



# Citizen Scientist Participation in Research on Private Lands Positively Impacts Multiple Conservation Behaviors

RESEARCH PAPER

RACHAEL E. GREEN

ASHLEY A. DAYER

AMY E. M. JOHNSON

\*Author affiliations can be found in the back matter of this article

ubiquity press

## ABSTRACT

Conservation research programs working on private lands provide invaluable data to support biodiversity conservation efforts and may also engender broader conservation outcomes by influencing the conservation behaviors of individuals that participate within the program. However, little is known about how conservation behavior outcomes may differ across varying levels of participation in a program and what factors may influence this conservation behavior change. We sought to elucidate the conservation behavior outcomes associated with citizen scientists and non-citizen scientists involved with a conservation research program, as well as the factors that are associated with a program's perceived impact on participants' conservation behaviors. We conducted an online survey of individuals ( $n = 193$ ) associated with Virginia Working Landscapes (VWL), a Smithsonian conservation research program that studies and promotes native biodiversity on private lands. Forty-nine percent of respondents had actively participated as citizen scientists whereas fifty-one percent had not. VWL citizen scientists had significantly higher perceived impacts of the program on their engagement in conservation behaviors compared with non-citizen scientists. Significant predictors of respondents' perceptions of VWL's impact on their conservation behaviors include participating as a citizen scientist and attending program events, while characteristics of the participants were not predictive of perceptions of impact. Our findings illustrate the added value, beyond data collection, of incorporating citizen science into conservation research programs. Results from this study may provide guidance on how these programs can increase their impact on participants' conservation behaviors and broaden their influence on private lands conservation.

## CORRESPONDING AUTHOR:

**Rachael E. Green**

Department of Fish and Wildlife  
Conservation, Virginia Tech,  
Blacksburg, Virginia, USA

Smithsonian National Zoo and  
Conservation Biology Institute,  
Washington, DC, USA

[rg1132@vt.edu](mailto:rg1132@vt.edu)

## KEYWORDS:

private lands; conservation  
behaviors; mixed methods;  
conservation research program

## TO CITE THIS ARTICLE:

Green, RE, Dayer, AA and  
Johnson, AEM. 2023. Citizen  
Scientist Participation in  
Research on Private Lands  
Positively Impacts Multiple  
Conservation Behaviors. *Citizen  
Science: Theory and Practice*,  
8(1): 53, pp. 1–13. DOI: [https://  
doi.org/10.5334/cstp.507](https://doi.org/10.5334/cstp.507)

## INTRODUCTION

Conservation research conducted on private lands can provide valuable insights into species-habitat relationships on working landscapes (Kamal et al. 2014) and engender broader conservation outcomes by influencing the conservation behaviors of individuals who participate in the program (Toomey and Domroese 2013). Yet, participants may engage with conservation research programs in varying capacities, and the extent of interactions with a program may be associated with a range of outcomes such as environmental awareness, knowledge, attitude, and participation in conservation behaviors (Jacobson et al. 2015). Although it is well documented that active forms of engagement (e.g., volunteering with a program) are more strongly linked with program outcomes than passive forms of engagement (e.g., reading a program newsletter) (Ardoin et al. 2020; Theobald et al. 2020), this has rarely been studied in the context of conservation programs on private lands. A participant may actively engage with a conservation research program as a citizen scientist, as in a volunteer member of the public who gathers or analyzes data for scientific research (Cooper et al. 2007). Understanding whether citizen science components of conservation research programs, compared with more general program outreach, are more strongly associated with conservation outcomes may aid programs aiming to expand their impact on participants' conservation behaviors.

Research has shown that participation as a citizen scientist may influence participants' engagement in pro-environmental behaviors (PEBs) (Lynch et al. 2018; Toomey and Domroese 2013). PEBs are any behavior that positively impacts the environment or reduces negative impacts to the environment (Steg and Vlek 2009). Specifically, Larson et al. (2015) distinguishes between four types of pro-environmental behavior: conservation lifestyle, social environmentalism, environmental citizenship, and land stewardship. Conservation lifestyle includes private sphere consumer behaviors such as turning off lights to reduce energy consumption. Social environmentalism includes behaviors that focus on social engagement, such as participants independently seeking out additional information on study species and environmental issues (Overdeest et al. 2004; Evans et al. 2005) or sharing their environmental knowledge with peers (Toomey and Domroese 2013). Environmental citizenship includes behaviors that support environmental causes through voting, donations, or civic engagement. Participants may become involved in environmental citizenship by attending public meetings (Overdeest et al. 2004; Church et al. 2019) and by making financial donations to environmental causes

(Larson et al. 2015). Land stewardship includes behaviors that improve the landscape to benefit wildlife, such as when participants implement pollinator-friendly gardening practices (Toomey and Domroese 2013; Lewandowski and Oberhauser 2017) and modify landscape maintenance practices to better accommodate bird species (Sullivan et al. 2017). Additionally, participation in citizen science may in of itself be categorized as a land stewardship behavior (Larson et al. 2015), and once a citizen science project has been completed, participants may go on to volunteer for additional projects (Lewandowski and Oberhauser 2016; Merenlender et al. 2016; Church et al. 2019). These latter three categories of PEB (i.e., social environmentalism, environmental citizenship, and land stewardship) are also referred to as "conservation behaviors" since they are more directly tied to tangible means of biodiversity conservation than conservation lifestyle behaviors.

Furthermore, understanding the effects of both program and participant factors are critical to discerning the drivers of program outcomes (e.g., Wilson 1994; Kanaya et al. 2005; Ehrenberg et al. 2007; Assumpcao Picorelli et al. 2014). As program and participant characteristics may influence program outcomes (Wilson 1994), this information is necessary to clarify whether there are certain aspects of a conservation research program that are impacting participants' engagement in conservation behaviors or rather some inherent characteristic of the participants themselves.

Program factors can be general or specific attributes of the program. These factors may include direct interactions, such as conversations, between researchers and participants (Lutter et al. 2018); researchers sharing research findings with participants (Hilty and Merenlender 2003); or researchers hosting conservation-related events (Newton 2001; Graham and Rogers 2017). Events provide participants with unique opportunities to meet like-minded individuals (Newton 2001; Graham and Rogers 2017), to exchange knowledge (Dean et al. 2018), and to interact with program staff (Singh et al. 2018). Direct interactions are often more effective at influencing conservation behavior adoption than indirect forms of engagement (Sharp et al. 2012). Yet, program factors may also include indirect interactions, such as reading program outreach materials. Outreach materials such as newsletters provide participants valuable opportunities to learn about conservation issues and to gain insights into the program (Lewandowski and Oberhauser 2017). Social norms (i.e., one's perception of how individuals behave or should behave in a given situation) have been found to be predictive of conservation behavior adoption (Ho et al. 2014; Sliwinski et al. 2018) and may be influenced through direct and indirect interactions with the program. For example, an individual who participates with a

conservation research program may be influenced to adopt a certain conservation behavior if they interact with other individuals within the program (e.g., program staff or citizen scientists) who engage in that behavior. Normative beliefs (i.e., one's perception of whether other individuals will approve or disapprove of a certain behavior) are antecedent to social norms (Ajzen 1991) and may influence individuals' management intentions (Kuhfuss et al. 2016). For example, an individual who participates with a conservation research program may be influenced to adopt a certain conservation behavior if they are encouraged to do so by other individuals within the program (e.g., program staff or citizen scientists).

