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Contributed Paper

Evaluating environmental education, citizen science, and stewardship through naturalist programs

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Abstract: *Amateur naturalists have played an important role in the study and conservation of nature since the 17th century. Today, naturalist groups make important contributions to bridge the gap between conservation science and practice around the world. We examined data from 2 regional naturalist programs to understand participant motivations, barriers, and perspectives as well as the actions they take to advance science, stewardship, and community engagement. These programs provide certification-based natural history and conservation science training for adults that is followed by volunteer service in citizen science, education, and stewardship. Studies in California and Virginia include quantitative and qualitative evaluation data collected through pre- and postcourse surveys, interviews, and long-term tracking of volunteer hours. Motivations of participants focused on learning about the local environment and plants and animals, connecting with nature, becoming certified, and spending time with people who have similar interests. Over half the participants surveyed were over 50 years old, two-thirds were women, and a majority reported household incomes of over $50,000 (60% in California, 85% in Virginia), and <20% of those surveyed in both states described themselves as nonwhite. Thus, these programs need to improve participation by a wider spectrum of the public. We interviewed younger and underrepresented adults to examine barriers to participation in citizen science. The primary barrier was lack of time due to the need to work and focus on career advancement. Survey data revealed that participants' ecological knowledge, scientific skills, and belief in their ability to address environmental issues increased after training. Documented conservation actions taken by the participants include invasive plant management, habitat restoration, and cleanups of natural areas and streams. Long-term data from Virginia on volunteer hours dedicated to environmental citizen science show an increase from 14% in 2007 to 32% in 2014. In general, participants in the naturalist programs we examined increased their content knowledge about ecosystems, had greater confidence in conserving them, and continued to engage as citizen scientists after completing the program.*

Keywords: diversity, ecological monitoring, natural history, UC California Naturalist, Virginia Master Naturalist, volunteers

La Evaluación de la Educación Ambiental, la Ciencia Ciudadana y la Administración por medio de Programas Naturalistas

Resumen: *Los naturalistas aficionados han jugado un papel importante en el estudio y la conservación de la naturaleza desde el siglo XVII. Hoy en día, los grupos naturalistas realizan contribuciones importantes para cerrar el vacío entre la ciencia y la práctica de la conservación en todo el mundo. Examinamos los datos de dos programas naturalistas regionales para entender las motivaciones de los participantes, las barreras y las perspectivas así como las acciones que se toman para avanzar en la ciencia, la administración y el compromiso de la comunidad. Estos programas proporcionan historia natural basada en la certificación y entrenamiento para adultos en la conservación de la ciencia que es seguido por servicios voluntarios en*

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la ciencia ciudadana, la educación y la administración. Los estudios en California y en Virginia incluyen evaluaciones cuantitativas y cualitativas de datos colectados por medio de censos pre- y postcurso, entrevistas y el rastreo a largo plazo de las horas de voluntariado. Las motivaciones de los participantes se enfocaron en aprender sobre el ambiente local, las plantas y los animales, conectar con la naturaleza, certificarse y pasar tiempo con personas con intereses comunes. Más de la mitad de los participantes censados tenían más de 50 años, dos-tercios eran mujeres y la mayoría de los ingresos domésticos reportados eran de más de $50, 000 (60 % en California, 85 % en Virginia) y <20 % de aquellos censados en ambos estados se describieron a sí mismos como no-blancos. Por ello, estos programas necesitan mejorar la participación ampliando el espectro del público. Entrevistamos a adultos más jóvenes y poco representados para examinar las barreras de la participación en la ciencia ciudadana. La principal barrera fue la falta de tiempo debido a la necesidad de trabajar y enfocarse en el avance académico. Los datos del censo revelaron que el conocimiento ecológico de los participantes, las habilidades científicas y la creencia en su habilidad de enfocarse en asuntos ambientales incrementaron después del entrenamiento. La documentación de las acciones de conservación realizadas por los participantes incluye el manejo de plantas invasoras, restauración de hábitat y limpieza de áreas naturales y arroyos. Los datos a largo plazo de Virginia sobre las horas de voluntariado dedicadas a la ciencia ciudadana ambiental muestran un incremento del 14 % en 2007 al 32 % en 2014. En general, los participantes de los programas naturalistas que examinamos incrementaron su conocimiento de contenido sobre los ecosistemas, tuvieron mayor confianza en conservarlos y continuar su compromiso como ciudadanos científicos después de completar el programa.

Palabras Clave: diversidad, historia natural, monitoreo ecológico, Naturalista UC California, Naturalista Virgina Master, voluntarios

Introduction

Broadening community participation in environmental science and stewardship is an important priority in acknowledgment of the role of human behavior in determining environmental conditions. Environmental education programs play a vital role in engagement in environmental stewardship (Wals et al. 2014), strengthening the link between knowledge and action for participants. Similarly, citizen science, defined as engaging nonprofessionals in scientific research, is a critical component of Earth stewardship that strengthens community involvement and helps people develop a sense of and commitment to place (Dickinson et al. 2012). Citizen science has a long tradition within the field of natural history and is increasingly recognized as being an important component of science learning and environmental education that provides real opportunities to strengthen global-change monitoring (Bonney et al. 2014). Participants in citizen science projects have strong positive attitudes toward the environment (Brossard et al. 2005; Crall et al. 2013; Toomey & Domroese 2013), which can be linked to proenvironmental behavior (Heimlich & Ardoin 2008). Citizen science also provides opportunities for the public to engage in research and management activities that affect natural and human communities (Danielsen et al. 2005; Fernandez-Gimenez et al. 2008).

