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# Why do people participate in app-based environment-focused citizen science projects?

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We investigated the motivations of participants in two environment-focused citizen science projects using an online questionnaire. The questions focused on the reasons for initial engagement and in how far these motivations were fulfilled by participating. The two projects, CrowdWater and Naturkalender (English: Nature's Calendar), use similar smartphone applications to collect data on water and phenology, respectively. The answers to the individual statements were analyzed based on a categorization framework that was previously used with other citizen science projects. The motivations to participate in the projects were similar for the two projects but there were also some differences. They were altruistic and related to participants' principles (e.g., to uphold a moral principle, such as through conservation). The main motivations for becoming engaged in the projects were to contribute to science, due to an interest in the project topic, and to protect nature. More CrowdWater respondents were motivated by being asked to participate than Naturkalender respondents. Naturkalender participants and participants in the 50–59-year age group of both projects agreed most to enjoying their participation, being outside and active, and learning something new. More super-users, i.e., users who participated at least once per week, were interested in sharing their knowledge and experience with others than occasional participants. This was particularly true for super-users in Naturkalender. Based on the results of this study, we recommend that to help sustain involvement of the most active participants, projects should focus on recruiting participants who are already interested in the topic, and highlighting opportunities to share knowledge, be outdoors, and contribute to science.

## KEYWORDS

citizen science, motivations, smartphone application, crowdsourcing, water level, phenology

## 1 Introduction

Engagement in citizen science projects depends strongly on motivational factors (Phillips et al., 2019). As the number of citizen science projects (Irwin, 2018) and the needs for data continue to grow, it is important to sustain participation. However, the motivations of people to participate in citizen science and how people benefit from their participation can be complex (West and Pateman, 2016; Haklay, 2018; Thornhill et al., 2019). Key motivations for joining citizen science projects are to contribute to science, to protect the environment, and to be part of a specific community (Raddick et al., 2013; Curtis, 2015; Alender, 2016). These have been observed across the globe through surveys, interviews, and

focus groups of participants and program leaders. For instance, in Bangalore, India, primary participant motivations identified through surveys and focus groups were “to protect wildlife”, “to give something back to society”, “to learn something about wildlife”, and “to spend time in nature” (Johnson et al., 2014). In the online project Galaxy Zoo, “contributing to science” was the primary motivation for almost 40% of 11,000 participants that responded to open questions and a survey (Raddick et al., 2010; Raddick et al., 2013).

Motivations for participation in citizen science projects have been classified and summarized in a variety of ways. The theoretical background on understanding motivations to participate in citizen science projects has often been drawn from psychology or the literature on volunteering. Several theories from the volunteering literature (Clary and Snyder, 1999; Penner, 2002; Locke et al., 2003; Finkelstien, 2009) have been brought together to describe the factors that influence participation in citizen science (West and Pateman, 2016). Intrinsic and extrinsic motivation (Finkelstien, 2009) were identified as two overarching categories among six categories of the ‘functional approach to volunteering’ (Clary and Snyder, 1999). Psychology-grounded self-determination theory, which is based on the three psychological needs of competence, relatedness, and autonomy (Ryan and Deci, 2000a), has also been used to categorize and explain participants’ motivations (Frensley et al., 2017). Motivations identified from a multitude of citizen science projects were reformulated into statements (Levontin et al., 2018) and subsequently grouped into categories of personal values, which encompass the entire spectrum of human motivation defined by Schwartz et al. (2012). In another framework, key motivational factors were manually extracted from the citizen science literature and grouped (Beza et al., 2017) according to a framework of motivations including altruism, collectivism, principism, intrinsic egoism, and extrinsic egoism (Batson et al., 2002; see also Section 3.2).

When assessing the motivations of people to participate in citizen science, most studies have focused on a single project (e.g., Raddick et al., 2013; Curtis, 2015; Land-Zandstra et al., 2016a). The broad array of approaches to assess participant motivations, the different frameworks to classify these motivations (with wide-ranging levels of detail), and the substantial variations in the projects themselves make it difficult to compare the results of these studies. Here, we aim to expand the knowledge on the motivations of citizen scientists by comparing the results of a questionnaire about reasons to initially participate and to continue to participate over time in two smartphone-based, environment and outdoor-focused citizen science projects in Europe: CrowdWater ([www.crowdwater.ch](http://www.crowdwater.ch)) (Seibert et al., 2019a; Seibert et al., 2019b) and Naturkalender ([www.naturkalender.at](http://www.naturkalender.at)). The aim of CrowdWater is to collect hydrological data, such as water levels, soil moisture, and the status of temporary streams. Naturkalender (English: Nature’s Calendar) focuses on documenting the phenology of indicator species and changes related to climate change. A comparison of the motivations to participate in these two projects enables a more explicit focus on how the project topic and thematic content may relate to the motivations of the participants. As such, the goals of this study were 1) to identify the motivations of citizens to join CrowdWater or Naturkalender, 2) to see whether these motivations were fulfilled

through participation, 3) to determine if the main motivations to participate differed among the projects, across age groups or between participants who contributed frequently and those who contributed occasionally, and 4) to contribute to the understanding of motivations to participate in citizen science projects in general.

