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NSF-GRFP Personal Statement, Relevant Background, and Future Goals

My commitment to research in tropical forest biology has at its core my understanding of a "scientific naturalist" as described by Doug Futuyma in his essay "Wherefore and Whither the Naturalist."[1] The essay stimulated my desire to synthesize a childhood love for nature with a growing academic interest in ecology and evolution. I already have the "inexhaustible fascination with biological diversity" that characterizes Futuyma's scientific naturalist. At the University of Minnesota, I gained a strong foundation in scientific research and its impacts beyond the lab. I am eager to pursue my research interests in plant evolutionary ecology and to develop a scientific naturalists' ability to "inspire ideas, evaluate hypotheses and design experiments" in Dr. Nathan Kraft's research group at the University of Maryland.

SCIENTIFIC BACKGROUND: I began my scientific research career in the University of Minnesota (UMN) Department of Bioproducts and Biosystems Engineering, where I worked in Dr. Bo Hu's bioprocess research group and learned a great deal about the process of science. My first task in the lab was to write a grant proposal to the UMN Undergraduate Research Opportunities Program (UMN-UROP). Dr. Hu asked me to identify a problem, conduct a literature review to assess the previous approaches to the problem, and propose a novel study. I collaborated with a graduate student to investigate the causes of foaming in swine manure pits, which is of major concern to the Midwest agricultural industry. I was awarded the UMN-UROP grant to determine the chemical differences between foaming and non-foaming swine manure using gas chromatography/mass spectrometry (GC/MS). We also decided to experimentally cause foaming in previously non-foaming manure. The GC/MS data and results of my experiments suggested that increased concentrations of long-chain fatty acids, especially oleic acid, are highly correlated with the foaming tendency of manure. This work has resulted manuscript, of which I am second author, which has been submitted to the Transactions of the American Society of Agricultural and Biological Engineers.

My learning was taken to a higher level when I joined Dr. George Weiblen's plant phylogenetics research group in the UMN Plant Biology department. This transition marks in my mind the beginning of my training to be a scientific naturalist. Dr. Weiblen suggested that I work on a broad project about the forests Papua New Guinea so that I could learn a variety of skills. I began by generating *rbcL* sequences of trees growing in a permanent forest dynamics plot. As I learned the ins and outs of molecular phylogenetics, I started to understand how molecular data can be used to recreate evolutionary histories. The more I learned, the more I wanted to understand why some genera like *Ficus* and *Macaranga* are hyperdiverse, or why individuals of *Sandoricum koetjape* make a terpene that is now used in chemotherapeutic cocktails as a DNA Polymerase β inhibitor. These were formative days: I was beginning to think about unanswered questions in tropical forest ecology, and was learning how to pursue their explanations.

I took on many responsibilities in the Weiblen lab, which have all prepared me for my graduate education and research career. For my molecular work, I learned wet-lab techniques, Bayesian statistical theory, and various phylogenetics software packages such as MrBayes and BEAUti/BEAST. I also worked as a curatorial assistant to Dr. Weiblen in the Bell Museum of Natural History's Herbarium. In this role, I managed large collections of specimens from Papua New Guinea and responded to data requests from the Minnesota Department of Natural Resources and other researchers. I was in charge of updating the Herbarium's database, for which I learned SQL and the database management software Specify. My experience in molecular and herbarium-based research has allowed me to develop an integrative research

vision involving a variety of comparative approaches. I wrote another grant to the UMN-UROP program to support my work, which was fully funded. After working in the Weiblen lab for eight months, I synthesized my *rbcL* sequences with published data to present a community phylogeny of more than 350 species in an oral presentation at the National Conference on Undergraduate Research. Writing grants and presenting finds are two key parts of a scientific career, and I am glad to have had the chance to do both early in my education.

By the end of my first semester spent in the Weiblen lab, I was sure of my desire to study tropical forests, and knew that I had the tenacity, commitment, and passion to succeed in academia. When I began my work with Dr. Weiblen, I was enrolled in 22 course credits, was teaching a lab-course in evolution and ecology to non-Biology majors, and was the President of the UMN Quizbowl team. My courses included a graduate level course in molecular ecology, and several senior level biology courses. That semester, I earned a 3.93 GPA and the Quizbowl team generated $5,000 under my leadership. My success in these efforts was due to excellent time management, willingness to collaborate with peers, a strong work ethic, and much support from colleagues, friends, and family.