There is a long-lived tradition of amateur naturalists collecting specimens, recording their observations in journals, and becoming experts on particular habitats or taxa since the 17th century (Miller-Rushing et al. 2012). This practice is still vital in most countries and is often performed by groups of local naturalists who form a key link between professional and public understanding of science. Some field-naturalist societies have a long history such as The Trinidad and Tobago Field Naturalists' Club, founded in 1891. This volunteer association brings together people interested in studying natural history and conserving natural resources. Other examples include Nature London (McIlwraith Field Naturalists), which was founded 150 years ago and is dedicated to the preservation and enjoyment of nature, and its sister organization, Nature Canada, which oversees the NatureNetwork—a partnership of Canadian organizations with more than 350 local clubs in cities across Canada. The missions of these groups vary but often include education, conservation, citizen science, and stewardship.

In the United States, the increasingly popular master-naturalist programs give the public one way to participate in citizen science. Master-naturalist programs usually focus on training, participant certification, and related conservation volunteer work. The first of these programs was started in 2001, and they now exist in 29 states (Rasmussan 2002; ANROSP 2016). Typically, program participants become certified after completing 40–50 hours of training during which they are introduced to a variety of ecological and natural resource information. Some programs offer participants the option to receive college credit, and some participants add the certification to their credentials for volunteer and paid employment opportunities. Most programs require or offer incentives for volunteering in citizen science, stewardship, and education or interpretation.

The popularity of these programs, and naturalist societies worldwide, may be a sign that a natural-history revival is occurring (Tewksbury et al. 2014). There are,

however, few people of color studying nature, contributing to citizen science, or working in the environmental field in the United States (Taylor 2014). It is well documented that engaging members of these historically underserved populations in natural resource management and citizen science is challenging (Pandya 2012).

Researching participant motivations is essential for understanding, recruiting, and retaining participants in citizen science activities (Batson et al. 2002; Wright et al. 2015). People are motivated to participate in citizen science projects when they believe their actions enhance scientific knowledge, educate the public, or provide evidence on environmental quality (Lawrence 2006; Jordan et al. 2011). Motivations for participating in master naturalist programs, specifically, have also been studied. For example, in Minnesota participants were motivated to learn about, benefit from, and teach others about nature and expected personal benefits such as stress reduction, relaxation, and opportunities for exercise while participating in volunteer activities (Guiney & Oberhauser 2009).

We examined 2 regional naturalist programs that connect environmental education, citizen science, and community service to advance on-the-ground conservation and to bridge the widely recognized gap between conservation science and implementation (Knight et al. 2006). The Virginia Master Naturalist (VMN) program was launched in 2005. Its mission is to engage volunteers in community-based natural resource education and conservation. The University of California's California Naturalist program (CA Naturalist) was started in 2012 to foster a diverse community of naturalists and promote stewardship of California's natural resources through education and service. Data collected on these programs reveal who has participated; participant motivations; potential barriers to diverse participation; possible strategies to diversify involvement; and conservation actions participants have taken.

Methods

Study Sites

In Virginia, 7 state natural resource agencies work together to oversee and support the VMN program (http://www.virginiamasternaturalist.org/). The University of California Division of Agriculture and Natural Resources oversees the CA Naturalist program (http://calnat.ucanr.edu/). California has 30 courses taught in partnership with private nonprofit organizations, local and state agencies, and community college and university facilities. In Virginia, there are 30 master naturalist chapters across the state managed locally by volunteers. Becoming a master naturalist in either state involves 40 hours of course training that focuses on biogeography, plant and animal communities, and environmental issues and skills to enhance nature observation and data-collection abilities. Certification in Virginia requires an additional 8 hours of continuing education and 40 hours of volunteer service, whereas California encourages and provides incentives for these but does not require them.

Both California and Virginia's programs integrate citizen science training into the course and facilitate continued participation in citizen science following certification. The California naturalist training program includes exposure to a multitude of citizen science projects applicable to California residents through an online project portal and in-class discussion about citizen science; training in a specific citizen science project while taking the course; documenting observations in iNaturalist, a citizen science project and online social network of naturalists focused on mapping and sharing species observations; and continued online correspondence about citizen science opportunities. In Virginia, each basic course is required to include an introduction to citizen science and research skills. Local chapters adapt skills taught in the training to facilitate volunteer participation in local, state, and national projects.

Data Collection and Analyses

We used data from both programs to address our research questions. However, because the data were collected independently, no attempt was made to compare data sets between programs or to use data from one program to explain findings in the other. We used multinomial goodness-of-fit (χ^2) tests for comparisons between observed demographic data and expected frequencies based on 2013 federal census data.

