Amigos Newsletter

No. 88, November 2017

Organization for Tropical Studies

Wilson Botanical Garden

Las Cruces Biological Station

Apdo. 73-8257 San Vito, Coto Brus, COSTA RICA

Who We Are

The Las Cruces Biological Station is one of three field stations owned and operated by the Organization for Tropical Studies (OTS) in Costa Rica. The station was acquired in 1973 and, along with the Wilson Botanical Garden, offers natural history visitors and researchers alike an extraordinary place to visit and conduct research.

Far from the noise and bustle of the country's capital city San José, Las Cruces is located in the remote southeastern corner of the country between Corcovado National Park on the Osa Peninsula, and the enormous La Amistad International Biosphere Reserve (472,000 hectares) that spans south-central Costa Rica and western Panama. In 1983, UNESCO declared Las Cruces and the Wilson Botanical Garden part of the Biosphere Reserve due to its incredible diversity and proximity to La Amistad.

The Wilson Botanical Garden, founded in 1962 by Catherine and Robert Wilson, is arguably the most important botanical garden in Central America and a "must see" stop on the itineraries of plant lovers, birders, and other natural history groups. It is famous for its worldwide collection of tropical plants that include palms, aroids, bromeliads, gingers, marantas, heliconias, and ferns. More than 3,000 exotic species of plants can be found in the 10-hectare (~ 25-acre) garden, including one of the largest collections of palms in the world.

There is an incredible diversity of animals that inhabit the Las Cruces reserve, and the forest fragments in the immediate surrounding area. The bird list has registered 410 species; close to half the number of birds found in all of Costa Rica. There are also more than 100 species of mammals, of which 60 are bats. Some of the more commonly sighted mammals include agoutis, white-faced capuchin monkeys, kinkajous, olingos, and tayras. Reptiles and amphibians also thrive in this moist, cloud-laden habitat and there is an impressive diversity of insects, and in particular moths and butterflies.

Las Cruces protects more than 200 hectares of primary forest (home to some 2,000 native plant species) and ~150 additional hectares that are in various stages of forest recovery. The reserve is surrounded by a mosaic of mixed-use agricultural fields and forest patches, and it is this fragmented setting that makes Las Cruces an ideal place to study the effects of forest fragmentation and isolation on animal and plant communities. The landscape surrounding Las Cruces is also ideally suited for research on biological corridors and restoration ecology; key fields of research that are of ever increasing importance. Part of our mission at Las Cruces is to continue to purchase land for reforestation and, in doing so, expand our protected areas and connect some of the isolated forest fragments around the station. For further information on this campaign please visit the Las Cruces website.

At approximately 1,200 meters elevation (3,900 feet), the prevailing temperatures at Las Cruces are cooler than one might expect. Temperatures range from 21-26 °C (70-80 °F) during the day and 15-21 °C (low 60's) at night. Mean annual rainfall is ~4,000 mm (157 inches)! The dry season runs from January – March, and the rainy season from May – November. Most visitors and researchers come during the dry season.

The station is well known for its visitor-friendly amenities: comfortable private sleeping quarters, excellent meals, knowledgeable and enthusiastic staff, and a well-maintained network of paths and trails. The nearest town is San Vito, the municipal capital of Coto Brus county. It was founded by Italian immigrants in the 1950's and to this day they have a strong presence in the community. For example, a Dante Alighieri Italian-Costa Rican Community Center provides Italian language instruction and Coto Brus is the only county in Costa Rica where Italian forms part of the elementary curriculum! But enough said here! We hope that you will be inspired to come and experience firsthand the splendid tropical diversity of the Las Cruces Biological Station and Wilson Botanical Garden!

Please visit the Las Cruces website at http://www.tropicalstudies.org/lascruces for more information or contact us directly by email at lcruces@tropicalstudies.org or telephone at: +506 2773-4004. Postal mail can be sent to: Estación Biológica Las Cruces/Jardín Botánico Wilson; Apdo. 73-8257; San Vito de Coto Brus, Puntarenas; Costa Rica.

Reservations can also be made by contacting the OTS office in San José by email: threepaths.reservaciones@tropicalstudies.org or by telephone +506 2524-0607.

The North American OTS office is located at Duke University, telephone: +1 (919) 684-5774 or email: ots@tropicalstudies.org

The Organization for Tropical Studies is a nonprofit consortium of universities and research institutions in the U.S., Costa Rica, Peru, Mexico, South Africa, and Australia.

Founded in 1963, OTS is dedicated to providing leadership in education, research and the responsible use of natural resources in the tropics. To this end, OTS offers graduate, undergraduate and professional education, facilitates research, participates in conservation activities, conducts environmental education programs and maintains three fields stations in Costa Rica: La Selva Biological Station in the Atlantic lowland rain forest; Palo Verde Biological Station in the Pacific deciduous dry forest; and Las Cruces Biological Station in the premontane cloud forest near the Panamanian border.

AMIGOS NEWSLETTER
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Front Cover: The new spring-fed ponds and garden at the forest edge in the Wilson Botanical Garden. Photo: Greg Nace.

Back Cover: Our environmental education program working with local school children to plant a new schoolyard garden. Photo: Carla Azofeifa

Editorial Committee: Leslee Schmitt, Rebecca Cole & Rodolfo Quiros.

Director's Keys and Notes

A Bit of Coto Brus History

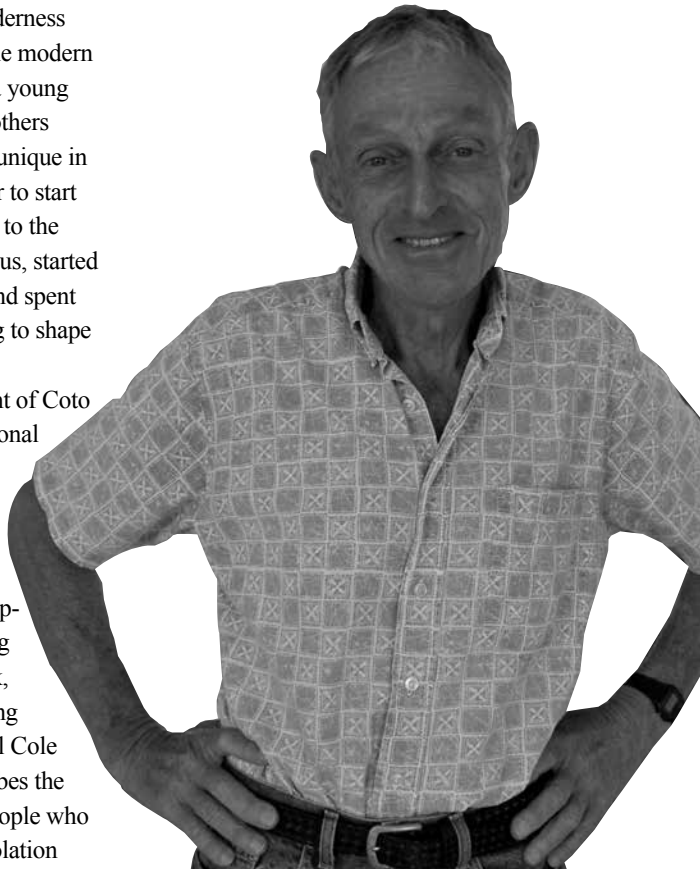
Rebecca Cole / rebecca.cole@tropicalstudies.org

Each place has its history and a set of characters who played a leading role in bringing about the realities we experience today. It seemed appropriate in this edition to remember a bit of the history of our spectacular region and the context for some of the challenges and opportunities of the present.

