Conceptualization, Supervision, Methodology, Writing - review & editing. **Janna Steadman:** Formal analysis. **Kate Risley:** Conceptualization. **Andrew A. Cunningham:** Conceptualization. **Zoe G. Davies:** Conceptualization, Methodology, Supervision, Writing - original draft, Writing - review & editing.

Declaration of competing interest

There are no conflicts of interest.

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Appendix A

Table A1
Eleven motivational statements based on anecdotal evidence and assumed motivations gathered by citizen science programme managers. Statements were developed into a closed-ended question ("*What were your personal reasons for contributing to Garden Wildlife Health (GWH)?*") to determine if they resonated more broadly. Contributors were asked to select up to five statements. They were also provided with a '*none of the above*' option if they felt none of the provided statements were relevant to them.

Motivational statement
To access veterinary advice
Concern about the potential health risk to humans
Concern about the potential health risk to domestic pets or livestock
To safeguard the welfare of wildlife in my garden
To help conserve my garden wildlife
To learn about the diseases that affect wildlife in my garden
I felt I had a responsibility to see if my actions were harming garden wildlife
I wanted to help the vets learn more about wildlife health
I wanted to learn more about how I could help conserve wildlife
Someone told me I should report the sick or dead animal
I hoped authorities would dispose of the animal

Table A2
The person-level characteristics of individuals who contributed to the large-scale citizen science programme Garden Wildlife Health (GWH), on a regular (*Systematic*, $n = 177$) and *ad hoc* (*Opportunistic*, $n = 218$) basis, compared with the wider UK population. National population data were obtained from the 2011 Census (Office for National Statistics, 2014), with the exception of household income (before tax) which was drawn from the Institute for Fiscal Studies (Brewer et al., 2007). The star indicates a combined percentage for individuals who have completed a Bachelor level qualification or higher.

Variable	*Systematic* %	*Opportunistic* %	GWH %	UK population %	Variable	*Systematic* %	*Opportunistic* %	GWH %	UK population %
Gender	*(n = 177)*	*(n = 212)*	*(n = 389)*		*Registered disability*	*(n = 149)*	*(n = 212)*	*(n = 361)*	
Male	38.3	33.0	35.4	48.5	Yes	9.4	11.3	10.5	10.8
Female	61.7	67.0	64.6	51.5	No	90.6	88.7	89.5	89.2
Age	*(n = 177)*	*(n = 217)*	*(n = 394)*		*Employment status*	*(n = 177)*	*(n = 205)*	*(n = 382)*	
18–29	0.0	5.1	2.8	17.9	Unemployed	2.9	8.8	6.1	5.1
30–49	9.1	21.2	15.7	36.6	Employed	18.9	27.8	23.7	60.5
50–64	34.2	45.2	40.2	23.9	Self employed	3.4	15.6	9.9	11.2
65–84	55.4	28.1	40.3	18.7	Student	0.0	2.9	1.6	4.0
Over 85	1.2	0.5	0.8	2.9	Retired	74.9	44.9	58.8	19.2
Ethnicity	*(n = 177)*	*(n = 218)*	*(n = 395)*		*Education*	*(n = 170)*	*(n = 209)*	*(n = 379)*	
White British	96.6	90.4	93.2	80.5	No formal qualifications	3.5	4.8	4.2	22.7
White Irish	0.0	1.4	0.8	1.0	GCSEs (or equivalent)	11.8	14.8	13.5	32.2
White Other	2.9	3.7	3.3	4.4	A levels (or equivalent)	11.2	16.7	14.2	12.3
Mixed	0.6	0.5	0.5	2.2	Bachelor level degree	25.9	18.7	21.9	
Black Caribbean	0.0	0.5	0.3	1.1	Professional qualification	28.2	23.9	25.8	27.2*
Other Ethnicity	0.0	3.7	2.0	10.8	Postgraduate qualification	19.4	21.1	20.3	
Household income	*(n = 103)*	*(n = 140)*	*(n = 243)*		Other qualification	N/A	N/A	N/A	5.7
Under £5000	0.0	2.1	1.2	2.8					
£5000–£14,999	10.7	15.0	13.2	28.4					
£15,000–£24,000	19.4	20.0	19.7	35.1					
£25,000–£34,999	24.3	25.7	25.1	19.7					
£35,000–£44,999	21.4	17.9	19.4	7.0					
Over £45,000	24.3	19.3	21.4	7.0					

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