La Selva 2017 REU Mentors and Projects

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Project 1: Niche partitioning of Tetragnatha spiders

Niche occupancy is the ecological space used by a species. Given resource limitation, character displacement contributes to prevent overlap between niches. *Tetragnatha* spiders are orb-weavers that live associated with streams and swamps. It has been suggested that their web structure and placement could be related to prey availability[1,2]. In previous fieldwork at La Selva, I have found up to three different *Tetragnatha* species living in the same place (Experimental swamp). Are there differences in web architecture and placement when multiple species co-occur? Are those species specialized for a particular environment? To answer these questions we will survey different freshwater environments, identify species and characterize web architecture/location.

Project 2: Population variability on web architecture of the spider Wendilgarda clara

Population variation could be produced by the capability of a species to respond to different environmental conditions. The genus *Wendilgarda* (12 species) has the largest diversity on web forms among orb-weabers[3]. Their webs correspond to horizontal lines linked to a series of vertical threads, which connect to the surface of water bodies. Previous studies have shown a great degree of variability on *Wendilgarda* webs at La Selva[3,4]. Is there any functional correlation between web structure and biotic/abiotic factors? To answer this question we will quantitatively characterize the web architecture and, by field observations and measurements, develop explanations of this variation. As a first approach, we will not assume a genetic component.

Literature cited:

1.- Gillespie RG. 1987 The mechanism of habitat selection in the long-jawed orb-weaving spider *Tetragnatha elongata* (Araneae, Araneidae). J Arachnol 15: 81-90.
2.- Blackledge TA and Gillespie RG. 2004. Convergent evolution of behavior in an adaptive radiation of Hawaiian web-building spiders. PNAS 101: 16228–16233.
3.- Eberhard WG. 2001. Trolling for water striders: active searching for prey and the evolution of reduced webs in the spider *Wendilgarda sp.* (Araneae, Theridiosomatidae). J Nat Hist 35: 229–251.
4.- Coddington J and Valerio CE. 1980. Observations on the web and behavior of *Wendilgarda* spiders (Araneae: Theridiosomatidae). Psyche 87: 93-106.

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Leaf cutter ants and carbon cycling
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What do leaf cutter ants do with carbon in the ecosystems where they are a dominant species?

Fauna can change the ecosystems where they live. For example, leaf cutter ants (LCA, Atta cephalotes) change the carbon and nutrient cycles in the ecosystems where they are a dominant species, modifying the conditions for other organisms to live there. Our research focuses in understanding the effects of LCA on carbon dynamics in the ecosystems where they are dominant, such as lowland tropical forests. The projects will focus on LCA behavior and their role in ecosystem services regarding the carbon cycling.

We will conduct a complete LCA nest survey, including location, size, site characteristics and CO_2 emissions (with user-friendly gas flux measuring chambers). We will use Maxent to model the LCA likelihood to occur based on environmental layers (canopy, geology, height, etc.).

We will study legacy effects of abandoned LCA nests using previous LCA nest surveys (REU program 2015). Are abandoned nest sites more favorable for some plant species? Are soil CO_2 emissions in abandoned nest sites different to non-nest sites?

One more topic is the LCA foraging behavior as they change the landscape of tropical forests. What leaf area do ants collect at La Selva? How much carbon do the ants collect? Which species do they prefer? We will monitor diel LCA foraging behavior with cameras and sample the vegetation they harvest (ants are particularly active at night).

The outcomes will contribute to understand tropical carbon and CO_2 emissions, and support conservation biology strategies. Students must have motivation, tireless spirit, and interest in soil ecology, technology and climate change.

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Increasing temperatures in the tropics will have multifaceted effects on aquatic ecosystems, and my proposed project involves examining the thermal tolerances of common aquatic macroinvertebrates. We will use laboratory mesocosm experiments to determine the critical thermal maximum, or CT_{max} (temperature at which an organism is no longer able to function normally), of common aquatic macroinvertebrates in La Selva streams. These data will be placed in the context of La Selva stream temperature data and compared to similar data collected from related macroinvertebrates in temperate streams.