This region, once known as the South Frontier, occupies the rugged land at the foot of the Talamanca mountain range and extends down the steeply dropping slope to the Pacific lowlands. Its history is a relatively recent one. The development of the South Frontier was shaped by individuals whose lives spanned a time of exceptional change, no more so than for the first settlers, or pioneers, who came here in the early days when Coto Brus was a remote wilderness and whose actions moved it into the modern era. One of these individuals was a young North American who, along with others seeking a chance to do something unique in the world, came to the new frontier to start a life. In 1953, Darryl Cole moved to the region that would become Coto Brus, started a farm on a remote piece of land and spent the next 64 years of his life helping to shape the future of the region.

The early days of the settlement of Coto Brus were marked by both exceptional promise and struggle. Like most frontiers, there was a culture of abundance – that is, a perception of unlimited land and natural resources. There was also the sharp-edged reality of carving out a living in a remote wilderness. In his book, *A Place in the Rainforest*, describing the settlement of Coto Brus, Darryl Cole captures these elements. He describes the grueling poverty of the landless people who came to the frontier, the intense isolation of a seemingly endless forest overhead, the ceaseless rain that made travel along muddy roads impossible and of the heartbreak when the inaccessibility of the region made reaching a hospital impossible and no help could come from outside. At the same time, he describes the breathtaking intricacy and beauty of the land, the forces that led to the transformation of a wilderness into a rural landscape, and the realization of the consequences that came with those changes.

Darryl Cole's life in the early decades of Coto Brus was marked with enviable adventure. As a writer, he penned articles about the search for a lost Spanish gold mine, expeditions into little-explored mountain regions, and harrowing journeys along muddy forest trails to bring horses and livestock to the new farm. The farm he started with his family was call Finca Loma



Darryl Cole (1934 - 2017), one of the first pioneers of the Coto Brus region.

Linda. Unlike most landowners at the time, he cleared only the forest necessary to make way for crops and houses. The primary forest remaining there, some of the most intact in the region, is the result of hard-won battles against the policies and practices of the time. The steeper land of the farm was carefully terraced to prevent erosion. Over the years, each section of land became the subject of detailed testing and study for new farming methods as the consequences of unsustainable land use across the region became evident.

As a leading member of the young community, Darryl Cole helped found the Coopa Buena coffee cooperative, maintained close ties with the Italian community in San Vito and was closely involved in development of policies for the region. In the 1970's and 80's Finca Loma Linda became a venue for testing new ideas in agriculture as visiting scientists developed ideas that would contribute to the emerging field of Agroecology. In the next few decades, he hosted many groups of OTS students and researchers, and introduced young people to the first-hand realities and challenges of farming in the tropics. In the local community, he was an instantly recognizable figure and one of the first and most eloquent voices for sustainable land use, conservation, and respect for the natural world. It was a voice that inspired many young people in their careers and choices, myself included.

A few months ago, I came across some old records in my office at Las Cruces. One of them was a 1990 report compiled by Luis Diego Gomez, the director of the station at that time. It contains a long letter from Darryl Cole written for the students and researchers at OTS from the perspective of a pioneer who had a hand in transforming a rainforest frontier and intensely lived those realities, choices and outcomes. It was an early draft of a chapter published years later in his book. One paragraph caught my attention. Although written more than 25 years ago, it is still relevant to the challenges we face here today. The version from the 1990 letter is below.

"The time of the pioneer of those earlier years has passed. Gone too is the challenge of that frontier. But no age and no time are without their challenge. The pioneer of that earlier time seized in their imagination a vision which was never complete, only a beginning. It remains to build on what was started, to recognize and reassess the exigencies that gave way to those earlier years. We must seek to understand; for we have acted upon scant knowledge. The new pioneer is the student, the researcher, the person who would learn. He or she must take on the burden which has been brought forward; for we have loved – yet despoiled; labored – yet destroyed; cherished – yet all but lost a world which we must now seek to recreate and restore. This is the frontier today in Coto Brus; may I wish you well in advancing to meet it."

The rest of this newsletter contains updates on new developments in the Wilson Botanical Garden and the results of studies ranging from the detailed world of tiny insects to a holistic view of the landscape. There is a report on the fun events of our first Open House Day at the Station and exciting progress in our environmental education program.

ENJOY AND SALUDOS!
REBECCA

What's New at Las Cruces?

New Spring-Fed Ponds in the Wilson Botanical Garden

Greg Nace / horticulture@tropicalstudies.org

A natural spring hidden underneath a tangle of invasive plants.

As you take the path that zig-zags downhill to the west from the Garden's library, you pass impressively large clumps of bamboo (which according to accession records, Mr. Wilson planted between 1976 and 1981). The trail continues below the bamboo where a small natural spring flows year-round into an almost hidden valley. It was actually more than almost hidden. Exotic invasive plants like the Velvet Pink Banana (*Musa velutina*) and Beehive Ginger (*Zingiber spectabile*) completely overtook the valley and wetland created by the spring. It was a tangled mass of exotic invasive vegetation.

After our intrepid garden staff cleared out the tangled mass of vegetation by hand, four small pools were dug into the underlying clay and the spoils used for pond embankments. We have located a few native Costa Rican marginal and aquatic plants to revegetate the pools and valley and are looking for additional local native plants to add. Frogs have moved in already, and we are on the lookout for native fish. This new garden will soon fill in. The forest setting behind the ponds makes this a special location to enjoy the sounds of running water, birdwatch, and spot frogs.

New ponds and native plants take shape at the edge of the forest.

Chester Remembers the Wilson Botanical Garden

Palmares de Alajuela, Costa Rica is home to Duraflor S.A., a large bromeliad nursery that supplies the world with a range of interesting and colorful hybrid plants related to pineapple. Chester Scotak, owner and renowned hybridizer, first came to Costa Rica in the early 1980´s, traveled across the country and wound up in San Vito where he met Catherine and Robert Wilson, fellow plant people. Chester worked for the Wilsons for five years during the time when the Wilson´s health was taking a turn for the worse and negotiations were underway to donate the Garden to the Organization for Tropical Studies.

