

# The Role of a Professional Society in Broadening Participation in Science: A National Model for Increasing Persistence

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*Professional societies can, and should, recruit and retain young scientists by providing a welcoming and inclusive intellectual home. SEEDS (Strategies for Ecology Education, Diversity and Sustainability), the flagship education program of the Ecological Society of America, is designed to broaden participation in ecology through mentoring, field trips, leadership development, and research fellowships. Nationally, fewer than 40% of college students who intended to pursue a career in science, technology, math, or engineering complete their degrees in these fields, and these numbers are even smaller for underrepresented minorities (URMs). In contrast, 80% of SEEDS alumni in our study had completed at least one degree in an ecology-related field, and the completion rate for URMs was 85%. In addition, 71% of working SEEDS alumni respondents have careers in ecology. SEEDS is a model for other professional societies wishing to increase students' self-efficacy and sense of belonging through professional development and positive social reinforcement.*

*Keywords: education, ecology, diversity, underrepresented minorities, professional societies*

**O**ver the last four decades, considerable time, money, and effort has been spent attempting to broaden the participation of people from traditionally underrepresented groups—such as women, racial and ethnic minorities, people with disabilities, sexual and gender minorities, first-generation college students, and those from low-income backgrounds—in science, technology, engineering, and mathematics (STEM; Metcalf 2016). However, lasting change has been elusive, in part because of a lack of systematic support for students as they navigate the complex maze of courses, research opportunities, departments, institutions, and careers (Gibbs and Marsteller 2016). To persist in STEM, students not only need academic and financial support, but they also need social, personal, and community support (Armstrong et al. 2007, Poirier et al. 2009, NAS et al. 2011, PCAST 2012, Taylor 2014, CEOSE 2015). A comprehensive network of support not only provides access to science degrees and careers, but it also promotes self-efficacy, science identity, and a sense of belonging—traits that are essential for persistence (Graham et al. 2013, Trujillo and Tanner 2014, Hanauer et al. 2016, Maton et al. 2016, Carpi et al. 2017).

Although many programs—including academic resources, scholarships, and mentoring—address critical aspects of a support network, comprehensive networks are rare and are often missing essential elements. One element that is frequently overlooked is the role that professional societies can play in promoting self-efficacy and a sense of belonging by providing an intellectual home for aspiring young scientists. In this article, we describe how the Ecological Society of America (ESA), representing 8000 professional ecologists in the United States and around the world, helped build and manage the award-winning program Strategies for Ecology Education, Diversity, and Sustainability (SEEDS). This program is designed to increase participation in the field of ecology by undergraduates, particularly underrepresented minorities, through activities such as mentoring, field trips, leadership development, and research fellowships. Here, we not only present the SEEDS program and describe how it is implemented, but we also present evidence of its success as illustrated by persistence in ecology-related undergraduate majors, graduate programs, careers, and leadership positions. We explore the ways in which SEEDS affected students' education and career plans, as well as their interest

in and level of engagement with the field of ecology. Finally, we discuss how SEEDS can be used as a model for other professional societies wishing to participate in creating a comprehensive network of support that is essential for persistence, and we examine the ways in which programs like SEEDS can be situated in a larger network of student support services to promote a deep sense of belonging within a science community.

### Presentation of the SEEDS model

The mission of SEEDS is to diversify and advance the ecology profession through opportunities that stimulate and nurture the interests of underrepresented minorities to participate and lead in ecology. SEEDS has been nationally recognized twice: In 2006, SEEDS was awarded the Presidential Award for Excellence in Science, Mathematics, and Engineering Mentoring (PAESMEM), and in 2008, it was awarded the American Institute of Biological Sciences Diversity Leadership Award. SEEDS was created in 1996 by a consortium led by the Institute of Ecosystem Studies in partnership with the ESA and the United College Negro Fund. With support from the Andrew W. Mellon Foundation, the first phase of SEEDS focused efforts on faculty development and student support at historically black colleges and universities (HBCUs). In 2002, the ESA assumed full management of SEEDS and expanded it to engage students from all backgrounds, including Asian, Hispanic, Native American, and white students.