My research interests focus on aquatic systems and invertebrate ecology, and I am also open to students' proposed project ideas within those areas. The ideal REU student would be hardworking, independent, interested in both fieldwork and lab experiments, and flexible in adjusting project plans (research rarely works out exactly the way you expect it to!).

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Project 1: Effects of global warming on herbivory rates by insect herbivores along an elevational gradient: an experimental approach

Global warming will reduce the area of certain habitats (e.g., high elevation ecosystems) and is becoming one of the main drivers of biodiversity loss. However, a more pervasive effect of a warmer future is the loss or alteration of biological interactions. Interactions between plants and associated insect herbivore are fundamental for ecosystem functioning as they represent the transition of energy and nutrients from primary producers (plants) to the animal kingdom.

Rolled-leaf beetles is a group of insect herbivores that feed on plants from the order Zingiberales (the banana-like plants). During the last decade, my laboratory studied the interactions between rolled-leaf beetles and Zingiberales along the La SelvaBarva elevational gradient. Using molecular markers and field records, now we know the elevational distributions and diets of rolled-leaf beetles inhabiting this tropical mountain.

The objective of this project is to determine how an increase in temperature under projected global warming will affect herbivory rates (i.e., the amount of plant tissue consumed by a herbivore over time) in insect herbivores present at different elevations. Using an experimental approach, we will use incubators and other physiology equipment available in my laboratory at La Selva Biological Station to explore how insect thermal limits are associated with herbivory rates at different temperatures.

As part of this project, the mentor together with the REU participant will generate a conceptual framework and state hypotheses and associated predictions regarding how herbivory rates of insect herbivores adapted to different elevations, ecosystems and temperatures should respond to global warming.

Project 2: Exploring the synergistic effects of global warming and plant invasions on insect herbivory rates in a tropical rain forest

Biological invasions, together with global warming are two major processes threatening biodiversity on earth. When exotic plants arrive to a novel location, local insect herbivores will face different challenges to colonize and incorporate in their diets the novel host. Global warming will also affect plant-herbivore interactions. Insect herbivores are ectoterms, and food intake varies with temperature. Therefore, herbivory rates will be affected by global warming.

At La Selva Biological Station, rolled-leaf beetles, a group of native insect herbivores feed on native plants from the order Zingiberales. In the last two decades, at least five exotic Zingiberales from the Paleotropics were introduced to La Selva. Seven rolled-leaf beetles are currently expanding their diets to these exotic hosts. The objective of this project is to determine if herbivory rates (i.e., the amount of plant tissue consumed by an herbivore over time) will increase under projected global warming. In addition, we want to explore if the magnitude of change in herbivory rates is equivalent in native or exotic hosts.

The approach of this project will be experimental, taking advantage of the physiology equipment and incubators available in my laboratory at La Selva. As part of this project, the mentor together with the REU participant will generate a conceptual framework and state hypotheses and associated predictions on how herbivory rates of insect herbivores expanding their diets to novel hosts are expected to change under projected global warming.

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Project 1: Investigating tolerance of stream fishes in Costa Rican Caribbean slope streams to elevated levels of suspended sediments

I hypothesize that cichlid, poeciliid, characoid, and other fishes common in small streams of the Sarapiqui region have evolved to be highly tolerant of elevated suspended sediment levels, allowing them to persist in streams with varying amounts of anthropogenic disturbance. Forest floors of even primary rainforests allow large amounts of sediments to enter streams during rain events, facilitating this tolerance. I will mentor a student or students in a project that measures stress in fishes exposed to varying levels of suspended sediments using oxygen consumption as a proxy for stress. The student(s) will use common fish species, such as *Astyanax aeneus* and *Astetheros alfari*, to run trials in respirometers to test the hypothesis. Most fishes used for the study will be released after the trials, although a smaller subset may be sacrificed so that gill tissues from fishes exposed to differing suspended sediments levels can be assessed for condition. These results will be compared to existing data collected for temperate fishes of streams near Purdue University that have already been evaluated using these methods.