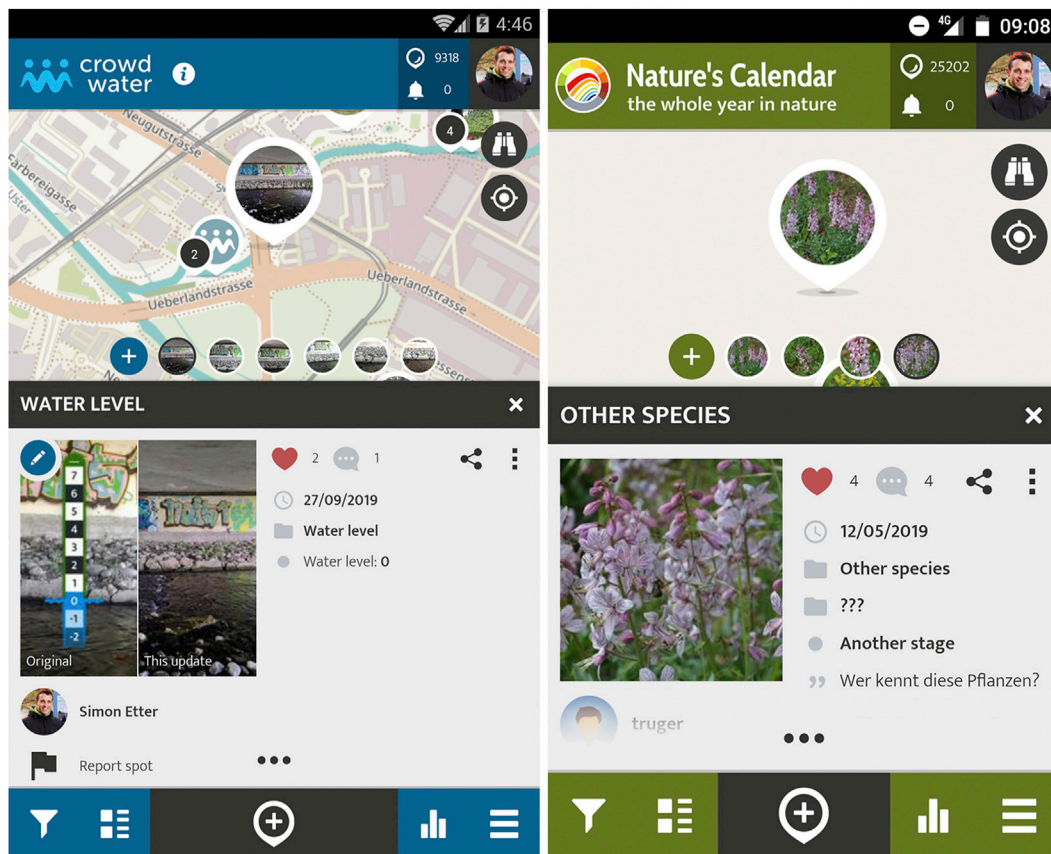
## 2 The projects

CrowdWater and Naturkalender are similar in terms of the visual design of their smartphone applications (“apps”), the way data are transmitted, and the cultural background of the participants. The two projects have, so far, mainly recruited participants from Switzerland and Austria. Both projects use smartphone apps that were developed in close collaboration with SPOTTERON, an Austrian company specialised in the development and maintenance of apps for citizen science projects. The apps are available for Android and iOS. Each app user can start observations at a new spot and contribute observations to existing spots (i.e., those started by other users) to obtain time series of observations. The apps include social media functions that enable interaction between participants, such as following other participants, commenting, and liking contributions (Figure 1).

### 2.1 CrowdWater

The CrowdWater app was launched in early 2017. The goal of the project is to develop a tool to collect hydrological information for models that can be used for water management applications. CrowdWater participants are asked to observe water-related variables such as stream water level classes based on a virtual staff gauge (Seibert et al., 2019a; Seibert et al., 2019b), soil moisture based on qualitative classes (Rinderer et al., 2012), the state of temporary streams (Kampf et al., 2018), plastic pollution (van Emmerik et al., 2020), or stream type. Citizen scientists are encouraged to make repeated observations at a location to obtain time series of observations for that location. CrowdWater has mainly been advertised *via* social media, and through private and work-related networks (e.g., presentations at conferences, schools and science fairs, and articles in university newsletters and magazines). Most of the initial participants were recruited *via* the social network of the project administrators. Observations can be—and have been made—around the globe. However, most of the advertisement and outreach activities so far have focused on German-speaking citizens; hence most observations have been made in Switzerland and Austria.

Social interaction in the CrowdWater app occurs mainly between the project team and citizen scientists *via* the comments function in the app or by personal communication *via* e-mail. Only in rare cases have citizen scientists commented on each other’s observations in the app. Since the value of the data is still subject to research, communication regarding the potential use of the data (e.g., for flood or drought warning systems) has been done very carefully. At the end of October 2018, when the questionnaire was closed, 265 users had contributed at least one observation *via* the CrowdWater app; there were on average 132 contributions per month between February 2017 and October 2018.



**FIGURE 1**  
 Screenshots of the CrowdWater app (left) and the Naturkalender app (right). For each, the social media features can be observed in the top row of the lower panel. From left to right, these include the like button and counter, the speech bubble that allows users to comment on the observation (with the counter to the right of it), and the sharing button that allows users to share contributions on Facebook, Twitter and Google+. More information on the app design can be found in Seibert et al. (2019a), Seibert et al. (2019b), and spotteron.net. Comment translation in English: “Who knows these plants?”.

## 2.2 Naturkalender

Naturkalender (in English: Nature’s Calendar) was established in 2014. It aims to document the phenology of several indicator plant species throughout the year, to record the behaviour of wild animals, and to document winter phenomena (e.g., the presence or absence of snow cover). By observing the start of, for instance, leaf development or the return of birds from their winter habitats, the project aims to assess the influence of climate change on flora and fauna. Citizen scientists can report the state of plant growth and behaviour and presence of birds, butterflies and bees on a map that covers the entire globe. However, most contributions have been made in Austria. The data collected in Naturkalender are included in the Pan European Phenology Project PEP725-database, an openly accessible data set used for research and education ([www.pep725.eu](http://www.pep725.eu)). Naturkalender attracted participants through press releases and outreach events.

Compared to CrowdWater, there is more communication between participants in Naturkalender. Many observations are commented on by different users, and users help each other with the identification of species. At the time the questionnaire closed, 642 users had provided at least one contribution to Naturkalender;

there were on average 422 contributions per month between April 2015 and October 2018.

## 3 Methods

### 3.1 Questionnaire

The questionnaire addressed both the motivations for initial engagement and the fulfilment of those motivations. In the first part of the questionnaire, the *engagement part*, we aimed to identify the motivations of citizen scientists that led to their engagement in either CrowdWater or Naturkalender. We interpreted the motivations to become engaged in a project as goals that could potentially be fulfilled by participation. This is in line with other studies on motivations or reasons for citizen scientists to participate (Raddick et al., 2010; Hobbs and White, 2012). In the second part of the questionnaire, the *fulfilment part*, we aimed to see which of these initial motivational goals were fulfilled by participation in the projects.

