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Does Eco-Certification Have Environmental Benefits?

Organic Coffee in Costa Rica

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Abstract

Eco-certification of coffee, timber and other high-value agricultural commodities is increasingly widespread. In principle, it can improve commodity producers' environmental performance, even in countries where state regulation is weak. However, evidence needed to evaluate this hypothesis is virtually nonexistent. To help fill this gap, we use detailed farm-level data to analyze the environmental impacts of organic coffee certification in central Costa Rica. We use propensity score matching to control for self-selection bias. We find that organic certification improves coffee growers' environmental performance. It significantly reduces chemical input use and increases adoption of some environmentally friendly management practices.

Key Words: certification, coffee, Costa Rica, propensity score matching

JEL Classification Numbers: Q13, Q20, 013, Q56

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1. Introduction

Initiatives certifying that agricultural commodities have been produced in an environmentally friendly manner are increasingly popular. For example, more than 120 million hectares of forest have been certified by the Pan European Forest Certification Agency, the Forest Stewardship Council, and other organizations (Rametsteiner and Simula 2003). And global production of organic, Rainforest Alliance, and other types of eco-certified coffees has recently grown by 10 to 20 percent per year, a rate far higher than that for other types of specialty coffee (Kilian et al. 2004).

According to proponents, certification schemes like these have the potential to improve commodity producers' environmental performance (Giovannucci and Ponte 2005; Rice and Ward 1996). In theory, they can do this by enabling the consumer to differentiate among commodities based on their environmental attributes. This improved information facilitates price premiums for certified commodities, and these premiums, in turn, create financial incentives for producers to meet certification standards.

If that logic holds, certification may help address pressing environmental problems associated with agricultural commodities in developing countries. Growing and processing bananas, cocoa, coffee, timber, and other high-value agricultural products in poor countries often entails deforestation, soil erosion, and agrochemical pollution. These problems are difficult to tackle using conventional command-and-control regulation because producers are often small, numerous, and geographically dispersed while regulatory institutions are undermanned and

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underfunded (Wehrmeyer and Mulugetta 1999). Certification schemes have the potential to sidestep these constraints by creating a private sector system of economic incentives, monitoring, and enforcement.

Yet certification programs that aim to improve commodity producers' environmental performance also faces important challenges. They must use standards stringent enough and monitoring and enforcement strict enough to ensure that poorly performing producers are excluded. In addition, they must offer price premiums high enough to offset the costs of certification. Even if these two challenges are met, certification schemes can still be undermined by selection effects. Commodity producers already meeting certification standards have strong incentives to select into certification programs: they need not make additional investments in environmental management to pass muster and can obtain price premiums and other benefits. But certification programs that mainly attract such producers will have limited effects on producer behavior and few environmental benefits.

Although a growing academic literature examines commodity certification, we still know little about whether it actually affects producers' environmental performance. As discussed below, few studies evaluate the environmental impacts of certification, and many of those that do rely on problematic methods that bias their results. To identify certification impacts, an evaluation must construct a reasonable counterfactual outcome, that is, an estimate of what environmental outcomes for certified entities would have been had they not been certified. However, most evaluations use problematic counterfactual outcomes: either certified producers' precertification outcomes or uncertified producers' outcomes. In the first case, results are biased whenever outcomes change during the study period because of factors unrelated to certification (including changes in commodity prices, input prices, weather conditions, and technology, all of which are common). In the second case, results are biased whenever commodity producers already meeting certification standards select into certification.

A variety of *ex post* statistical methods are available to overcome these problems including propensity score matching and instrumental variables (Ferraro 2009; Frondel and Schmidt 2005). A recent comprehensive review of the empirical studies of certification of agricultural commodities and tourism operations found only three that use such methods to identify environmental impacts (Blackman and Rivera 2010). None of these studies examined certification for one of the most prominent high-value agricultural commodities: coffee.

As a first step toward filling that gap, this paper presents an evaluation of the environmental impacts organic coffee certification in central Costa Rica. We use rich farm-level data from a recent census of coffee growers and a geographic information system (GIS) that comprises detailed geophysical data. We rely on propensity score matching to control for selection bias. We find that certification does have an environmental benefit. It significantly reduces use of all three chemical inputs for which we have data (pesticides, chemical fertilizers, and herbicides) and spurs adoption of at least one of the four environmentally friendly management practices for which we have data (organic fertilizer).

The remainder of this paper is organized as follows. The second section briefly reviews the literature evaluating the environmental effects of coffee certification. The third section presents background on coffee production, organic certification, and our study area. The fourth section discusses our empirical strategy and data. The fifth section presents our results, and the last section discusses their policy implications.

