

Dear Volunteers,

I would really like to express my gratitude to you for all your positive energy, support, and for possessing an inclination towards making improvements in the world!! I know that Oldemar, Odilio, Rafael, Gilbert, Alvaro, Olivier, their children, the Emerald Toucanet, the Yellow Faced Grassquit, the Yellow throated Euphonia, the Blue-Gray Tanager, the Clay Colored Robin, the Rufous and White Wren, the Masked Tityra, and the bee with the tan abdomen would also really like to thank you! I am sure they would all want you to know how much they appreciate your work towards making their environment more healthy and sustainable.

As you will read below, I have chosen to plant the red flowered *Hamelia patens* in all the coffee plantations in order to test whether a keystone plant resource, which produces floral resources all year long, can be responsible for maintaining bees within a coffee farm. I credit volunteers from July 2006 with teaching me that this species is not only visited by hummingbirds, but also by native bees.

Also of interest to you might be the winners of the bird diversity contests. Oldemar won for July 2006 as well as November 2006. Odilio, down by the cemetery, had a fruiting Ficus in February 2007 which earned him second place for bird diversity, after Oldemar of course. In fact, Oldemar led in bird diversity for the entire year by at least 10 species, until June-July 2007. In June/July 2007, there was no particular farm with higher fruit availability. This diluted differences between farms with regard to bird abundances and diversity, and led to a tie between Gilbert and Rafael for bird diversity during this period. I have attached an excel file containing the bird list for each farm. For total values of bird diversity per farm we have Alvaro=50, Gilbert=60, Odilio=51, Oldemar=63, Olivier=53, and Rafael=60 after more than a year of bird surveys. Now it's time to relate this to either fruit energy availability or an environmental variable (resource vs. structure availability).

Well, thank you again, and I look forward to sending some more detailed results in the future as the research progresses!

# EARTHWATCH INSTITUTE ANNUAL FIELD REPORT

**Project title:** Costa Rica's Sustainable Coffee

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**Research Site:** San Luis, Costa Rica

## 1. Research objectives

**Objective 1:** Understand how shaded coffee plantations can conserve ecosystem services

**Objective 2:** Investigate how constant resource availability in shade coffee plantations affects abundance of key frugivore species

**Objective 3:** Investigate how constant resource availability and environmental factors affect diversity of bird species in shade coffee plantations.

**Objective 4:** Investigate how constant resource availability through planting the native shrub species *Hamelia patens* affects native bee abundance and diversity

**Objective 5:** Investigate how constant resource availability through planting the native shrub species *Hamelia patens* affects coffee flower pollination and seed set

**Objective 6:** Investigate how resource availability in shade coffee plantations affects MCP and breeding success of Emerald Toucanets

## 2. Data Collection and Results

### 2.1 Seed Dispersal service provider data

In order to demonstrate avian use of coffee plantations, it is necessary to make observations throughout the year and in different seasons. In the past year we have recorded observations of 33 focal frugivorous bird species in six coffee plantations during July (early rainy season), November (late rainy season), February (early dry season) and April (late dry season). In addition, migratory birds and other common coffee plantations birds' presence in the coffee plantations were recorded when positive identifications were possible.

Thanks to the help of the volunteers, I was able to collect bird diversity and abundance data in all six coffee plantations simultaneously. For each fifteen day period we were able to monitor each plantation for about 5 to 7 days. Without volunteer help, this number of data days would take around 30 to 40 days, and as the seasons change so rapidly in the tropics for certain bird species, this length of time might not allow for direct comparisons among the plantations. The simultaneous data collection is a much more powerful way to demonstrate that the diversity or abundance differences among farms is due to farm variables and not season/weather variables.

In addition, we measured environmental variables in all six coffee plantations. The species of all individual trees in the coffee plantations were identified. The farms were surprisingly diverse, with an average diversity of 20 species per farm. Tree height, DBH and nearest neighbour measurements were taken for each individual tree in all six coffee plantations. Shade canopy density was measured along two parallel 100 meter transects within each coffee plantation, and along 100 meter transects in the four cardinal directions outside the perimeter of each coffee plantation.