We selected 35 of the 58 statements of the questionnaire developed during a citizen science COST action workshop<sup>3</sup> in

Latvia in March 2018 and published by Levontin et al. (2018). We asked the CrowdWater and Naturkalender participants to what extent they agreed with these statements based on a five-point Likert-scale with the options “don’t agree at all,” “rather don’t agree,” “undecided,” “rather agree,” and “fully agree.” Most statements were rephrased to make them more suitable for the fulfilment part. It was, however, not possible to rephrase all of them in a meaningful way. This was, for example, the case for the statements “trying to act in a way that does not harm or upset anyone and fulfils social expectations or norms,” and “maintaining or achieving social status and prestige by controlling or acquiring resources.” To avoid confusion, we decided to leave out “I enjoy this activity” in the engagement part because we assumed that participants of CrowdWater were very unlikely to have participated in hydrological data collection before their initial participation in the project and thus could not reliably state that they already enjoyed this activity before participating in the project.

Using a convenience sampling approach, an invitation to fill out the online questionnaire on [surveymonkey.com](https://www.surveymonkey.com) was sent (in English and German) to all participants of the two projects with push messages in the apps on 8 August 2018. On the same date, it was also sent by e-mail to the 400 people who had registered for the CrowdWater newsletter at that time. The participants of CrowdWater were reminded by a second push message on 22 August 2018.

## 3.2 Categorization of the statements

To develop broad categories of motivation, statements in the questionnaire were classified according to the framework of Batson et al. (2002), which was adapted by Beza et al. (2017) and is hereafter referred to as the “Batson-framework” (Supplementary Table S1). The Batson-framework was designed to describe motivations for community-involvement and has been used previously for citizen science projects (Beza et al., 2017). It was chosen because it provided a good overview of the motivations of the participants with relatively simple and easily interpretable categories.

The Batson et al. (2002) framework classifies motivations for community engagement based on four categories: *egoism*, *altruism*, *principlism*, and *collectivism*. *Egoism* describes the motivation of persons who seek primarily to benefit themselves in doing something. The actions taken might still serve the community or the greater good, e.g., volunteering in a citizen science project to be able to include that in one’s résumé. *Altruism* is defined as the motivation to fulfil someone’s needs and is mainly motivated by the feeling of empathy towards the other person. An example is volunteering in a citizen science project to help the researchers with their work. *Collectivism* is the motivation to increase the welfare of a group, e.g., by measuring and reporting lead pollution in tap water of the local community (Pieper et al., 2018). *Principlism* is defined as the motivation to uphold some moral principle(s), like justice or the conservation of wildlife (Batson et al., 2002).

The Batson et al. (2002) framework was combined with another framework (Ryan and Deci, 2000a) to distinguish intrinsic egoism (*egoism*, *intrinsic*) from extrinsic egoism (*egoism*, *extrinsic*). Intrinsic egoism is focused on a person’s satisfaction (e.g., fun, or interest in sharing information), while extrinsic egoism aims to achieve a

desirable and separate outcome (e.g., expecting something in return). The attribution of the statements used in the questionnaire to these five categories can be found in Supplementary Table S1.

## 3.3 Analyses

For each statement, we determined the percentage of respondents who agreed (i.e., those who chose “rather agree” or “fully agree”) with the statement. We also determined the average percentage of respondents who agreed with the different statements in each of the five categories of the Batson framework.

To assess the reliability of the categories, we assessed the consistency of the agreements to the different statements in a category. For categories with more than two statements, we used Cronbach’s alpha (Cronbach, 1951). For the categories with only two statements, we used the Spearman-Brown coefficient (Eisinga et al., 2013).

To determine the statistical significance of differences in agreement with the statements for initial engagement and fulfilment between the two projects, answers to the statements in the questionnaire were converted into numbers from 1 to 5: 1 for “don’t agree at all,” 2 for “slightly disagree,” 3 for “undecided,” 4 for “slightly agree,” and 5 for “fully agree.” We used the paired Wilcoxon signed rank test to determine the significance of the differences in the median response to the statements regarding the motivations for initial engagement and the fulfilment of these motivations by participating. To test the significance of the differences in the median response between the CrowdWater and Naturkalender respondents, we used the Mann-Whitney U-test. We used a significance value of 0.05 for all of these analyses.

We classified respondents who stated that they contributed to the projects at least weekly as super-users and all other users as occasional participants. We did not test for the statistical significance in the median responses between super-users and occasional participants due to the small number of super-users. Similarly, we did not test for the statistical significance in the median responses between the different age groups due to the small number of users in some of the groups and bias to users of Naturkalender in the age 50–59 group.

## 4 Results

### 4.1 Number of responses and demographics

Ninety questionnaires with complete responses were received. Of those, 54 were submitted by CrowdWater participants and 36 by Naturkalender participants. Based on the 265 active participants in CrowdWater and 642 participants in Naturkalender when the questionnaire was distributed, we estimate the response rate to be about 10%. Most respondents ( $n = 25$ ) were in the 30–39 age group (Table 1). There was a gender balance for the respondents (54% female vs. 46% male). Twenty-six percent of CrowdWater respondents were super-users and 47% of Naturkalender respondents were super-users (Table 2). Super-users tended to be older than occasional participants, with most super-users reporting

**TABLE 1** Number (and percentage) of respondents by gender and age group, and number of super-users and occasional participants for the two projects. Super-users are users who said that they contributed at least one observation per week.

Age group	Gender		Project		Frequency of contribution	
	Female	Male	CrowdWater	Naturkalender	Super-users	Occasional participants
<18	3 (6)	1 (3)	3 (6)	1 (3)	1 (3)	3 (5)
21–29	12 (23)	4 (11)	13 (24)	3 (8)	1 (3)	15 (25)
30–39	13 (25)	12 (32)	18 (33)	7 (19)	7 (23)	18 (31)
40–49	6 (12)	7 (19)	9 (17)	4 (11)	4 (13)	9 (15)
50–59	10 (19)	9 (24)	7 (13)	12 (33)	11 (35)	8 (14)
60+	8 (15)	4 (11)	4 (7)	8 (22)	6 (19)	6 (10)
not stated	1 (1)		0 (0)	1 (3)	1 (3)	0 (0)
Total	52	37	54	36	31	59

**TABLE 2** Number (and percentage) of respondents that were super-users and occasional participants for CrowdWater and Naturkalender.

	Super-users	Occasional participants
CrowdWater	14 (26%)	40 (74%)
Naturkalender	17 (47%)	19 (53%)
Total	31 (34%)	59 (66%)

ages of 50–59, and most occasional users reporting ages between 30 and 39 (Table 1).

