

Amigos

Newsletter

No. 71, May 2009



Wilson Botanical Garden
Las Cruces Biological Station
Apdo. 73-8257 San Vito, Coto Brus, COSTA RICA



**Organization for
Tropical Studies**

Who We Are

The Las Cruces Biological Station is one of three tropical field stations owned and operated by the Organization for Tropical Studies (OTS) in Costa Rica. Along with the Wilson Botanical Garden, Las Cruces was acquired in 1973 and is a hidden jewel that 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 southwestern corner of the country between Corcovado National Park on the Osa Peninsula, and the enormous La Amistad 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 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 which include palms, aroids, bromeliads, ginger, marantas, heliconias, and ferns. More than 3,000 exotic species of plants can be found in the 12-hectare (~30-acre) garden, including one of the largest collections of palms in the world.

There is an incredible diversity of animals at Las Cruces, and in the immediate area surrounding the station. The most recently updated bird list includes 410 species; close to half the number of birds found in all of Costa Rica. There are also over 100 species of mammals, of which 58 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 over 200 hectares of primary forest (home to over 2,000 native plant species) and several smaller adjacent areas that are in various stages of forest recovery. The forest 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 our 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, delicious meals, knowledgeable and enthusiastic staff, and a well-maintained network of paths and trails. We also provide internet

access to overnight visitors who bring a laptop computer.

The nearest town is San Vito, the capital of Coto Brus County. It was settled in the 1950's by Italian immigrants and to this day there is a strong Italian presence. There is an excellent pizzeria, and the Dante Alighieri Italian-Costa Rican Community Center provides language instruction. Indeed, Coto Brus is the only county in Costa Rica where Italian forms part of the elementary curriculum!

We invite you and your family and friends to come visit us for an afternoon, an overnight stay or a week to see and experience firsthand the splendid tropical diversity of the Las Cruces Biological Station and Wilson Botanical Garden.

For more information please visit the OTS website at <http://www.ots.ac.cr/> or contact us directly by email: lcruces@ots.ac.cr. Postal mail can be sent to: Estación Biológica Las Cruces/Jardín Botánico Wilson, Apdo. 73-8257, San Vito de Coto Brus, Costa Rica. Telephone (from the U.S.): 011 (506) 2773-4004.

Reservations can also be made by contacting the OTS office in San José by email edu.travel@ots.ac.cr, postal mail: ESINTRO/OTS, Apdo. 676-2050, San Pedro de Montes de Oca, Costa Rica, or by telephone (from the U.S.): 011 (506) 2524-0607.

The North American OTS office is located at Duke University, telephone: (919) 684-5774 or email: nao@duke.edu.

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 field 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.

Director's Keys and Notes

AMIGOS NEWSLETTER No. 71, May 2009

- 3** Director's Keys and Notes
- 4** What's New at Las Cruces
- 6** Research at Las Cruces
The Role of Mycorrhizal Fungi in Restoration
Conservation in Tropical Forest Fragments: Seeing the Forest for the Trees...and Animals
- 10** GIS Corner
Historical Data and Finca Las Alturas
- 11** Flora and Fauna
Bligh – The Las Cruces Connection
The Luis Diego Gómez Herbarium
- 13** De la Comunidad
Environmental Education and Cookware: Something in Common?
Community Medicinal Garden Project
- 14** Our Donors
Donations Update – Our Spring Supplication
Donations to the Library

Front Cover: A Las Cruces herbarium specimen of *Bomarea edulis*, one of our newly scanned images that just went online.

Back Cover: Las Cruces staff pose for a photograph after the inauguration of the new research cabins in December.

Editorial Committee: Víctor Milla, Alison Olivieri, Rodolfo Quirós, Emilce Ramírez, Ariadna Sánchez, Zak Zahawi, Alejandra Zúñiga.

Zak Zahawi / zahawi@ots.ac.cr

I decided to focus this issue's article on the topic of how to be a green and sustainable biological field station. Las Cruces is almost 50 years old and, as one of three field stations owned and operated by the Organization for Tropical Studies (OTS), it has a long history of promoting tropical research and education. Over the years countless courses and biologists have visited our field stations – indeed, you would be hard pressed to find a tropical biologist who hasn't had some type of interaction with OTS during their career. Aside from biologists, OTS also caters to natural history enthusiasts and several thousand visitors who come to spend one or two nights at one of our renowned stations, and at Las Cruces, there is of course the added draw of the Wilson Botanical Garden. So when you think of being green and sustainable, you likely assume that this is an integral part of such an organization. Indeed, by the very definition of the organization's objectives and activities you would think that is the case. But being green is not that simple.

The mission for OTS might be as green as it gets: after all we are promoting research (which can loosely be viewed as promoting the understanding and, in turn, conservation of biodiversity in the tropics), we cater to visitors and impress upon them the importance of protecting such biodiversity, and we train future biologists at all levels of the education spectrum. But a 50-year history of growth and development means that a lot of our infrastructure is old and, as a result, outdated and perhaps not so green. And so, over the last few years, we have been retrofitting Las Cruces to become more green and sustainable. But this is challenging and is more reminiscent of a puzzle that can be further unraveled with each additional step.

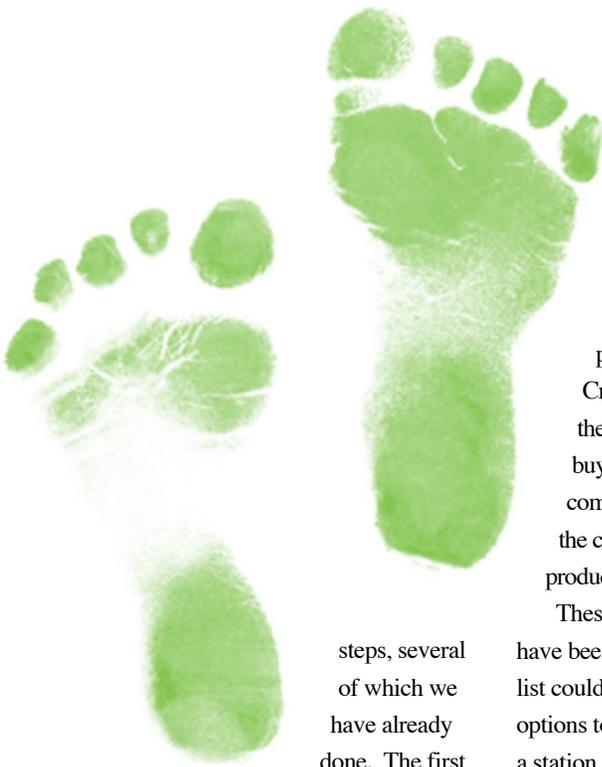
For example, with some 5,000 visitors per year and more than 10,000 overnights

at the station, we use a lot of water.

