La Selva REU 2020 mentors and projects

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Project topic: Mechanisms and patterns of scavenging in tropical rainforests
The scavenging communities of tropical rainforests are understudied, and little is known about how scavengers fit into the food webs of these ecosystems. Work from previous REU students found that beetles are important members of the scavenging communities, particularly for small carrion (dead animals). These beetles will locate and bury a large proportion of carrion very quickly, yet there is likely a limit to the size of carrion that they can actually tunnel underground, and where bigger animals, like mammals and birds, are the main scavengers. Students interested in these topics will develop projects to further understand the ecology and behavior of the burying beetles and scavenging. For example, projects might look at how quickly beetles find carrion, how long it takes for them to bury the carcass, and what species of beetles are involved in doing this. In addition, students can test how factors like carrion size affect the ability of the beetles to bury the carrion, and what other scavengers eat this larger carrion. These projects will include fieldwork off trails at La Selva with carrion and camera traps, and identification of various animals.

Brian O'Neill – University of Wisconsin-Whitewater
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Project topic: Animal movement in a human-altered environment
Human-altered habitats can have an effect on how animals move across the landscape. Given that the vast majority of habitats on Earth are highly modified by humans, it is important to understand what features may inhibit or encourage movement of animals, particularly vertebrates. The movement of individuals among populations can have big ecological impacts affecting reproduction, genetics, etc. Generally, I am interested in working with students who want to assess 1) the use of manmade bridges by wildlife within La Selva, and 2) how the border/edge of La Selva's property line affects the movement of animals. I will work with students to develop specific research questions within these general topics. Students interested in working on these projects will learn how to use trail cameras and to identify animals from trail camera footage. Students working on these projects will need to hike long distances in uneven terrain to set up and retrieve trail cameras.

Colin Morrison – University of Texas at Austin
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Project 1: Larval feeding habit and predator susceptibility
Predators selects for herbivorous insects to specialize on toxic plants that make them unpalatable. Nonetheless, some visually oriented wasps and ants still feed on specialist insect larvae if the trade-off between foraging effort and nutritional payoff is worth it. Group-feeding and solitary larvae represent different nutritional payoffs to a potential marauder and predator taxa with different

foraging behaviors may respond differently to larval feeding habits. Do butterfly species with group-feeding larvae suffer predation from social wasps more frequently than ants and vice versa? The student that accepts this project will collect group-feeding and solitary *Heliconius* larvae and present them to wasps and ants in experimental arenas in the field.

Project 2: Specialist and generalist flea beetle cyanide sequestration patterns
Do generalist and specialist *Passiflora* flea beetles sequester different amounts of toxic chemicals from their host plants? Leaf cyanide concentration varies considerably among
Passiflora species and these plants host many specialist flea beetles. Some flea beetle species only consume one *Passiflora* species, others consume several. All assimilate cyanide from their hosts. However, it is unknown whether specialists and generalist species sequester different concentrations of these toxic chemicals. Monophagous *Heliconius* sequester high cyanide concentrations as larvae while generalists assimilate lower concentrations. This variation provides a set of testable predictions to compare with *Passiflora* flea beetles. The student that chooses this project will investigate this system by collecting flea beetles in the field and measuring their cyanide concentrations on the LS spectrophotometer.

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Project 1: How do canopy gap dynamics affect carbon and nitrogen cycling?
Treefall gaps create windows through the rainforest canopy, dramatically altering the conditions at the forest floor. Although the effects of canopy gaps on understory species composition are well known, changes in biogeochemical cycling in rainforest canopy gaps are less well understood. Increases in woody debris and decreases in root biomass can lead to high decomposition rates and soil nutrient leaching – fundamentally altering how the forest operates within a canopy gap. This project will investigate how carbon and nitrogen cycling change in canopy gaps of varying sizes and ages. Because canopy gaps are a critical part of tropical forest dynamics, this project will provide important information on the broader biogeochemistry of tropical forests as a whole.

