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The diverse motivations of citizen scientists: Does conservation emphasis grow as volunteer participation progresses?

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ABSTRACT

Citizen science has proven to be a valuable tool for biodiversity conservation. However, to maximize the conservation benefits of citizen science programs, researchers and practitioners would gain from a better understanding of project volunteers and what drives them to participate. We examined the diverse motivations of volunteers ($n = 3041$) participating in Audubon's Christmas Bird Count, one of the world's oldest ecological monitoring citizen (or community) science projects. Principal axis factor analysis along a 16-item scale revealed six distinct intrinsic and extrinsic motivational constructs: science and conservation, outdoor recreation and discovery, commitment and tradition, social interaction, classic birding, and personal accomplishment. Most participants reported multiple motivations, but 40% indicated contribution to science and conservation was their primary reason for initially engaging with the project. As project participation continued, science and conservation-related motives became even more important (with 55% listing as primary continuing motivation). Regression analyses showed motivational orientations varied by socio-demographic attributes and levels/type of project participation. For example, social interaction and tradition were more important to aspiring project leaders than casual observers. Results highlight insights into deepening project engagement and recruiting and retaining citizen scientists. Adapted and applied across different contexts, our instrument and motivational constructs could help to facilitate volunteer management and enhance citizen science's capacity to advance biodiversity conservation goals.

1. Introduction

Citizen science is a rapidly growing field emphasizing collaboration between scientists and members of the general public (Jordan et al., 2012) that has proven to be a valuable tool for biodiversity conservation (Cooper et al., 2007; Ellwood et al., 2017; McKinley et al., 2017). Data generated by citizen scientists have helped scientists track species distributions for birds (Sullivan et al., 2014) and mammals (McShea et al., 2016), monitor plant phenology (Feldman et al., 2018), predict the spread of infectious diseases (Meentemeyer et al., 2015), and monitor the effectiveness of natural resource management practices (Conrad and Hilchey, 2011; Jordan et al., 2016).

The benefits of citizen science also extend beyond generating ecological data. Research has shown that well-designed projects can enrich volunteers, leading to increased understanding of the subject matter (Forrester et al., 2017; Jordan et al., 2012; Shirk et al., 2012), development of new skills and confidence (Shirk et al., 2012), interest in and understanding of science (Bonney and Phillips, 2016), trust between scientists and the public (Bonney et al., 2014; Jordan et al., 2012), and conservation behaviors (Lewandowski and Oberhauser, 2017; Peter et al., 2019; Toomey and Domroese, 2013). Using increasingly collaborative tools and resources, citizen science projects can advance

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conservation science, support public participation in science, and enhance appreciation and engagement in environmental stewardship (Dickinson et al., 2012; McKinley et al., 2017; Phillips et al., 2018).

Despite the multifaceted benefits of citizen science, successful outcomes can only be achieved through an active and engaged population of volunteer participants. Many groups (including the National Audubon Society) have adopted "community science" as a preferred and more inclusive term to describe programs which involve volunteer participation; here, we are using the term citizen science synonymously following common usage in the scientific literature. Although research into the practice of citizen science is expanding (Jordan et al., 2015), much of this work has focused on contributions to conservation science and the evaluation of participant outcomes (Peter et al., 2019; Phillips et al., 2018). Far less is known about forces driving the engine behind these outcomes: the motivations of the citizen scientists themselves (Domroese and Johnson, 2017; Phillips et al., 2019). Phillips et al. (2019) describe the critical importance of understanding volunteer motivations in citizen science, defined as "the underlying psychological need for why someone does something, expressed as initial cause for participation or why they stay involved in the project" (p. 674). Because volunteer motivation and engagement are closely linked (Vecina et al., 2012), a more advanced understanding of factors motivating citizen scientists, and how these factors might change over time, could facilitate recruitment and retention of volunteers (West and Pateman, 2016). If citizen science project design and activities mesh with volunteer motivations (Geoghegan et al., 2016; Van Den Berg et al., 2009; Wright et al., 2015), managers and scientists will be better positioned to realize the full potential of citizen science as a tool for biodiversity conservation (Theobald et al., 2015).

1.1. Motivations to volunteer

A substantial body of literature has explored motivations for volunteering and social participation both within and outside of natural resource contexts (Asah and Blahna, 2012; Batson et al., 2002; Bruyere and Rappe, 2007; Clary and Snyder, 1999; Clary et al., 1998). Self-determination theory (SDT) is often used to understand the different factors that motivate people to engage in volunteerism. This theory posits that people have basic psychological needs to feel competent, autonomous, and connected to others (Ryan and Deci, 2008). Applications of SDT suggest that citizen science is an activity that can help volunteers achieve all of these goals (Nov et al., 2014; Tiago et al., 2017).

Within the context of SDT, motivations can be categorized as intrinsic or extrinsic (Ryan and Deci, 2000). People who are intrinsically motivated engage in an activity for personal interest or enjoyment and for the sake of the activity itself; people who are extrinsically motivated engage in an activity based on incentives, perceived rewards, desirable outcomes, and other factors that stimulate interest (Deci and Ryan, 1985; Ryan and Deci, 2008; Vallerand, 2000). In most cases, multiple intrinsic and extrinsic motivations interact simultaneously to inspire a particular action (Clary and Snyder, 1999; Vallerand, 2000). Different combinations of motivations might be particularly relevant for citizen scientists (Curtis, 2018; Domroese and Johnson, 2017; Geoghegan et al., 2016; Raddick et al., 2013; Tiago et al., 2017). For example, someone might participate in a project because they enjoy the activity and are inherently interested in the topic (intrinsic reasons), but they also hope to support ecological research or improve technical skills that might translate to other contexts (extrinsic reasons).