Aside from avoiding wasteful usage and conserving water from an environmental perspective, in high season this results in a not so insubstantial monthly bill. So saving water can even result in reduced expenses! Simple things can be done to make sure that taps don't drip and toilets don't run and to ask people to be conscious of their water consumption and perhaps not have their towels and sheets washed on a daily basis. I would call this a first step in unraveling the puzzle. But what about more pro-active measures?

A simple observation is that it sure rains a lot in this part of the country...around 4,000 mm to be exact! So why not try to capture some of that rainfall and put it to use? This led to the purchase and installation of two water tanks that funnel rainfall from roof runoff. The water is then used in areas that consume large quantities – such as the laundry room and the bathroom in the main building complex. In turn, we have started retrofitting older buildings with low water consumption toilets and have installed them in all new construction projects at the station. We now have 17 such toilets – almost half of the station thus far has been retrofitted. These ideas can also be applied to washing machines in that we only purchase front-loading, low-water consumption machines that are energy efficient. Another piece of this puzzle is what to do with wastewater such as grey water (e.g., shower water, sinks, laundry), of which we generate copious amounts. To address this we are designing a small pond on the botanical grounds, that will filter gray water (through physical and biotic mechanisms) to a sufficient degree that it can be released into nearby streams with no concern for the potential of contamination.

Becoming more sustainable can also mean reducing energy consumption and this again translates to a series of potential



steps, several of which we have already done. The first step in this case is again to engage people who utilize the service and remind them to turn off lights when they are not in use. To that end, all light switches and outlets have a simple sticker reminding people to unplug or turn off the lights when they are not in use. Installing motion sensors that activate when a person enters would be more practical and efficient but this is also more costly. A further step is to retrofit the station with more energy efficient devices – such as replacing traditional light bulbs with low-consumption alternatives (this is underway and we will soon replace ~250 light bulbs)! We have also installed insulation in many places, and particularly in rooms that have climate control (such as the herbarium and IT area) to conserve cooler air. Even more ambitious steps would be to replace all the shower-heating units in the cabins and dorms with solar powered systems – currently the only solar setup is in the kitchen. But this would be a considerable investment - and the list can keep on going...

Other areas can also become greener – reducing the use of toxic products and, whenever possible, using environmentally-friendly alternatives. This can range from cleaning products in the laundry room (we use biodegradable products) to the purchase of organic foods to serve in the dining room,

which promotes greener agricultural practices and is healthier for Las Cruces visitors. We also try to balance these objectives with the goal of buying locally, important to promoting community development and reducing the carbon footprint of transporting products long distances.

These are but a few examples of what we have been doing at Las Cruces. Of course the list could be much longer and there are many options to take into account when greening a station or making it more sustainable. One thing is for certain, however, it is not cheap! Over the last two years or so since we began, we have spent well over \$20,000 and that does not include the labor invested by salaried employees at the station to install these improvements! Normally, such changes would only be noticed by an observant visitor. But that won't be the case this time as we are following a protocol laid out by the Costa Rican Tourism Institute (ICT) to comply with what they consider green and sustainable tourism practices. In turn, we will receive their sustainable tourism certificate (<http://www.turismo-sostenible.co.cr/EN/home.shtml>). That isn't our endgame but it will allow us to announce to our visitors that we are a certified green and sustainable field station. Indeed, we are more than that as many of the aforementioned changes are a result of our own creative ideas. May we have more of them!

Please feel free to contact us if you would like further information on our green and sustainable practices and if you have suggestions please let us know! I hope this finds all of you in good spirits and I look forward once again to seeing you at Las Cruces and the Wilson Botanical Garden in the future.

Saludos,
Zak

What's New at Las Cruces?

Zak Zahawi / zahawi@ots.ac.cr

Lightning Strike Recovery

I thought I would update those of you who received the previous edition of *Amigos* in which I wrote about a costly lightning strike causing severe damage to two research cabins and to many expensive IT items as well. Damages incurred were estimated to be somewhere in the range of \$40-50,000 and represented a huge setback for the station given all the recent upgrades. Thankfully in all of this no-one was injured. So over the last six months we have been slowly repairing the damage and I would say that the station has replaced perhaps 70-80% of the damages occurred. In fact you wouldn't notice any difference anymore but a few expensive IT items such as the main station server, which was largely destroyed have not been replaced and we are operating on a backup setup for now. Several of you were also generous in your donations to Las Cruces and we are very appreciative of the help.

We are also looking into understanding how this event occurred and taking steps to prevent this kind of a disaster from happening again. In essence, we are installing surge protection equipment throughout the station to prevent such a discharge from being able to travel throughout the station's grid.

Cabin that was damaged by the lightning strike last September.
Photo Víctor Milla.



Forging a New Alliance with Las Alturas

Las Cruces (and OTS) have entered into an exciting alliance with Finca Las Alturas (FLA) to revive the old field station that was initially built by Stanford University in the 1980's and has long fallen into neglect. FLA is a privately-owned 10,000 ha reserve and farm abutting the immense Amistad Biosphere Reserve, which straddles the Talamanca mountain range, the central backbone of Costa Rica. The Biosphere Reserve is one of the wildest remaining regions in Central America with almost 500,000 ha protected and is divided between Costa Rica and Panama. Most of Las Alturas is forested and the new agreement with the private reserve will allow interested researchers and courses to visit the small and rustic field station that will be remodeled and upgraded to be able to accommodate a full course. Researchers will be able to setup projects in a similar forest to Las Cruces with one major distinction; the former forest was never fragmented and is relatively undisturbed (some selective logging was carried out in the past). Accordingly, the ecosystem at Las Alturas is still intact; no fauna have gone extinct and large mammals



The forest surrounding the Las Alturas field station. Photo Zak Zahawi.

such as tapirs and jaguars are still found there. As such, the reserve can act as a 'control' or reference system to what Las Cruces would have been like prior to fragmentation; we can also develop a better understanding of the impacts of fragmentation on the forest preserve at Las Cruces.