### 4.2 Reliability of the categories

The consistency of the agreement of the different statements in a category (i.e., the reliability of the category) can be considered “good” or “acceptable” for all categories (Cronbach’s alpha >0.7; George and Mallery, 2003) with more than two statements (Supplementary Figure S1). The category *altruism*, which only included two statements, had a Spearman-Brown score of 0.64 for the engagement part and 0.53 for the fulfilment part, which indicates a “questionable” and “poor” consistency, respectively, but it is still somewhat acceptable according to George and Mallery. (2003). Because of the relatively low consistency for this category, we provide the results per statement as well.

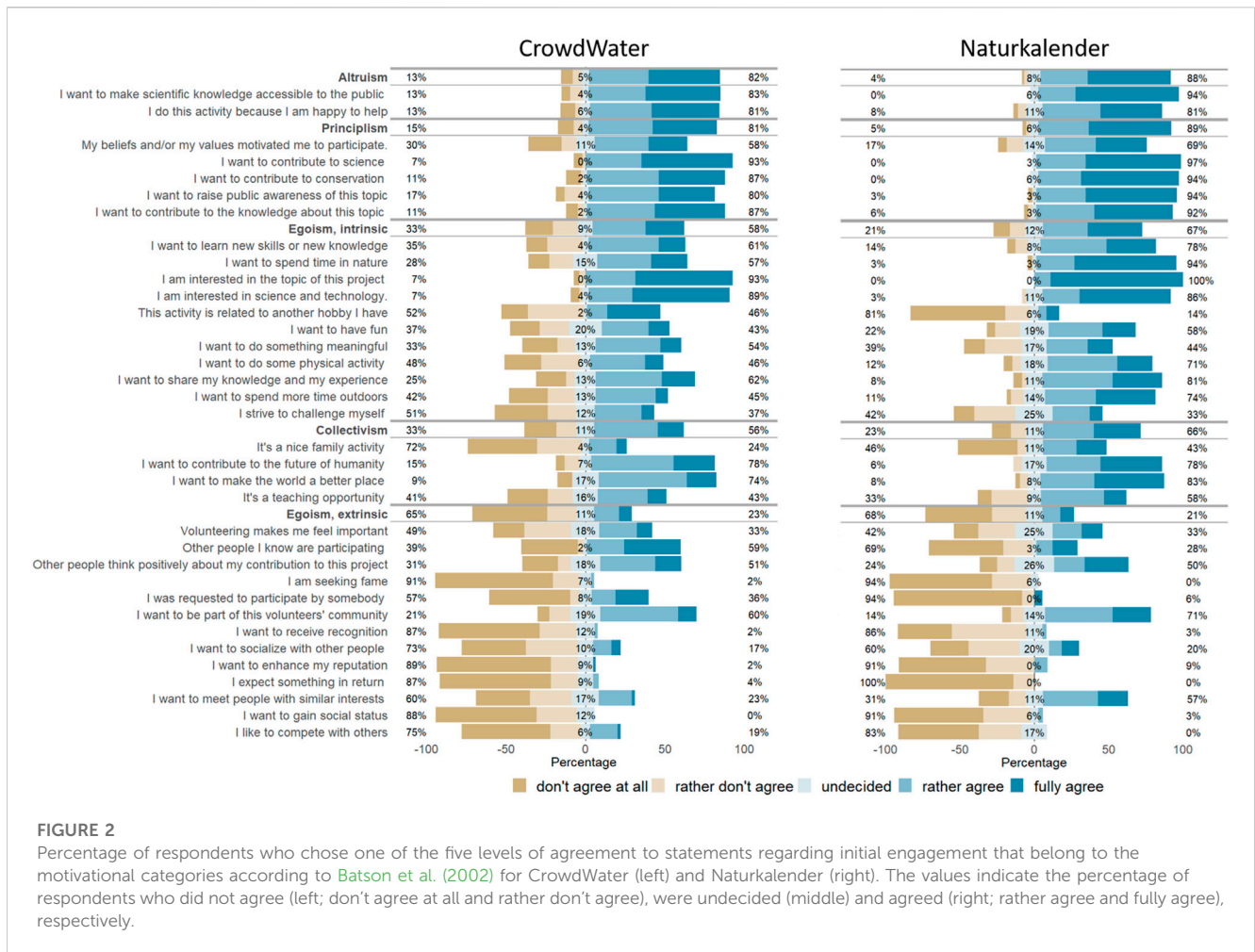
### 4.3 Motivations for initial engagement

*Altruism* was the factor with the highest average agreement (82%; Figure 2) and was thus the main motivational factor to join CrowdWater. For Naturkalender, the main motivational factor for engagement was *principlism* (89%; Figure 2). However, *altruism* was the second most common motivational factor in Naturkalender and *principlism* was the second most common motivational factor in CrowdWater. The order of the categories with the highest average agreement did not differ between the two

projects for any of the other categories. However, significantly more Naturkalender respondents agreed with *egoism-intrinsic*, *collectivism*, and *principlism* than CrowdWater respondents (all *p*-values <0.01).

When considering the responses per statement rather than categories, initial engagement for both projects was mainly related to the participants’ interest in contributing to science and conservation, and their interest in the topic (Figure 2). Of the CrowdWater respondents, 93% expressed agreement with the statement “I am interested in the topic of this project” vs. 100% of Naturkalender respondents. Similarly, 93% of CrowdWater respondents agreed to the statement, “I want to contribute to science” vs. 97% of the Naturkalender respondents. This was followed by agreement to the statements “I want to contribute to conservation,” and “I want to contribute to knowledge about this topic.” Rounding out the most agreed upon statements was, “I want to raise public awareness of this topic.” Conversely, few respondents were motivated by receiving recognition for their contributions, getting something in return, socializing, or gaining social status (Figure 2).

Overall, the median agreement to the statements for initial engagement was significantly higher for the Naturkalender respondents than for the CrowdWater respondents (median 4—“rather agree” for Naturkalender vs. 3—“undecided” in CrowdWater). In fact, there were only 10 (out of 35) statements, for which more CrowdWater respondents expressed agreement than Naturkalender respondents (Figure 2). While many of the statements resulted in somewhat similar levels of agreement between respondents from the two projects, several statements resulted in a more than 30% separation in level of agreement between the projects. The most pronounced difference was for the statement, “I want to spend time in nature,” where significantly fewer CrowdWater respondents (57%) expressed agreement than Naturkalender respondents (94%). Other statements with large differences in agreement included, “I want to meet people with similar interests” (23% of CrowdWater respondents vs. 57% of Naturkalender respondents), “this activity is related to another hobby I have” (46% vs. 14%), “other people I know are participating” (59% vs. 28%); and “I was requested to participated by somebody (36% vs. 6%).



