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Connection for conservation: The impact of counting butterflies on nature connectedness and wellbeing in citizen scientists

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Highlights

- Citizen science research rarely considers nature connectedness, an important driver of pro-conservation behaviours.
- A quasi-experimental design explored the impact of citizen science participation on nature connection and wellbeing.
- Big Butterfly Count participation increased nature connectedness and nature and butterfly noticing, and decreased anxiety.
- Stronger emotional experiences were associated with greater increases in nature connection and nature noticing.

- By improving human-nature relationships, citizen science makes important contributions to biodiversity conservation.

Abstract

Biodiversity conservation is fundamentally linked to human values, attitudes, and behaviours. Nature connectedness, the strength of a person's relationship with nature, is an important determinant of pro-nature actions, and therefore vital for counteracting biodiversity loss. Citizen science may improve nature connectedness, though such outcomes are underexplored in comparison to scientific and educational results. Addressing this gap, we studied the experiences of participants in the Big Butterfly Count, a UK mass-participation citizen science activity that aims to raise awareness and gather data on the abundance of widespread butterfly and moth species. Participants completed surveys before and after the three-week Big Butterfly Count period (n=382), and at six- to seven-week follow up (n=345). Improvements in nature connectedness, decreased anxiety, and increased tendency to notice nature and butterflies, were found immediately after the count period, with improved wellbeing and nature noticing at follow-up. Stronger emotional responses during the butterfly count were associated with greater increases in nature connectedness and nature noticing. Qualitative data revealed mixed emotions, from sadness and concern about biodiversity loss, to feelings of hope and optimism through taking actions to help butterflies. These findings suggest that citizen science participation prompts people to notice and enjoy nature in ways that enhance their wellbeing and connection with nature, supporting the mutual health of people and the rest of the natural world. The study highlights the potential for nature-based citizen science to benefit conservation beyond the focal species or habitat, by changing how people think, feel and act towards nature more broadly.

Previous Next

Keywords

Citizen science; Pollinator conservation; Butterflies; Nature connection; Wellbeing; Emotions; Conservation

1. Introduction

The human-nature relationship is at the heart of the biodiversity crisis. Anthropogenic drivers of nature depletion such as changing land use, climate change, and pollution are a product of how people tend to think about, feel towards, and relate to the more-than-human world. With dominant systems largely dependent on exploitation and control of nature to serve human interests, efforts to promote relationships and actions based on stewardship and reciprocity with nature have a crucial part to play in conservation and restoration of biodiversity (IPBES, 2019; Ives et al., 2018; Soga and Gaston, 2023a, Soga and Gaston, 2024).

Nature connectedness is a psychological construct that refers to a person's subjective sense of relationship with the natural world, including the extent to which they feel a part of nature. It has emerged as a critically important measure of the human-nature relationship, with a large body of evidence showing its link with both human wellbeing, and pro-nature behaviour (Barragan-Jason et al., 2022, Barragan-Jason et al., 2023; Mackay and Schmitt, 2019; Pritchard et al., 2020; Whitburn et al., 2020). There is a rapidly growing interest in the value of nature connectedness for conservation and sustainability in interdisciplinary academic work (Barragan-Jason et al., 2022, Barragan-Jason et al., 2023; Ives et al., 2017, Ives et al., 2018; Selinske et al., 2023; Zylstra et al., 2014), by conservation organisations (e.g. Carr and Hughes, 2023) and in the policy arena (e.g. IPBES, 2019). Research is exploring methods for improving people's relationship with nature (Sheffield et al., 2022), and identifying benefits for both human wellbeing and nature conservation (Barragan-Jason et al., 2023; Soga and Gaston, 2022, Soga and Gaston, 2023b). A recent meta-analysis found a positive relationship between nature experiences and pro-environmental behaviours (Soga and Gaston, 2024). By offering opportunities for direct engagement with nature, environmental citizen science projects could, therefore, have an important role to play in counteracting the 'extinction of experience' (Soga and Gaston, 2016), and potentially improving people's sense of connection with nature and engagement in pro-environmental behaviour (Schuttler et al., 2018).

Nature-based citizen (community) science projects involve public participation in research with volunteers taking part in data collection, analysis, and interpretation (Pocock et al., 2017), and are increasingly recognised for their benefits to conservation science and practice, environmental management, and policymaking (McKinley et al., 2017). By allowing access to data that an individual team of researchers could not collect alone, citizen science makes a crucial contribution to ecological research and biodiversity conservation (Devictor et al., 2010; Ellwood et al., 2017; Fontaine et al., 2022; McKinley et al., 2017; Pellissier et al., 2020; Vasiliades et al., 2021). Importantly, though,

citizen science may also contribute to conservation through impacts on public awareness, knowledge and understanding, attitudes, values and behaviour, and motivation to engage in policy-relevant and decision-making processes (Jørgensen and Jørgensen, 2021; McKinley et al., 2017; MacPhail and Colla, 2020; Turrini et al., 2018). However, trade-offs may occur between these different aims of nature-based citizen science (Lakeman-Fraser et al., 2016); in particular, projects that aim to maximise public engagement and increase awareness may compromise scientific rigor and data quality (Kosmala et al., 2016; Lewandowski and Specht, 2015).

Research on the outcomes for participants in citizen science projects is dominated by reports on knowledge and learning outcomes (Finger et al., 2023; Peter et al., 2019; Schuttler et al., 2018). There is some evidence to suggest that taking part in citizen science projects also increases people's ecological awareness and pro-environmental behaviour, even if these are not project aims, but the nature and extent of such changes can vary (Peter et al., 2019, Peter et al., 2021; Phillips et al., 2018). Peter et al.'s (2021) survey of participants in 63 different citizen science projects across Europe, Australia and New Zealand found that the most pronounced behaviour changes involved adoption of wildlife-friendly gardening practices and increased communication with others about conservation issues. This is in line with the key behavioural outcomes of other pollinator-focused citizen science projects (e.g., Deguines et al., 2020; Lewandowski and Oberhauser, 2017). Additional reported behavioural outcomes included involvement in other conservation activities, signing petitions, or donating to an environmental organisation (Peter et al., 2021). Far less studied are the links between citizen science participation and increased nature connectedness, a key stepping stone towards pro-environmental attitudes and behaviours. Understanding how citizen science participation could drive nature connectedness is vital to enable the effective design of projects to deliver this outcome alongside the usual aims of gathering scientific data and/or increasing public engagement.