Las Cruces has had a long history with Finca Las Alturas and researchers and courses

have been visiting the small station for close to 20 years. But in recent years the agreement had lapsed and so had the rustic building. The idea is to resurrect this important alliance and diversify the options available to researchers who want to conduct research in the region. If you are interested in further information on research opportunities at Las Alturas please feel free to contact me.



The corridor of the rustic Las Alturas field station, soon to be repaired and expanded. Photo Zak Zahawi.

Donating Computers

To end this section on another nice note, we are finally in a position at Las Cruces to be able to donate some of our surplus computer hardware. Up until now we have always been short on computers and they have usually become wholly obsolete or non-functional before we even begin to think of making a donation! This year we were able to donate three computers to local schools in the surrounding community and we hope that we will be able to continue to make such gestures in the future.

Research at Las Cruces

The Role of Mycorrhizal Fungi in Restoration

Riley Pratt/UCalifornia-Irvine /prattr@uci.edu

The famous ecologist and philosopher Aldo Leopold once referred to soil as Nature’s “dark laboratory”. Such a depiction captures not only the morbid nature of soil’s business—to decompose recently deceased plants and animals—but also its obscurity. Written nearly 50 years ago, ecologists still know surprisingly little about the creatures that live below-ground carrying out the dirty—and complex—task of soil formation and nutrient cycling.

Often dismissed as mere dirt, a handful of soil can contain over a million microscopic critters—a sea of invertebrate animals, bacteria, fungi, and viruses—collectively called microorganisms (or microbes for short). Some of these microbes breakdown complex organic molecules into simpler components that can be readily taken up by living plants. Without these “decomposers”, the planet would be littered with fallen tree trunks and animal corpses! Other microbes specialize at nutrient transport, shuttling resources from unexplored corners of soil to the roots of plants. Decomposition and nutrient transport are key functions of soil microorganisms, both in natural and agricultural ecosystems. In many places of the world, the loss of soils through intensive farming and poor land use has resulted in erosion, declining agricultural yields, and human starvation.

One reason the workings of soil remain a mystery is that they operate on a microscopic scale. We can’t very easily put our binoculars to the ground and watch soil form or observe the exchange of nutrients from soil to plants. Furthermore, it’s hard to determine who the important players are below-ground. The vast majority of microbes have yet

to be identified by scientists. And for those that have, they can be visibly indistinguishable from other species. As a result, microbial ecologists tend to draw functional boundaries between broad categories of microbes (e.g. fungi, bacteria, and viruses). In reality though, some members of these groups overlap in what they do, while others play distinct and specialized roles in ecosystems.

A particularly important and ubiquitous group of microbes are called mycorrhizal fungi. Mycorrhizal (my-co-rise-al) fungi form intimate partnerships with plant roots, transporting resources like nutrients and water to the plant in exchange for sugar. It is not uncommon for plant growth to double with the aid of mycorrhizal fungi, and explains today’s growing commercial industry of mycorrhizal inoculum (you can now buy mycorrhizal inoculum at your local plant nursery). These findings have also caught the eye of restoration ecologists, scientists interested in restoring degraded landscapes—and the processes therein—into something resembling a natural ecosystem. Indeed, mycorrhizal fungi additions have been shown to improve tree seedling establishment and growth in restoration experiments. But the effects of mycorrhizal fungi are not always positive. While widely considered to be a *mutualistic symbiosis*—an interaction that benefits both partners—the fungi can act as a parasite, taking more resources from its host than it pays back.

So what mycorrhizal fungi should be used in restoration? One approach is to use fungi *from* the planned restoration site. The prediction here is that fungi currently occupying a patch of soil are actually the most fit for that patch. In a dog-eat-dog world, a resident mycorrhizal



Inga spectabilis seedlings in the greenhouse. Photo Riley Pratt.

community ought to represent the winners of competition for limited resources, owing primarily to unique adaptations to the local environment. By the same token, the identical community transplanted into a new environment will survive and grow poorly because its traits are unlikely to be advantageous in the novel environment and will eventually be out-competed by the more resilient, resident community.

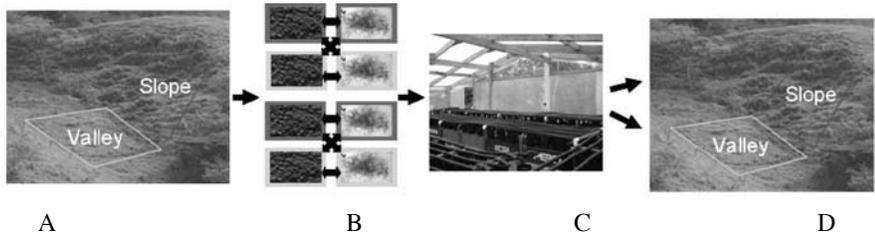
To test the existence of local adaptation among soil-mycorrhizal associations, I selected paired slope and valley restoration plots on abandoned pasture 12 km south of the Las Cruces

Biological Station. Slopes and valleys were chosen because their soils differed consistently in a number of biologically relevant ways, including fewer available nutrients and greater acidity in slope soil, and therefore might encompass distinct mycorrhizal habitats and communities. Next, mycorrhizal inoculum—in the form of fresh pasture grass roots—and sterilized soil from slopes and valleys was combined in

all possible combinations, added to small pots, and sowed with seeds of the legume tree Guaba (*Inga spectabilis*). Non-mycorrhizal control seedlings were also grown using the same sterilized soil but using steam-sterilized roots instead. After four-months in a greenhouse, Guaba seedlings were transplanted into the field, with half the seedlings of each treatment planted in the appropriate slope plots and half in the valley plots.



