Landscape Study of Undergraduate Field Experiences

Report from the Field on the Design, Outcomes, and Assessment of Undergraduate Field Experiences

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Executive Summary

Introduction. Anecdotal evidence suggests that "learning in the field" has distinctive benefits to undergraduate education, but direct evidence about these benefits and effective practices in field-based science education is limited. The Undergraduate Field Experiences Research Network (UFERN) aims to address this gap as well as the opportunity for broadening participation in field sciences by building an interdisciplinary collaborative research network that fosters effective undergraduate field experiences. The landscape study, which this report is based upon aims to provide a landscape view of the nature of extended field programs, collection of evidence by these programs and a sense for their design. This survey serves as a launching point for UFERN with the goal of inspiring conversations, questioning assumptions, and providing perspective of practitioners leading undergraduate field experiences.

Purpose. Guiding this study were the following questions: 1) What is the nature of extended undergraduate experiences at field stations and marine labs (and similar)? 2) What do practitioners think students gain from participating in extended undergraduate field experiences? 3) Are programs collecting empirical evidence on student outcomes and how are they using it? 4) Are practitioners using instructional strategies in their undergraduate field experiences and are these strategies promoting inclusivity? 5) What resources are needed by undergraduate field programs to enhance the use of evidence in program design and assessment?

Scope of the study. In this report, we summarize responses from an online questionnaire administered in 2018 to practitioners involved with managing undergraduate field experiences in the (FSML) community.

Results. Data from the survey supports professional claims to the long history of undergraduate field programs. The responses from practitioners support the variation in types (e.g., field course, research experience, service learning) and aspects (e.g., summer intensive, residential, international) of field programs, yet all with a common theme of undergraduate research. A majority of practitioners from the survey desire students to gain scientific literacy and core content knowledge, yet there is an overall need in instructional strategies, and program design to promote inclusivity, especially among undergraduates who are underrepresented in STEM majors.

Significant findings from this report include:

- The landscape of what constitutes extended undergraduate field experiences is varied. Yet, the history of field programs is rich with most programs in existence for more than 40 years.
- Minority participation in field experiences lags behind the country's demographics, supporting the need to diversify field experiences.
- Field courses in particular have potential to or are already serving as gateways to developing interest in field-based sciences and STEM in general and improve persistence of underrepresented students in STEM because of their significant research component and capacity to reach higher numbers of lower-division students.
- Development of research skills as a perceived student benefit aligns with the extensive time focused on research activities across both field courses and research experiences. In contrast, 64.4% of field courses responded that no time was spent on career counseling and professional competencies, though professional growth was considered a perceived student benefit among several respondents.
- The highest ranked desired student outcomes were related to increased knowledge, skills and abilities, yet there was expressed interest in collecting more evidence on the affective student outcomes (often associated in environmental education). The intersection of science education and environmental education could be explored to incorporate best practices in program design and assessment.
- Survey data supports the need for undergraduate field programs to build the capacity to more consistently collect evidence about student outcomes and to connect desired student outcomes to design of the experience and collecting evidence about the experience for improvement over time.

Key findings are discussed in greater depth in the Key Findings section of the report.

Undergraduate Field Studies: An Introduction

Learning "in the field" plays a traditionally important role in preparing students for careers in field-based sciences (e.g., marine science, geology, ecology) (Risser, 1986; Lohr, S.A., Connors, P.G., Stanford, J.A., Clegg, J.S., 1996; Mogk & Goodwin, 2012; Petcovic, H., Stokes, A., & Caulkins, J., 2014). Undergraduate field experiences can take many forms, from short field "labs" as part of traditional on-campus university courses, immersive weeks or months-long field courses at field stations and marine labs, traveling geology courses, to weeks-long research experiences. Researchers and practitioners have suggested that these field learning experiences have distinctive benefits to learning, but direct evidence for these specific benefits and about effective practices in field-based science education is limited (Mogk & Goodwin, 2012).

Nearly 450 institutions are associated with the National Association of Marine Laboratories (NAML) and the Organization of Biological Field Stations (OBFS). Almost all of these sites include education as part of their mission; thus, leveraging their significant investments in research for student programs in environmental sciences. Beyond these field stations and marine labs are NSF-supported Research Experiences for Undergraduates (REU) sites with a field or marine component, Long-Term Ecological Research (LTER)-based programs, geology field camps, or other extended field-based programs. Together, these programs serve a large pool of students, often providing specific types of training not provided anywhere else in the undergraduate education system (Hodder, 2009). Because of the potential for reaching a broad range of undergraduates across the U.S. and the world, it is critical to consider how to provide effective educational experiences at field stations and marine labs that is inclusive of all students.

Assessing the impacts of these experiences has been identified as a priority by the FSML community (Billick, I., Babb, I., Kloeppel, B., Leong, J. C., Hodder, J., Sanders, J., and Swain, H., 2013) and by the National Academy of Sciences (National Research Council, 2014). A similar need for a better understanding of the impacts of undergraduate research experiences was recently featured in Science magazine (Linn, M. C., Palmer, E., Baranger, A., Gerard, E., & Stone, E., 2015) and a National Academies of Science report focused entirely on Undergraduate Research Experiences (National Academies of Sciences, 2017). A better understanding around the impact of the programs, effective designs for meeting their diverse goals, and the audience they are serving could inform the direction and support of field-based education programs. Current research and assessment of Undergraduate Field Experiences (UFEs) at FSMLs is limited for several reasons. UFE practitioners often are academically trained scientists without a) the expertise to be readily adept at assessment, b) the time to develop the expertise themselves, and c) connections to collaborators that can help (Klug, M.J., Hodder, J., Swain S., 2002).

A recent report by the National Academy of Sciences stated, *"Field stations are venues for discovery-based learning, and they offer rich opportunities for other types of active learning, which have been shown to promote diversity and persistence in STEM fields*" (National Research Council, 2014, p 2). Field experiences embody the idea of active learning. The "No-Child Left Inside" movement has explored the value of outdoor experiences at the K-12 level (Louv, R., 2011; Gill, 2014), but less is known about the distinctive role of field experiences at the undergraduate level (National Research Council, 2014). Evidence suggests that extended field and marine experiences are important for undergraduates in some disciplines (Eisner, 1982; Klug, et al., 2002; Hodder, 2009; Billick et al., 2013), with positive impacts on students understanding of the scientific process, choice of STEM careers, and improved self-confidence as scientists. Preliminary data from a biology REU program (Sally O'Connor, pers. comm-2016) suggests that not only did research training at one field station substantially increase the retention of students in STEM fields, as well as the likelihood of going on to graduate school, but that the field station experience offered additional benefits beyond the typical undergraduate research opportunity such as being part of an interdisciplinary community and deep connection to place.