In 2013, the VMN program used a 2-phase exploratory sequential mixed-methods research design to conduct a comprehensive needs assessment (Creswell & Plano Clark 2011) (details in Supporting Information). On the basis of focus-group findings, the program asked volunteers, sponsors, and partners to "Please rank on a scale of 0 (none) to 100 (a lot) to what degree you feel the Virginia Master Naturalist program volunteers are making a difference in their communities in each of the ways" listed in Table 1. We collected responses from 533 volunteers, 117 sponsoring-agency staff members, and 51 partnering-organization staff members (Table 1).

In California, we conducted semistructured interviews with 28 program graduates in 2012. We conducted approximately 1-hour in-person interviews at 2 sites in Northern California immediately after course completion. Interview questions we analyzed focused on participant motivations for joining the CA Naturalist program and motivations for and barriers to participating in citizen science. To explore reasons why individuals did or did not engage in citizen science projects after becoming certified California Naturalists, we conducted follow-up

Table 1. Responses (mean) from 533 volunteers, 117 sponsoring agency staff, and 51 partnering organization staff to the question, "Please rank on a scale of 0 (none) to 100 (a lot) to what degree you feel the Virginia Master Naturalist program volunteers are making a difference in their communities in each of the following ways."

Impact	*Volunteers (SD)*	*Sponsors (SD)*	*Partners (SD)*
Participating in environmental stewardship projects	76 (20)	72 (27)	82 (23)
Contributing data through citizen science to inform research or management	71 (23)	56 (28)	71 (28)
Educating and engaging the public	67 (26)	67 (26)	75 (22)
Creating knowledgeable and credible volunteers in the local community	66 (29)	69 (27)	81 (16)
Supporting work of natural resource professionals	65 (26)	66 (26)	74 (23)
Generating advocates for natural resource agencies	58 (28)	61(26)	71 (27)
Increasing self-confidence of volunteers	58 (29)	66 (25)	69 (22)
Developing community through social connections	54 (30)	57 (27)	64 (24)
Increasing economic activity through improvements of natural resources or environmental services	51 (28)	41 (27)	42 (27)
Increasing economic activity through visitation or tourism during master-naturalist events	39 (25)	40 (27)	41 (29)
Providing professional development and job opportunities	28 (28)	39 (26)	43 (31)

interviews by phone 6 and 12 months after the training course and asked, "Have you participated in any citizen science activities in the last 6/12 months, and if not, why not?" We used QSR (2012) Nvivo qualitative analysis software to code themes that emerged from the data and then calculated the number of responses that related to each coded theme.

We also surveyed California Naturalists at the beginning and end of their courses in 2013 and 2014. In the precourse survey, we collected data on participant characteristics and motivations for participating. We requested instructor evaluation and information about course content at the end. Standardized evaluation questions used in the pre- and postsurveys came from the developing, validating, and implementing standardized evaluation instruments (DEVISE) protocol developed from a comprehensive evaluation of citizen science project participants (Phillips et al. 2014; Bonney et al. 2016). The questions measure individual learning outcomes as a result of project participation and rely on a 9-point Likert scale. We also asked 16 ecological-knowledge questions about information covered in the curriculum, such as geological and watershed processes, California's climate, the Linnaean system of classification, parts of a plant, and changes expected due to climate change, to measure differences in knowledge before and after the course (de Nevers et al. 2012). We used paired (based on a unique numeric identifier for each participant) pre- and postcourse surveys for 154 individuals who took the CA Naturalist course in 2013 and 2014. We calculated mean scores from before and after the course, significant differences based on paired t tests, 95% confidence intervals, and statistical power for comparing means given observed standard deviation. All participant data collection complied with U.S. federal regulations and policies for the protection of human subjects (Virginia IRB 13–529; California IRB 258312-2).

Finally, we analyzed data on the volunteer activities of the naturalists following the training courses, for both state programs, from an online volunteer reporting system. Data included the number of hours of service contributed by type of project (i.e., citizen science, conservation and stewardship, interpretation, and education), activity descriptions, comments on activities, and detailed information on activities. We assigned each activity a geographic scope: local, intrastate regional, state, multistate (in California only), national, or international. We also coded the volunteers' activities by type and further by taxonomic group, subject, or phenomenon of interest. Types included environmental quality, monitoring of restoration projects, mapping and monitoring of invasive species, and collection of baseline ecological data.

Results

The Virginia Master Naturalist program has trained approximately 3,300 volunteers since the program began in 2005. The California program has certified 1,200 naturalists through collaborations with 20 local institutions, including 2 community colleges by the end of 2014. Several hundred new volunteers are trained and provide service across both states each year. In both programs the participants are mostly older white females from higher socioeconomic classes, and most participants have college degrees. Detailed demographic data for a large sample of participants from both states are in Table 2.

Participant Motivations

Motivations for taking the training course and becoming certified were similar for both programs. California Naturalists ($n = 530$) took the training to "learn more about local environments, plants and animals" (87% of

Table 2. Demographic data from surveys of participants in the University of California California Naturalist (CA) and the Virginia Master Naturalist (VA) Programs and goodness-of-fit results based on comparisons with 2013 U.S. census data (in parentheses).