Other factors that are associated with conservation behavior adoption are characteristics of the participants themselves. Demographic information, such as identifying as a woman, attaining a higher level of education, being older, and having a high annual income are all predictive of conservation behavior adoption (Kollmuss and Agyeman 2002; Ho et al. 2014, Prokopy et al. 2019). Although many citizen science projects collect demographic data from their participants, limited diversity of participants often impedes investigations into the relationship between demographics and conservation behavior adoption. In addition to demographics, participant cognitions and stronger personal norms toward conservation behaviors (Park and Ha 2014) are predictive of conservation behavior adoption. Perceived behavioral control (i.e., one's perceptions they can do a behavior) is also associated with conservation behavior adoption (Park and Ha 2014; Sliwinski et al. 2018).

## STATEMENT OF PURPOSE

We conducted an online survey of individuals associated with a Smithsonian conservation research program, Virginia Working Landscapes, to investigate how citizen scientists and non-citizen scientists perceive that a conservation research program impacts their engagement across conservation behaviors (i.e., social environmentalism, environmental citizenship, and land stewardship). We also performed a qualitative analysis of open-ended survey items to gain a better understanding of how respondents engaged in each conservation behavior, as well as the outcomes of their attendance at program events and reading program communications.

## METHODS

### VIRGINIA WORKING LANDSCAPES

Virginia Working Landscapes (VWL) is a program of the Smithsonian Conservation Biology Institute (SCBI) that studies and promotes native biodiversity and sustainable land use through research, education, and community

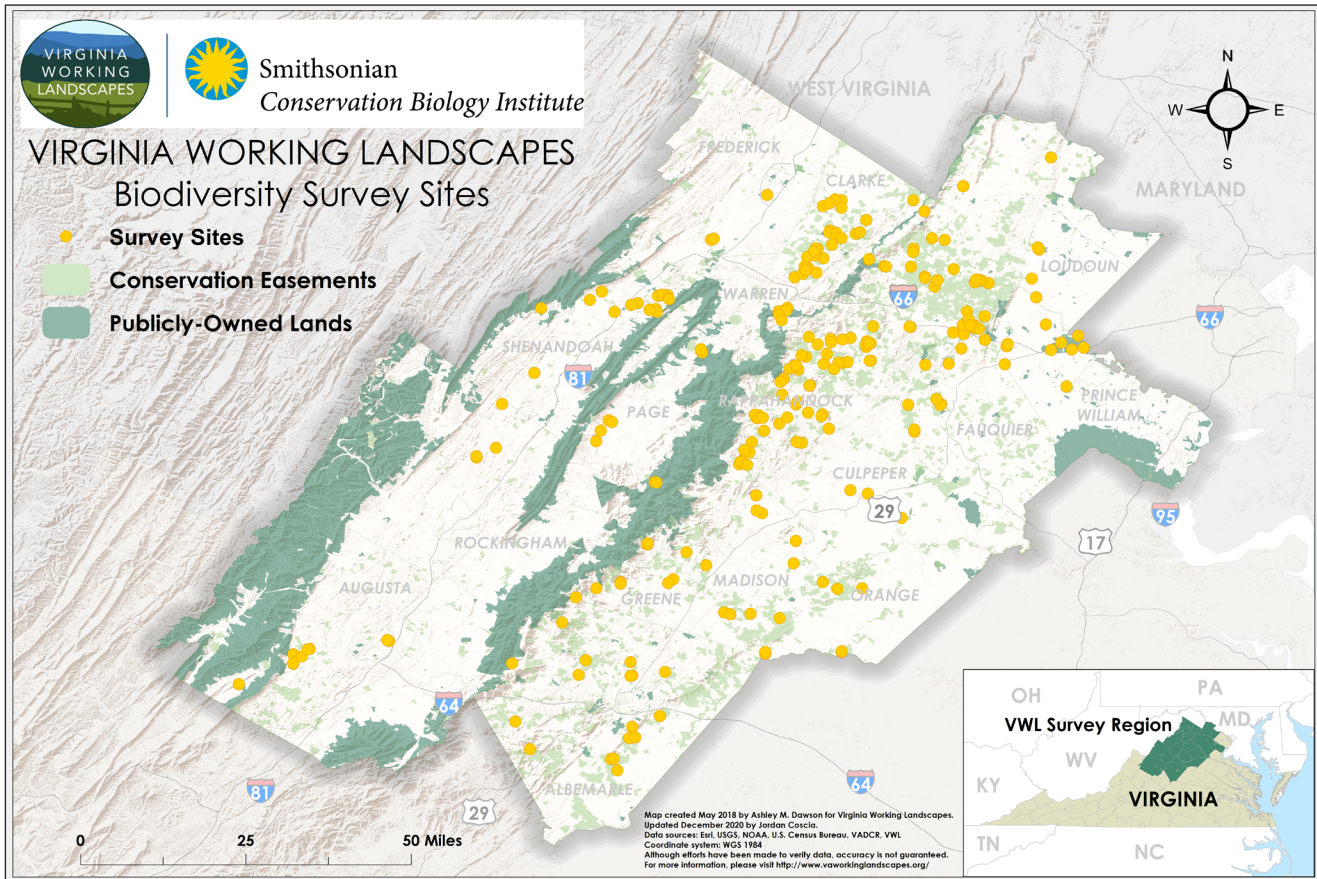
engagement. VWL engages with a broad array of individuals through monthly emailed newsletters. These newsletters are distributed to more than 1,000 individuals and contain information on the program, summaries of recently published literature pertinent to mid-Atlantic working landscapes, updates on research projects, and notices of upcoming events. VWL also works with a network of 207 citizen scientists who, together with professional scientists and interns, have surveyed more than 80,000 acres of private lands since 2010. These citizen scientists perform biological surveys throughout 16 counties in northern Virginia on an annual basis (Figure 1). Examples of these surveys include grassland pollinator inventories, vegetation surveys, avian point counts, and soil sampling. Before every survey season, VWL hosts training sessions to prepare citizen scientists to conduct surveys on private and public lands. Additionally, all VWL participants have opportunities to attend VWL outreach events, educational trainings, workshops, public lectures, farm tours, management demonstrations, and nature walks. These events aim to engage participants in conservation science and to inspire best management practices for conserving biodiversity on individuals' properties (VWL Annual Report 2020).

## SURVEY DESIGN AND IMPLEMENTATION

We conducted an online survey of individuals who volunteered as VWL citizen scientists between 2010 and 2020 ( $n = 207$ ) and individuals who subscribed to VWL's newsletter between 2010 and 2020 but never volunteered, henceforth referred to as "non-citizen scientists" ( $n = 608$ ). Names and contact information were cross-checked between the citizen scientist and non-citizen scientist listservs to ensure there was no overlap. If a name or contact information was present on both listservs, we contacted the individual to participate only in the citizen scientist survey, and we removed them from the non-citizen scientist list. Additionally, we removed individuals who had subscribed to the newsletter listserv using a natural resources work-associated email to avoid including individuals who engaged in conservation behaviors owing to job responsibilities. We did not remove any citizen scientists from the listserv as no citizen scientists had a natural resources work-associated email.

