Rainforest Alliance

EVALUATING THE RESULTS OF OUR WORK

Impacts of Rainforest Alliance Certification on Coffee Farms in Colombia

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Impacts of Rainforest Alliance Certification on Coffee Farms in Colombia

The Rainforest Alliance awarded its first Colombian coffee farm certification in 2004 through its local partner organization, Fundación Natura. By the end of 2009, more than 2,100 farms in Colombia, covering 12,400 hectares, had achieved certification—many of them concentrated in the Santander and Cundinamarca regions.[1] This rapid growth, combined with the longevity of many of the certificates and the presence of an accessible noncertified control group, created an opportunity for the Rainforest Alliance to examine the outcomes and impacts of its work in this region.

To this end, the Rainforest Alliance contracted Cenicafe,[2] a Colombian coffee research institute, to carry out four studies to evaluate the impacts of certification on water quality, soil quality, farmer livelihoods and arboreal mammals. The first three studies are farm-based, meaning that they compare a large sample of certified and noncertified farms. These three studies were carried out in the Colombian states of Santander and Cundinamarca. The fourth study examines the habits and movements of night monkeys and other arboreal mammals within their home ranges to draw conclusions about the usefulness of shaded coffee farms as habitat. This study was carried out in Santander.

Completed in 2010, the study results are summarized below and presented in detail in the body of this report, along with observations about the complexities of measuring impact.

1. Water quality and aquatic macro-invertebrates in streams on Rainforest Alliance Certified™ and noncertified farms in Santander and Cundinamarca

Researchers measured indicators of stream quality on 27 Rainforest Alliance Certified farms and 27 noncertified farms with streams that originated on the farm. Streams were sampled once during the harvest season and once off-season, at both the point of origin and the place where the stream left the farm. Researchers measured diverse indicators of water quality: structural indicators such as erosion and streamside vegetation, biological indicators such as the number of pollution-sensitive macro-invertebrate taxa, and chemical indicators such as dissolved oxygen and pH.

Results showed that in both regions, certified farms had significantly healthier streams than noncertified farms, as measured by the Streamside Visual Assessment Protocol (SVAP), a scoring system that takes into account the condition of the stream channel, vegetation and woody debris and water clarity, among other indicators. The percentage of the stream bank covered in vegetation—another indicator of stream health—was also significantly higher on certified farms.

In Cundinamarca, streams on certified farms contained significantly more pollution-sensitive macroinvertebrate species than those on noncertified farms (using both the EPT/ELPT[3] measure and the Biological Monitoring Working Party's scoring system), indicating higher water quality. In Santander, no difference in water quality was observed, but experts say that the severe drought in that region during the study period may have affected results.

Streams on certified farms in Cundinamarca had significantly higher dissolved oxygen and lower biological oxygen demand (BOD) than those on noncertified farms; in Santander, chemical oxygen demand (COD) was significantly lower on certified farms than noncertified. These results indicate higher water quality on certified farms.

2. Soil arthropod diversity, microbial activity and physical-chemical characteristics of soil on Rainforest Alliance Certified and noncertified farms in Santander and Cundinamarca

This study compared the soil characteristics of 52 Rainforest Alliance Certified farms and 52 noncertified farms. Researchers visited each farm once during the harvest season and once again during the non-harvest season. During each visit, researchers collected 20 samples of litter and 20 samples of soil.

Arthropods found in the samples were classified to family and then grouped into morphospecies.[4] Additional indicators such as shade tree species, relative humidity, nitrogen and organic matter were also measured.

A total of 36,288 soil arthropod specimens were collected in both regions, representing 1,147 morphospecies and 26 higher taxonomic groups. The groups with the highest number of morphospecies were Coleoptera (beetles), Formicidae (ants), Hemiptera (cicadas, hoppers, aphids) and Hymenoptera (wasps). Arthropod richness[5] was significantly higher on certified farms than on noncertified farms in both regions, which indicates better soil health on certified farms. No significant differences were found in measures of soil arthropod abundance,[6] arthropod diversity,[7] or soil chemistry.

Table 1
Number of examined variables that fell into each of the three performance categories (certified performed better, no difference, noncertified performed better). Variables were grouped into "types" for simplicity. Results for both regions are combined; see Table 13 for full results.

Variable Type	Certified Farms Performed Better	No Difference	Noncertified Farms Performed Better
Rate of best management practice implementation	16	4	0
Sustainability index (SI) score	7	3	0
Structural indicators of water quality	4	0	0
Biological indicators of water quality	3	3	0
Chemical indicators of water quality	4	10	0
Biological indicators of soil quality	2	6	0
Chemical indicators of soil quality	0	14	0
Economic viability	1	1	0

3. Identification of the economic and social advantages and disadvantages of the adoption of the Sustainable Agriculture Network standard in Santander and Cundinamarca

Researchers visited 72 certified and 72 noncertified farms an average of eight times each, recording data on farm demographics, rate of application of Best Management Practices (BMPs), and costs and benefits related to certification.

This study revealed that certified coffee farms implement best management practices related to water quality (e.g. use of septic tank), agrochemicals (e.g. use of protective equipment), solid waste (e.g. solid waste collected) and training (e.g. workers trained in first aid) at a significantly higher rate than noncertified farms. Certified farms again performed significantly better than noncertified farms in both regions when farm performance was converted into a single sustainability index.

In Santander, researchers found that the productivity of certified farms was twice as high as that of noncertified farms. Researchers calculated net revenue by subtracting each farmer's expenses (including certification costs) from his/her income from the production of agricultural crops. Results showed that in Santander, average net revenue was significantly higher on certified farms ($2,029 USD/hectare) than on noncertified farms ($813 USD/hectare). The prices that certified and noncertified farmers received for their coffee were also compared, but no significant difference was observed, indicating that the difference in net revenue is likely attributable to varying degrees of farm productivity. In Cundinamarca, no significant difference was observed between certified and noncertified farms, either in productivity or net revenue.

4. Ecological value of shade coffee for the conservation of night monkeys (*Aotus lemurinus*) and other arboreal mammals in Santander

In this study, researchers (1) radio tagged individuals from two groups of night monkeys to determine their habitat preferences in a landscape containing natural forest fragments and coffee grown under various shade densities, and (2) used food platforms and motion-sensitive cameras to determine mammal densities in natural forest fragments and coffee grown under various shade densities.

While night monkeys' natural habitat is forest, results show that they also spend significant amounts of time in coffee plantations with dense shade cover (in this study, 80 percent). Night monkeys also visited coffee plantations with medium shade cover (60-65 percent), but much less frequently. The most important foods from shade trees were the fruits of *Prunus integrifolia* and *Inga* spp., and the flowers of *Erythrina poeppigiana*. Other important species were *Cecropia* spp., *Citrus* spp. and *Myrcia* spp.

Researchers observed twelve species of arboreal mammals in natural forests, nine species in coffee farms with dense shade (> 80 percent) and two species on coffee farms with medium shade (60-80 percent). The researchers conclude that densely-shaded coffee plantations can serve as buffer for designated protected areas (such as the Yariguíes National Park, one kilometer away) by providing habitat for a variety of mammals.

Summary table

The findings of the three farm-based studies are summarized in Table 1. Taken together, they show that Rainforest Alliance Certified farms are performing better than noncertified farms in the implementation of BMPs, the multi-variable sustainability index, many structural and biological indicators of water quality, and economic viability. Soil quality was not different between treatments. There were no variables for which noncertified farms performed better than certified ones.

Introduction

Certification is a powerful mechanism for linking sustainable agricultural production to consumers interested in buying sustainably produced goods. For the Rainforest Alliance, the goals of this process are biodiversity conservation and improved farmer livelihoods. Yet the question of whether certification produces real environmental and socio-economic benefits is difficult to answer. The Biodiversity Conservation in Coffee (BCC) project, funded by the Global Environment Facility (GEF), implemented by the UNDP and executed by the Rainforest Alliance, aims to conserve biodiversity in coffee landscapes through sustainability certification and stimulate demand for certified coffee. To provide credible scientific evidence related to the outcomes and impacts of certified coffee production in Colombia, the Rainforest Alliance contracted Cenicafe,[8] a Colombian coffee research institute, to carry out four studies to evaluate how certification affects water quality, soil quality, farmer livelihoods and arboreal mammals.

This document summarizes the results of these four studies, which were completed in 2010, beginning with the following background information on certification and coffee production in Colombia. This is followed by a description of the study area and sampling approach for the four studies. The remainder of the document then describes the methods and results of each of the four studies.[9] Finally, the conclusion summarizes what this body of research reveals about the impacts of Rainforest Alliance certification on coffee farms, workers and biodiversity in Colombia— and highlights some ideas for future research.

How does sustainability certification work?

The foundation of Rainforest Alliance agricultural certification is the Sustainable Agriculture Network[10] (SAN) standard, which was developed by a group of farmers, scientists, conservation organizations and communities. Based on ten principles of sustainable agriculture, the standard provides a concrete measure against which environmental and social practices can be evaluated. Coffee farms that are in compliance with the SAN standard are awarded the Rainforest Alliance Certified™ seal of approval and can sell a specified quantity of product as Rainforest Alliance Certified. This certification seal travels with the product up the chain-of-custody to the consumer, verifying that it was produced following sustainable farming practices. Certified farms are audited annually to ensure continued compliance with the SAN standard.

Measuring the outcomes and impacts of certification

A rigorous examination of an intervention's outcomes and impacts requires that the treatment group—in this case, certified farms—be compared to a counterfactual—a measure of what might have occurred in the absence of certification. Establishing a counterfactual that takes the true measure of what would have occurred in the absence of certification is difficult for many reasons. Self-selection bias occurs when the two treatment groups—in this case, certified and noncertified–are not selected in a truly random fashion. For example, farms that already comply with most of the certification requirements might be more inclined to pursue certification, since there is little or no additional cost for compliance; conversely, farms with poor practices might be less inclined to pursue certification. The result is a self-selection bias. In a biased sample, many of the impacts attributed to certification would have occurred even in the absence of certification. Statistical modeling approaches, such as propensity score matching, can help address this issue.