Project 2: Are canopy gaps "hotspots" of symbiotic nitrogen fixation?
This project will examine the effects of gap dynamics in regulating symbiotic nitrogen fixation (SNF), which provides a large nitrogen input that can dramatically alter ecosystem function. Nitrogen is critical to ecosystem productivity, but most nitrogen exists in a form unavailable for biological use. SNF is a symbiosis that occurs in root nodules on leguminous plants, where nitrogen-fixing bacteria convert atmospheric nitrogen to a bioavailable form. A large majority of SNF has been proposed to occur in tropical treefall gaps. Gaps are common in the landscape and alter light dynamics, which are predicted increase SNF. This prediction is based on reasonable assumptions but has never been mechanistically tested. This project will test (1) if nodule mass differs between gaps and intact forests, and (2) if the nodule mass found in a gap is related to gap age or size.

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Project 1: Emergence of aquatic insects across a stream gradient
We envision one project examining the emergence of aquatic insects in two streams that differ in their chemistry and frequency of disturbances. This will be a field and lab work intensive project, requiring checking of deployed emergence traps for several hours and subsequent identification of adult insects in the lab. We hope this project can further inform biological differences and physiological responses to stream chemistry and frequency of acidification experienced across the gradient of streams at La Selva and corroborate previous work from the STREAMS project.

Project 2: Wood as the fuel in stream trophic networks
A second project will examine the rates of wood decomposition across this same gradient in the streams at La Selva. We hypothesize wood decomposition will vary strongly across the gradient as a function of stream chemistry and larval aquatic insect abundance. We will compare decomposition of naturally occurring wood material with a standardized wood material (i.e. popsicle sticks) to compare the influence of surface area and quality (C:N) on decomposition process.

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Project 1: Energy budgets and cognitive abilities in hummingbirds
Memory abilities are pivotal for the exploitation of food sources that do not offer visual or olfactory cues, such nectar enclosed in flowers. Both spatial and temporal memories improve the energy gain as individuals are able to harvest nectar at the minimizing the travel cost, as they match their visits to nectar production and quality. In Mediterranean environments territorial hummingbirds facing low environmental temperatures show extremely well developed spatial-temporal cognitive abilities positively impacting their energy budgets. However, these abilities are developed in males but not in females, at least at the same spatial scale. In tropical environments, we have documented that spatial memory abilities in long-billed hermit hummingbirds seem to play a central role in the territorial status, and it is as important as bill weapons. In this context, the role of other traits that impact energy gain -such body size and foraging strategies- on cognitive abilities across species remain unexplored. In this study we aim to expand our previous scope study including other species with different body sizes and different foraging strategies (i.e., territorial and trapliners). Trapliners invest higher amounts of energy traveling between different feeding sites, and species with low body mass have comparatively higher metabolic rates per unit in comparison with bigger species. Thus, we hypothesize that species with lower body mass and trapline strategies will display better cognitive abilities in comparison with territorial and species with high body mass due to higher energy demands. For these experiments we aim to implement “smart feeders” that will record hummingbird visits in different locations across La Selva Biological station, providing an accurate data collection.

Project 2: Costs and benefits of vocal coordination strategies in lekking hermit hummingbirds
We have documented coordinated singing in long-billed hermits. In this behavior, simultaneously singing males modify the timing of their songs to achieve synchronization. The type of coordination is dependent on the distance between individuals: non-overlapping singing is more common in close proximity while overlapping singing is mostly used when singing at farther distances. We hypothesize that, by overlapping their songs birds may amplify their combined signals and communicate across greater distances, but this benefit is diminished in close proximity, where the ability of bystanders (i.e. females) to locate singers decreases when songs are overlapped by nearby singers. A feasible project would involve measuring the response to overlapping songs emitted by speakers at both close and far distances, expecting that the ability of an individual to find a "singing intruder" (a speaker) will be affected by the distance between the speakers and the type of coordination. This project would require playback experiments and documentation of behavioral responses in lekking hermit hummingbirds.