The survey consisted of both closed- and open-ended items to explore respondents' familiarity with the program, participation in conservation behaviors, attendance at program events, reading of program materials, personal norms, social norms, normative beliefs, and actual behavioral control (see Supplemental File 1: Survey Items, Supplemental File 2: Citizen Scientist Survey Instrument, and Supplemental File 3: Non-Citizen Scientist Survey Instrument).





**Figure 1** Virginia Working Landscapes study area 2010 – 2020 (shown in green). Research sites are located within 16 counties in northern Virginia: Frederick, Clarke, Shenandoah, Warren, Loudoun, Fauquier, Prince William, Page, Rappahannock, Culpeper, Orange, Madison, Greene, Albemarle, Rockingham, and Augusta.

Closed-ended items explored respondents' engagement in social environmentalism, land stewardship, and environmental citizenship conservation behaviors. We did not include survey items regarding respondents' engagement in the fourth category discussed in Larson et al. 2015 (i.e., conservation lifestyle behaviors) as VWL's research does not promote conservation lifestyle behaviors. Specific survey items were slightly modified from their original form in Larson et al. (2015). In the environmental citizenship category, voting for environmental policies and contacting government representatives were combined into one overarching behavior "supporting conservation issues through civic engagement." In land stewardship, the survey item referring to wildlife studies and ecological monitoring was modified to "participating in a conservation-based citizen science project, other than VWL" as this was more pertinent to participants. Private and public land-enhancement survey items were modified to "creating, managing, or restoring wildlife habitat on private/public lands." VWL had been established for ten years at the time of the survey, so survey respondents were asked about their engagement in conservation behaviors only within

the past ten years. To measure respondents' perceptions of VWL's impact on their adoption of each conservation behavior, we asked respondents how VWL impacted them using a 7-point Likert scale. Respondents were asked about VWL's impact on each conservation behavior type only if they had previously indicated that they participated in that specific conservation behavior.

Closed-ended survey items also consisted of participant factors (i.e., gender, age, level of education, annual household income, actual behavioral control, personal norm) and program factors (i.e., social norms, normative beliefs, average annual attendance at VWL events, average number of VWL monthly newsletters read annually, and status as a VWL citizen scientist or non-volunteer). Perceived behavioral control is antecedent to actual behavioral control (i.e., one's possession of the skills and resources required to execute a behavior) and is also associated with conservation behavior adoption (Park and Ha 2014; Sliwinski et al. 2018). When feasible, it is more accurate to use actual behavioral control measures when evaluating actual behaviors rather than behavioral intentions (Fishbein and Ajzen 2010).

We also included open-ended survey items in order to gain a better understanding of how respondents engaged in each conservation behavior, as well as the outcomes of their attendance at program events and the program communications they read. Open-ended response questions related to conservation behaviors were phrased, “Could you tell us more about how you (conservation behavior)?”; open-ended response questions related to program event attendance were phrased, “What have you gained from attending these events?”; and open-ended response questions related to reading program communications were phrased, “What have you gained from reading the VWL monthly conservation newsletter?”.

Prior to distribution, six social scientists from Virginia Tech, three staff and research fellows from VWL, and three additional individuals with expertise in conservation-related volunteer programs reviewed the survey. The Virginia Tech Institutional Review Board (Protocol #19-1018) and Smithsonian Institutional Review Board approved the project. We conducted surveys from February to March of 2021 using the Qualtrics online survey platform (Qualtrics 2021) with a direct email invitation. Following the Dillman method, we maximized response rates by sending up to two reminders at 10-day intervals following the first recruitment email, tailoring email subject lines for each reminder, and altering the day of the week and time of day eligible participants were contacted (Dillman et al. 2014). A non-response bias check was performed via email by sending all non-respondents a shortened version of the survey in March 2021. Non-respondent surveys covered program factors (i.e., social norms, normative beliefs, average annual attendance at VWL events, average number of VWL monthly newsletters read annually) and participant factors (i.e., personal norms, actual behavioral control, gender, age, level of education, and annual household income). Only survey items that were used for the analysis will be discussed in this paper.

## ANALYSIS

### Quantitative data analysis

We ran a non-response bias check using independent sample t-tests to compare citizen scientist respondents with citizen scientist non-respondents, as well as non-citizen scientist respondents with non-citizen scientist non-respondents. Descriptive statistics were used to summarize respondent demographics. Next, we performed a chi-square test to determine differences in positive VWL impact on citizen scientist and non-citizen scientist engagement in each conservation behavior type. We transformed the 7-point Likert scale impact responses into a binary variable for each conservation behavior type. Very few respondents

reported a negative impact; therefore, responses that ranged from “Very negative impact” to “No impact” were re-coded as 0 for “No impact.” Respondents who were not asked about VWL’s impact on their behavior because they had previously indicated that they had not engaged in that behavior in the past 10 years were also re-coded as “No impact.” Responses that ranged from “Slight positive impact” to “Very positive impact” were re-coded as 1 for “Positive impact.”

We performed an exploratory factor analysis (EFA) to determine the underlying structure of conservation behavior survey items, as well as respondents’ social norms, normative beliefs, and actual behavioral control using IBM SPSS statistics Version 27. A principal component analysis with promax rotation determined the appropriate number of factors to extract when computing factor loadings. If a survey item did not meet the minimum coefficient threshold of  $< 0.40$ , then it was removed from subsequent analyses. We then calculated Cronbach’s alpha scores for survey items that loaded onto corresponding factors to measure inter-item reliability. For variables with high inter-item reliability, we calculated the mean of the items to create a single measure for the concept.

Before conducting regression analyses, we first reduced the dimensionality of our data using non-metric multidimensional scaling (NMDS) and discerned underlying trends in the ordination using the environmental fit function from the vegan package (Oksanen et al. 2020) in RStudio version 1.4.1717 (R Core Team 2021). We omitted missing data listwise and used Euclidean distance to calculate distance. Euclidean distance is appropriate for non-ecological data (Holland 2008) and has been used in many social science studies (Dahlani and Maharani 2018; Giguère 2006; Green and Manzi 2002; Whaley and Long 2008). We performed two separate NMDS analyses on average perceived VWL impact: One included only program factors and one included only participant factors. After each NMDS, the environmental fit function was used to determine the strength of the relationship between each factor and the dependent variable (average VWL impact). Only factors that had a significant correlation with the dependent variable, as indicated by a p-value less than or equal to 0.05, were included in the corresponding regression models.

The dependent variable, average VWL impact, used in our regression model was calculated by averaging responses to each conservation behavior impact question. Average impact for each conservation behavior type was calculated using the responses of those who had indicated that they engaged in that specific conservation behavior. We performed the Durbin-Watson test check for the presence of autocorrelation in the residuals.

## Qualitative data analysis

We coded open-ended responses using Dedoose (version 8.3.47) software (SocioCultural Research Consultants LLC 2021). The lead author inductively coded all open-ended responses following a thematic analysis approach. Data were first compiled and emergent codes were used to inform themes that, in turn, aided the interpretation of the data (Castleberry and Nolen 2018). Following the first round of coding, the codebook and code definitions were discussed with a co-author to confirm their clarity and utility. The lead author then performed a second round of coding to ensure that all open-ended responses were coded with the full list of codes (as in O'Brien et al. 2021).