From its inception, SEEDS has had three core programs: extensive mentoring for undergraduates at the ESA annual meeting, high-impact field trips in partnership with Long Term Ecological Research (LTER) sites and other research stations, and campus chapters. Over time, SEEDS expanded to include undergraduate research fellowships (added in 2004) and a leadership meeting for SEEDS campus chapter leaders and research fellows (added in 2006). Between 2009 and 2011, half-day field trips were added to the annual meetings of the Society for Advancement of Chicanos and Native Americans in Science (SACNAS). Each program is described in detail below.

The guiding philosophy of SEEDS is that its programs should offer hands-on, engaging experiences that illustrate the relevance and applications of ecology to the world around us. Each program provides opportunities to interact with a diverse group of ecologists and other motivated students to both broaden and deepen students' understanding of ecology and potential careers. All SEEDS programs include time for reflection and debriefing during a closing session at which students express what they have learned and what they felt, reflect on the importance of diversity in science and society, and consider what their roles will be in this field. Practices such as these have been shown to promote metacognition, engagement, and self-efficacy (Schraw 1998, Trujillo and Tanner 2014).

Beyond these programs, SEEDS creates a sense of community and belonging by recognizing each student as unique

and celebrating their perspectives as assets. To encourage a sense of belonging, SEEDS is explicitly promoted as a science "family" that helps students grow personally and professionally. At every SEEDS event, students are invited not only to share their professional interests but also some of their personal struggles and achievements. For example, students are invited to introduce themselves in their native language, creating a welcoming environment for all. Regardless of race, culture, sexual orientation, gender, income, or age, the SEEDS culture is such that all voices are heard and respected. In addition, SEEDS participants and alumni regularly stay in touch via monthly news bulletins, LinkedIn, and, most commonly, Facebook.

All programs except the campus chapters, regional field trips, and leadership meetings are competitive, recruiting primarily from SEEDS chapters and from minority-serving programs such as SACNAS (the recruitment for particular programs are described in the SEEDS programs section below). Because the goal of SEEDS is to diversify the field of ecology, students from all backgrounds are encouraged to participate. Annually, SEEDS accepts up to 25 annual meeting participants, 45 national field trip participants, 24 regional field trip participants, and 5 undergraduate research fellows. Leadership meeting and regional field trip participation are by invitation only, based on chapter advisor nominations. Leadership meetings include all active and incoming cohorts of research fellows, resulting in approximately 25 participants per year.

SEEDS programs cost approximately \$300,000 annually, serving approximately 124 students per year. Approximately one-third of students participate in more than one SEEDS program, reflecting our nurturing philosophy. Throughout its history, SEEDS is supported primarily by extramural funding, including major grants from the Andrew W. Mellon Foundation, the National Science Foundation, the US Department of Agriculture Forest Service, the David and Lucile Packard Foundation, and the Mitsubishi Corporation for the Americas Foundation. Additional funding is provided by institutions with SEEDS chapters (e.g., to support travel to an ESA meeting for chapter members), small grants, and ESA member donations. Between 2002 and 2012, SEEDS was administered by two to three full-time staff. Currently, SEEDS is managed by the ESA's director of education and diversity programs (coauthor TMM) and a full-time program manager (coauthor FA). The program also receives support from a highly enthusiastic and active volunteer advisory board.

### SEEDS programs

Participation and mentoring at ESA annual meetings is the centerpiece of SEEDS. Prior to ESA's annual meeting, SEEDS students select mentors from a list of ESA members, mostly faculty and graduate students, who have been recruited to be mentors by SEEDS staff. Mentors and students are encouraged to reach out to each other before the meeting to share their science interests. Before the annual meeting begins,

students participate in a half-day orientation, pre-meeting workshops or field trips, and a welcome dinner with mentors. SEEDS students then attend a breakfast with mentors on the first day of the meeting to plan which sessions to attend. Additional activities include a SEEDS student chapter workshop, a diversity mixer (through 2013), a career and graduate school fair, and the ESA diversity luncheon hosted by the vice president for education and human resources. Most SEEDS students present their research at the annual meeting and attend symposia or oral sessions coordinated by current undergraduates and former SEEDS students.