Inga spectabilis seedlings planted out in the experimental plots. Photo Riley Pratt.



A chronology of the field experiment, beginning with (A) the collection of field soil and mycorrhizal inoculum from one slope-valley pair, (B) the establishment of experimental treatments, (C) seed germination and growth in the greenhouse, and (D) the reciprocal-transplanting of seedlings into the field.

These combinations of treatments permitted me to ask a number of questions, like *Do seedlings raised in soil from valleys grow faster than those raised in soil from slopes? Do seedlings inoculated with mycorrhizae from slopes grow faster than those inoculated with mycorrhizae from valleys? Or, as initially predicted, Do seedlings grow fastest with resident mycorrhizae?* That is, best with slope mycorrhizae on slopes and valley mycorrhizae in valleys.

After the first five months in the field, inoculated seedlings were larger than control seedlings, suggesting an overall positive effect of mycorrhizal inoculation on tree growth. The most striking pattern, however, was that seedlings initially raised in soil and mycorrhizae from the same plot were larger. In other words, seedlings raised in soil and mycorrhizae from slopes together, and soil and

mycorrhizae from valleys together performed better than seedlings where the source of soil and mycorrhizal inoculum were different. This result suggests that mycorrhizal fungi are more beneficial to their hosts in the field if initially inoculated into a familiar soil background.

After an entire year in the field, mycorrhizal inoculation is still having an overall positive effect on plant growth but current trajectories of growth suggest mycorrhizae from slopes may *always* increase plant growth more than valley mycorrhizae. One explanation for this pattern is that the composition of mycorrhizal species is different between slopes and valleys. Slopes may have some species of mycorrhizae not currently found in valleys (perhaps because of poor dispersal ability) but that are highly effective partners in either environment.

Another possibility is that the composition of fungal species in the two environments is the same, but that mycorrhizal populations on slopes have evolved under stronger selection for efficient uptake and transport of nutrients to plants. Given that slopes have fewer available resources, competition for

scavenging and transporting nutrients on slopes should be fiercer, maintaining beneficial mycorrhizal partners and knocking-off less beneficial ones. Over several generations, you're left with a more beneficial slope population of mycorrhizae.

Determining which of these two explanations is correct requires mapping-out which mycorrhizal species are where and in what abundance. I am currently addressing these gaps in the laboratory with molecular identification techniques. Regardless of the outcome however, the growth responses of Guaba are intriguing and have a number of important implications. From a scientific standpoint, functional differences between neighboring mycorrhizal populations (in some cases separated by only a few meters) suggests local environmental conditions are much more important at shaping the structure and functioning of mycorrhizal communities than previously thought. From an applied perspective, restoration practitioners and landowners interested in restoring degraded land ought to include *resident* strains of mycorrhizae into their overall restoration strategy.

Conservation in Tropical Forest Fragments: Seeing the Forest for the Trees...and Animals

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What happens to a forest community—the assemblage of birds, mammals, plants, amphibians, insects, and other critters that characterize a forest—when all the trees are cut down, the roof (in fact, the whole house) removed right from over their proverbial heads? Well, while the details depend somewhat on the species, the simple answer is fairly obvious: for most of those creatures, life becomes...worse. Much worse. Small children have no trouble grasping that when you take away an animal's (or plant's) "home", it must find a new place for shelter, for gathering food, for rearing (or dispersing) its young in relative safety. Or it may perish.

Now consider a subtler alternative: what if, in fact, the forest trees and all the vegetation were left mostly intact? But, rather insidiously, some of the animals were removed? Perhaps they fell victim to hunting at unsustainable rates; or their forest, their "world", were dramatically decreased in size, due to forest fragmentation, leaving not enough space and food to sustain them. Both overhunting and habitat fragmentation are all too common in tropical forests, perhaps even more common than wholesale destruction of entire forests. Yet their effects on the community that remains are much less straightforward and much less studied.

To lend insight into the health of myriad and ever-multiplying tropical forest fragments, I decided to address the question, *what happens to the community of woody plants, the trees and shrubs which nominally are "the forest", when some of their mammalian tenants are evicted?* On the surface, one might think "Not much! Trees don't depend on mammals for survival. It's the other way around!" But herein lies the intricacy, the elegance—and sometimes the delicacy—of ecology. Everything is connected. Each mammal

In action photo measuring seedling height.

8 Amigos Newsletter



One of many seed 'depots' used in the study to monitor seed predation. Photo Chris Graham.



interacts not only with its animal co-inhabitants, but also with the forest plants, soils, water, leaf litter. Pumas hunt rodents. Rodents eat seeds. Seeds grow into seedlings and then saplings, that compete with their cohorts for space, light, and nutrients. Deer eat seedlings and saplings, as do insects, rodents, and other animals. When a significant change, such as local extinction, occurs to one of these components, the effects may "cascade" through the system, ultimately altering even the community of trees that superficially seems so impassive of the dwellers at its feet.

Las Cruces provides a wonderful setting for tackling this problem. It is a large forest fragment surrounded by a matrix of agricultural lands and other, smaller forest patches. Its 200-odd hectares (over 600 acres) consist mostly of seemingly undisturbed, primary (old-growth) forest. It is beautiful. Yet it *is* disturbed. Although it seems to be a large chunk of forest to many of us, it has proved to be nowhere near large enough to contain *numerous* large mammal species. Tapirs, those gentle, primeval-looking plant browsers, are gone, perhaps the first to go considering their tremendous size (150-300 kg) and space requirement of hundreds of hectares *per* individual. Both peccary species, “chancho de monte”, have gone—they often roam in large packs and require vast spaces and abundant fruit for sustenance, not to mention their conspicuousness and desirability to hunters. And white-tailed deer are a rarity (yes, the very same of eastern North American infamy).

