Abstract

A key outcome of an effective undergraduate experience is for students to gain disciplinary knowledge and develop a range of skills and habits of mind that prepare them for career success. In 2018, the Ecological Society of America (ESA) entered into an agreement with the US Geological Survey (USGS) to recruit students and recent graduates and place them into field ecology/biology internship positions at research sites across the United States. This paper focuses on field research jobs and presents a literature review to gain an understanding of workforce development issues and preliminary perspectives on critical skills in which employers might be interested. This paper is based on a case study of one employer (USGS) and investigates the potential alignment between employer expectations, field training, and perceived student outcomes. To conceptualize new graduates’ readiness and employer expectations, we identified a set of skill categories sought by field research sites. We did this by analyzing the job descriptions available through the 2019 ESA/USGS Cooperative Summer Internship Program and prior literature. These categories were incorporated into a new post-internship student survey that was used to collect data from students. We found a potential gap in some transferable skills in both fieldwork and office work expected by employers and those offered by undergraduate field training programs. This could be explored in future studies involving a more extensive set of employers who seek to hire students with field ecology/biology skills.

Key words: careers; education; employers’ expectations; field research; students’ skills; undergraduate field programs.
Introduction

In 2018, the Ecological Society of America (ESA) entered into a partnership with the US Geological Survey (USGS) to recruit participants (undergraduates and recent graduates) to the 2019 ESA/USGS Cooperative Summer Internship Program. This program provided an ideal opportunity to (1) explore the relationship between student preparation, employer expectations, and student work experiences (which serves to advance the goals of ESA’s Next Generation Careers: Innovation in Environmental Biology Education project), and (2) inform the Undergraduate Field Experiences Research Network (U-FERN), which seeks to build a vibrant, supportive, and sustainable collaborative network that fosters effective undergraduate field experiences. This study is an initial approach to conceptualizing the relationship between employer expectations and field training by studying the skill sets indicated in the 2019 USGS internship job descriptions. This is compared to the field skills gained by students through their prior field experiences with their undergraduate field programs.

Background

Modeled after a similar 50-year partnership with the National Association of Geoscience Teachers (NAGT), the USGS sought to expand the program, based on feedback from its scientists, to include students trained in biological or ecological field methods. The agency employs research scientists who work on its mission areas in all states and territories, including ecosystems, environmental health, water, and climate, as well as traditional geologic areas such as natural hazards, energy, geology, and minerals. The ESA/USGS Cooperative Summer Internship Program provided an opportunity to begin an effort to explore the skills sought by an employer for field ecology/biology training positions (pre-workforce), along with student outcomes from field ecology/biology programs.

Since 1965, the NAGT-USGS Cooperative Summer Field Training Program has placed more than 2,000 students and recent graduates into USGS internships, with many participants moving into careers with the USGS, academia, or industry. Similar to the NAGT-USGS internships, undergraduates with “excellent training” in field methods had to first be nominated by faculty or directors of field training courses, or have experiences completed within the preceding six months. In the case of ESA-USGS internships, nominees are expected to be trained in biological field methods.

It became quickly apparent that what constituted as “excellent training” had not been formalized by ecologists. ESA consulted key education leaders to agree on a preliminary operative definition of “excellent training” for the ESA/USGS Cooperative Summer Internship Program. The following experiences are regarded as meeting the criteria for excellent field training:

1. a 4- to 6-credit hour course, taught in the field in which students learn to make observations, collect, and analyze data. An average of 40 hours of field training is expected.
2. a series of laboratory experiences across multiple courses that together may add up a 4- to 6-credit hour course; or
3. a research experience of 10 or more weeks where the student participates in field research.
Below is a list of biological field skills from the preliminary operative definition of “excellent training” for the ESA/USGS Cooperative Summer Internship Program:

1. Identification of plants, vertebrates, invertebrates, or microorganisms
2. Physiological field measurements (in situ photosynthesis, respiration, water relations, etc.)
3. Population assessment (quadrats, transects, mark–recapture, etc.)
4. Community-level assessment (measuring density and diversity, etc.)
5. Ecosystem-process field assessment (carbon or nutrient flux, whole system metabolism, watershed studies, etc.)
6. Assessment involving two or more trophic levels
7. Soil analysis (e.g., moisture, organic matter content, texture, functions, etc.)
8. Use of ground truth remotely sensed images (e.g., Google Earth, NEON, etc.)
9. Water analysis (physical and biological measurements, flow, etc.)

