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Scientific Life

How Field Courses Propel Inclusion and Collective Excellence

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Field courses have been identified as powerful tools for inclusion and student success in science. However, not all students are equally likely to take field courses. How do we remove barriers to equity in field courses, to make them engines for inclusion, diversity, and collective excellence in ecology and evolution?

How Can Field Courses Be Catalysts, not Barriers?

Ecology and evolutionary biology (EEB) lags other subfields of biology such as the biomedical sciences, in diversity and inclusion [e.g., in the USA, 5.8% of EEB graduate students are from under-represented minority (URM) backgrounds, compared with 10.1% in biomedical sciences] [1]. Students from under-represented racial, cultural, economic, and other backgrounds drop EEB majors at higher rates than their peers, in part because of hurdles like institutional barriers and a limited sense of belonging [2,3]. We highlight how field-based courses can be a powerful vehicle for addressing demographic gaps in EEB, and we provide guidance for inclusive field course design. A well-structured field research course can inspire and prepare students for scientific careers (self-efficacy, science identity, and competence), and create shared experiences and relationships that retain students who might otherwise feel disconnected from their backgrounds and previous experiences (identity, belonging, and community) [4,5]. Participation by URM students in field-based science courses has often been low [4], creating the impression that field courses are not a path to increased STEM (science, technology, engineering, and mathematics) inclusion. We contend that barriers, like cost, schedules, information, specialized equipment, and a lack of staff role models, reduce access and participation (Figure 1). Removing these barriers enables diverse students to pursue field experiences, propelling more diverse leadership, cultural change, and collective excellence in ecology and evolution.

Why Can Field Courses Increase Inclusion in EEB?

Many of us identify field courses as catalysts for our EEB careers. Field courses can provide the key factors that attract and retain students in our field: self-efficacy gains, community and belonging, and comfort in the outdoors (Table 1). First, a sense of belonging, including social belonging and connectedness, strongly shapes students' major choice and graduate school interest [6]. Uncertainty about belonging in EEB can be especially strong for students who see fewer members of their group among faculty and peers [7]. Field courses can boost belonging through sustained, shared experiences that build peer and mentor relationships and expose students to role models beyond the classroom. For many students, belonging in science is also associated with pursuit of shared goals and service to society [6]. Field curricula can emphasize cooperative problem solving rather than competition along with connections between research and the wider world, from conservation and resource management to public education and cultural values. Second, through hands-on scientific experiences, field courses boost students' confidence in their professional abilities, ranging from experimental design and research methods to natural history skills like species identification [4]. These gains in self-efficacy and science identity can be particularly significant for students who begin with lower confidence in their skills, including URM students [4,8]. Finally, an area of competence especially linked to belonging in ecology and evolution and interest in graduate studies is a student's degree of comfort outdoors [6]. Field courses can provide less experienced students with crucial familiarity as well as highlight competence for URM students who already have strong place-based outdoor knowledge [9].

Field courses work because they can serve many students together and reach students early in their university careers. Research experiences like summer internships and senior theses can also deliver experiential and community benefits equitably if they fund students [10]. However, these individualized experiences are harder to scale than courses because of higher per-student costs and resource needs, and they often are available only to students near graduation. Laboratory- and classroom-based research experiences can boost self-efficacy and belonging [11,12], but these approaches cannot level disparities in outdoor experience and typically allow less mentor and peer community formation [6,13]. Contact time and creation of shared memories and community are often higher in field-based experiences. Shared meals, physical and research challenges, travel and experiences like waking to the night sky elicit excitement and awe, build friendships, and introduce students to the visceral joy of discovery. These experiences can also help the majority of students overcome preconceptions about URM groups and motivate their participation in diversity and inclusion efforts.

Why Are Field Courses Underutilized?