As a “plant person”, I tingle to think about three important processes that these large herbivores would have known intimately at Las Cruces: herbivory upon young plants, consumption, or predation, of fallen fruits and seeds, and secondary dispersal of seeds after they have reached the ground. Deer, tapirs, and peccaries all are important plant herbivores, and thus inhibit plant growth and increase mortality rates within the “layer” of plant regeneration. Peccaries and tapirs are famous as well for gobbling up great quantities of fallen fruits and seeds, also hindering the targeted plant species. But a seed is not a seed. Peccaries and tapirs have their predilections, and past research has shown that these are often larger seeds, perhaps 2 cm across or more. At the same time, studies have shown that removal of large predators (such as jaguars and pumas, absent from Las Cruces) may “release” rats, mice, and other small rodents to attain higher population levels and consumption of small seeds, to which they are inclined. And so, I expect to find that the Las Cruces forest “favors” large-seeded tree species, and that forest regeneration reflects this imbalance. Looking not so far into the future, we might project a forest canopy

But herein lies the intricacy, the elegance- and sometimes the delicacy-of ecology. Everything is connected.

drastically different from the one that now exists—with yet unknowable ramifications for forest animals, soils, and even humans.

And what of secondary seed dispersal? Well, as anyone who has spent some time here in recent years may have perceived, another purveyor of forest seeds, seedlings, and all things plant seems to have benefited by the absence of its top predators: the agouti. Unlike peccaries, however, which ingest most seeds upon discovering them, agoutis (and their nocturnal counterpart, pacas) are known to “scatter-hoard” some of their finds, burying them for later use just as squirrels do. The trick for plant regeneration, though, is that some fraction of these buried gems are forgotten by the large rodents, leaving the seeds dispersed, planted, and protected from consumption. But which sizes of fruits do agoutis prefer? And, given their high numbers, will they predate enough seeds to compensate for the absence of the bulkier large-seed predators? Here we have another major question: in such cases of tropical “defaunation”, what is the exact balance between seed predation (a hindrance to the target species) and seed dispersal (a benefit) that the remaining fauna will strike? At Las Cruces, hyper-reproductive agoutis may disperse enough seeds to produce a net benefit; or they may be so ubiquitous as to have effectively filled the “niche” of the departed large-seed predators.

To answer such questions with any credibility, I must apply the methods of sound ecological research, rigorously and systematically, piece-by-piece to the multifaceted conundrum. Enter some of the old scientific standards: a control site; widespread and random sampling of the forests at both

sites; many replications of these samples; and, of course, a keen eye for detail. The control site, aside from containing most or all of the large mammals absent from Las Cruces, must also experience similar weather, be of a similar tree community, have a similar elevation—all to eliminate variation outside the scope of my hypotheses. Such a site has been hard to come by, but I have finally (nearly) settled on Finca Las Alturas, a large, mostly intact private reserve and ranch adjacent to La Amistad International Park.

At both sites I will carry out several experiments. I am establishing small study plots across the forest in which I will monitor herbivory levels and characterize the seedling community (e.g. diversity, total abundance, relative abundance of large- and small-seeded species). To gauge seed interactions, I am collecting seeds of various tree species across a range of seed-sizes and placing them in small groups throughout the forest. I will then track their fate over a month-long period. Tethering some of these seeds to a common anchor point will allow me to estimate the proportion consumed and the proportion intended for dispersal (an established method). Around a subset of both the seed stations and the seedling plots I will erect fenced “exclosures” to keep out all animals larger than rats, so that I may tease apart the effects of small and large mammals. Small mammal trapping, agoutis surveys, and hopefully motion-sensor camera “traps” will help provide a clearer picture of who exactly is visiting my plots...and eating my forage.

Numerous studies have illuminated the incipient, cascading effects of mammal loss in lowland tropical forests, but few have added to our picture of such ripples in highland forests. If we are to conserve remaining forests, we must understand the processes they might naturally house and the forces we are working against. While completely denuded lands are plentiful throughout the tropics, and certainly are more severe in their penury of ecosystem services and biodiversity, perhaps the sleeping giant of tropical forest loss lies in those seemingly pristine forests where, in fact, no sleeping giant lies.

Historical Data and Finca Las Alturas

Victor Milla / vmilla@ots.ac.cr

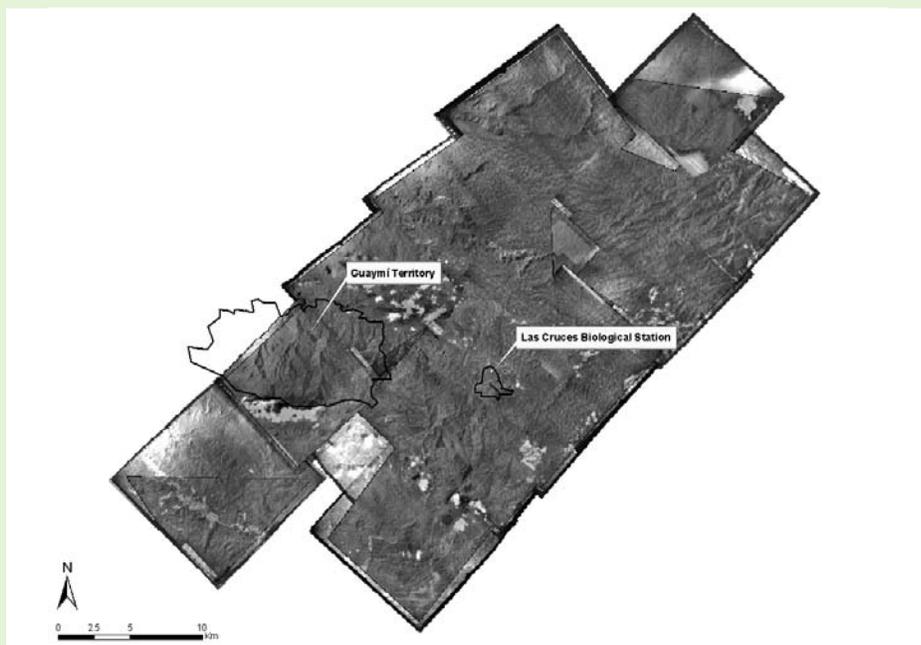
In recent months we have continued with pending projects in the GIS laboratory. One of them was the orthorectification of the historical aerial photographs of the region taken in the 40's. Three lines of flight were selected to continue in the development of this project, which included eighteen photographs. One of the major problems we had to contend with was determining the rough location of each photograph as all typical landmarks (such as roads, buildings, soccer fields, etc) were absent! For this we had the help of Mr. Willy González, who lived for many years in the San Vito area and helped orient us with the photographs, which took three days.