## RESULTS

### RESPONSE RATE AND DEMOGRAPHICS

Of the 207 citizen scientists we attempted to contact, 20 contact emails were undeliverable. This resulted in a total of 187 citizen scientist surveys successfully sent; of these, we received 114 from those who consented to participate, for a response rate of 61.0%. Respondents who answered less than the first third of the citizen science survey ( $n = 27$ ) were removed from our analysis. Seven respondents from the non-citizen scientist survey indicated that they were current or past VWL citizen scientist volunteers; therefore, responses from these individuals were added to the citizen scientist dataset. This yielded a final sample of 94 citizen scientist respondents. We checked for non-response bias between citizen scientist respondents and citizen scientist non-respondents using independent sample t-tests (Supplemental File 4: Results of Independent Sample T-Tests). Respondents and non-respondents ( $n = 14$ ) did not significantly differ in any participant or program factors. Of the 608 non-citizen scientists we attempted to contact, 14 emails were undeliverable. This resulted in a total of 594 non-citizen scientist surveys successfully sent, of which we received 215 from those who consented to participate (one of whom was under 18 and therefore ineligible, leaving 214), for a response rate of 36.1%. Seven individuals indicated that they were current or past VWL citizen scientist volunteers. Their responses were removed from the non-citizen scientist dataset and moved to the citizen scientist dataset as described above. Furthermore, 89 individuals did not complete at least the first third of the survey, and 19 individuals indicated that they were “not at all familiar” with VWL, thus were removed from our analysis. This yielded a final sample of 99 non-citizen scientist respondents. Again, we checked for non-response bias using independent sample t-tests. Respondents and non-respondents did not significantly differ for any program or participant factors.

All citizen scientist and non-citizen scientist respondents were then combined into a single dataset ( $n = 193$ ). Overall, both citizen scientist (62.6%) and non-citizen scientist (57.6%) respondents were a majority female and were an average of 61.6 and 61.7 years of age, respectively. Respondents were also highly educated, with 93.1% of citizen scientists and 81.9% of non-citizen scientists having obtained a bachelor's degree or higher. Approximately half of citizen scientist respondents (48.8%) and non-citizen scientist (55.6%) respondents had an average annual household income over \$100,000. Citizen scientist respondents had volunteered for an average of 36.6 hours per year (with a range of 2 to 200 hours per year) for an average of 3.0 years (with a range of 1 to 11 years). For non-citizen scientists, only 12.1% indicated they were extremely or very familiar with VWL, whereas the majority of non-citizen scientists indicated that they were moderately (50.5%) or somewhat familiar (37.4%) with VWL.

### QUANTITATIVE RESULTS

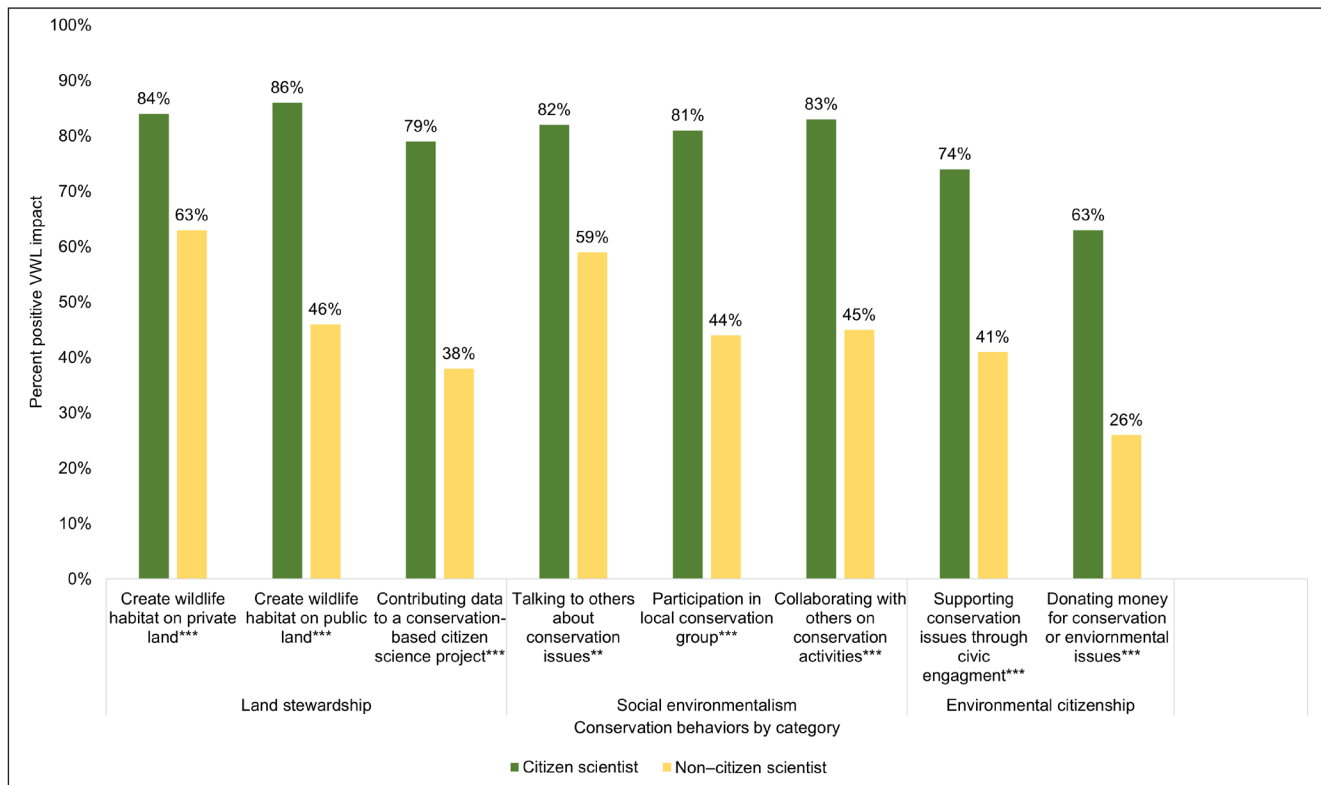
#### Drivers of perceived Virginia Working Landscapes impact on conservation behavior adoption

Citizen scientist and non-citizen scientist respondents engaged in conservation behaviors in each of the Larson et al. (2015) categories (Supplemental File 5: Conservation Behavior Engagement Graph); however, citizen scientists' perceptions of VWL's impact on their engagement in conservation behaviors were significantly greater than non-citizen scientists' across all conservation behavior types and categories (Figure 2).

The EFA of the conservation behavior survey items identified one underlying factor, and all items loaded onto this factor with excellent inter-item reliability ( $\alpha = 0.96$ ). We then averaged these items to create the response variable, average VWL impact, used in the later NMDS, environmental fit, and linear regression model. The EFA of respondents' normative beliefs identified one underlying factor and all items grouped onto this factor with good inter-item reliability ( $\alpha = 0.83$ ); therefore, we labeled this factor “normative beliefs.” For the EFA of respondents' norms, social and personal norm items grouped onto two separate factors. We labeled the first factor “social norms” because it included items that focused solely on descriptive and injunctive social norms ( $\alpha = 0.89$ ). The second factor referenced “personal norms” and was labeled as such ( $\alpha = 0.67$ ). The EFA on actual behavioral control identified one underlying factor, and all items grouped onto this factor with acceptable inter-item reliability ( $\alpha = 0.67$ ) according to George and Mallery (2019).