Table 1. Opportunities for undergraduates at field stations and marine laboratories (FSMLs).

Undergraduate opportunity	Percentage of FSMLs (*n* = 88)
Formal courses for freshman/sophomores	41
Formal courses for juniors/seniors	65
National Science Foundation Research Experiences for Undergraduates (REU) site program	21
REU experience with individual investigators	33
Other research experience opportunities	72
Joint research and service internships	61
Service-only internships	22

Figure 1: Image from Hodder (2009) illustrating the variety of field-based opportunities.

In a 2013 survey of field stations with U.S. mailing addresses, over 90 percent of respondents report that their most popular audience are researchers and university students (NAML-OBFS 2013). It is uncertain from the literature how many undergraduate students visit, work at, or participate in an education program at field stations each year. We do know that undergraduate attendance at field stations varies widely; of the 78 field stations that responded to a 2008 survey (Hodder, 2009), undergraduate attendance ranged from 6 to 5000 students per year. Just over half of these field stations report serving more than 100 students per year, with the rest serving 100 students or less per year. A variety of opportunities are available for undergraduates at these field stations, some of the most popular offerings being research experiences, service internships, and formal courses for juniors/seniors (Figure 1, from Hodder, 2009).

Aggregated empirical evidence of the contribution of FSMLs to research, education, and outreach is slim (National Research Council, 2014). The National Academies (2014) recommends that a set of common metrics be developed and compiled in an accessible format to document and compare the impact of FSMLs. Specifically, regarding assessing the impact of education provided at FSMLs, these metrics could include alumni success stories, long-term tracking of field station students (e.g., graduation and career outcomes), number of students conducting independent research (e.g., in Research Experience for Undergraduates and Experimental Program to stimulate Competitive Research), and learning-outcomes assessments (NRC, 2014). Common metrics could also be a powerful tool for investigating student field learning across a network of sites and experiences.

Similarly, Fleischner et al. (2017) have provided the following recommendations to improve undergraduate field education:

- Identify consistent ways to demonstrate value of field programs
- Improve communication, diversity, and student outreach
- Create incentives for faculty involvement in field programs so that participation is not a burden for career goals
- Re-define “field” to encompass more habitats

The FSML community is not unique in its need to improve measurement of education programs quality and impact. For example, a recent report by the National Academies (2017) recommended that, “Institutions should collect data on student participation in undergraduate research experiences...to look for opportunities to improve quality and access (pg. 8).” The National Academies (2016) recommended institutions “make better use of faculty in departments of economics, education, and sociology who are trained to work with administrative datasets that can determine the causal connection between universities’ efforts to improve quality and student outcomes (pg. 33).” They also recommended programs should clearly articulate learning objectives and connect them to student outcomes (National Academies of Sciences, 2016).

Purpose of the Landscape Study

The Undergraduate Field Experiences Research Network (UFERN) is building a collaborative network that fosters effective undergraduate field experiences by:

1. Identifying and sharing evidence-based models and practices
2. Identifying, modifying, developing, and sharing assessment tools
3. Investigating how undergraduate field experiences may help broaden the participation and retention of students
4. Harnessing the power of a network to do research on student learning.

This report provides an overview of current programming and assessment efforts around extended undergraduate field experiences to provide a broader context and launching point for UFERN. Findings from this landscape study will inform and build a common understanding among potential network participants, inform development of the network to be responsive to its membership and stakeholders, inform the network of fruitful areas for research, and offer insight to a broader community of researchers and practitioners interested in field-based learning experiences. The purpose of the landscape study is to inspire conversations, to question assumptions, and better understand the perspective of the field.

The landscape study was guided by the following questions:

1. What is the nature of extended undergraduate experiences at field stations and marine labs (and similar)?
2. What do practitioners think students gain from participating in extended undergraduate field experiences?
3. Are programs collecting empirical evidence on student outcomes and how are they using it?
4. Are practitioners using instructional strategies in their undergraduate field experiences and are these strategies promoting inclusivity?
5. What resources are needed by undergraduate field programs to enhance the use of evidence in program design and assessment?

Scope of the Study

The focus of this study is to guide conversations and better understand the nature and impact of extended undergraduate field experiences. The study includes the development of a 37-item online questionnaire. As the main area of focus for this landscape study, we sent survey invitations in March of 2018 to members of OBFS and NAML and individuals in other communities of interest such as LTER, geology field camp directors, and site REU programs with a potential field component. A total of 563 targeted emails were sent. In all, 143 individuals from 165 undergraduate field programs responded. More than half (54%) of respondents self-identified as directors, 39% as lead instructors, 23% as coordinators, and 16% as mentors. Respondents could also write-in a self-identified role.

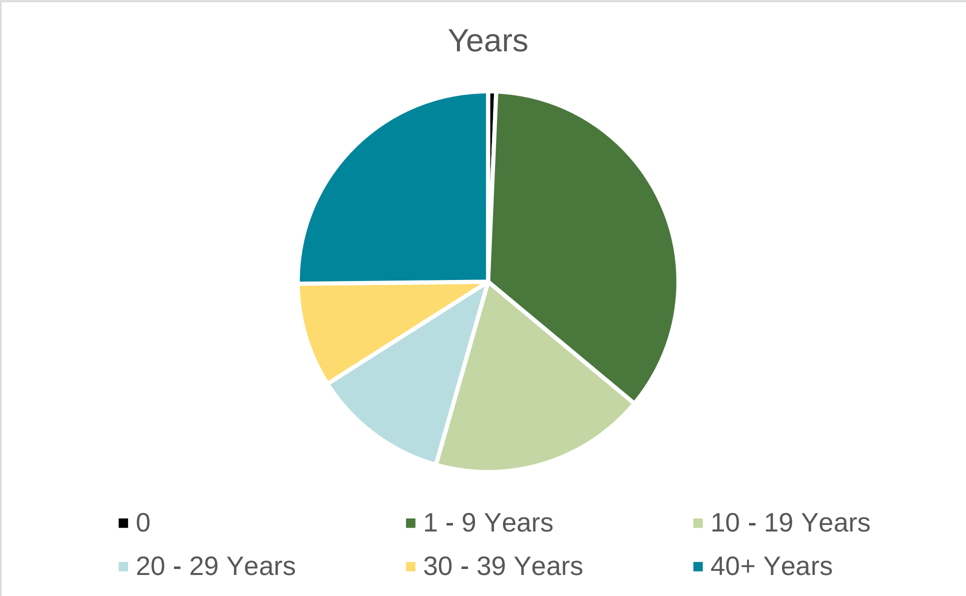
The sample size and response rate vary across results. The variation is due to participants not answering all questions but continuing through the survey.

