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Broadening the ecological mindset

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Abstract. Over the past three decades, the Harvard Forest Summer Research Program in Ecology (HF-SRPE) has been at the forefront of expanding the ecological tent for minoritized or otherwise marginalized students. By broadening the definition of ecology to include fields such as data science, software engineering, and remote sensing, we attract a broader range of students, including those who may not prioritize field experiences or who may feel unsafe working in rural or urban field sites. We also work towards a more resilient society in which minoritized or marginalized students can work safely, in part by building teams of students and mentors. Teams collaborate on projects that require a diversity of approaches and create opportunities for students and mentors alike to support one another and share leadership. Finally, HF-SRPE promotes an expanded view of what it means to become an ecologist. We value and support diverse career paths for ecologists to work in all parts of society, to diversify the face of ecology, and to bring different perspectives together to ensure innovations in environmental problem solving for our planet.

Key words: broadening participation; data science; ecologies; grand challenges; near-peer mentoring; teamwork.

Introduction

How do people discover ecology and how does that process influence the face of ecology? These are questions posed by Bowser and Cid (2021) (henceforth "B&C"), wherein they describe an "ecological mindset" and focus on how it can be solidified by field experiences. We agree with B&C that their logic model focusing on the "4C's" (*comfort* with ecological field experiences, *connection* to the study site through sense of place, *confidence* through team-building exercises and fieldwork engagement, and *capability* through comprehensive field research programs [italics as in B&C]) can provide an entrée for minoritized or marginalized students into an ecological mindset. Here, we complement the focus in B&C's 4C's on fieldwork and field experiences by exploring other pathways into it. Alternative paths that occur in tandem with or separate from field experiences may broaden the ecological community to include students who may place a lower priority on fieldwork or may be unable to work in the field. Our thoughts about broadening the ecological mindset and alternative paths into it derive from our roles as mentors and program directors of the Harvard Forest Summer Research Program in Ecology (HF-SRPE).

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Ecology or ecologies?

Before considering paths into an ecological mindset it is helpful to understand how others may perceive the field of ecology. Ecology certainly is "[t]he branch of biology that deals with the relationships between living organisms and their environment...[and] the relationships themselves, esp. those *of* a specified organism" (OED 2020: 1.a.; italics in original), but it is also (since 1908) "[t]he study of the relationships between people, social groups, and their environment; (also) the system of such relationships in an area of human settlement" (OED 2020: 1.b.) and (since 1963) "[t]he study of or concern for the effect of human activity on the environment; advocacy of restrictions on industrial and agricultural development as a political movement; (also) a political movement dedicated to this" (OED 2020: 2.). More broadly, ecology is used in an attributive sense, relating ecological or environmental concerns in, for example, artistic, architectural,

economic, educational, or political activities (OED 2020). Although many prominent and classically educated ecologists have embraced this diversity of ecologies (Strong 2008), others have been much more cautious (Burke and Lauenroth 2009, de la Rosa 2009).

The many broad definitions of ecology suggest that a similarly diverse set of pathways into ecology will broaden participation in the field. For example, in the last 20 years, ecology sensu stricto has become an increasingly data-intensive science (Peters et al. 2014); in the early 1980s, Long Term Ecological Research sites annually produced kilobytes of data collected by hand in the field and manually entered into computers, whereas today's sensors automatically compile gigabytes-to-terabytes of data every day. Analysis and synthesis of these types of data and those amassed by other large-scale collaborative observation networks have greatly expanded the range of important and interesting ecological questions. Answering such questions and addressing any of ecology's "Grand Challenges" (National Research Council 2001) is far beyond what a single researcher can accomplish on their own, whether in the field, greenhouse, laboratory, or with a single personal computer. Indeed, data science, as well as software engineering, remote sensing, or simulation modeling provide different paths into ecology careers for minoritized (and other) students. These paths, like those focused on lab- or mesocosm-based ecological research can coincide with field experiences.