We ran two separate NMDS analyses on participant factors ( $n = 153$ ) and program factors ( $n = 149$ ). Both NMDS ordinations resulted in a two-dimensional solution, with





**Figure 2** Comparison of citizen scientists’ and non-citizen scientists’ perceptions of Virginia Working Landscapes’ impact on their engagement in conservation behaviors. Asterisks denote significant Chi-square differences between citizen scientists and non-citizen scientists (\*\* < 0.01, \*\*\* < 0.001). Conservation behaviors are grouped into three categories in line with Larson et al. (2015): land stewardship, social environmentalism, and environmental citizenship.

the NMDS of participant factors yielding a final stress value of < 0.05, and the NMDS of program factors resulting in a final stress value of < 0.05. The environmental fit revealed no significant participant factors. Significant program factors included normative beliefs, event attendance, the newsletters, and status as a citizen scientist (Supplemental File 6: Environmental Fit Output).

Our linear regression model explained 22.9% of the variation in respondents’ perceptions of VWL impact on their conservation behavior engagement. As previously mentioned, the response variable, average VWL impact, was calculated by averaging responses to each conservation behavior impact question. The Shapiro-Wilk test ( $p = 0.35$ ) confirmed that the model residuals were normally distributed, and the Durbin-Watson test confirmed that there was no autocorrelation among the residuals (D-W statistic = 1.98;  $p = 0.87$ ). Significant program factors included participation as a VWL citizen scientist and attendance at VWL events. Individuals that had participated as citizen scientists had higher perceptions of VWL’s impact on their adoption of conservation behaviors compared with non-citizen scientists. Similarly, attending VWL events were predictive of positive perceptions of VWL’s impact on participants’ engagement in conservation behaviors (Table 1).

INDEPENDENT VARIABLES	UNSTANDARDIZED $\beta$ COEFFICIENTS	P-VALUE
<b>Citizen scientist</b>	<b>0.622</b>	<b>0.00003</b>
Normative beliefs	-0.015	0.6015
<b>Events</b>	<b>0.1676</b>	<b>0.0003</b>
Newsletters	0.0272	0.068

**Table 1** Summary of multiple linear regression model for explaining respondent perceptions of Virginia Working Landscapes’ impact on conservation behaviors. Independent variables with a significant p-value are emboldened.

## QUALITATIVE RESULTS

### Participation in and impact on conservation behaviors

Creating, restoring, or managing wildlife habitat on private lands was the most frequent land stewardship conservation behavior engaged in by both citizen scientists and non-citizen scientists ( $n = 171$ ). Respondents engaged in this behavior through planting native species on their property (59.7%), removing invasive species (39.8%), and supporting wildlife through other activities (32.8%) such as building

brush piles for the benefit of insects, birds, and small mammals, as well as putting up bird boxes and bee houses.

For environmental citizenship behaviors, respondents who donated to environmental organizations ( $n = 146$ ) generally donated to organizations that work within their local community (47.6%) or organizations that operate on a national scale (44.1%). Supporting conservation issues through civic engagement ( $n = 131$ ) was less common than donating money for conservation or environmental issues. For those who did support conservation issues through civic engagement, contacting local and federal representatives regarding environmental issues was most common (30.5%).

### Qualitative reflections on participation in events and reading the newsletter

Respondents who elaborated on their attendance of VWL events ( $n = 112$ ) most often stated that these events helped them to connect with their peers and broader community (34.8%). Their attendance provided opportunities to meet like-minded people, share their love of nature, and develop a strong sense of community. Events also served as a mechanism for respondents to gain new knowledge. Many respondents deepened their understanding of ecology, conservation issues, and conservation land management practices (33.0%). Other respondents described a more general increase in scientific knowledge (27.7%). Some respondents expressed that they have not been able to attend VWL events (21.4%), commonly describing living too far away from VWL, time conflicts, or events being canceled due to COVID-19 safety precautions.

Respondents who reported reading VWL's monthly newsletters and commented about them ( $n = 127$ ) most often reported an increase in environmental and conservation knowledge (30.7%) or knowledge in general (17.3%). They stated that the newsletters allowed them to access peer-reviewed articles, stay up to date on current conservation research, and learn about conservation projects around the world. The newsletters also gave respondents a deeper look at VWL (29.9%). Respondents were able to learn about VWL projects they were not familiar with, get updates on VWL's research, and receive notices of upcoming VWL events and volunteer opportunities.

## DISCUSSION

We sought to elucidate the conservation behavior outcomes associated with varying levels of participation in a Smithsonian conservation research program, Virginia Working Landscapes (VWL), as well as factors that are associated with VWL's perceived impact on these

outcomes. Perceived impact was calculated by averaging responses to each conservation behavior impact question. Although citizen scientist and non-citizen scientist respondents were demographically similar, our regression analysis demonstrated that citizen scientists reported significantly higher VWL impacts on their adoption of conservation behaviors than non-citizen scientists. This suggests that respondents' engagement in conservation behaviors is not inherently tied to the individual participant, but rather there are certain aspects of the program that are influencing this higher perceived impact. Indeed, our results revealed that program factors were predictive of respondents' perceptions of VWL's impact on conservation behavior adoption, rather than participant factors. Our findings may aid conservation research programs aiming to increase their impact on participant conservation behavior outcomes. Below, we detail how program factors were predictive of the program's perceived impact, and provide suggestions on how conservation research programs may integrate these findings into their program.

Participation as a VWL citizen scientist was significantly predictive of respondents' perceptions of VWL's impact on their conservation behaviors. The relationship between citizen science participation and conservation behavior adoption has been well studied (e.g., [Toomey and Domroese 2013](#)), and a program's influence on citizen scientists' conservation behaviors has been found to increase with time spent with the program ([Lewandowski and Oberhauser 2016](#); [Overdeest et al. 2004](#)). Our findings may be attributable to a deeper level of involvement that citizen scientists have with the program compared with non-citizen scientists. While both groups can attend VWL events and read VWL's monthly newsletter, citizen scientists have opportunities to become trained in research protocols, conduct ecological research, observe conservation practices being implemented on survey properties, and interact with VWL staff and other citizen scientists. These added opportunities may lead to various outcomes such as increased science efficacy, inspiration for land management practices, new knowledge about species-habitat relationships, and direct influences from staff, landowners, and their peers.

Attending events is another way that participants can become more involved with a program, and we found event attendance to be predictive of participants' perceptions of VWL's impact on conservation behavior adoption. Past studies have also illustrated the connection between event attendance and engagement in conservation behaviors ([Lewandowski and Oberhauser 2017](#); [Dean et al. 2018](#)). Our qualitative analysis further revealed the importance of events for cultivating both scientific knowledge and a sense of community. Not only are attendees learning



new conservation land management techniques, but they are also meeting new people, interacting with staff, and expanding their network of contacts. Thus, programs may increase their impact on participant conservation behavior adoption by hosting events that foster opportunities for participants to interact with their peers (Newton 2001) and program staff (Singh et al. 2018). This may include hosting educational events, field days, or site visits showcasing successful conservation practices (Newton 2001; Singh et al. 2018).