Fruit energy availability indices were calculated and assigned to each coffee plantation during each season. A fruit availability index was determined by counting the number of fruits on a selection of branches picked at random and then extrapolated to the tree. The fruit index used was 1) 1 to 10; 2) 11 to 25; 3) 26 to 50; 4) 51 to 100; 5) 101 to 200; etc. Fruits were collected, weighed and measured. Fruit samples were taken to the lab and dried with a Standard Food Dehydrator and later analyzed for energy content with a bomb calorimeter back at the University of Georgia.

### 2.2 Pollination service provider data

Bees were collected throughout the year to establish a bee reference collection. Bee species were identified when possible through the assistance of Manuel Solis of the National Biodiversity Institute, INBIO. In order to estimate the diversity of bees using a possible keystone resource, bee visitations were recorded to *Hamelia patens*. Through these observations, a minimum of 10 native bee species were found to visit and take resources. As we determined that *Hamelia patens* provides resources to a wide assemblage of native bee species, and when planted in sunlight will produce floral resources constantly throughout the entire year, it is an excellent species to experimentally enhance

the coffee plantations. *Hamelia patens* grows quickly and within one year will begin to produce flowers, which makes it an excellent species to test whether a constant floral resource can maintain native bee species within coffee plantations. Six to ten *Hamelia patens* shrubs were planted in July 2007 within each of the six coffee plantations, in full sunlight.

Bee visitation to coffee flowers was quantified in April 2007, during the very brief coffee flowering season (approximately 3 days). Eight individual coffee plants were observed per farm for 10 minute intervals. Individual bees were identified to species. Approximately 90% of visits to coffee flowers were from the non-native honeybee, *Apis mellifera*. Native bees however were observed to visit coffee flowers and in greater abundances after the masses of *Apis* departed. This phenomenon will be investigated further in the upcoming coffee flowering season.

Floral stigmas were collected from 40 coffee flowers per farm. Using fuchsin jelly, slides were prepared to determine pollen grain deposition on the stigmatic surface. As of now, pollen grains have not yet been counted. Two environmental variables will be related to bee abundance, bee diversity, pollen deposition and seed set. Using the same index discussed above, a flower availability index was calculated and assigned to each coffee plantation during each 15 week season. The Canopy Density Cover calculation will also be used to analyze bee data.

This study is too new to have results of any significance, as many of the questions asked require long term research over several sampling seasons. However, I have attached a list showing the richness of bird species at each of the six individual coffee farms.

### 3. Significance/Benefits of Research

At the local level the beneficiaries of this research are the coffee farmers and the communities of San Luis at the base of the Monteverde Cloud Forest Reserve in Northwest Costa Rica. This involves two groups, Finca La Bella and the Monteverde Cooperative. Finca la Bella is a group of formerly landless farmers who have been provided with one to two hectares to farm in an environmentally friendly way. There are a total of approximately 30 farmers and their families residing in Finca la Bella, although only six of those families work in coffee production. Not only are these the farms where this research is being conducted, but the farmers also participate in and learn about the scientific aspects of the study. After each field season, I present the results to the farmers and their families, and educate them about the benefits of conservation. The ways in which these farmers manage their lands, and the importance they place upon conservation will change through the findings of this research. In addition, these farmers will be capable of training other farmers in the benefits of biodiversity within the coffee plantation.

The Monteverde Cooperative has already looked towards Finca la Bella for this type of training or sharing of information. Finca la Bella farmers comprise less than 10% of the coffee crop sold by the Monteverde Cooperative, but Finca la Bella farmers have the most bio-diverse farms in the Cooperative. For this reason, the Monteverde Cooperative has asked the farmers of Finca la Bella to provide concrete examples to other farmers in the Cooperative of how to manage their farms. The first training meeting took place in July 2007 to discuss the potential for this, and how to involve the Costa Rica Ministry of Agriculture so that farmers could be trained nationally. There were approximately 40 participants in this meeting, which also included presentations focusing on the benefits of shade grown coffee for bird conservation given by me and another University of Georgia PhD student.