While many people who take part in citizen science report being motivated by their desire to connect with nature (Ganzevoort et al., 2017; Vasiliades et al., 2021), it is not always clear whether this desire relates to a physical connection (i.e., by being outside and watching nature), or a psychological connection (i.e., a sense of feeling part of nature). In their review of meta-analytic studies, Barragan-Jason et al. (2023) note that while physical connection with nature improves psychological connection (often in the short-term), only psychological connection is beneficial for conservation. There has been very limited research exploring whether taking part in citizen science improves measures of psychological connectedness, and findings have been mixed.

Three recent experimental studies have found increased levels of nature connectedness after taking part in citizen science activities. In a large-scale randomised controlled experiment Pocock et al. (2023) recorded increases in both nature connectedness and wellbeing for participants in a range of citizen science and nature-noticing activities. The second experimental study was based on the methodology for the UK's Big Garden Birdwatch, and found increased nature connection and wellbeing after 15 minutes of counting or 'joy-rating' species of garden birds (White et al., 2023). A third study found increased nature relatedness (a measure that is conceptually equivalent to that of nature connectedness, Nisbet and Zelenski, 2013) and increased self-efficacy in relation to biodiversity loss in a study testing the use of wildlife camera-traps over a period of eight months (Eichholtzer et al., 2023). While no statistical changes in wellbeing were noted in the latter study, focus group participants reported positive physical and mental wellbeing outcomes.

Conversely, Lynch et al. (2018) found no significant change in nature relatedness amongst a small sample of citizen scientists involved in a range of entomological studies, although interviews revealed participants' increased awareness and appreciation of insects. Similarly, Ganzevoort and van den Born (2021) did not find significant increases in measures of nature relatedness amongst citizen scientists in the Dutch National Bee Survey, although participants reported enhanced appreciation of wild bees.

As evidence suggests that citizen science can but doesn't always lead to increased nature connectedness, we need to understand which aspects of participation generate this increase in order to develop projects that seek to improve people's relationships with nature. Research has identified that the pathways to nature connectedness (engaging with nature through sensory contact, emotions, sense of beauty, meaning and compassion, Lumber et al., 2017) are often activated when people pay attention to and appreciate the more-than-human world (Richardson et al., 2022). Focused moments with nature are more important for connection, wellbeing, and pro-nature behaviour than the amount of time spent in nature (Richardson et al., 2020, Richardson et al., 2021). Sensory and emotional engagement during focused moments with nature are at the heart of many citizen science experiences. For example, Toomey and Domroese (2013) found that the fascination that arose from close observation of bees in the Great Pollinator Project played an important role in participants' increased appreciation for bees. Similarly, Cosquer et al. (2012) found that taking part in a butterfly survey increased participants' attentiveness to and knowledge of butterflies, and awareness of the local environment, and that this was key to the development of attitudes that shape pro-environmental behaviour. Thus, creating a shift in

nature noticing seems an important outcome of citizen science activities that aim to increase nature connectedness (Richardson et al., 2020).

There is evidence to suggest that promoting emotional engagement may also impact on citizen scientists' pro-nature behaviour. For example, Sturm et al. (2021) found that experiencing joy on seeing pollinators predicts both pro-conservation intentions and behaviour. Larson et al. (2016) found that emotional responses to house sparrows and native songbirds impacted on the management decisions of citizen science nest monitors in the United States. Thus, a focus on psychological impacts, including emotions, of citizen science activities may be important in understanding its potential contribution to increased nature connectedness and pro-nature conservation behaviour (Knapp et al., 2021; Martin et al., 2020; Otto and Pensini, 2017). If taking part in citizen science involves both nature noticing and appreciation and can lead to increased levels of nature connectedness, citizen science projects may be making contributions to human-nature relationships in ways that have not yet been appreciated.

In addition to potential nature connectedness benefits, several studies of citizen science projects have reported outcomes that Schuttler et al. (2018) categorised as 'wellbeing' variables, including feelings of satisfaction, enjoyment, and other psychological and emotional benefits (e.g., Koss and Kingsley, 2010; Phillips et al., 2018; Pocock et al., 2023; White et al., 2023). Applying a positive psychology framework, Buijs and Jacobs (2021) argue that the pleasure, engagement and meaning people gain from interacting with wildlife and taking part in conservation activities (such as citizen science) can play an important role in promoting wellbeing and pro-conservation behaviours. In a study using pre-post design, Coventry et al. (2019) found improved mood and reduced stress after taking part in citizen science activities. While these studies have highlighted the importance of experiential, psychological, and emotional aspects of participation in citizen science projects, these factors are often overlooked in favour of learning and science outcomes, and we still know relatively little about how the process of taking part might relate to conservation behaviour.

As a fairly new area of research, there remains a lot to be learnt about the impact of citizen science participation, with current research limited in terms of both methodology and scope of enquiry. Peter et al. (2019) suggest that a relative lack of social scientists involved in citizen science research may be responsible for limited knowledge of the psychological outcomes and processes. Many studies use retrospective measures to explore outcomes, with few using repeated measures to examine impact. When psychological factors such as nature connectedness and emotions are explored, it is usually with qualitative data rather

than validated scales. Studies which have found increased nature connectedness have been experimental studies based on citizen science activities (Eichholtzer et al., 2023; Pocock et al., 2023; White et al., 2023). We address these research gaps quantitatively and qualitatively with a repeated measures quasi-experimental design to examine the impact of a real-world citizen science project, the Big Butterfly Count, on participants' nature connectedness and related wellbeing, behavioural and emotional factors.

Given previous research, we hypothesised that after participation in the Big Butterfly Count, citizen scientists would report:

1. Increased nature connectedness,
2. Improved wellbeing,
3. Increased nature noticing,
4. Increased pro-environmental behaviours,
5. Decreased anxiety.

We also expected that the stronger the emotional experience of taking part, the greater the increases in outcome measures. Open-text responses were invited to supplement the quantitative analysis and gain richer insight into participants' experience of taking part in the project.

2. Method

2.1. Big Butterfly Count

The Big Butterfly Count (www.bigbutterflycount.org ↗) is a United Kingdom citizen science project developed and run by Butterfly Conservation. Launched in 2010, it has become one of the world's largest nature-based citizen science projects with a mean estimated annual participation of 63,067 people (2010–2022). The count takes place over a three-week period in July and August each year and is focussed on common and widespread species of butterflies and day-flying moths. Participants spend 15 minutes in good weather watching and counting the species they observe at a location of their choice and then upload their sightings via a free app or website. People are encouraged to undertake more than one count during Big Butterfly Count, with a mean of 70,449 counts submitted each year in total. Although such mass-participation online citizen science activities with no training and simple sampling protocols are often better suited to public engagement and education (

Brown and Williams, 2019; Chase and Levine, 2016; Lewandowski and Specht, 2015), estimates of species population change derived from the Big Butterfly Count are comparable to those obtained through standardized monitoring methods (Dennis et al., 2017). The species occurrence records collected through Big Butterfly Count are used, after verification, together with data from other schemes to assess temporal trends for UK butterflies that feed into conservation (e.g. Red Listing; Fox et al., 2022) and scientific research (e.g. Montràs-Janer et al., 2024; Platts et al., 2019).