Field trips are typically two to three full-day experiences (not including travel) and consist of a tour of a field station, talks by scientists and/or graduate students, and hands-on field exercises in which students collect data. After the field exercises, students analyze their data and present their results. Students work in groups to produce a collaborative journal of their experiences that is then disseminated on the SEEDS website. Additional time is allocated for professional development activities, such as career panels on which professionals from diverse sectors are invited to share their career journeys, as well as for discussion and reflection with local environmental or tribal leaders. Critical social time, such as campfires and hikes, are built into the programs.

In addition to national field trips, SEEDS also hosts regional field trips (although these began after 2013), which are co-organized by participating SEEDS chapters. SEEDS participants within six hours of driving distance from the field trip site are invited to attend, and participants are recruited with the help of SEEDS chapter faculty and student leaders. Depending on funding sources that might have a regional emphasis, different SEEDS chapters are invited to co-organize these trips.

Half-day field trips were organized in conjunction with the SACNAS conferences between 2009 and 2011. Each year, students recruited by SACNAS were invited to dinner, held the night before the field trip, with a SACNAS leader engaged in ecology, and they participated in hands-on experiences during the field trip at a location within 30 minutes of the conference site.

Campus chapters, co-organized by faculty and students, vary widely in the level and types of activities organized but include career talks, field trips, and campus BioBlitz events designed to spark interest in ecology. By 2016, there were approximately 100 campus chapters with hundreds of students from across the United States participating every year.

Undergraduate research fellowships provide a stipend, research and housing allowance, and travel support that allow students to conduct independent research at a field station for one summer. The fellowship is the highest honor in the SEEDS program. This prestigious program begins with a leadership meeting prior to their summer research, a second leadership meeting the next year, and travel support to present their research at the ESA annual meeting. Prior to 2015, the SEEDS advisory board reviewed applications, and SEEDS staff interviewed students to make the final selection.

Beginning in 2015, SEEDS began partnering with field stations to sponsor summer research experiences, and students select their top three stations of interest. After an initial staff interview, partners make the final decision in consultation with staff.

Leadership meetings offer the opportunity for SEEDS student leaders to engage in dialogue about the connections between science and society. Held annually, these meetings provide a venue for students to develop twenty-first-century skills in communications, policy, community outreach, and education, rounding out their experience as young scientists. The meetings include talks, workshops, and tours of relevant projects that showcase the applications of science and civic engagement. Students are given the opportunity to develop an outreach activity on the theme. Each leadership meeting is also an opportunity for students to exchange ideas on ways to enhance chapter engagement. As with field trips, one of the highlights of the leadership meetings is a career panel: a diverse group of graduate students, researchers, and professionals are invited to share their career journeys, and students are able to ask questions and interact one-on-one with scientists.

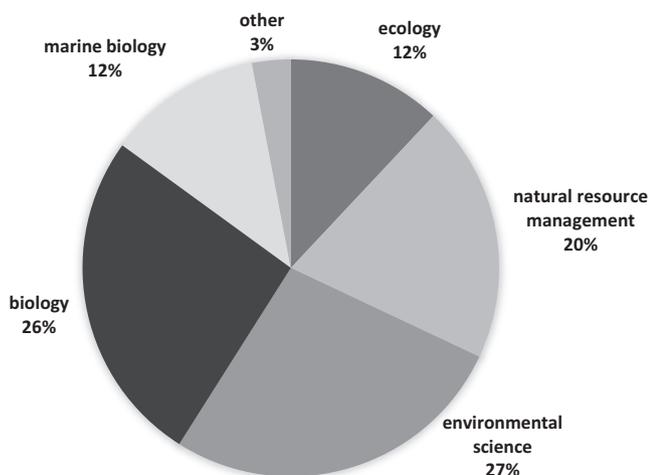
### Evaluation methods

In 2013, we conducted a systematic retrospective evaluation of the impact of SEEDS in order to document outcomes; assess the impact of SEEDS on participants (education, careers, achievements, leadership, and engagement in ecology); assess the value of SEEDS components; and develop recommendations for strengthening SEEDS. With funding through a grant from the National Science Foundation, we partnered with independent consultants (Formative Evaluation Research Associates—coauthors AFM, DL, and KT) to develop an evaluation plan based on in-depth interviews with a sample of SEEDS alumni and active participants, SEEDS staff (coauthors TMM and FA), the 2013 SEEDS advisory board, and ESA's vice president for education and human resources 2012–2016 (coauthor JAR).