2. Literature

Rigorous evaluations of the environmental impacts of certification are rare, and those that have been conducted have failed to find significant effects. Blackman and Rivera (2010) reviewed 133 studies of commodity certification and identified only three that both constructed a reasonable counterfactual and focused on environmental (versus socioeconomic) impacts. These studies, which examine timber and tourism sectors, conclude that the environmental effects of certification are negligible. De Lima et al. (2008) analyze Forest Stewardship Council (FSC) certification in the Brazilian Amazon. They find few statistically significant differences in indicators of environmental performance for four FSC-certified forest associations and two matched uncertified associations. Rivera and de Leon (2004) and Rivera et al. (2006) analyze the Sustainable Slopes Program, a voluntary certification program established by the U.S. ski areas' industry association. Using a Heckman procedure to control for self-selection bias, they compare third-party environmental performance ratings of certified and uncertified ski areas. They find that in the Sustainable Slopes Program's early years, uncertified areas actually had better environmental performance than certified areas, and subsequently, they had equivalent but not superior levels.

As for farm-level studies of coffee certification, to our knowledge, all existing studies that construct a reasonable counterfactual focus on socioeconomic impacts.[1] Several less rigorous studies analyze environmental impacts by comparing environmental outcomes for

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[1] See Blackman and Rivera (2010). Only two of these studies—Arnould et al. (2009) and Bolwig et al. (2009)—find that certification has significant socioeconomic benefits, but in both cases the effects are weak or idiosyncratic: Arnould et al. (2009) find that although certification generates a price premium, it is not consistently correlated with socioeconomic indicators, and Bolwig et al. (2009) argue that in their case, these socioeconomic benefits are mainly due to a design anomaly of the certification scheme.

certified farms before and after certification or comparing outcomes for certified farms and unmatched uncertified farms. Most find few differences. Quispe Guanca (2007) uses survey data on changes in environmental management practices before and after certification (organic, FT, Rainforest Alliance, Utz Kapeh, and C.A.F.E. Practices) for a sample of 106 certified farms in Costa Rica. He finds that although all farms reduced herbicide use after certification, most did not reduce other agrochemicals. Philpott et al. (2007) compare ecological indicators for farms belonging to three certified organic, three certified organic and Fair Trade, and two uncertified cooperatives in Chiapas, Mexico. No effort is made to match the three types of cooperatives. They find no differences among the farms in ecological indicators. Finally, Martínez-Sánchez (2008) compares ecological indicators for 10 certified organic and 10 unmatched uncertified farms in northern Nicaragua. He finds that organic farms do not have significantly different shade levels, bird diversity, or bird abundance.

3. Background

3.1. Coffee in Costa Rica

Although coffee is no longer the backbone of Costa Rica’s economy, it remains a leading agricultural commodity. Roughly 57,000 growers working on 100,000 hectares produce more than 2 million quintals (100-pound bags) of coffee beans annually, and coffee exports generate over US$200 million in export revenues annually. The coffee sector is dominated by thousands of small-scale growers: more than 90 percent produce less than 100 quintals of coffee per year (ICAFE 2007).

Coffee growing in Costa Rica has serious environmental consequences that at least partly offset those economic benefits. Traditionally, Costa Rican coffee, like most coffee in Latin America, was grown alongside shade trees, an agroforestry system that predated the development of agrochemicals and therefore did not rely them. However, since the 1980s, 90 percent of the country’s coffee has been converted to a high-yielding “technified” monocrop in which coffee is grown with minimal shade cover and intensive application of agrochemicals, a system that was pioneered in Costa Rica (Adams and Ghaly 2007; Rice and Ward 1996). The switch to technified coffee has hastened soil erosion and contributed to such off-site negative externalities as the contamination and sedimentation of surface and groundwater (Adams and Ghaly 2006; Loria 1992; Babbar and Zak 1995).

3.2. Organic Coffee Certification

Organic agriculture certification requires producers to adhere to five broad production principles (Van der Vossen 2005; IFOAM 2010):

- use of composted organic matter instead of chemical fertilizers to maintain soil quality;
- use of natural methods for controlling disease, pests, and weeds instead of synthetic pesticides and herbicides;
- use of soil conservation practices, including contour planting, terracing, planting cover crops, mulching, and planting shade trees;
- minimum use of fossil fuels in the production process; and
- minimum pollution during postharvest handling.

Several international organic certifying bodies, the largest of which is the International Federation of Organic Agriculture Movements (IFOAM), formulate basic organic standards for various commodities. These large organizations accredit smaller national ones, which in turn certify individual producers (not cooperatives) and conduct follow-up monitoring. Organic certifications require growers to complete a transition period of two to three years during which they must discontinue use of chemical inputs and adopt various conservation and pollution prevention practices. Certified producers are monitored at least once a year to ensure they continue to continue to meet organic standards.

From coffee growers' perspective, organic certification has both benefits and costs (Giovanuci and Ponte 2005; Van der Vossen 2005; Calo and Wise 2005). The main benefit is the price premium, which is set in international markets and averages 10 to 20 percent, depending on coffee quality. In addition, organic production reduces the costs of purchased inputs for growers who formerly depended on chemical inputs. It can also improve coffee quality. On the cost side, organic production typically increases labor costs and reduces yields for growers who formerly depended on chemical inputs. In addition, transaction costs—for initial certification, for subsequent annual monitoring and reporting—are significant. Annual costs can easily amount to 5 percent of sales. All of these costs are generally borne by the grower. Note that the transition period implies that the grower must pay them for two to three years without the principal benefit of certification—a price premium.