The aims of the Big Butterfly Count are to gather data and raise awareness of butterfly conservation. While there is no explicit objective to enhance participants' nature connectedness or wellbeing, this research sets out to explore whether these outcomes are a bonus consequence of taking part.

2.2. Procedure and participants

The study used a 1×3 (A-B-B) repeated measures time-series design where self-reported scores were taken at three time-points: pre-participation, post-participation, and follow-up.

Invitations to take part in the study were shared widely by Butterfly Conservation via newsletter and social media channels in the weeks before Big Butterfly Count 2022. Participants were advised that participation would involve completing three surveys at pre-, post- and follow-up time points, and gave their consent to receive the invitations for subsequent surveys when agreeing to take part in the research. The first survey (T1) remained open during the sign-up period and closed just before the start of the count period. The day after the end of the count, people who had completed the T1 survey were sent an email to invite them to complete the post-survey (T2) during the subsequent two-week period. An invitation to complete the follow-up survey (T3) was sent a further three weeks on (i.e. eight weeks after the Big Butterfly Count opened) to all people who had completed the initial survey, whether or not they had completed the T2 survey (see Fig. 1 for an overview of the timeline and number of completed surveys at each time point).

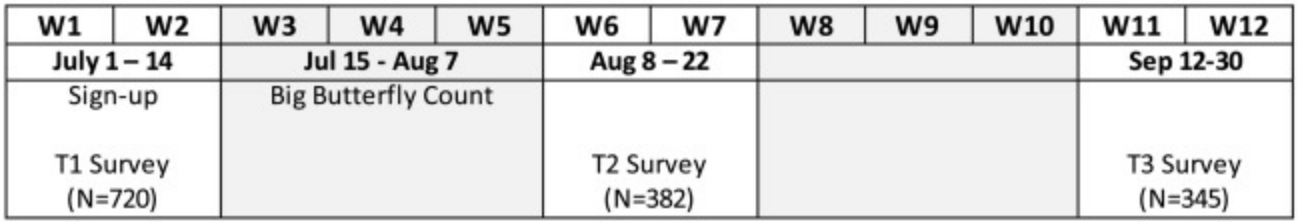

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Fig. 1. Timeline for the surveys (T1, T2 and T3) and Big Butterfly Count period and number of completed surveys at each time point.

The T1 survey was completed by 720 people. 382 people completed both T1 and T2 surveys and 345 participants completed both T1 and T3 surveys. We did not collect demographic data from survey participants, but were able to assess retrospectively whether respondents had taken part in Big Butterfly Count in previous years. Of the 382 people who completed T1 and T2 surveys, 84% had participated in Big Butterfly Count previously (at least once in the preceding five years).

2.3. Measures

An overview of the measures and scales used in each time-point is shown in Fig. 2.

Measures	Scales	Phase
Nature Connectedness	Inclusion of Nature in Self (INS) Short Nature Relatedness Scale (NR-6)	T1, T2, T3
Health and wellbeing	Single-item self-rated health (SRH) Short Warwick-Edinburgh Mental Wellbeing Scale (SWEMWBS) Personal Wellbeing (3 items from ONS-4: Sense of worthwhile life, happiness, anxiety)	T1, T2, T3
Nature noticing	Noticing nature and butterflies	T1, T2, T3
Nature friendly behaviour	Gardening items from the Pro-Nature Conservation Behavior Scale (ProCoBS)	T1, T3
Big Butterfly Count experience	Participation, number of counts, emotional experience, participation experience Impact on thoughts, feelings and behaviour towards butterflies and wildlife	T2 T3

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Fig. 2. Measures and scales used for the surveys at each time point.

2.3.1. Nature connectedness

Nature connectedness was measured using two widely-used scales: The Inclusion of Nature in Self (INS) and Nature Relatedness short-form scale (NR-6).

2.3.1.1. Inclusion of Nature in Self

The INS measure is a single-item scale with graphical response options to assess how connected to nature a person feels they are (Schultz, 2002). Respondents are asked to "Please select the picture below which best describes your relationship with the natural environment. How interconnected are you with nature right now?" and choose from one of seven images. Each image is composed of two circles with one labelled "self" and the other "nature". The circles range from being entirely separate (equated in this study to a score of 1) to being entirely overlapping (equal to 7). The measure is quick and easy to use, has been found to correlate well with other nature connectedness measures, and is sensitive to temporal changes in a person's felt sense of nature connectedness (Tam, 2013).

2.3.1.2. Nature Relatedness Scale – Short-Form

The NR-6 is a six-item scale that measures subjective connectedness with the natural environment (Nisbet and Zelenski, 2013). Four items assess self-identification with nature through the statements "I always think about how my actions affect the environment," "My connection to nature and the environment is a part of my spirituality," "My relationship to nature is an important part of who I am," and "I feel very connected to all living things and the earth." Two items assess individuals' experiences and engagement with nature: "My ideal vacation spot would be a remote, wilderness area" and "I take notice of wildlife wherever I am". The scale has good internal consistency and temporal stability (Nisbet and Zelenski, 2013), which makes it less sensitive to change than the INS.

2.3.2. Health and wellbeing

2.3.2.1. Self-Rated Health (SRH)

A single-item measure of participants' self-rated health (SRH) in which participants were asked to complete the statement "In general, would you say your health is:" with a rating from Poor (1) to Excellent (5). SRH measures are well-established and widely used, appearing in many large-scale health surveys and across academic disciplines (Jylhä, 2009) and recognised as a valid and reliable proxy for objective health status (Calvey et al., 2022; Östberg and Nordin, 2022). SRH has been found to capture both physical and mental health effectively, and to predict mortality (Jylhä, 2009), depression and anxiety symptoms (Östberg and Nordin, 2022).