Once we had a rough geographic location for each photograph, information concerning the flight mission was obtained by means of mathematical calculations, using a precise estimation of the characteristics of the camera and other details of the flight. The results, when compared with recent data, clearly show the process of deforestation that the region suffered in subsequent decades.

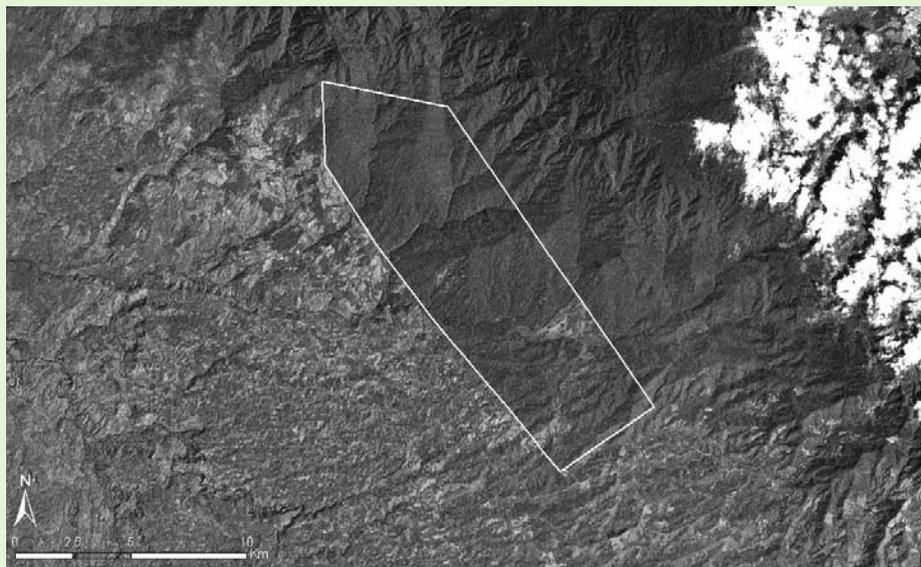
These studies form part of the process of obtaining old information for Las Cruces and surrounding areas. This can help us understand the magnitude of the environmental degradation, and also help find new ways to better understand and reverse this situation.

On another topic, we have initiated GIS work at Las Alturas (see the What's New section for more details). We began by putting together a general map of the property, and analyzing the land use of the property using aerial photographs taken in 1997-98 (Terra Mission) and a 2000 satellite image (Landsat ETM+). A field excursion to Las Alturas was organized, and the process to map the paths of the property began. We covered nearly 30 km of trails, which was very helpful to the subsequent work with the aerial photographs.

10 Amigos Newsletter



A mosaic of orthorectified aerial photographs taken in 1947 and 1948 (a work in progress).



The Las Alturas property (Landsat image 2000); Las Cruces is approximately 35 km to the southwest (not visible).

The property, located next to La Amistad International Park, is approximately 10,000 ha in size, and more than 85% of the area is covered by primary forest. Research projects have determined that 5 of the 6 species of big cats reported for Costa Rica are found inside the property! There are more than 100 km of trails through a great part of the

property, and approximately 100 people live at Las Alturas.

Finally, a meeting with the administrators of GIS from all three OTS stations was organized at Las Cruces. In this way, we can continue to standardize the information management process and develop new methods for our work in the laboratories.

Flora and Fauna

Captain Bligh – The Las Cruces Connection



Fern (*Angiopteris evecta*) along trail to Río Java. Photo Robbin Moran.



Spore cases (thick dark lines near margin) on lower surface of leaflet of *Angiopteris evecta*. Photo Robbin Moran.



Gametophyte of *Angiopteris evecta* with first sporeling leaf erupting through the leaf tissue. Photo Robbin Moran.

Robbin Moran / rmoran@nybg.org

About 100 meters uphill from the entrance to the Río Java trail stand several huge ferns planted in a row. Their arching leaves up to 4 meters long and low massive trunks up to 1 meter wide command the attention of hikers by. Planted by Robert Wilson, these ferns have a curious history. They are the direct, lineal descendents of plants brought to the West Indies by Captain Bligh, of Mutiny on the *Bounty* fame.

In 1787 Bligh set sail for Tahiti on the *H.M.S. Bounty*. His orders were to obtain living plants of breadfruit (*Artocarpus altilis*) and transport them to the West Indies where they might serve as food for slaves on the sugar plantations. But soon after leaving Tahiti, the famous mutiny occurred, and the plants never arrived. In 1791 Bligh made a second voyage to Tahiti aboard the *H.M.S. Providence*. This time he succeeded in bringing breadfruit to the West Indies, although it never caught on with the slaves.

Bligh brought other plants besides breadfruit. Among them was a fern, *Angiopteris evecta*, that seemed to be a potential food source because of its starchy rhizomes and petioles. Like breadfruit, however, it never became popular with the slaves.

How, then, did Bligh's fern get to Las Cruces? Plants from his second voyage were

first taken to the Botanic Gardens of Bath, Jamaica (St. Thomas Parish), where the ferns languished for decades. Sometime during the 1860s cuttings of the fern were taken to a more favorable location—the more sheltered and humid Castleton Gardens (St. Mary's Parish). In the 1950s, young plants of this fern from Castleton Gardens were obtained by Charles Lankester, of Lankester Garden fame (this garden is located in Cartago and owned and operated by the University of Costa Rica). He gave cuttings to Robert Wilson, who planted them at Las Cruces around 1965. Wilson's original plants can still be seen today exactly where he planted them near the entrance to the Río Java trail. (The fern can also be seen in the OTS office in San José. A cutting from the plants at Las Cruces was placed in the building's indoor planting area.)