Our evaluation consisted of an anonymous, online survey of both active SEEDS undergraduates and SEEDS alumni who participated in any of the core program components between 2002 and 2013 (see supplemental materials for survey details). Students who only participated in SEEDS chapters were not surveyed because chapters are autonomous student organizations with their own activities that ESA does not manage. All the respondents were asked for feedback on SEEDS program components, their experiences, and suggestions for improving SEEDS. IRB approval was obtained through Duke University (Protocol no. B0860, Diverse People for a Diverse Science).

### The response rate and demographics of the respondents

Of the 522 students who participated in core SEEDS components during the evaluation period, we were able



**Figure 1.** The fields of study of the active SEEDS student respondents who had declared a major ( $n = 59$ ).

to locate 517. Of these, we received responses from 161 alumni and 61 active students (combined  $n = 222$ ), for a 43% overall response rate. The majority of the survey respondents were female (75% of alumni and 67% of active students). Approximately 81% of the SEEDS participants were from groups that are traditionally underrepresented in the field of ecology, primarily Hispanic or Latino (41%); African American or black (19%); Native American, Native Alaskan, Native Hawaiian, or Pacific Islander (13%); and biracial (8%). The remaining participants were white (13%), Asian or Asian American (5%), and other (1%). The respondents ranged in age from 18 to 56; 84% of the alumni were 22–34 years old, whereas 82% of the active students were 18–26 years old. Most of the alumni and students were from the United States (76% and 84%, respectively).

## Education

Almost all the active SEEDS student respondents (95%) were pursuing a bachelor's degree when surveyed, and 59% were majoring in ecology, natural resource management (including fisheries, forestry, range science, and wildlife), or environmental biology or environmental science (figure 1). An additional 38% were majoring in biology or marine biology, and although we have no way of knowing what percentage of these students were concentrating in ecology, we assume that there was certainly some overlap.

Of the SEEDS alumni surveyed, 98% completed a bachelor of science (BS) or bachelor of arts (BA) degree, nearly all of which were in the sciences, science education, or science policy. Overall, 80% had completed at least one degree in ecology or an ecology-related field: 70% of the alumni completed ecology-related BS or BA degrees, 26% completed ecology-related master of science (MS) degrees, and 4% completed doctor of philosophy degrees (PhDs) in ecology. In addition, many of the alumni surveyed were actively

pursuing an advanced degree in ecology or an ecology-related field: 21% were pursuing MS degrees, and 17% were pursuing PhDs in ecology (figure 2). Of those who had completed master's degrees in any field ( $n = 52$ ), 29% are African American, 42% are Hispanic, and 10% are Native American or Alaskan Native. Of those who hold PhD degrees in any field, two are African American, four are Hispanic, and two are biracial or multiracial.