Sara Shuger Fox – Central College
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Project 1: Sarapiquí public health - investigating dietary and agricultural factors contributing to longevity
The objectives for this site study are to explore the feasibility of my current research agenda on the investigation of the correlation between dietary intake and longevity in the designated Blue Zones of Costa Rica, specifically targeting the rural population in the Sarapiquí region. Specific objectives are:

1. Conduct an in-country population comparison of individuals over the age of 80 where research has yet to be conducted (Nicoya vs. Sarapiquí)
2. To further explore Blue Zone research methods in conjunction with the current International Blue Zones Initiatives.
3. Develop preventative medicine protocol for local practitioners based on data obtained from the Sarapiquí region.

Project 2: Rural Sarapiquí - evaluating and preventing type 2 diabetes in the Sarapiquí region of Costa Rica
The objectives for this site study are to explore the rural populations of Sarapiquí, Costa Rica, specifically identifying prevalence of type 2 diabetes and developing preventative measures to articulate public health literature. Specific objectives are:

1. Allow students to develop cross-cultural competency in Costa Rica by fostering experiential learning goals.
2. Investigate the differences in a universal vs. public healthcare system (access for preventative care).
3. Establish literature for preventative public health promotion outreach in Central American communities, specifically on prevention of type 2 diabetes.

Susan Whitehead – Virginia Tech
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Project 1: Effects of fruit bat gut passage on seed pathogen susceptibility
Project 2: Effects of seed chemistry on seed survival in tropical forests
Seed dispersal is a critical ecological process that contributes to the maintenance of biodiversity of tropical forests. REU students working with our group will study seed dispersal interactions in one of the most diverse groups of tropical plants (the genus *Piper*) and their primary animal seed dispersers--short-tailed fruit bats. Here we describe two potential REU projects that would focus on a critical but understudied aspect of seed dispersal ecology--how the chemical traits of fruits influence seed dispersal success. Note that these are just two of many possible projects, and we hope to work closely with the students to tailor their project to their interests. First, one project could test the hypothesis that the passage of seeds through the bat gut affects the susceptibility of seeds to pathogen attack. This project would involve: 1) capturing wild bats in mist nets, 2) conducting feeding trials with bats in flight cages, 3) comparing pathogen attack and seed germination rates in seeds that have been removed from intact fruits or bat feces. A second project could test the hypothesis that chemical traits of fruits influence the probability that seeds will germinate and survive at different distances from the parent plant. This project would involve: 1) supplementing seeds with plant extracts that are enriched with defensive metabolites found in fruits and seeds, 2) placing arrays of seeds in the forest at different distances from parent plants, and 3) monitoring seeds for germination, secondary seed dispersal, or pathogen attack.

Las Cruces REU 2020 mentors and projects

Johana Goyes - University of Missouri
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Project 1. Benefits of egg attendance in the Emerald glass frog
Early studies of the natural history of this species report little or no parental care. Jacobson (1985, *Herpetologica* 41:396–404) observed females near the eggs for a few minutes after oviposition but later deserted the clutch. Previous studies on this species at Las Cruces Biological Station revealed that the females stay between 45–85 minutes with the clutch before deserting it. Females who stayed with the clutches longer do no have higher hatching success, but no studies have evaluated if female presence provides a direct benefit to the clutch. To test this, the student will use enclosures in the field to carry out parent-removal experiments. After fertilization and oviposition occurs, females assigned to the removal treatment will be displaced from the clutch. Hatching

success and sources of mortality will be compared between the two treatments to determine if egg attendance provides any benefit to the offspring.

Project 2. Predation experiments with clutches of the Emerald glass frog
Previous studies on the reproductive behavior of this species indicate that predation is one of the main sources of egg mortality in *E. prosoblepon*. To determine if egg attendance behavior provides any benefit to the offspring in the form of anti-predatory deterrents, the student will carry out prey-choice tests using natural predators of *E. prosoblepon* eggs. If egg attendance provides any benefit, removal clutches (female was removed after oviposition) will suffer higher predation than control clutches. This study will provide evidence of the benefits (or lack of) of egg attendance behavior in this species, and ultimately will provide critical information to study the evolution of parental care behaviors in the glass frog family.