Ideally, in addition to the presence of a noncertified control group, an impact study will also collect baseline data from both treatment groups pre-intervention. Unfortunately, for the majority of certification impact studies, the collection of baseline data is extremely difficult. This is due to the typically short window of time between the farmer's decision to pursue certification and the implementation of practices to bring the farm into compliance with certification standards.

The three farm-level studies presented here have no baseline, but each has a counterfactual; that is, they compare randomly selected certified farms with randomly selected noncertified farms but do not examine the situation before certification. Due to the low density of night monkeys, the mammal study uses a different methodology, described in detail later in this report.

The Sustainable Agriculture Network Standard and coffee production in Colombia

Since the early 1900's the cultivation of coffee has been an important source of income for rural farmers in Colombia, dramatically modifying natural landscapes by replacing native ecosystems with semi-natural agricultural ones. Although the natural forests that once blanketed this region contained higher levels of biodiversity, a landscape dominated by an agroforestry crop such as coffee does support more biodiversity than most other agricultural land uses. And through the adaptation of certain best management practices, the biodiversity conservation capacity of a coffee-dominated landscape can be significantly improved with little or no loss in its capacity to generate revenue.

The SAN has developed standards that promote efficient and productive agriculture, biodiversity conservation and sustainable farm livelihoods. The Rainforest Alliance certification system is based on the SAN Standard.[11]

Some elements of the SAN Standard that support

Table 2
Four studies carried out by Cenicafe

Topic	Study Name	Research Scientist(s)
Water quality	Water quality and aquatic macro-invertebrates in Rainforest Alliance Certified and noncertified farms in Colombia	Luis Miguel Constantino; Luz Angela Galindo
Soil arthropod diversity	Soil arthropod diversity, microbial activity and physical-chemical characteristics in certified and noncertified farms in Colombia	Luis Miguel Constantino; Luis Gabriel Perez
Socio-economic impacts	Identification of the economic and social advantages and disadvantages of the adoption of the Rainforest Alliance coffee certification standard in Colombia	Cesar Serna
Mammals	Ecological value of shade coffee for the conservation of night monkeys (*Aotus lemurinus*) and other arboreal mammals in Santander, Colombia *Part 1:* Use of shade coffee plantations by two groups of night monkeys *Part 2:* Richness of arboreal mammals in coffee farms and natural forest fragments	Adriana Guzman

the conservation of biodiversity are:

- Identification and protection of all existing natural ecosystems
- Protection of aquatic ecosystems, including the maintenance of buffers of natural vegetation
- Maintenance of at least 12 native species per hectare and a canopy of 40 percent for agroforestry crops
- Restrictions on hunting wildlife within the farm
- Implementation of a plan to maintain and restore connectivity of natural ecosystems
- Appropriate treatment of wastewater and a prohibition on the discharge of industrial or domestic wastewater into natural water bodies without demonstrating that discharge complies with legal requirements
- Implementation of an integrated pest management program based on ecological principles
- Reduced use of agro-chemicals and the elimination of those chemicals identified by the World Health Organization as being most toxic (Classes Ia and Ib)
- Soil erosion prevention and control

With regards to livelihoods, the SAN Standard includes the following certification criteria (among others):

- Commitment to comply with labor laws and international agreements
- Nondiscrimination, in labor and hiring policies, on the basis of race, gender, age, religion, social class, political views, nationality, syndicate membership or sexual orientation
- Wages greater than or equal to the regional average
- Respect of workers' right to organize and negotiate
- Guaranteed worker housing with facilities for bathing and cooking, as well as access to potable water
- Worker access to medical services and access to education for school-age children
- Use of personal protective equipment
- Implementation of an occupational health and safety program
- Proper use and storage of agrochemicals to reduce the risk of accidents and negative impacts on human health
- Contribution of farms to economic development of local communities through training and employment

Cenicafe Studies

Under the guidance of Biological Conservation Program Coordinator Dr. Jorge Eduardo Botero,[12] the Colombian National Center for Coffee Research (Cenicafe) conducted four studies to evaluate the impacts of Rainforest Alliance certification requirements on different aspects of biodiversity and livelihoods (Table 2).

Study area

The states of Cundinamarca and Santander were chosen for these studies because both have coffee farms that have been Rainforest Alliance Certified for at least three years prior to this study. SAN member Fundación Natura Colombia conducted all certification assessments and annual audits. Coffee farms in both areas are located between 1,200 and 2,000 meters above sea level and receive an annual precipitation between 1,400 and 2,300 mm, although there is much variation within each state. Coffee is cultivated on slopes from 12 percent to 100 percent. Soils are generally rocky and thin with little organic matter. In Santander the dry season is longer (between June and August), and farmers have traditionally protected coffee plants from the sun with shade trees. The main harvest in Santander occurs between September and November; in Cundinamarca the main harvest

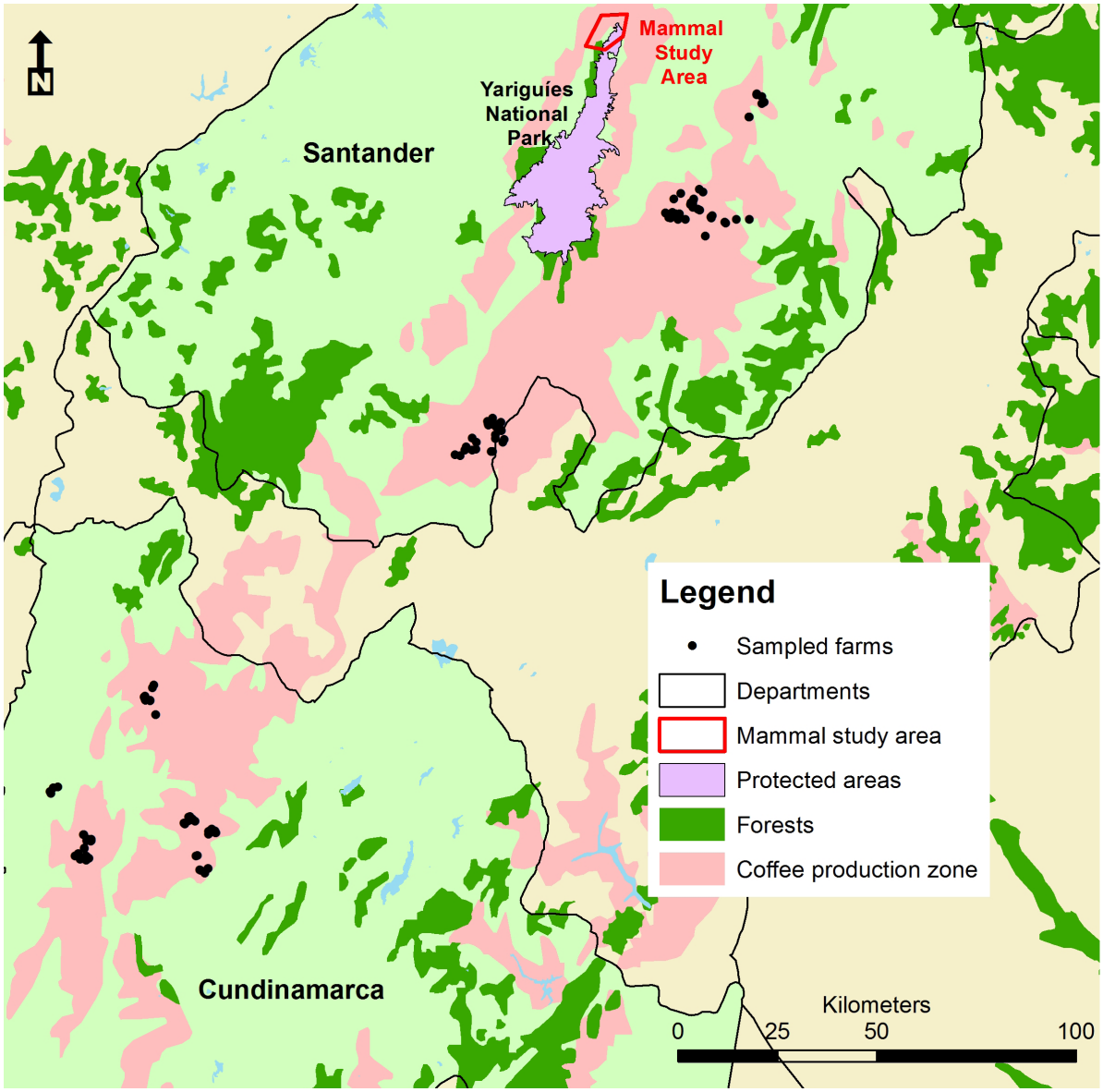


Figure 1
Location of sampled farms and mammal study areas

is from April to June, with an intermediate harvest between September and November.

Figure 1 shows the Cundinamarca and Santander regions, the locations of sampled farms and the mammal study area.

Sample selection for farm studies

The first three studies in Table 2 (referred to collectively as the "farm-based studies") all use a similar experimental design to compare certified and noncertified farms, and they share many of the same farms in their respective samples. To establish these samples, researchers first randomly selected 36 certified farms in each of the two states, and then, for each certified farm, selected the nearest noncertified farm with a similar size, topography and elevation as a control. The Colombian National Coffee Growers Federation's Coffee Production Information System (abbreviated as SICA in Spanish), which is a register of all coffee farms in Colombia, provided information on all the farms in the study areas, including the location, area, variety and date planted, as well as the certification status of each parcel. This information allowed the researchers to identify pairs of similar farms.