Field courses cost more than lecture classes per student credit earned; a reality that limits scaling of field opportunities in today's budget-constrained departments. However, this measure undervalues the

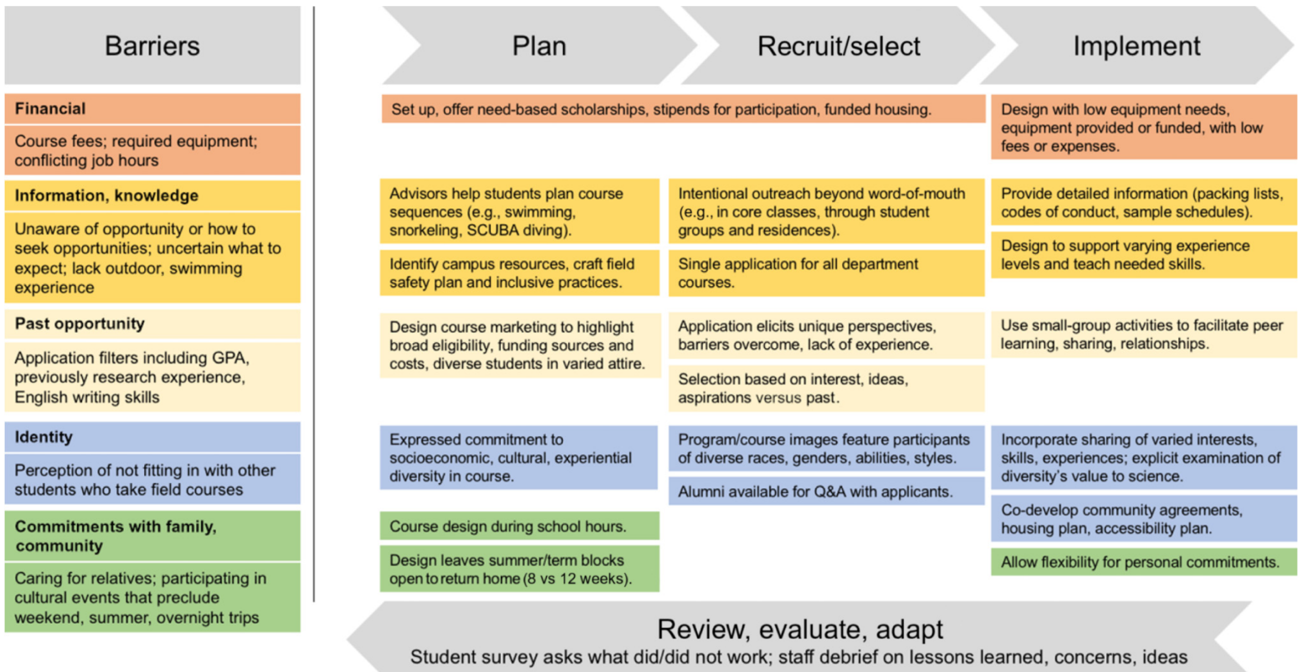

Figure 1. Project Timeline for Inclusive Course Design.

For a Figure360 author presentation of Figure 1, see the figure legend at https://doi.org/10.1016/j.tree.2020.08.005.

How to remove five common types of barriers to teach an inclusive field course at the planning, recruitment and selection, implementation and evaluation stages. Not all suggested actions will apply to every field course; for instance, courses without overnight trips will not need housing plans or funds. Abbreviation: GPA, grade point average.

Table 1. Factors That Support or Enhance Retention and/or Career Interest in Ecology and Evolutionary Biology and Recommendations for Their Incorporation into Field Courses

Factor	How field courses can promote
Belonging – social belonging, feelings of membership [6,7]	• Have students work, travel in groups/teams • Have community meal preparation, celebrations • Include group assignments such as presentations, papers • Build in time off outside the classroom.
Self-efficacy – confidence in science skills, competence [4,15]	• Facilitate research design by students, participation • Teach and provide experience in specific science skills like data collection and analysis using field tools, species identification, making and recording observations, and communicating findings • Recognize student contributions to science.
Comfort outdoors – field work, living skills [6]	• Explicitly teach, model outdoor skills • Provide supported experience living, working outdoors
Role models – of any identity, of same identity [6]	• Have staff, instructors travel, work, eat with students • Have 1:1 mentoring (as well as instructional) interactions • Hire a diverse staff
Communal goals/ service to society [6]	• Focus on cooperative problem solving • Practice varied leadership skills • Use student-led inquiry to facilitate discovery • Explore EEB links to stewardship of nature, education, environmental quality and health
Science identity – recognition by self, others as scientist [8]	Provide scientific ownership through authentic research experiences such as original hypothesis generation, experimental design, using evidence to explain findings.