In this study, the expectation of “excellent training” as used by ESA includes any kind of biological field program or field course in any setting. The outlined criteria are regarded as the minimum expectations for a course director to be able to nominate a student for the USGS internship.

This study involves three components: (1) a literature review to gain insight into field ecology/biology workforce preparation, (2) a set of categories of identified job skills that analyze employer, student, and pre-workforce training expectations, with a focus on ecology, and (3) considerations for the design of the post-internship survey.

Keywords used to search for relevant literature include the following: education, field research, careers, undergraduate field programs, employers’ expectations, and students’ skills. The post-internship student survey and the categories for the job skills were derived from both the literature review and the job descriptions provided by the USGS sites that participated in 2019. The objective of modifying the student survey is to gain data on student perceptions of the skills they used during the internship and how well they felt prepared for it by their field program experience.

**Literature Review**

Since the United States launched its outer space program in response to Sputnik, there has been a steady public interest in the development of a world-class science, technology, engineering, and mathematics (STEM) workforce with the knowledge and skills to drive global competition and innovation (NRC 2007, USCRS 2018). In recent years, this discussion has focused on the alignment between STEM education, including the role of research experiences (Rodrigo-Peiris et al. 2018) and employer expectations (BHEF 2013, NASEM 2016a, 2016b, 2017).

Our current effort is made in the context of a broader interest in employer expectations, including those from consulting, nonprofit, agency, research, and industry organizations who employ research scientists with field ecology/biology skills. We note that there are few studies on the expectations of employers who are hiring from pre-workforce training programs or entry-level positions in field ecology/biology positions. Few studies report on whether new hires meet those expectations.
Employer expectations and student experience

A scan of the literature yielded limited direct quantitative evidence specifically connecting undergraduate field experiences in ecology to preparing students for the workforce (O’Connell et al. 2020). Most of the literature discussed in this paper was related to the geosciences. The available studies that compared employer expectations and incoming student knowledge from their undergraduate careers suggest that there is a gap between employer expectations and student knowledge and skills.

Field experiences

A study of the value of undergraduate geoscience field education (Petcovic et al. 2014) revealed that 89.5% of all respondents (learners, instructors, and industry professionals) and particularly, 88% of industry professionals (employers), agreed that geoscience undergraduate programs should include fieldwork as a fundamental requirement. Among respondents, the value of undergraduate field programs was mainly attributed to the variety of cognitive benefits (knowledge and skills). Additionally, 87.5% of employers also agreed that field method courses and/or residential camps should be required as part of the field program. Employers responding to the survey identified the most significant outcomes from undergraduate field programs as follows: (1) improved understanding of fundamental theories/concepts, (2) proficiency in field skills, and (3) development in critical thinking and problem-solving skills.

Fleischner et al. (2017) documented the loss of field studies in biology, particularly in the last two decades, and suggested that students involved in field experience have a greater chance to “cultivate the critical connections to real places that transform abstract concepts into tangible realities.” However, Petcovic et al. (2014) found that effective dimensions such as motivations, attitudes, and values were considered important but not as valuable as the above-mentioned skills. This was consistent across all respondents of the survey, including employers.

Lab, field, and professional skills

Career opportunities both in laboratory and field settings require certain skills. In a scientific community, a basic understanding of the scientific method, experimental design, and statistical analysis is expected for an entry-level position (Byers 2018). Other skills, such as learning new software/applications or gaining in-depth knowledge of a specific subject area, could be developed through on-the-job training or experience (Dale 2018).

In addition to research skills, transferable skills such as effective communication, adaptability, and persistency overlap across employment expectations in the science research sector (Aplet et al. 2017, Klemow et al. 2017, Dale 2018, Nuttle and Klemow 2018). Mostly, transferable skills are presumably what students should acquire before entering the workforce (Byers 2018, Dale 2018). Aside from what students learn in the classroom, gaining practical experience through internship programs, fellowships, or volunteer opportunities are highly valuable because they indicate the students’ adaptability in various work settings (i.e., laboratory, field, and office; Morales et al. 2020).