Lastly, our results showed that while newsletters were significant in the NMDS and environmental fit, they were not significantly predictive of perceptions of VWL's impact on conservation behavior adoption with the other more important program factors in the model. Similarly, other research has shown that mailing communications can have varied effects (Lutter et al. 2018) and that indirect forms of engagement are generally less effective than direct forms of engagement (Sharp et al. 2012). Still, our qualitative analysis revealed that many respondents appreciated being kept up-to-date with the program, research outcomes, and events. Additionally, the newsletters feature layperson summaries of recently published peer-reviewed articles that were focused on topics relevant to readers. Based on our findings, we suggest that conservation research programs use more indirect forms of engagement (e.g., newsletters and mailings) as supplemental to, rather than replacement for, more direct forms of engagement (e.g., events) in order to maximize their impact on participant conservation behavior adoption.

Our survey relied on self-reported measures where participants reported their own perceptions of how VWL impacted their engagement in conservation behaviors. Although there has been debate on the correspondence of self-reported measures and direct measures of conservation behavior engagement, self-reported measures are often more feasible given that they are cost-effective and convenient (Kormos and Gifford 2014). If feasible, future studies could employ direct measures of conservation behavior engagement in order to gain a broader understanding of a conservation research program's impact on participant conservation behaviors (e.g., Crall et al. 2012).

Findings from this study highlight several avenues for future research. Although it has been well established in the literature that citizen scientists' adoption of conservation behaviors may increase as they spend more time with a program (Overdevest et al. 2004; Lewandowski and Oberhauser 2017), future research could compare citizen scientists' and non-citizen scientists' time spent engaging

with a conservation program to assess how this may influence conservation behavior engagement. Additional studies could develop a survey instrument to investigate the life cycles of volunteers within the program; specifically, whether program characteristics directly influenced them to become more involved with the program. This research could explore whether there is progressive involvement in a conservation research program—for example, whether reading program materials may influence an individual to attend program events and, ultimately, volunteer as a citizen scientist with the program. Furthermore, future research may benefit from exploring not only participants' engagement in each conservation behavior, but also the frequency of their engagement. This may provide insights into whether participation in a conservation research program influences engagement in a specific conservation behavior at a higher rate when compared with other conservation behaviors.

## CONCLUSION

Our findings illustrate that individuals involved with a conservation research program perceive that the program is impacting them to adopt an array of conservation behaviors. The citizen scientists and non-citizen scientists we surveyed were likely already conservation-minded individuals, as both groups voluntarily elected to be involved with VWL, yet our findings revealed that program factors, rather than participant factors were significant predictors of VWL's perceived impact on conservation behavior adoption. This suggests that participants' adoption of conservation behaviors transcends the individual, and that their association with the program influences conservation behavior change. Thus, our results emphasize the prominent role that program factors play in an individual's perception of a program's impact on their conservation behaviors. These findings have implications for conservation research programs aiming to expand their impact on participant conservation behavior adoption. They illustrate the added value, beyond data collection, of incorporating citizen science into conservation research programs.

## DATA ACCESSIBILITY STATEMENT

Data from this study is not publicly available to respect the confidentiality of survey respondents. A copy of the codebook is available in Supplemental File 7.

## SUPPLEMENTARY FILES

The Supplementary Files for this article can be found as follows:

- **Supplemental File 1.** Variables with each corresponding survey item and scale used in the analysis. DOI: <https://doi.org/10.5334/cstp.507.s1>
- **Supplemental File 2.** Citizen scientist survey instrument. DOI: <https://doi.org/10.5334/cstp.507.s2>
- **Supplemental File 3.** Non-citizen scientist survey instrument. DOI: <https://doi.org/10.5334/cstp.507.s3>
- **Supplemental File 4.** Non-response bias check results for citizen scientists and non-citizen scientists. DOI: <https://doi.org/10.5334/cstp.507.s4>
- **Supplemental File 5.** Citizen scientist and non-citizen scientist engagement in conservation behaviors. DOI: <https://doi.org/10.5334/cstp.507.s5>
- **Supplemental File 6.** Environmental fit output. DOI: <https://doi.org/10.5334/cstp.507.s6>
- **Supplemental File 7.** Codebook used in qualitative analysis of open-ended survey responses. DOI: <https://doi.org/10.5334/cstp.507.s7>

## ETHICS AND CONSENT

This study was reviewed and approved for human subject research by the Virginia Tech Institutional Review Board (Protocol #19-1018) and Smithsonian Institutional Review Board. Informed consent to participate in the study was obtained from each individual at the beginning of the survey.

## ACKNOWLEDGEMENTS

We would like to thank all respondents for taking our survey and contributing to this study. We would also like to thank the individuals who reviewed the survey and the three anonymous reviewers and the Editor for their feedback that improved the manuscript.

## FUNDING INFORMATION

This research was funded by the Jacquemin Family Foundation and the Smithsonian Conservation Commons Working Land & Seascapes Amplification and Innovation Award (grant no. WLS-2019-010).

## COMPETING INTERESTS

One author (Amy EM Johnson) was employed by Virginia Working Landscapes during the duration of the project and one author (Rachael E Green) was employed by Virginia Working Landscapes during part of this project.

## AUTHOR CONTRIBUTIONS

Rachael E Green: data curation, methodology, formal analysis, software, manuscript writing, and editing.

Ashley A Dayer: secured funding, project administration, project design, implementation, methodology, reviewing, and editing.

Amy EM Johnson: secured funding, project administration, implementation, reviewing, and editing.

## AUTHOR AFFILIATIONS

**Rachael E. Green**  [orcid.org/0000-0002-1054-6627](https://orcid.org/0000-0002-1054-6627)

Department of Fish and Wildlife Conservation, Virginia Tech, Blacksburg, Virginia, USA; Smithsonian National Zoo and Conservation Biology Institute, Washington, DC, USA

**Ashley A. Dayer**  [orcid.org/0000-0002-8105-0776](https://orcid.org/0000-0002-8105-0776)

Department of Fish and Wildlife Conservation, Virginia Tech, Blacksburg, Virginia, USA

**Amy E. M. Johnson**  [orcid.org/0000-0002-9288-1305](https://orcid.org/0000-0002-9288-1305)

Smithsonian National Zoo and Conservation Biology Institute, Washington, DC, USA

## REFERENCES

- Ajzen, I.** 1991. The Theory of Planned Behavior. *Organizational Behavior and Human Decision Processes*, 50(2): 179–211. DOI: [https://doi.org/10.1016/0749-5978\(91\)90020-T](https://doi.org/10.1016/0749-5978(91)90020-T)
- Ardoin, NM, Bowers, AW and Gaillard, E.** 2020. Environmental education outcomes for conservation: A systematic review. *Biological Conservation*, 241. DOI: <https://doi.org/10.1016/j.biocon.2019.108224>
- Assumpcao Picorelli, AM, Maximo Pereira, LS, Pereira, DS, Felicio, D and Sherrington, C.** 2014. Adherence to exercise programs for older people is influenced by program characteristics and personal factors: a systematic review. *Journal of Physiotherapy*, 60(3): 151–156. DOI: <https://doi.org/10.1016/j.jphys.2014.06.012>
- Castleberry, A and Nolen, A.** 2018. Thematic analysis of qualitative research data: Is it as easy as it sounds? *Currents*