An important national contribution would occur through the Costa Rica Ministry of Agriculture through trainings conducted jointly by me, Manuel Solis of the National Institute of Biodiversity (INBIO), Finca la Bella farmers, and the Monteverde Cooperative. These trainings would focus on native bee conservation and the role that they play in pollination and coffee production. If the results of this study indicate that a constant floral resource such as *Hamelia patens* can increase abundance and diversity of native bees in coffee plantations, then these results can be widely applied to coffee farms not only in Costa Rica but throughout the range of this plant species, i.e. Mexico to Bolivia. Application of this research would be a direct contribution to sustainability through the conservation of ecosystem services with the agricultural lands themselves. This would be a new approach as other ecosystem service studies have focused on the proximity of the agricultural lands to forest reserves, which is not always possible.

Finally, this research is co-advised by the Director of the Smithsonian Migratory Bird Center (SMBC), which is the organization responsible for the movement toward promoting shade-grown coffee in Latin America. In order to make this more attractive to farmers, the SMBC initiated the certification program for 'Bird-Friendly Coffee'. The organization provides farmers with guidelines for production which will be modified in accordance with the results of this study.

## 4. Communication of results

As this year was the first year of study, the results are not yet ready for publication to journals. However, I have given presentations locally for both the farmers and their families where the research is being conducted and for the Monteverde Cooperative. Presentations to farmers and their families are usually attended by approximately 30 to 50 people, which also often include other students currently studying at the research station. The presentation to the Monteverde Cooperative had approximately 40 attendees, comprising farmers, local students and co-op administrators and directors.

## 5. Volunteers

### 5.1 Tasks and achievements

At the start of this research, I hoped to identify plant species that could be pivotal for native bees utilizing the coffee plantations. I had learned about pollinator syndromes in many college courses and, because of this, I was not interested by one particular shrub species with red, tubular flowers, *Hamelia patens*, despite the fact that it produced fruit and flowers constantly throughout the year. Earthwatch volunteers collecting bees for the reference collection, without knowledge of pollinator syndromes, brought back bees that they had found on *Hamelia patens*. I assumed that the bees would have been 'passing by' the *H. patens* when the volunteers found them, but after several volunteers made the same claim, I decided to look into it myself and found that there were many native bees visiting the flowers for both nectar and pollen! Without the help of the volunteers, I might never have considered this plant important for native bees, but now I am directly testing the importance of this plant in maintaining native bee populations within the coffee plantations. Recently, in June 2007, we planted 6 to 10 shrubs per farm, and after one year these plants will begin to produce flowers. Through this, I hope to determine what role *Hamelia patens* could play in supporting native bees within coffee and what effects this will have on coffee seed set and production. *H. patens* ranges from Mexico to Columbia, common at mid-elevations where coffee grows. Depending on our results, planting this shrub species within coffee could be a critical management strategy for the conservation of native bees throughout most of Latin America, where coffee comprises about 44% of all permanent croplands.

I was also impressed by most of the volunteers' desire to learn. Some volunteers came prepared, having studying the birds of the region before arrival at the field site, and this was always invaluable. In general, though, I watched amazed as volunteers soaked up not only sustainable development and conservation focused information, but also cultural experiences such as playing soccer with 2 year old Laura or making pizza at Oldemar's house. This is a unique Earthwatch program because we spend each day at someone's home, and the culture is very unique. Volunteers are guests each day on someone's farm and I was very proud of the way that volunteers interacted with their very gracious hosts.

The greatest day, for me, of all the days of the expedition, is always the 'despedida' party, where volunteers thank the farmers for their kindness and hospitality. Most of all, it is an opportunity for fun and sharing between the two or more cultures. Volunteers are in charge of planning the event, and I have really appreciated their great efforts with this. I want to especially thank the creativity and motivation with which volunteers planned these special parties.

Finally, probably the biggest task that I had asked of the volunteers was in July 2006 when we collected tree data from all the coffee plantations. This amazing team measured not only the DBH and height of all individual trees within all six of the coffee plantations, but they also measured distances between all individual trees and the closest four neighbours. As you all know, but especially the July 2006 team, it is not an easy task to manoeuvre through a field of coffee plants and weeds that are as tall as a person!