Students perceived that the key skills sought by employers are time management, teamwork, communication, and problem-solving, and were unlikely to prioritize other skills such as independent learn-
ing, adaptability, and initiative (Hill et al. 2019). This provides a concise picture of the gap between employer expectations and what recent graduates recognized as priority skills for certain workplaces. Developing the skills that employers prefer is important for students/recent graduates in developing a successful career path (Hill et al. 2019). It was interesting to note that while professional growth was considered a perceived student benefit, the U-FERN study found that 64.4% of field courses spent no time on career counseling or professional competencies (O’Connell et al. 2020).

Workforce preparation

The challenges to recent graduates’ employment, both finding employment and succeeding in their positions, are often attributed to the lack of preparation in their undergraduate education, which would have helped them understand employer expectations and interests (BHEF 2013, NASEM 2016a, 2016b, Thompson et al. 2018). A major takeaway from the literature review is that detailed research has not been done on the relationship between employer expectations and student skill sets at the time of graduation, particularly for field research careers, which require more than typical office and laboratory skills to be successful. This shows the need for a study that particularly focuses on field research.

Many field-related majors offer internships and laboratory courses to better prepare students for their chosen career path. There is also a general agreement that fieldwork provides skills and knowledge that cannot be learned in a classroom setting (Aplet et al. 2017, Fleischner et al. 2017, Byers 2018, O’Connell et al. 2020, Morales et al. 2020). However, while field programs at the undergraduate level have been offered for decades, they are often not required for graduation in a field-related major.

Twenty-first century employers expect that the scientists they hire will be involved in teamwork, community engagement, and collaboration with other disciplinary experts (Aplet et al. 2017, Klemow et al. 2017, Nuttle and Klemow 2018). To meet these expectations, integrating career counseling opportunities within the curriculum could overcome the challenges encountered by employers and new graduates (O’Connell et al. 2020).

Field research programs and perceived outcomes

We now turn to the literature on field programs, which provide the undergraduate research experiences that are so pivotal for students in STEM fields. Such programs provide an opportunity for students to experience various aspects of their career, such as their scope for work, and give them a platform to network.

The National Academies of Sciences, Engineering, and Medicine report (NASEM 2017) on Undergraduate Research Experiences (UREs) highlights the importance of research experiences in career preparation for STEM fields. UREs enable students to master specific research techniques, understand the research process, design their research project addressing a relevant problem of interest, and efficiently communicate their research to the scientific community and the general audience (NASEM 2017). A study by U-FERN surveyed directors of field programs and courses in a wide variety of settings, such as field stations, marine laboratories, geology camps, and research sites. The study focused on what they perceived students as gaining from participating in such undergraduate field experiences and what they believe to be the most important desired student outcomes. It surveyed a total of 163
undergraduate field programs/courses across the United States. The study sought to understand design features and attributes of field experiences, instructional strategies and learning activities, and desired student outcomes. These include attributes such as residency, duration of field experience, and opportunity for extended engagement. In these programs, students engaged in independent, mentored, or small group research. The directors believed students gained many skills from their programs, most of which could be categorized under three themes: development of research skills and hands-on experience with scientific thinking, professional growth, and personal growth (O’Connell et al. 2018, 2020).

Methods

In attempting to identify skills that employers expected students or recent graduates to have in field research, we found little in the literature that provided a comprehensive set of categories for skills specific to fieldwork. The study by O’Connell et al. (2018, 2020) on student outcomes from field experiences provided some key insights. We proceeded to categorize and list the skills that could help us gain a better understanding of the employer expectations and provide a medium to obtain quantifiable data from students through the student evaluation survey. To do this, we referred to literature and the job descriptions from the 2019 ESA/USGS internships. We obtained job descriptions from site directors/principal investigators and the undergraduate field program descriptions from the program directors/instructors that nominated their students. These descriptions served as the primary resource for the categorization of the skills in our study.

We categorized all the skills into three major categories: technical skills, transferable skills, and program-specific skills. The complete breakdown of all categories and skills is provided in Appendix S1. Technical skills can be defined as specific skills needed to perform a certain task in the work environment (e.g., the ability to perform a certain procedure in the field). Transferable skills are the skills that are not limited in use to a single workspace or discipline but can be applied to multiple jobs. A classic example of this is teamwork. While teamwork skills are crucial in several field settings, it is also integral to jobs in other sectors like business. Lastly, program-specific skills are skills specific to one specific setting under the larger “field research” umbrella. An example would be the theoretical knowledge required to succeed in performing the tasks of a particular field/research setting.

To ensure that the list of skills and our categorization was comprehensive for field research in ecology/biology, we consulted field professionals from our collaborators, U-FERN and USGS, to review our list and categorization.