3.3. Study Area and Period

We examine organic coffee certification in Turrialba, Costa Rica, an agricultural region (an administrative unit that would fall between a state and county in the United States) in the country's central valley, about 40 miles east of San José, Costa Rica's capital city. The leading organic certifying organization in Turrialba is a Costa Rican organization called Eco-Logica, which is accredited by the U.S. Department of Agriculture, among other organizations. Certified farmers in this region belong to the Association of Organic Producers of Turrialba (*Asociacion de Productores Organicos de Turrialba*, APOT). For reasons discussed below, we analyze coffee certification in 2003, the year of our farm-level census data. In this year, Eco-Logica had certified 38 growers and was tracking 44 more in the transition phase. APOT's organic production standards are included as Appendix A.

4. Empirical Strategy and Data

4.1. Propensity Score Matching

Our analysis of organic certification's impact on environmental performance confronts the usual program evaluation challenge (Rubin 1974; Holland 1986). Ideally, the impact of a program would be measured by comparing the outcome of interest for each agent both with and without program participation. However, we never actually observe both outcomes. In practice, therefore, a program's impact is typically measured by comparing the average outcome for participants and for a control group of nonparticipants—with the latter average serving as the counterfactual. But as discussed in the introduction, this approach can be undermined if certain types of participants who tend to have certain outcomes select into the program. For example, in our case, small, undercapitalized farms that cannot afford to use chemical inputs may self-select into organic certification because the net benefits are high: they can meet organic standards and obtain price premiums without having to discontinue chemical input. Or farms on steeply sloped land that already use soil conservation measures may self-select into certification because they do not have to adopt them to meet organic standards. An evaluation that failed to control for such selection would conflate the effects of certification on outcomes with the effects of preexisting differences between certified and uncertified farms.

To address this selection problem, we use a matching estimator. That is, following Rosenbaum and Rubin (1983) and more recently Blackman et al. (2010), List et al. (2003), and Dehejia and Wahba (2002), we construct a matched control sample of uncertified farms that are very similar to the certified farms in terms of observable characteristics. We measure program impact as the average treatment effect on the treated (ATT)—the difference between the percentage of certified farms that use a management practice and the percentage of matched uncertified farms that use it.

This approach depends on two identifying assumptions. The first assumption, "ignorability" or "conditional independence," is that conditional only on agents' observed characteristics, the participation decision is ignorable for purposes of measuring outcomes. That is, we are able to observe and control for all variables that simultaneously affect the participation decision and the outcome variables. This first assumption is untestable. The second assumption, "common support" or "overlap," is that the distribution of observed characteristics for nonparticipants is similar to that for participants, such that agents with similar characteristics have a positive probability of being participants and of being nonparticipants.

Creating a large set of matched pairs of farms with the exact same observed characteristics is challenging when, as in our case, these characteristics are numerous. However, Rosenbaum and Rubin (1983) demonstrate that we need to match farms only on the basis of their propensity score—that is, their likelihood of certification as predicted by a regression model—which amounts to an index of farm and grower characteristics weighted by their importance in predicting certification. The propensity score method collapses the difficult problem of matching all observable characteristics to a much simpler one of matching a single summary variable.

Various methods are available to match participants and nonparticipants based on propensity scores (Caliendo and Kopeining 2008; Morgan and Harding 2006). To ensure robustness, we report results from five: (i) nearest neighbor 1-to-1 matching, wherein each certified farm is matched to the uncertified farm with the closest propensity score; (ii) nearest neighbor 1-to-4 matching, wherein each certified farm is matched to the four uncertified farms with the closest propensity scores and the counterfactual outcome is the average across these four; (iii) nearest neighbor 1-to-8 matching; (iv) nearest neighbor 1-to-16 matching; and (v) kernel matching, wherein a weighted average of all uncertified farms is used to construct the counterfactual outcome. For all five models we enforce a common support and allow matching with replacement.

Calculating standard errors for ATT estimated using propensity score matching is not straightforward because these errors should, in principle, account for the fact that propensity scores are estimated and for the imputation of the common support (Heckman et al. 1998). Therefore, following Dehijia and Whaba (2002) and others, we bootstrap standard errors (using 1,000 replications).

4.2. Data

The data used for our analysis come from three sources. The first is a national census of Costa Rican coffee growers conducted by the National Statistics and Census Institute (*Instituto Nacional de Estadística y Censos*, INEC) in collaboration with the Costa Rican Coffee Institute

(*Instituto del Café de Costa Rica*, ICAFE). Data for Turrialba and Coto Brus (a neighboring region), with more than 6,000 farms, were collected in 2003. The INEC/ICAFE census includes dichotomous dummy variables that indicate whether farms use seven of the agriculture practices monitored by organic certifiers. We divide these into three "negative" practices that must be discontinued for APOT organic certification and four "positive" practices that must be adopted. The negative practices are use of:

- nematicides (pesticides);
- chemical fertilizers; and
- herbicides.