Demographic factor	*CA*	*VA*
Race or ethnicity[a]		
white (%)	82 (58)	97 (68)
Hispanic or Latino (%)	9 (37)	1 (8)
other (%)	9 (5)	2 (24)
Employed or student[b]		
unemployed or not working by choice (%)	8 (12)	NA
part or full-time students (%)	17 (11)	NA
part of full-time work (%)	55 (64)	NA
retired (%)	20 (10)	NA
Education level[c]		
no college (%)	5 (39)	NA
junior college or technical training (%)	26 (30)	NA
bachelor's degree (%)	30 (20)	NA
graduate degree (%)	39 (11)	NA
Average income (US$)[d]		
< 20,000	14 (34)	2 (33)
20,000–50,000	25 (24)	13 (26)
50,000–100,000	34 (26)	34 (26)
>100,000	27 (16)	51 (15)
Age (years)[e]		
CA 18–29; VA 15–24 (%)	19 (15)	1 (14)
CA 30–39; VA 25–34 (%)	13 (14)	5 (14)
CA 40–49; VA 35–44 (%)	14 (14)	6 (13)
CA 50–59; VA 45–54 (%)	23 (13)	16 (14)
CA 60–69; VA 55–64 (%)	25 (8)	38 (12)
CA >70; VA >65 (%)	6 (8)	34 (13)
Sex[f]		
female (%)	67 (50)	70 (51)
male (%)	32 (49.7)	30 (49.2)

[a]*Statistical values: CA, $n = 477$, $\chi^2 = 170.5$, $df = 2$, $p < 0.00$; VA, $n = 491$, $\chi^2 = 183.2$, $df = 2$, $p < 0.00$.*
[b]*Statistical values : CA, $n = 594$; multiple selection allowed, not comparable with census data.*
[c]*Statistical values: CA, $n = 522$, $\chi^2 = 546.8$, $df = 3$, $p < 0.00$.*
[d]*Statistical values: CA, $n = 477$, $\chi^2 = 102.7$, $df = 3$, $p < 0.00$; VA, $n = 431$, $\chi^2 = 563$, $df = 3$, $p < 0.00$.*
[e]*Statistical values: CA, $n = 503$, $\chi^2 = 356.8$, $df = 5$, $p < 0.00$; VA, $n = 501$, $\chi^2 = 626.8$, $df = 5$, $p < 0.00$.*
[f]*Statistical values: CA: $n = 510$, $\chi^2 = 61.3$, $df = 1$, $p < 0.00$; VA, $n = 499$, $\chi^2 = 73.1$, $df = 1$, $p < 0.00$.*

respondents); "become a certified UC California Naturalist" (77%); "spend time outside" (56%); and "meet others with similar interests" (56%). Virginia Master Naturalists ($n = 533$) sought "to learn more" (87%), "to connect with nature" (74%), "to meet others with similar interests" (48%), and "to volunteer and give back to the community" (45%).

Qualitative data from the California Naturalists interviewed at the start of the training in 2012 offered a slightly more nuanced set of reasons for participating in the course. The most frequently cited reasons for joining the program were consistent with the survey data: to learn about local natural history (52% of respondents), for social reasons or being with like-minded people (17%), spending time outdoors or to connect to their local place (10%), and a desire to make a contribution as a volunteer (10%). But an additional key reason was the desire to take the course to help prepare for college or careers in the natural sciences (21%). This may stem from the high proportion of young adults who were interviewed, relative to the typically older naturalist population. For example, one young woman commented, "I'm thinking about changing careers and going back to school and doing something more naturey, more specifically with birds, so I wanted to get more experience that might help me get into a program and also experience that will expose me to more aspects of nature."

Barriers to Participation in Naturalist and Citizen Science Programs

As part of the comprehensive needs assessment conducted in Virginia, focus groups identified a number of obstacles to recruiting a diverse audience to naturalist communities. One of these obstacles was the time commitment required to take courses and engage in volunteer service. The demographic data (Table 2) shows lower participation in younger people (25–39 years old), whose career building and family can be all consuming. The expense of naturalist courses, materials, computers, field supplies, and travel can be prohibitive for some. Science education and skills were also identified as roadblocks for some people, and this was corroborated by the predominance of participants with higher education levels, as seen in the California demographic data (Table 2). Virginia focus-group participants also discussed physical abilities as potential barriers, as well as feelings of not fitting in that people different from the majority of the participants might experience.

Of those California Naturalists interviewed 6 and 12 months after the course, 55% reported participating in citizen science. Fourteen percent had not participated at 6 months but had participated at 12 months, 21% had participated at 6 months but had ceased at 12 months, and 21% had not participated in citizen science at either 6 or 12 months. Results from these interviews offer a rare glimpse into the barriers to participation in citizen science (Table 3).The predominant reason offered was lack of time (21%). Younger adults (under 30 years) also cited the need to work (7%) or to do an internship that would further their career interests (14%).

Impacts of Naturalist Programs on Participants

The CA Naturalist training course affected participants' ecological knowledge, perceived skills, and volunteer conservation actions in several ways. The average knowledge scores for 2013–2014 California Naturalists increased 12% after the course (Table 4). Equally important,

Table 3. Barriers to citizen science reported by California Naturalists at 6- and 12-month follow-up interviews based on coded responses to the question, "Have you participated in any citizen science activities in the last 6 months, and if not, why not?"

