# Costa Rican Coffee from Community to Cup

# (Coffee Research)

# 2011 FIELD REPORT

## Background Information

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Dear Earthwatch volunteer,

I am very happy to inform you that in 2011 Earthwatch successfully carried out its fifth consecutive year doing research in the Los Santos coffee growing region in Costa Rica. Over this period, we have received the invaluable help of hundreds of volunteers. Being part of this group of people who are working to support sustainable management strategies in one of Costa Rica's most important coffee growing region should make you feel proud.

In 2011, we carried out three field research programs. First, as a continuation of the previous years, the research team led by Dr. John Banks continued exploring the role of pollinators in determining coffee fruit set and yields. We are also interested on exploring how the distribution of habitats, in particular forest remnants, affect the communities of native and honey bees. In other regions of Costa Rica, yields of coffee trees that grow near important forest remnants may be up to 15% higher than those trees which are far away. Encouraging farmers to protect and restore habitat that supports rich insect pollinator communities may enhance pollination services to coffee crops and support sustainable farming and biodiversity conservation in Tarrazú.

Our research also continued to focus on nutrient cycles in coffee agricultural systems. For better or worse, farmers in Los Santos region generally rely on synthetic fertilizers to provide the macronutrients, including Nitrogen, required by the coffee crop. We are seeking to better understand nitrogen efficiency under varying climatic and soil conditions. We are also starting to explore which practices would maximize yields in low –nutrient input coffee farms. We hope that our research results will inform the cooperative's agricultural extension service providers and coffee farmers on the economic and environmental costs of their farm management choices and encourage them to adopt more sustainable practices.

In 2011, we were pleased to welcome a new co-Principal Investigator to the Earthwatch research team in the Los Santos region, Costa Rica. Milagro Montero, who is a plant pathologist and PhD student at the University of Costa Rica, worked with volunteers in two expeditions, looking at the incidence and severity of 'Ojo de Gallo' (*Mycena citricolor*). This fungal disease is becoming a serious constraint to coffee production in commercial highland farms in Costa Rica and other Central American countries. Her work will ultimately help determine the growth rates of the disease and how it is affected by agroecological conditions found in commercial coffee farms. Her work will provide a more in-depth knowledge of the factors that contribute to 'Ojo de Gallo' outbreaks, which may help identify more sustainable controls of this disease.

In addition to our field research, we continued developing a capacity building and training curriculum. For example, in 2011, we carried out a series of six workshops including 128 coffee farmers and agronomists under the "Coffee Leadership program". This training has allowed us to share ideas on sustainable coffee nutrient management programs, the risk of climate change. And of course, our local partners in Los Santos continue to amaze us with their commitment to excellence and environmental stewardship. One example is that during 2011, CoopeDota R.L. launched the first coffee brand certified to be 100% carbon neutral. In addition, all cooperatives continue to support environmental and social certification schemes such as Fair Trade, Rainforest Alliance and others. We believe these are important steps

taken by this community of farmers to proactively participate in building more sustainable and accountable food systems.

Sincerely,

Sebastián Castro Tanzi

Principal Investigator, Earthwatch

# SECTION ONE: Scientific research achievements

## Top highlight from the past season

Currently, in many coffee regions of the world, Nitrogen-based fertilizers are used to fulfil the nutrient requirements of high yielding coffee systems. More coffee is harvested in those plantations receiving high doses of Nitrogen –based fertilizers. However, it is well established that as the dose of nitrogen fertilizer inputs increase, lower proportions of these Nitrogen inputs are assimilated by the crop, thus leading to nutrient loadings into the environment. For example, the excessive reactive Nitrogen increases the risk of water pollution. In addition, higher nitrogen input rates lead to higher rates of nitrous oxide ($NO_2$) emissions from soils. $NO_2$ is a potent green house gas. Furthermore, fertilizers represent a significant portion of the capital investment of conventional coffee farms.

During 2011, we implemented an experimental design meant to estimate Nitrogen use efficiency (NUE) of coffee agroecosystems. This experiment will give us insight into how fertilizers perform as strategies to increase coffee yields under different climatic and pedologic gradients found in the Los Santos coffee growing region in Costa Rica.