2.3.2.2. Short Warwick-Edinburgh Mental Wellbeing Scale (SWEMWBS)

A short version of the Warwick-Edinburgh Mental Wellbeing Scale which was developed for monitoring mental health and evaluations of interventions to improve mental wellbeing (

Tennant et al., 2007). The seven-item scale asks people to rate their feelings and thoughts over the past two weeks, with five response categories from 'none of the time' to 'all of the time'. The scale is psychometrically sound, with high internal consistency and good validity (e.g. Stewart-Brown et al., 2009).

2.3.2.3. Personal wellbeing

Personal wellbeing was measured with three items from the ONS-4, a scale created and used by the UK Office for National Statistics (Dolan and Metcalfe, 2012). The questions assessed feelings of happiness, anxiety and a sense that life is worthwhile. Responses were made on an eleven-point scale from 'not at all' (0) to 'very' (10).

2.3.3. Nature noticing

Two single-item questions asked participants if they had noticed a) nature and b) butterflies over the past week (Never/Rarely/Some of the time/Often/All of the time). These questions aimed to capture participants' subjective sense of how much attention they paid to nature or butterflies.

2.3.4. Pro-Nature Conservation Behaviour Scale (ProCoBS) – Gardening

The ProCoBs is a psychometrically robust scale that measures behaviours that support the conservation of biodiversity (Barbett et al., 2020). Nine items focused on active gardening and land management behaviours were used in this study, assessing how often people engaged in nature-friendly planting and supported wildlife, from never (0) to always (7). The scale was used at T1 and T3.

2.3.5. Big Butterfly Count experience

The T2 survey included four questions that explored participants' experience of the Big Butterfly Count, asking whether, and how many times, they completed a count, and their emotional experience of participating. The emotional experience question measured the extent to which people experienced feelings of joy, anger, fascination, compassion, disgust, fear and interest on a scale from 'not at all' (1) to 'very much' (7). These discrete emotions are often explored in studies of wildlife (Sturm et al., 2021).

Open-text questions were asked at the end of the T2 and the T3 surveys. The T2 survey invited participants to share any other thoughts about their experience of taking part in the Big Butterfly Count. The T3 survey invited participants to share whether taking part in the

Big Butterfly Count had any impact on how they think, feel, or behave towards butterflies and other wildlife.

2.4. Analytic approach

First, to investigate the effect of participation in the Big Butterfly Count on nature connectedness, health and wellbeing, nature-friendly behaviour and the extent to which participants noticed nature, a series of paired *t*-tests were performed that examined differences in scores on these outcome measures between T1 and T2, and between T1 and T3. We employed one-tailed tests for hypothesis testing, specifically analysing at the $p<0.1$ level. This decision was grounded in several considerations reflective of our research design and theoretical framework. First, our hypotheses were directional in nature: we posited that the intervention would lead to an improvement in the measured outcomes. Our directional hypotheses allowed us to utilise a one-tailed test, which is more powerful than a two-tailed test for detecting an effect in the hypothesised direction. Second, our hypotheses were not formulated on an ad hoc basis but were derived from a well-established theoretical framework. This theoretical grounding provided a strong rationale for expecting an effect in a specific direction, thereby justifying the use of a one-tailed test. Third, supporting our directional hypothesis, there exists a substantial body of empirical evidence suggesting a similar trend in outcomes as a result of other nature-based interventions. This precedent in the literature further supports the appropriateness of a one-tailed approach.

Then, to investigate whether participating more often in the butterfly counts led to greater improvements in these outcome measures, a series of partial correlation analyses were performed which examined the correlations between the number of butterfly counts undertaken by participants and T2 scores on the outcome variables, while controlling for T1 scores on the outcome variables. A final set of quantitative analyses investigated whether the emotions experienced during the butterfly counts were related to the extent of improvements in the outcome measures. This was examined by performing a series of partial correlation analyses that examined the correlations between ratings of emotions experienced during the count and T2 scores on the outcome variables, while controlling for T1 scores on the outcome variables. Analyses were undertaken using IBM SPSS Statistics 27.

Qualitative data analysis was used to analyse the open-text responses to optional questions about participants' experiences of taking part in the Big Butterfly Count (T2, $n=321$), and whether taking part in the Big Butterfly Count had any impact on how they think, feel, or behave towards butterflies and other wildlife (T3, $n=260$). Responses to the questions were combined into a single collection (581 responses, 18,079 words) and coded by C.W.B in NVivo 12, using inductive thematic coding for a qualitative content analysis (Mayring, 2004

). An iterative process was used, based on Braun and Clarke's (2006) six-step method for thematic analysis involving 1) becoming familiar with the data 2) generating initial codes 3) collating codes into possible themes 4) reviewing themes 5) defining and naming themes and 6) producing the report.

The themes were chosen to generate a summary of the key features of participant responses and capture the dominant threads of the data, while telling a story about the reported thoughts, feelings and experiences relating to taking part in the Big Butterfly Count. In line with a reflexive thematic analytic approach to coding (Braun and Clarke, 2022), the subjectivity and agency of the coder is understood to be a valuable tool for generating rich insight into participant experiences. Quality of the coding was ensured by deep engagement with the data, thorough and iterative development of codes, close consideration of each extract in relation to each theme, checking themes against data, and reviewing the internal consistency and distinctiveness of each theme (Braun and Clarke, 2022).

3. Results

3.1. Quantitative results

Comparing the T1 and T2 surveys, participants experienced statistically significant improvements in nature connectedness on both the INS measure (t=5.23, p<0.001) and NR6 scale (t=1.87, p=0.063) after taking part in the Big Butterfly Count, representing increases of 5.37% and 1.21% on pre-count (T1) baseline levels, respectively (Table 1). Big Butterfly Count participants also benefited from significantly reduced levels of anxiety (t=2.22, p=0.027), equivalent to an 8.71% reduction from the pre-count level after undertaking the citizen science activity (Table 1). Other health and wellbeing measures did not show significant differences before and after Big Butterfly Count participation. The extent to which survey respondents noticed butterflies (t=9.69, p<0.001) and nature more generally (t=2.49, p=0.013) increased significantly following participation in the Big Butterfly Count.

Table 1. Means and t-test results for Big Butterfly Count participants taking part in both T1 (pre) and T2 (post) surveys (N=382).