The positive practices are use of:

- soil conservation measures such as deviation canals, water collection holes, water ladders, and vegetative barriers;
- shade trees;
- windbreaks; and
- organic fertilizer.

In addition to information on these practices, the INEC/ICAFE data include information on grower characteristics (age and education), farm characteristics (e.g., geolocator information, size, and coffee variety), and geophysical characteristics (e.g., temperature and precipitation).

Our second source of data is a GIS complied from a variety of sources. It comprises spatial data on geophysical characteristics of coffee farms, including elevation, aspect (directional orientation), slope, Holdridge life zone, and distances to coffee markets and population centers.

Our final source of data is a list of 82 APOT farmers for 2003, the year of the INEC/ICAFE census, including 38 certified organic farms and 44 that were in transition. Because the APOT and INEC/ICAFE databases do not include a common identifying code, records were matched by owner name and farm size.

Although the INEC/ICAFE census for Turrialba and Coto Brus covered more than 6,000 farms, responses to certain questions are missing in some records. We drop all records for which responses needed to generate the variables used in our regressions are missing. The resulting data set contains 2,603 observations: 36 certified organic farms and 2,567 uncertified farms.

4.3. Variables

Table 1 lists, defines, and presents summary statistics for the variables used in our matching analysis, including both outcome variables and grower and farm characteristics. In addition to the seven dichotomous outcome variables listed above, we include counts of negative and positive practices on each farm—the sum of the three dichotomous outcome variables for negative practices, and the sum of the four dichotomous outcome variables for positive practices. Mean use rates for the negative practice outcome variables range from a low of 16 percent for nematicide use to a high of 73 percent for herbicide use. On average, farms use 1.48 of the three negative practices for which we have data. The mean use rates for the positive practice outcome variables range from a low of 10 percent for organic fertilizer to 95 percent for use of some shade cover. On average, farms use 1.59 of the four positive practices for which we have data.

To match certified and uncertified farms, we used propensity scores generated by regressing an organic certification dummy onto a rich set of grower, farm, and geophysical characteristics from our coffee census and GIS data. The grower characteristics are AGE, the age of the farmer in years, and four dichotomous dummy variables that indicate the farmer's highest level of education: ED_NONE for no formal education, ED_PRIMARY for primary education, ED_SECONDARY for secondary education, and ED_SUPERIOR for more than secondary education.

The farm characteristics are AREA_COFFEE, the number of hectares planted in coffee; AREA_COFFEE_SQ, the square of the number of hectares planted; OTHER_LOT, a dichotomous dummy variable that indicates whether the farmer has noncontiguous patches of coffee in the same "work area"; and four dichotomous dummy variables that indicate the variety of coffee planted on the farm: VARIETY_CATA for caturra, VARIETY_CATI for catuai, VARIETY_CR95 for Costa Rica-95, and VARIETY_CATE for catimore.