## **5.2 Project development**

The biggest logistical challenge for me in the past season has been with regard to the re-location of bird transects within each coffee plantation. The plantations are one-hectare or 100 m<sup>2</sup>, a very small area of land. Although the area is small, it appears uniform to unfamiliar visitors who may not have a lot of experience in the woods or natural areas. After the first team, I created a map to give to volunteers so that they would find each individual coffee plantation more easily. After the second team, I developed a flagging system where yellow flagging tape marks the approach to the transect, blue flagging tape shows the actual transect, and red flagging tape signifies the end of the transect and the return to the approach. After the third team, I placed more flagging tape along the way, and it is still an ongoing learning process to facilitate for volunteers the task of locating each transect. Additional difficulties with transect location occur because children or animals remove flagging tape, and severe storms wrap them around branches, causing them to be barely visible. In order to address the issue that all volunteers will locate transects differently, we walk through the farms together at first, with individual locating flagging tape on their own to ensure that they will be capable of re-locating the transect on future visits.

Scientifically, not all volunteers have the same ability when it comes to identification of birds. This is crucial to the research, and the best start for bird identification comes with a good pair of binoculars. Lessons learned from the first team in July 2006 inspired the following changes. Two weeks prior to the start of the expedition I send all volunteers bird cards with colour pictures of the 33 focal frugivores, common birds, and migrants. This enables them to learn field marks prior to arrival in Costa Rica. I also explain and stress to them the importance of purchasing or bringing a good pair of binoculars. Upon arrival, I now give a lecture on bird families and bird identification. Finally, I partner volunteers who may have less experience with volunteers who have more experience or are more comfortable with bird identification.

One other scientific challenge has been the new addition of radio telemetry to this project. The most certain way to determine habitat requirements for, and frugivore use of, coffee plantations is by tracking individuals of a species that may be considered a model for the questions that are being proposed. To this

end, I have selected to capture and track the Emerald Toucanet. As with most highly frugivorous species, this bird spends the majority of its time in the canopy, making its capture extremely difficult. In six weeks, only three individuals were captured, using elevated mist nets. In order to address this challenge, I plan to make nest boxes. Red-Cockaded woodpeckers are captured right from their nest cavities utilizing extension poles and butterfly nets. Emerald Toucanets will nest between 2 and 27 meters above the ground, although they prefer to nest as high as possible, causing the majority of the nests to be beyond reach. By placing nest boxes at approximately 2 to 3 meters, I hope to be able to have more efficient capture rates using the methodologies that scientists have used with Red-cockaded woodpeckers.

## **6. Educational Opportunities**

### **6.1 Community involvement**

This research project focuses on defining criteria to ensure the sustainable production of *Coffea arabica* through understanding the habitat requirements of ecosystem service providers. Therefore, coffee producers both locally and regionally play an integral role both logistically and through the distribution of information. Regionally, the Monteverde Cooperative has always stressed to their farmers the importance of sustainable coffee production. The Monteverde Cooperative recently produced a documentary about their fair trade coffee and conservation. The Monteverde Cooperative is also working with the Ministry of Agriculture to raise awareness of sustainable coffee production throughout the nation. The results of this research are important to demonstrate to the Ministry of Agriculture that these farms are important to local biodiversity. In July 2007, I offered a workshop to all farmers and members of the Monteverde Cooperative where I presented preliminary information from the past field season. The Monteverde Cooperative is especially interested in learning more about and supporting work relating to native bee conservation.

Locally, this research involves the San Luis community and Finca La Bella. Both Earthwatch volunteers and myself have had countless impacts and interactions with the members of this community and farm. At the end of each volunteer team, I have presented preliminary results to the farmers. Their enthusiasm and curiosity for this research is extraordinary. The farmers and families of Finca La Bella are the main motivation for this research. I have come to understand, through discussions with the farmers, that the discoveries I share with them about the natural world around them are truly meaningful, because they have never had the opportunity to pay close attention to this part of their environment. The farmers ask specific questions about the research. One farmer asked me if I could tell him how biodiversity on his farm had changed over time. This particular farmer was interested in this because he had converted his land from cattle pasture to a shade grown coffee plantation, and wanted to ensure that the trees were indeed useful to biodiversity conservation in the area. He felt that the best way to show this would be if biodiversity had increased on his land over the year of study. Another farmer, during a presentation that I was giving on bees and coffee, reminded me that I had taken information on seed sets of coffee in the plantations and he was curious to know the results.