Batson et al. (2002) offered a four-pronged typology of motivations that is particularly useful for understanding reasons why people volunteer. In this framework, intrinsic motivational constructs include *egoism*, or increasing one's own welfare, and *principlism*, or upholding personal values. Motivational forces that are more extrinsic include *altruism*, or increasing the welfare of others, and *collectivism*, or increasing the welfare of one's group. These categories apply well to environmental volunteerism. In one study, Bruyere and Rappe (2007) found that principlism and altruism were the most important motivators for pro-environmental engagement, expressed through strong valuation of nature and a desire to help the environment. In other words, volunteer efforts became a source of personal identity and a means of self-expression. Collectivism and egoism were secondary motivators, expressed through a want to improve areas for personal use, to learn about the natural environment, and to socialize with other volunteers. However, other research suggests that for some conservation stewards, personal and social benefits are more important than environment-related reasons for volunteering (Asah and Blahna, 2012).

Many citizen science volunteers report a similar range of motivations. In online citizen science projects, dominant motivations often include personal interest in science (egoism), contributions to scientific research (altruism), and collective motivations such as feeling part of a group (collectivism) (Curtis, 2015; Jennett et al., 2016; Nov et al., 2014; Raddick et al., 2013; Rotman et al., 2012). In ecological and conservation oriented projects where motivations of participants are less often studied, personal interest and contribution to science have also emerged as key motivators (Domroese and Johnson, 2017; Geoghegan et al., 2016; Phillips et al., 2019; Tiago et al., 2017). However, much of this research has focused on qualitative measures of motivation (Jennett et al., 2016; Phillips et al., 2019; Rotman et al., 2014) or adapted versions of existing motivation inventories from other sectors (Nov et al., 2014; Tiago et al., 2017; Wright et al., 2015). Few studies have attempted to develop and implement scales that can be used to assess the specific motivations of citizen scientists (Domroese and Johnson, 2017; Porticella et al., 2017).

1.2. The dynamic nature of volunteer motivations

Evidence suggests that volunteer motivations can shift as time progresses and engagement deepens (Clary and Snyder, 1999; Ryan et al., 2001). This may occur in citizen science projects, with motivations changing over the lifespan of a volunteer's project involvement. Studies of online citizen scientists indicate that initial motivations mostly revolve around egoism expressed as personal interest in the subject or in science and altruism, making contributions to science with more collectivist and socially-driven motivations emerging and participation progresses (Curtis, 2015; Nov et al., 2014; Rotman et al., 2014). As Rotman and colleagues note (Rotman et al., 2012, 2014), volunteers may need to extend beyond "self" to sustain participation over time. Other research focused on ecological monitoring projects suggests that extrinsic motivators were most important at the beginning of a project, with intrinsic motivations becoming more important for retention of volunteers over time (Geoghegan et al., 2016; Tiago et al., 2017). In some cases, motivations appear relatively static even as participants gain more experience with a project (Domroese and Johnson, 2017). Considering the dynamic nature of citizen science motivations, more research is needed to understand how changes occur over time and the implications of those motivational shifts for project management and outcomes (West and Pateman, 2016; Wright et al., 2015).

Motivations can vary among socio-demographically diverse groups of volunteers as well. Research suggests that women and individuals with higher levels of education are more likely to engage in broader volunteer efforts (Bureau of Labor Statistics, 2016; Einolf, 2011; Lammers, 1991; Mesch et al., 2006). Skill acquisition, networking, and career development might be key motivators for younger volunteers, whereas older volunteers may be more interested in altruistic acts such as sharing information and teaching others (Asah et al., 2014; Clary and Snyder, 1999; Jacobsen et al., 2012). However, relatively little is known about demographic differences in the motivations of citizen science volunteers specifically, and many studies have featured small samples and yielded null or inconclusive results (Geoghegan et al., 2016; Tiago et al., 2017). Additionally, although researchers have examined the citizen science volunteer life cycle (Lorek Strauss and Rager,

Table 1a
Motivations[a] of CBC Volunteers: Pattern Matrix Coefficients for Principal Axis Factoring With Promax Rotation of Six-Factor Solution Examining (n=3041)

Factor/Item	Mean (SD)	Pattern Matrix					
		A	B	C	D	E	F
A. Science & Conservation[b]	**4.37 (0.71)**						
Contribute to important scientific research	4.23 (0.87)	**0.813**					
Help to generate data that support bird conservation efforts	4.49 (0.76)	**0.775**					
Document and track changes in bird populations over time	4.38 (0.84)	**0.731**					
B. Outdoor Recreation & Discovery[c]	**4.08 (0.76)**						
Learn new things from other birders	3.90 (1.08)		**0.766**				
Discover new information about ecosystems where I live	3.90 (1.07)		**0.473**				
Get outdoors and enjoy time in nature	4.44 (0.81)		**0.390**				
C. Commitment & Tradition[d]	**3.83 (0.86)**						
Obligation to contribute to local compiler or CBC as a whole	3.69 (1.24)			**0.557**			
Feel good being part of a group effort	3.84 (1.09)		0.360	**0.461**			
Continue an important tradition	3.92 (1.08)			**0.440**			
D. Social Interaction[e]	**3.32 (0.97)**						
Introduce friends to the joys of birdwatching	3.03 (1.29)				**0.750**		
Build friendships with others who share my enjoyment of birds	3.58 (1.12)		0.469		**0.524**		
Share my knowledge and skills with others	3.32 (1.14)				**0.452**		0.419
E. Classic Birding[f]	**2.83 (1.19)**						
Potentially see a rare bird	3.05 (1.24)					**0.842**	
Add more birds to a personal bird list	2.61 (1.31)					**0.789**	
F. Personal Accomplishment[g]	**2.62 (1.08)**						
Feel proud of myself and what I can accomplish	3.12 (1.28)						**0.822**
Gain recognition and respect from others	2.13 (1.15)						**0.690**