Results

Nature of undergraduate field experiences. Of 165 respondents, when given the choice of *Field Course, Research Experience, Service Learning, or* Other, 61% described their programs as field courses, while 32% (52 programs) described their programs as research experiences. Three respondents (2%) described their programs as service learning and the remaining respondents (6%) selected “Other” and wrote in responses best described as some combination of these categories. Eighty percent of the respondents described their programs as taking place at a site designated as a field station, marine lab, geology camp or research site. Nineteen percent described their programs as traveling, at a university campus, student-selected site, and other options.

Respondents reported a wide variation in length of time programs have existed, ranging from less than one year (presumably in its first year of programming) to 119 years. About one-third of respondents reported programs existing between 1 to 9 years (53 programs) and another one-third for 40 or more years (52 programs). The remaining programs have existed between 10 and 39 years (Figure 2).

Figure 2. Distribution of length of program existence.



Most respondents reported having less than 40 student participants per program in 2017, though the range of student participants per program was wide (2 – 658 students) (Table 1). The overall mean of student participants was 42 participants per program (*SD*=84.21), but elevating the mean was a small handful of very large field programs with 500 or more participants (Table 1). On average, field courses had more participants (*M* = 46.90, *SD* = 85.90) than research experiences (*M* = 11.00, *SD* = 9.49). The reported distribution of participants also differed within the two program types during 2017, with the greatest distribution of participants in field courses around 20-25 participants per program and programs classified as research experiences with 5-10 students as the greatest distribution of participants within a program.

Table 1. Student participation numbers by program type

Program Types	***Total Programs***	***Mean participants per Program Type***	***Standard Deviation***	***Min***	***Max***
field course	99	46.90	85.90	2	658
research experience	51	11.00	9.49	2	48
service learning	3	218.67	287.96	9	547
other	9	106.00	86.87	12	250
Grand Total	***162***	***42.25***	***84.21***	***2***	***658***

Nature of the participants. Of the demographics, respondents reported STEM majors to comprise a greater mean across all program types versus non-STEM majors. The same division was reported for upper-division students versus lower-division students (Table 2). Participation of underrepresented minorities (as defined by the National Science Foundation) comprised 9.9% of total student participants reported across all four program types. Additional demographics of interest included community college students, students with disabilities and first-generation college students, which comprised three, less than one, and five percent, respectively of the total number of student participants reported. Note that survey respondents had the option of skipping these questions during the survey; the table reports only those who reported numbers for listed categories. For example, only 53 respondents (67.9% missing data/no response) entered a response for first-generation college students (response range of 0-70). This could imply that responding programs are not tracking this demographic or the data on a particular demographic was not available to the respondent during the survey. Also note that the student participant numbers could be recalled information and not actual. In addition to the high level of missing data, there was a high level of zeros entered, as reflected in the median value for several of the demographics.

Given the level of missing data among responses, it was appropriate to use non-parametric analysis. The difference in the number of STEM participants, number of students given class standing, and number of community college students were each statistically significant between the two program types.

Table 2. Reported participant demographics (N=6860 student participants)

Student groupings	*All Programs*			*Field courses*		*Research experiences*	
	Sum	*Mean*	*Std. Dev.*	*Sum*	*Median*	*Sum*	*Median*
*STEM majors**	4324	30.24	61.61	3237	21.00	482	8.50
Non-STEM majors	511	3.55	12.90	222	0	26	0
First generation college students	362	6.83	13.91	163	3.00	69	2.50
*Freshman-Sophomore**	925	6.42	19.46	438	0	165	2.00
*Junior- Senior**	3355	22.98	25.99	2585	20.00	349	7.00

*Community college students**	205	1.46	9.10	31	0	44	0
Students with disabilities	30	.24	.57	23	0	6	0
*African American or black students*ɣ	280	2.14	7.90	151	.50	40	0
Hispanic or Latinx students ɣ	371	3.02	3.99	251	2.00	96	1.00
American Indian or Alaska Native students ɣ	30	.25	.65	17	0	13	0

Note: ɣ NSF defines these groups as underrepresented minorities   Note: *p<.05

Respondents that indicated that they specifically target certain student populations more often report higher participation rates within the populations they target. Table 3 provides the percentage of reported students that belong to each population for all programs, percentage of students in programs that do not target a specific population, and percentage of students in programs that do target a specific population. Over all, the percentage of student participants that belong to a specific population is higher for the programs that report targeting that population as opposed to those that do not report targeting that population. For example, 97.1% of black or African American students attended programs that targeted this population versus only 2.9% attending programs that did not target this population. This was not the case, however, for students with disabilities, Hispanic/Latinx students, or American Indian/Alaska native students. There was no correlation between programs targeting STEM majors and number of STEM majors, nor was there a significant correlation for programs that targeted students with disabilities and the number of students with disabilities reported. In programs that targeted specific populations and the number of targeted students within those programs the strongest significant correlations existed for community college students (r=.653, N= 130, p<.01), non-STEM students (r=.65, N= 132, p< .01), lower division students (r=.601, N=132, p<.01), and first generation college students (r=.494, N=50, p<.01). Though smaller, there were also significant positive correlations between programs that targeted Hispanic/Latinx students (r=.284, N=114, p<.01), upper division students (r=.272, N=134, p<.01), African American/black students (r= .272, N=122, p<.01) and American Indian/Alaskan native students (r=.217, N=112, p=.05).

Table 3. Number of programs that report targeting student populations and reported student participation rates.

