

Reflections on how field stations and undergraduate research opportunities paved the way for me to be where I am today and also provided me the opportunity to pay it forward

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I practice, learn and teach a discipline that claims its purpose is to understand biological and environmental variation. Expanding this base of understanding puts us in a position to apply that knowledge to creating solutions that improve our ability to live in harmony with nature. These are the reasons that ecology has provided me with a purpose. Doing ecology brings me personal joy, motivates me to hone skills that I can contribute to society, and provides me a platform from which I can empower others to walk paths toward careers in STEM. So, what is the point of walking my path as a researcher if I fail to do it in a way that allows me to mentor others?

Early on I was attracted to biology (I didn't know what ecology was yet) because I thought that it would provide me with opportunities to spend time outside and get me a job with coworkers who also enjoyed the outdoors. This was a good assumption because both of these wishes were granted! But the real value that I have gained from ecology has everything to do with the nuanced lessons learned and life experiences that have taken place while doing it. For example, practicing ecology gives me a way to situate my personal values within an ethical and intellectual framework. This framework puts me in an advantageous position to responsibly study how patterns emerge and processes govern them. Likewise, the framework serves as a personal roadmap that manifests in practically all other aspects of my life. The everyday skills that I get to practice while following this map include everything from interpersonal communication, carpentry, time management, accounting, developing technological literacy, etc. The flexibility and the variety of different opportunities to learn and grow that ecology presents me are key reasons why I encourage other people to pursue this career path.

As of this month I have spent a third of my life doing science. Yet, creating a script for passing on the things that I have learned to junior researchers and young people who are interested in STEM fields is something that I am still working on. This is the reason I am writing this essay and reflecting on how the nexus of field stations and programs provide the research experience opportunities for undergraduates that changed my life and inspired me to pay it forward to others.

I had no idea what I was in for when I enrolled into my undergraduate Biology program at the University of Nevada, Reno in 2008. I spent the next two years trying to work, pay the bills and get passing grades. Despite my struggles learning how to live the real life, I had become fascinated with the content that I was learning in class about biological levels of organization from cells to ecosystems. In 2011, several events changed the direction of my life. During the Spring Semester I was enrolled in two classes taught by Lee Dyer, Tropical Ecology and Ecology & Population Biology Lab. Both of these courses were interesting, engaging, and required a degree of critical thinking that I had not brought to bear on my studies until that point.

I was starting to see how the course material that I had been learning manifested in the real world with researchers asking questions and designing studies to answer them. With this new awareness, the wheels were beginning to turn in my mind about how science could actually be a part of my future. During Tropical Ecology class, Lee shared with us that he enjoyed bringing students to the tropics to work with his lab group. I had no idea what he meant by this. Did he mean taking students on some kind of study abroad program? How did anyone get paid for this? It was not long until I found out what he meant. I lost my primary job at a restaurant in Reno that March. I needed to find another job quickly before I ran out of money. So, I asked Lee if he would hire me to do something related to what we were learning in class. He said yes! He had a National Science Foundation (NSF) - Research Experience for Undergraduates (REU) grant to support undergraduates to work at one of his long-term field sites in a cloud forest of the eastern Andes in Ecuador. I flew from Reno, Nevada to Quito, Ecuador in May 2011 to begin an adventure that truly transformed my life.

That field site is called Yanayacu Biological Station and Center for Creative Studies. I vividly remember the first day we hiked along a trail close to the station. The air was moist and clean, the temperature was cool, there were mysterious and beautiful sounds coming from all directions, and there were plants growing on everything. The biodiversity I observed on that first day was unlike anything I had ever seen before! I had my work cut out for me trying to find plants and insects among all of that richness, because I was not even very good at identifying the woody plants of the Sierra Nevada or Great Basin where I had lived for almost three years. My supervisor was Lee's graduate student, Andrea Glassmire. My fellow undergraduate assistants were Elia Pirtle (undergrad peer of mine from Nevada) and Jessica Hogue, a student of Tom Walla, a longtime collaborator with Lee from Colorado Mesa University. With Andrea at the helm, we studied the effects of *Piper* leaf chemistry on the community structure of inch worm caterpillars (Lepidoptera: Geometridae) and the parasitoid wasps and flies that use them as hosts



Photos from my experiences as a REU student and as a REU field mentor. (A) A crew of 2018 La Selva REU students and I whitewater rafting the Rio Sarapiquí on an off day. (B) Field and home mentors for the Louis Stokes Alliance for Minority Participation REU program students at La Selva in 2019. (C) Andrea Glassmire and I in 2011 showcasing the finishing touches of a dry box that we built to keep the *Piper* leaf samples dry at Yanayacu with the help of fellow REU students Elia Pirtle (the artist) and Jessica Hogue. (D) Driving to do field work in Yanayacu's Toyota pickup truck with the gusaneros, Luis 'Lucho' Salgaje and Wilmer Simbaña in 2011. (E) REU Team *Passiflora* 2019 - Alana Gipson, Ashlyn Nest and their field mentor in the La Selva Lab Clearing (who let him out of the insectary!).