NOTE: Primary factor loading coefficients for each item are bold; only coefficients ≥ .300 are reported
[a] Motivations were rated on the following scale: 1=Not at all important, 2=Slightly important, 3=Moderately important, 4=important, 5=Very important
[b] Cronbach's α=0.828; Eigenvalue=5.56, Percentage of Variance Explained=34.86%
[c] Cronbach's α=0.647; Eigenvalue=1.02, Percentage of Variance Explained=6.34%
[d] Cronbach's α=0.618; Eigenvalue=.82, Percentage of Variance Explained=5.14%
[e] Cronbach's α=0.753; Eigenvalue=.89, Percentage of Variance Explained=5.58%
[f] Cronbach's α=0.849; Eigenvalue=1.94, Percentage of Variance Explained=12.11%
[g] Cronbach's α=0.717; Eigenvalue=1.26; Percentage of Variance Explained=7.90%

2017), characterized motivational connections to different dimensions of project engagement (Phillips et al., 2019), and considered motivational differences across stakeholder groups such as scientists vs. practitioners (Geoghegan et al., 2016), research has not yet explored how motivational orientations shift as citizen scientists take on different leadership roles within a project. Answers to these questions could help citizen science project managers recruit and retain a more diverse group of volunteers (Chu et al., 2012).

1.3. Toward a broader understanding of citizen scientists' motivations

Collectively, the body of research focused on motivations of citizen scientists has yielded inconclusive and often conflicting results. This has been problematic, especially when recruitment and retention of volunteers relies on matching communication, activities, and program outcomes to motivations (Phillips et al., 2019; Rotman et al., 2012; Tiago et al., 2017; Van Den Berg et al., 2009; Wright et al., 2015). To address these gaps, our study aimed to develop and implement a survey instrument and subsequent factor analysis for measuring citizen science volunteer motivations that could pertain to wide range of projects. We tested the utility of the scale by focusing on participants in one of the world's oldest ecological monitoring citizen science projects, Audubon's Christmas Bird Count (CBC). Our objectives were to: 1) Identify, measure, and compare the different factors that motivate participation in citizen science; 2) Explore how the importance of different motivations changes as project participation progresses; 3) Examine socio-demographic and experiential factors associated with different types of motivations; and 4) Investigate differences in motivations among individuals participating in different project roles.

2. Methods

We collected data from volunteers who participated in the National Audubon Society's (NAS) annual 2015–2016 Christmas Bird Count (CBC). Initiated in 1900, the CBC is among the longest-running citizen/community science projects in the world (National Audubon Society, 2019). From December 14 through January 5 each season, tens of thousands of volunteers throughout the western hemisphere band together to record observations of birds in pre-approved, 15-mile diameter geographic circles and create a database of avian population distributions that is informative for researchers and conservationists. The CBC represents a cross section of currently active birdwatchers and provides a unique opportunity to learn more about these volunteers and the factors that motivate them – factors that would likely extend to many other biodiversity monitoring projects.

2.1. Participants & data collection protocol

The National Audubon Society currently receives limited contact information from individual observers in the CBC. Instead, most communication is routed through a tiered system of project managers and participants. "Observers" work with "section leaders" to record bird observations within each of the CBC's geographic circles or monitoring areas. "Compilers" assigned to each circle coordinate these observations, then synthesize and manage all the data that are generated. For this study, we asked compilers to complete a web-based survey and forward it to all of the section leaders and observers who had participated in their circle(s). We emailed a survey to all of the 2131 U.S. based compilers who were involved in the 2015–2016 CBC as well as to over 20,000 U.S. participants with active email addresses within the CBC system. Initially, 822 compilers and 2479 section leaders and observers completed the survey (total $n = 3301$). Because it is impossible to know with certainty how many different individuals participated in the CBC (in many cases, one person participates as an observer in multiple circles) or how many observers actually received the survey from compilers, we were not able to calculate a precise response rate.

However, records suggest that overall compilers reported 59,039 observers in the field or at bird feeders participated during the 2015–2016 CBC in the United States. If we assume that the average participant observed two or more times (LeBaron, 2016), we estimate that our sample contained about 12% of the entire population of CBC participants (including observers, section leaders, and compilers).

2.2. Survey instrument

The web-based survey instrument, designed as part of a larger study to examine CBC participation and associated outcomes, contained a set of specific questions focused on participant motivations. The questions asked: "How important are the following reasons to you when deciding to take part in the Christmas Bird Count?" For each item, participants could then choose one of five response options ranging from 1 = Not at all important to 5 = Very important. Potential motivations included a list of 16 specific items (Table 1a) adapted from themes and items used in other studies focused on measuring citizen science motivations (Domroese and Johnson, 2017; Porticella et al., 2017; Raddick et al., 2013; Rotman et al., 2012). Items from these existing scales were integrated and adapted, based on feedback from citizen scientists, to ensure coverage across the four dimensions of volunteer motivations articulated by Batson et al. (2002): egoism, principlism, altruism, and collectivism. For dimensions not adequately addressed by existing scales, we created new items. Using informally gathered input from volunteers participating in bird-focused citizen science projects, we conceptualized six themes associated with these four motivational dimensions in our survey: outdoor recreation and discovery (egoism), personal accomplishment (egoism), classic birding (principlism), contributions to science and conservation (altruism), commitment and tradition (collectivism), and social interaction (collectivism). Our final survey instrument accounted for distinct motivations within each of these categories. After rating the importance of each of 16 potential motivations (see Table 1a), participants then answered the following two questions. First, "Which ONE of the following general motivations was your primary reason for initially deciding to take part in your first CBC?" Then, "Which ONE of the following general motivations is the primary reason that you continue taking part in the CBC?" In both questions, participants could select one of the six overarching themes described above using a drop-down menu.