## Careers

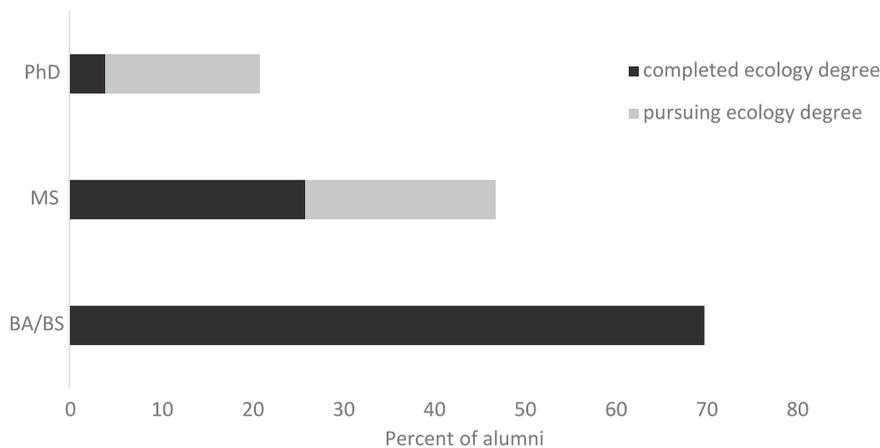
At the time of the survey, 78% of the SEEDS alumni respondents were working or conducting research in a variety of sectors, including academia (44%), government (21%), non-profits (7%), business (6%), K–12 education (5%), and other (17%; figure 3). It is also interesting to note that among the alumni who are ESA members ( $n = 51$ ), 63% indicated they were in academia, 18% were in the government sector, and the rest were spread out in other employment sectors. More than half of the alumni respondents (56%) were working in ecology-related fields, including conservation and natural resource management (e.g., agriculture, forestry, marine, and fisheries), earth and environmental science, energy and sustainability, environmental toxicology, urban ecology or urban planning, environmental law, and environmental journalism. Many of the respondents were performing multiple roles in their careers, and the alumni who were working in ecological fields reported working as research scientists (77%), educators (22%), program coordinators (13%), managers or administrators (10%), policy analysts (6%), and consultants (3%).

## Leadership

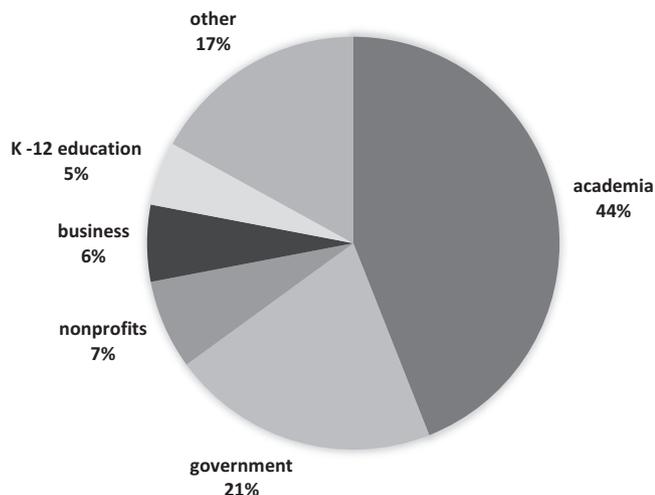
After becoming involved in SEEDS, 75% of the active student respondents reported that they served in leadership roles: 51% were officers in a club or organization, 34% were team leaders, 33% had leadership roles within community engagement and outreach, 30% were student peer mentors, and 23% were event organizers. Among the alumni surveyed, 26% indicated they were in leadership roles related to ecology: 17% were leaders at their workplace; 14% were mentors for ecology students; 14% were involved in their local community organization, such as a school; 8% were advocates for environmental-related policies; and 7% were involved in a national organization. Another 31% were involved in a leadership role not related to ecology. We also found that 8% of the alumni were involved in ESA leadership roles.

## Achievements

Of the 161 alumni surveyed, 63% reported that they had received a fellowship, scholarship, award, or some other recognition, including seven students who specified that they received the prestigious National Science Foundation Graduate Research Fellowship award. The active students are similarly accomplished: 56% have won some type of award or recognition.



**Figure 2.** The percentage of the SEEDS alumni respondents who had completed or were pursuing degrees in ecology or ecology-related fields at the time of our survey ( $n = 161$ ).



**Figure 3.** The career sectors of the working SEEDS alumni respondents ( $n = 126$ ). Of these, 56% were working in ecology-related fields.

### Engagement in ecology

We found that 81% of the SEEDS alumni respondents have been engaged in the field of ecology in a variety of ways: 49% had presented at ESA annual meeting(s); 41% contributed ecology-related content to blogs, social media, or other nontechnical publications; 32% were ESA members; 27% had published peer-reviewed articles about ecology in scientific journals; and 20% attended ESA annual meetings regularly (figure 4). In addition, 34% were involved in advocacy related to environmental issues, and 43% volunteered for ecology-related organizations.