The samples for all three farm-based studies were obtained from this global set of 144 farms (72 in Cundinamarca and 72 in Santander). The different selection and sampling requirements of each study, combined with the logistical issues associated with sampling certain farms, meant that not all the 144 selected farms were included in all studies. Most notably, only farms with a water source originating on the farm were included in the water quality study. The final sample sizes of the three farm studies are presented in Table 3.

Sample selection for mammal studies

The mammal study was different from the farm studies in that night monkeys are so rare that a random sample of certified and noncertified farms

Table 3
The number of certified and noncertified farms sampled for each study by state.

Study	Cundinamarca		Santander	
	Certified	Noncertified	Certified	Noncertified
Water quality	13	13	14	14
Soil arthropod diversity	26	26	26	26
Socio-economic impacts	36	36	36	36

would almost certainly reveal too few animals for a valid comparison. Therefore, the approach used for this study was to first find groups of night monkeys in the Santander region, and then use radio telemetry to determine how each group uses the available habitat, which consists of coffee plantations with light shade, coffee plantations with heavy shade, and forest fragments.

Water quality and aquatic macro-invertebrates in Rainforest Alliance Certified and noncertified farms in Santander and Cundinamarca

The SAN standard contains three principles and several criteria that aim to ensure good water quality on certified farms (see text box). These include appropriate treatment of wastewater, conservation of streamside habitat and restrictions on the use of certain agro-chemicals known to be extremely damaging to the environment. While one would expect these stringent requirements to improve water quality, the few studies that address this issue tend to focus on the implementation of water-related best management practices (BMPs) rather than on-site measurements of water quality. The present study was designed to help fill this gap.

Methodology

To determine whether Rainforest Alliance certification improves water quality, researchers measured indicators of stream quality on 27 certified and 27 noncertified farms containing streams that originated on the farm. Each stream was sampled at the origin and at the place where it left the farm. All farms were sampled twice: once during the harvest season (when coffee beans are processed on the farm) and once during the non-harvest season. The variables measured included: 1) macroinvertebrate abundance and richness; 2) stream bed and riparian area integrity; and 3) physical and chemical measures of water quality, such as turbidity, dissolved oxygen and pH.

SAN principles especially relevant to water quality:

Principle 2. Ecosystem conservation

Principle 4. Water conservation

Principle 8. Integrated crop management

Principle 10. Integrated waste management

To sample a stream, biologists agitated the stream substrate and used fine mesh nets to collect macroinvertebrates. These specimens were then taken to the laboratory, where they were separated and identified down to the taxonomic family and morphospecies[13]. From these specimen data the abundance (total number of specimens) and species richness (the total number of morphospecies) were tallied for each farm and summarized by farm type (certified and noncertified) and state.

Two bioindicators specifically designed for assessing water quality were then applied to the macroinvertebrate data. The Biological Monitoring Working Party (BMWP) has assigned each macroinvertebrate family a score of 1 to 10 based on its tolerance to contamination, with a higher score indicating less tolerance and, hence, better water quality. By adding up the scores corresponding to the macroinvertebrate families found in a given stream sample, researchers create an indicator of that stream's water quality.

The second bioindicator, EPT/ELPT, is very similar except that it is based on the taxonomic orders that are known to be very intolerant to contamination. EPT corresponds to the orders

Table 4
Total abundance and richness of morphospecies collected in Cundinamarca and Santander. The direction of the arrows in the Water Quality column indicates which type of value (higher or lower) signifies better water quality.

Variable	Units	Water Quality	Cundinamarca		Santander	
			Certified	Non-certified	Certified	Non-certified
Species abundance	number of specimens	↑	3,934	3,043	2,536	1,731
Species richness	number of species	↑	212	204	115	67

Variable	Units	Water Quality	Cundinamarca			Santander		
			Certified Average	Noncert. Average	Probability[14]	Certified Average	Noncert. Average	Probability
SVAP	index	↑	8.8*	6.56*	< 0.001	7.78*	5.59*	0.005
Vegetation cover	%	↑	74.00*	57.08*	0.011	76.20*	57.65*	0.011
BMWP	index	↑	118.46*	71.73*	< 0.001	65.00	48.87	0.093
EPT	# species	↑	6.12*	4.34*	0.040	3.54	2.18	0.131
ELPT	# species	↑	6.23*	3.76*	0.009	4.83	3.23	0.173
Water hardness	mg/l cd CaCO3	↓	16.30	95.07	0.377	10.56*	2.22*	0.011
Dissolved oxygen	ppm	↑	6.45*	4.47*	0.027	3.39	3.32	0.938
Temp.	° C	↓	20.05	20.13	0.204	19.96	19.41	0.639
pH	pH	↑	5.64	5.59	0.191	6.26	5.99	0.738
Suspended solids	ppm	↓	27.69	23.60	0.681	0.14	0.10	0.211
Flow	l/sec	↓	0.20*	0.12*	0.039	0.06	0.06	0.833
COD[15]	ppm	↓	39.81	25.99	0.357	20.33*	39.90*	0.026
BOD	ppm	↓	5.36*	5.83*	0.015	10.41	11.74	0.693

Table 5
Macroinvertebrate, stream integrity and water quality results for 27 certified and 27 noncertified coffee farms in Cundinamarca and Santander. An asterisk identifies statistically significant differences ($p \leq 0.05$) between certified and noncertified farms. The direction of the arrows in the Water Quality column indicates which type of value (higher or lower) signifies better water quality.

Ephemeroptera, Plecoptera and Trichoptera, while ELPT represents the orders Coleoptera, Elmidae, Plecoptera and Trichoptera. In both cases, the index is the number of morphospecies in these orders. A higher number of EPT/ELPT species indicates better water quality.

Stream bed and riparian area integrity were assessed using the Stream Visual Assessment Protocol or SVAP (NWCC, USDA, NRCS 1998), a methodology promoted by the US Department of Agriculture. This protocol applies a scoring system that takes into account the condition of the stream channel, vegetation and woody debris, water clarity and other variables that can be assessed visually without high-tech instruments. A higher SVAP score indicates better water quality.

Finally, laboratory analyses of water samples on certified and noncertified farms were conducted to determine a series of physical/chemical properties of each sample, such as suspended matter, water turbidity, water color, pH and dissolved oxygen.

Results

A total of 11,244 macroinvertebrate specimens were collected at all 54 streams. These specimens were distributed in 35 orders, 114 families and 353 morphospecies. The majority of organisms were found at the water source (as opposed to the place where the stream left the farm), possibly because the stream source usually supplies the farm with clean water and is therefore protected more stringently by the farm manager. More macroinvertebrates were found during the wet (non-harvest) seasons than in the dry season; however, according to project biologists an unusually dry period in Santander resulted in a lower number of specimens than would have normally been expected (Table 4). The major results from the stream bed and riparian area integrity, and water quality are presented in Table 5.

Certified farms in Cundinamarca contained significantly higher numbers of EPT/EPLT species and higher BMWP indices than noncertified farms, both of which indicate better water quality.

In both regions, the SVAP index was higher for certified farms than noncertified, indicating that streams on certified farms showed more evidence of good stream condition than those on noncertified farms. Certified farms in both regions had significantly higher amounts of streamside vegetation, a sign of stream health.

The various physical and chemical analyses of water quality revealed important differences between certified and noncertified farms. Certified farms in Cundinamarca had significantly higher amounts of dissolved oxygen and lower biochemical oxygen demand (BOD), while certified farms in Santander had significantly lower amounts chemical oxygen demand (COD). These significant differences all indicate higher water quality on certified farms. One variable that did not follow this trend was water hardness in Santander, which was greater for certified farms (indicating poorer water quality).

Discussion

This study found that, in the state of Cundinamarca, certified farms had better water quality, as evidenced by better SVAP scores, more vegetation cover, more contamination-sensitive species (BMWP, EPT, ELPT), more dissolved oxygen (BOD) and a higher flow rate. Taken together, this suite of variables provides compelling evidence that streams flowing through certified coffee farms in Cundinamarca have higher water quality than those flowing through noncertified farms.

In Santander, certified farms had a significantly higher SVAP score, vegetation cover and levels of dissolved oxygen. Researchers suggested that the drought occurring in Santander during the study period could have masked additional differences and should be considered when interpreting results.

Soil arthropod diversity, microbial activity and physical-chemical characteristics in certified and noncertified farms in Santander and Cundinamarca

The SAN standard requires practices that are known to improve soil health and support long-term agriculture production.[16] These practices include soil erosion prevention, judicious and limited use of chemicals for fertilization and pest control, maintenance of vegetative ground cover and, in the case of coffee, the maintenance of a tree canopy. Arthropod fauna occurring in the soil are sensitive to the soil texture, structure and fertility, making them good indicators of soil health in productive agro-ecosystems. This study compares arthropod[17] diversity and a range of other soil variables in Rainforest Alliance Certified and noncertified coffee farms.

Methodology

This study compared 52 Rainforest Alliance Certified and 52 noncertified farms in Cundinamarca and Santander. At each farm, 20 samples of litter and 20 samples of soil at a depth of 10 cm were collected. All samples were sifted and placed in "Winkler bags" for 48 hours to separate the arthropods from the other materials. Winkler bags are tapered such that, when hung, the

Figure 2
A Winkler bag, used to separate arthropods from other materials

arthropods separate from the other sampled materials and accumulate in an ethanol-filled container (see Figure 2). The specimens collected were classified by order and family and then grouped into morphospecies. This process was carried out once during the harvest season and once again during the non-harvest season.