Demographic information provided by respondents included gender, age, education (advanced degree, or not), career (professional in life or natural sciences field, or not), and political view (measured on a five-point scale with response categories ranging from 1 = "liberal" to 5 = "conservative"). Past experience with the CBC was measured with two variables: years participating in the CBC and average number of yearly "circles" where observations took place. We also asked participants to identify the CBC roles in which they participated (observer, section leader, or compiler) and to indicate how likely they would be to participate in these different CBC roles going forward. Respondents were removed from our analysis if they did not complete the portion of the survey that pertained to participation motivations, resulting in a final effective sample size of 3041.

2.3. Data analysis

To understand the diverse motivations of citizen scientists (Obj. 1), we conducted a principal axis factor analysis with our 16-item motivation scale. We applied an oblique (promax) rotation to account for potential correlations among the factors, using the pattern matrix to identify factor loadings (or standardized regression coefficients linking each item to a particular factor) and the structure matrix to assess correlations between each item and other factors. We extracted factors with eigenvalues accounting for at least 5% of the variance explained (>0.80) and retained items within factors whose pattern and structure matrix loadings were >0.400 (Costello and Osborne, 2005). In the case of cross loading, items were grouped with the factor demonstrating the highest loading. Cronbach's alpha was used to assess the internal consistency of items in each factor (Vaske, 2008). We compared mean ratings to determine which of the motivational subscales were most important to participants.

To explore differences in the primary motivations driving initial vs. continuing participation in the CBC (Obj. 2), we used proportional chi-square comparison tests with 2 × 2 contingency tables (Campbell, 2007). We focused on shifts (or percentage change) in the number of individuals who reported one primary motivation initially and a different motivation for continuing participation.

To explore associations between motivations and socio-demographic and experiential variables (Obj. 3), we used two separate multinomial logistic regression models (one for initial and one for continuing motivations) to examine significant correlates. Model fit was assessed using likelihood ratio chi-square tests and Nagelkerke R^2. The most popular "science and conservation" motivation category served as the reference category in each model. We used the odds ratios (*OR*) of parameter estimates to assess the relative importance of each variable when predicting a particular type of motivation compared to this reference category.

To investigate relationships between different motivations and citizen science project roles and responsibilities (Obj. 4), we developed three logistic regression models with likelihood of future CBC participation (as an observer, section leader, or compiler) as the dependent variable and the various motivation subscale means as independent variables. After assessing model fit using chi-square tests, Hosmer & Lemeshow tests, and Nagelkerke R^2, we examined the significance of *OR* at $\alpha = 0.05$ to identify motivations that were particularly important to volunteers aspiring to each project role. All data were analyzed using IBM SPSS Statistics, Version 25.0 (IBM Corp., 2019).

3. Results

Our overall sample of CBC volunteers was 54% male. Other demographic attributes generally reflected populations of citizen scientists as a whole. Respondents from the CBC were primarily white (97%), much older than the average American (mean age = 61.6 years), highly educated (50% held an advanced degree), and high income earners (33% reported annual income over $100,000). About 46% of the sample identified as a natural or life science professional, and respondents generally skewed toward the liberal end of the political spectrum. We observed a wide range of experience with the CBC: about 13% of the sample was in their first two years of CBC participation, while 8% of the sample had been participating for 40 years or more. Overall, many participations were highly engaged, with an overall average of 15.3 years participating in the project and volunteers engaging in an average of 1.9 observation circles (or sites) annually. Likelihood of future participation among respondents was high, with almost 94% of respondents likely or very likely to participate in the CBC in some capacity in future years.

3.1. Motivations of citizen scientists

Using the KMO measure of sampling adequacy (0.87) and Bartlett's test of sphericity, $\chi^2_{(120)} = 18{,}790$, $p < 0.001$, we determined that factor analysis of the motivation items was appropriate. Our promax rotation of the data converged in seven iterations, yielding the six distinct motivational factors or themes that we anticipated (Tables 1a, 1b). Eigenvalues for the themes ranged from 5.56 (34.9% of variance explained) for science and conservation to 0.82 (5.1% of variance explained) for commitment and tradition. Though distinct, many of these factors – especially outdoor recreation and discovery - were also correlated with other factors (Table 2). According to mean subscale ratings, the most important motivational themes for CBC participants were science and conservation ($M = 4.27$, $SD = 0.71$), outdoor recreation

Table 1b
Motivations[a] of CBC Volunteers: Structure Matrix Coefficients for Principal Axis Factoring With Promax Rotation of Six-Factor Solution Examining (n=3041).