Project 2: Assessing the relative importance of terrestrial vs. aquatic insects as prey for fishes in small streams with varying riparian compositions

I hypothesize that stream fish communities of rainforest streams are largely food limited, with great reliance on using terrestrial insects that fall into the streams as food sources vs. aquatic insects in the streams themselves. Alternatively, I expect that stream fish communities in pasture streams rely more heavily on instream insects vs. terrestrial insect as food and that aquatic insects are more readily available in these streams compared to forest streams. The student(s) will use terrestrial insect traps placed above the water surface in both rainforest and pasture streams to measure potential contributions of those insects as prey. In addition, students will use dip nets to sample aquatic insects in available habitats of both stream types to determine the abundances of these insects as potential prey. Finally, a subset of fishes of multiple species will be collected and their stomach contents evaluated to determine the relative contributions of terrestrial and aquatic insect taxa to the diets of these fishes.

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Project 1: Variation in the terrestrial mammal community along a tropical elevational gradient and how this affects seed and seedling survival

La Selva Biological Station is ideally situated at the base of the longest continuously-forested elevational gradient in Central America. The La Selva-Volcán Barva transect spans approximately 2800 m in elevation and comprises four life zones and one transitional zone: (1) lowland tropical wet forest, (2) tropical premontane forest, (3) lower tropical montane forest, (4) tropical montane forest, and (5) tropical cloud forest. The floristic and faunal communities along this elevational gradient are extremely diverse and vary dramatically among elevations. Large-bodied ungulates (collared peccaries, *Pecari tajacu*) dominate the terrestrial mammal fauna in the lowlands, where small rodents are uncommon; further upslope, peccaries are replaced by tapirs (*Tapirus bairdii*), and small rodents (*Peromyscus* spp., *Reithrodontomys* spp.) are found in greater numbers. The presence and absence of certain mammal species, and their relative abundances, can have profound effects upon regional plant communities. I propose to form a project with an REU participant to determine how seed fates and seedling survival vary along the La Selva-Barva elevational transect in the context of this mountain's diverse terrestrial mammal community. We will design a project to test fundamental hypotheses related to plant-animal interactions in a tropical mountain ecosystem. We will perform field experiments using varied methods: camera trapping, seed tracking in space/time, and exclosure experiments to determine seedling survival when exposed to varying mammal communities. We will also use advanced techniques to analyze our data (*e.g.*, failure-time analyses to compare seed and seedling survival data among habitats and hierarchical modeling approaches to analyze camera trap data).

Project 2: Thermal tolerance of invertebrate seed predators and the effects of temperature on seed infestation behavior

Invertebrates play key roles in plant life cycles, affecting plant propagation, survival, and dominance in vegetative communities. Insect-plant interactions are particularly prevalent in tropical ecosystems. Under projected climate change, tropical ecosystems are expected to shift upslope, however we do not know how insect seed predator assemblages and interactions will change in a warming world. Predation of seeds by insects is extremely common in the lowland wet forest of La Selva Biological Station and negatively affects plant demography. Predicting how increasing ambient temperatures will affect insect survival/performance and seed predation effectiveness is essential to understanding how tropical ecosystems and the plant-animal interactions therein will change in the Anthropocene. I propose to form a project with an REU participant to assess the critical thermal maxima (CT_{max}) of lowland insect seed predator species and to determine how temperature affects seed infestation behavior in a controlled laboratory environment. Depending on seed and insect availability, we have two potential systems with which to work: (1) *Carmenta surinamensis* (Lepidoptera: Sesiidae), which infest seeds of *Pentaclethra macroloba* or (2) *Coccotrypes* spp. (Coleoptera: Curculionidae), which infest palm seeds. We will use precision equipment to measure CT_{max} of seed predators and we will also have access to controlled-temperature incubators to measure seed infestation responses in the lab. Understanding how specialized insect-seed interactions transform under altered ambient temperatures is fundamental to predicting how ecosystems will evolve in a changing world.