### Impact of SEEDS

Both the alumni and active students reported that SEEDS increased their knowledge about the field of ecology and the pathways to enter the field. Nearly all the respondents

reported that they “agree” or “strongly agree” with the following statements: “Because of SEEDS, I have...” “learned about educational opportunities in ecology” (96%), “increased my interest in ecology” (95%), “increased my knowledge about the ecological research process” (94%), “been exposed to a wide range of ecology-related careers” (93%), and “increased my knowledge about the pathways to enter the field of ecology” (90%).

The majority responded that SEEDS had a “great deal” to “quite a bit” of impact on them in the following areas: personal growth (83%), education (75%), career (72%), and community involvement (72%). The majority of the alumni (67%) and active students (82%) reported

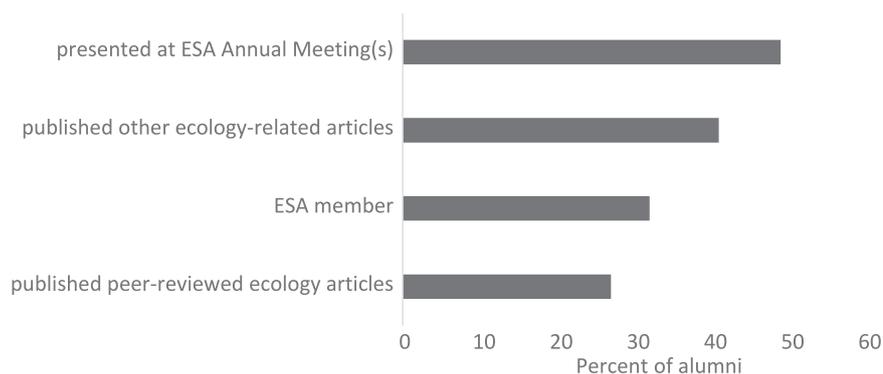
that participation in SEEDS programs played a “very important” or “quite important” role in shaping their decision to pursue ecology or a related field as an undergraduate.

### Assessment of particular SEEDS programs

Overall, the active students and alumni found all of the SEEDS programs in which they had participated to be valuable. In response to the question, “Overall, how valuable were each of the following SEEDS components in helping you connect to the field of ecology?” the majority responded that SEEDS had a “great deal” to “quite a bit” of an impact on them in the following areas: field trips (93%,  $n = 160$ ), attending ESA annual meetings (92%,  $n = 154$ ), leadership meetings (89%,  $n = 124$ ), and campus chapters (88%,  $n = 155$ ).

### Discussion

Nationally, it has been reported that fewer than 40% of college students who intended to pursue a career in STEM complete their degree in those fields (PCAST 2012). These numbers are even smaller for students from traditionally underrepresented groups (Gibbs and Marsteller 2016), and within the field of ecology, only 6% of ESA’s members report belonging to underrepresented minority groups (ESA 2017). Of the SEEDS alumni respondents who are URM, 85% had completed their undergraduate degree in ecology or an ecology-related field, 35% had completed a master’s degree or PhD in these fields, and many more were in the pipeline. Although a limitation of this study is that there is undoubtedly selection bias in students who participate in SEEDS and in those who completed the survey, the results clearly show that SEEDS has achieved its primary goals of recruiting and retaining URM in the field of ecology. A secondary goal was to increase diversity within the professional society itself, and about one-third of the SEEDS alumni respondents are ESA members; of those, 81% are URM. Given that ESA comprises primarily academic and government scientists, it



**Figure 4.** The percentage of the alumni respondents who were actively engaged in ecology-related activities.

is impressive to note that approximately 80% of the SEEDS alumni respondents on academic and government tracks were ESA members.