Factor/Item	Structure Matrix					
	A	B	C	D	E	F
A. Science & Conservation						
Contribute to important scientific research	**0.837**	0.365	0.420			0.413
Help to generate data that support bird conservation efforts	**0.800**	0.397	0.420			0.311
Document and track changes in bird populations over time	**0.737**		0.390			
B. Outdoor Recreation & Discovery						
Learn new things from other birders		**0.718**		0.357	0.456	0.394
Discover new information about ecosystems where I live	0.485	**0.608**	0.442		0.322	0.424
Get outdoors and enjoy time in nature		**0.512**	0.355		0.308	0.346
C. Commitment & Tradition						
Obligation to contribute to local compiler or CBC as a whole	0.334		**0.537**	0.337		0.311
Feel good being part of a group effort	0.315	0.636	**0.695**	0.340		0.571
Continue an important tradition	0.364	0.430	**0.575**	0.302		0.445
D. Social Interaction						
Introduce friends to the joys of birdwatching		0.421	0.426	**0.791**		0.401
Build friendships with others who share my enjoyment of birds		0.623	0.454	**0.680**		0.445
Share my knowledge and skills with others	0.394	0.422	0.417	**0.637**		0.611
E. Classic Birding						
Potentially see a rare bird		0.492			**0.873**	0.426
Add more birds to a personal bird list		0.466			**0.841**	0.425
F. Personal Accomplishment						
Feel proud of myself and what I can accomplish	0.327	0.555	0.548	0.339	0.344	**0.836**
Gain recognition and respect from others		0.367	0.383	0.393	0.369	**0.685**

NOTE: Primary factor loading coefficients for each item are bold; only coefficients ≥ .300 are reported.
[a] Motivations were rated on the following scale: 1=Not at all important, 2=Slightly important, 3=Moderately important, 4=important, 5=Very important.

Table 2
Correlation Matrix Depicting Relationships Among Motivational Factors for CBC Participants.

Factor	A	B	C	D	E	F
A. Science & Conservation	1					
B. Outdoor Recreation & Discovery	0.399	1				
C. Commitment & Tradition	0.485	0.600	1			
D. Social Interaction	0.295	0.463	0.443	1		
E. Classic Birding	0.129	0.486	0.194	0.293	1	
F. Personal Accomplishment	0.390	0.608	0.611	0.485	0.438	1

and discovery (M = 4.08, SD = 0.76), commitment and tradition (M = 3.83, SD = 0.86), social interaction (M = 3.32, SD = 0.97), classic birding (M = 2.83, SD = 1.19), and personal accomplishment (M = 2.62, SD = 1.08; Table 1a). The most important single items motivating CBC participation were "helping to generate data that support bird conservation efforts" (M = 4.49, SD = 0.76) and "getting outdoors and enjoying time in nature" (M = 4.44, SD = 0.81).

3.2. Relative importance of initial and continuing motivations

Compared to other potential motivations, more people (40.2%) listed contributions to science and conservation as the primary reason for initiating their participation in the CBC (Fig. 1). Social interaction (25.7%), classic birding (14.3%), and outdoor recreation and discovery (9.9%) were primary initial motivations for large numbers of CBC participants. The prevalence of these motivation themes shifted as project participation progressed, however. Continuing participation in the CBC appears to driven even more by science and conservation than any other factor, with 14.9% more respondents listing conservation contributions as the most important reason for continuing CBC participation (Fig. 1). Commitment and tradition also became more important as longevity in the project increased (8.7% more people listed this as most important). Other factors such as social interaction, classic birding, and outdoor recreation and discovery significantly diminished in importance over time (Fig. 1). About 4% of respondents listed other reasons for initiating participation in the CBC (and 2% for continuing participation). The most frequent responses in the other category included gaining access to new areas, exercise, spending time with and/or educating family members, and simply the enjoyment of watching birds.

3.3. Demographic and experiential factors associated with motivations

Multinomial regression models examining associations between demographic variables and different citizen science motivation categories were nearly identical for both initial and continuing motivations (hence, only initial motivation correlates are reported in Table 3). Males were more likely than females to report classic birding as a key motivation and less likely to cite social interaction and commitment and tradition as important. Natural and life science professionals were more likely to list science and conservation as a key initial motivation compared to volunteers from other backgrounds, who were fueled by a more diverse range of motivations (Table 3). Compared to older volunteers, younger volunteers were more likely to report social interaction, commitment and tradition, and classic birding as motivations. Liberal volunteers were more strongly driven by science and conservation than conservative volunteers. Associations between education, income, and motivations were generally weak, though higher income individuals were more likely to report classic birding as a motivation (Table 3).

One experiential factor, years participating in the CBC, was strongly associated with motivations to participate. People who had participated in the CBC for more years were more likely to list commitment and tradition, classic birding, and social interaction as initial motivations, and less likely to report science and conservation as an initial motivator (Table 3). Intensity of participation (based on average numbers of yearly circles) was only associated with one initial motivation category: personal accomplishment. However, many of these patterns shifted when continuing motivations were considered. In that model, volunteers with more years of CBC experience were equally likely as those with less experience to be motivated by classic birding (OR = 0.992, p = 0.335) and personal accomplishment (OR = 1.011, p = 0.501), and significantly less likely to be motivated by social interaction (OR = 0.988, p = 0.042). In other words, the relative importance of science and conservation motivations grew for this population. For CBC