Table 1. Variables, Definitions, and Means

Variable	Definition	Mean All (n=2603)	Mean Certified (n=36)	Mean Uncert. (n=2567)
OUTCOME VARS.				
Negative practices				
NEMATICIDE	applies nematicide (0/1)	0.16	0.00	0.17
CHEM_FERT	applies chemical fertilizer (0/1)	0.58	0.11	0.59
HERBICIDE	applies herbicide (0/1)	0.73	0.11	0.74
COUNT_NEG	count above negative practices	1.48	0.22	1.50
Positive practices				
SOIL_CON	uses soil conserv. practices (0/1)	0.46	0.58	0.46
SHADE	uses shade (0/1)	0.95	1.00	0.95
WINDBREAK	uses windbreaks (0/1)	0.14	0.14	0.14
ORG_FERT	applies organic fertilizer (0/1)	0.10	0.67	0.10
COUNT_POS	count above positive practices	1.59	2.36	1.58
GROWER/FARM CHARACTERISTICS				
Grower				
AGE	age (years)	50.61	46.11	50.67
ED_NONE	no education (0/1)	0.09	0.06	0.09
ED_PRIMARY	primary education (0/1)	0.71	0.64	0.71
ED_SECONDARY	secondary education (0/1)	0.08	0.25	0.08
ED_SUPERIOR	> secondary education (0/1)	0.11	0.06	0.11
Farm				
APOT	organic cert or transition (0/1)	0.01	1.00	0.00
AREA_COFFEE	area coffee on farm (ha.)	1.29	1.64	1.28
AREA_COFFEE_SQ	area coffee on farm (ha.) squared	5.66	3.97	5.68
OTHER_LOT	2 separate plots of coffee (0/1)	0.37	0.08	0.37
VARIETY_CATA	coffee variety=caturra (0/1)	0.89	0.97	0.89
VARIETY_CATI	coffee variety=catuai (0/1)	0.06	0.03	0.06
VARIETY_CR95	coffee variety=costa rica-95 (0/1)	0.02	0.00	0.02
VARIETY_CATE	coffee variety=catimore (0/1)	0.02	0.00	0.02
Geophysical				
PRECIPITATION	rainfall (mm)	2994.83	2997.25	2994.80
PRECIPITATION_SQ	rainfall (mm) squared	9139495	9102179	9140018
ELEVATION	elevation (m. above sea level)	894.66	811.03	895.83
TEMPERATURE	avg. annual temperature (C^o)	22.89	23.09	22.89
A_LEVEL	% farm level	0.05	0.03	0.05
A_NORTH	% farm facing north	0.07	0.06	0.07
A_NORTHEAST	% farm facing northeast	0.15	0.14	0.15
A_EAST	% farm facing east	0.15	0.14	0.15
A_SOUTHEAST	% farm facing southeast	0.14	0.10	0.14
A_SOUTH	% farm facing south	0.12	0.17	0.12
A_SOUTHWEST	% farm facing southwest	0.11	0.12	0.11
A_WEST	% farm facing west	0.08	0.12	0.08
A_NORTHWEST	% farm facing northwest	0.10	0.06	0.10
SLOPE	average slope (%)[†]	27.12	27.36	27.12
SLOPE_MAX	maximum slope	53.21	54.15	53.20
SLOPE_SD	standard deviation slope	10.10	9.79	10.10
LZP_BMHP	% farm v. humid premontane	0.71	0.81	0.71
LZP_BPP	% farm rain forest premontane	0.17	0.03	0.18
LZP_BHTTP	% farm v. humid trans prem.	0.02	0.00	0.02
LZP_BHP	% farm humid premontane	0.03	0.00	0.03
DISTANCE_SJOSE	ln road distance San José (minutes)	4.79	4.80	4.79
DISTANCE_CANCAP	ln road distance nearest of 15 Canton capitals (minutes)	3.27	3.11	3.27

[†] % Slope = 100*tan(π angle/180). 100% slope = 45 degrees. [‡] The 15 canton capitals are Aserri, Cartago, Desamparados, Juan Viñas, Pacayas, Paraiso, Parrita, Quepos, San Ignacio, San Marcos, San Pablo, Santa Maria, Siquirres, Tejar, and Turrialba.

The farm-level geophysical variables are PRECIPITATION, the average annual rainfall in millimeters; PRECIPITATION_SQ, the square of average annual rainfall; ELEVATION, the average elevation in meters above sea level; TEMPERATURE, the average annual temperature in degrees Celsius; SLOPE, the average slope in percent; SLOPE_MAX, the maximum slope in percent; SLOPE_SD, the standard deviation of slope; DISTANCE_SJOSE, the natural log of travel time in minutes from the farm centroid to San José; and DISTANCE_CANCAP, the natural log of the travel time from the farm centroid to the nearest of 15 canton (county) capitals in the Turrialba and Coto Brus regions.[2] The geophysical variables also include several self-explanatory aspect variables that indicate the percentage of the farm oriented in different directions: A_LEVEL, A_NORTH, A_NORTHEAST, A_EAST, A_SOUTHEAST, A_SOUTH, A_SOUTHWEST, A_WEST, and A_NORTHWEST. Finally, we include four variables that indicate the percentage of the farm that falls within the most common Holdridge life zones in our study area: LZP_BMHP, very humid premontane forest; LZP_BPP, premontane rain forest; LZP_BHTTP, very humid transpremontane forest; and LZP_BHP, humid premontane forest.[3]

5. Results

5.1. Propensity Scores and Balance Tests

Table 2 presents the results from the probit regression (of organic certification on grower and farm characteristics) used to generate propensity scores. The results indicate that compared with average growers in our sample, certified growers tend to be younger, and that compared with average farms in our sample, certified farms tend to be larger (although not extremely large), have contiguous growing areas, grow the caturra variety of coffee, and be located at low altitudes and in certain life zones. Also, certified farms tend not have a large percentage of their farms sloped in certain directions.

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[2] % Slope = 100*tan(π angle/180). 100% slope = 45 degrees. The 15 canton capitals in our study area are Aserri, Cartago, Desamparados, Juan Viñas, Pacayas, Paraiso, Parrita, Quepos, San Ignacio, San Marcos, San Pablo, Santa Maria, Siquirres, Tejar, and Turrialba.

[3] The Holdridge life zone system is a widely used method of classifying land on the basis of climate and vegetation (Holdridge 1979).