Barriers to participating in citizen science	*Percentage of respondents (n = 29)*	*Example quote*
Need to work or do internship to pursue career interests, rather than volunteer	21 (7 and 14 respectively)	"You have to weigh it on a scale which [activities] are closest to where you want to go, or where you can get to."
Lack of time	21	"I would say it's lack of time, lack of money because I have to work full time because I don't have a lot of money right now, but I definitely do want to get involved after this job ends."
Interest in other volunteering (education or stewardship) or citizen science just not a priority	17	"I think some of it is the immediate gratification . . . if you do (stewardship) vegetation work you see the results immediately, where I think some of the citizen science things you're part of the study but it's going to be a long time. So it's an important thing and I . . . appreciate how important it is, but I think maybe it's a lack of patience . . . ."
Lack of transportation or no projects nearby	14	"A lot of the stuff I get from you guys is of course . . . up in [the Preserve], and that area, and that's pretty far for us to go."
Didn't find any interesting projects	10	"I guess you'd kind of have to have a project in mind or have some sort of goal . . . . I would want to find an organization that needs something done [but] I haven't seen flyers that say, 'We need bird counts!'"

the percentage of low scores (<60% correct) declined from 27% before to 6.5% after the course.

Similarly, participants' responses to the survey regarding their confidence in performing 11 scientific-inquiry tasks (testing skills such as following scientific protocols and making observations) increased significantly across all tasks after the course (Table 4). Identification of species, habitats, and other features in nature; observational skills; and ability to use field equipment all improved markedly (Table 4). This was consistent with the emphasis in the California program of developing skills for nature observation.

With regard to participants identifying themselves as scientists and their interest in the scientific endeavor, observable shifts occurred. There were fewer low scores in the post-course survey; although the average overall scores were not significantly different (Table 4). However, when participants were asked about their capacity to address environmental issues, higher mean scores across all questions in this survey strand were observed after the course (Table 4).

Participant Actions

In both programs, participants recorded extensive conservation volunteer actions after completing naturalist certification training. These included citizen science, education, and stewardship activities in both states. We also found evidence in the Virginia focus groups that volunteers' thought their actions added value to natural resource conservation. Volunteers, members of sponsoring agencies, and staff of partnering organization that participated in the Virginia needs assessment all ranked environmental stewardship projects as having the greatest impact and ranked educating and engaging the public as having the third greatest impact. Volunteers ranked contributions to citizen science as having the second greatest impact among those listed, whereas sponsoring agencies and partnering organizations ranked these contributions as seventh and fifth, respectively (Table 1).

From 2005 to 2014, Virginia Master Naturalists contributed over 526,000 hours of natural resource volunteer service. In 2014, the program had 1,468 active volunteers (i.e., those who reported volunteer service during the year). For the younger California program, participants had recorded just over 21,000 hours at the close of 2014. The percentage of each type of service contributed by the naturalists from both states is shown in Fig. 1.

In Virginia, citizen science hours increased more rapidly than any other service type, from 14% in 2007 to 32% in 2014 (Fig. 1). These hours were divided fairly evenly among local, state, and national citizen science projects. In California, local efforts received the majority of the attention; 62.1% of the 4,840 hours contributed to citizen science focused on local projects. The rest were roughly equally divided among an intrastate region, the California or Pacific western United States, and a national or international scales. Most of the citizen science hours (89%) were categorized as basic ecology science projects, in contrast to 3.5% classified as invasive species and disease monitoring and 7.5% as restoration and environmental quality monitoring, including data collection on water quality as well as watershed conditions. In Virginia, 88% of the citizen science hours were spent on activities categorized as ecology science projects, 11% on

Table 4. Results from California Naturalist program on changes in participants' knowledge, skills, science, and environmental identity ($n = 154$).

Question type	*P**	*Precourse mean % (95% CI)*	*Postcourse mean % (95% CI)*
Ecological knowledge ($p < 0.01$)			
percent correct for 16 questions (e.g., ecological and watershed processes, California's climate, the Linnaean system of classification, parts of a plant, and changes expected due to climate change)	1	67.08 (64, 70)	79.22 (77.22, 81.22)
Scientific inquiry skills ($p < 0.05$)			
sum of scores for 11 total tasks (e.g., observing species and habitats, following scientific protocols, and using field equipment)	0.89	76.90 (74.76,79.05)	81.47 (79.64, 83.31)
Seeing ones self as a scientist ($p > 0.05$)			
"It's hard for me to imagine myself as a scientist."	0.18	7.21 (6.88, 7.54)	7.45 (7.14, 7.76)
"I have always had a natural talent for doing science."	0.06	6.59 (6.26, 6.92)	6.53 (6.18, 6.88)
"I can easily imagine myself as a scientist."	0.08	7.01 (6.71, 7.32)	7.14 (6.81, 7.47)
Address environmental issues ($p < 0.01$)			
"I believe that I personally working with others can help solve environmental issues. (p to go above)"	0.81	7.57 (7.30, 7.84)	8.04 (7.86,8.21)
"Compared to other people, I think I can make a positive impact on the environment."	0.98	7.03 (6.74, 7.32)	7.53 (7.54, 7.97)
"I believe I can contribute to solutions to environmental problems by my actions."	0.83	7.73 (7.53, 7.92)	8.11 (7.94, 8.28)
"I am able to help take care of nature."	0.84	7.76 (7.54, 7.98)	8.16 (8.01, 8.31)
"I am capable of making a positive impact on the environment. "	0.87	7.78 (7.58, 7.99)	8.18 (8.03, 8.33)
"I feel confident in my ability to help protect the planet."	0.83	7.22 (6.98, 7.46)	7.71 (7.48, 7.93)