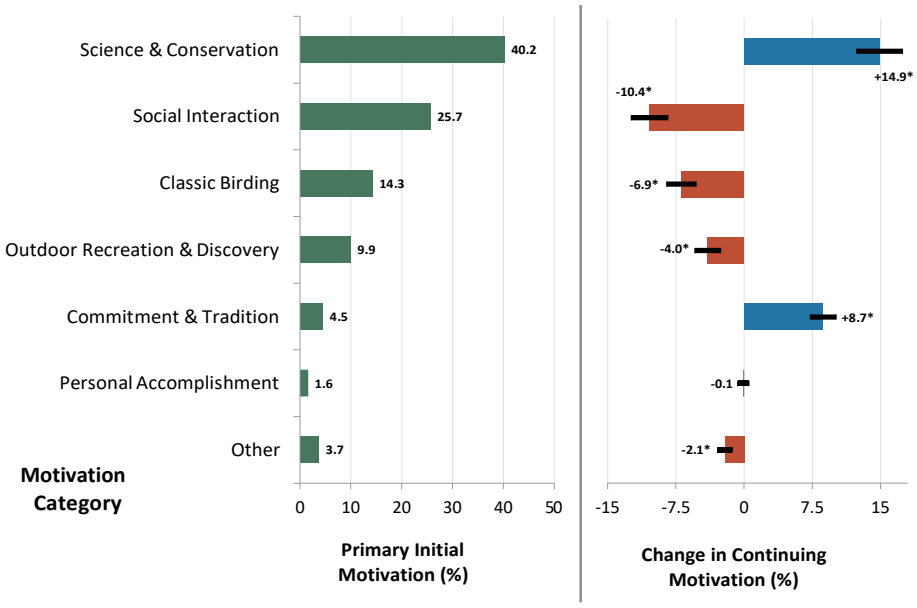

Fig. 1. Most important motivations for initiating and continuing participation reported by citizen science volunteers in Audubon's Christmas Bird Count ($n = 3041$). Changes in primary continuing motivation frequencies that are significantly different than zero (based on proportion chi-squared comparison test) are denoted by *.

volunteers with more experience, only commitment and tradition retained its original prominence ($OR = 1.043, p < 0.001$). These results support the apparent shift toward conservation- and tradition-focused motivations as project participation progresses (Fig. 1).

3.4. Differences in motivations by project role

We found that individuals in our sample were likely to participate in future CBCs as an observer (94%), section leader (54%), or compiler (61%). Logistic regression models indicated that motivations, when considered in isolation, were relatively poor predictors of future participation in specific project roles (Nagelkerke $R^2 = 0.02$ to 0.06). Science and conservation motivations were significant predictors of future participation in every role ($OR \geq 1.14$, Table 4). Future observers were also strongly motivated by outdoor recreation and discovery ($OR = 1.53$), while social interaction was less important ($OR = 0.78$). On the other hand, volunteers eager to take on more leadership roles downplayed the value of outdoor recreation and discovery ($OR \leq 0.73$) and placed a much stronger emphasis on social interaction (OR $\geq$ 1.56). Personal accomplishment appeared to be particularly important to future section leaders ($OR = 1.09$), while compilers were more strongly motivated by commitment and tradition

Table 3
Odds Ratios (OR) for Multinomial Logistic Regression Model Coefficients Depicting Demographic and Experiential Factors Associated with Initial Motivations for CBC Participation.

Variable	Sample Averages	Motivation Categories (note: Science & Conservation is the reference group)					
		Social Interaction	Classic Birding	Outdoor Rec & Discovery	Commitment & Tradition	Personal Accomp-lishment	Other
N	2233[a]	581	337	222	97	29	72
Gender (Male)	56.7%	.729**	1.821***	1.125	.606*	.722	.946
Race (White)	97.8%	1.763	.896	.890	1.000	.282	.584
Age (years)	60.71	.988*	.977***	.997	.981*	.986	.985
Job (Life or Nat. Sciences)	46.6%	.602***	.552***	.606**	.606*	.780	.773
Education (Advanced degree)	50.9%	1.037	.988	1.157	1.410	1.517	.918
Income (< $100k)	33.5	1.119	1.359*	.999	1.332	1.170	1.148
Political View[b]	2.12	1.100*	1.244***	1.135*	1.414***	1.363*	1.150
Years Participating in CBC	16.23	1.019***	1.024***	1.000	1.038***	1.039*	1.024*
Avg. Number of Yearly Circles	1.93	1.036	1.045	.988	.899	1.278**	1.073

NOTES: "Science & conservation" motivations (n=895) serves as the reference group. ORs > 1 suggest that individuals in a demographic group or individuals with higher variables scores are more likely to report a particular motivation relative to science and conservation. *,**, and *** denote statistical significance of OR of α=.05, .01, and .001, respectively. Model Fit: Likelihood Ratio Test: $\chi^2(54)=182.58$, $p<.001$; Nagelkerke $R^2 = .082$. Continuing motivation (not reported) models reflects identical trends.

[a] Total sample size for this model reflects 1,068 cases that were excluded due to missing data on the demographic or experiential variables.

[b] Political View scale: 1=Liberal to 5=Conservative.

Table 4
Binary Logistic Regression Models Depicting Relationship Between Citizen Science Motivations and Likelihood of Future Project Participation by Project Role.

Motivation Category	Future Project Role								
	Observer[a]			Section Leader[b]			Compiler[c]		
	B	SE	OR	B	SE	OR	B	SE	OR
Science & Conservation	.216	.124	1.24*	.362	.074	1.44***	.127	.075	1.14*
Classic Birding	-.049	.080	0.95	-.099	.043	0.91**	-.068	.045	0.93
Personal Accomplishment	-.080	.094	0.92	.087	.051	1.09*	-.004	.052	1.00
Outdoor Recreation & Discovery	.426	.138	1.53***	-.431	.079	0.65***	-.315	.080	0.73***
Social Interaction	-.253	.107	0.78*	.449	.057	1.57***	.447	.060	1.56***
Commitment & Tradition	-.018	.121	0.98	.025	.065	1.03	.144	.067	1.16**

[a] 93.9% likely to participate as observer; n = 2843; Model Fit Statistics: χ^2(df=6) = 18.9, p = 0.004, Hosmer & Lemeshow χ^2(df=8) = 5.4, p = 0.718, Nagelkerke R^2 = 0.02.
[b] 54.0% likely to participate as section leader; n = 2300; Model Fit Statistics: χ^2(df=6) = 138.1, p < 0.001, Hosmer & Lemeshow χ^2(df=8) = 9.2, p = 0.328, Nagelkerke R^2 = 0.08.
[c] 61.3% likely to participate as compiler; n = 2283; Model Fit Statistics: χ^2(df=6) = 100.3, p < 0.001, Hosmer & Lemeshow χ^2(df=8) = 4.8, p = 0.783, Nagelkerke R^2 = 0.06.

than other groups (*OR* = 1.16, Table 4). Classic birding motivations were not positively linked to future participation in any CBC role.