In addition to the classification of arthropods, physical and chemical analyses of each sample were carried out. Specifically, the following variables were measured:

- Arthropod richness, abundance, composition and diversity
- Jaccard similarity index, to compare farms using a presence-absence matrix for each species found
- Fertility analysis and soil texture
- Bulk density and relative humidity
- Microbial activity based on CO_2 fixation

Farm managers were also surveyed to determine which conservation and soil management practices

SAN principles especially relevant to soil health:

Principle 2. Ecosystem conservation

Principle 8. Integrated crop management

Principle 9. Soil management and conservation

State	Certified	Non-certified	Probability
Cundinamarca	54%	47%	0.221
Santander	68%	62%	0.171

Table 6
Average percent shade cover of coffee plantations in the two states and between certified and noncertified farms

they employ, and which fertilizers they use. Shade cover on the coffee farms was also measured.

Results

Characterization of sampled farms

While no significant differences were found in the percentage of shade cover between certified and noncertified farms in either state (Table 6), the farms in Santander were found to have greater shade (probability < .001) than those in Cundinamarca. Independent of certification efforts, coffee farmers in Santander have traditionally grown coffee under a shade canopy to protect the plants from the intense rays of the sun and conserve moisture. In Santander, the most widely used shade cover tree is *guamo* (*Inga* spp.), due to its quick growth, cover and edible pods. In Cundinamarca, laurel (*Cordia alliodora*) and cedar (*Cedrela* spp.) were the most popular species because of their high value for timber.

With regards to fertilization practices, it was found that coffee farmers use a wide variety of chemical and nonchemical fertilizers (Figures 3 and 4). Because researchers did not collect data on the quantity or frequency of fertilizer application, the figures below present a very broad-brush picture of fertilizer use.

While no statistical tests were done on these data, Figure 3 shows that in Cundinamarca, more noncertified farmers use urea, a type of fertilizer that has an acidifying effect, while certified farmers use more coffee pulp. This finding suggests that many certified farmers in that region are managing the soil nutrition on their farms using natural fertilizers rather than synthetic.

Arthropod and soil variables

In the two states 36,288 arthropod specimens were collected, representing 1,147 morphospecies and 26 higher taxonomic groups. The groups with the highest number of morphospecies were Coleoptera, Formicidae, Hemiptera and Hymenoptera (Table 7).

A comparison of the combined number of morphospecies on certified and noncertified farms in each region is shown in Figure 5. While there were more morphospecies found on the certified farms than the noncertified farms in both regions, these differences are not statistically significant (Table 7).

The descriptive statistics presented in Table 8 compare the certified and noncertified farms in the two states. The values for most variables are greater on

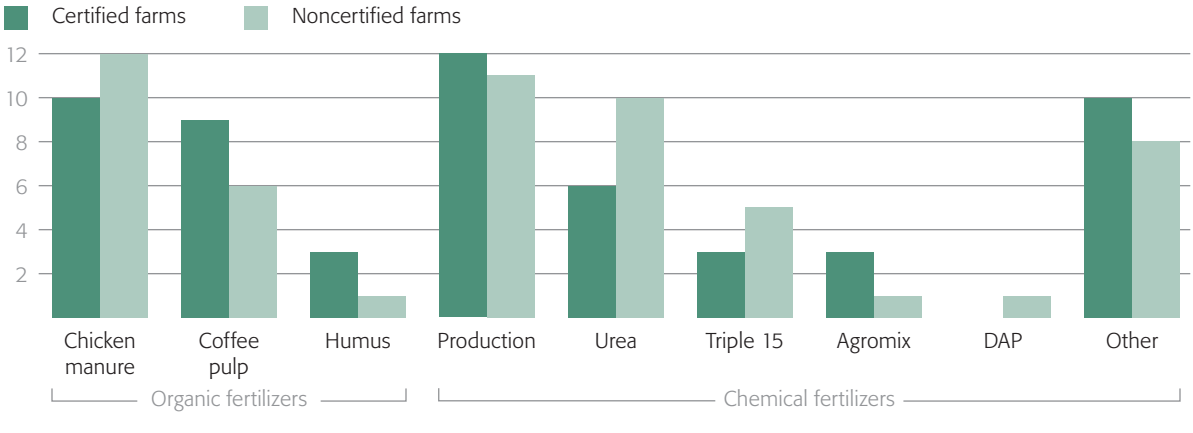


Figure 3
Number of certified farms and noncertified farms in Cundinamarca that use each type of fertilizer. Farmers could choose more than one fertilizer type. "Production" here and in Figure 4 refers to the standard fertilization of 240 kg N, 40 kg PsO_5 and 240 kg of K_2O per hectare per year.

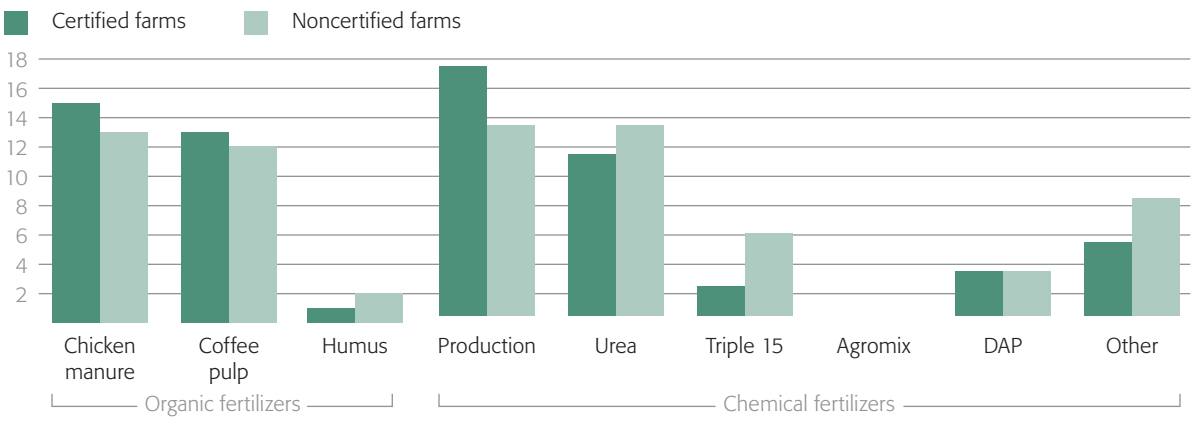
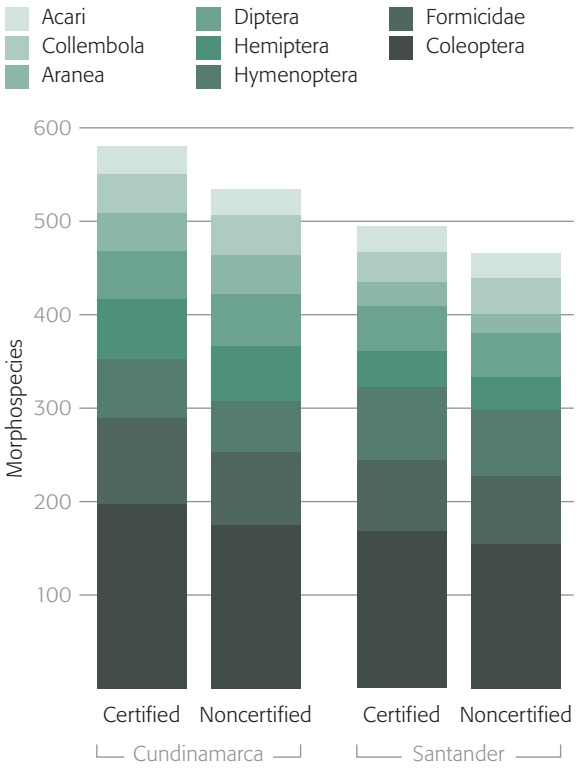


Figure 4
Number of certified farms and noncertified farms in Santander that use each type of fertilizer. Farmers could choose more than one fertilizer type.

Table 7
Number of morphospecies of the eight most abundant taxonomic groups found on farms in Cundinamarca and Santander. Due to their abundance and diversity, the ants (Formicidae) are tabulated separately from the other insects in the class Hymenoptera.

Taxonomic Group	Class	Common Name	Cundinamarca		Santander	
			Certified	Non-certified	Certified	Non-certified
Coleoptera	insect	beetles	197	175	168	155
Formicidae	insect	ants	92	78	77	72
Hymenoptera (except ants)	insect	bees and wasps	64	54	78	71
Hemiptera	insect	true bugs	64	59	38	35
Diptera	insect	flies	51	56	48	47
Aranea	arachnid	spiders	41	42	26	21
Collembola	insect	springtails	41	42	32	38
Acari	arachnid	mites and ticks	31	28	28	27

Figure 5
The number of morphospecies found in the eight most represented taxonomic groups in certified and noncertified farms in Santander and Cundinamarca



the certified farms; however, only species richness showed statistically significant differences ($p \leq 0.10$).

Discussion

The results obtained here help establish a baseline for the monitoring of soil arthropods in coffee ecosystems. Arthropod richness was found to be significantly higher on the certified farms in both regions ($p \leq 0.10$). No significant differences in arthropod abundance or diversity, or in soil chemistry, were found between certified and noncertified farms. Future research should determine whether this lack of significant difference is due to the inability of the BMPs to produce detectable changes in the variable measured, or by possible confounding factors, such as the sample size, the short time since certification (less than four years), or the adoption of certification BMPs by noncertified farmers. A research design that spans a longer time frame, includes more farms, and measures the implementation of BMPs on certified and noncertified farms would determine whether these factors were masking differences.

Identification of the economic and social advantages and disadvantages of the adoption of the Sustainable Agriculture Network coffee certification standard in Santander and Cundinamarca

Among the potential benefits of Rainforest Alliance certification are improved coffee farmer and worker livelihoods. These socioeconomic impacts are studied here through a survey of certified and noncertified coffee farmers.