Justin Montemarano – Georgia Southern University
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Project 1: Constructing a particulate carbon budget for a neotropical stream.
Allochthonous organic matter is an important source of energy and nutrients in forested streams, and understanding the deposition, retention, transport and decomposition of these sources of organic matter is crucial to monitoring stream health and change. While characterization of organic matter processing in temperate forested streams has been well described, analogous studies are lacking for neotropical streams. I would like to construct a budget of particulate organic matter within the Las Cruces stream network by conducting surveys of litter deposition rates, measuring standing stock, and using a series of litter releases to characterize litter retention and transport. Additionally, I am interested in developing related projects, such as surveying macroinvertebrate community structure associated with leaf litter packs in streams and monitoring decomposition rates.

Project 2: Controllers of freshwater crab behavior and implications for decomposition dynamics.
We have found two species freshwater crab (Pseudothelphusidae) associated with stream systems at Las Cruces. Previous projects show that (1) the distribution of the crabs within and outside of streams is highly variable, and (2) that the crabs contribute to the decomposition of leaf matter through shredding. I would like to explore factors controlling crab behavior, densities, and leaf processing rates. For example, crab species and parasite load (trematode metacercariae were discovered in both crab species) may impact activity.

Patricia Esquete – Universidade de Aveiro
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Project 1: Microhabitat preferences of benthic invertebrates in tropical streams

Benthic environments in tropical streams host a variety of organisms of different life strategies, ranging from soft bodied, infaunal plathelmints to insects with aquatic larvae or macrocrustaceans. The REU student will develop a project that examines the factors affecting the aquatic invertebrates' preferences for certain microhabitats, their abundances or species composition across a tropical stream. For this purpose, they will use different field capture techniques, animal manipulation methods and habitat characterization, as well as laboratory methods including the use of microscopes and identification tools. If more than one student is interested, two projects could be carried out on this subject.

Project 2: Predation-prey relationships of semi-aquatic spiders

Semi-aquatic spiders are fascinating animals that live in rocks and crevices in the vicinity of water bodies, preying on insects, frogs, tadpoles, and other organisms including small fish. Two species of the non-web genus Trechalea are abundant in the rainforest's streams of Costa Rica, where they play an important ecological role by controlling other species' populations. However, little is known about their behaviour and the factors affecting their hunting/resting activities. This study aims to investigate their predation strategy and activity rhythms; The REU student can expect searching rivers for big spiders during different times of the day, observing activity patterns, and mapping their movements. If more than one student is interested, two projects could be carried out on this subject.

Lindsey Swierk – Binghampton University
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Project 1: Water anole home range and microhabitat use. Understanding how individuals distribute themselves in space is a fundamental problem in ecology. This project will explore the social structure of water anole populations and their relationship to the microhabitat. The student conducting this research will study water anole home range sizes and shapes to address natural history question regarding sex- and age-related habitat use, territoriality, and density.

Project 2: Communication in courtship and aggressive encounters. How animals use signals to communicate is an essential component of behavioral ecology. This project will test how water anoles use behavioral and morphological cues during inter- and intra-sexual encounters. Several morphological cues are of interest, namely dewlaps ("chin-flaps" of skin) in males and rapid body coloration changes. These traits have never been quantified in relation to contest outcome in water anoles. Hypotheses generated may focus on the relationship of a) male body/dewlap characteristics with female mate choice, b) effect of color change on aggressive encounters, or c) male courtship in relation to female reproductive value.

Elizabeth Clifton - University of Connecticut
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Project 1: How does elevation affect termites and will termite species be able to adapt to the warming of the climate by changing their elevation?
This project would have transects set at 0m, 500m, 1000m, 1500m, and 2000m above sea level (La Selva and Barva Transect). Each transect would be surveyed for termites to evaluate at diversity at different elevations. A sample of termites from each colony would be taken back to the lab, where the student will perform CTmax and CTmin experiments. This will allow us to determine what temperature ranges these termites can withstand and if they will be able to live in our changing climate.