Table 2. Probit regression results (dependent variable = organic certification)

Variable	Coefficient	S.E.
Grower		
AGE	-0.150**	0.066
ED_PRIMARY	0.049	0.324
ED_SECONDARY	0.494	0.367
ED_SUPERIOR	-0.148	0.454
Farm		
AREA_COFFEE	0.541***	0.206
AREA_COFFEE_SQ	-0.083*	0.044
OTHER_LOT	-0.644***	0.227
VARIETY_CATA	0.641*	0.368
Geophysical		
PRECIPITATION	1.115	3.162
PRECIPITATION_SQ	-0.252	0.548
ELEVATION	-1.486***	0.568
TEMPERATURE	0.294	0.832
A_LEVEL	-1.436	1.088
A_NORTH1	-1.426	0.928
A_NORTHEAST	-0.998	0.649
A_EAST	-1.001	0.656
A_SOUTHEAST	-1.454**	0.723
A_SOUTH	-0.377	0.644
A_SOUTHWEST	-1.140*	0.665
A_WEST	-0.656	0.649
A_NORTHWEST	-2.032**	0.933
SLOPE	-0.044	0.104
SLOPE_MAX	0.006	0.008
SLOPE_SD	-0.346	0.316
LZP_BMHP	-0.053	0.252
LZP_BPP	-0.742*	0.417
DISTANCE_SJOSE	-0.006	0.395
DISTANCE_CANCAP	0.015	0.144
CONSTANT	-1.698	4.283
Observations	2603	
Pseudo R2	0.194	
LL	-153.097	

***, **, * = significant at 1%, 5%, 10% level

Having generated propensity scores and used them to match certified and uncertified farms, we performed balance tests for the five matching estimators. All except the kernel estimator achieved balance (a statistically insignificant difference in covariate means for certified and matched uncertified plants) for all 29 covariates. The kernel estimator achieves balance for all 29 covariates except OTHER_LOT. Table 3 reports median standardized bias—Rosenbaum and Rubin's (1983) balance statistic—across all covariates for each matching estimator.[4] The highest median standardized bias is 11.659 for the nearest neighbor 1-1 estimator, and the lowest

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[4] Standardized bias is the difference of the sample means in the certified and uncertified subsamples as a percentage of the square root of the average of sample variances in both groups.

is 2.694 for the nearest neighbor 1-16 estimator. Although a clear threshold for acceptable median standardized bias does not exist, according to Caliendo and Kopeining (2008), a statistic below 3 to 5 percent is generally viewed as sufficient. These encouraging balance statistics are likely due to the fact that even though our probit selection model has 29 explanatory variables, our sample includes 75 uncertified farms for each certified farm. As a result, we are able to find close matches for each certified farm.

Table 3. Matching quality: Median standardized bias (SB) after matching for five propensity score matching methods[a,b]

Method	SB
(i) Nearest neighbor 1-1	11.659
(ii) Nearest neighbor 1-4	4.679
(iii) Nearest neighbor 1-8	4.284
(iv) Nearest neighbor 1-16	2.694
(v) Kernel	7.530

[a]For a given covariate, the standardized bias (SB) is the difference of means in the certified and matched uncertified subsamples as a percentage of the square root of the average sample variance in both groups. We report the median SB for all covariates.
[b]Median SB before matching is 16.422.

5.2. Average Treatment Effect on the Treated

Table 4 presents results from the five matching estimators for the negative practices—nematicides, chemical fertilizers, herbicides—and for a count of negative practices.[5] The results strongly indicate that certification significantly reduces use of negative practices. For each negative practice, ATT is negative and significant for all five matching estimators. In each case, the magnitude of the effect is substantial. For nematicides, it ranges from 14 to 18 percentage points; that is, the rate of nematicide use is 14 to 18 percentage points lower among certified growers than among matched uncertified growers who represent the counterfactual. For chemical fertilizers, ATT ranges from 43 to 45 percentage points, and for herbicides, it ranges from 61 to 71 percentage points. Finally, for the count of negative practices, ATT ranges from 1.2 to 1.3, implying that on average, certified growers use 1.2 to 1.3 fewer negative practices than matched uncertified growers.

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[5] Note that the mean of the outcome variables for certified farmers is positive, albeit small, implying that a handful of the 32 certified growers in our sample used chemical inputs in 2003. APOT organic standards allow the occasional use of chemical inputs when deemed necessary and preauthorized by a local Eco-Logica inspector (see Appendix A, items 1g and 5c).

Table 4. Negative practices: Average treatment effect on treated (ATT) estimates, by outcome variable and matching method; critical value of Rosenbaum's Γ