Methodology

During 2008 and 2009, a sample of 72 farms in Cundinamarca and 72 farms in Santander were surveyed. On average, each farm was visited eight times. The first visits familiarized the farmers with the objectives of the study and the role they would play. The farmers were given a calculator, notebook, pencils and instructions on how to tabulate

SAN principles especially relevant to farmer livelihoods:

Principle 5. Fair treatment and good working conditions for workers

Principle 6. Occupational health and safety

Principle 10. Integrated waste management

Variable	Units	Cundinamarca			Santander		
		Certified Mean	Noncert. Mean	Proba-bility	Certified Mean	Noncert. Mean	Proba-bility
Arthropod abundance	# specimens	406.96	362.81	0.28	306.42	319.27	0.79
Arthropod richness	# species	104.96*	92.58*	0.057*	78.35*	70.27*	0.1*
Arthropod diversity	Shannon index	4.72	4.68	0.47	4.66	4.56	0.06
Percentage cover	%	0.54	0.47	0.22	0.69	0.62	0.17
Microbial activity	gm CO_2	0.61	0.6	0.95	0.49	0.43	0.32
Relative humidity	%	25.05	22.72	0.23	26.62	27.62	0.81
pH	pH	5.52	5.42	0.65	4.93	4.99	0.8
Nitrogen	%	0.47	0.44	0.55	0.47	0.47	0.95
Organic matter	%	12.63	11.53	0.54	13.16	12.6	0.8
Potassium	cmol/kg[18]	0.68	0.79	0.52	0.64	0.54	0.54
Calcium	cmol/kg	10.5	9.04	0.51	10.43	9.89	0.88
Magnesium	cmol/kg	2.71	2.57	0.78	1.55	1.61	0.87

Table 8
Results of statistical tests comparing arthropod and soil variables on certified and noncertified coffee farms in Cundinamarca and Santander. Stars indicate statistically significant differences ($p \leq 0.10$).

the information requested for the study.

The data collected in the survey can be grouped as follows:

- Social: land tenure, farm characteristics, farmer and family demographics, housing, conditions for farm laborers, farmer perceptions of certification
- Technological: coffee varieties, planting techniques, weed and disease control, use of shade, coffee processing
- Environmental: land conservation, protection of water sources, agrochemical use, waste disposal, burning policy, erosion control
- Economic: costs related to each stage of coffee production, certification costs, revenue from coffee production

Researchers used data from the year 2009 and ensured that it covered a full annual production cycle.

The data collected by the farm survey were intended to answer three questions:

- Do Rainforest Alliance Certified coffee farms implement agricultural BMPs at a different rate than noncertified farms?
- Can the survey data on farm characteristics and performance be rolled up into a single 'Sustainability Index (SI)' for each farm, and if so, how do SI values differ between certified and noncertified farms?
- What are productivity rates and net revenue (income from coffee sales minus expenses incurred, including certification costs) on certified and noncertified farms?

Results

Compliance with the SAN standard

To assess compliance with the SAN standard, researchers determined the number of certified and noncertified farms that implemented certain BMPs related to the SAN standard (see Table 9). In all cases where there was a significant difference between certified and noncertified farms, the certified farms outperformed the noncertified farms.

Information about gender, salary and working hours are shown in Table 10. No significant differences were found between these variables on certified and noncertified farms.

Sustainability analysis

The sustainability analysis applied the methodology described by Sepúlveda (2008) to create an index

Table 9
Percentage of certified and noncertified farms implementing various agricultural best management practices. An asterisk identifies statistically significant differences ($p \leq 0.05$) between certified and noncertified farms. Note that Rainforest Alliance certification requires that farms comply with 80% of the total criteria and 100% of the 'critical criteria.'

	Cundinamarca		Santander	
Variable	**Certified**	**Noncertified**	**Certified**	**Noncertified**
Use of septic tank	58*	14*	53*	17*
No agro-chemicals used	22	31	31	25
Employ service for the recollection of solid wastes	33*	17*	61*	31*
No burning of agricultural residues	94*	33*	97*	47*
Warehouse specialized for the storage of chemicals	36*	8*	19*	0*
Use of protective equipment for working with chemicals	30.6*	8.3*	53.8*	8.3*
Training provided in recycling	31*	3*	93*	24*
Training provided in first aid	59*	7*	93*	24*
Training provided in correct use of pesticides	69*	14*	93*	14*
No hunting of wild animals	100	100	100	94

between 0 and 1 for each farm, with a higher value indicating higher sustainability. Researchers first submitted each variable to several analyses, such as independence tests and correlation analysis, to identify a minimum set of variables for further processing. They then calculated separate 'dimensional' sustainability index (SI) values for each of the four dimensions (social, technological, environmental and economic).

The SI values for each farm permitted the comparison of the farms, regions and certification status for each of the dimensions. Researchers then combined these four SI values into a single "integrated sustainability index" (ISI) for each farm by taking a weighted average of the four dimensional indices. The weights assigned to each SI were determined in consultation with a group of academics with expertise in this field, and were 0.3, 0.1, 0.4, 0.2 for the social, technological, environmental and economic dimensions, respectively. The values for the four individual SIs and the ISI are shown in Table 10.

An Analysis of Variance found that SI values vary significantly between certified and noncertified

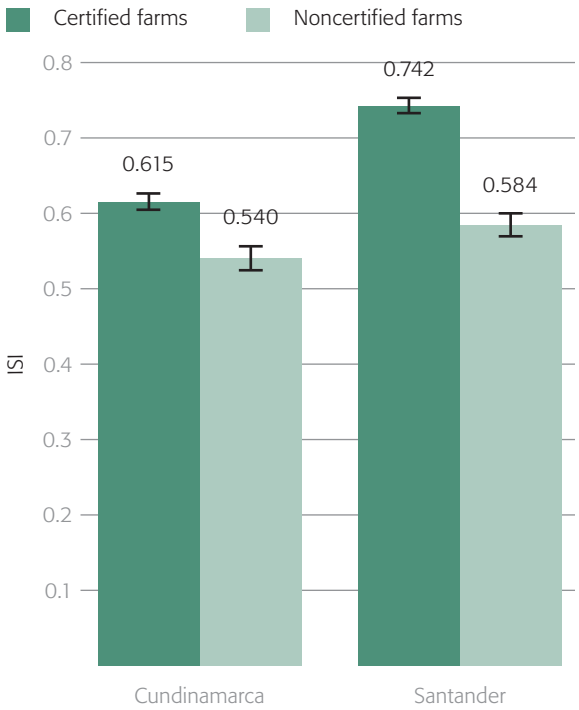
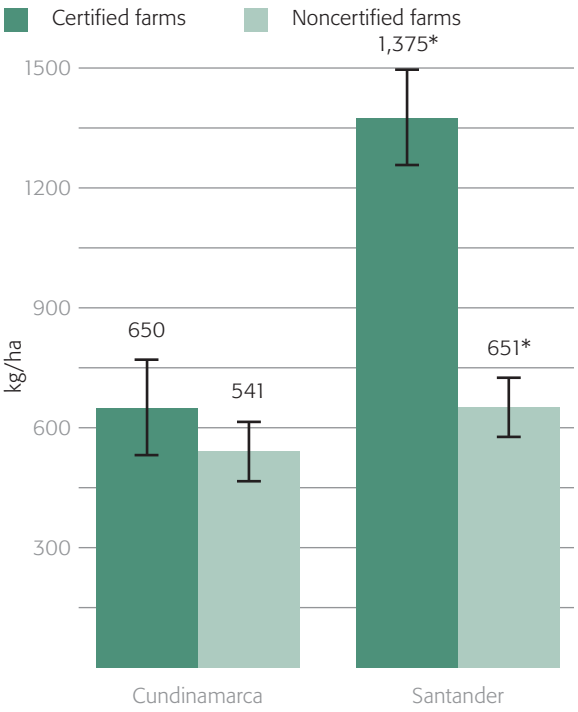


Figure 6
Comparison of Integrated Sustainability Index values on certified and noncertified farms, in Cundinamarca and Santander. Higher ISI values indicate higher sustainability. Standard error bars are shown; differences between ISI values on certified and noncertified farms were statistically significant ($p \leq 0.05$) in both regions.

Table 10
Gender, salary and working hours on certified and noncertified coffee farms. Differences are not statistically significant

	Cundinamarca		Santander	
Variable	**Certified**	**Noncertified**	**Certified**	**Noncertified**
Female producers (%)	17	14	25	25
Daily salary (includes lunch) in USD[19]	7.08	7.43	6.19	6.43
Hours worked/day	8.4	8.7	8.1	8.2



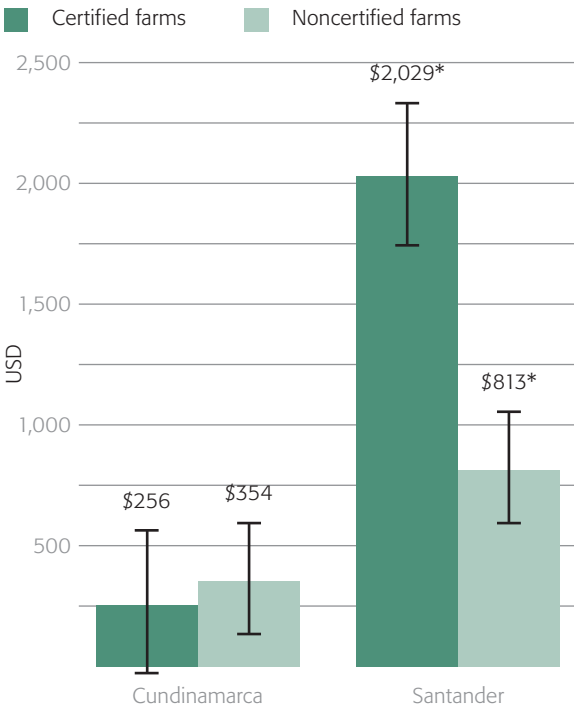


Figure 7
Coffee production (kg/ha) for certified and noncertified operations in Cundinamarca and Santander. Standard error bars are shown. Stars indicate statistically significant differences ($p \leq 0.05$).