- in *Pharmacy Teaching and Learning*, 10(6). DOI: <https://doi.org/10.1016/j.cptl.2018.03.019>
- Church, SP, Payne, LB, Peel, S and Prokopy, LS.** 2019. Beyond water data: benefits to volunteers and to local water from a citizen science program. *Journal of Environmental Planning and Management*, 62(2): 306–326. DOI: <https://doi.org/10.1080/09640568.2017.1415869>
- Cooper, CB, Dickinson, JL, Phillips, T and Bonney, R.** 2007. Citizen Science as a Tool for Conservation in Residential Ecosystems. *Ecology and Society*, 12(2). DOI: <https://doi.org/10.5751/ES-02197-120211>
- Crall, AW, Jordan, R, Holfelder, K, Newman, GJ, Graham, J and Waller, DM.** 2012. The impacts of an invasive species citizen science training program on participant attitudes, behavior, and science literacy. *Public Understanding of Science*, 22(6): 745–764. DOI: <https://doi.org/10.1177/0963662511434894>
- Dahlani, L and Maharani, MDD.** 2018. *Palm Oil Sustainable Management Using MDS Model from Social Dimension*. 231(Amca): 50–53. DOI: <https://doi.org/10.2991/amca-18.2018.15>
- Dean, AJ, Church, EK, Loder, J, Fielding, KS and Wilson, KA.** 2018. How do marine and coastal citizen science experiences foster environmental engagement? *Journal of Environmental Management*, 213: 409–416. DOI: <https://doi.org/10.1016/j.jenvman.2018.02.080>
- Dillman, DA, Smyth, JD and Christian, LM.** 2014. *Internet, Phone, Mail, and Mixed-Mode Surveys: The Tailored Design Method*. John Wiley & Sons.
- Ehrenberg, RG, Jakubson, GH, Groen, JA, So, E and Price, J.** 2007. Inside the Black Box of Doctoral Education: What Program Characteristics Influence Doctoral Students' Attrition and Graduation Probabilities? *Educational Evaluation and Policy Analysis*, 29(2): 134–150. DOI: <https://doi.org/10.3102/0162373707301707>
- Evans, C, Abrams, E, Reitsma, R, Roux, K, Salmonsén, L and Marra, PP.** 2005. The Neighborhood Nestwatch Program: Participant Outcomes of a Citizen-Science Ecological Research Project. In *Conservation Biology*, 19(3). DOI: <https://doi.org/10.1111/j.1523-1739.2005.00s01.x>
- Fishbein, M and Ajzen, I.** 2010. *Predicting and Changing Behavior: The Reasoned Action Approach*. Taylor & Francis. DOI: <https://doi.org/10.4324/9780203838020>
- George, D and Mallery, P.** 2019. IBM SPSS Statistics 26 Step by Step: A Simple Guide and Reference. In *IBM SPSS Statistics 26 Step by Step* (6th ed.). Routledge. <https://doi.org/10.4324/9780429056765>
- Giguère, G.** 2006. Collecting and analyzing data in multidimensional scaling experiments: A guide for psychologists using SPSS. In *Tutorials in Quantitative Methods for Psychology*, 2(1). DOI: <https://doi.org/10.20982/tqmp.02.1.p026>
- Graham, S and Rogers, S.** 2017. How Local Landholder Groups Collectively Manage Weeds in South-Eastern Australia. *Environmental Management*, 60(3): 396–408. DOI: <https://doi.org/10.1007/s00267-017-0859-7>
- Green, RJ and Manzi, R.** 2002. A comparison of methodologies for uncovering the structure of racial stereotype subgrouping. *Social Behavior and Personality*, 30(7): 709–727. DOI: <https://doi.org/10.2224/sbp.2002.30.7.709>
- Hilty, J and Merenlender, AM.** 2003. Studying Biodiversity on Private Lands. *Conservation Biology*, 17(1): 132–137. DOI: <https://doi.org/10.1046/j.1523-1739.2003.01361.x>
- Ho, SS, Liao, Y and Rosenthal, S.** 2014. Applying the theory of planned behavior and media dependency theory: Predictors of public pro-environmental behavioral intentions in Singapore. *Environmental Communication*, 9(1): 77–99. DOI: <https://doi.org/10.1080/17524032.2014.932819>
- Holland, SM.** 2008. *Non-Metric Multidimensional Scaling (MDS)*. **Jacobson, SK, McDuff, MD and Monroe, MC.** 2015. *Designing successful conservation education and outreach*. Oxford University Press. DOI: <https://doi.org/10.1093/acprof:oso/9780198716686.003.0002>
- Kamal, S, Grodzińska-jurczak, M and Brown, G.** 2014. Conservation on private land: a review of global strategies with a proposed classification system. *Journal of Environmental Planning and Management*, 58(4): 576–597. DOI: <https://doi.org/10.1080/09640568.2013.875463>
- Kanaya, T, Light, D and Culp, KM.** 2005. Factors Influencing Outcomes From A Technology-Focused Professional Development Program. *Journal of Research on Technology in Education*, 37(3): 313–329. DOI: <https://doi.org/10.1080/15391523.2005.10782439>
- Kollmuss, A and Agyeman, J.** 2002. Mind the Gap: Why do people act environmentally and what are the barriers to pro-environmental behavior? *Environmental Education Research*, 8(3): 1469–5871. DOI: <https://doi.org/10.1080/13504620220145401>
- Kormos, C and Gifford, R.** 2014. The validity of self-report measures of proenvironmental behavior: A meta-analytic review. *Journal of Environmental Psychology*, 40: 359–371. DOI: <https://doi.org/10.1016/j.jenvp.2014.09.003>
- Kuhfuss, L, Préget, R, Thoyer, S, Hanley, N, Le Coent, P and Désolé, M.** 2016. Nudges, social norms, and permanence in agri-environmental schemes. *Land Economics*, 92(4): 641–655. DOI: <https://doi.org/10.3368/le.92.4.641>
- Larson, LR, Stedman, RC, Cooper, CB and Decker, DJ.** 2015. Understanding the multi-dimensional structure of pro-environmental behavior. *Journal of Environmental Psychology*, 43: 112–124. DOI: <https://doi.org/10.1016/j.jenvp.2015.06.004>
- Lewandowski, EJ and Oberhauser, KS.** 2016. Contributions of Citizen Scientists and Habitat Volunteers to Monarch Butterfly Conservation. *Human Dimensions of Wildlife*, 22(1). DOI: <https://doi.org/10.1080/10871209.2017.1250293>