In the last three decades, HF-SRPE has been at the forefront of expanding the ecological tent for minoritized and marginalized students by offering a diversity of paths to a broader ecological mindset. At its inception in the early 1990s, HF-SRPE focused almost entirely on field research and associated rites of passage for a small number (5–10 students/yr) of almost entirely white students. As the program has evolved to encompass ecological data science and other fields that contribute to ecological knowledge (e.g., modeling and software engineering) or apply it in other fields (e.g., hydrology, soil science, epidemiology and public health; McDevitt et al. 2020), it has more than doubled in size (20–30 students/yr) and the proportion of minoritized students in it has increased steadily to its current ≈50% (McDevitt et al. 2016).

Increasing inclusion through resilience

The "resilience mindset" (sensu Yaeger and Dweck 2012) that B&C identify as a crucial characteristic for ecologists can be extended to these other pathways into ecology. Its key attributes—student goals, beliefs about effort, attributions, and learning strategies—solidified by self-organized and self-designed research projects can be cultivated in any research setting. Certainly development of observational skills, a sense of place, and inclusion in a community of ecologists can happen in the field. But recent discussion around Black Birders Week highlighted how the development of a resilience mindset may happen more naturally outside of a field experience. This may be especially true for minoritized or marginalized students who may feel physically or emotionally unsafe when they are in rural field sites where intense discrimination and systemic racism are commonplace, but even urban field sites can be unsafe (Dowtin and Levia 2018). Although ecologists working in universities in the United States and Western Europe take for granted that LBGTQ+ students are safe in the field, inclusive field courses simply should not be held in the ≈70 countries where homosexuality is still illegal. In addition, the very nature of field experiences may present physical barriers to accessibility that prevent many students from participating.

At the same time, field research very much remains a core part of ecology, and it is up to all of us to develop a more resilient society in which minoritized or marginalized students are safe and welcome in rural and urban field environments. How? First, field programs need to have clear and enforced codes of conduct that address racism, similar to recommendations to combat gender-based harassment at field sites (Nelson et al. 2017). Second, mentors and programs need to be ready to advocate for their students, as powerfully demonstrated by Dowtin and Levia (2018) and Demery and Pipkin (2021). Third, our experience in HF-SRPE shows the effectiveness of developing diverse student-mentor teams to work together and support one another.

The importance of teams

Ecological research, like that in other STEM fields, now is frequently done in diverse teams organized not only around field campaigns or networks of field sites but also in working groups at synthesis centers or "in the cloud" (Baron et al. 2017). Ecologists who represent the broad range of human diversity not only should have complementary skills and expertise but also need to develop abilities for working in heterogeneous teams.

As HF-SRPE has expanded the ecological tent, we have also shifted from the classic "one mentor one student" apprenticeship model of undergraduate research to collaborative, team-based projects with multiple students and multiple mentors (McDevitt et al. 2016). Within a team, some students may focus on fieldwork while others focus on lab work or computational modeling. Thus, students are exposed to different aspects of the ecological mindset while building mastery and identity in their niche. We assemble teams that include students new to research and students with prior research experience; the latter serve as "near-peer" mentors for the former. All the students share responsibility for study design and reporting results. Team-based work adds to the students' sense of belonging while also exposing them to issues of, and team-based solutions for, intellectual ownership, shared credit, and differential contributions that professional ecologists deal with every day on any project. It appears that this is also a workable

model for staunching leaks in the STEM pipeline: our long-term assessment of HF-SRPE students has shown that >75% of them have gone on to graduate or professional schools and subsequent careers in ecology and environmental science (McDevitt et al. 2020).

On becoming an ecologist

Broadening the ecological mindset implies an expansion of the career paths valued by the field. Classic training in ecology is typically geared toward preparing students for academic careers. Key metrics of success for programs such as NSF's Research Experience for Undergraduates (REU) include the number of participants who publish papers, attend graduate school, and eventually become tenured faculty; meeting these metrics creates a positive feedback cycle in which an academic career path is seen as the only path to "success" in the field. Increasing the number of minoritized tenured ecology faculty is unquestionably an urgent goal. This goal could usefully be complemented by the creation and support of a community of "ecologists in practice" who build and travel diverse career paths in all parts of society. Expanding the definition of what an ecologist is and does will increase human diversity in our discipline and increase our collective power to understand and solve the pressing ecological questions and existential challenges of living together on our shared planet.

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