Chester grew up in Houston, Texas, and had always been interested in the tropics and tropical plants, especially bromeliads. After a few years of owning a nursery in southern Florida, he escaped further into the tropics where he could pursue his passion: discovering new plants. He is one of the plant hunters, a rare breed that will try to stop an express bus to go explore a valley where something unusual was spotted.

Horticulturist Greg Nace with Chester Scotak on right.

Chester´s passion became a very successful business, propagating and bringing rare and unusual plants into reach for those with an eye for beautiful plants. Not satisfied to just grow species found in the wild, he taught himself the art and science of hybridizing bromeliads to bring even more striking forms of these plants into cultivation. He is currently developing a red pineapple, a project he has been working on for 23 years. “I’m only one generation away” he says. The man has perseverance!

We are grateful to Chester for his recent donation of a truck full of sixteen outstanding species and cultivars. These plants will help refresh the bromeliad collection around Casa Wilson. In the next three years or so, if you see red pineapples in your grocery store, thank Chester Scotak and his love of bromeliads.

Jardín para Mariposas

Soon after I started at the Wilson Botanic Garden, Rosibel Ortiz, one of the forest rangers at Las Cruces, suggested a new garden, one which would be specifically for attracting butterflies. Raising butterflies was what she did before moving to San Vito, working for a commercial farm near San Jose that exports a variety of tropical butterflies to conservatories around the world. A garden of this type was a great idea, but where could we find the necessary space in this mature garden, and didn´t we already have a large Pollinator Garden that still called for more plants to fill the empty beds?

As we propagated and collected more plants, the Pollinator Garden began to fill up and we realized most of the plants were for either birds or bees. Not many were butterfly plants, so we got busy propagating the few that were. The question of where the Butterfly Garden would be located was resolved when we decided on a setting for the planned Wedding Gazebo. Of course we would need a garden around the area where we want to build the Wedding Gazebo, and what better garden than a Butterfly Garden! I told Rosibel about this space and asked her to put together a list of local plants that attract butterflies. With her help, Jesus Marchena, the Garden´s nurseryman, started to search the surrounding countryside for plants. He found many in nearby pastures. After taking measurements and locations of existing features, I drafted a sketch for the new garden and we got busy laying out the garden and moving in plants. The Butterfly Garden will be a work in progress for a while, but the goal is to have butterflies grace the first wedding ceremony.

The layout for the new butterfly garden.

Research at Las Cruces

The Wonderful World of Insects

Jeffrey R. Smith

Insects are the most diverse and abundant group of animals.

This is a simple fact that I remember learning early on in primary school, and I'm sure many of you do as well. However, even if we had not, it would not be hard to reach this conclusion on our own. A simple walk through our own backyards, or even better yet, the forest here at Las Cruces, reveals that even among the dozens of mammal species, hundreds of species of birds, and thousands of different types of plants, the number of insect species far outnumbers any of the above.

Perhaps this is better illustrated with a mental exercise. Imagine you lined up every single species of plant and animal on earth. You then pick up the first 5 species, the next 5, and so on. In each group of five you would expect to find, on average, one beetle, three other types of insects, and one non-insect animal or plant. To put it another way, there are as many species of beetles (the most speciose group of insects) as there are the rest of plant and animal life put together.

Insects play key roles in the web of life and in the day-to-day machinery of nature, providing essential life-support services to society. We rightly turn our attention first to the bees, wasps, flies, moths, and butterflies (to name a few) that pollinate much of our planet's foods. However, insects are also essential for the control of crop pests and disease vectors, as well as the regulation of earth's biogeochemical cycles (i.e. making nitrogen available to crops and other plants as well as sequestering carbon in the soil). But their value to ecosystems does not end there. They form the base of virtually every vertebrate (birds, mammals, reptiles, and amphibians) food web. Recent estimates put the percentage of birds that consume insects as a key part of their diet above 97%!

Despite their overwhelming abundance and vital importance, we have described only ~20% of insect species and understand the ecological function of a small fraction of that number. Their diversity and abundance makes the study of these fascinating creatures costly in terms of time, money, and expertise. Many great scientists have made productive careers of studying a small family or genus of insects in sufficient detail for us to make meaningful conclusions.

Yet insects are in rapid decline globally. The reasons are thought to be a complex suite of interacting factors including increased pesticide use, conversion of natural habitats to agriculture or other human uses, climate change, and the tendency of increased global travel to bring new species to novel regions ill-equipped to respond to the ecological challenges the species poses. Given the expected major economic and health consequences of the continued loss of insects, it is clear that we can no longer be content with traditional methods of predicting how insects will respond with increased human impact around the globe.

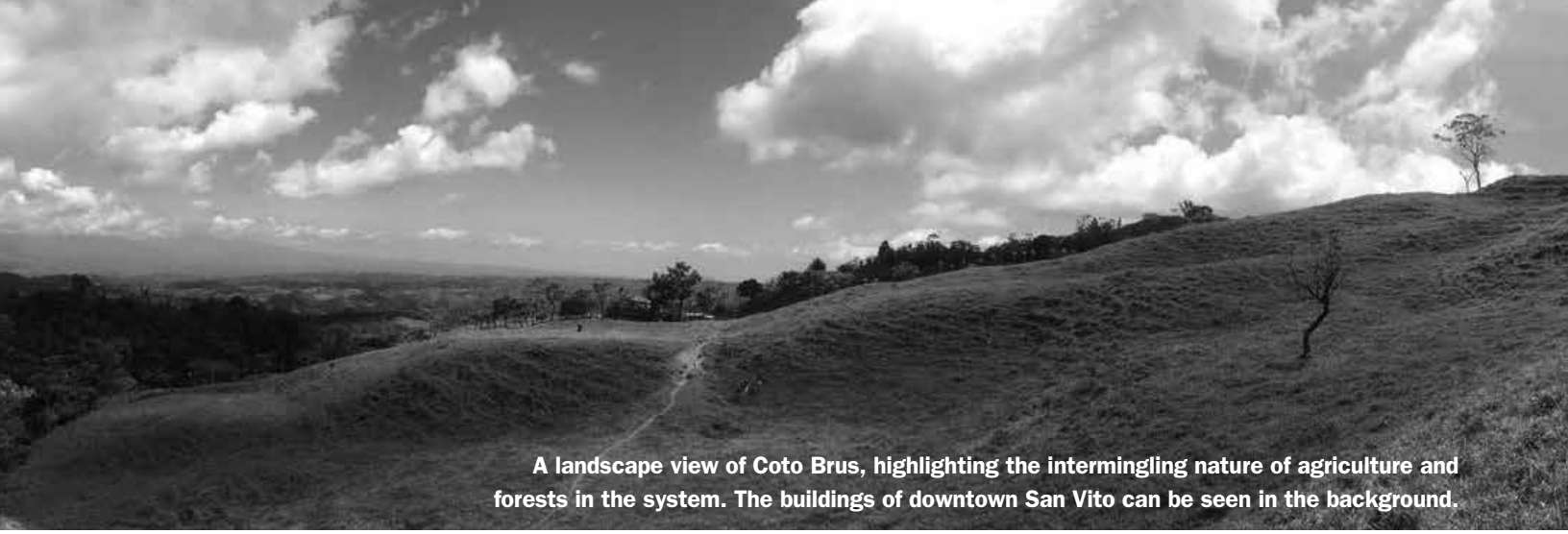
This is the key challenge I hope to address with my research here in Costa Rica.