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My research explores opportunities for maintaining biodiversity in the context of anthropogenic change. Habitat loss and modification are major drivers of biodiversity declines, and many species-rich tropical regions experience high rates of habitat loss. In Costa Rica, my research focuses on 1) how land use affects species diversity and movement and 2) how behavior, thermal biology, and life history traits may explain which species are most sensitive to habitat modification. Please see examples of my work in Costa Rica here: http://justinnowakowski.wixsite.com/nowakowski/publications.

Possible avenues for REU projects related to my research include the following: 1) The cumulative outcomes of individual behavior scale up to shape population responses to habitat modification. A behavioral landscape-ecology project could involve displacement or choice experiments that examine aspects of ectotherm (amphibians, reptiles or insects) behavior in response to features of altered landscapes, such as open microhabitats and remnant trees. 2) Habitat modification can drastically alter local microclimates (temperature and humidity). However, very few studies have integrated thermal biology into research on habitat modification. An REU student could study the thermoregulatory behavior of amphibians or reptiles in natural and altered habitats at La Selva. By measuring differences between field body temperatures and preferred temperatures (measured in the lab), a student could address questions about thermal suitability of forest versus altered habitats for multiple species. The REU student would also have an opportunity to extend their data to analyze variation in responses of amphibians or reptiles to habitat modification by drawing on our existing datasets in the region.

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Project 1: Comparison of plant functional traits, traits that characterize the ecology of an organism, is an increasingly popular way to characterize differences among individuals, populations and communities. Several general trait patterns have emerged from global and regional analyses of trait data, showing the effects of environmental factors on traits. For example, my research has focused on how traits differ among related tree species according to soil type preferences and found that leaf density is higher in species that preferentially occur in residual soils. A preliminary study of leaf functional traits of common understory herbs at La Selva indicated that their leaf mass per area was lower for species found growing on residual soil than those growing on alluvial soil, a pattern opposite that predicted by global trait analyses. Large herbs (gingers and their relatives) are an important component of the understory community in many Neotropical forests. The REU project I propose would compare functional traits of several understory herb species according to soil type preference (or forest successional status preference). The project would involve learning to identify herbs to species, characterizing light environment, collecting leaves from several individuals per species, working in the lab to measure leaf traits and the use of GPS and GIS. Available preliminary data would make understory herbs ideal for this project, but I am open to working with other groups of plants.

Project 2: Comparison of plant functional traits, traits that characterize the ecology of an organism, is an increasingly popular way to characterize differences among individuals, populations and communities. Several general trait patterns have emerged from global and regional analyses of trait data, showing the effects of environmental factors on traits and the correlation of suites of traits. For example, my research has focused on how suites of traits vary according to soil type preferences of tree species. Of particular interest to me is how seed traits are related to other life history traits such as leaf density and wood specific gravity. The REU project I propose would compare functional traits of several plant species (chosen by the student based on seed availability) according to soil type preference. The project would involve learning to identify plants to species, characterizing light environment, collecting seeds and leaves from several individuals per species, working in the lab to measure leaf traits and the use of GPS and GIS.

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Assessing the role of plant latex chemistry on the ecology and evolution of the fig family

Plants are one of the most dominant and diverse life forms in the planet. This diversity is only surpassed by the variety of chemical compounds plants manufacture, from basic nutrients like sugar and starch to useful metabolites like caffeine and aspirin. One of the most commonly used plant secondary metabolites is Latex. Although synthetic alternatives have been developed, natural latex is still a very important industry currently worth more than 30 billion dollars and expanding from the production of chewing gum to memory foam. Nevertheless, we still do not fully understand the role of latex on the ecology and evolution of plant species. Why do plants produce latex? Why are all latex producing plant families among the most diverse plant families in the world? How can latex give plant species an evolutionary advantage? These questions are still unanswered. In this project we will test the role of the physical and chemical characteristics of plant latex on the evolution and ecological defense of the fig family (Moraceae). Specifically the project will test two questions: (a) are latexes' chemical and physical traits associated with the different phylogenetic and diversification patterns across the fig family? And (b) what chemical and physical latex traits are responsible for the defense properties of plant latex? The project will use a combination of ecological fieldwork, laboratory analysis (chemical and physical analysis of plant latex), and manipulative experiments (plant-latex-herbivore interactions) to tackle these questions.

