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Commentary

Growing as an Undergraduate Researcher and the Benefits of Directed Research

—Jake Gehrung

Scientific research has become the foundation for much of today's public policy, medicine, lifestyle choices, and financial investments. We generally conduct research to learn more about the world and maybe find objective truth in the process, like the truth we have found in the existence of gravity and time. In many ways, science has allowed us to improve our quality of life and our society as a whole. Because of this, we take science seriously and try to maximize its success by investing in it, giving it structure, and treating it with rigor.

Science starts with motivated students and their interest in getting involved with research. Bringing along young researchers is arguably the most important part of science today. Inspiring and guiding young researchers ensures that our society will continue to benefit from research in the future. Fortunately, academic institutions have several ways of getting students involved with the research process and sparking their interest in new subjects. As a fourth-year environmental science major and undergraduate researcher at the University of New Hampshire (UNH), I can say wholeheartedly that directed research has been the most transformative experience in allowing me to grow as a young scientist.



The author summiting the Travers-Sabine Saddle on his backpacking trip with fellow EcoQuesters.

My Undergraduate Research Journey

As a second-year student, before taking part in directed research, I was fortunate to get involved with a research group at UNH studying water systems. The group consisted of undergraduate students, graduate students, and postdocs researching water system issues throughout the world. I started as a research assistant for two semesters and was later awarded a summer research grant from the National Science Foundation through the New Hampshire Established Program to Stimulate Competitive Research (EPSCoR). Interested in the mitigation of nitrogen runoff in watersheds, I focused my research on the spatial variability of denitrification in local reservoirs. This project wasn't structured in such a way that I could expect extensive guidance from the members of my lab. I met with my mentor occasionally, but because of the independent nature of this project, I struggled with

communication, executing the scientific process, and grasping the implications of the research. Had I had more experience, I likely would have felt more comfortable; nevertheless, I was inspired to grow as a researcher and to develop fundamental skills in new projects.

I sought an opportunity to study abroad and joined the EcoQuest Education Foundation program in New Zealand during the spring of my junior year. This UNH-administered program welcomes students of many majors and universities and gives students the opportunity to understand sustainability, what challenges the ability of New Zealanders to live sustainably, and the solutions they have explored to address these challenges. The program is based in a rural area close to Auckland on the North Island of New Zealand. The first nine weeks of the program are dedicated to three courses: restoration ecology, biogeography, and policy. The courses center on place-based learning consisting of lectures, field exercises, discussions, and guest lectures. This format is employed throughout the curriculum to offer firsthand educational experience for all three courses. Learning takes place in a variety of indoor and outdoor locations on the North Island, as well as in three weeks spent on the South Island, that focus on ecotourism, alpine ecology, and beech forest ecology.

The final five weeks are spent completing a directed-research project: two weeks of preparation and data collection, two weeks of analysis, and a week to complete the final report and presentation. In the simplest sense, a directed-research project emphasizes the collaboration of a student team with a research mentor who offers fundamental guidance in the research process. Collectively, it is the most efficient way for a novice researcher to develop core research skills, focusing entirely on fundamental techniques without the expectations of advanced research. The group setting allows the mentor to support several students, making the more intensive effort worthwhile. For me, this experience was extremely helpful, my only regret being that I had not had a chance to complete it sooner in my college career.

For our project, my team assessed a restoration project at Lake Waikare in the Waikato Region of the North Island. The lake has suffered pollution in the form of pathogen intrusion, nutrient runoff, and excessive sediment deposition. To combat these processes, the local government and scientists have strategically planted native tree species around the lake. To assess the success of this effort, my team studied the biodiversity of invertebrates in the surrounding soil ecosystems. The presence of high species diversity, particularly rare native species, would indicate a healthy ecosystem at the lake. I worked with four of my classmates every day, adhering to a strict schedule set by our research mentor. Though the schedule was strict, our mentor was devoted to making sure we understood how to approach each task. We started with intensive literature review of papers already retrieved for us from scientific journals by our mentor. This was followed by data collection, which involved invertebrate sampling and water sampling.

To sample invertebrates, we used common methodology from other invertebrate studies. We set up pitfall traps (insects walk into a container), took soil samples, used a beating tray to sample the branches of vegetation (hitting a plant with a stick to knock insects into a tray), and took detritus samples (gathering leaves into a bag). This allowed us to compare biodiversity across reference sites composed of different vegetation types representing varying stages of restoration. Water sampling entailed using test kits to measure phosphorus, nitrogen, and pH in addition to using other instruments for measuring the *E. colic* content, temperature, and conductivity at various sites around the lake. With water and invertebrate sampling experience, we learned the process of finding

common practices for a certain type of study and modifying them in our methodology to address the specific research question. This aspect of the research was very interesting and helpful for future research.