for their larvae. This was a pivotal moment in my life as a researcher and as a person. The project mixed natural history, field work, ecological theory, entomology, chemistry, and adventure! We all became great friends that summer. Biodiversity of the cloud forest blew my mind so profoundly that I knew I must do my best to study and conserve biodiversity for the rest of my life. My confidence grew a lot, and I will forever be grateful to Lee and Andrea for trusting me to contribute to the project. Their support made me feel competent and gave me confidence to try new things, make mistakes, learn from them, and improve. In addition to the scientific skills that I developed, I learned some important lessons that are key to the well-being of a field ecologist (especially one working in the tropics). For example, I got experience learning how to navigate a foreign country with diverse cultures and customs, how to coexist harmoniously with my teammates in a remote location, and how to be patient. Halfway through the field season I realized that I had to help Lee and Andrea manage the team of Earthwatch Institute volunteers that was coming to work with us in the field for two weeks despite the fact that I was young and just learning how things worked! I helped them teach the Earthwatchers how to follow our sampling protocols, collect host plants, do vegetation plots, rear caterpillars, and tried my best to keep everyone as safe as possible. This experience had a huge impact on my ability to take a leadership role in the field. One of the volunteers on that expedition was a high school science teacher from Southern California named Danielle Salcido! Dani was a rockstar on the expedition, and she was clearly hooked on tropical ecology. I still cannot get over how cool it is that we became friends on our first trip to the Neotropics and now we are both graduate students, doing tropical ecology with the support of amazing advisors, and writing reflective essays about our experiences for *eCanopy* (see the December 2020 issue)!

I would not have had this amazing opportunity without two key scientific institutions: NSF's REU Program and a field station (it could be any station; in my case it was Yanayacu). Following my first field season in Ecuador, I continued to work with the Dyer Lab as a research assistant for several years, sampling caterpillars, doing field work, and working with many Earthwatch volunteers. In 2015, I earned a Fellowship with the Smithsonian Tropical Research Institute (STRI) in Panamá to develop my own research program on the ecology of tortoise beetle dietary specialization. As the research progressed and my network grew at STRI, I began working with the *Heliconius* butterfly system in addition to the tortoise beetle study. Working with *Heliconius* provided me an opportunity to re-connect with the REU Program. STRI had a REU Site Grant and one of my supervisors, Owen McMillan, received several students to work on independent *Heliconius* projects. I was asked to co-supervise two REU students in collaboration with other lab members and I got to see a new take on how a successful REU Program can be run. These students performed a variety of complex experimental tasks that ranged from designing CRISPR/Cas9 primer sets for knocking out color pattern elements from *Heliconius* wings, collecting butterfly stocks in the jungle, injecting butterfly eggs with the gene editing solution in the field lab, to mass rearing caterpillars on host plants that we had harvested in the field. This opened my eyes to the fact that REU students at a quality field station could

perform a wider variety of studies than I thought possible, extending beyond observational and collections-based field studies, if the instrumentation and facilities permit it.

These REU projects were very productive and the students agreed that they had valuable experiences. However, I felt that there was a degree of distance between the students and their mentors that I had not experienced when I was an REU student in Ecuador. I think this was because many labs that participated in the program followed a student mentorship model based on the idea that several people in a lab group (a mix of Fellows, PIs, Post-docs) would collectively supervise cohorts of students. Co-supervision is a fairly common REU model in labs around the world, and it certainly has many benefits. However, it had a different ethos than what I experienced in Ecuador. I believe that a model in which one or two individuals are present for most of the field season acting as the primary supervisors for a small cohort of students provides especially well-rounded engagement for the students (with respect to research and professional development). I was eager to get involved in an undergraduate research program that followed this model once I started graduate school at The University of Texas at Austin in 2017.

My proposal coming into graduate school was to leverage decades of natural history information on passion vines and their specialist insect herbivore associates to try and disentangle the relative importance of environment, plant chemistry and trophic interactions in shaping the structure of this community. My first step was to choose a tropical research station to set up my field operation. Ideally it would be a site with habitat heterogeneity, quality research infrastructure, a dedicated community of collaborative scientists, and opportunities to involve undergraduates in the research. My PhD advisor, Larry Gilbert, felt that Costa Rica would be the best country for me to achieve my PhD goals with the passion vine system. So, Larry and my committee member John Smiley (John is also Larry's former graduate student) recommended that I spend part of my first field season at the Organization for Tropical Studies' (OTS) La Selva Biological Station. I spent three months at La Selva in 2018 exploring, collecting, and figuring out what questions I would ask. The Louis Stokes Alliance for Minority Participation (LSAMP) REU program was in full swing by the time that I arrived in June. The LSAMP program is designed to engage students from populations that are historically underrepresented in STEM. This caught my attention because directly participating in programs that contribute to advancing Diversity, Equity and Inclusion (DEI) goals in our field was something toward which I wanted to contribute more. It