Figure 8
The net revenue per hectare for certified and noncertified operations in Cundinamarca and Santander. Standard error bars are shown. Stars indicate statistically significant differences ($p \leq 0.05$).

farms for all dimensions in Santander, and for the environmental dimension in Cundinamarca (Table 11 and Figure 6). ISI values were also significantly different between certified and noncertified farms for both regions, indicating that certified farms were performing at a higher level of sustainability.

Production and Net Revenue

To understand differences in the financial performance of farms, researchers examined coffee production (kg/ha) and net revenue.[20] The net revenue is calculated as the farm's income from the production of agricultural crops minus the expenses incurred, including the expenses related to Rainforest Alliance certification.

Figure 7 compares coffee production on certified and noncertified farms. In Santander, certified farms produced over twice as much coffee as noncertified farms ($p=0.0012$), while production in Cundinamarca is similar regardless of certification status ($p=9.60$).

As shown in Figure 8, certified farms generate more than twice as much revenue as noncertified farms in Santander, a difference that is statistically significant ($p=0.017$). In Cundinamarca, no significant differences in net revenue were observed between certified and noncertified farms ($p=0.77$).

Discussion

This study revealed that certified coffee farms implement BMPS related to water quality, agrochemicals, recycling and solid waste disposal at a significantly higher rate than noncertified farms. When implementation rates for these variables were converted into a single sustainability index, certified farms again performed significantly better than noncertified farms in both regions.

In Santander, net revenue was significantly higher on certified farms than noncertified farms, with certified farms earning a net revenue of $2,029 per hectare, compared with $813 per hectare for noncertified farms. No significant difference was found on farms in Cundinamarca. The net revenue

	Cundinamarca		Santander	
Dimension	**Certified**	**Noncertified**	**Certified**	**Noncertified**
Social (SI)	0.619	0.579	0.859*	0.588*
Technological (SI)	0.510	0.446	0.670*	0.484*
Environmental (SI)	0.730*	0.640*	0.691*	0.580*
Economic (SI)	0.433	0.398	0.704*	0.636*
Integrated (ISI)	0.615*	0.540*	0.742*	0.584*

Table 11
The dimensional sustainability index (SI) values and integrated sustainability index (ISI) averaged for certified and noncertified farms within each state. Higher SI and ISI values indicate higher sustainability.

Figure 9
Night monkey
photo by Joachim S. Müller

findings combined with the productivity findings suggest that increases in net revenue were due to higher productivity on certified farms, not due to a price premium for certified coffee.

Worker salaries and the number of hours worked did not differ significantly between certified and noncertified farms in either region. This is likely explained by Colombia's relatively stringent labor laws, with which all farms generally comply.

SAN principles especially relevant to the conservation of wildlife and their habitat:

Principle 2. Ecosystem conservation

Principle 3. Wildlife protection

Ecological value of shade coffee for the conservation of night monkeys (*Aotus lemurinus*) and other arboreal mammals in Santander

The requirement that coffee farmers maintain shade trees in coffee plantations is one way that Rainforest Alliance certification contributes to biodiversity conservation. Many wildlife species depend on the forest canopy for shelter and food. One such species is the arboreal Andean night monkey (*Aotus lemurinus*), which is categorized as "threatened" by the World Conservation Union (Defler et al. 2003, IUCN 2010). Occurring naturally in Andean forests above 1,000 meters in Colombia and Ecuador, the decline of this species has been attributed to the conversion of high-elevation forests to agricultural lands. Fortunately, these monkeys are able to survive in small forest fragments, as long as these fragments contain adequate foraging areas with tree cover.

Researchers hypothesize that shaded coffee plantations can provide foraging area for arboreal mammals. In this study,[21] they tested this hypothesis by:

1. observing the foraging habits of night monkeys that have access to both forest fragments and coffee plantations of varying shade cover; and
2. comparing the species richness of arboreal mammals in the following three habitat categories:
   - coffee farms with medium shade (50 percent – 60 percent cover)
   - coffee farms with dense shade (> 80 percent cover)
   - forest fragments

The relatively low density of night monkeys meant that the certified/noncertified comparison used in the three farm studies would likely yield too few individuals for a meaningful conclusion if applied here. Therefore, researchers chose to study two groups of night monkeys and observe their behavior in a landscape that contained a variety of habitats, ranging from forest fragments to coffee grown under different shade densities. The primary variable of interest was the amount of time each group

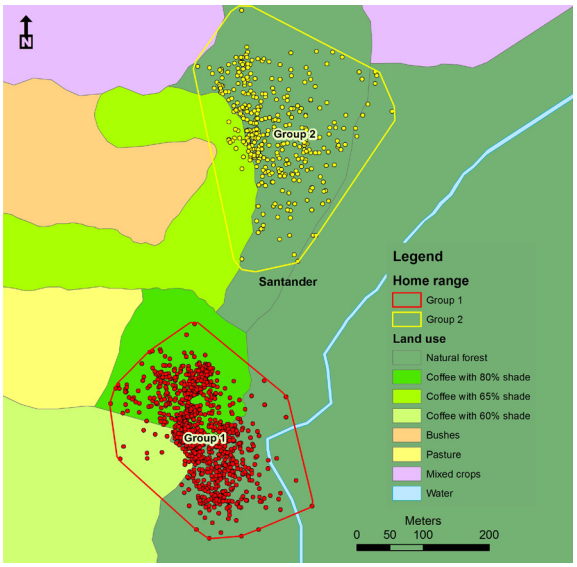


Figure 10
Night monkey observations with group home ranges and land use class. Each dot indicates the location of each group at 20 minute intervals.

	Group 1	Group 2
Number of months studied	16	7
Number of individuals in group	3	5
Number of monkeys collared	1	1
Mean distance traveled each night	600 m	603 m
Mean area occupied each night	1.1 ha	1.4 ha
Home range	6.6 ha	7.1 ha

Table 12
Characteristics of the two groups of night monkeys

of monkeys spent foraging in each habitat type.

The study of other arboreal mammals employed food platforms and motion-sensitive cameras to determine mammal densities in coffee plantations with medium shade, coffee plantations with dense shade, and natural forest fragments.

Mammal Study – Part 1: Use of forest fragments and shade coffee plantations by two groups of night monkeys

Methodology

A biologist monitored the foraging behavior of two groups of Andean night monkeys near the municipality of San Vicente del Chucurí, which is located one kilometer from the boundary of the Yariguíes National Park in Santander.

To locate and track the monkeys, one individual in each group was captured and equipped with a radio collar. Each group was monitored between the hours of 6 p.m. and 6 a.m. for five nights each month. Biologists recorded the groups' vertical and horizontal locations, behavior, and diet.The first group (Group 1) inhabited a natural forest beside a coffee plantation with an average canopy cover of 80 percent. It was monitored for 16 months (March 2009–June 2010). The second group (Group 2) inhabited a natural forest beside a coffee plantation with an average canopy cover of 65 percent and was monitored for seven months (December 2009–June 2010). During monitoring hours, the group's location was recorded every 20 minutes using a GPS. This permitted the calculation of the group's total distance traveled and area occupied each night using a GIS (see Figure 10).

To study the monkeys' behavior and diet, visual observations were made every two minutes during the period of 12–20 minutes, at which time the group's current activity was noted. If the group was foraging, the type of material eaten was also noted. The results of this analysis are presented as percentages in Figures 12 and 13, respectively.

The habitats occupied by the monkeys were studied by collecting data in one-hectare sample transects (20 m x 500 m). All trees with a diameter at breast height (DBH) greater than 2.5 cm were measured, and for fruiting trees, the abundance of fruit produced was calculated (dry kg/ha).

Results

Group 1 consisted of three monkeys. Originally, two monkeys in Group 1 (a female and a juvenile male) were fitted with radio collars, but unfortunately the tagged female died in December 2009. A new monkey joined the group soon thereafter; it was assumed to be a female due to its social interactions with the tagged juvenile male. Group 2 consisted of five individuals: two adults, two juveniles and one dependent infant. Group characteristics and some results are summarized in Table 12.

Habitat use

As shown in Figure 10, the home range of monkeys in Group 1 consisted of three habitats: natural forest, coffee farms with 80 percent shade cover, and coffee farms with 60 percent shade cover. Radio telemetry observations revealed that monkeys spent the majority of their time in natural forests (54 percent) and farms with 80 percent shade cover (44 percent). Monkeys rarely entered the coffee farms with 60 percent shade (2 percent) (Figure 11).