	T1 (Pre)		T2 (Post)		Paired-test		% change from baseline
	Mean	SD	Mean	SD	T	P	
INS	5.21	1.29	5.49	1.24	5.23	<0.001*	+5.37
NR6	4.14	0.60	4.19	0.58	1.87	0.063*	+1.21

	T1 (Pre)		T2 (Post)		Paired-test		% change from baseline
	Mean	SD	Mean	SD	T	P	
Health (SRH)	3.27	0.98	3.32	1.00	1.52	0.128	+1.53
Wellbeing (SWEMWBS)	22.57	3.31	22.67	3.28	0.74	0.460	+0.44
Sense worthwhile life	7.39	1.67	7.48	1.75	1.27	0.207	+1.22
Happiness	7.29	1.94	7.34	1.95	0.57	0.569	+0.69
Anxiety	3.79	2.89	3.46	2.75	2.22	0.027*	−8.71
Noticing nature	4.38	0.70	4.47	0.57	2.49	0.013*	+2.05
Noticing butterflies	3.76	0.99	4.25	0.77	9.69	<0.001*	+13.03

INS: Inclusion of nature in self, NR6: Nature relatedness, SRH: self-rated health, SWEMWBS: Short Warwick-Edinburgh Mental Wellbeing Scale.

* Significant 1-tailed test (i.e. $p<0.1$).

The results of the T3 survey show that increased noticing of butterflies ($t=1.97$, $p=0.049$) persisted at least five weeks after participation in the Big Butterfly Count (Table 2), although there was a drop between T2 and T3. In contrast, the positive effects on nature connectedness and reduced anxiety present at T2 were no longer statistically significant at T3. There was also a statistically significant increase in wellbeing between T1 and T3 ($t=1.75$, $p=0.081$), though it should be noted that the wellbeing scores of the T1-T3 sample were lower at baseline than those of the T1-T2 sample.

Table 2. Means and t-test results for participants taking part at both T1 and T3 (N=345).

	T1 (Pre)		T3 (Follow-up)		Paired-test		% change from baseline
	Mean	SD	Mean	SD	T	p	
INS	5.25	1.28	5.32	1.20	1.36	0.175	+1.33
NR6	4.15	0.61	4.17	0.59	0.37	0.591	+0.48
Health (SRH)	3.27	0.99	3.28	1.04	0.34	0.734	+0.31
Wellbeing (SWEMWBS)	22.35	3.08	22.58	3.37	1.75	0.081*	+1.03
Sense worthwhile life	7.32	1.72	7.39	1.66	0.94	0.349	+0.96

	T1 (Pre)		T3 (Follow-up)		Paired-test		% change from baseline
	Mean	SD	Mean	SD	T	p	
Happiness	7.18	2.00	7.15	1.97	0.26	0.793	−0.42
Anxiety	3.91	2.89	3.66	2.69	1.63	0.104	−6.39
Noticing nature	4.38	0.71	4.34	0.67	1.01	0.313	−0.91
Noticing butterflies	3.76	1.00	3.87	0.89	1.97	0.049*	+2.93
PROCOBS**	53.71	8.20	53.50	8.74	0.65	0.515	−0.39

INS: Inclusion of nature in self, NR6: Nature relatedness, SRH: self-rated health, SWEMWBS: Short Warwick-Edinburgh Mental Wellbeing Scale, PROCOBS: Pro-nature conservation.

* Significant 1-tailed test (i.e. $p<0.1$).

** $N=282$.

Interestingly, further partial correlation analyses revealed that the number of butterfly counts made by participants did not have a significant effect on improvements in inclusion of nature in self ($r(379)=0.01$, $p=0.804$), nature relatedness ($r(379)=0.05$, $p=0.292$), anxiety ($r(379)=-0.010$, $p=0.851$), the extent to which participants noticed nature ($r(379)=0.08$, $p=0.128$), or wellbeing ($r(265)=-0.03$, $p=0.325$); however, it did have a small but significant positive effect on the extent to which participants noticed butterflies ($r(379)=0.09$, $p=0.093$). Thus, most of the nature connectedness and wellbeing benefits gained by taking part in Big Butterfly Count were generated by carrying out a single 15-min count.

The before (T1) and after (T2) improvements in nature connectedness, reduced anxiety, and increased noticing nature and noticing butterflies gained by Big Butterfly Count participants were strongly correlated with the intensity of emotions (joy, anger, fascination, compassion, disgust, fear, and interest) they experienced while taking part (Table 3). Specifically, increases in scores on the Nature Relatedness scale were associated with all seven emotions; increases in scores on the Inclusion of Nature in Self scale were associated with the experience of joy, compassion, and interest; and increases in noticing nature and noticing butterflies were associated with the experience of joy, fascination, compassion, and interest.

Table 3. Partial correlations between the outcome variables that improved across time (T1-T2) and emotional experiences of participation, controlling for baseline outcome variable scores.

	Joy	Anger	Fascination	Compassion	Disgust	Fear	Interest
INS	0.101*	0.000	0.056	0.089*	0.018	−0.024	0.195***
NR6	0.213***	0.127**	0.183***	0.179***	0.135**	0.100*	0.170***
Anxiety	0.034	0.047	0.000	0.065	−0.011	−0.032	0.061
Noticed nature	0.219***	0.022	0.203***	0.197***	0.037	0.036	0.285***
Noticed butterflies	0.261***	0.000	0.137**	0.111*	−0.063	0.000	0.175***

INS: Inclusion of nature in self, NR6: Nature relatedness.

* Significant 1-tailed $p<0.05$.

** $p<0.01$.

*** $p<0.001$.

3.2. Experience of taking part in the Big Butterfly Count

After taking part in the Big Butterfly Count, participants were invited to share their thoughts about their experience and, specifically, about whether being involved with the count had any impact on how they think, feel, or behave towards butterflies and other wildlife. The comments provided give some insight into the nature of the wellbeing benefits and the quality of experiences associated with the outcomes measured quantitatively through the survey questionnaires. People's responses helped to show something of the processes through which the outcomes are brought about – from positive emotional experiences to heightened attention to butterflies, and from desire to help to positive action and repeated participation.

3.2.1. Joy and fascination: benefits of counting, noticing and appreciating butterflies

The most widely reported experience was one of enjoyment, with people reporting that they liked, loved, enjoyed, '*always looked forward to*' taking part in the count, or that it was fun, lovely, and a pleasure. For some participants, the basis for their enjoyment and pleasure was the opportunity '*to just sit quietly*', which allowed them to relax, take their mind off other things and into a '*peaceful place*'. Some compared it to meditation or mindfulness and '*being totally in the present moment*'.

Taking part in the count helped some people through difficult times, and many people commented on wellbeing benefits:
Going away from my house to look for butterflies has been a huge solace for me these past few weeks (…) counting the butterflies and watching their activities absolutely helps my wellbeing.