ability of field courses to deliver greater retention and progress towards student learning objectives [4]. Accurate pricing, in the form of increased credits awarded for field courses to reflect their relative contributions to learning goals, is one way to recognize their curricular value. Awarding more credits to field courses can address another constraint they pose: most universities do not reward faculty or teaching assistants for the extra time field courses require. More credits for field courses (or allowing field courses to satisfy university or major requirements) can reduce teaching load and increase non-tenured instructor compensation and allocation of teaching assistants to offset the high demands of field courses.

Lower course expenses – to both students and the institution – could also increase their feasibility. This can be attained by securing external funds to subsidize field courses and designing lower-cost courses. While immersive field experiences involving travel and camping have tremendous value, it is possible to teach field courses on and near campuses, using day trips, public transportation, and minimal equipment [5,14]. Even while the coronavirus disease 2019 (COVID-19) pandemic necessitates remote learning, we have adapted to guiding student-led observation and study from yards, rooftops, and parks. Variety in approaches can reduce costs and widen accessibility, especially for students whose circumstances preclude overnight travel or who have physical limitations.

Finally, to iteratively improve our work and convey the importance of field courses to our institutions, we can include simple review and evaluation measures as well as more rigorous study of field course effectiveness and sharing of inclusive course designs. Evaluation can include student surveys and open-ended check-ins as well as staff conversations about lessons, concerns, and ideas. Course applications can also help measure progress. By including optional questions about race, ethnicity, first-in-family, and economic status, for example, we can track disparities and trends among general campus and EEB major populations, applicant pools and accepted students. By tracking numbers of applicants relative to available slots, we can make transparent to students and our institutions that participation is competitive and that students who want the experience are getting turned away.

How Do We Design Inclusive Field Courses to Reinvigorate EEB?

For field courses to boost rather than limit inclusion requires intentional effort to recognize and remove barriers for URM students (Figure 1). To reduce financial barriers, we can fund or reduce equipment needs and course fees, and offer local field courses. We can reduce information hurdles by ensuring that field opportunities reach all students and simplify the process of applying, such as by having a common application for each department's field opportunities. Explicitly valuing diversity throughout course design reduces uncertainty about whether certain students belong or are able to meet personal and cultural needs. Inclusive images are powerful; for example, one of our students shared that her family let her participate in an intensive field course because photos of the previous cohort included a woman wearing a hijab.

Removing barriers must happen at every stage, from course scheduling, to reaching and selecting underserved students, to the course itself (Figure 1). We cannot rely on existing social networks to reach less connected prospective students. We can keep applications simple, since students who work or care for family members might not have time to write multiple essays. We can convey in words, images, and selection criteria that we value varied perspectives, a need for experience as much as extensive experience, and the chance to have an impact as much as the chance to teach students who will succeed with or without us. In addition to grades, which can amplify inequities and reflect student circumstances such as the need to work and care for relatives, we can value perseverance and creativity. Field course applications can elicit information about these qualities through questions like: 'How have your life experiences uniquely positioned you to contribute to the diversity of perspectives in EEB?' and 'Describe any obstacles you have overcome to attend university'. Once we have selected our students, we can engage them in developing community agreements, housing and accessibility plans that keep them safe, and prepare them fully with detailed information about how to prepare and how to work and live in the field. Field curricula can attend to both the practice of science – inquiry, research opportunities, and collaboration – and the nature of science as an endeavor strengthened by diverse perspectives, teamwork, and constructive exchange.