Student groups and early scientists have also participated in this research. The Ecolodge San Luis is blossoming into an official University of Georgia campus with the idea that students will be able to study not only tropical ecology but also art, culture, language, and other subjects specific to the campus location. The Ecolodge also offers positions to young scientists who work for six month periods as Resident Naturalists. On different locations both resident naturalists and student groups, wanting to learn more about this research, have participated in data collection.

## **6.2 Contribution to postgraduate research**

This research will eventually lead to the completion of my doctoral dissertation.

## **7. Partnerships**

### **7.1 The Costa Rica National Institute for Biodiversity (INBIO)**

The most effective new partnership that has been developed over the past year has been with the Costa Rica National Institute for Biodiversity (INBIO). The Entomologist, Manuel Solis, has been responsible for the critical task of bee identification. Once the bees are identified by Manuel they are added to the reference collection, which volunteers can then use to identify which bee species are visiting both coffee flowers and *H. patens* flowers.

### **7.2 The Costa Rican Conservation Foundation (FCC)**

Another new partnership which has developed over the past year is with the Costa Rican Conservation Foundation (FCC), an organization created by Costa Ricans and biologists concerned with loss of important habitat on the Pacific slope of the country. Currently the FCC has a grant from the U.S. Fish and Wildlife to conduct reforestation activities within abandoned cattle pastures blanketing the severely degraded Pacific slope. During one morning of each 15 day field season, the volunteers visit the main station of the FCC to work with reforestation activities, such as planting trees or filling bags with soil for the tree nursery. A focal species for the Costa Rican Conservation Foundation is the Three Wattled Bellbird, *Procnias tricarunculata*, which is listed as endangered with the IUCN.

### **7.3 The Smithsonian Migratory Bird Center (SMBC)**

The Smithsonian Migratory Bird Center (SMBC) continues to assist with technical advisement and support. Russ Greenberg, the director of the Center, is involved in structuring the research and provides feedback on questions as they arise. The SMBC has produced a guidebook, in Spanish, that is distributed to farmers who wish to produce 'Bird-Friendly Coffee'. Upon completion of this study, stronger criteria will be defined and distributed via the organization.

## 7.4 The Monteverde Cooperative

The most recent partnership has been with the Monteverde Cooperative, of which the coffee farmers of Finca La Bella comprise less than 10% of the annual coffee sold. The Monteverde Cooperative currently sells their coffee under the label of Montana Trading Company. The owner of this company supports both sustainable agriculture and fair trade, which has been a big influence on the coffee farmers associated with the Monteverde Cooperative. This partnership will allow the results of this study to be more widely and effectively distributed to farmers throughout Costa Rica. In July 2007, I presented this research to the Monteverde Cooperative, representatives and farmers, whose goal it is to work jointly with the Costa Rican Ministry of Agriculture, to educate farmers throughout the nation on Sustainable Coffee farming.

## 8. Acknowledgements

Team 1 July 2006 were by my side through a tragic family accident, and were not only extremely supportive, but kept collecting data even when I was unable. I am very grateful to them for their hard work and determination. I also want to especially thank Pernille who listened to me for hours and Jim who listened to me in the pouring rain.

I would also like to say a special thank you to the volunteers who taught me that *Hamelia patens* (the red flower shrub) was not only pollinated by hummingbirds (as I had assumed) but also by a variety of native bees.

And finally a special thanks to my one-man team of Sarah H. who ran ALL over Finca la Bella and San Luis with me in the HOT April dry season trying to capture the VERY brief three day coffee flowering season, and who was very brave when ants invaded her clothing drawer and taught me of the pitfalls of flossing your teeth in bed.