Propensity score matching method	Mean treated	ATT	S.E.[a]	P-value	Γ^{*b}
Nematicide					
(i) Nearest neighbor 1-1	0	-0.143	0.074	0.053	3.0
(ii) Nearest neighbor 1-4	0	-0.150	0.052	0.004	10.6
(iii) Nearest neighbor 1-8	0	-0.179	0.041	0.000	17.6
(iv) Nearest neighbor 1-16	0	-0.157	0.030	0.000	17.2
(v) Kernel	0	-0.152	0.012	0.000	17.2
Chemical fertilizer					
(i) Nearest neighbor 1-1	0.114	-0.429	0.118	0.000	4.6
(ii) Nearest neighbor 1-4	0.114	-0.464	0.086	0.000	6.2
(iii) Nearest neighbor 1-8	0.114	-0.454	0.075	0.000	5.4
(iv) Nearest neighbor 1-16	0.114	-0.448	0.064	0.000	8.0
(v) Kernel	0.114	-0.449	0.058	0.000	10.0
Herbicides					
(i) Nearest neighbor 1-1	0.114	-0.714	0.105	0.000	7.8
(ii) Nearest neighbor 1-4	0.114	-0.643	0.080	0.000	10.0
(iii) Nearest neighbor 1-8	0.114	-0.607	0.074	0.000	10.0
(iv) Nearest neighbor 1-16	0.114	-0.582	0.064	0.000	11.0
(v) Kernel	0.114	-0.595	0.058	0.000	10.0
Count negative practices					
(i) Nearest neighbor 1-1	0.229	-1.286	0.193	0.000	9.8
(ii) Nearest neighbor 1-4	0.229	-1.257	0.153	0.000	16.8
(iii) Nearest neighbor 1-8	0.229	-1.239	0.129	0.000	13.4
(iv) Nearest neighbor 1-16	0.229	-1.188	0.110	0.000	13.4
(v) Kernel	0.229	-1.197	0.095	0.000	12.2

[a] Computed using bootstrap with 1,000 repetitions.

[b] Critical value of odds of differential assignment to organic certification due to unobserved factors (i.e., value above which ATT is no longer significant).

Table 5 presents results from the five matching estimators for the positive practices—soil conservation, shade, windbreaks, and organic fertilizer—and for a count of positive practices.[6] The results provide strong evidence that organic certification increases the use of only one positive practice: organic fertilizer. For this practice, ATT is positive and significant for all five matching estimators, and the magnitude of the effect is substantial, ranging from 59 to 63 percentage points. The results provide much weaker evidence that organic certification increases the use of shade cover and soil conservation. For shade cover, ATT is significant for three of the five matching estimators (all but nearest neighbor 1-1 and 1-4). However, the magnitude of the

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[6] Note that the mean of the outcome variables for certified farmers is less than 1, implying that some of the certified growers in our sample had not adopted the four environmental management practices we consider. In particular, less than one-sixth of certified farmers adopted windbreaks. Eco-Logica inspectors relax certification requirements in certain cases—for example, when winds are so inconsequential that windbreaks are not needed. In general, inspectors enforce prohibitions against negative practices (use of agrochemicals) more stringently than they require the positive ones (soil conservation, etc.) (Soto 2009).

effect is small, ranging from 4 to 5 percentage points. For soil conservation, ATT is significant for two of the five matching estimators (nearest neighbor 1-1 and 1-16). In each case, ATT is significant, ranging from 15 to 29 percentage points. For windbreaks, none of the matching estimators generate a significant ATT. Finally, for the count of positive practices, ATT is positive and significant for all five matching estimators, although the magnitude of the effect is not large, ranging from 0.8 to 0.9.

Table 5. Positive practices: Average treatment effect on treated (ATT) estimates, by outcome variable and matching method; critical value of Rosenbaum's Γ

Propensity score matching method	Mean treated	ATT	S.E.[a]	P-value	Γ^{*b}
Soil conservation					
(i) Nearest neighbor 1-1	0.571	0.286	0.128	0.026	1.6
(ii) Nearest neighbor 1-4	0.571	0.143	0.102	0.162	--
(iii) Nearest neighbor 1-8	0.571	0.132	0.092	0.150	--
(iv) Nearest neighbor 1-16	0.571	0.146	0.087	0.094	1.4
(v) Kernel	0.571	0.134	0.087	0.125	--
Shade					
(i) Nearest neighbor 1-1	1.000	0.029	0.042	0.501	--
(ii) Nearest neighbor 1-4	1.000	0.043	0.032	0.181	--
(iii) Nearest neighbor 1-8	1.000	0.043	0.022	0.056	6.2
(iv) Nearest neighbor 1-16	1.000	0.045	0.017	0.008	11.6
(v) Kernel	1.000	0.049	0.007	0.000	17.2
Windbreak					
(i) Nearest neighbor 1-1	0.143	0.000	0.087	1.000	--
(ii) Nearest neighbor 1-4	0.143	0.014	0.075	0.849	--
(iii) Nearest neighbor 1-8	0.143	0.043	0.064	0.501	--
(iv) Nearest neighbor 1-16	0.143	0.032	0.064	0.616	--
(v) Kernel	0.143	-0.010	0.065	0.877	--
Organic fertilizer					
(i) Nearest neighbor 1-1	0.657	0.629	0.084	0.000	13.8
(ii) Nearest neighbor 1-4	0.657	0.614	0.086	0.000	9.0
(iii) Nearest neighbor 1-8	0.657	0.604	0.085	0.000	4.4
(iv) Nearest neighbor 1-16	0.657	0.589	0.084	0.000	3.4
(v) Kernel	0.657	0.587	0.082	0.000	3.6
Count positive practices					
(i) Nearest neighbor 1-1	2.343	0.9143	0.2110	0.000	3.8
(ii) Nearest neighbor 1-4	2.343	0.7929	0.1731	0.000	3.8
(iii) Nearest neighbor 1-8	2.343	0.8107	0.1577	0.000	3.6
(iv) Nearest neighbor 1-16	2.343	0.8143	0.1613	0.000	3.2
(v) Kernel	2.343	0.7748	0.1446	0.000	2.6

[a] Computed using bootstrap with 1,000 repetitions.
[b] Critical value of odds of differential assignment to organic certification due to unobserved factors (i.e., value above which ATT is no longer significant).