* *Statistical power analysis for comparing means ($P = ß - 1$).*

environmental monitoring (all water-quality monitoring in this case), and 1% on invasive species and disease monitoring. Bird, fish, and other wildlife studies made up over half of the effort expended by the naturalists doing citizen science. Studies of plants and fungi were the focus in 14% of the recorded time in California and 7% in Virginia. Weather and water monitoring received 8% of the recorded time in California and 13% in Virginia.

Trained naturalists in Virginia and California participated in citizen science programs that differed in the degree participants engaged in each step of the research process (Bonney et al. 2009). The degree of engagement in citizen science ranged from contributing data that required some degree of training, to training others to collect data, to coordinating a project with a researcher, and finally to creating a research study. A good example of the latter is the TeenNat program at the Pepperwood Preserve, where certified California Naturalists trained teenagers to use iNaturalist.org as a data-collection tool. In Virginia volunteers from multiple chapters provided data to the state through a monitoring effort targeting water quality. Others did additional outreach on behalf of citizen science projects they were engaged in, such as contributing to a blog, which served to magnify the impact of these projects. Several certified naturalists also developed their own field investigations that contributed to ecosystem stewardship, such as studying the spread of invasive Argentine ants (*Linepithema humile*) at Pepperwood Preserve in California. In Virginia, volunteers worked alongside managers to design and implement studies to identify the most effective control strategy for Japanese stilt grass (*Microstegium vimineum*), a species negatively affecting a longleaf pine ecosystem that is home to the endangered Red-cockaded Woodpecker (*Leuconotopicus borealis*).

Participants spent time educating others in their community about nature and environmental issues in both states. Between 2005 and 2014, VMN volunteers contributed over 135,000 hours to educating youth and adults about natural resources. During that time, the volunteers spent face-to-face time with more than 421,025 individuals to provide science-based information on the environment. Some of these educational programs reached audiences typically not served by natural resource programming. Although the VMN volunteers were primarily white, their outreach and education programs

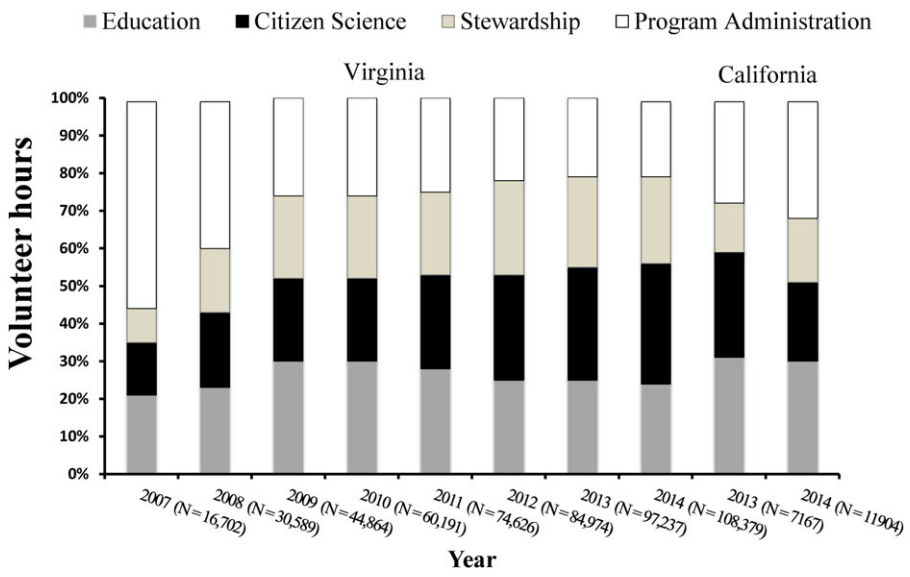

Figure 1. Percentage of volunteer hours reported in 4 areas of service for the Virginia Master Naturalist Program (2007–2014) and the University of California Naturalist Program (2013–2014) (total number of hours in parentheses on x-axis).

reached people who, although still significantly different from the general population (based on state census data, $\chi^2 = 50{,}053$, df $= 4$, $p < 0.00$), more closely matched the demographic makeup of Virginia (Fig. 2).

Naturalists in California contributed 6,479 hours to interpretation and education from 2012 to 2014 and documented working with 4,611 individuals through their outreach and education service activities. At least 822 hours were committed to youth, including school groups, scout troops, and homeschoolers or through more informal youth science educational opportunities. Of those, at least 181 hours were devoted to youth from underserved communities. In addition, 21 hours were devoted to interpreting nature with visually impaired adults.