A number of participants commented on the enjoyment of watching and noticing butterflies and their increased awareness of *'the wonders of nature'* more broadly. The count offered a new way of experiencing nature, encouraging people to turn their attention to wildlife and tune into the natural world. One participant said it was *'good to do with my school children to foster a connection and fascination with nature'*. Respondents described how the count '*encouraged* [them] *to look for butterflies more*', and that they also began to notice other wildlife. Noticing details, patterns, and behaviours of butterflies and other wildlife, brought enjoyment, wonder and awe, as well as increased awareness and understanding of butterflies:

This time, I also noticed that when I was very still in the field, some butterflies were 'sunbathing' close to the ground, for much long period than I had realised when I'm just walking through the field. Observing them for a longer period of time made we wonder exactly what they were doing and how they were feeling. I also realise that when I walk through the fields, I'm actually disturbing them, far more than I'd thought.

Some participants shared their enjoyment of butterflies themselves, with comments that suggested the intrinsic value of butterflies, as '*wonderful creatures*'. People noted the beauty, fragility and resilience of butterflies. There were several comments relating to joy and delight at seeing specific species (e.g. '*delighted that I saw a holly blue and 7 common blues*').

The enjoyment for some people arose from the opportunities to learn more about butterflies and develop their identification skills, with a sense of pleasure arising from heightened involvement and learning:

I really got the 'bug' after last year's count and have been using iRecord most days this summer. […] I have even met a couple of 'proper' recorders who have transects to survey- they have both been very helpful and I learned a lot from them. I am looking at getting my own transect to

survey. One of the surveyors said "you are well on your way to becoming a butterfly anorak, like me"… I took it as a compliment!

Many people reflected on their gardens and land management in relation to their observations about the number, variety, and behaviour of butterflies they observed, for instance by encouraging *'plants that act as service stations for them'*. Joy was expressed by those who had managed their gardens to attract and nurture butterflies and other pollinators and noticed an increase the variety of species observed:

Such and joy and excitement felt at seeing species in our garden never seen before, hopefully due to changes in the [way] it's managed.

3.2.2. Sadness and concern: noticing decline and biodiversity loss

While enjoyment was the most common emotional response reported, there were many comments expressing sadness and concern about observing declining numbers and diversity of butterflies. People referred back to their experience of taking part in previous years' counts, or their memories of earlier decades in which there was much greater abundance of butterflies and other insects:

I have enjoyed doing the count for the past four years but have been concerned that while I was seeing a lot of butterflies the numbers year on year are decreasing. This year was by far the worst with few butterflies in my garden though I haven't changed it at all. I find that very worrying.

People often shared their emotional reaction to observations of the absence or decline of the number and variety of butterflies. Emotional responses fell into two main categories a) feelings of sadness and disappointment; and b) feelings of concern, anxiety, and fear. The first category captures emotional states which reflect a negative response to the way things are, speaking to a sense of loss relative to what was in the past. The second category was future-focused, with emotions aligned with what may be still to come, and a wider reflection on the biodiversity and climate crises. A few respondents also reported feelings of anger and/or hopelessness. There was a sense in many comments of the mixed and at times conflicting emotional response to taking part, with the joy and pleasure of taking part and watching butterflies, often accompanied by feelings of sadness or worry. The following quote illustrates these mixed emotions:

I enjoyed doing the Butterfly Count because it got me out into nature and I felt that I was contributing to an important count for biodiversity. I felt happy that I was doing it in a beautiful place but I also felt sad as I didn't see as many butterflies as I would have liked. I also felt too hot.

The planet is warming up because of climate change and I felt very anxious. I had a mixture of emotions doing this.

Participants touched on reasons for the declines. Some focused on local and/or immediate factors, such as how their own garden may or may not attract butterflies, the effects of neighbours' land management choices (e.g., cutting down ivy and trees, use of plastic grass), housing developments, or the impact of recent weather. Others identified the wider factors involved in declining numbers – climate change, the '*state of the environment*', '*loss of meadows and green spaces*' and '*human activity*'.

Those who reported feelings of anger or hopelessness pointed to the (in)actions of government and business who are '*not responding urgently to the threat of climate change*,' or are '*indifferent*', or driven by *greed*, *profits*, and the *'pursuit of so-called economic growth*'. Human (in)activity was also implicated in comments pointing at people's lack of awareness, care, or attention to the natural world:

Butterflies are so beautiful & so important in the environmental context. I just wish more people noticed & cared for them & gardened with them & other wildlife upper most in their planning. People are too selfish or absorbed in their own world to even notice butterflies & other wildlife most of the time.

3.2.3. Taking action for conservation: hope and helping

While feelings of helplessness and hopelessness were expressed by some people, others identified feelings of hope and optimism. Contributing to the Big Butterfly Count was identified as a way of bringing hope as it enabled people to feel like they were helping, and *'feeling useful by contributing to research'*. Taking action serves to buffer against the emotional impact of observing fewer butterflies and reflecting on the human activities that contribute to declines. As well as taking part in the count, people reported that planting nature-friendly gardens, joining Butterfly Conservation, or encouraging other people to get involved gave them a sense of 'doing something' that might help change things.

I also feel there is a genuine sense of contribution to citizen science and a small bit of data that might help make a better decision for wildlife. […] I can't help but think we are all losing the battle worldwide as the population and greed takes over the needs of wildlife. But if I have helped in the most minute way to provide some data that makes us all think that little bit deeper about the problems we are causing then I'm happy.

The count was described as *'important'* and '*worthwhile*' by a number of people. Participants (particularly those who take part every year) commented on the importance of their

connection with, and interest in, nature for their involvement in the count and their gardening decisions. For others, this connection and interest and appreciation for the importance of participation appeared to grow through the act of taking part:

Taking part has focused me a little more on the plight of butterflies and will further influence my management of the areas where I have recorded butterflies at home, and to better observe their presence through the seasons.

Some people highlighted the value of feeling like a member of a group of '*like-minded people* […] *so you do not feel you are alone in your concerns*'. Others reported getting other people involved – particularly family and children. Some used the count as an opportunity to '*raise awareness*' by telling people what they were doing, and others tried to persuade others to record butterflies.

The following respondent highlighted the value of the count for their personal wellbeing, followed by an account of taking additional conservation actions and involving grandchildren:
This experience helped me through 8 months of chemotherapy. I'm now in remission and will be volunteering next year and have made contact. The grandchildren have been involved too and have just installed a butterfly box in their fairy garden. We are now planning to replant a new area of the garden to attract even more butterflies next year.