### 4.4 Fulfilment of motivations

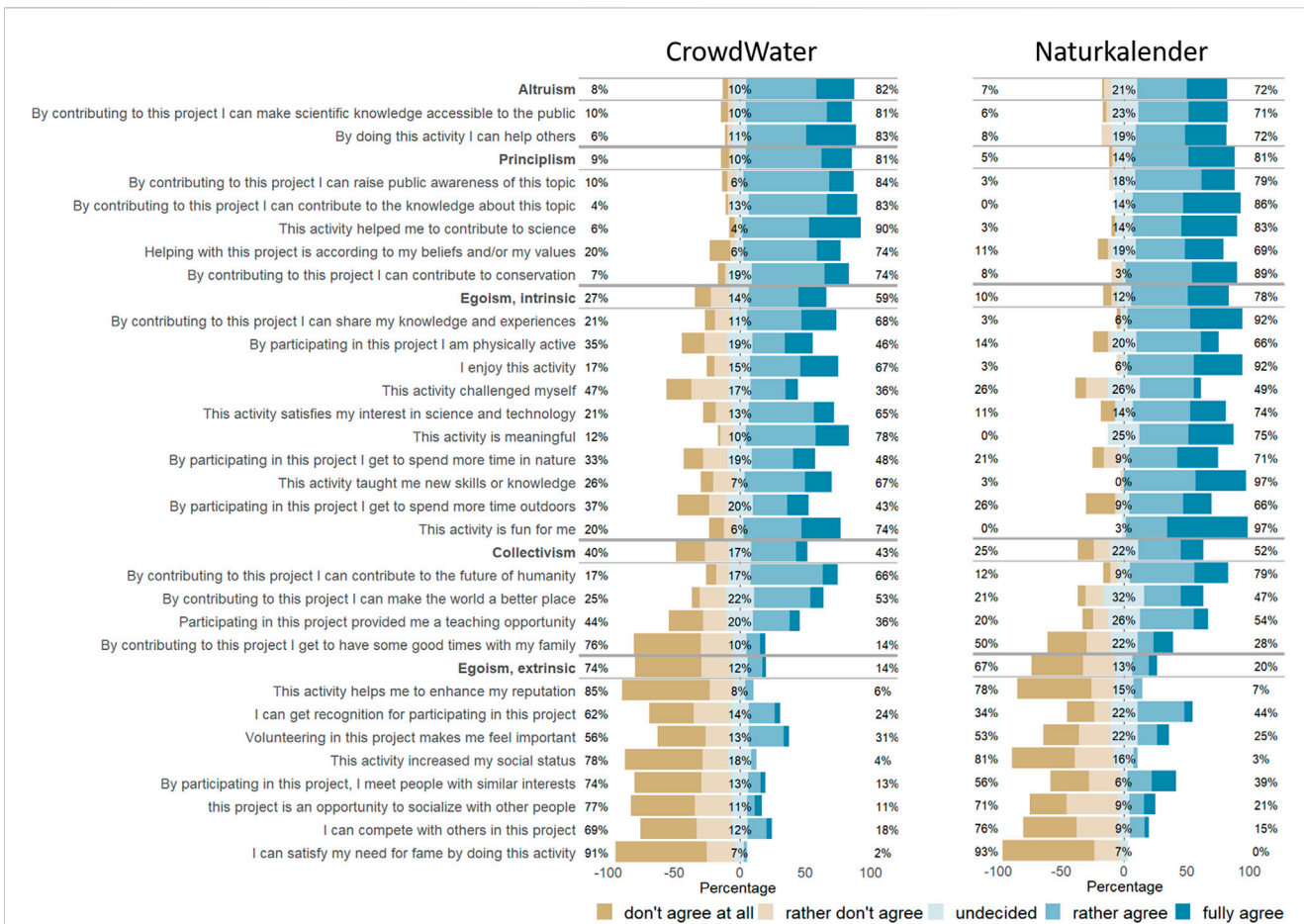
The top motivational factors that were fulfilled by participating in the projects were *altruism* and *principlism* (Figure 3). Even though the average agreement for *principlism* was 81% for both projects, the median response for the Naturkalender respondents was significantly higher due to the larger percentage of respondents who fully agreed with these statements (23% for CrowdWater vs. 37% for Naturkalender,  $p = 0.02$ ). However, agreement to individual statements to which most respondents agreed (i.e., contributing to science, conservation, and knowledge, and interest in science, technology, and the project topic) all declined compared to initial engagement both projects. Compared to the motivations for initial engagement, the CrowdWater respondents agreed significantly less with the statements in the *collectivism* ( $p < 0.01$ ) and *egoism-extrinsic* ( $p = 0.02$ ) categories. For the Naturkalender respondents, there was a significant decrease in the median response to the statements in the *altruism* ( $p < 0.01$ ), *collectivism* ( $p = 0.04$ ) and *principlism* ( $p < 0.01$ ) categories, and a significant increase in the agreement for the *egoism-intrinsic* category ( $p = 0.02$ ).

In the *egoism-intrinsic* category, more respondents in both projects agreed that the project was fun and that they learned new skills or knowledge through participation than for the initial engagement. Notably, after participating, nearly all of the

Naturkalender respondents agreed with statements about fun and learning: 97% agreed with the statements “this activity taught me new skills or knowledge,” and “this activity is fun for me,” while 92% agreed to the statement “I enjoy this activity.” In comparison, 67%, 74%, and 67% of the CrowdWater respondents agreed to these statements, respectively. While both projects saw increased agreement to these statements compared to initial engagement, significantly fewer CrowdWater respondents agreed to the statements about enjoying project activities than Naturkalender respondents ( $p < 0.01$ ), and in general, fewer CrowdWater respondents agreed to the statements across the *egoism-intrinsic* category ( $p < 0.001$ ). Nonetheless, the median response for the statements, “this activity satisfies my interest in science and technology,” and “this activity taught me new skills or knowledge” was 4 (rather agree) for both projects.

There was also increased agreement in both projects to the statement that participants were able to share their knowledge and experiences. Like with fun and enjoyment, significantly more Naturkalender respondents indicated the ability to share knowledge than CrowdWater respondents.