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Are glass frogs choosy?

My current research focuses on change in amphibian and reptile community composition over the course of tropical forest succession in riparian and upland habitats. While conducting surveys focused on amphibian and reptile composition in secondary forests, I have started documenting glass frog egg deposition sites across a variety of land-use types. Glass frogs (family Centrolenidae) are nocturnal frogs that deposit their eggs on vegetation overhanging streams and rivers. Currently, the level of specificity in choosing egg deposition site and whether egg deposition site may change as a result of habitat disturbance is unknown.

Students that work with me will get their feet wet in amphibian ecology (figuratively and literally) by conducting stream surveys for glass frog egg deposition sites. Potential projects focused on egg deposition site selection include: determining if glass frogs select for specific plant species, determining if glass frogs select for specific plant species characteristics or comparing egg deposition sites among stages of forest regeneration. Students will use data collected from surveys during the REU program and additionally have access to my database of egg deposition site surveys in Sarapiquí from the past two years.

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Tropical forests are dynamic places that are in part shaped by disturbance that varies in type, frequency, intensity, and spatial scale. For instance, animals may cause frequent low-intensity disturbance at a small scale through foraging while humans may cause infrequent high-intensity disturbance at a large scale through habitat fragmentation. Disturbance results in forest recovery and regeneration, which is driven by seed dispersal and seedling recruitment. In turn, recruitment is mediated through species' functional traits in response to microsite conditions, soil characteristics, light availability, and other distance- or density-dependent processes. Forest regeneration will also be affected by characteristics of the surrounding area at the plot, patch, and landscape level. Therefore, the species composition witnessed at a particular forest area has been shaped by a history of factors, interactions, and processes that are both deterministic and stochastic. I am interested in how forest regeneration affects species composition in various forest types including second-growth, old-growth, riparian, restored, and degraded. Specifically, my research has focused on plant-animal interactions and seedling recruitment in second-growth forests.

For summer 2017, I seek a REU student that can become excited about forest disturbance and the way a forest grows back, and I have a myriad of ideas for projects. For instance, we could explore local levels of disturbance in the form of treefall gaps and how their frequency is influenced by forest type and landscape characteristics. Or, we could focus on riparian areas to determine what species of trees are regenerating and how this is influenced by site characteristics and disturbances like flooding or fragmentation. The student would be able to take leadership to choose or develop the specific research question and hypothesis based on their particular interests and will be expected to become familiar with many aspects of tropical forest ecology to place their research into a rich conceptual framework.

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Seed dispersal is a critical ecological process that contributes to the maintenance of biodiversity of neotropical forests. My research focuses on seed dispersal interactions in one of the most diverse groups of plants in the tropics—pepper plants in the genus *Piper.* Most species in this group are dispersed primarily by a group of fruit bats in the genus *Carollia*; however, many other animal species can move *Piper* seeds, including birds and also ants that often carry seeds to different microsites once they are dropped by bats or birds. There are numerous potential REU projects that could focus on different aspects of the seed dispersal ecology of *Piper* plants. For example, one project could test the hypothesis that gut passage of seeds by bats influences the probability that seeds will be secondarily moved to new microsites by ants. This project would involve: 1) capturing bats using mist nets to obtain fecal samples containing seeds, 2) placing arrays of seeds in the forest that would include seeds that have passed through bat guts and seeds from intact fruits, and 3) monitoring seeds for removal by ants or other invertebrates. A second project could test the hypothesis that the location and spatial configuration of *Piper* fruits affects the rate at which bats and birds are able to detect and remove fruits. This project would involve: 1) creating artificial arrays of *Piper* fruits at different ripening stages, and 2) monitoring removal during daytime and nighttime hours to record removal behaviors by birds and bats.