During this time, we also met with several professionals who offered us information we could use in writing our report. Because the directed-research projects are part of long-term projects at EcoQuest, stakeholders of various cultures and organizations (e.g., universities and government agencies) have also become invested in working with students on their research projects. This allowed us students to work with different professionals and officials while also giving them the opportunity to learn from our findings. We each wrote our own papers in segments throughout the five weeks, following a chronology set by our mentor (introduction, methods, results, discussion, acknowledgments, then abstract). For each segment we wrote two drafts, the second of which was graded. This gave us the opportunity to go over a draft with our mentor and learn how to perfect our writing.



Like other research teams at EcoQuest, Jake and his team were given their own space to conduct research and collaborate on their project.

As a team we worked together constantly on data collection, analysis, and writing. We identified and counted more than 40,000 invertebrates from the various kinds of samples we took. This massive data output gave us a robust basis for assessing the effect of the restoration strategy at the lake and making recommendations for improvement. Although we wrote our papers independently, we often discussed what we planned to include as the main features of our research. This allowed us to see the data and literature from different perspectives and develop our analytical skills. Any confusion throughout the research process, whether derived from a team conflict or a misunderstanding of the materials, was always resolved by our mentor and turned into a learning experience. Our final papers ranged from thirty to fifty pages long, and as a team, we gave a twenty-five-minute PowerPoint presentation to local stakeholders, staff, classmates, and family.

For major stakeholders, like the local Māori tribe members and the Department of Conservation, our results were incredibly insightful, giving these people updated information on the status of the lake and offering new ideas on how to address the problem. Particularly for the Māori, protecting the native species and the quality of the water at the lake are of the utmost importance, because these entities have sacred significance in their culture. It was an honor to contribute to this cause through the directed-research project. We hope our findings will inform the design of conservation policy and help protect the environmental quality of the lake's ecosystem, given its profound cultural value in the local community and culture.

The team presentation was a great way to complete the project, because we had to work as one unit and condense our weeks of research into a short description that adequately informed our audience.

Learning to overcome the pressure and present with confidence was just as important as learning to complete a literature review, writing the reports, or any other aspect.

A New and Improved Researcher

Before and during my time in New Zealand, I had been working with Dr. Shadi Atallah at UNH on an application for a Summer Undergraduate Research Fellowship Abroad (SURF Abroad), a program offered by the Hamel Center for Undergraduate Research at UNH. We proposed a social science research project studying rural livelihood dependence on an endemic palm species in western Ecuador. While in New Zealand, I was informed that my application had been approved, so two weeks after returning to the United States, I traveled to Ecuador to start my research. I am interested in Latin American culture and the pressing issue of deforestation in the face of climate change, so this project was an amazing opportunity to use my new research skills while taking on a project with personal significance. Through focus groups and interviews with members of several indigenous communities, my foreign research mentor, Dr. Rommel Montúfar, and I found that a majority of benefits the communities perceived were not among the benefits being taken into account by the government. For example, the palm was very important to building and maintaining community relationships; many participants reported that their interaction with others depended on tasks related to the palm.

My SURF Abroad research was very complex and required that I perfect skills beyond those of a beginner researcher. I often planned meetings with researchers from around the world and constantly switched between using Spanish and English to complete the research. With a great deal of traveling required to conduct interviews, I faced several obstacles that pushed me to further my ability to improvise and form plans. In the lab, I spent hours going through literature on a wide variety of topics, and I learned to synthesize my findings in an expedited manner.

Having written the proposal for SURF Abroad before going to EcoQuest, and then completing the SURF research after returning from New Zealand, it is clear that my directed-research project experience allowed me to grow strides beyond the researcher I had been. Writing my SURF proposal took many hours because I struggled with big-picture research concepts, literature, and writing structure. However, these tasks and skills became almost trivial after completing my directed-research project, which then allowed me to focus on more advanced research skills while in Ecuador. Completing mass quantities of literature review, coordinating with a team, collecting data, analyzing it, and writing were far less daunting tasks than they would have been before my directed-research experience. The field of my research in New Zealand was also very different from that of my research in Ecuador. This shows how the benefits of the directed-research project were not specific to my topic, and my growth as a researcher was not bound to a particular field.



Jake personally conducted many interviews as part of his research in Ecuador. They always took place in participants' homes or other settings where they felt comfortable.

In reflecting on my undergraduate research experiences, it is obvious to me now that a directed-research project would have been a perfect way to start as a researcher. In only five weeks, I developed fundamental skills quickly, and any confusion that arose was settled smoothly by my mentor. It would have been best if I had participated in the water systems research after my directed-research project. The water systems project structure was more appropriate for a student with more experience and skills who could function more independently from a lab group and research mentor. I believe if I had had the directed-research experience first, my water systems project would have gone far better and could possibly have allowed me to coauthor a paper.

The Future of Science and Research

Research has allowed me to explore several facets of sustainability, which is my passion in my career and my life as a whole. With experience studying environmental systems, restoration, and economics, I am now prepared to investigate new facets of sustainability, such as agriculture, investing, and advocacy. Research has taught me much about my life and my place in the world, which is knowledge I would hope any passionate student could access through undergraduate research.