For the CrowdWater respondents, the average agreement to the statement, “helping with this project is according to my beliefs and/or my values” was higher for the fulfilment than the initial motivation for engagement, but the difference in the median



**FIGURE 3** Agreement of CrowdWater and Naturkalender respondents to the statements related to how their initial motivations were fulfilled by participation in the projects grouped per category of the Batson-framework. The categories are sorted by decreasing percentage of agreement for the CrowdWater respondents in the engagement part. The values indicate the percentage of respondents who did not agree (left; don't agree at all and rather don't agree), were undecided (middle) and agreed (right; rather agree and fully agree), respectively.

response was not statistically significant;  $p = 0.11$ ). For Naturkalender respondents, the average agreement for this statement did not change compared to the initial motivations (Figure 2; Figure 3).

Decreases in agreement were observed across several statements. For Naturkalender respondents, there was a significant decrease in agreement to the statements about being outside and active, including “by participating in this project I get to spend more time outdoors,” “by participating in this project I get to spend more time in nature,” and “by participating in this project I am physically active.” Both projects also had significant decreases in statements related to making the world a better place, satisfying an interest in science and technology, contributing to the future of humanity, meeting people and socializing, and enhancing their reputation ( $p < 0.01$ ).

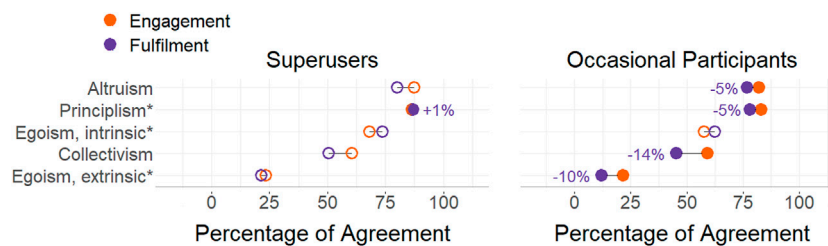
### 4.5 Fulfilment by age

In the fulfilment part, the respondents younger than 50 agreed most to statements related to *altruism* (83%–88%) and second most

to statements related to *principlism* (79%–88%). This includes agreeing most with statements about contributing to science and knowledge. Whereas the 50–59-year-old respondents agreed most with statements in the *egoism, intrinsic* (78%) and *principlism* (78%) categories. The 50–59 age group agreed most to statement, “This activity is fun for me” (90%). The respondents above 60 years agreed most with statements in the *principlism* category (77%). Furthermore, the respondents in the 50–59 and above 60 age group agreed significantly more with statements about doing physical activity (68% and 67% vs. 46% for those under 50) and spending more time outdoors (68% and 58% vs. 41% for those under 50). No other notable age-related differences were observed.

### 4.6 Motivations of super-users vs. occasional participants

The super-users and occasional participants agreed similarly to the majority of the 35 statements for initial engagement, but there were several motivations where the two groups diverged (Figure 4). About two-thirds of super-users wanted to meet others with similar



**FIGURE 4**  
 Comparison of the percentage of super-users and occasional participants who agreed to the categories of motivations for engagement (orange) and whether these were fulfilled by participating in the project (purple). Significant differences in the median agreement for engagement and fulfilment are shown in solid circles; insignificant differences are shown by open circles. The graph elements are sorted by decreasing agreement to the categories of the Batson-framework for the engagement part for the CrowdWater respondents. The asterisks in the y-axis labels indicates a significant difference between the super-users and the occasional participants.

interests, while only about a quarter of the occasional participants had such a motivation. Further, almost all super-users “want to share knowledge and experience,” while just more than half of the occasional participants agreed with that statement. About half of the super-users agreed with the statement “I strive to challenge myself,” whereas only about a quarter of the occasional participants agreed with that statement. Finally, nearly all super-users “want to spend time in nature” but only about two-thirds of the occasional participants demonstrated such interest. However, this difference depended on the project. Almost all occasional participants of Naturkalender agreed that an initial motivation was that they “want to spend time in nature,” whereas only about half of the CrowdWater occasional participants agreed. Another initial motivation for which the agreement differed between the super-users of the two projects was, “it’s a nice family activity,” for which none of CrowdWater super-users and about two-thirds of Naturkalender super-users agreed.

Almost none of the super-users were requested to participate by someone else, while about one in three occasional participants were recruited in such a manner. This difference was most notable for CrowdWater: less than 10% of the super-users in CrowdWater agreed to the statement “I was requested to participate by somebody” compared to almost half of the occasional participants. Nearly all of the Naturkalender participants participated without such a personal invitation.

In terms of fulfilment, super-users and occasional participants also generally agreed similarly with the statements, but there were a few where the two groups diverged. More super-users than occasional participants agreed with statements related to meeting people with similar interests, getting recognition for participating in the project, satisfying an interest in science and technology, and competing. The greatest difference was observed for “meet people with similar interests” where almost half of super-users agreed and only about one in ten occasional participants agreed. Similarly, about half of super-users agreed that they “can get recognition for participating in this project,” while only about one in five occasional participants agreed. Nearly all super-users reported that “this activity satisfies my interest in science and technology,” while just over half of occasional participants agreed. Finally, about a third of super-users agreed they could “compete with others in this project,” while only about one in 10 occasional participants agreed.

However, differences sometimes depended on the project. For instance, more than half of Naturkalender super-users agreed that they meet people with similar interests and that participating in the project provided them with a teaching opportunity, whereas less than one in five CrowdWater super-users agreed with those statements. Conversely, about two-thirds of CrowdWater occasional users agreed that “other people I know are participating,” while only about one in five Naturkalender occasional participants agreed with this statement. Another notable difference between the projects was observed for “I can compete with others in this project.” Almost half of CrowdWater super-users agreed with the statement but none of the super-users in Naturkalender did.

## 5 Discussion

### 5.1 Overview

All citizen science projects depend on dedicated participants; communication with the right target audiences is key to success (Parrish et al., 2018). Therefore, it is essential to identify target groups by characterizing the motivations of potential participants, and particularly the super-users. Although this depends on the project (including the topic and tasks involved), some general recommendations can be made based on the findings from this questionnaire and those reported in the literature. As such, in the discussion that follows we incorporate a suite of recommendations intended to aid other citizen science projects in recruiting and sustaining participation by a strong cadre of participants over an extended period.