Our preliminary results support the hypothesis that total fruit load (mean number of fruits per coffee tree per plot) is affected by nitrogen fertilizer input rates. However the response varied from farm to farm: in some farms, those plots receiving higher doses of N fertilizer showed higher fruit loads, while in others this relationship did not hold. Further analysis needs to be performed to relate this to variations in site climatic and soil properties.

In addition, preliminary trials have allowed us to develop field methods to study the epidemiology of the *Mycena citricolor*, a fungal disease affecting the coffee crop. With this research we will inform extensionists and coffee farmers of potential alternative control practices of this disease.

Finally, our follow –up research has allowed us to confirm an increase in the soil pH of farms where lime has been applied in the past. We expect that in these farms the use of nutrients by the crop will be more efficient allowing a decrease in the rate of fertilizers inputs. This will lead to lower production costs, lower environmental impact and a lower carbon footprint in these farms.

## Reporting against research objectives

Objective 1, 2, 4 and 5:

1) Estimate the NUE of the coffee crop in a gradient of climatic and soil fertility conditions.

2) Identify potential impacts of global warming and soil acidification in coffee production and quality under different nutrient management strategies.

4) Estimate the efficiency of compost for providing nitrogen and sustaining economical yields.

5) Estimate the carbon footprint associated with different nutrient management strategies in coffee.

We identified 14 farms and successfully implemented the experimental design in all of them (Figure 1). These farms will be monitored for at least two more years.

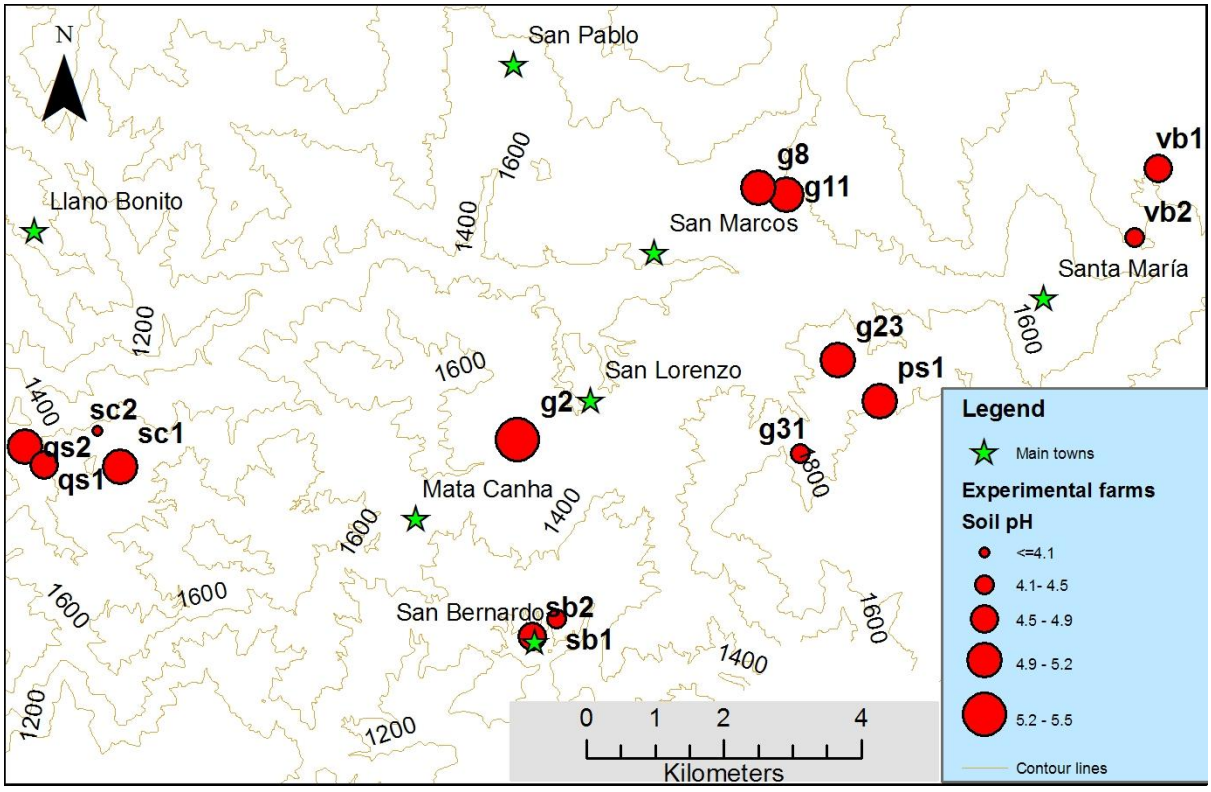


**Figure 1**: Map showing location of experimental farms and soil pH

The first year of field data has been collected and processed. Our preliminary results support the hypothesis that total fruit load (mean number of fruits per coffee tree per plot) is affected by nitrogen fertilizers inputs rates (fig. 2). However the response varied from farm to farm: in some farms, those plots receiving higher doses of N fertilizer showed higher fruit loads, while in others this relationship did not hold. Further analysis needs to be performed to relate this to variations in site climatic and soil properties of each farm.