Based on my experience with the EcoQuest program, it is clear that it would be extremely beneficial to make directed research available to more students. Although directed-research projects can be enhanced in an international setting, they would be equally beneficial on a local scale. An appropriate chronology in undergraduate research is also important. With the support and guidance offered by directed research, an aspiring researcher can make early strides in meeting their full potential by pursuing this kind of project first. Such a student could move swiftly into advanced research as early as their third year of college, committing to programs like SURF. Given that young researchers are the future of science, investing in their development should be a priority, and I believe that directed research presents an amazing opportunity to do this.

I am so lucky to have completed three research projects as an undergraduate student, and none of it would have been possible without the support of my amazing mentors and peers. Thank you to Dr. David Clarke for his mentorship and contribution to all aspects of my directed-research project. Thank you to Jono Clark, Ria Brejaart, and Dean Kimberly Babbitt, the coordinators of the EcoQuest program. Thank you to the Nikau Estate Trust at Matahuru marae, Lake Waikare. Thank you to Dr. Rommel Montúfar (PUCE) and Dr. Shadi Atallah (UNH) for their mentorship and contribution to all aspects of my Summer Undergraduate Research Fellowship. Thank you to Dr. Wil Wollheim, my academic adviser and head of the Water Systems Analysis Group at UNH. Thank you to the Hamel Center at the University of New Hampshire for funding my Summer Undergraduate Research Fellowship. Thank you to the EcoQuest Education Foundation for funding my directed-research project. Thank you to the National Science Foundation for funding my summer research with the NH EPSCoR Ecosystems & Society Project. Thank you to Dr. Georgeann Murphy for assisting in the logistics of conducting my Summer Undergraduate Research Fellowship, for encouraging me to publish in Inquiry, and for motivating me to work harder.

Author and Mentor Bios

Jake Gehrung, from Walpole, New Hampshire, is completing a major in environmental science and two minors: business administration and Spanish. He will graduate with his bachelor of science degree in May 2020. His passion is “to gain a holistic view of sustainability, and drive change through political and economic efforts.” Jake participated in several research projects through programs at the University of New Hampshire and says, “Research is one of the most sophisticated ways of learning about the world. Educating myself on people and the environment has been my priority as a college student.” In particular, Jake enjoyed research that involved cultural connections. “In New Zealand, I was able to support indigenous stakeholders and present my findings to them; in Ecuador, I learned so much about both rural and urban culture and how they alter the perception of the natural world.” Jake decided to write a commentary for *Inquiry* to inform others about the great value of a rigorous directed-research experience.

David Clarke is a lecturer for EcoQuest Education Foundation in Whakatiwai, Kaiaua, New Zealand. He shares responsibility for teaching the EcoQuest program content as well as designing and coordinating EcoQuest directed-research projects. Dr. Clarke’s own research interests include wetland restoration ecology, invertebrate ecology, acarology (the study of mites), and the study of long-tailed bats, an endemic species in New Zealand. When Jake attended the Ecology in Action semester program, Dr. Clarke served as his EcoQuest research mentor in New Zealand. Their research project focused on assessing soil invertebrates as bioindicators in a degraded lake catchment. Dr. Clarke has been the designer and supervisor for all directed-research projects related to the wider research initiative, which involves input from regional councils, community groups, universities, and private research institutions. He has supervised many undergraduate researchers, both during his PhD candidacy at the National University of Ireland Galway (2010–2015) and in his role at EcoQuest since 2016.

Shadi S. Atallah is an assistant professor in the Department of Natural Resources and the Environment at the University of New Hampshire, where he has taught since 2015. Dr. Atallah’s research encompasses agricultural, resource, and environmental economics, and he specializes in bioeconomics, the study of the economic management of biological resources. He recently started a collaboration with universities in Ecuador, Colombia, and France to research biodiversity and ecosystem services in the tropical Andes. It is through this collaboration, LMI BIO-INCA, that he met Jake’s mentor in Ecuador, Rommel Montúfar. One of their areas of interest is the ivory palm, which became the focus of Jake’s summer research. “Through Jake’s research, I now have an assessment of the relative importance of economic uses to noneconomic uses of the tagua palm,” Dr. Atallah said. “This information is critical for me before I embark on assessing the resource and its use from an economic perspective.”

Rommel Montúfar is an associate professor at Pontificia Universidad Católica del Ecuador in Quito, Ecuador. He mentored Jake during his Summer Undergraduate Research Fellowship in that country. Dr. Montúfar is also a director of LMI BIO-INCA, an international consortium of scientists. His current research projects include genetic diversity of *Mauritia flexuosa* (Arecaceae) in Yasuní National Park in Ecuador and regional genetic patterns of *Oenocarpus bataua/Euterpe precatoria* (Arecaceae) in northwest South America.