Nowadays, *Angiopteris evecta* is not only flourishing at Las Cruces, but also spreading into the nearby forest. Its offspring—some of which are now quite big—are the result of sexual reproduction by tiny dustlike spores produced on the parent plants (the fern has no means of asexual, or vegetative, reproduction, such as from buds or stolons or proliferous roots). The spores are released from the lower surfaces of the leaves, where they are produced in spore cases (sori) located near the edges

of the leaflets. The spores land on the soil and germinate, eventually developing into a flat rounded plantlet called the prothallus or gametophyte. These plantlets are about the size of a nickel and constitute the sexual phase of the life cycle. They produce male and female sex organs (archegonia and antheridia) on the lower surface, and after fertilization occurs, a new plant is formed—the “typical” fern plant, the one with roots, stems, and leaves.

Gametophytes can be found near their parents, especially on bare soil. I often show these gametophytes to students in my OTS *Tropical Plant Systematics* courses. It is easy for the students to identify them: the first embryonic leaf pokes straight up through the green tissue of the gametophyte, not outward and around it as in other ferns.

Because *Angiopteris evecta*, a non-native fern, is invading the forest at Las Cruces, it might eventually need to be removed before it displaces too many native plants. Such a removal might constitute, so to speak, a mutiny on the *Angiopteris*. – Robbin Moran is the Curator of Ferns at the New York Botanical Garden.

The Luis Diego Gómez Herbarium



Federico Oviedo pressing a plant in the field. Photo Rodolfo Quirós.

Federico Oviedo/Rodolfo Quirós
foviedo@ots.ac.cr/ rquiros@ots.ac.cr

During the fire of November 1994, the facilities housed at “The College”, the main academic building of Las Cruces, were completely lost. The reconstruction efforts revolved around the immediate needs of the station, bringing academic life into action once again. Nonetheless, there were needs that could not be met.

One of the most important research facilities of a biological station is the herbarium, consisting of a collection of preserved and catalogued samples of plants. The scope of the collection is determined by the needs of the station, and in the case of Las Cruces, the old collection included samples of plants mainly from the surrounding forest, thus the loss of the herbarium was significant.

Over the intervening years, several efforts at building a collection of preserved samples of plants were carried out: the *Charral* Project with its

collection of early successional plants from abandoned pastures, the wetland vegetation survey of David Bart, the collection of forest trees made by Tania Bermúdez and Reinaldo Aguilar (see *Amigos* No 51, May 1999), Fred Werner’s collection of bird dispersed plants, and several other efforts from various researchers. But there was a problem: the maintenance of these samples requires special environmental conditions, and neither the cabinets located at the station’s laboratory nor the efforts of the resident biologist were sufficient to secure the protection of these samples.

As former director Luis Diego Gómez once said, the station would not have a real herbarium until a specific place is properly built. The dream of such a place stayed in our minds and wish lists for several years. Finally, during the last three years, this dream is coming true.

We are proud to introduce the **LUIS DIEGO GOMEZ HERBARIUM**

(**HLDG**) at the Las Cruces Biological Station. A room in the Library has been modified with air conditioning, double glass windows, and rubber lining in the door frame. It is equipped with five old cabinets – survivors of the 1994 fire that were repaired and repainted-, working tables and shelves, dissecting scopes and magnifying glasses, mounting materials, appropriate literature and a computer for the processing of information and identification of the collection. The name of the herbarium honors Luis Diego, our former director for more than 18 years, and a life dedicated to research and understanding of tropical forest diversity.

The herbarium aims to build a reference collection of the native plant species of the forest protected by Las Cruces and surrounding areas of interest. The scope of the collection includes the mid-elevation native forest of the Coto Brus Valley. A good amount of time was devoted to creating the first part of the collection including samples recovered from previous efforts (see above) and collections made by several groups of the OTS Tropical Plant Systematics course. We have begun building a data base to secure and manage information for each sample. Both the collection and the data base will evolve into a digital herbarium that can be accessed via Internet.

During this past year we began our own collecting phase with forays into the forest, pasture areas, and other environments around Las Cruces to increase the number of species collected. Currently, the herbarium collection has more than 1100 samples catalogued and several thousand more that need processing. The most important part of the work is identification of the samples for use by researchers. To date, the collection includes 660 specimens identified to species, plus several

Environmental Education and Cookware: Something in Common?

Ariadna Sánchez / asanchez@ots.ac.cr

Yes, although it could sound weird, both subjects have a very good point of union...

Cuisinart, a recognized brand of kitchen tools, launched a line of eco-friendly cookware denominated GreenGourmet™. The exclusive nonstick technology is ceramic-based instead of petroleum based, and is completely free of PTFE and PFOA (Teflon and oil derivatives). The coating is applied at a temperature one half that of conventional nonsticks and the cookware's hard anodized construction provides high heat conductivity, which requires less energy for cooking. Riveted stainless steel handles are made from 70% recycled steel and the packaging is 100% recycled material and printed with biodegradable soybean inks.

One of the most important aspects of this interesting campaign was educating consumers about how to apply good environmental practices, since most domestic waste is generated in the kitchen. In order to do so, we held a series of public lectures at various locations in San José and designed informative pamphlets on how to conserve water, energy, and reduce solid waste.

In addition to the promotion of this new line of products, Cuisinart together with Cemaco, a store for household goods, and Sabores, a culinary TV program and magazine, decided to set a solid example and donate US \$5,000 to Las Cruces and the Outreach and Environmental Education Program with the sale of Cuisinart-brand products.

In return, the Environmental Education Program gave some consulting services to these companies on how to reduce their ecological footprint.

samples that have not been identified properly because of lack of floral parts or because we do not have the right bibliographic information to identify them accurately.

The exciting part of this process is the fact that we have found several species that are actually flagged with notes such as *local endemic* (several species are only found in the Las Cruces mountain range, or in the southern section of the Coastal mountain range), *rare species* (those that have small populations and have not been collected properly), and *threatened species* (species with reduced populations due to exploitation or disturbance). These flags are important for the management of the station and the surrounding places, especially for the Las Cruces-Guaymi Corridor effort.