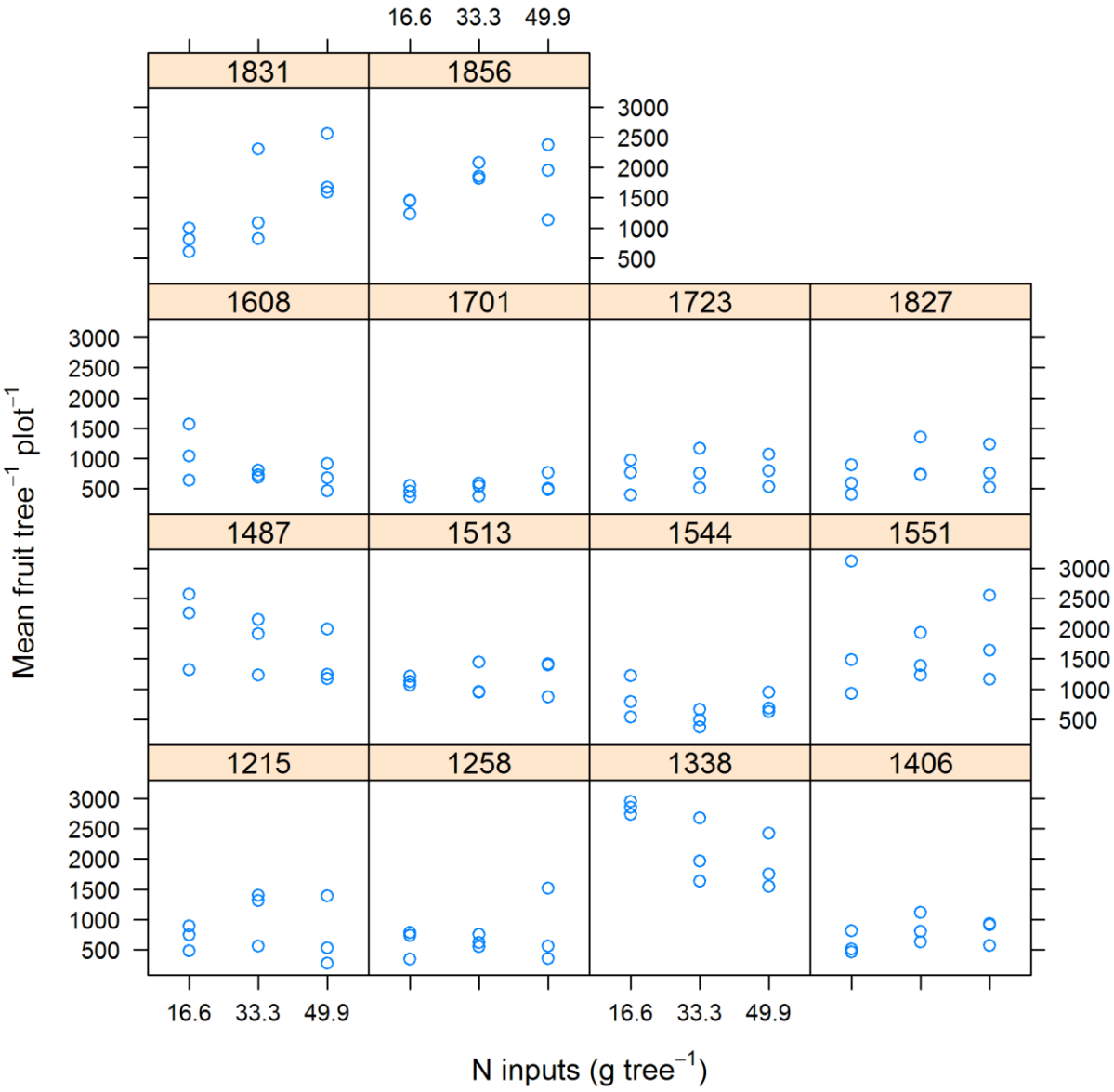


**Figure 2**.

In addition to this data, the scientific team collected coffee samples, which will help determine cupping quality, fruit weights and determined the fruit fall per coffee plant to have a better estimation of final yields. Activities where preliminary results are presented to cooperative extensionists and farmers are being scheduled. In addition, monthly temperature and precipitation data was acquired from the Costa Rican Institute of Energy (ICE). With this, we are planning to create agroclimatic zones within the study area and validate our experimental design. Outcomes and lessons learned from the "Sustainable Coffee Farming Practices in Tarrazu, Costa Rica" continued to be disseminated in the Tarrazú coffee farming community through a series of workshops and farmer-to-farmer experiences. These activities were part of the Sustainble Coffee Leadership Program supported by Starbucks

Coffee Company. A total of 128 farmers from Coopetarrazu, Coopellanobonito, Coopedota and Coopenaranjo, four cooperatives representing around 4200 coffee farmers, participated in this program. Based on previous findings and jointly with extension workers from the cooperatives and agroecologists working in coffee, we developed workshops that focused on plant nutrition and soil quality enhancement, shade tree and ground cover management and climate change. Finally we were awarded a small training grant to support projects designed by our local partner CoopeTarrazú. This project will establish a commercial tree nursery meant to support agroforestry projects. This grant will finance the development of skills for tree nursery management for employees of the cooperative. We hope that this will open the door for further research, development and support for large-scale agroforestry projects.

Objectives 6, 7 and 8:
6) Identify and quantify the different sources of inocula of M. citricolor.
7) Evaluate the severity of the disease caused by M. citricolor on coffee plants in contrasting soil fertility levels.
8) Determine the impact of different starting levels of initial inocula of M. citricolor on the severity of the epidemics.
2011 was used to test field methods for: quantifying the incidence and severity of M. citricolor in coffee and collecting innocula for lab processing. Severity and incidence was estimated in 5 farms. Counts of leisure found in leaf tissue were performed in plants found in these farms. These estimators showed a very good correlation with observations scales performed by a trained pathologist, suggesting that leisure counts capture the variation in severity of the disease. However, this method seems limited in capturing defoliation. We consider that this problem would be solved through repeated measurements of the same laterals (branches) of the plant.