During my time at Las Cruces I have been setting up a system of field sites than span a gradient of human land-use. I, along with many great collaborators, have identified sites both in the primary forests of Las Cruces and in smaller forest elements scattered across the countryside of Coto Brus. By carrying out insect sampling in these forested sites, we can gain a glimpse into what the insect community might look like in the absence of human impact on the landscape, and what amount of variation we might expect to see between different types of forests.

In addition to these forest sites, we have also worked to establish relationships with coffee farmers across the countryside, who graciously allow us to sample insect diversity in their farms. By contrasting these farms with both the forest sites, and one another, we can gain a sense of how conversion of forest to agriculture affects insect diversity, as well as the impact of different on-farm management practices (i.e. mixing different crops with coffee, pesticide application, and distance to neighboring forests).

In each of these sites I've employed 6 different types of insect sampling methods. Given the immense diversity of insects discussed earlier, using such a diversity of methods is key to ensure we are adequately representing the insect community at large and not just specific groups. Our methods include the familiar (butterfly nets, fly paper) to the bizarre (google Berlese funnels).

That's the fun part. What comes next is not nearly as great as spending all day in a tropical rain forest. I, along with a great team of undergraduates, high school students, and even a high school teacher, have been going through the samples to identify, count, and weigh every insect. What we've found is that human land use both reduces the number of species you find in a given site and changes the types of insects you find there. One of my favorite ways of looking at the data is to look at the amount of tree cover surrounding a given point where we sampled insects. This allows us to look at both differences between coffee (few trees) and forest (many trees) as well as between different types of



A landscape view of Coto Brus, highlighting the intermingling nature of agriculture and forests in the system. The buildings of downtown San Vito can be seen in the background.

coffee (those with many shade trees and those with few) and different sizes of forest (small patches versus large contiguous forests). What we find is that when there are more trees around where we sampled, we find more species, and that that community of species more closely resembles the community we find in the primary forest.

However, while all of what I have described so far may help us understand how human land use impacts insect diversity, it does not get us any closer to addressing the issues of time, cost, or expertise. This brings me to the second phase of my project, which I will be embarking on in the coming months.

In this part of the project I will be taking the samples of insects that we've laboriously identified under the microscope and emulsifying them into a slurry of insects and ethanol. From this slurry, I will be using emerging genomic techniques to extract the bulk insect DNA, amplify it, and sequence the base pairs. For each sample, we will get back sequences of DNA a few hundred base pairs long. This process is commonly known as metagenomics or Next Generation Sequencing.

Importantly, we will be targeting very specific regions of DNA that are known to be conserved within a species, but variable between species. That is to say, insects of the same species have the same DNA base pair sequence, but those of two species would have different sequences. Using existing online databases, we hope to line up results from our above-mentioned morphological work with the genetic work to evaluate the efficacy of the two methods. Our hope is that the two methods give more or less the same answer to the question of how human land use impacts insect biodiversity, providing a large-scale validation of a potentially key conservation tool moving forward that would markedly cut down the processing time and cost for insect samples.

However, you'll have to wait for a future Amigos newsletter for those results!

A sample of one of my insect sampling points in the Las Cruces preserve. Pictured are a sticky card, pitfall trap, and pan trap equipped to handle the rains of the wet season.

Piecing the Puzzle Together: an Interdisciplinary Approach to Understanding the Effects of Fragmentation in Costa Rica

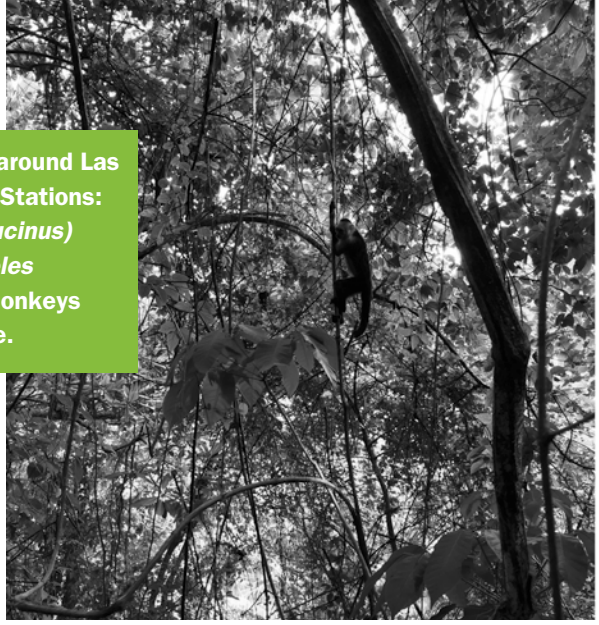
C. Eric Johnson / cjohns10@stedwards.edu

Imagine for a minute that you are an arboreal primate living in the canopy in a tropical rainforest in Costa Rica. As you go about your daily activities, you are faced with many decisions with consequences that could not only put your life in peril, but your offspring's life as well. First, you must decide where you are travelling that day in search of food. Which path are you going to take? Which branches are you going to trust to support your weight? Then, you must decide if that area is safe to explore and which specific trees will bear the best food sources.

These decisions, along with countless others, are all now influenced by human activity, especially through a forest's response to management and conservation practices, or lack thereof. How a landowner or land manager uses their forest changes its condition and quality. As many forms of wildlife, especially primates, rely on the products of a healthy tropical forest for food and shelter, they are vulnerable to any changes made to the forest condition. Likewise, the way the primate relationship with the forest changes will also affect overall forest quality. For example, if a troop of primates decides that a patch of forest is not desirable for food or shelter and chooses not to explore it, this could potentially affect the dispersal and recruitment success of certain trees in that area.

The fragmentation of forest communities in Costa Rica is a perfect example of a multifaceted problem affecting primate decisions that ties together components from biological, social, ecological, economical, and political perspectives. As we think about the effects of fragmentation having roots in each of these disciplines and being a sum of all parts, it is important to study fragmentation

We measured the life stage of each adult tree.