Even though the collection is not complete and the overall process has just begun, we already have produced several results based on these efforts; for example, the list of trees for the area has been improved with information from the herbarium (<http://www.ots.ac.cr/images/downloads/biological-stations/las-cruces/species-lists/lc-trees-jan09.pdf>). We also have a data base containing information about all the samples that has been built up with the participation of people from different departments of OTS. Our main objective here is the production of a digital herbarium where users can review basic information and see good quality

scanned images of all the samples in the collection and of live plants in the forest! You can access the Luis Diego Gomez Herbarium at <http://www.ots.ac.cr/herbarium>

It would be incomplete to not mention all the people who have been involved in the "herbarium project" over the years. Our Director, Zak, took charge of the idea of building the project and located the funding that made setup of the facilities possible and financed the stay of Melissa Arce, who had the job of recovering the samples collected by previous researchers and courses; she also participated in the definition of the basic structure of the data base together with personnel from the OTS Informatics department. The IT people in our main office in San José have taken the project as an important component of their work, dedicating the time of two persons, first Arturo Castro and later Pablo Aviles, to build and improve the digital herbarium idea and design the web interface. Many people have helped in collecting samples: researchers from the Illinois Natural History Survey, Zak, the authors of this note and several other researchers and volunteers. Finally, the images that will accompany the information of the samples in the digital herbarium have been made by Ariadna Sánchez, Javier Fernández, Federico and Rodolfo, with help from Victor Milla, the station's coordinator of informatics projects for biodiversity.

EDITOR'S NOTE:

I would like to single out Federico Oviedo for his incredible contribution to the herbarium over the last 6 months. With his help, the processed collection grew from 400 to over 1100, he identified many of the specimens in our collection – including the ones that were collected prior to his arrival, and he helped to build our tree species list through collections and identifications of specimens in the field.

Muchas gracias Fede!!

Our Donors

Donations Update – Our Spring Supplication

Alison Olivieri / maoawo@gmail.com

Twice a year we undertake the task of writing this note to acknowledge your generosity – and to ask you for more.

This time it feels a little different. Discretionary money is gone. It almost seems hard to believe there ever was such a thing. People who enjoy sending donations to help causes they believe in are finding they have to choose to buy groceries and clothing instead. The world is in an economic paroxysm and, along with many other countries, Costa Rica is going to suffer the consequences. Already the English-speaking newspaper here, *The Tico Times*, is running feature articles about declining statistics for the tourism industry with fewer hotel reservations and falling numbers of arriving travelers.

Donations to the Library

Las Cruces is thankful to all the friends of the Library who continue supporting it by making gifts in the form of books and scientific publications.

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Jardín Botánico Lankester, Costa Rica
Tzukuba Botanical Garden, Japan



Receiving the donation in the main office. From left to right: Zak Zahawi, Ana Catalina Salas (Multiformas), Elke Nane (Cemaco), Ariadna Sánchez, and Liana Babbar (Director OTS Costa Rica). Photo Minor Porras.

Community Medicinal Garden Project

The Outreach and Environmental Education Program of Las Cruces, Cooperativa CoopePueblos, and the Community Agroecology Network (CAN) are now working together on a project called Community Medicinal Gardens.

CoopePueblos is a coffee cooperative, located in La Copa, Agua Buena, whose members are committed to sustainable farm management and Fair Trade Direct sales assisted by the Community Agroecology Network of Santa Cruz, California.

The purpose of the project is to establish two demonstrative medicinal gardens for the community. One garden will be located at the Wilson Garden as part of the botanical collection and the other will be at the coffee mill of Coopepueblos.

The idea is to involve interns of CAN that come every year to do volunteer work in the communities, and also incorporate elders of the senior center of Agua Buena and San Vito. They will be researching the uses and properties of the plants and doing the planting and maintenance of the garden. The goal of the project is to harness traditional-based knowledge about medicinal plants and use it to showcase some of the most common alternatives to modern allopathic (conventional) medicine to the rest of the community and groups of foreign and local students.

We are apprehensive, like everybody else. We wonder what will happen in the next two years – will our natural history guest visitations lessen? Will the OTS college and university consortium suffer a decline in funding for visiting students? What will happen to support for ongoing and future research projects?

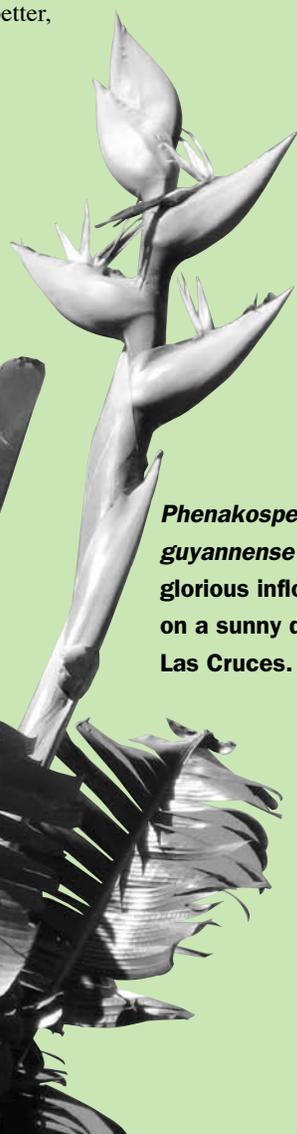
It is enough to give anyone a cracking headache.

But, you know, we have HOPE. And we have this hope because we have you, our dedicated and loyal “Amigos” who help us keep the facilities open and available to all comers, whether they are looking for butterflies, photographing amphibians or studying the genetic composition of fern spores.

We need your help -- as always -- to cook and clean, to rake and weed, to add property to our Land Acquisition Campaign and to keep moving and improving our unique facility.

So, as we write this important message, we think of you and how grateful we are for your support. We think of your visits, our shared nature walks in the Garden and the forest, your faces, our conversations and your comments. Now, we must ask you to please help us once again by sending a tax deductible donation today to our Annual Fund or the Land Campaign – or, even better, to both.

As always, Director Zak Zahawi welcomes your communications and questions. We all hope you might be able to visit the beautiful and tranquil Wilson Botanical Garden/Las Cruces in the not too distant future.



***Phenakospermum
guyanense* with a
glorious inflorescence
on a sunny day in
Las Cruces.**

A big thank you to all Amigos - especially in these tough times!

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