In the summer of 2013, I was an NSF-REU intern at the Smithsonian National Museum of Natural History (NMNH) Botany department. My project focused on understanding hybridization patterns in the genus *Isoetes*, a group of basal land plants (the quillworts). I investigated two instances of speciation via hybridization and subsequent polyploidy, which is common in the genus. I extracted DNA, optimized PCR primers and protocols, and generated DNA sequences from several individuals of the parental, primary hybrid, and allotetraploid species. The data suggest that all hybrid individuals across populations received their chloroplast from the parental species *I. engelmannii*. At the NMNH REU symposium, I presented my findings to curators and other researchers, whose feedback inspired many ideas for further research questions. During the internship, I got some practice using next-generation sequencing techniques and data, and attended a short course in Real-Time PCR. By interacting with graduate students, postdocs, and curators, I learned how scientists can use the rapidly expanding molecular biology toolkit to help answer ecological questions. The research I propose to conduct at the University of Maryland involves using these techniques to understand the relationship between tropical soils and plant diversity.

BROADER IMPACTS: My commitment to science extends beyond the laboratory and into the classroom. When I taught a course in Ecology and Evolution to non-Biology majors at UMN, I realized that all of my students were eager to learn about life around them, irrespective of their primary academic focus on finance, physics, French, or theatre. I consider this to be an example of "Biophilia," E. O. Wilson's idea that humans are innately programmed to appreciate other living things. It was challenging to channel my students' curiosity about "ant-eating" *Cordyceps* fungi to an interest in changing allele frequencies as described by the Hardy-Weinberg Equation, but it was rewarding to help my students develop their fascination with life into a scientific understanding of nature in the same way that I had done a few years prior. Later, at the NMNH, I mentored two high school students from the Youth Engagement in Science (YES) program in basic biology techniques. YES recruits students from minority groups to spend a summer with Smithsonian scientists, and I eagerly look forward to a future of working alongside former students from the program. I plan to develop summer projects for YES students while a student at the University of Maryland (see "Broader Impacts" in *Research Proposal*).

Participating in a field-course in Costa Rican forest ecology at the Area de Conservación Guanacaste (ACG) and the Advanced Field-course in Ecology and Conservation (AFEC) at the Chinese Academy of Science's Xishuangbanna Tropical Botanical Garden (XTBG) has given me not only critical field ecology skills but also a strong perspective on international collaborations. At ACG, I designed a study to compare water-use related leaf functional traits of lianas to evergreen and deciduous trees. I measured several "soft-traits" like leaf size and specific leaf area and some "hard-traits" like leaf toughness, and leaf water potential. Although my dataset was not robust enough to yield insight into the plants' biology, I came away from the course with a much deeper understanding of hypothesis testing, experimental design, the use and limitations of functional ecology, and the practical considerations of doing field-based science.

At the time of this submission, I am a student at XTBG, where all of my 23 classmates are South-East Asians. The AFEC schedule involves daily lectures by XTBG researchers and an independent research project, which I plan to conduct in Dr. Jiao-Lin Zhang's Plant Ecophysiology research group. It is often challenging to communicate detailed scientific ideas with my peers given the vast linguistic diversity in our group, but I never give up on a conversation because I know that each discussion will help me grow scientifically and personally. For example, after I helped one of my classmates, who is the Chief of Science and International Cooperation at Vietnam's Cat Tien National Park, through our Statistics and R modules, he invited me to collaborate with his team to analyze their large forest inventory datasets. These are the types of partnerships that will help science to progress globally.

Conducting both field and lab based research has diversified my interest to the interactions between environmental factors, plant biodiversity, and forest community dynamics. For my PhD research, I hope to study the role of soil factors on driving diversification in Neotropical legume trees. I plan to focus on understanding how soil factors contribute to ecological differences between closely related tree species and how these ecological differences impact the trees' responses to environmental factors (see *Research Proposal*). My research interests, which integrate across environmental and biological scales, match the expertise of Dr. Nathan Kraft, my proposed advisor at the University of Maryland's Behavior, Ecology, Evolution and Systematics (BEES) program. Dr. Kraft has shown that species level ecological strategies are important in structuring forest communities in Ecuador.[2] Understanding the ecological divergence between closely related species in the same forest may yield mechanistic explanations to this result. The BEES faculty regularly collaborates with NMNH scientists, and I also plan to seek guidance from Dr. Ashley Egan, the NMNH Curator of Legumes. Dr. Egan is an expert in the next-generation sequencing techniques I will use to describe the rhizosphere microbiomes of legumes. When I met with Dr. Kraft to discuss my proposed research, he shared my enthusiasm for integrative science and global collaboration. My commitment and demonstrated ability to develop as a scientific naturalist of tropical forests mirror the goals of the faculty, resources, and community at the Smithsonian National Museum of Natural History and the University of Maryland's Behavior, Ecology, Evolution and Systematics program.

[1] Futuyma, D. 1998. "Wherefore and Whither the Naturalist?" Am. Soc. Nat. 1998 151:1.
[2] Kraft, N.J.B., et al. 2008. Functional traits and niche-based tree community assembly in an Amazonian forest. Science, 322:580-582.