Three primate species present around Las Cruces and La Selva Biological Stations: capuchin monkeys *(Cebus capucinus)* upper left, spider monkeys *(Ateles geoffroyi)* upper right, howler monkeys *(Alouatta palliata)* lower picture.

in such an interdisciplinary manner. That way, the potential conservation strategies implemented to protect remaining forest fragments and their biodiversity and ecosystem services are as robust and holistic as the problem of fragmentation itself.

As fragments and forest corridors begin to blend over time as deforestation in Costa Rica decreases and reforestation increases, a heterogeneous forest mosaic is emerging that differs in structure and age across the landscape. How this mosaic will sustain wildlife, including arboreal primates, over the long-term remains uncertain. The potential positive and negative impacts that certain conservation incentive programs and current management practices have on forest quality and primate health remains uncertain as well.

With all of this in mind, this larger puzzle of forest fragmentation comprised of smaller pieces of social and ecological factors is being investigated by student researchers from St. Edward's University in Austin, Texas, under principal investigator, Dr. Peter Beck (peterab@stedwards.edu), and from Indiana University under principal investigator, Dr. Michael Wasserman (mdwasser@indana.edu). This project, through a National Science Foundation International Research Experience for Students (NSF-IRES) grant, allows students to design and conduct their own independent research project in Costa Rica for ten weeks to uncover a telling component of the larger forest fragmentation puzzle. As the projects can be of social, biological, or ecological study design, these different studies independently tell intriguing stories about fragmentation in Costa Rica. However, more robust and compelling implications are also being explored by analyzing the different student data sets in relationship with one another. As this larger project will take place for three years between 2017 and 2019, the result will be 15 different independent projects, or puzzle pieces, all able to be analyzed together spatially and temporally, to see how these pieces fit together to tell us about fragmentation in Costa Rica and its effects on people and primates.

As this past year was the inaugural year for the study, the first five independent projects were conducted between January and March 2017 at nearby fragments in two study areas: Las Cruces and La Selva Biological Stations. The project team visited different forest fragments daily, either privately owned or publicly owned (e.g. national parks, high schools), to collect data relevant to each specific hypothesis or question. Two social science studies were conducted by Sarah Mattecheck and Teresa Johnson to investigate if landowners participated in conservation incentive programs or in community led conservation programs. A primate census was completed by Tessa Steiniche to quantify the species presence and group size of arboreal primates in each fragment. Two ecological studies were conducted by C. Eric Johnson and Abigail Kropf to uncover how abiotic factors and fig tree (*Ficus spp*.) recruitment and success varied across the different forest fragments (Fig. 1).

Preliminary results of this past year's projects are that landowners with 200 or more hectares of forest are those who are most likely to participate in conservation incentive programs. Even though smaller privately owned fragments did not participate in conservation programs, arboreal primate populations and fig tree recruitment were still present and viable in these fragments, in both study areas. However, the national parks (La Amistad and Braulio Carrillo) in both study areas contained the highest overall basal area (m^2 per 150m2) of trees as well as the highest relative abundance of *Ficus spp.* present. Further, these national parks and the Las Cruces and La Selva Biological Stations were of key importance to the presence and abundance of the three primate species observed: capuchin, howler, and spider monkeys (Fig. 2).

As the next round of student projects will begin in January 2018, we will soon be able to explore further details on the interconnected effects that fragmentation has on people, forests, and primates in Costa Rica. These new projects will examine primate behavior and health, air and water pollution, bat diversity, human-wildlife interactions, and ecotourism across the Las Cruces and La Selva landscapes. Fragmentation brings human and natural systems into closer contact, and understanding the dynamics of these closer interactions will be of growing importance in our constantly changing environment for both human well-being and sustainability of wildlife and forest ecosystems. Therefore, the next group of student projects will explore these interactions by building off of our results from 2017 and incorporating novel methods such as hormone and microbiome analysis that will provide a few more pieces to the fragmentation puzzle.