# SECTION TWO: Impacts

## Partnerships

During 2011, our partnership with CoopeTarrazú R.L. allowed us to identify the farms where the field trials of most of the experiments are being carried out. This cooperative also contributed with the organic fertilizer and some of the nutrient amendments used in the field experiment. In addition, the lab facilities used by our research project belong to and are facilitated by this institution. During 2012, we will continue developing our partnerships with CoopeTarrazú R.L. We expect that CoopeTarrazú will continue facilitating communications with the farmers where the field experiments are taking place. In addition, we expect that

they will continue to provide the compost and some of the other nutrient input amendments used in the field experiments. Finally, we expect that they will continue hosting our field lab. Finally, with the support of the Neville Shuman award and through the existing partnership with this cooperative, we are exploring the possibility of developing a tree nursery to service coffee farmers. During 2012, we expect to carry on additional field experiments at the research farm owned and managed by CoopeDota.

## Contributions to conventions, agendas, policies, management plans

- **International**

Our project will contribute to inform the worldwide community of researchers working in coffee agroforestry systems. We expect to provide information of the nitrogen use efficiency in commercial farms and nitrous oxide emission factors in commercial farms managed in ultisol soils which will allow more accurate estimates of the carbon footprint of coffee farming.

- **National or regional**

We expect that this project will inform Nationally Appropriate Mitigation Actions (NAMAs) being promoted by authorities of the Costa Rican coffee and agriculture sector. These NAMAs are required to organize and coordinate national initiatives meant to address climate change mitigation and adaptation. One of the needs indicated by these initiatives is for accurate quantification of the carbon footprint of the life cycle of coffee within Costa Rican borders. This initiative will join other case studies of coffee agroecosystems found in distinct ecological conditions.

- **Local**

We have presented our findings among the community of coffee extension providers. Results of this current research, in combination with other information technology applications which have been developed by Earthwatch in this project, will support extension services in providing more rational advice with regard to nutrient input recommendations.