Employer expectations vs. undergraduate field training experiences

After analyzing the job descriptions and the field program descriptions, we wanted to see whether the field programs highlighted the skills that the employers from the job descriptions typically expected students to have. In order to quantify the data and make the comparison easier to visualize, we created a tally system for each category of skills (Appendix S1). If the description references the skills in a particular category, that site gets a tally for that category. For example, if the description included skills for specimen preparation, then the category “Technical Skills—Fieldwork” gets a tally for that site. Using this methodology, a tally count was made for all of the internship sites (n = 25; see Appendix S2).
To have a better understanding of what skills undergraduate field programs have highlighted in their curriculum, we used the brief description provided by the field programs that nominated their students for the 2019 ESA/USGS Cooperative Summer Internship Program. We used the same methodology for our analysis of the job descriptions and created a tally for all of the field programs (n = 57; see Appendix S2).

**Post-internship student survey**

The ESA/USGS Cooperative Summer Internship Program administers a post-internship evaluation survey every year. For the 2019 program, in collaboration with ESA, we modified the survey to get information on students’ perceptions of the skills they have developed during the internship. We also wanted to identify the skills that were developed during their field program or course that helped them (which were completed within six months of their nomination in the fall of 2018). Using the categories both from the literature review and as described above, we have modified the survey by adding questions that will yield quantifiable data for analyzing the skills students needed for their internship. The modified survey also helped in understanding the degree to which the field courses or programs students completed in the preceding six months prepared them to develop those skills. The survey was designed to assess student outcomes and overall experience from their internships.

**Survey design**

The survey was developed to analyze the use and development of the skills from the categories discussed in the above sections. The survey was divided into several sections. The complete design can be found in Appendix S3. The survey consisted of questions that asked the participating interns about their development and use of the skills that are in the categories listed in Appendix S1. In addition, the survey asked students questions about their experience at their internship site, their professional development during their internship, and their satisfaction with the program.

**Results**

In the field program descriptions, we found that nearly two thirds of the participating undergraduate field programs (61.4%) included fieldwork technical skills (see Fig. 1) as their intended student outcomes in their program description section. A similar number included laboratory work technical skills (see Fig. 1). However, in comparison, only a few programs listed transferable skills in their descriptions. Only 12.3% of the field programs mentioned transferable fieldwork skills in their descriptions, which is comparably lower than the 52% of job sites that expected these skills from incoming students (See Figs. 1, 2). Similarly, 22.8% of the field programs mentioned transferable office skills, but more than 85% of the job descriptions expected these skills (Fig. 2).

Among the field research job descriptions that we analyzed from USGS, we found that all of them expected the incoming students to show some type of transferable skills (See Fig. 2). Among the categories of transferable skills, most field research sites (88%) highlight office skills. The descriptions mostly reference the expectation for the student to have basic data management skills. Laboratory work came in second with 60% of all internship sites identifying it as an expectation in their descriptions. And 20% of all sites expected students to possess transferable skills in fieldwork, laboratory work, and
office work. Another interesting result was that 84% of all internship sites expected incoming students to have a knowledge base for their particular program (Fig. 3). This aligns with what respondents in the landscape study (O’Connell et al. 2018) say regarding their intended student outcomes for their field programs/courses.

Discussion and Conclusion

From the limited literature available, we know that there is a need for research to be done on careers in field research. We offer an approach toward conceptualizing the expectations of field programs and courses, employers, and students. We have attempted to fill the knowledge gap through a study of the ESA/USGS summer internship program, which offers a glimpse of the skills that field programs and courses aim to develop and the skills a government agency hiring interns might expect. We developed categories that allowed us to analyze the requirements provided in the job descriptions against the experiences provided by field programs. The same categories were integrated into the post-internship student survey instrument and administered to students.
The next step of this study will focus on analyzing the data collected from the student survey and comparing it to the information gathered from our analysis and the literature review. Particularly, we would like to analyze the experience of students during the 2019 internship program and understand the level of preparation they received from their respective undergraduate field programs. In further efforts, we hope to broaden the types of employers and the undergraduate field programs we looked at to provide a more comprehensive view.

In the future, we also hope to unpack what “excellent training” in field programs and courses mean, particularly in the light of the coronavirus pandemic, which has forced many field programs and courses to limit their operations and programs while still offering internships. While beyond the scope of the present study, it is also of interest to investigate issues of access and inclusion of underrepresented students in field research and how employer expectations, program outcomes, and student expectations may vary.