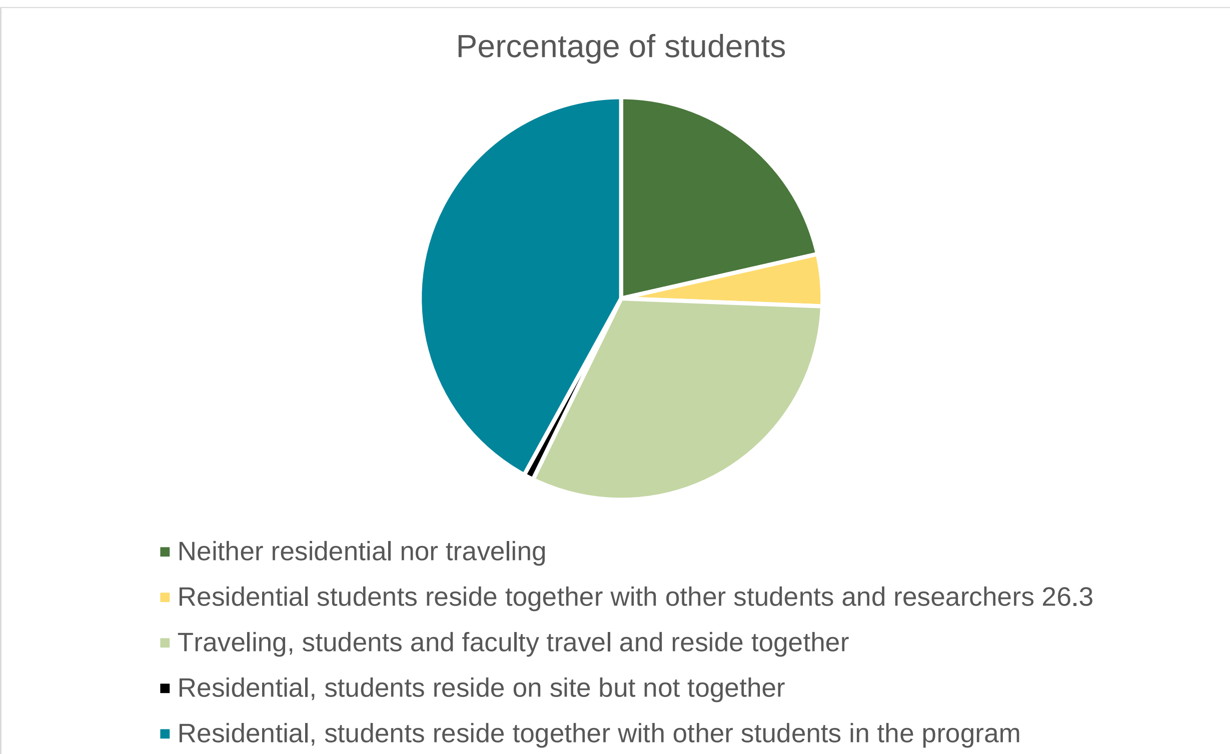
	How many programs target the following populations? (n=149)	*What percentage of student participants within the demographic attend targeted vs. non-targeted programs?*		
		All programs (%)	Programs that do not target the population (%)	Programs that do target the population (%)
STEM majors	127	63	5	86.3
*Non-STEM majors**	20	7.4	12.1	77.1
*First-generation college students**	34	5.3	25.7	71.8
*Freshman/Sophomores**	35	13.5	30.2	63.4
*Juniors/Seniors**	104	49	17.9	70.7
*Community College students**	22	3	2.9	97.1
Students with disabilities	11	<1	80	13.3
*African American or black students**	36	4.1	39.6	58.9
*Hispanic or Latinx students**	39	5.4	54.7	38.8
*American Indian or Alaska Native students**	32	<1	50	50

Note: * p<.05 nonparametric Spearman Rho (2-tailed).

Nature of program design. Most respondents (151 programs or 92%) reported that program duration is less than one year, with only eight percent or 14 respondents reported program duration longer than one year. The average program duration across all programs was 10 weeks (*M* = 9.96; *SD.* = 13.69). Most programs occur primarily during the summer (116 programs or 70%) while another 22 programs (13%) occur both in the summer and academic year. Only 27 programs (16%) primarily occur during the academic year. Respondents with summer programs selected from a list of activities in which they engaged students before and/or after the summer program. Most commonly, the activity included mentorship by faculty or instructors (reported by 67 programs) but a few other activities were meeting with students ahead of time, coursework, or opportunities to attend or present at a conference.

Another aspect of the program was the variation in residential aspects (of program and students within program). The majority of respondents reported that their programs did have a residential aspect and 79.4% of programs were considered programs at either a field station, marine lab, geology camp, or research site, although the exact nature varied (Figure 3).

Figure 3. Percentage of students in a particular residential aspect



Students are engaging in independent, mentored, or small group research in both programs described as research experiences AND field courses. The time spent in a variety of activities, however, varied for field programs and research experiences (Table 4). Among the respondents, a majority of field courses indicated no time within the program spent on career counseling. In contrast, a majority of research experiences reported spending up to 50% of the allocated time on career counseling. Both field courses and research experiences reported that students in their program spend more than 50% of the time engaging in research, whereas very few indicated spending more than 50% of the time on direct instruction.

Table 4. Percentage of responding programs and indicated percent of time spent on one of the five given activities

	Percent of programs not spending time on…	*Percent of programs spending 1-49% of time on…*	*Percent of programs spending 50-100% of time on…*
	RESEARCH		
Field Courses	7.2	34	**58.8**
Research Experiences	0	7.2	**86**
	DIRECT INSTRUCTION		
Field Courses	4.1	**77.3**	18.6
Research Experiences	15.7	**52.6**	2
	CAREER COUNSELING & PROFESSIONAL COMPETENCIES		
Field Courses	**64.4**	35.6	NA
Research Experiences	27.1	**72.9**	NA
	WORKSHOPS ON RESEARCH SKILLS		
Field Courses	39.1	**56.3**	4.6
Research Experiences	16	**82**	2
	SOCIAL/RECREATION		
Field Courses	48.3	**49.4**	2.3
Research Experiences	31.3	**68.8**	0

Perceived student Gains. We began this part of the survey by asking an open-ended question, "Broadly speaking, how do you think students benefit from participating in the program?" We asked this question prior to providing a list of potential outcomes to first gain a broad sense of what respondents might identify as predominant student benefits without leading them to specific responses pre-identified by the research team.

Respondents noted an array of perceived student benefits, with many responses following similar themes:

- Development of research skills and hands-on experience with scientific thinking
  - Many respondents note the benefit of participating in research from start to finish; development of research questions, data collection, analysis, and communication of the research findings to a broad audience
  - Development of scientific content knowledge; a deeper appreciation for that content may arise from the direct, immersive experience
- Professional growth
  - Gaining skill and comfort with field-based activities
  - Application of skills learned in the classroom to a real-life scenario
  - Broad exposure to different science fields helps students identify what content areas are of most interest to them
  - The opportunity to network with other scientists and participate as part of the scientific community is seen as highly valuable
  - Practice completing some independent work and incorporating that as part of a team effort to solve a larger problem
  - Increased identity as a scientist and confidence in ability to be a scientist
  - Development of problem-solving and critical thinking skills.
- Personal growth
  - Increased sense of environmental stewardship and conservation ethic
  - Strong friendships and relationships develop as a result of working together in challenging or new environments
  - Increased cultural tolerance and appreciation for people from other backgrounds

Two respondents brought up an observation about the benefits of their domestic field programs being very similar to the benefits commonly associated with international study abroad experiences, with the added benefit that the domestic programs are more accessible to a broader diversity of students.

To give us an idea of the relative weight of different options, we asked respondents to choose desired outcomes for students in their program from a list. Table five ranks the outcomes from most often desired to least often desired among all the programs. The three most highly desired student outcomes were those related to knowledge and skills followed by sense of belonging in scientific community, stronger professional skills and increased interest in career in field-based science and general STEM field, which were weighted equally (Table 5). We highlight that desired student outcomes related to sense of place and connection to nature, which are Environmental Education outcomes and likely distinctive to field-based experiences were some of the lower ranked desired student outcomes

Table 5: Ranking of selected desired student outcomes for all programs (most desired to least). Percentage of programs who report collecting evidence of outcome or would like to within field courses and research experiences.