Project 2: How effective are different species of termites at fighting different enemies?
Termites have morphologically distinct castes, which includes a soldier caste for defense of the colony. Soldiers can have a wide variety of weapons, including different size and shape mandibles, nozzles for spraying chemicals, and the ability to rupture and "explode." Termite populations are regulated more by other termites than by predators (i.e. ants, vertebrates). However, personal observations suggest that some of these soldier weapons are not effective against other termites. This would be tested by collecting termites and performing fighting trials between different species of termites and ants. Effectiveness will be evaluated by injury assessment post-trial. If a termite is not effective against either of these arthropods, it is assumed they are adapted to fight off vertebrate predators. This would be tested using clay models, as using live vertebrates would be unethical.

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My research tackles a pressing question in ecology: how will tropical species and communities respond to climate change? One way to answer this is to conduct field heating experiments to predict how animals will be affected by a warmer future. Students working with me will perform field and lab experiments using heaters to warm invertebrate communities found in the rolled leaves of heliconias. In these communities, ants often "farm" aphids for their sugar-rich honeydew. In return, the aphids are protected from predators. These mutualistic ant-aphid interactions are very common, but these aphids are less heat-tolerant than the ants that tend them. Students will manipulate aphids and ants to test how this interaction will respond to climate change.
One student will test whether aphids attract ants to rolled leaves and how their interaction is affected by heating. The second student will test how aphid survival and honeydew production respond to temperature. Students will work together in the field and lab to collect insects and set up heating experiments. They will gain experience in experimental design, tropical field work, and some basic electrical engineering skills. Students will have the opportunity to publish a research article based on these projects.
Project #1 summary/title: Insect farmers: Do aphid-tending ants prefer aphids or heat?
Project #2 summary/title: Insect livestock: How will climate change affect aphids' honeydew production?

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Project 1: Insect Diversity and Behavior in a New Light

Light is arguably the most important abiotic factor for living organisms. Organisms evolved under specific lighting conditions and their behavior, physiology, and ecology are inexorably linked to light. Understanding light effects on biology could not be more important as present anthropogenic effects are greatly changing the light environments in which animals exist. The two biggest anthropogenic contributors to changing light environments are: (1) anthropogenic lighting at night (i.e., light pollution); and (2) deforestation and the built environment. We will survey insect diversity and behavior along a canopy cover gradient using the four regions within the Las Cruces Biological Station: primary forest, secondary forest, selectively logged primary forest, and abandon pasture.

Project 2: Selective Regimes and Animal Signaling in a New Light

Many animals balance the trade-offs between various selective pressures. How animals balance the costs and benefits of signaling is important for understanding signal evolution. Most animals must signal to attract mates, while also avoiding predation. Additionally, many animal signals, particularly visual signals, are difficult and energetically expensive to produce. Furthermore, visual signals require certain light environments to best broadcast to potential mates and to predators and parasites. Understanding light effects on biology could not be more important as present anthropogenic effects are greatly changing the light environments in which animals exist. We will survey butterfly diversity and signals along a canopy cover gradient using the four regions within the Las Cruces Biological Station: primary forest, secondary forest, selectively logged primary forest, and abandoned pasture.

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Project 1: Habitat use by phyllostomid bats (Chiroptera: Phyllostomidae) across the landscape
Phyllostomidae is one of the most diverse bat families worldwide, which presents a range of morphological adaptations for different feeding habits, such as frugivory, nectarivory, insectivory, and sanguivory. These morphological adaptations might have also enabled them to use and explore their environment in different ways, creating microhabitat specializations. However, the relationship between habitat use and morphological specialization has not been very well explored for phyllostomid bats. In this project, we will compare the habitat use of phyllostomid bats from different feeding guilds at sites with different habitat characteristics (gaps, clutter, and open) to check the importance of their morphology on the way that they use their environment.

Project 2: Frugivory rates of phyllostomid bats (Chiroptera: Phyllostomidae) across the landscape

With more than 1,400 bat species spread across 21 families worldwide, only two families have evolved to include fruits on their diet. Phyllostomidae is a diverse family of Neotropical bats that have evolved frugivory as one of their main feeding habits. Some bat genera within this family are known to specialize in specific plant genera. However, these relationships have been mostly studied from the bats point of view by looking at their diets through their feces. Very few studies have analyzed this aspect of their ecology from the plants point of view. In this project, we will use camera traps to analyze frugivory rates of different plant species by phyllostomid bats.