Certified naturalists in both states also engaged in volunteer ecosystem stewardship activities. The VMN volunteers contributed over 114,000 hours, and in California the total over 2 years was 3,755 hours specifically to ecosystem stewardship projects. Invasive plant removal and management; stream, trail, and beach cleanups; and habitat improvement projects were common areas of stewardship service. In California, frequent activities included treatments to help prevent fire, postfire restoration, and native-plant propagation for ecological restoration.

Discussion

Based on a comprehensive needs assessment, participant data, and program evaluation, we found impacts on the participants in these programs. Participants were motivated to take naturalist courses to increase their understanding of nature and hence expected to gain knowledge about natural systems, and participants did increase their scientific knowledge and skills. The data on motivations also revealed a desire to spend time with people who have similar interests and to learn from others. It is apparent that sharing information and learning together build important social capital within these naturalist groups similar to what has been observed among volunteer groups involved in water-quality monitoring (Overdevest et al. 2004).

Participants engaged in citizen science projects have strong positive attitudes toward the environment (Brossard et al. 2005; Crall et al. 2013; Toomey & Domroese 2013), which can be linked to proenvironmental behavior (Heimlich & Ardoin 2008). Overall there is evidence that improved perceived self-efficacy correlates well with proenvironmental attitudes, but less is known about the relationship of these to behavioral change related to environmental stewardship (Meinhold & Malkus 2005). Many note there can be a gap between acquiring environmental knowledge and displaying proenvironmental behavior (e.g., Kollmuss & Agyeman 2002). We found increased knowledge of ecological content and improved confidence to address environmental issues. We also provide data from monitoring volunteers that documented proenvironmental behavior, defined as actions that affect the environment directly (e.g., beach cleanup) or indirectly (e.g., ecological monitoring) (Stern 2000). However, we were not able to demonstrate a causal effect of increased knowledge, environmental self-efficacy, or other impacts of the naturalist program on proenvironmental behavior because data are lacking on participant's levels of environmental volunteerism prior to the program. Further research on these programs should include assessment prior to participation to gather the data essential for examining these relationships.

Although there may have been an unidentified bias in who returned both a pre- and postcourse survey, we have no reason to believe this bias was toward individuals who changed more as a result of the program. Our findings concur with evaluation of participants in similar efforts

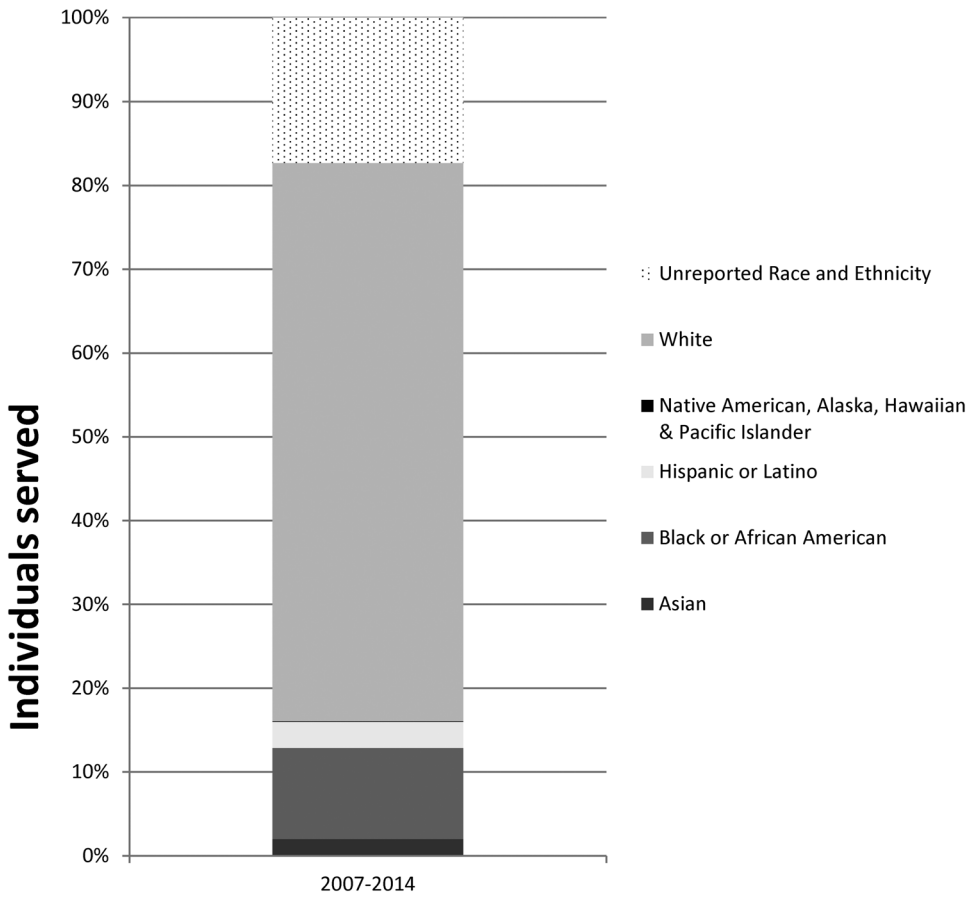

Figure 2. Percentage of individuals of all ethnic and racial backgrounds reached by the Virginia Master Naturalist Program summed from 2007 to 2014. The total number of educational contacts made in which individuals received environmental science and conservation information is 421,025.