	Are you collecting evidence of the outcome in your field course?			***Are you collecting evidence of the outcome in your research experience?***		
Student Outcomes Ranked	*Yes (%)*	*No, but would like to (%)*	*No (%)*	*Yes (%)*	*No, but would like to (%)*	*No (%)*
*1.Increased understanding of specific concepts and content (e.g., marine ecosystem concepts, forest ecology, soil science, biodiversity) **	61.4	22.7	15.9	40	30	30
2. Stronger skills in discipline-specific procedures (e.g., measuring soil temperature, collecting water samples, small mammal trapping)	60.5	17.3	22.2	51.3	20.5	28.2
3. Increased understanding of and proficiency with research practices (e.g., development of research questions, design research protocol, data analysis and interpretation, presenting results)	64.5	17.1	18.4	63.8	19.1	17
4. Greater sense of belonging in the scientific community	17	36.2	46.8	40	35.6	24.4
5. Stronger professional skills (e.g., collaboration, communication, persistence, problem-solving)	40.8	32.4	26.8	52.3	34.1	13.6

*6. Increased interest in a career in general STEM field**	10.2	42.9	46.9	56.1	31.7	12.2
*7. Increased interest in a career in field-based science**	20.7	31	48.3	61.3	25.8	12.9
8. Stronger connections to place (e.g. awe, wonder)	13.8	35.4	50.8	23.1	38.5	38.5
9. Increased respect or care for the environment	13.7	45.1	41.2	15.4	50	34.6
10. Increased stewardship intention or behavior	15.9	43.2	40.9	12	52	36
*11. More refined career goals**	18.9	43.2	37.8	52.8	30.6	16.7
12. Stronger development as informed citizens	25	32.5	42.5	14.8	55.6	29.6
13. Increased sense of connection to large-scale problems or issues (e.g. climate change, biodiversity loss)	15.8	42.1	42.1	25.8	41.9	32.3
14. Expanded professional networks	25.8	35.5	38.7	48.6	32.4	18.9
15. Increased sense of connection to local/community problems or issues	17.4	43.5	39.1	13.6	63.6	22.7

Note: * indicates statistically significant results of Mann-Whitney *U* tests $p<.05$ between field courses and research experiences per outcome.

Knowing that a constructed answer from a close-ended list does not capture all possible student outcomes, we gave respondents an opportunity to list additional desired student outcomes that were not included in the provided list. Less than 30 respondents named additional outcomes. Below we list responses that based on our interpretation are not already included in the close-ended choices (Table 5):

- Love for nature, intense respect for the environment, commitment to sustainability
- Increased self-confidence in STEM abilities
- Generation of research products
- Ability to live and work in primitive or adverse camping conditions
- Exposure to approaches outside their own discipline
- Listening and being still
- Increased connection to the K-12 community
- Increased awareness of scientific ethics

We highlight, "ability to live and work in primitive or adverse camping conditions," "Love for nature, intense respect for the environment, commitment to sustainability," and "listening and being still," as possible student outcomes that are distinctive to field learning experiences.

In the survey, respondents had an opportunity to indicate for which of the desired student outcomes they had chosen, they are collecting empirical evidence (to support of fund the program). Respondents could choose between three options, "yes," "no" or "No, but would like to." A "no" response indicates respondents are not collecting evidence on that outcome, and they do not want to in the future (See Table 5).

For the top three desired student outcomes (Increased understanding of specific concepts and content, Stronger skills in discipline-specific procedures, and Increased understanding of and proficiency with research practices), empirical evidence is being collected by more than half of the respondents across all program types (Table 5). In contrast, under 20% of the respondents who desired student outcomes of "Increased respect or care for the environment," "Stronger connections to place," or "Increased stewardship intention or behavior" collected evidence about that outcome. This lower rate of collection of evidence for these outcomes is notable in that these are outcomes likely to be distinctive to field experiences as opposed to lab or classroom based undergraduate courses and research experiences. Also worthy of note is that "greater sense of belonging in the scientific community" was the 4th most highly desired student outcome with 76% of respondents choosing it, yet only 17% indicated they are collecting evidence on this outcome and 36.2% checked the "no, but would like to" response.

Considering these results between programs best described as field courses versus research experiences indicates a few important distinctions. Overall, respondents selected a greater number from the list of possible desired student outcomes for research experiences than field courses (68% versus 60%). The proportion of programs who report collecting empirical evidence on desired student outcomes is statistically significant different between field courses and research experiences. The method of evidence collected was not reported. Respondents could choose among if the program was collecting evidence on the outcome, if they would like to start collecting evidence on the outcome, or no they are not collecting evidence. Evidence of increased understanding of specific concepts and content was collected proportionately more often in research programs than field courses. For field courses, evidence collected on participating students with an increased interest in a career in general STEM fields and an increased interest in a career in field-based science were both statistically significant in greater proportion in comparison to research experiences (Table 5).

An important part of the landscape study is to assess needs of potential members of UFERN. Respondents indicated highest interest in collecting evidence about "increased sense of connection to local/community problems or issues, and next ranked "increased respect or care for the environment" and "increased stewardship intention or behavior" (Table 5). We also asked what assistance they would request to improve their collection of evidence on student outcomes for program goals. Over half of respondents provided an open-ended answer summarized as follows:

- 14 Respondents report not wanting help for a variety of reasons, such as:
  - Too busy
  - Already have strategies they are using that are working fine
  - Concern that an instrument/tool/survey would not be able to adequately capture the complexity of student outcomes
- 18 Respondents were uncertain, stating they were not sure or would "possibly" be interested:
  - Uncertainty over what an effective approach would be given the complexity of their program
  - Would consider improving what they do now, but depending on what that would entail
  - Would consider with the help of an expert from social or behavioral sciences
  - Insufficient time to collect this type of data
  - Difficulty of collecting data because it would need to be long-term longitudinal data including career outcomes

- 53 respondents did express wanting help, some providing more specific information about what that would mean:
    - Not sure how to do it, or what would truly be able to capture the outcomes
    - Many respondents mention a desire for longitudinal data on student outcomes
    - Request access to know what others in the field are doing now; a template
    - Many respondents report that what they would want is someone to do it for them (perhaps free of charge)
    - Several respondents desire a template or rubric for a pre/post evaluation instrument

We asked programs to select from a list how they were using empirical evidence to guide their work (Table 6). Respondents could select "Yes," "No," or "No but would like to." Overall, the most common ways respondents use empirical evidence is: to make changes in program design to improve student experiences and to improve instructor/mentor experiences. Less common is the collection of empirical evidence for reporting to supervisors, reporting to funders, to make changes to the application process or to make changes to recruitment. For all of these outcomes, less than 20 percent of the respondents reported that that they would like to use empirical evidence to guide their work (in an area they were not currently doing so).