Large demographic gaps in EEB mean that our field is missing many of the best ecologists and evolutionary biologists. We need them to tackle the grand challenges that EEB and society face, and they deserve a place in those efforts. Field experiences drew many of us to EEB and can propel the growth of our discipline. If we remove barriers to inclusion, field courses can inspire careers and propel collective excellence among students less certain about their place in ecology and evolution.

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Science & Society

Confronting the Modern Gordian Knot of Urban Beekeeping

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With insect population declines, cities are important habitats for wild pollinators. Urban beekeeping is an increasingly popular activity, yet honeybees present important risks to wild insect pollinators in cities. We argue for new, scientifically evidenced urban pollinator strategies to simultaneously enhance the benefits of urban beekeeping while protecting wild pollinators.

Urban Beekeeping and Pollinator Conservation

While wild pollinators are declining in many landscapes, cities provide habitat for a surprisingly high diversity of these pollinators, which may counteract habitat loss and land use intensification [1]. Concurrently, many cities are buzzing with managed European honeybees (*Apis mellifera*). Though the relationship between humans and bees of the Apidae family is ancient, modern beekeeping has recently proliferated in cities, including New York, Paris, London, and Berlin as 'an ecologically inspired urban lifestyle phenomenon' [2]. Activities involve hobby beekeepers with balcony hives and professional keepers with many hives across a city, leading to high colony densities (e.g., 6.5 colonies/km^2 in Paris) [3,4]. Supported by an environmentally engaged citizenry, managed (and feral) European honeybees (*A. mellifera*) can dominate urban bee communities [5].

In turn, urban beekeeping supports many social benefits, from food production to environmental awareness [2,3]. These benefits boost urban beekeeping's popularity and could support conservation stewardship. However, urban beekeeping also creates new conservation concerns. Higher honeybee densities could threaten urban wild insect pollinators and their important ecological functions, which includes pollination of wild and cultivated plants [1]. This could change the composition of flora within city habitats. Here, we consider this conundrum as a contemporary Gordian Knot (Figure 1): a highly timely and challenging problem for urban conservation and policy. Policy makers must provide evidence for the benefits and risks of urban beekeeping to develop conservation policy, while simultaneously enhancing beekeeping's social benefits.

Conservation Benefits

There is some indication that urban beekeeping may yield nature conservation benefits. As a well-intentioned activity to conserve insect pollinators, urban beekeeping likely involves people in proenvironmental behaviors, including pollinator habitat management and political engagement [3]. Enhanced awareness among residents about pollinators and plant pollination may promote environmental stewardship, potentially shifting aesthetic norms around lawn care. Residents may deliberately plant flowers or tolerate wild plants in pollinator-friendly gardens or roadside verges that likely benefit wild pollinators. By perceiving environmental issues and 'nature' within city boundaries, residents may advocate for greenspace conservation and transformation and increase political engagement for stronger environmental regulations in urban regions. For example, concern about the negative effects of pollutants and pesticides on insect pollinators increases urban beekeepers' calls for stricter environmental policies [2]. Both habitat management and political engagement may lead to a positive spillover of conservation benefits beyond city hives to rural regions. Such benefits, however, need further investigation.

Social Benefits

Urban residents are directly involved by managing honeybee hives, creating a demographically diverse group of practitioners in some cities [3], or indirectly involved with urban beekeeping through educational events, purchasing products, and online platforms (blogs, forums). Associated social benefits are multiple and diverse (see [2,3]). Honey and beeswax products can support some urban residents' livelihoods and promote regional economies. Cooperatives and online communities (e.g., 'NYC Beekeeping MeetUp') foster community. Like urban gardening, outdoor activity and interactions with natural elements boost physical and mental health and can enhance nature connection among often disconnected urban populations [6]. People learn about managed honeybees along with tangential life science information, deepening the appreciation of interconnectedness between plants, pollinators, and people. Furthermore, people learn how environmental contamination, climate change, and biodiversity loss affect all bees [3].