Taking part in the count was reported by many as inspiring them to take further action in their gardens to support butterflies and other pollinators. Some who reported feelings of disappointment about seeing few butterflies made plans to plant more or plant differently in their gardens in the future, to *'work harder'* and *'do more'*. As the respondent below suggested, recognising the contribution that 'small things' can make is important not only for the sake of the environment and biodiversity, but for personal wellbeing.

As a lover of butterflies and nature as a whole, I am concerned by how habitats are under pressure. What we do as humans to the environment is also troubling. It is important that we understand that every small thing that we do as individuals makes a positive contribution. That is how I stay positive.

4. Discussion

The study has shown that taking part in the Big Butterfly Count, a brief (15-min) citizen-science activity, was associated with increased nature connectedness, decreased anxiety, and increased noticing of butterflies and nature. Increased wellbeing and noticing of

butterflies were sustained at six to seven weeks after the end of the count period, however nature connection increases were not. Improvements in nature connectedness, decreases in anxiety, and increased noticing of butterflies were associated with the strength of people's emotional experiences of taking part in the survey; feelings of joy, compassion and interest related to increases in the extent to which people feel they are a part of nature, and – along with fascination – increased noticing of nature and butterflies.

These results support previous experimental research showing that taking part in citizen science activities can benefit wellbeing and improve nature connectedness (Eichholtzer et al., 2023; Pocock et al., 2023; White et al., 2023). As far as we are aware, our study is the first to find improved measures of nature connection and lessened anxiety amongst participants in an ongoing, real-world citizen science project. It also extends prior research by showing that increases in nature connectedness are associated with participants' emotional experience of taking part – the more people respond emotionally to the task, the greater the impact on their relationship with nature. Interestingly, while increases in nature noticing and scores on the Inclusion of Nature in Self measure were linked only to the strength of participants' 'positive' emotional experiences, increases in the NR6 scale were significantly associated with both 'positive' and 'negative' (i.e. anger, disgust, and fear) emotions. One possible explanation for this is that the broader aspects of nature connection measured with the NR6 (including spiritual, identity and behavioural elements) could be more sensitive to any heightened emotional experience regardless of valence. It raises questions about the appropriateness of categorising emotions as positive or negative – perhaps any nature-based emotional activation can help initiate improved relationships. As evident in the qualitative data, 'negative' emotions may be a motivator for action. These issues warrant further investigation.

While the emotional aspects of taking part in citizen science have been discussed in qualitative research (Evans et al., 2005; Ganzevoort and van den Born, 2019; Koss and Kingsley, 2010), this study has demonstrated the significance of people's emotional responses for participation outcomes and measured improvements to a psychological wellbeing measure. Stronger positive emotional experiences (joy, fascination, compassion and interest) of participation were also associated with increases in nature and butterfly noticing, suggesting the potential for emotions to impact everyday engagement with nature. These results support White et al.'s (2023) finding that rating how much joy was experienced on seeing garden birds increased nature connectedness and wellbeing, with greater decreases in anxiety than those who simply counted numbers of each species. Emotional responses to wildlife may not only predict future involvement in citizen science projects (Sturm et al., 2021), but promote a stronger sense of connection with nature,

enhance wellbeing, and increase everyday attention to the more-than-human world. These findings align with Buijs and Jacobs' (2021) call for a positive psychology of human-wildlife interactions, which recognises the pleasure, engagement and meaning possible through such interactions as pathways to wellbeing and happiness.

The finding that participation in the Big Butterfly Count had a sustained impact on people's tendency to notice butterflies is important as research shows that noticing nature is key to improving nature connectedness, wellbeing, and pro-nature behaviour (Hamlin and Richardson, 2022; Richardson et al., 2022; Richardson and Hamlin, 2021). Looking for and watching butterflies is a simple yet effective way to tune into the natural world, and this sort of attention has the potential to become a habit or reflex (Cosquer et al., 2012). The qualitative comments illustrate participants' emotional experiences of noticing and appreciating butterflies during the count, and reaffirm the importance of considering affective aspects of citizen science participation (e.g., Ganzevoort and van den Born, 2019; Larson et al., 2016).

The initial increase in noticing nature more generally was not sustained, and neither were the improvements in nature connection or decreases in anxiety. There are a number of possible explanations for this, which would require further research to explore. Study designs employing longitudinal methods, additional measures, and qualitative methodologies would all help to build a picture of the factors that might enhance or hinder the short-term benefits of participation in projects such as this. Exploring individual differences would be useful to identify if there are factors that might lead to lasting effects in some participants but not others. For instance, some participants may have joined Butterfly Conservation as a result of taking part in the count, which could have ongoing effects on their engagement with nature, wellbeing and pro-environmental behaviour. There is also potential for applied research, and ongoing collaboration between conservation organisations and social scientists, to identify and develop projects that explicitly aim to produce lasting impacts.

While no quantifiable change in pro-conservation behaviour (as measured by ProCOBS) was observed, the qualitative comments show clear intention towards future change. Perhaps the people who take part in the Big Butterfly Count already have a high baseline of pro-nature gardening behaviour, leaving little room for change to be captured by the scale. While ProCOBS is unique as a measure of pro-nature conservation behaviour, it captures individual differences that are season-dependent and perhaps less likely to change over the short-term. The scale asks people about their planting and garden maintenance actions which are likely to be concentrated in specific parts of the year (e.g. not cutting hedges

during bird breeding season or planting native trees and shrubs when they are dormant in winter). Other actions, like using insecticides or leaving undisturbed areas or logpiles, may be established practices with potential to be binary options. However, Pocock et al. (2023) used a different version of ProCOBS, which also included questions about civic pro-nature actions, and found improvements at one-week post intervention. Given the limited time to engage in the behaviours, respondents presumably answered in terms of intentions rather than actual actions. Deguines et al. (2020) analysed longitudinal data over an eight-year period and found that pro-biodiversity gardening practices increased with sustained participation in a citizen-science butterfly survey. Further work is needed to develop measures for pro-conservation behaviour that are appropriate for pre- post- testing over relatively short periods, alongside collection of longitudinal data, and additional exploration of the factors that may shape adoption of pro-conservation practices.