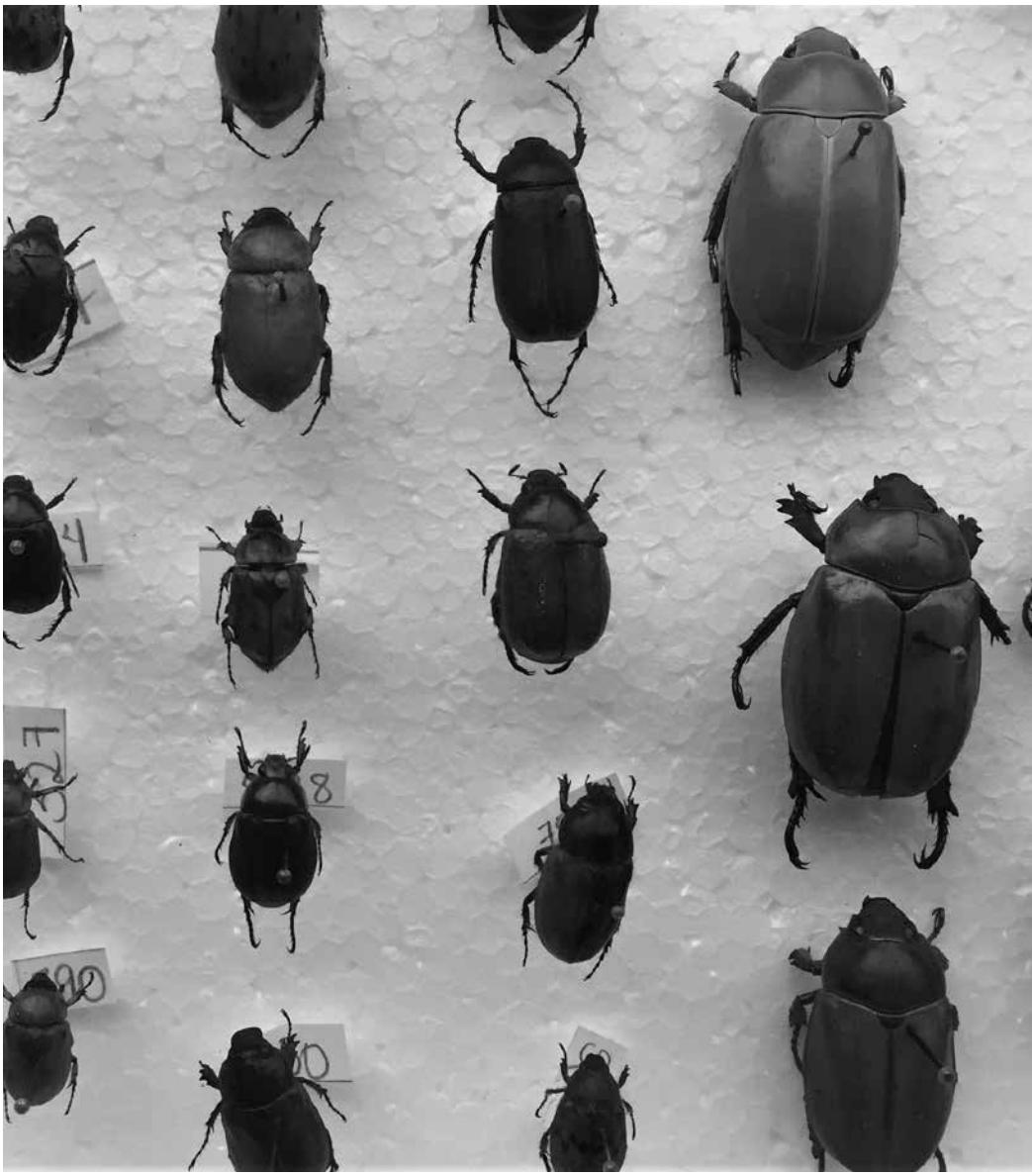
Flora and Fauna

Litter Critters: Recovery of Arthropods in Restored Forests

Rebecca Cole / rebecca.cole@tropicalstudies.org

Arthropods (including the insects) are the most diverse groups of animals on the planet. This extraordinary diversity peaks in tropical forests where one recent study found over 25,000 arthropod species in an area of 6 hectares or just 0.023 square miles. Several recent estimates of the number of terrestrial arthropod species on earth place the number over 6 million. Of these, the vast majority have not been described to species level. Most terrestrial arthropods spend some part of their life cycle hidden from view in the soil or in the decaying plant material on the ground. That makes studying these hugely diverse soil and litter communities an interesting mix of logistical challenges, excitement and not insignificant tedium as I found out when trying to quantify how litter-dwelling arthropods respond to forest restoration.

Before talking about study, it is worth asking why we should care when and how communities of non-descript arthropods return to forests restored on degraded pastures. For one thing, they perform a set of critical roles in ecosystem functioning. Arthropods like millipedes, woodlice, and earwigs are essential to nutrient cycling. They break down plant litter and help drive the availability of nitrogen in the soil, which in turn influences the types of plants that can grow there. Termites and ants are ecosystem engineers. They affect the patterns of soil formation, soil porosity and hydrological processes. We also know that arthropods can be pests, predators, pollinators and that as a group, they are the basis of major food webs. So, it is safe to say that arthropods are pretty important to having functioning ecosystems. We also know that when forest is cut down and converted to pasture, the complex communities that live there are drastically altered or entirely lost. What we know much less about is the extent to which arthropod communities and the functions they perform recover when we try to restore forest to degraded lands.



Scarab beetles are a small part of the rich fauna that lives in the leaf litter in forest restoration sites.

This study began back in 2005 when I was just starting my PhD research and my advisor, our collaborators and I, set up a large-scale restoration research project in the landscape around Las Cruces. This set of twelve 1-hectare restoration plots

was dubbed the Islas Project because it tested how planting trees in small patches or 'islands' works as a restoration strategy. The idea is that forests naturally recover through a process whereby small patches of vegetation establish in open areas and over time, the patches grow and coalesce. We compared the cost-effective method of planting tree islands to the more expensive strategy of planting large plantations and both of these techniques were compared to natural regeneration (no tree planting). The plots were set up on abandoned agricultural lands and degraded pastures and over the next 12 years, our group of collaborators measured just about every visible aspect of recovery across the different treatments. When the plots were eight years old, I decided it was time to look at the less visible world developing in the soil and leaf litter.

The study focused on ground-dwelling macro-arthropods, meaning just the animals that were visible to the eye without magnification (> 1mm in size). We systematically collected arthropods from multiple points in each island, plantation and natural regeneration plot at four different sites in the landscape (4 replicates of each restoration treatment). We also collected arthropods from four primary forest sites in order to compare these more intact communities with the restoration treatments. Because arthropods can have seasonal or cyclic life cycles, we sampled during both the dry and the wet seasons over one year. The arthropods were collected two different ways. First, we used pitfall traps, which were basically plastic cups filled with a mix of water and ethanol that were placed in the field. After 48 hours from the time of deployment, the cups were picked up, the contents strained and stored in ethanol. Second, we collected arthropods directly from the litter. This involved putting a 50 × 50 cm metal frame on the ground, rapidly scooping all the litter in the frame into a mesh bag before the litter critters could run away, taking the ~100 lbs. of litter collected on any given day back to the lab and spending most of the night sifting the live contents into apparatuses awkwardly named Winkler extractors. To catch any arthropods not collected from the extractors, we later hand-picked though all the litter (around 700 lbs. of it) with tweezers.

Several experts kindly helped with identifying the mature insects and building a reference collection from which my assistant and I could classify our samples. Because only a small percentage of the arthropods we collected had been described to species level, most were identified to family or genus level and then placed into morphospecies (groups based on quantifiable morphological characteristics). We also divided the arthropods into functional groups, that is, their apparent feeding strategy like predator, herbivore, fungivore, detritivore, or dung consumer. After approximate six months of peering through microscopes, we had divided the arthropods collected from a total of about a 100-m^2 area (~1000 ft^2) into 25 orders, 52 families and 302 morphospecies. The abundance, number of functional groups and arthropod diversity were compared across the three restoration treatments and to the primary forest. We also tested to see if there were any patterns with environmental measurements such as soil and litter nutrients or forest structure.

Despite the concern that data from such a diverse group of animals would not be conducive to clear results without an even more intensive collection effort, the results were surprisingly and happily very informative. The island treatment hosted the greatest abundance of arthropods of the three restoration treatments and were on par with the primary forest. The islands also had the highest numbers of morphospecies and functional groups and these were also at similar levels as the primary forest. So, why would an area that was only planted in small patches of trees have more diversity and functional groups than an area planted all to trees (plantations) or an area that was recovering naturally? One explanation has to do with the idea of heterogeneity and more diverse resources. The island treatments are more patchy, have more diverse physical structure and include both trees and the successional vegetation that grows back naturally between the tree patches. This variety of habitats probably provides a greater variety of resources that in turn can support a greater diversity of arthropods. Overall, this is a nice result, along with many other measurements taken over the years, to support the use of the 'tree island' strategy for restoring degraded lands.

But, of course, it is a bit more complicated than that. When we compared the composition of the arthropod communities in the restoration treatments to the primary forest, only a small number of the species (and morphospecies) overlapped. Even though function groups (like litter decomposers) were present in the same abundances as in primary forests, the identity of the animals were different. The majority of the species found in the 8-year-old restoration treatments were probably types commonly found in disturbed habitats. Recovery of the full complement of arthropod diversity to restored forests, if it occurs at all, is likely to happen on the scale of many decades to over a century. Taken together, the results provide promising support for the tree island restoration strategy but also highlight the importance of protecting remaining primary forests in order to conserve the region's full complement of biodiversity.