We hope this study will serve as a reference for educators, students, and employers by offering insight into the relationship between student skills and employer expectations within the framework of workforce preparation.
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Literature Cited

Aplet, G., J. Corney, L. Famolare, and M. W. Schwartz. 2017. Ecological careers in nature-based non-governmental organizations. Frontiers in Ecology and the Environment 15:338–339.

Business-Higher Education Forum (BHEF). 2013. Proceedings from the Business-Higher Education Forum’s 2013 Winter Member Meeting. http://www.bhef.com/sites/default/files/201306/BHEF_W13_Proceedings.pdf
Byers, B. 2018. Ecological consulting as a career option. Frontiers in Ecology and the Environment 16:248–249.
Dale, V. H. 2018. Ecological careers at federally funded research and development centers. Frontiers in Ecology and the Environment 16:605–606.
Fleischner, T. L., et al. 2017. Teaching biology in the field: Importance, challenges, and solutions. BioScience 67:558–567.
Hill, M. A., T. L. Overton, C. D. Thompson, R. R. Kitson, and P. Coppo. 2019. Undergraduate recognition of curriculum-related skill development and the skills employers are seeking. Chemistry Education Research and Practice 20:68–84.
Klemow, K., G. Bowser, C. Cid, M. Middendorf, T. Mourad, and J. Herrick. 2017. Exploring ecological careers—a new Frontiers series. Frontiers in Ecology and the Environment 15:336–337.
Morales, N., K. Bisbee O’Connell, S. McNulty, A. Berkowitz, G. Bowser, M. Giamellaro, and M. N. Miriti. 2020. Promoting inclusion in ecological field experiences: Examining and overcoming barriers to a professional rite of passage. Bulletin of the Ecological Society of America 101:e01742.
National Academies of Sciences, Engineering, and Medicine (NASEM). 2016a. Developing a National STEM Workforce Strategy: A Workshop Summary. The National Academies Press, Washington, D.C., USA.
National Academies of Sciences, Engineering, and Medicine. 2016b. Quality in the undergraduate experience: What Is It? How Is It Measured? Who Decides? Summary of a Workshop. https://doi.org/10.17226/23514
National Academies of Sciences, Engineering, and Medicine. 2017. Undergraduate research experiences for STEM students: Successes, challenges, and opportunities. The National Academies Press, Washington, D.C., USA.
National Research Council. 2007. Rising above the gathering storm: Energizing and employing America for a brighter economic future. The National Academies Press, Washington, DC.
Nuttle, T., and K. Klemow. 2018. Ecological consultants: serving on the front lines of species and ecosystem conservation. Frontiers in Ecology and the Environment 16:421–422.
O’Connell, K., K. Hoke, A. Berkowitz, J. Branchaw, and M. Storksdieck. 2020. Undergraduate learning in the field: Designing experiences, assessing outcomes, and exploring future opportunities. Journal of Geoscience Education. https://doi.org/10.1080/10899995.2020.1779567
O’Connell, K., K. Hoke, and R. Nilson. 2018. Report from the field on the design, outcomes, and assessment of undergraduate field experiences. Technical Report. Oregon State University, Corvallis, Oregon, USA.
Petcovic, H., A. Stokes, and J. Caulkins. 2014. Geoscientists’ perceptions of the value of undergraduate field education. GSA Today 24:4–10.
Rodrigo-Peiris, T., L. Xiang, and V. M. Cassone. 2018. A low-intensity, hybrid design between a “Traditional” and a “Course-Based” research experience yields positive outcomes for science undergraduate freshmen and shows potential for large-scale application. CBE—Life Sciences Education 17:ar53.
Thompson, C., J. Sanchez, M. Smith, J. Costello, A. Madabushi, N. Schuh-Nuhfer, and D. Rivers. 2018. Improving undergraduate life science education for the biosciences workforce: Overcoming the disconnect between educators and industry. CBE—Life Sciences Education 17:es12.
U.S. Congressional Research Service (USCRS). 2018. Science, Technology, Engineering, and Mathematics (STEM) Education: An Overview. Congressional Research Service. R45223 Version 4 updated. Granovskiy, B. https://crsreports.congress.gov/product/pdf/R/R45223
Supporting Information

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