## Developing Environmental Leaders

During 2011, a series of 24 workshops were carried out under the outreach and capacity building program called “Sustainable Coffee Leadership Program”. A total of 128 people participated, mainly coffee farmers and the some agronomists working for the four cooperatives who hosted the program. The workshops built upon the four years of research done by Earthwatch in the Los Santos region. It included modules on integrated soil fertility

and pest management, risk of climate change in coffee systems, shade tree management and financial management of coffee farms.

## Actions or activities that enhance natural and/or social capital

We expect that with our results farmers will be able to more rationally manage the amount of their farming inputs, specifically nutrients added through fertilizers. This will have a direct impact on non-point nitrogen and phosphorous pollution of surface and underground waters. Furthermore, we expect that by reducing the amount of excessive nitrogen (i.e. nitrogen not assimilated by the coffee crop) we can reduce soil acidification rates, which would improve soil quality.

## Conservation of Habitats

We expect that by reducing the impact of excessive nitrogen on increased soil acidification rates in coffee farmers, soil quality will increase. This will probably lead to a restored habitat for soil biota and its associated ecological functions and potential ecosystem services.

## Ecosystem Services

We plan to contribute with climate regulation services provided by coffee agroecosystems. The scientific literature suggests that there is an important possibility of reducing inorganic fertilizers inputs in coffee agroecosystems which would lead to decreased emissions of greenhouse gases (GHG). Our research will quantify the magnitude of this reduction, which will further support the environmental certification efforts of local cooperatives. Reduced GHG emissions will contribute to a better global ecosystem by reducing the risk of climate change.

## Conservation of Cultural Heritage

Our project integrates wherever possible an appreciation for Costa Rican coffee traditions and improves connections between consumers and producers as part of a larger global coffee culture. Volunteers gain an unique perspective on their daily cup of coffee through their interactions with coffee farmers and by visiting the cooperative “beneficio”, where coffee cherries are processed into green coffee beans. Farmers benefit from these interactions as well by seeing what a deep appreciation the volunteers have for their efforts, particularly those farmers using more sustainable practices.

## Impacting Local Livelihoods

Our research has shown the potential for enhanced livelihoods with reduced expenses in

conventional coffee agroecosystems. Due to the high levels of inorganic fertilizer use by many farmers in Los Santos, we found that farmers who reduce fertilizer inputs in coffee agroecosystems not only save on production costs but can do this without affecting coffee yields. Reduction of variable expenses by farmers would lead to increased net profits from farming activities. Furthermore, we plan to promote ecological management of soil fertility. We expect to support any potential grassroots activities initiated by farmers to explore the use of compost, increasing the use of leguminous trees, and promoting soil conservation.

## Local community activities

The relationship with the local community is essential for carrying out this project. During 2011, Earthwatch community engagement activities focused on a series of sustainability workshops delivered as part of the Sustainable Coffee Leadership program. In addition, farmers in the community supported the field research activities and educational activities provided to volunteers. In 2012, we expect to promote a participatory -action research approach with the community of farmers.

## Dissemination of research results

### Scientific peer-reviewed publications

In 2011 the following publications were completed.

Castro, S.,Dietsch, T.V., Ureña, N.,Vindas, L.,Chandler, M. Forthcoming. Analysis of management and site factors to improve the sustainability of smallholder coffee production in Tarrazú, Costa Rica. *Ag. Eco Env*..

### Grey literature and other dissemination

Castro, S.,Chandler, N.W., Ureña, N., Dietsch, T.V. (2011) *Nitrogen -based fertilizer application on coffee agroecosystems: Effect on soil nutrients and possible long term impact on productivity*. Oral Presentation. 96th ESA Annual Meeting. Austin, Texas.

Castro, S., Ureña, N., Dietsch, T.V. (2011) *Above ground biomass and soil organic matter in coffee, pasture, and forest land-uses in a montane tropical landscape of Costa Rica*. Oral Presentation. 96th ESA Annual Meeting.

## SECTION THREE: Anything else


### Acknowledgements

We would like to acknowledge Dr. Arthur Riggs and the Arthur Rigg's Emerging Scientist Fellowship for funding. In addition, we would like to thank Starbucks Coffee for additional funding. Finally, it is important to recognize the support of CoopeTarrazú R.