- Lewandowski, EJ** and **Oberhauser, KS**. 2017. Butterfly citizen scientists in the United States increase their engagement in conservation. *Biological Conservation*, 208: 106–112. DOI: <https://doi.org/10.1016/j.biocon.2015.07.029>
- Lutter, SH, Dayer, AA, Heggenstaller, E** and **Larkin, JL**. 2018. Effects of biological monitoring and results outreach on private landowner conservation management. *PLoS ONE*, 13(4). DOI: <https://doi.org/10.1371/journal.pone.0194740>
- Lynch, LI, Dauer, JM, Babchuk, WA, Heng-Moss, T** and **Golick, D**. 2018. In their own words: The significance of participant perceptions in assessing entomology citizen science learning outcomes using a mixed methods approach. *Insects*, 9(16): 1–15. DOI: <https://doi.org/10.3390/insects9010016>
- Merenlender, AM, Crall, AW, Drill, S, Prysby, M** and **Ballard, H**. 2016. Evaluating environmental education, citizen science, and stewardship through naturalist programs. *Conservation Biology*, 30(6): 1255–1265. DOI: <https://doi.org/10.1111/cobi.12737>
- Newton, BJ**. 2001. Environmental Education and Outreach: Experiences of a Federal Agency. *BioScience*, 51(4): 297–299. [www.nhq.nrcs.usda.gov/CCS/Back-](http://www.nhq.nrcs.usda.gov/CCS/Back-). DOI: [https://doi.org/10.1641/0006-35682001051\[0297:EEAOE\]2.0.CO;2](https://doi.org/10.1641/0006-35682001051[0297:EEAOE]2.0.CO;2)
- O'Brien, RSM, Dayer, AA** and **Hopkins, WA**. 2021. Understanding landowner decisions regarding access to private land for conservation research. *Conservation Science and Practice*, 3(11): 1–12. DOI: <https://doi.org/10.1111/csp2.522>
- Oksanen, J, Blanchet, FG, Friendly, M, Kindt, R, Legendre, P, McGlenn, D, Minchin, PR, O'Hara, RB, Simpson, GL, Solymos, P, Stevens, MHH, Szoecs, E** and **Wagner, H**. 2020. *vegan: Community Ecology Package* (R package version 2.5-7). <https://cran.r-project.org/package=vegan>.
- Overdevest, C, Huyck Orr, C** and **Stepenuck, K**. 2004. Volunteer Stream Monitoring and Local Participation in Natural Resource Issues. In *Society for Human Ecology*, 11(2).
- Park, J** and **Ha, S**. 2014. Understanding Consumer Recycling Behavior: Combining the Theory of Planned Behavior and the Norm Activation Model. *Family and Consumer Sciences Research Journal*, 42(3): 278–291. DOI: <https://doi.org/10.1111/fcsr.12061>
- Prokopy, LS, Floress, K, Arbuckle, JG, Church, SP** and **Eanes, FR**. 2019. Adoption of agricultural conservation practices in the United States: Evidence from 35 years of quantitative literature. *Sociology Publications*, 74(5): 520–534. DOI: <https://doi.org/10.2489/jswc.74.5.520>
- Qualtrics**. 2021. *Qualtrics* (1.2021). <https://www.qualtrics.com>. Accessed April 2022.
- R Core Team**. 2021. *R: A language and environment for statistical computing*. Accessed March 2022.
- Sharp, RL, Larson, LR, Green, GT** and **Tomek, S**. 2012. Comparing Interpretive Methods Targeting Invasive Species Management at Cumberland Island National Seashore. *Journal of Interpretation Research*, 17(2): 23–40. DOI: <https://doi.org/10.1177/109258721201700203>
- Singh, A, MacGowan, B, O'Donnell, M, Overstreet, B, Ulrich-Schad, J, Dunn, M, Klotz, H** and **Prokopy, L**. 2018. The influence of demonstration sites and field days on adoption of conservation practices. *Journal of Soil and Water Conservation*, 73(3): 276–283. DOI: <https://doi.org/10.2489/jswc.73.3.276>
- Stiwinski, MS, Burbach, ME, Powell, LA** and **Schacht, WH**. 2018. Factors influencing ranchers' intentions to manage for vegetation heterogeneity and promote cross-boundary management in the northern Great Plains. *Ecology and Society*, 23(4). DOI: <https://doi.org/10.5751/ES-10660-230445>
- SocioCultural Research Consultants LLC**. 2021. *Dedoose* (8.3.47). [www.dedoose.com](http://www.dedoose.com). Accessed March 2022.
- Steg, L** and **Vlek, C**. 2009. Encouraging pro-environmental behaviour: An integrative review and research agenda. *Journal of Environmental Psychology*, 29(3): 309–317. DOI: <https://doi.org/10.1016/j.jenvp.2008.10.004>
- Sullivan, BL, Phillips, T, Dayer, AA, Wood, CL, Farnsworth, A, Iliff, MJ, Davies, IJ, Wiggins, A, Fink, D, Hochachka, WM, Rodewald, AD, Rosenberg, KV, Bonney, R** and **Kelling, S**. 2017. Using open access observational data for conservation action: A case study for birds. *Biological Conservation*, 208: 5–14. DOI: <https://doi.org/10.1073/pnas.1916903117>
- Theobald, EJ, Hill, MJ, Tran, E, Agrawal, S, Arroyo, EN, Behling, S, Chambwe, N, Cintrón, DL, Cooper, JD, Dunster, G, Grummer, JA, Hennessey, K, Hsiao, J, Iranon, N, Jones, L, Jordt, H, Keller, M, Lacey, ME, Littlefield, CE, ... Freeman, S**. 2020. Active learning narrows achievement gaps for underrepresented students in undergraduate science, technology, engineering, and math. *Proceedings of the National Academy of Sciences*, 117(12): 6476–6483. DOI: <https://doi.org/10.1073/PNAS.1916903117>
- Toomey, AH** and **Domroese, MC**. 2013. Can citizen science lead to positive conservation attitudes and behaviors? *Research in Human Ecology*, 20(1): 50–62. <https://www.jstor.org/stable/24707571>.
- Virginia Working Landscapes Annual Report**. 2020. [https://www.vaworkinglandscapes.org/wp-content/uploads/VWL\\_AnnualReport\\_2020.pdf](https://www.vaworkinglandscapes.org/wp-content/uploads/VWL_AnnualReport_2020.pdf). Accessed March 2021.
- Whaley, AL** and **Longoria, RA**. 2008. Assessing cultural competence readiness in community mental health centers: A multidimensional scaling analysis. *Psychological Services*, 5(2): 169–183. DOI: <https://doi.org/10.1037/1541-1559.5.2.169>
- Wilson, JL**. 1994. *Interventions for pregnant and parenting adolescents: the effects of program and participant characteristics on program outcomes*. Unpublished thesis (PhD), The Pennsylvania State University.



---

**TO CITE THIS ARTICLE:**

Green, RE, Dayer, AA and Johnson, AEM. 2023. Citizen Scientist Participation in Research on Private Lands Positively Impacts Multiple Conservation Behaviors. *Citizen Science: Theory and Practice*, 8(1): 53, pp. 1–13. DOI: <https://doi.org/10.5334/cstp.507>

**Submitted:** 08 March 2022    **Accepted:** 27 July 2023    **Published:** 01 September 2023

**COPYRIGHT:**

© 2023 The Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution 4.0 International License (CC-BY 4.0), which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited. See <http://creativecommons.org/licenses/by/4.0/>.

*Citizen Science: Theory and Practice* is a peer-reviewed open access journal published by Ubiquity Press.