GIS Corner

A New Weather Station at Las Alturas

Yerlyn Blanco / yerlyn.blanco@tropicalstudies.org

We will soon have climate data available from a newly installed weather station at our satellite field station at Las Alturas! Once functioning, anyone may access the data that will be available on the OTS website.

Las Alturas is located directly adjacent to the protected area of La Amistad International Park and is one of the largest intact remaining forests in Central America. Nestled at the edge of the Talamanca mountain range, the station is at 1600 masl in montane tropical forest. Having this data available is an exciting addition to our research tools because it provides a nice counterpoint to data currently being collected at Las Cruces and will enable comparisons between a more intact forest and a fragmented, agricultural landscape. The data that will be available will be similar to those currently collected in Las Cruces, including max and min temperatures, precipitation, atmospheric pressure, radiation, relative humidity, wind speed and direction, soil moisture and temperature. This data will be helpful in monitoring climate variability and will contribute baseline information to the AMISTOSA Corridor initiative.

De la Comunidad

Open House Day at Las Cruces

Carla Azofeifa / carla.azofeifa@tropicalstudies.org

Hello friends, I hope you are very well. I want to share some of the recent, fun events at the station. For starters, on July 29, Las Cruces Research Station and the Wilson Botanical Garden hosted our inaugural Open House Day. It was a big success with over 450 people from our local community visiting the station! This outreach event was aimed to share our science, conservation and sustainability efforts with the community through guided walks, workshops, talks and exhibitions.

All the events were made possible by a committed group of staff and volunteers, including scientists and research technicians from Stanford University, UC-Berkeley, UC-Santa Cruz, Oregon State University, the San Vito Bird Club, Finca Los Patos Suertudos, and UNED Ecological Group.

The Open House Day carried forward community interactions that began with the EcoCultural Festival that Las Cruces started several years ago. This year, we added new activities like the Science Center where children and adults alike explored collections of insects, learned how the movements of arachnids could help us build better robots and prosthetics, saw a bird's eye view of our region through cameras mounted on drones, deciphered bird songs, and marveled at the extraordinary diversity of tree seeds. All the while, a live band filled the station with lively marimba music and enthusiasm.

All the activities were well attended. We had barely enough guides to host nature walks and all talks and workshops were filled. Local artisans enjoyed brisk sales. The tree donation was a success, with over 400 native trees given away for planting at local homes and farms. The San Vito Bird Club were busy all day selling delicious baked goods and enjoying smiles of the children who lined up for face painting. At the close of the event, we were delighted by the talent of Coto Brus's youth with an outstanding performance by the Symphony Orchestra of the School of Music (SINEM).

Thanks to the efforts of the many volunteers, the Open House Day was a great blend of education, science, conservation and fun. Among the most rewarding outcomes were seeing so many local families who came to visit the station and botanical garden for the first time. We plan to continue this new tradition at the station and look forward to seeing new and familiar faces here next year!

The exhibitions at the Science Center fascinated kids and adults alike.

Students break ground for the new harvesting garden at their school.

Harvesting Gardens

In my visits to schools and communities, people often ask me for advice on the logistics of establishing home and school gardens. Many of the questions are about organic fertilizers, ecological pest control, selection of native plants etc. The demand is high and the interest is growing. Based on this interest, the Harvesting Gardens pilot project was born. Its objective is to encourage the creation of edible gardens in schools by promoting the harvest of diversified food, promoting native biodiversity and reducing waste.

For the planning of this pilot project, we have the help of two allies. One is the Finca Los Patos Suertudos and the other is the Ecological Group of the Universidad Estatal a Distancia. These allies are helping with labor, plant donations and many ideas. The pilot project is taking place at three schools (Federico Gutiérrez-Agua Buena, Concepción-Agua Buena and Santa Elena-Pittier). The schools are very different from each other but were selected because of some common strengths. Each school has demonstrated high level of interest and commitment to the project and has at least two staff members committed to the Garden who maintain communication and coordination with our Program for Environmental Education.

Throughout the remainder of the year, we will establish pilot gardens with visits to the schools every two weeks. The plant species that will be cultivated are also suitable for pollinators like birds, bats, bees, and butterflies. The Harvesting Gardens will also provide a space for integrated learning opportunities. For example, we are designing theoretical-practical work sessions that promote the creation of small ecosystems that in the future could be converted into classrooms within educational centers, literally taking the botanical garden to the communities. Stay tuned for updates on this fun, new pilot project!

Pro-Blue Flag Program at Concepción de Agua Buena

The Blue Flag Program (BAE in Spanish) promotes the organization of different sectors of civil society with the objective of achieving sustainable development across the country. There are several different categories for participants, one of which is the Community category. Concepción de Agua Buena is one of the nearest neighbors to Las Cruces. At the initiative of members of the community, the Pro Ecological Blue Flag Committee was formed last March. The committee is made up of representatives of the Community Development Association, the Rural Aqueduct, the Municipality of Coto Brus, the Ministry of Health, the Catholic Church, the Public Force, the Organization for Tropical Studies, the School Education Board, and members of the community. The annual work plan is already underway and there have been several major achievements so far, including monthly trash collection service, information campaigns and training with adults and children on solid waste issues, and liquid waste treatment monitoring.

Upcoming activities include a day of tree planting for reforestation and trash cleanups and other events. By next year, we will find out how these efforts are rewarded in the annual award competition. A full report will be prepared and sent to the National Commission who will review the evidence and assess the results. We wish the community of Concepcion many successes and send our thanks for the efforts of the work that this team is carrying out.

Station staff lead a trash clean up and recycling effort in the town of Concepcion.