### 5.2 Motivations for initial engagement

The similar order of the percentage of respondents who agreed with the statements for the motivations to engage in the CrowdWater and Naturkalender projects suggests that the participants had similar expectations prior to participation. The largest percentage of respondents for both projects were motivated to contribute to science, to protect nature, to satisfy their interest in the topic, and to contribute knowledge and make that accessible to



the public. These top motivations align with findings from a variety of other types of citizen science projects, particularly being motivated to contribute to science (Cosquer et al., 2012; Hobbs and White, 2012; Raddick et al., 2013; Curtis, 2015). This was observed in air (Land-Zandstra et al., 2016a) and water quality monitoring projects (Alender, 2016), in natural sciences and health-related projects (Land-Zandstra et al., 2016b; De Vries et al., 2019), and in online projects (Raddick et al., 2013; Curtis, 2015; Lotfian et al., 2020). In environment-related citizen science projects, the topics or issues addressed by the project are often important motivational factors as well (Ryan et al., 2001; Hobbs and White, 2012; Johnson et al., 2014; Alender, 2016; Fuchslin et al., 2019). In terms of recruitment, participants need to be interested in the topic of the project and the activities involved. Participants may also be eager to share their knowledge with others (Bell et al., 2008).

Alternatively, participants may be more motivated to join because of social pressure because they were asked to help with the project, as was the case for the newer CrowdWater project. This might be particularly true for projects in an early phase that still rely on family, friends, or acquaintances, or those in which members of an existing group are targeted for recruitment (Lowry et al., 2019). In fact, moral obligation has been demonstrated to influence people's decision to volunteer to some extent (Schwartz, 1977). The CrowdWater app had been available for only 17 months prior to the launch of the questionnaire. The first contributions for Naturkalender were made 41 months prior to the start of the questionnaire. At the time of the questionnaire, it seems that CrowdWater participants still reflected this recruitment strategy. The Naturkalender participants seemed to feel less obliged to participate. We conclude that asking people (particularly friends, colleagues, or family members) to participate leads to a light form of social pressure for those who may otherwise not be motivated to participate. However, more occasional participants than super-users were motivated by being asked or knowing other participants. Taken together, these observations suggest that while directed recruitment through personal networks can enhance participation, to recruit individuals with better chance of engaging in consistent long-term data collection, it may be better to target individuals with an interest in the topic and to highlight specific types of opportunities available through participation (e.g., opportunities to contribute to science, to share knowledge, to be outdoors, to spend time with family). This will allow potential participants to choose projects that are best aligned with their interests (Land-Zandstra et al., 2021). Recruiting participants who are members of existing topically relevant organizations has also been demonstrated to be effective (Dickinson et al., 2012).

The significantly higher agreement to statements related to being outside and active for the Naturkalender respondents than the CrowdWater respondents suggests that more Naturkalender participants valued being outdoors, in nature and doing a physical activity than CrowdWater participants. Activities in Naturkalender that related to being outdoors and in nature seemed to pique participants' interests in engaging in the project. This is supported by the multitude of existing animal or plant phenology projects that involve volunteers (Beaubien and Hamann, 2011; Fuccillo et al., 2015). As fewer CrowdWater than Naturkalender respondents demonstrated a motivation to spend time outdoors in nature or to be physically active, a recommendation for other

projects is to provide details that help ensure people clearly understand tasks and monitoring logistics when they are considering whether to participate or not. Providing sufficient guidance for volunteers to effectively participate has been noted as an essential aspect for successful outcomes across numerous citizen science projects (Robinson et al., 2021). In the case of CrowdWater, if a site is easily accessible, a stream observation can be made with little time spent outdoors or required physical activity. Stream observations can also be made in cities. To help make this clear to participants in CrowdWater or similar projects, sites could be marked based on their difficulty to access or the estimated time required to make an observation. Project administrators could also provide tips to clarify aspects of data collection that have challenged others to help reduce on-site time commitments.

## 5.3 Fulfilment of expectations

### 5.3.1 Knowledge and learning

The higher level of agreement to having an opportunity to share knowledge as a motivator for the continued engagement of Naturkalender respondents suggests that more participants in Naturkalender were able to share their knowledge than in CrowdWater. Such knowledge sharing opportunities in Naturkalender include helping other participants with species identification *via* comments in the app and sharing entries made to the app on social media.

The opportunities for sharing knowledge are directly related to the opportunities for learning. This is probably the reason that the statement "this activity taught me new skills or knowledge" was ranked higher for Naturkalender respondents than CrowdWater respondents. Similarly, motivations like personal interest and curiosity were the most influential factors for continued participation in other environment-related projects (Rotman et al., 2012). In Naturkalender, participants can acquire new knowledge about plant and animal species from information in the app and comments from other participants. While CrowdWater offers information about hydrology on the homepage and links to an online course called "Water in Switzerland," so far these options are rarely used. This may be due to them being mentioned on the homepage, rather than in the app. Thus, opportunities for learning in CrowdWater may be limited compared to Naturkalender.

### 5.3.2 Contributions to society

While contributing to a conservation goal or benefitting society were strong initial motivators, neither were fulfilled as much as initially expected in the two projects. This suggests that participants in the projects did not observe how the data they collected contribute to addressing societal needs. Participants may have been unaware of certain data uses beyond the direct use of the observations to address the scientific goals of the individual projects. For instance, data from Naturkalender may have informed climate change impact and phenological modelling studies through their inclusion in the Pan European Phenology Project PEP725-database (Templ et al., 2018). A recommendation for these and similar projects is for project leaders to communicate uses of data that benefit society (Ghariesifard and Wehn, 2016). Ongoing communications between project

leaders and participants about the use of data has been identified as essential to sustain participation in hydrology-focused projects (Devlin et al., 2001; Lowry et al., 2019), and other types of citizen science efforts (Deci and Ryan, 2000; Rotman et al., 2014). In fact, the level of participant motivation has been demonstrated to increase if a project tackles problems that impact the everyday life of participants (Frensley et al., 2017), such as a local issue of a community (e.g., Public Lab; Rey-Mazón et al., 2018). To promote enhanced long-term motivation of participants, project coordinators should consider if facilitating the use of the data to address societal needs aligns with the project's goals, and if so, take steps to build collaborations with potential data users and ensure data are of sufficient quality to inform decisions (Hager et al., 2021). For instance, in CrowdWater, the local relevance of stream observations may be less evident because the data are not yet linked to any forecasts or flood/drought risk communications. In CrowdWater and other hydrological observation projects, people may expect (and this may indeed be the case) that the government is responsible for flood or drought forecasting and water management. In such instances, facilitating collaborations may be particularly challenging (Wehn et al., 2015). As a result, motivations to participate in CrowdWater or similar projects and to contribute to addressing societal needs might be better fulfilled in locations where people are more exposed to flood hazards or droughts and connections have been developed between risk communicators and the citizen science project (Ferri et al., 2020).