The home range of monkeys in Group 2 consisted of both natural forest and coffee farms with 65 percent shade. Here, the vast majority of observations (93 percent) occurred in natural forests, with the

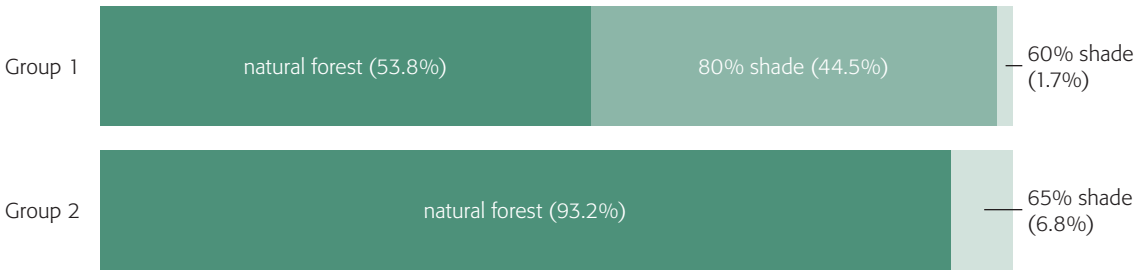


Figure 11
Percentage of time spent in each available habitat, by group

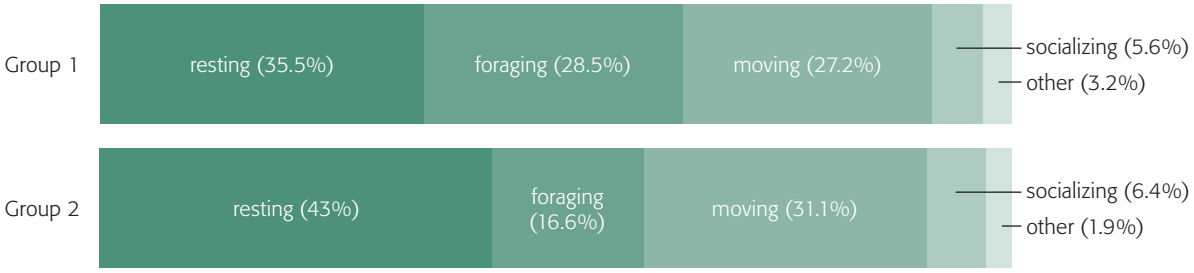


Figure 12
Use of waking time by two groups of night monkeys

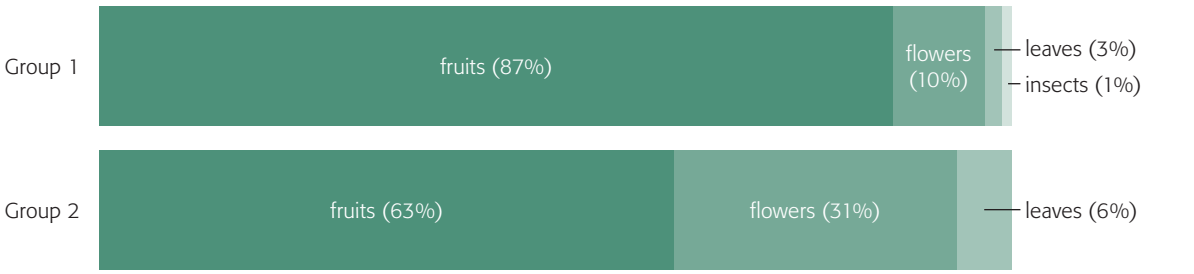


Figure 13
Time that night monkeys spent eating different foods, as a percentage of total foraging observations

remainder in the coffee plantation.

Although night monkeys have been shown to adapt to transformed habitats (Castaño et al. 2010), this study's results indicate that they spend the vast majority of their time in natural forest and coffee plantations with heavy shade. Coffee plantations with medium shade cover (60-65 percent) are used by night monkeys, but much less frequently (Figure 12).

Behavior

Monkeys in Group 1 spent 29 percent of their time foraging, compared with 17 percent for Group 2 (a statistically significant difference at $p \leq 0.05$) (Figure 12).

The diet of both groups consisted primarily of the fruits, flowers and leaves of 19 plant species (Figure 13). For Group 1, the most important foods from shade trees were the fruits of *Prunus integrifolia* and the flowers of *Erythrina poepiggiana*; for Group 2 they were fruits from *Inga* spp. and flowers from *E. poepiggiana*. Other important species were *Cecropia* spp., *Citrus* spp. and *Myrcia* spp.

Discussion

These findings suggest that although night monkeys prefer to inhabit natural forest area, they also spend significant amounts of time foraging in coffee plantations with dense shade cover (in this study, 80 percent). Monkeys did not seem to use the coffee plantations with medium shade cover (60–65 percent) nearly as frequently, even though this habitat was available in their home ranges.

Clearly, fruit trees are a critical part of the night monkey habitat. To provide good habitat for night monkeys, shade trees on coffee farms should offer high quality food resources, such as fruits with pulp, and trees that bear fruit at different times throughout the year to guarantee continual access to resources. Fruit-bearing shade trees that provide alternative income to farmers could be prioritized. For example, the tree *P. integrifolia* served as an important food source for Group 1 and can also provide timber for construction, industry floors, wagon bodywork and construction beams (Acero-Duarte 1985).

Mammal Study – Part 2: Richness of arboreal mammals in coffee farms and natural forest fragments

Methodology

Arboreal mammals were surveyed in three habitat types: coffee plantations with dense shade (canopy cover > 80 percent), coffee plantations with medium shade (canopy cover 60 percent to 80 percent) and natural forest fragments. A total of 13 platforms were constructed; five in dense shade, four in medium shade, and four in the natural forest. Bananas and guava (guayaba) were used to attract the animals, and camera traps recorded the mammals that visited each platform. Each platform was observed for a minimum of seven and a maximum of 15 days between February and September 2009.

The cameras recorded every visit made by an

Table 13
Summary results for each of the three habitat types studied

	Forest Fragment	Coffee Dense Shade (80%)	Coffee Medium Shade (60–65%)
Platforms	4	5	4
Species richness	12	9	2
Similarity with forest fragment	100%	67%	22%

Species (Latin name followed by Spanish common name)	**Forest Fragment**	**Coffee Dense Shade (80%)**	**Coffee Medium Shade (60–65%)**
Aotus lemurinus – mono nocturno	0.12	0.12	
Bassarycion gabbii – olingo	0.80	0.02	
Caluromys lanatus – aarigueya lanuda	1.02	0.62	
Coendou refescens – puerco espin	0.43	0.04	
Didelphis alviventris – zarigueya cariblanca	0.10	0.02	
Didelphis marsupialis – zarigueya comun	1.04	0.19	0.43
Nasua nasua – cuzumbo	0.14	0.10	
Potos flavus – perro de monte	0.10	0.06	
Marmosops sp. – zarigueyita	0.04		
Muride sp. – ratoncito de monte	0.04		
Sciurus sp. 1– ardilla colorada	0.39	0.19	0.09
Sciurus sp. 2 – ardilla gris	0.04		

Table 14
Capture rate (number of visits by individual or group/24 hours) for each species in the three habitat types studied

animal to the platform. After leaving the platform, the animal had to be absent for at least 40 minutes for its return to be counted as a new visit. For gregarious species, the group's visit was counted as a single visit. From these data the biologist calculated the species capture rate (the number of visits over 24 hours), species richness (number of mammal species observed at the platform), and the habitat Bray-Curtis similarity index. The results are presented in Table 14.

Results

After a total of 157 days of monitoring the platforms, 12 different species were recorded. The Common Opossum (*Dildelphis marsupialis*) and Western Wooly Opossum (*Caluromys lanatus*) visited the platforms most frequently (see Table 14).

Discussion

This study finds that shaded coffee plantations provide habitat for a variety of mammal species, and that plantations with denser shade (> 80 percent) have species richness closer to that of natural forest than plantations with medium shade (60–80 percent). The researchers conclude that densely-shaded coffee plantations can serve as buffer for designated protected areas (such as the the Yariguíes National Park, one kilometer away), by providing habitat for a variety of mammals.

Conclusions

The three farm-based studies presented in this report examine the effects of certification at both the outcome and impact levels. At the outcome level, the studies ask "Do certified coffee farms implement BMPs at a different rate than noncertified farms?" At the impact level, the studies ask "Are water quality, soil quality, and farmer livelihoods different on certified farms than on noncertified farms?" A third question, related to the relationship between a single BMP—shade cover—and the use of coffee farms as habitat for mammals, was asked in the mammal study.

BMP implementation rates were examined in the socioeconomic study. Researchers found that in both the Santander and Cundinamarca regions, eight BMPs related to agrochemicals, treatment of solid waste, and training were implemented at a significantly higher rate on certified farms than on noncertified farms (Table 15). Two BMPs showed no difference in implementation rates between treatment groups, and zero BMPs were implemented at a significantly higher rate on noncertified farms. Certification is therefore associated with better on-farm practices.

This conclusion draws support from the sustainability index analysis, whereby researchers rolled a large set of data on farm characteristics and performance into four thematic indices (environmental, social, economic and technical). They found that in Santander, all index scores were significantly higher on certified farms than noncertified farms.

In Cundinamarca, the environmental index score was higher on certified farms, and the other three

showed no difference. Most importantly, the integrated sustainability index, which takes all practices into account, was significantly higher on certified farms than on noncertified farms in both regions.

At the impact level, eight of the eleven structural, biological and chemical indicators of water quality in Cundinamarca were significantly higher on streams originating on certified farms than those on noncertified farms; the remaining three variables were the same on both types of farms. In Santander, three of the eleven indicators were higher on certified farms, and the rest revealed no difference; however, researchers warn that the unusual drought in the Santander region during the study period means that the results should be interpreted with caution.

Biological and chemical indicators of soil quality were essentially the same between certified and noncertified farms in both regions, with the exception of arthropod richness, which was higher on certified farms.

In terms of farmer livelihoods, both production rates (kg/ha) and net revenue on certified farms were more than double those on noncertified farms in Santander These values suggest that productivity increases are driving net revenue, especially in this case where no price difference between conventional and certified coffee was identified. Worker salaries and the number of hours worked were the same on certified and noncertified farms in both regions, most likely due the fact that the coffee sector is generally in compliance with Colombia's stringent labor laws.

The mammal study added to the body of knowledge regarding an important BMP: the planting of shade trees on coffee farms. The findings of this study suggest that although the threatened Andean night monkey inhabits natural forests, it also spends significant amounts of time in coffee plantations with dense shade cover (in this study, 80 percent), and much less time in coffee plantations with medium shade cover (60–65 percent), despite the availability of this type of habitat in its home range.

The mammal study also revealed that shaded coffee plantations in the Santander region provide habitat for at least nine mammal species. It also showed that the density of shade cover is important: plantations with denser shade (> 80 percent) have species richness closer to that of natural forest than plantations with medium shade (60–80 percent). The researchers conclude that densely-shaded coffee plantations can serve as good buffers for designated protected areas, by providing habitat for a variety of mammals.