Table 6. Reported ways respondents use empirical evidence to guide their work.

	N	*Yes (%)*	*No, but would like to (%)*	*No (%)*
To make changes in program design to improve student experiences	149	69.8	14.1	16.1
To make changes in program design to improve instructor/mentor experiences	149	59.7	17.5	22.8
To make changes in the application process	150	35.3	12.7	52
To make changes in recruitment	150	34	17.3	48.7
For reporting to funders	146	26.7	12.3	61
For reporting to supervisors	146	26.7	11.6	61.6

To understand more deeply how respondents are collecting evidence about desired student outcomes, we asked survey participants what if any assessment tools they are currently using to measure student outcomes. The 53.9% of the respondents who reported using assessment tools mentioned the following: an external evaluation tool (i.e., SURE III (©Grinnell College 2005-18), SALG (Seymour, 1997), NSF BIO REU Assessment Tool (NSF, 2018), Cornell evaluation, and URSSA (Weston, T. J. and Laursen, S.L., 2015) were the most commonly mentioned assessment tools followed by assignments in the form of quizzes, papers, and journal entries. Collection of longitudinal data about students who participate in the program is less common, with only 34 percent of programs reporting that they collect longitudinal evidence. Of these 53 programs, most described this data as tracking of students through social networks, email, or through employee records or graduate student enrollment. About 20 reported using a survey but have experienced low response rates or only recently initiated the survey. One respondent specifically mentioned having hired an external evaluator.

Instructional and Pedagogical Strategies. In the survey, we asked about the extent that programs explicitly use a list of instructional and pedagogical strategies. We did not make the list with the purpose of including every possible instructional and pedagogical strategy possible, but instead used our knowledge of the literature and the expertise of members and advisors of UFERN (M. Storksdieck, B. Cuker, T. Mourad, P. Chigbu, pers. comm.) to come up with a list of commonly used strategies when designing and implementing programs for inclusivity of underrepresented students.

By far, the most commonly used strategy was providing written guidelines of expectations for mentors/instructors and/or students (43% reported using this strategy a great deal). Thirty-four percent, 32%, and 30%, respectively reported using the following strategies a great deal: give students choice, connect the program topic to large-scale problems or issues, and connect research or program topic to careers (Table 7). Many more programs responded “not at all” or “a little” for the explicit use of the listed strategies. For example, incorporating Traditional Ecological Knowledge, providing diversity training to students and/or mentors had over 50% report not using this strategy at all. Respondents were most interested in using the following strategies more or better: collecting information from the student participants before the program starts and use it to inform program design and provide clear and safe pathways for addressing individual and group concerns.

Table 7. Reported percent of programs who use indicated instructional strategies and percent of programs who indicated interest in using this strategy more or better.

	To what extent do you explicitly use this strategy? (%)				***Would you like to use this strategy more or better? (% "Yes")***
	Not at all	*A little*	*A moderate amount*	*A great deal*	
Provide written guidelines of expectations for mentors/instructors and/or students (n=140)	7.1	15	35	42.9	15.8
Give students choice (about research project topic, about mentors, etc.) (n=140)	35.7	11.4	18.6	34.3	6.1
Connect the program topic to large-scale problems or issues (n=140)	14.3	20	33.6	32.1	10.9
Connect research or program topic to careers (n=139)	10.1	20.1	40.3	29.5	13.3
Develop formal agreements with students and/or mentors/instructors such as code of conduct and code of ethics (n=140)	21.6	18	31.7	28.8	13.3
Provide clear and safe pathways for addressing individual and group concerns (n=142)	6.3	27.5	43	23.2	21.2

Connect the program topic to local/community problems or issues (n=140)	25.7	24.3	27.9	22.1	12.1
Provide pre-program training and/or support for students to prepare them for success (n=143)	28.7	28	25.2	18.2	18.2
Provide need-based support to address disparities in student resources (n=139)	36.7	21.6	27.3	14.4	18.8
Include opportunities for students to interact with mentors, instructors and/or other experts from groups underrepresented in STEM (n=137)	32.8	26.3	27	13.9	17.6
Provide mentoring system where students support each other (e.g., near-peer mentoring from program alumni) (n=139)	33.1	38.8	19.4	8.6	20
Collect information from the student participants before the program starts and use it to inform program design (n=143)	37.8	39.9	15.4	7	21.8
Incorporate Traditional Ecological Knowledge or other alternative ways of knowing (n=140)	55	24.3	14.3	6.4	12.1
Provide diversity training to students and/or mentors (n=141)	53.2	31.9	10.6	4.3	20

Limitations

The limitations of this study reflect the nature of a landscape study in which the full community of undergraduate field programs is not clearly delineated or defined. This lack of a defined population or audience for the survey presented challenges to survey recruitment. The notion of what constitutes a "field program" is not consistent across disciplines or individuals. The research team made every effort to reach out to a broad range of communities and professional associations likely to include individuals directly involved in undergraduate field programs, but given this ambiguity and the overall low response rate expected of online and email based surveys, final recruitment may not have been a random representation of the undergraduate field program community. Certain individuals may have been more likely to see the survey recruitment or more motivated to respond based on familiarity or prior connection with the UFERN principal investigators.

We did not provide clear definitions of key concepts in the survey like, "extended" and program type (field course vs. research experience vs. service-learning program), but instead gave the respondents agency in defining where their programs fit into these terms. We will use this data to help craft these definitions for UFERN.

The data on desired student outcomes are responses from survey participants, therefore student outcomes or benefits are as perceived by the instructors or program directors. We did not yet aim to assess whether the desired student learning outcomes are achieved; the goal of UFERN is to help instructors do so and the starting point is to figure out what kinds of outcomes they want to assess.

Key Findings

This landscape study has provided a unique opportunity to explore the nature of extended undergraduate field experiences and summarize needs as defined by stakeholders. We conclude the report with the following key findings that members of UFERN can use to guide next steps.

<u>Key Finding 1:</u> The landscape of what constitutes extended undergraduate field experiences is varied. Undergraduates are engaging in field courses, research experiences, and service-learning experiences on average lasting ten weeks and occurring primarily during the summer, but some programs occur during the academic year and many summer programs offer mentorship by faculty or instructors during the academic year. Another key aspect of

undergraduate field experiences is the residential nature of the programs, where students reside with other students in the program. Undergraduates are engaging in undergraduate field experiences that in about one-third of the cases have existed for 40 years or more, indicating the strong tradition and value of field learning that these programs offer, as well as the potential for research and learning across diverse and inclusive audiences.