that also revealed greater knowledge of science content and stronger positive attitudes toward the environment than among the general public (Brossard et al. 2005; Bonneau et al. 2009; Van Den Berg et al. 2011). Our findings suggest that amateur naturalist programs offer an important way for people to pursue their interest in learning about nature that can then be transformed into feelings of self-efficacy regarding environmental stewardship, and this argues for development and strengthening of naturalist communities. It is important to distinguish between the significant increase in content knowledge we observed among the naturalists and their attitudes toward science and comfort in one's ability to do science, which did not significantly change between pre- and postsurvey results. We did not research potential changes in understanding the nature of science and research methods because this is not explicitly addressed in the program curriculum. Furthermore, the changes in content knowledge we did observe should not be assumed to translate to an increased understanding of the scientific method—an integral part of science literacy (Jordan et al. 2011).

The number of citizen science volunteer hours increased in both programs over time; local citizen science projects received greater attention in California than Virginia. This may be because CA Naturalist participants worked closely with partner organizations that had local research projects. In Virginia, volunteers are currently developing several local projects as part of an externally funded effort to initiate community-relevant citizen science projects (collaborativescience.org). In California, an online project database developed for naturalist programs by University of California researchers includes over 150 projects applicable to California, many of them with regional focus, which may also increase the proportional contribution of citizen science hours to local projects in the state. The focus in both programs on avian research may be a result of the prevalence of bird watchers, the ease with which budding naturalists can observe birds, and the long history of citizen science projects established through the Audubon Society and the Cornell Lab of Ornithology. It is interesting that groups, such as those formed by naturalist programs, who work together on citizen science projects provide more observations per participant, with greater retention, than individuals contributing on their own (Crimmins et al. 2015).

Tracking the number of hours contributed in each of the types of volunteer conservation actions (citizen science, education, and stewardship) provides detailed information on the actions taken by the participants. This set of data of actual conservation behaviors over multiple years following an environmental education program

is unique; more commonly programs only collect data on participants' intentions to carry out various actions. However, more data are needed on the extent to which these volunteer actions aid species conservation and benefit the environment. Equally valuable would be investigating the impacts on people and institutions in the broader community that certified naturalists engage with on a regular basis. For example, a study of the experiences that the educational contacts (Fig. 2) had with the volunteer naturalist might show a multiplicative effect on the community at large. Also, further study of how engaged a similar population would be in citizen science, stewardship, and outreach in the absence of naturalist training and service programs would be useful, but a sufficiently large comparable data set would be difficult to obtain. Similarly, identifying barriers faced by people who decided not to participate would be valuable to understand and compare with the information we gathered by interviewing participants.

Our findings regarding the demographics for naturalists in both states, and barriers to participation in citizen science in particular, join a growing body of evidence and concern on the lack of diversity in these programs. Both state programs have more women participating, which may directly relate to the fact more women volunteer in general (Taylor 2014). However, this older demographic, as seen in these programs, has been recognized by informal science education institutions as a rapidly increasing audience seeking intellectual engagement and learning opportunities and also as one seeking ways to contribute to society and gain fulfillment through volunteering (Bell et al. 2009).

Our findings revealed that younger audiences require more targeted recruitment, and course credit or financial incentives are often needed to help increase the likelihood of their participation. Based on the lessons learned through the research presented here, the UC California Naturalist program now provides inexpensive college credit, offers scholarships to low-income trainees and full-time students, encourages rather than requires volunteer service, and partners with private nonprofit organizations and community colleges that serve these communities. New collaborations with workforce education training efforts that engage minority young adults, such as with the Los Angeles Conservation Corps, are under way to couple job training with naturalist training to advance a green workforce and engage a diverse audience. The criterion that an activity should be considered participatory or qualify as citizen science only if it is done by an unpaid volunteer has been discussed in the participatory literature. Collaboration with job-corps programs intersects with an ongoing discussion about whether an activity should be considered participatory or qualify as citizen science only if it is done by unpaid volunteers (Long et al. 2015). We believe the focus should be on engaging people who are not professional scientists, rather than compensation, to avoid restricting participation to upper-middle-class members of society who make up the traditional volunteer pool.

Our research on naturalist training programs showed that participants increase their knowledge about ecosystems and have greater confidence in conserving them and that many continue to engage as citizen scientists after completing the program. Continued focus on reducing barriers to participation by younger, less privileged, and more ethnically diverse people is vitally important. To engage society broadly in conservation of biodiversity, the benefits of naturalist and citizen scientist training programs need to be extended to a wider and more diverse audience.

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Supporting Information

A summary of the design of the VMN program's comprehensive needs assessment (Appendix S1) is available online. The authors are solely responsible for the content and functionality of these materials. Queries (other than absence of the material) should be directed to the corresponding author.

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