Select organisms from the passion vine system that my REU students studied at La Selva in 2019. (A) *Disonycha quinquelineata* larva. (B) *D. quinquelineata* with her egg mass. (C) *Heliconius doris* caterpillars feeding on their host plant *Passiflora ambigua*. (D) Red morph *H. doris* adult freshly emerged from the pupa.

became clear that getting involved with this program would be a fulfilling opportunity for me to mentor students, contribute to DEI initiatives, and collect data that would help me to answer my dissertation questions. This REU program had the same character of supportive partnerships between students and their mentors that I benefited from when I was an REU student in Ecuador. The cohort of field mentors and the program coordinator, Carissa Ganong, were adept at guiding the students to design interesting projects that were achievable in a short time frame (9 -10 weeks). They also passed along practical wisdom to the students with grace. These folks were a welcoming, collaborative, and laid-back group that I looked up to a lot during my first field season of grad school.

I was sold on committing to La Selva as a field site for the next few years and the REU Program that it hosted was just the ticket for my own mentoring preferences. So, I applied to be a field mentor for the 2019 field season, and I was accepted. The process for pairing students and field mentors is well thought out. Both the potential students and mentors get to rank their top choices so that the coordinators can make informed decisions about which research interests and personality styles will match best. My students flourished during the 2019 field season! They were a pleasure to work with and I suspect that I learned just as much (if not more) from them as they did from me. It was extremely rewarding to be able to serve as their field mentor. The field and lab work did not always go well, but we were able to pivot and make the most out of



Places, organisms, and people that set the context at the La Selva Biological Reserve. (A) The Old Lab Building porch, a solid place to chill out, share stories and have fun! (B) The Don Stone Bridge is an incredible place to observe animal activity in the La Selva canopy. (C) A colorful view of the emergent canopy layer above the Holdridge Arboretum taken from a camera attached to Paolo Segre's research drone. Thanks for trusting me with it, Paolo! (D) Zaínos (*Pecari tajacu*, or collared peccaries) socializing with each other in the Lab Clearing is a familiar sight to La Selva guests. (E) Gazing out from the Don Stone Bridge as dusk begins to fall on the Rio Puerto Viejo is a fantastic way to end a day after hard work in the field. (F) My mentor and friend John Smiley on the Sendero Tres Ríos in 2018 standing next to a fallen ceiba tree (*Ceiba pentandra*, or kapok) that was featured on BBC's *Planet Earth* series.

whatever came our way. I think that we can all relate to this - conducting field work and experimentation requires resourcefulness. This is one of the reasons that undergrad research programs taking place at field stations provide such a fantastic opportunity for students to build character, practice leadership, and learn about what they want to do with their lives through experience (and just as importantly... what they do not want to do). A strong sense of camaraderie developed amongst the students and the mentors in 2019. I believe that everyone got to experience something new and insightful that would serve them down the road, regardless of where they want to study or which career path they want to pursue.

There is an obvious need to have field stations filled with eager researchers for the sake of doing the science, but there is also something wonderful how about field stations provide a space for people to learn, share, make friends, and have life-changing experiences. This is why they are some of the best places for programs designed to facilitate undergraduate research training in fundamentals of STEM to have a positive influence on students. This combination of scientific institutions allows the scientific leaders of tomorrow to realize their connection with nature, learn the scientific method, and take ownership of the results that they help create.

It is fascinating to me to reflect on my career thus far and be able to realize that the connection between field stations and undergraduate research is beginning to come full circle for me. My career started at a field station with the backing of the NSF REU program and my graduate training has now been aided greatly by getting involved with the REU program at an OTS field station. I strongly recommend that everyone with a platform use it to encourage undergraduates to apply to the REU program at an OTS field station (e.g., La Selva, Las Cruces), and take advantage of the opportunity to be a field mentor. I never looked back from the opportunity I was given by committed mentors, and now I have had the privilege of being an REU mentor. This is one way that I will try and pay it forward and I hope that others will find ways to do the same.



Animals that students and I have encountered in during past REU Programs at La Selva. (A) Honduran white nose bats (*Ectophylla alba*) roosting in a shelter made from a *Heliconia* leaf on the Sendero Tres Rios. (B) Bullet ants (*Paraponera clavata*) harvesting sugar water during a feeding assay in La Arboleda. (C) Red-washed satyr (*Pierella helvina*) alighting on a leaf of the palm *Geonoma* on the Sendero Jaguar. (D) Central American spider monkey (*Ateles geoffroyi*) resting in a tree by the River Station. (E) Orb-weaving spider (*Argiope* sp.) with stabilimenta sewn into the web characteristic of diurnal orb weavers behind the Academic Center. (F) Emerald basilisk lizard (*Basiliscus plumifrons*) resting over a pond near Monteverde.