<u>Key Finding 2:</u> Respondents reported that 6,851 undergraduate students participated across the 165 undergraduate field experiences in 2017 for which we have data. The majority of these students were upper-division STEM majors and upper-division students. Participation of underrepresented minorities (as defined by the National Science Foundation) comprised 9.9% of total student participants reported across all four program types as compared to these same groups comprising 31% of the U.S. population in 2015. Thus, minority participation in field experiences lags behind the country's demographics, supporting the need to diversify field experiences. Survey results also indicate that programs that target underrepresented demographics tended to report a greater percentage of students within the particular demographic (Hispanic or Latinx as an exception in the survey data). This result may be attributed to the idea that these respondents are tracking this information more so than others are, however it may also support the need for programs to explicitly target underrepresented populations in order to recruit these students.

<u>Key Finding 3:</u> Students are engaging in independent, mentored, or small group research in both programs described as research experiences AND field courses. In both program types, respondents reported that direct instruction of science content was largely less than 50% of how time was spent in their programs, in contrast, students spend more time doing research, which indicates the active, hands-on learning aspects of these field-based experiences. A greater number of freshman and sophomores, non-STEM majors, and students overall participated in field courses as compared to research experiences, thus indicating that these field course have potential to or are already serving as gateways to developing interest in field-based sciences and STEM in general. The format and size of field courses are worth exploring as a way to make research more accessible, particularly for underrepresented minority students (Auchincloss et al. 2014). This accessibility providing an opportunity to improve persistence of underrepresented students in STEM, as well as produce science-literate non-STEM majors.

<u>Key Finding 4:</u> Respondents noted an array of perceived student benefits for participation in undergraduate field experiences, such as development of research skills and hands-on experience with scientific thinking, professional growth, and personal growth. Development of research skills as a perceived student benefit aligns with the

extensive time focused on research activities across both field courses and research experiences. In contrast, 64.4% of field courses responded that no time was spent on career counseling and professional competencies, though professional growth was considered a perceived student benefit among several respondents. Data from the survey also indicated that a greater proportion of field courses ranked an increased interest in career in field-based science or general STEM field as a more highly desired student outcomes than programs defined as research experiences. It may be that both field courses and research experiences find value in professional development and attainment of research skills, but the mentoring and apprenticeship model of research experiences (Linn et al., 2015) may lend itself to more time spent on professional development. Data indicates the importance professional development given the model of mentorship largely reported (70%) by summer programs and could be a fruitful area of further exploration.

<u>Key Finding 5:</u> Among all the programs who responded, the highest ranked desired student outcomes were related to knowledge, skills and abilities (discipline-specific skills, research practices, conceptual knowledge) vs. place-based outcomes (e.g., Increased sense of connection to local/community problems or issues and stronger connections to place). It is clear that science education (SE), with a focus on content knowledge and skills is desired and more often represented in the greater percentage of evidence collected on these outcomes to support and/or guide the work of undergraduate field programs, but we highlight the expressed interest in collecting more evidence around placed-based or environmental education (EE) focused outcomes, especially within research experiences. Environmental science education, which we assumed was the focus of most of undergraduate field experiences, is different than EE, which is often geared more towards behavior change or has an element of community, placed-based value (Wals, Brody, Dillon, & Stevenson, 2017), but we call out the opportunity for EE or aspects of EE to occur at these field stations (Mogk and Goodwin, 2012) and survey data supports the desire to collect more evidence on these affective outcomes in order to guide and/or support future work. This echoes a theme of affective development in undergraduate students in a study by Petcovic, Stokes, and Caulkins (2013), supporting undergraduates as they develop a positive identity within the field-based community. In addition, when given the opportunity to list additional desired student outcomes in an open-ended way, respondents provided several student outcomes that are likely distinctive to field learning such as “Love for nature, intense respect for the environment, commitment to sustainability,” “Ability to live and work in primitive or adverse camping conditions,” and “Listening and being still.” The network could explore intersections of SE and EE in field-based programs both in terms of lessons learned for improving program design and in thinking about how best to assess student learning. Also, worth exploring are how these affective attributes recruit,

support, and retain underrepresented populations, as there is some evidence to support that value-based socio-emotional learning can reduce the achievement gap (Harackiewicz, Canning, Tibbetts, Priniski, and Hyde, 2016) in underrepresented minority populations in STEM fields.

Key Finding 6: For the top three desired student outcomes (Increased understanding of specific concepts and content, stronger skills in discipline-specific procedures, and Increased understanding of and proficiency with research practices), empirical evidence is being collected by more than half of the respondents who chose that desired student outcome. In contrast, for all of the other desired student outcomes including some of the highly desired student outcomes such as greater sense of belonging in the scientific community, stronger professional skills, and increased interest in a career in field-based science, less than half of the respondents are collecting evidence about that outcome. The respondents to the survey expressed a strong interest in receiving assistance to improve their collection of evidence on student outcomes, most urgently for student outcomes of increased sense of connection to local/community problems or issues, increased respect or care for the environment, and increased stewardship intention or behavior. Help or support mentioned by respondents include: 1) a template or rubric for a pre/post evaluation instrument, 2) information about what others in the field are doing, 3) help collecting longitudinal data on student outcomes, and 4) help from experts from social or behavioral sciences. Survey data supports the need for undergraduate field programs to build the capacity to more consistently collect evidence about student outcomes and to connect desired student outcomes to design of the experience and collecting evidence about the experience for improvement over time.

Key Finding 7: When choosing from a list of instructional and pedagogical strategies commonly used when designing and implementing programs for inclusivity of underrepresented students, respondents reported they most widely "provided written guidelines of expectations" as a strategy during their undergraduate field-based program. However, even as the most widely used strategy, only 42.9% responded they used it a great deal. "Giving students choice (e.g., about research project topic)" was the next most commonly used strategy, again with less than half of the respondents utilizing this strategy. For particular strategies (i.e. "incorporating Traditional Ecological Knowledge or other alternative ways of knowing," and never using diversity training) more than half of respondents selected "not at all" or "little" for the explicit use of most of the strategies. These results may indicate a serious need for professional development and training around evidence-based practices for engaging *all* students and in particular, those underrepresented in the field-based sciences. When asked about support for using these strategies in the future, respondents were most interested in using the following strategies more or better: collecting information from the student participants before the program starts and use it to inform program design and provide clear and safe pathways for addressing individual and group concerns.

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Technical Appendix (Methods)

The landscape study included both a review of the literature and a questionnaire with closed and open-ended questions. The review of the literature provided initial understanding at a broad level of the nature of extended field experiences and guided the survey questions, which were designed to better understand the current programming and assessment efforts around undergraduate field experiences.