### 5.3.3 Networking, enjoyment and fun

Tools and features of app-based projects that help participants to form a network can be the basis for a self-organized community, where participants assist and correct each other and share their experiences (Serret et al., 2019). However, the low agreement to having an opportunity to socialize for the CrowdWater and Naturkalender respondents indicates that commenting in the apps does not fulfil the motivation to socialise with people with similar interests. However, it was also not an important motivation to join the projects. The two projects are, in that perspective, more similar to other smartphone-based projects, such as flu-tracker (Land-Zandstra et al., 2016b) or online projects that do not generally include real-world interactions with other participants (Nov et al., 2014).

While participants from the two projects had little motivation to socialize with others, the majority were motivated to be part of a volunteer community, and most Naturkalender respondents were also motivated to join to meet other people with similar interests. Thus, these and other similar projects should consider developing some way for participants to get to know one another. For instance, enhanced gaming functions (e.g., leader boards), publicly displayed volunteer recognition accolades (e.g., years of participation lists), or other types of online acknowledgement (Cappa et al., 2018) could be established. Another option might be to establish online gatherings for volunteers, which was observed to be an effective way to bring together participants from expansive geographic areas during the COVID-19 pandemic (Stepenuck and Carr, 2022). The CrowdWater project now organizes online meet-the-team events, where participants can also meet each other.

While the participants did not join the projects for the fun factor, they continued to participate because they enjoyed it. Reasons for

the higher agreement to enjoyment as a motivator for continued participation for the Naturkalender respondents than the CrowdWater respondents might be that in the Naturkalender app, there were many more types of observations that could be made, including observations of plants, animals, and winter phenomena. Conversely, the types of observations in the CrowdWater app were, at the time of the questionnaire, restricted to water levels in streams and rivers, and soil moisture. Therefore, we assume that increasing the types of observations that can be contributed, together with more virtual social interaction, increases fun and enjoyment, and thereby the overall motivation for continued participation in Naturkalender. Project administrators might consider offering more choices and options to contribute, especially those that might extend participants' time outside and in nature for those in Naturkalender. CrowdWater has now added the possibility to monitor plastic pollution in rivers and on riverbanks, and the option to provide general information on streams and water quality. Administrators might also consider adding gaming elements (Jennett and Cox, 2018) or adding more ways to interact with the app (Reed et al., 2013), as such elements may promote prolonged participation (Nov et al., 2014).

## 5.4 Super-users and their motivations

Super-users tended to be older than occasional participants. This has been observed by many other citizen science projects as well (Wright et al., 2015; Sheppard et al., 2017; Jones et al., 2018; Fuchslin et al., 2019; West et al., 2021). This may be because individuals are more likely to volunteer as more time becomes available (e.g., upon retirement; Wilson, 2000). This is supported by rational choice theory (Scott, 2000). The hint of more of the older respondents being intrinsically (*egoism, intrinsic*) motivated and, at the same time, making significant contributions to data collection is also interesting. A high degree of intrinsic motivation of participants is desirable for citizen science projects because it leads to more and better contributions (Deci and Ryan, 2000). This is largely because most citizen science projects cannot offer compensation for the contributions.

The projects fulfilled some of the intrinsic motivations for super-users in the 50–59 age group by providing an opportunity to go outdoors and be physically active as part of a regular routine. This aligns with a study of 8,245 US citizens above the age of 65, in which physical activities were chosen as the favourite leisure activity across all income and racial groups (Szanton et al., 2015). In the Community Collaborative Rain, Hail, and Snow Network (CoCoRaHS), older participants reported rainfall observations in a more timely fashion, more reliably, and over longer periods. As a result of these findings, it may be an effective strategy for citizen science projects that require long-term consistent data sets to focus recruitment on people above the age of 50. Once the monitoring habit is established, older people are more likely to contribute repeatedly over extended periods (Venkatesh et al., 2012; Sheppard et al., 2017).

Finally, the higher agreement of super-users to the statement that they "can get recognition for participating in this project" than the occasional participants suggests that the super-users felt that their contributions were seen and valued, particularly for

Naturkalender respondents. This might motivate them to contribute more than others (Nov et al., 2014). There might be a self-energising mechanism here: participants who contribute more, will probably also have received more likes, “Thank You” comments, recognition, and feedback by the project administrators, which then encourages them to contribute more (de Vries et al., 2019). This leads to their “dominance” over other participants regarding the number of contributions (e.g., a high place on the leader boards).

## 6 Conclusion

Altruism and principlism were the primary motivators for initial and continued participation in CrowdWater and Naturkalender. Participants mainly joined to contribute to science and conservation, and to satisfy their interest in science, technology, and the topic of the project. Respondents from Naturkalender were also motivated to continue to participate by *intrinsic egoism*. They agreed more than CrowdWater participants to being motivated by the opportunity to learn and teach others, be outdoors and physically active, and because they enjoyed their participation. Super-users were most often 50–59 years old and were universally motivated initially by having interest in the topic of the project. They were more commonly motivated to want to share their knowledge and to spend time in nature than occasional participants. These top motivations to join a project were not always fulfilled through participation. Although the participants did not join the projects because of the fun factor, this motivation was fulfilled by participating.

Recommendations to sustain active participation in these and similar citizen science projects that build upon these findings and draw from other citizen science literature include: 1) targeting recruitment to older individuals with interest in the topic and highlighting (as relevant) opportunities to contribute to science, share knowledge, be outdoors, and have fun; 2) providing sufficient guidance to ensure participants clearly understand if project activities align with their interests; 3) enhancing use of data to address societal challenges and increasing communications with participants to build their understanding of how their data contribute to science, conservation and help society.

## Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

## Author contributions

SE, BS, JS, HM, and KN designed the study. SE carried out the study. SE, HM, and KN analyzed the results. SE, BS, JS, HM, and KN

wrote the manuscript. SE, BS, JS, HM, KN, and KS reviewed and edited the manuscript. All authors contributed to the article and approved the submitted version.

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## Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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## Supplementary material

The Supplementary Material for this article can be found online at: <https://www.frontiersin.org/articles/10.3389/fenvs.2023.1105682/full#supplementary-material>

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