Application of results to other regions

Some of the conclusions drawn from the four

Table 15
Summary of the results of the three farm-based studies comparing certified and noncertified farms in the states of Cundinamarca and Santander

	Cundinamarca			Santander		
Variable	**Certified Performed Better**	**No Difference**	**Noncertified Performed Better**	**Certified Performed Better**	**No Difference**	**Noncertified Performed Better**
Rate of best practice managment implementation						
Use of septic tank	✓			✓		
Employ service for the recollection of solid wastes	✓			✓		
No burning of agricultural residues	✓			✓		
Warehouse specialized for the storage of chemicals	✓			✓		
Training provided in recycling	✓			✓		
Training provided in first aid	✓			✓		
Training provided in correct use of pesticides	✓			✓		
No agrochemicals used		✓			✓	
No hunting of wild animals		✓			✓	

Table 15 cont.

Variable	Cundinamarca			Santander		
	Certified Performed Better	No Difference	Non-certified Performed Better	Certified Performed Better	No Difference	Non-certified Performed Better
Sustainability index (SI) score						
Environmental SI score (S)	✓			✓		
Social SI score (S)		✓		✓		
Economic SI score (S)		✓		✓		
Technological SI score (S)		✓		✓		
Integrated SI score	✓			✓		
Structural indicators of water quality						
Streamside visual assessment protocol score	✓			✓		
Streamside vegetation cover %	✓			✓		
Biological indicators of water quality						
Presence of contamination-sensitive macroinvertebrates (BMWP[22])	✓				✓	
Presence of contamination-sensitive macroinvertebrates (EPT[23] species)	✓				✓	
Presence of contamination-sensitive macroinvertebrates (ELPT[24]) species	✓				✓	
Chemical indicators of water quality						
Dissolved oxygen	✓				✓	
Flow rate	✓				✓	
Chemical Oxygen Demand		✓		✓		
Biological Oxygen Demand	✓				✓	
pH		✓			✓	
Suspended solids		✓			✓	
Biological indicators of soil quality						
Arthropod richness	✓			✓		
Arthropod abundance		✓			✓	
Arthropod diversity		✓			✓	
Microbial activity		✓			✓	

Table 15 cont.

Variable	Cundinamarca			Santander		
	Certified Performed Better	No Difference	Non-certified Performed Better	Certified Performed Better	No Difference	Non-certified Performed Better
Chemical indicators of soil quality						
Relative humidity		✓			✓	
pH		✓			✓	
Nitrogen		✓			✓	
Organic matter		✓			✓	
Potassium		✓			✓	
Calcium		✓			✓	
Magnesium		✓			✓	
Economic viability						
Coffee production rate		✓		✓		
Net revenue		✓		✓		

studies presented here could apply to other coffee growing regions. The coffee varieties and the cultivation practices are similar with those in other parts of the world, with the exception of the high yield, sun grown coffee beans grown in countries like Brazil, Kenya and Vietnam. However, the social and economic characteristics associated with the production and commercialization of coffee are variable among the different coffee growing regions, decreasing the ability to extrapolate the results of the socio-economic study to other countries.

Colombian coffee farms process their coffee on-farm, which is rare in other coffee growing regions. In this process the pulp is removed and the coffee dried so that dry coffee beans (referred to as "pergamino") are sold. In most other countries coffee farmers sell their unprocessed coffee "cherries" to coffee associations, where they are combined and processed in bulk. Colombian on-farm processing means the characteristics of the coffee can be traced back to the farm, but also means the environmental impacts of processing—particularly related to water quality—will occur on the farm. Therefore the results of this study that are related to water quality likely only apply in regions where coffee is processed on the farm.

Areas for future research

Future research is needed to determine how the differences observed between certified farms and noncertified farms work together at the watershed level. Certification might have an important impact on a single farm, but if there are few certified farms in a given watershed then the overall impact of certification might not be detectable. This is especially so if a watershed has a large area of destructive alternative land uses, such as cattle ranches with little or no protective vegetation around streams. One avenue of future research would therefore be to determine whether a threshold of certified area exists above which watershed-level impacts can be observed.

Another avenue for future research involves the finding that night monkeys and other arboreal mammals appear to use heavily-shaded coffee farms in a similar way to natural forests, and tend to avoid medium-shaded farms. While this finding is very preliminary, it does suggest that a shade threshold might exist above which a coffee farm can function (for some species) as natural habitat. In such a study the implications of high shade levels for farm productivity must also be considered.

Our finding that in Santander productivity was more than twice as high on certified farms than noncertified could also be the starting point for further research that explores which practices increase productivity. Similar productivity increases have been observed on certified farms in the cocoa sector (Potts et al. 2010). Understanding this result (and the lack of productivity difference in Cundinamarca) will likely have important implications for coffee farmers everywhere.

Literature Cited

Acero-Duarte, L. E. (1985). Árboles de la zona cafetera Colombiana. In Fondo Cultural Cafetero (eds.). Pp. 303. Bogotá.

Castaño, J. H., Cardona, D. M. & Botero, J. E. (2010). Ecología del mono nocturne andino (*Aotus lemurinus*), en fragmentos de bosque subandinos de Colombia. In V. Pereira.Bengoa, P. R. Stevenson, M. L. Bueno & F. Nassar-Montoya (Eds.), *Primatología en Colombia: avances al principio del milenio* (pp. 69-90). Asociación Colombiana de Primatología, Bogotá.

Clarke, M. R., Collins, D. A., & Zucker, E. L. (2002). Responses to deforestation in a group of mantled howlers (*Alouatta palliata*) in Costa Rica. *International Journal of Primatology*, 23, 365–381.

Defler, T. R., Rodríguez-M, J. V., & Hernández-Camacho, J. I. (2003). Conservation priorities for Colombian primates. *Primate Conservation*, 19, 10-18

Potts, J., Bennett, M., Giovannucci, D., Russillo, A., Wunderlich, C., Cuming, D (2010) Committee on Sustainability Assessment (COSA); Rainforest Alliance Certified Cocoa Farms in Côte d'Ivoire: COSA Analysis of Sustainability. Summary Report to the Rainforest Alliance.

SAN, 2010. Sustainable Agriculture Standard. 49 pages http://sanstandards.org.

Sepúlveda S., (2008). Biograma: metodología para estimar el nivel de desarrollo sostenible de territorios. San José Costa Rica. IICA 132 p.

IUCN. (2010). Red List of Threatened Species. <www.iucnredlist.org> IUCN, Gland, Switzerland and Cambridge, UK.

NWCC, USDA, NRCS. 1998. Stream Visual Assessment Protocol. Technical Note 99–1, December 1998.

Endnotes

Executive Summary

1 By the end of 2012 these numbers had risen to 7,018 farmers and 29,301 hectares.

2 The Colombian "National Center for Coffee Research" (Cenicafe, http://cenicafe.org/).

Introduction

3 EPT/ELPT represent taxonomic orders of insects that are known to be very intolerant to contamination. EPT represents Ephemeroptera, Plecoptera, Trichoptera, while ELPT represents Coleoptera, Elmidae, Plecoptera and Trichoptera. A higher number of EPT/ELPT species indicates better water quality.

4 Morphospecies are species that are differentiated solely by anatomical differences, rather than by genetic, geographic or other differences.

5 The number of different arthropod species collected.

6 The number of individuals collected, regardless of species.

7 Diversity was measured using the Shannon index, which takes the relative abundances of different species into account.

8 The Colombian Coffee Growers Federation's (FNC in Spanish) "National Center for Coffee Research" (Cenicafe, http://cenicafe.org/). Cenicafe is Colombia's largest and most important coffee research organization.

9 More detailed information about these studies is available in the original reports (in Spanish) prepared by Cenicafe scientists.

10 http://sanstandards.org/sitio/

11 http://sanstandards.org/sitio/archivos/display/15

Cenicafe Studies

12 www.cenicafe.org

Water quality and aquatic macro-invertebrates in Rainforest Alliance Certified and noncertified farms in Santander and Cundinamarca

13 A morphospecies is a group of specimens with similar morphological (physical) characteristics that are assumed to represent the same species.

14 Prob or p: the probability that the difference between certified and noncertified farms is due to random error. This is based on a standard t-test. A probability less than 0.05 indicates a significant difference.

15 The "biochemical oxygen demand" (BOD) is the oxygen bacteria will consume decomposing organic matter while the "chemical oxygen demand" (COD) is the total oxygen required to decompose all organic material. Higher values of BOD and COD indicate lower water quality.

Soil arthropod diversity, microbial activity and physical-chemical characteristics in certified and noncertified farms in Santander and Cundinamarca

16 See Principle 9 "Soil Management and Conservation" of the Sustainable Agriculture Standard (SAN, 2010).

17 Arthropods are animals with exoskeletons, six or more jointed legs, and a segmented body. Insects, spiders, centipedes and lobsters are examples of arthropods.

18 Centimoles per kilogram.

Identification of the economic and social advantages and disadvantages of the adoption of the Sustainable Agriculture Network coffee certification standard in Santander and Cundinamarca

19 The average exchange rate during the life of the study of 1,850 Colombia pesos to USD was applied.

20 More complete and sophisticated analyses carried out by the CENICAFE economist are documented in the CENICAFE socio-economic report: www.cenicafe.org/es/publications/arc061%2803%29222-2403.pdf

Ecological value of shade coffee for the conservation of night monkeys (*Aotus lemurinus*) and other arboreal mammals in Santander

21 This study's original design involved attaching radio locator collars on at least one monkey in each of four groups of monkeys. Unfortunately, due to difficulties capturing the monkeys, the biologist was only able to place collars on monkeys in two different groups. To compensate for this reduced scope, researchers added a second part to this study; they used camera traps to monitor the mammalian diversity on food platforms in three different habitat types.

Conclusions

22 Biological Monitoring Working Party

23 Ephemeroptera, Plecoptera, Trichoptera

24 Coleoptera, Elmidae, Plecoptera and Trichoptera

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