Survey development. An online questionnaire with 37 items was developed for directors/instructors/coordinators of extended undergraduate field experiences. The items were developed *de novo* based on pre-determined guiding questions for UFERN, input from UFERN steering committee and advisors and a literature review. A mixed-methods approach was used with closed-ended questions that answered the program details (e.g., type, role, student demographics, desired student outcomes) as well as qualitative open-ended questions around pedagogy and evidence-based program design. The questionnaire was pilot-tested, revised, and implemented on Qualtrics, an established online survey tool.

Survey sample and distribution. Our area of focus for this study was field stations and marine labs and thus we focused our survey invitations on members of OBFS and NAML. The selection of these email addresses was purposive and convenient, in that we attempted to reach the major organizations of people that were likely to include those involved in undergraduate field programs but were somewhat limited based on accessibility to email lists. In addition, we sent similar survey invitations to other listservs and contacts as identified by the UFERN steering committee and members of the network (e.g., geosciences field camps, NSF-funded Research Experiences for Undergraduates site programs with an apparent field component) to get a broader perspective about extended undergraduate field experiences. In all we sent 553 email invitations to the survey on March 14, 2018. These email addresses were from:

- Organization of Biological Field Stations (OBFS) 2017 meeting participants (115 emails)
- National Association of Marine Laboratories email contact list (77 emails)
- List of faculty participants in Geosciences field camps (170 emails)
- Long-Term Ecological Research (LTER) network members recommended by LTER Education & Outreach Committee (10 emails)
- List of faculty who received NSF Research Experience for Undergraduates (REU) site funding that were likely to have a field component (181 emails).

An additional 10 email addresses were gained from snowball sampling (recommendations of other respondents), and those individuals were emailed the survey link on March 21, 2018. Of this total of 563 targeted email respondents, we received 175 email responses for a rate of 31 percent, though some of these participants did not complete the survey past providing a name of a field program in which they were involved. We collected an additional 49 survey responses as of April 2, 2019 utilizing an anonymous link that was distributed to a variety of listservs, such as Ecolog, Council for Undergraduate Research Community Forum, and OBFS. This additional effort brought total responses received up to 224; the total sampling population and response rate is unknown given the anonymous link distribution.

Table A-1

Total responses received	224
Responses of individuals not directly involved in field programs	17
Responses with no useful data (less than 20% completion)	64
Responses with usable data	143
Number of responses who provided data on 2 programs	23
Total field program data	165

Because no agreed-upon definition exists of what constitutes an “extended” field experience, we allowed potential participants in the survey to self-identify what “extended” experience meant to them. Specifically, in the survey recruitment language

we invited them to take the survey, “If you are a program director, instructor, or coordinator directly involved in extended field courses, geology field camps, research experiences, or other kinds of structured field programs for undergraduates.”

Survey response. The survey gathered useable data from **143** individuals about **165** undergraduate field programs (23 individuals provided information on two programs).

Seventeen individuals entered the survey but responded that they were not currently directly involved in any field programs. Additionally, 64 survey respondents did not complete the survey past providing the name of their program (less than 20 percent completion). The sample size and response rate varies across results. The variation is due to participants not answering all questions but continuing through the survey.

More than half (54%) of respondents self-identified as directors, 39% as lead instructors, 23% as coordinators, and 16% as mentors. Respondents could also write-in a self-identified role. The majority of respondents mentioned filling a director role within their program (same respondents when given closed-ended question); however, 32% of all respondents listed more than one role, showing overlap in the roles. For example, when writing in responses some respondents listed Associate Professor as well as Director of Research as roles/titles.

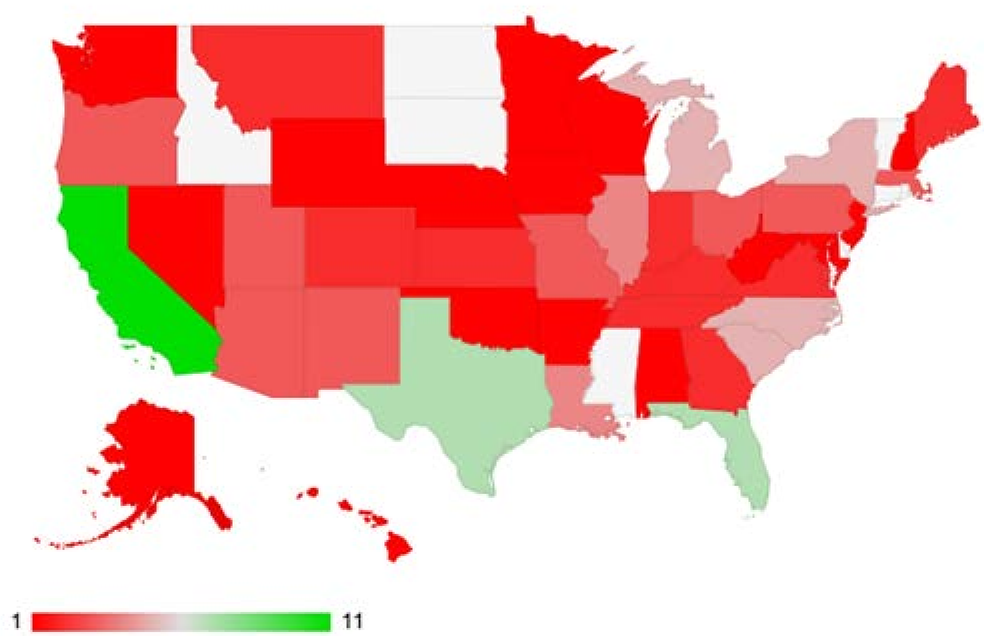
Table A-2

Role	**Respondents in this role (with overlap)**
Director	44
Coordinator	16
Lead Instructor	32
Mentor	4
Other	5

Number of institutions represented by state. The 143 unique respondents represented 115 institutions spread across the United States (111 institutions) and abroad (4 institutions).

This map displays the spread of institutions across the U.S.; where many states in red had one or two institutions, and green states had multiple institutions represented in the sample. California had the most institutions represented (11 institutions).

We received no responses from institutions in the white states.



Data analysis. For analysis, exported data from Qualtrics, was entered into Excel to be cleaned. IBM SPSS version 24 was used to calculate descriptive statistics, and check assumptions. Due to the high level of missing data, non-parametric tests, given assumptions not met, were employed. Analyses did not included missing data, employing listwise deletion, and all analyses were considered significant with a $p \leq .05$. To compare student demographics by program type, a Mann-Whitney test was used. To determine the significance of the proportion of a program's type on collection of evidence on outcomes between program types, a chi square test was used. To determine the correlation between the number of students within a population and the number of students within the programs that targeted that particular population, a nonparametric Spearman Rho (2-tailed) was used.

Open-ended data were sorted into themes. We did not attempt to quantify this data as the analysis was focused on identifying typical answers (rather than how many of the respondents thought in a particular way). We also identified interesting comments and ideas and highlighted them in the report.