4. Discussion

This study helped to advance knowledge of citizen science motivations in several ways, answering recent calls to move beyond data collection and think more holistically about volunteers and how they experience projects (Phillips et al., 2019; West and Pateman, 2016).

First and foremost, our approach provided a tool and an analytical framework that revealed the variety of motivations fueling citizen science participation.

4.1. Citizen scientists report many different motivations

Like volunteers in other sectors (Clary and Snyder, 1999; Ryan and Deci, 2000), CBC participants reported a range of intrinsic and extrinsic motivators across each of Batson et al.'s (2002) motivational constructs. Although altruistic motives for advancing science and conservation received the highest average ratings and were listed as the primary motivating force for over 40% CBC participants, our study shows that many other motivations were also important.

Some volunteers were fueled by collectivist tendencies, seeking social interaction with like-minded colleagues. Other studies have demonstrated that collectivist motivations focused on social norms and relationships are key correlates of engagement for both online (Curtis, 2015; Nov et al., 2014; Rotman et al., 2012) and field-based projects (Bell et al., 2008). Egoistic motivations were also common in our sample, as outdoor recreation and discovery motivations were highly correlated with all other subscales. These relationships underscore the importance of intrinsic interest and enjoyment for citizen science volunteers (Frensley et al., 2017); they also highlight connections between recreation participation and conservation behavior (Larson et al., 2018). Some volunteers were driven by principlism, typically manifested as a commitment to their identity as birders and dedicated CBC contributors. Identity-driven behavior is common in the highly-specialized birding community (Scott et al., 2005), but it may apply to citizen science projects in other realms too. Regardless of discipline, citizen science project managers seeking to understand volunteers and improve their experience should be aware of these dynamic motivations and dimensions of engagement and how they could influence project design (Phillips et al., 2019; Wright et al., 2015).

4.2. Conservation-oriented motivations more prominent as participation progresses

The fact that science and conservation-related themes dominate initial motivations for the CBC, a conservation-focused ecological monitoring project, is not surprising. Other research suggests that citizen scientists engaged in online projects are driven by a strong sense of purpose and dedication to advancing scientific knowledge (Nov et al., 2014; Raddick et al., 2013). Volunteers in field-based biodiversity projects, in particular, want to help generate scientific data that informs conservation of focal species (Domroese and Johnson, 2017; Geoghegan et al., 2016; Phillips et al., 2019). But we did not expect to find that the importance of motivations centered on advancing science and conservation would grow with project participation as other motivations declined.

This appears to contradict previous studies suggesting extrinsic motivations may be needed to help citizen scientists build on their initial intrinsic interest to foster competence, autonomy, and connections (Dickinson et al., 2012). For example, Rotman et al. (2014, 2012) found that collectivist motivations and a need for enhanced social interaction among long-term participants eventually eclipsed the egoistic and altruistic motivations that inspired initial project involvement. However, other researchers have noted that as volunteer participation progresses, actions that begin as altruistic contributions to science may eventually morph into intrinsically rewarding deeds themselves (Domroese and Johnson, 2017; Geoghegan et al., 2016; Tiago et al., 2017). When the allure of extrinsic motivators erodes, those intrinsic motivations may be needed to sustain support and involvement. Such a shift might be especially relevant in place-based, ecological monitoring projects, where conservation outcomes are more tangible and valuable to volunteers dedicated to protecting their local area (Haywood et al., 2016; Newman et al., 2017). For example, if volunteer observers witness changes in their favorite places over time, their commitment to conserving those habitats might increase. If managers help volunteers see the value of their contributions as they engage with projects, those volunteers may be even more inclined to work toward conservation goals (Ballard et al., 2017; Domroese and Johnson, 2017).

The importance of commitment and tradition as a continuing motivation for citizen scientists should also be acknowledged. Tradition is a critical element of established projects like the CBC, where volunteers appreciate the legacy of impact and the opportunity to become part of a larger collective monitoring effort. Many birders are therefore eager to contribute to the CBC and other avian-focused citizen science projects (Sullivan et al., 2014); similar commitment among enthusiastic volunteers might extend to other taxa as well (Theobald et al., 2015). As citizen science projects evolve, they cultivate social norms and

interactions that play a key role in group identity-building (Cialdini and Goldstein, 2004). By striving to forge identity around these social norms, citizen science project managers can create a tradition of sustained engagement and build a larger community of practice committed to advancing scientific, conservation, and educational goals (McKinley et al., 2017).