Our Donors

A Year at Las Cruces

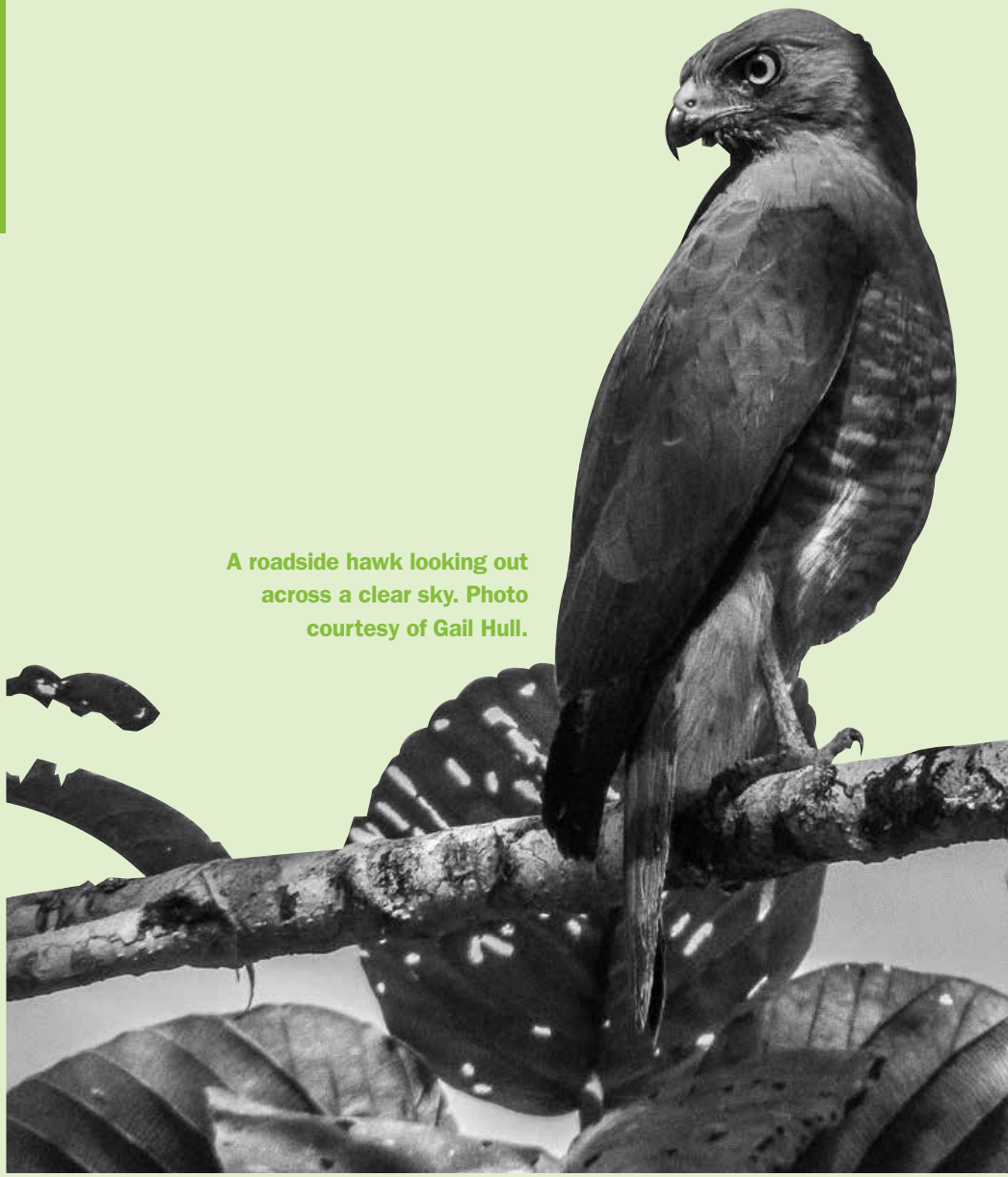
Rebecca Cole / rebecca.cole@tropicalstudies.org

It seems hard to believe, but today marks the completion of an entire year that I have been here at Las Cruces. And quite a year it has been! In that time, the station has weathered one hurricane, one major tropical storm, and a kaleidoscope of new projects, challenges and opportunities. We enjoyed the company of expert tree climbers who built platforms in towering, emergent trees, hosted the most well-attended Environmental Fair ever held at Las Cruces, listened to fascinating presentations on science and travel in a new seminar series, planted gardens in school yards, and watched the Wilson Garden grow and brighten under the guidance of our new horticulturist.

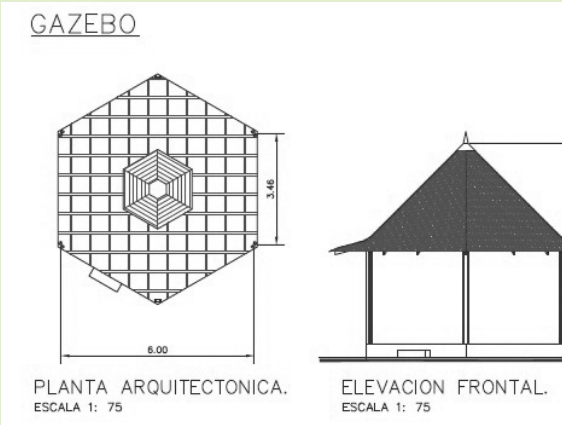
It has truly been a fantastic year and there are many people to thank for their support of our endeavor up here in the Coto Brus highlands. Our wonderful donors have helped keep the station running, contributed to the land campaign, and added new books to the library. The members of the San Vito Bird Club have not only gone above and beyond with their enthusiastic support of our projects but have also made me feel welcomed to the community. Researchers from many universities pitched in to create a fascinating science center at our Open House Day that delighted kids of all ages from the local community. The hard-working staff at the station have displayed no small amount of patience and forbearance as I learned (and occasionally blundered) my way through the many moving parts of this operation. Although there is not enough space here to list all of the individuals who have contributed in different ways over the past year, I am grateful for, and awed by, the ongoing commitment of the supporter who enable this special place to thrive.

In the coming months, there are two additional ways to help move Las Cruces towards a more sustainable future. The first is to help us build a wedding gazebo which will be the venue for these special events for which there is a growing demand. We have already drawn up architectural plans and prepared a lovely new area surrounded by a butterfly garden for the building site. With your help, we could start hosting outdoor weddings by next year.

The second new way to help is through a set of naming opportunities across the grounds of the Wilson Garden. There are three beautiful new garden areas including the spring-fed ponds, the butterfly garden, and the pollinator garden that are available for naming. In addition, we are designing a set of new benches overlooking peaceful grounds and forest locations that make for a very special way to honor a loved one. Please contact me (rebecca.cole@tropicalstudies.org) for details on the wedding gazebo or for naming opportunities in the Wilson Botanical Garden. In the meantime, here are a couple of photos of some favorite residents at the station.

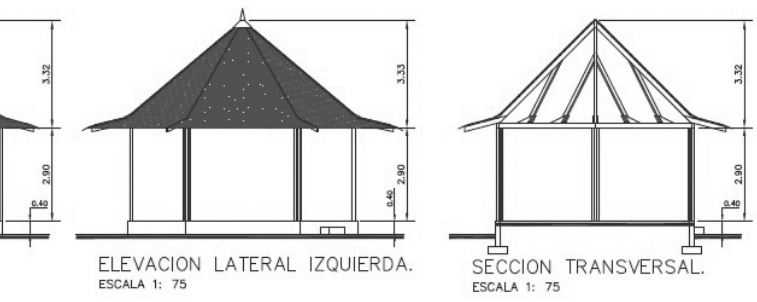


A roadside hawk looking out across a clear sky. Photo courtesy of Gail Hull.



A pair of agoutis searching for seeds in the garden. Photo courtesy of Gail Hull.

Sketch of the Wedding Gazebo.



As always, a big THANK YOU to you all!

Las Cruces donors through October 2017.

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