Although the research is novel methodologically, and important in terms of its findings, there are some limitations. First, we were not able to standardise the length of time between pre-, post- and follow-up questionnaires or between conducting a butterfly count and completing the survey. Some may have carried out a count at the beginning of the three-week Big Butterfly Count period, while others may have done it the day before the T2 post-survey. However, the sample size achieved reduced the likelihood of such variation influencing the results. Second, the sample is largely comprised of people who already interact with Butterfly Conservation via social media or newsletters and who might be expected to have higher than average levels of nature connectedness and pro-nature behaviour. A high baseline level of nature relatedness was proposed to explain a lack of improvement amongst citizen scientists participating in the Dutch national bee survey (Ganzevoort and van den Born, 2021), but the changes we observed show the potential for improvement amongst the already-connected. These limitations reflect the consequences of the naturalistic design, exploring the impact of a pre-existing citizen science project. It is interesting to note, though, that similar findings have been observed in experimental studies (Coventry et al., 2019; Pocock et al., 2023). Similarly, past experience of citizen science or other volunteering may be an important influence on the impacts on individuals. Eichholtzer et al. (2023) found evidence that nature relatedness increases following citizen science were greater for participants with no prior involvement in volunteering. We have insufficient information about the volunteering backgrounds of our survey participants to explore this aspect in detail. However, 84% of our participants had taken part in Big Butterfly Count in at least one previous year which, together with information from the qualitative information we gathered, suggests that our results are not dependent on 'first-timers'. More research is needed to explore the impact of participation on different groups, including the effects of repeat versus first-time involvement in citizen science. Finally, while we had a

good sample size, we are limited in generalising our results to all Big Butterfly Count participants because we did not gather demographic information.

The findings and methodology of this research have implications for research on citizen science, for the design and implementation of citizen science projects, and for the development of approaches to dealing with the climate and biodiversity emergencies. First, the research demonstrates the value of moving beyond knowledge, skills, and social connection in assessing participant outcomes and including emotional responses and nature connection. As evident in qualitative studies, the affective and psychological aspects of citizen science are key to people's experiences and likely to link to the conservation actions people take. Citizen scientists are not only contributing to the scientific knowledge base, but engaging in activities that change how they feel and lead to closer relationships with nature. Nature connection is easily measured and should be included as an outcome of citizen science participation. The emotional impact of taking part in citizen science projects should also be considered. There is a clear need for further quantitative studies to examine the quality of citizen scientists' experiences and outcomes, and more collaborations between natural and social scientists. The study also demonstrates that value of a quasi-experimental before and after design to explore change in measures – as others have noted, such designs are rare in the field (Schuttler et al., 2018).

Second, the findings lend themselves to recommendations for citizen science projects. The decreased levels of anxiety illustrate a wellbeing potential for citizen science participation, which could be linked up with initiatives like green social prescribing (Leavell et al., 2019; NHS England; Robinson and Breed, 2019) to deliver benefits for both people and nature. The potential for noticing to become habitual could lead to longer-term shifts in attention and awareness of the natural world, which may benefit other aspects of wellbeing. Citizen science projects could make use of this link in promoting engagement, as well as seeking out partnerships with organisations and schemes focused on mental wellbeing. The emotional experience of taking part could also be highlighted as part of recruitment and marketing activities. As Ganzevoort and van den Born (2019) suggest, communication with volunteers should reflect how they themselves experience nature – drawing on ‘emotional and evocative descriptions of nature’ not only aligns with participants accounts, but can help foster a stronger sense of connection with nature (Andrews, 2018). There may be options to encourage heightened emotional engagement as part of citizen science activities (e.g., White et al., 2023).

Finally, the study demonstrates the potential impact of citizen science for conservation and environmental action, and suggests a greater focus on nature connection as a core outcome

of citizen science. By changing how people think about, feel towards, and relate to nature, the emotional aspects of citizen science can help to nurture the inner transformation that is increasingly recognised as key to sustainable and regenerative futures (Wamsler et al., 2021). With established links between nature connectedness and pro-environmental behaviour (Mackay and Schmitt, 2019), this finding highlights the broader impact of citizen science for nature conservation – supporting a cycle of attention to nature, greater wellbeing and nature connection, more actions for nature, more nature to pay attention to, and so on (see Garfinkel et al., 2024; Hamlin and Richardson, 2022).

Overall, the research has found that taking part in the Big Butterfly Count benefitted citizen scientists' wellbeing and nature connectedness, and led to sustained increases in noticing butterflies. People's emotional responses to watching and counting butterflies were associated with greater improvements in nature connectedness and nature noticing. While the primary response to the task is one of enjoyment and fascination, sadness and worry triggered by observing fewer butterflies prompts some people to do more to help. The opportunity to contribute to butterfly conservation by taking part in the count can serve as a remedy against concerns around biodiversity loss, offering people a sense of 'constructive hope' (Chawla, 2020).

Butterfly Conservation describes the Big Butterfly Count as "taking the pulse of nature". Butterflies and moths are key biodiversity indicators, with population changes providing insights into anthropogenic impacts (such as climate change, environmental pollution and land-use change) on other wildlife (Habel et al., 2019; Boyes et al., 2021; Hill et al., 2021; Roth et al., 2021). By exploring the impact on the citizen scientists who spend 15 minutes with their finger on nature's pulse, this study has shown that the Big Butterfly Count contributes more than just scientific data and raising awareness. Citizen scientists benefit from the calming effects of watching nature and their emotional response to engaging with it, grow stronger and deeper connections to the more-than-human world, and increase their tendency to notice butterflies and nature in everyday life. Such changes in how people feel about and engage with nature are important for individual wellbeing as well as contributing towards a culture of caring for and protecting nature. By prompting people to notice and enjoy nature, the Big Butterfly Count helps to forge stronger human-nature relationships that are essential for the mutual health of people and the rest of the natural world.

CRediT authorship contribution statement

C.W. Butler: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Writing – original draft, Writing – review & editing. **I. Hamlin:** Data

curation, Formal analysis, Writing – original draft, Writing – review & editing. **M. Richardson:** Conceptualization, Methodology, Writing – review & editing. **M. Lowe:** Conceptualization, Data curation, Methodology, Project administration, Writing – review & editing. **R. Fox:** Conceptualization, Methodology, Writing – review & editing.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests:

University of Derby reports financial support was provided by Butterfly Conservation. Butterfly Conservation reports financial support was provided by the Nature, Art & Wellbeing Community Fund (a collaborative of the National Lottery Community Fund via Stepping into Nature, NASP Fund via Thriving Communities Nature Buddies & Contain Outbreak Management Fund via Dorset Council). ML and RF are employees of Butterfly Conservation.

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Ethics statement

The study was approved by the University of Derby Health, Psychology and Social Care Ethics Committee [ETH2122-3819]. Participation was voluntary and confidential, with Butterfly Conservation anonymizing data to be shared with University of Derby for analysis.

Data availability

The authors do not have permission to share data.

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