4.3. Motivations vary among different groups of volunteers

We also observed socio-demographic patterns in motivations that reinforce a key observation: not all citizen scientists are the same, and they will likely respond differently to different types of project messaging and framing (West and Pateman, 2016). For example, we found that female volunteers were more likely than males to be motivated by social interaction and commitment and tradition and less likely to motivated by classic birding, reflecting other studies of gender differences in social participation behaviors (Lammers, 1991; Mesch et al., 2006). Age also appeared to matter, with younger volunteers more likely to report social interaction, classic birding, and commitment and tradition as key motives. Volunteers who were more liberal and those engaged in natural resource or life science professions were more likely to report science and conservation motivations than other groups. Demographic differences based on race, education, and income were minimal, mirroring previous studies (Geoghegan et al., 2016; Tiago et al., 2017) and in part reflecting the homogeneity of the larger population of citizen scientists (Chu et al., 2012) and underscoring a need to engage more diverse populations.

Our results align with previous studies suggesting citizen science motivations can vary by levels of project participation (Jennett et al., 2016; Tiago et al., 2017). This is important because most citizen science projects feature a large portion of participants who contribute in small quantities (dabblers) and a few who do the bulk of the work (divers) (Cooper et al., 2017; Eveleigh et al., 2014). We found that volunteers with more years of project experience were less likely to report initial motivations focused on science and conservation but equally likely to list science and conservation as continuing motivations, supporting the general shift toward conservation-oriented motives discussed earlier. Volunteers who participated in more CBC observation circles per year were the most likely to list personal accomplishment as a motivation. Motivations also appeared to differ as volunteers aspired to take on different project roles as observers, section leaders, or compilers. Motivations centered on science and conservation were linked to future participation in each role. However, whereas observers reported stronger outdoor recreation and discovery motives, individuals inclined to adopt leadership roles in the CBC were more interested in social interaction and commitment and tradition. These differences suggest that, while science and conservation motives remain important throughout the citizen science volunteer lifespan, managers hoping to deepen engagement in projects through leadership roles must provide social infrastructure that allows collective knowledge generation to flourish (Curtis, 2015).

4.4. Future research on motivations in citizen science

Although this study focused on one biodiversity monitoring project, the large and relatively varied sample of CBC volunteers suggests that our scale and motivational constructs could be applied across a range of contexts. Such applications would undoubtedly require some adaptations. For example, rather than using the instrument as a whole in its current form, projects focused on community and environmental health might substitute contributions to community development or social well-being for conservation dimensions (Den Broeder et al., 2018). Additional and more sophisticated forms of validation (e.g., predictive validity, content validity) are needed to confirm the utility of the motivations scale across these diverse citizen science contexts. Additional qualitative and longitudinal inquiries examining if and how motivations shift over time, similar to some previous work (Everett and Geoghegan, 2016; Rotman et al., 2014), would also help to reveal causal mechanisms driving motivational change to inform dynamic volunteer management (Wright et al., 2015). In addition to motivations, future research should also consider barriers to citizen science participation (Frensley et al., 2017; Geoghegan et al., 2016), and how changes in program communication, results distribution, and provision of digital tools may be influencing volunteer motivations. Finally, despite some promising leads (Domroese and Johnson, 2017; Lewandowski and Oberhauser, 2017), more studies are needed to explore relationships between self-reported volunteer motivations and overt conservation outcomes and behaviors.

5. Conclusions

To maximize the conservation impact of citizen and community science, scientists and project managers should engage in systematic efforts to understand volunteers and what drives them to act (Domroese and Johnson, 2017; Phillips et al., 2019; West and Pateman, 2016). This knowledge will not only reveal new ways to empower current volunteers (Garner and Garner, 2011; Wright et al., 2015), but also strategies for recruiting and retaining more diverse populations of citizen scientists (Pandya, 2012), as well as informing participants of the outcomes of their work. Our results show that contribution to science and conservation are the most important motivation for CBC participants, and often become more important as project participation progresses. To boost volunteer engagement and morale (Yanay and Yanay, 2008), project-related communication should emphasize positive feedback in these domains, helping participants recognize their positive conservation impacts (Tiago et al., 2017). But managers should also recognize the wider range of other motivations (e.g., outdoor recreation and discovery, social interaction) embraced by volunteers and attempt to consider these motivational orientations in the design, development, and communication about citizen science programs (Skarlatidou et al., 2019). Ultimately, an enhanced understanding of factors motivating participation in citizen and community science - and how those factors might change over time – could enhance volunteer capacity to advance biodiversity conservation goals and outcomes. The instrument and motivational constructs outlined in this study could help researchers and practitioners accomplish those goals.

CRediT authorship contribution statement

Lincoln R. Larson: Conceptualization, Methodology, Formal analysis, Investigation, Writing - original draft, Writing - review & editing, Supervision, Project administration. **Caren B. Cooper:** Conceptualization, Methodology, Formal analysis, Investigation, Writing - original draft, Writing - review & editing, Supervision, Project administration. **Sara Futch:** Data curation, Writing - original draft, Writing - review & editing. **Devyani Singh:** Data curation, Writing - original draft, Writing - review & editing. **Nathan J. Shipley:** Conceptualization, Methodology, Formal analysis, Writing - review & editing. **Kathy Dale:** Conceptualization, Investigation, Writing - review & editing, Project administration. **Geoffrey S. LeBaron:** Conceptualization, Investigation, Writing - review & editing, Project administration. **John Y. Takekawa:** Conceptualization, Investigation, Writing - review & editing, Project administration.

Declaration of competing interest

The project was conducted without financial support, but several co-authors on this paper are affiliated with National Audubon Society (NAS), the organization that manages the Christmas Bird Count (CBC). All data collection, analysis, and interpretation was conducted independently by members of university research teams not affiliated with NAS or the CBC. Co-authors from NAS provided input during the writing of the report.

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Appendix A. Supplementary data

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