Although our survey was not designed to determine the mechanisms by which SEEDS was able to achieve these successes, we hypothesize that the primary mechanisms were increases in both *scientific self-efficacy* (i.e., confidence and a belief in one's abilities to do science) and *scientific identity* (i.e., a sense of belonging within a scientific community; Kelman 2006, Trujillo and Tanner 2014). The respondents used the open-ended questions of our survey to say things such as, "Had SEEDS not been available, I would not have been on my current path, educationally nor professionally," "Before I had attended a SEEDS event I was a little hesitant on a career in ecology...if I did not attend a SEEDS event I do not think I would be furthering my education," and "SEEDS programs transform students' lives by providing them with leadership skills that allow students to thrive and take ownership of the environmental field. We should all be proud of the remarkable work of SEEDS because it is transforming a field that desperately needs more diverse perspectives." We are currently investigating the mechanisms of effect in a follow-up qualitative analysis of open-ended survey questions.

Self-efficacy, an essential prerequisite to persistence (Graham et al. 2013), is hypothesized to be derived from four primary sources: previous experience successfully completing a task (i.e., task mastery), feelings associated with successfully completing that task, external encouragement and support, and witnessing others similar to oneself successfully completing a similar task (Usher and Pajares 2008). By design, SEEDS gives students opportunities to develop mastery with ecological techniques (through research experiences and hands-on activities during field trips) as well as opportunities to apply ecological knowledge by fostering leadership and community engagement. The SEEDS community not only creates positive feelings associated with this mastery but also provides encouragement and role models. SEEDS's three levels of mentoring—professional mentoring, near-peer mentoring (SEEDS alumni mentoring

SEEDS undergraduates), and peer mentoring—create multiple opportunities for the development of self-efficacy through all four sources.

Similarly, a sense of belonging seems to be an important factor that increases persistence, particularly among underrepresented minorities (Stolle-McAllister et al. 2011). A sense of belonging occurs when students feel that they fit into the community—that they have the right skills and dispositions to be a member of the group (Trujillo and Tanner 2014). SEEDS works intentionally to create that sense of belonging within the SEEDS community and within the ecological

community more broadly. SEEDS provides a safe space for students to explore ecology without feeling judged or having their "insider status" questioned. In addition, our results suggest that SEEDS students receive important information about ecology and career options from our programs that they otherwise might not learn about on their own, helping them see how they could make a vital contribution to the field.

Not only does SEEDS promote persistence by all students, particularly those from groups traditionally underrepresented in science, but it also creates opportunities for students to have important conversations about culture, race, and ethnicity in science. Often, field trips and leadership meetings intentionally include encounters with local culture, tribal experiences, or social justice issues. SEEDS facilitators do not shy away from explicitly discussing uncomfortable issues of race and ethnicity with students but instead create "safe spaces" where students are free to share the challenges they encounter, including the challenge of having to defend their career interests among their own friends and families or within their home institutions. SEEDS encourages students to voice their concerns, reflect on their hopes and aspirations, and turn to those with similar experiences for professional and emotional support.

### SEEDS as a model for other professional societies

We have long known that students need financial and academic support to have access to higher education, but increasingly, we understand how critical it is for students to have community support to persist. Professional societies can, and should, play a critical role in welcoming aspiring young scientists into our disciplinary families through programs such as SEEDS. These programs should explicitly aim to increase students' self-efficacy through hands-on experiences and positive reinforcement on both a social and professional level. In addition, professional societies are ideally positioned to promote a deep sense of belonging within their science communities, particularly through multileveled mentoring and multiple opportunities to stay involved. And unlike financial and academic

support, which are best addressed within the college and university setting, professional societies can bring together students with shared career interests from across institutions to build the critical mass necessary for a true sense of inclusion. This is particularly crucial for underrepresented minorities in ecology who may be isolated in their home institutions.

The success of a program like SEEDS requires committed leadership, dedicated staff, sustainable funding, and key partnerships. Sustainable funding continues to be a challenge for SEEDS, but we have been fortunate to have funding from a variety of sources, including organizational support, member donations, funded partnerships, and external grant support, with approximately 40% of that support coming from the National Science Foundation. Although these programs are resource intensive, they have demonstrated that they make a dramatic impact in increasing the diversity of scientists in the next generation.

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### Supplemental material

Supplementary data are available at *BIOSCI* online.

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