Hence, our results suggest that organic certification has a stronger causal effect on negative practices than positive ones. This finding comports with anecdotal evidence that Eco-Logica inspectors do not enforce all of the organic certification standards listed in Appendix A equally: enforcement is more stringent for standards prohibiting negative practices than for those requiring positive ones (Soto 2009).

5.3. Sensitivity Analysis

Might endogeneity drive our results? As noted above, the effectiveness of our matching estimators in controlling for selection bias depends on the untestable identifying assumption that we are able to observe confounding variables that simultaneously affect growers' decisions to obtain organic certification and to use (or not use) the production practices that serve as our outcome variables. That is, we essentially assume endogeneity is not a problem. We calculate Rosenbaum bounds to check the sensitivity of our results to the failure of this assumption (Rosenbaum 2002; Aakvik 2001).[7] Rosenbaum bounds indicate how strongly unobserved confounding factors would need to influence growers' decisions to obtain organic certification in order to undermine the matching result. To be more specific, the Rosenbaum procedure generates a probability value for Wilcoxon sign-rank statistic for a series of values of Γ, an index of the strength of the influence that unobserved confounding factors have on the selection process. $\Gamma = 1$ implies that such factors have no influence, such that pairs of growers matched on observables do not differ in their odds of obtaining organic certification; $\Gamma = 2$ implies that matched pairs could differ in their odds of certification by as much as a factor of two because of unobserved confounding factors; and so forth. The probability value on the Wilcoxon sign-rank statistic is a test of the null hypothesis of a zero ATT given unobserved confounding variables that have an effect given by Γ. So, for example, a probability value of 0.01 and a Γ of 1.2 indicate that ATT would still be significant at the 1 percent level even if matched pairs differed in their odds of certification by a factor of 1.2 because of unobserved confounding factors.

We calculate Γ^*, the critical value of Γ at which ATT is no longer significant at the 10 percent level in each case—that is, for each combination of production practice and matching estimator—where ATT is significant (Tables 4 and 5, last column). Except in the case of soil conservation, Γ^* is at least 3.0, and in most cases it is considerably larger. For the nematicide estimators, Γ^* is at least 10.6 for four of the five matching estimators; for the chemical fertilizer models, it is at least 4.6; for the herbicide models, it is at least 7.8; and for the count of negative practices models, it is at least 9.8. Except in the case of soil conservation, the results for positive practice ATTs are similar. For shade, Γ^* is at least 6.2; for organic fertilizer, it is at least 3.4; and

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[7] An example of an unobserved confounder might be environmental consciousness or managerial skill. Each could cause growers to select into organic certification and—independent of certification—to use fewer negative practices and more positive ones.

for a count of positive practices, it is at least 3.2. Hence, our sensitivity tests suggest that unobserved confounders would need to be quite strong to undermine our statistically significant results. In other words, endogeneity is unlikely to drive our results.

6. Conclusion

We have used detailed cross-sectional data on more than 2,600 coffee farms in central Costa Rica to identify the environmental impacts of organic coffee certification. We have used propensity score matching techniques to control for self-selection bias. Our findings suggest that certification significantly reduces use of all three chemical inputs for which we have data—pesticides, chemical fertilizers, and herbicides—and increases adoption of at least one of the four environmentally friendly management practices for which we have data—organic fertilizer.

Our findings contrast with those from the only three methodologically rigorous studies of commodity certification environmental impacts, all of which find that eco-certification has no causal effects. They also contrast with findings from several less rigorous studies of coffee certification. What might explain these differences? First, we have examined a certification scheme that has relatively well defined, stringent standards enforced at the individual farm level by independent third-party monitors. The forest and tourism certification schemes summarized in Section 3 do not have these attributes. The Sustainable Slopes Program examined by Rivera and de Leon (2004) and Rivera et al. (2006) has relatively lax standards enforced by a trade association, and at least some of the coffee certification programs analyzed by Quispe Guanca (2007) (e.g., Rainforest Alliance) are at the cooperative level rather than the farm level.

Second, in Costa Rica's coffee sector, opportunities for certification impacts to be undermined by self-selection—that is, opportunities for growers already meeting organic standards to obtain certification—may be relatively limited. As noted in Section 3, coffee growing in Costa Rica is heavily technified. Most farmers use chemical inputs, and few use organic fertilizers (Table 1). Therefore, relatively few farms are able to obtain certification without significantly changing their management practices. This is not the case in the regions of Nicaragua and Mexico studied by Philpott et al. (2007) and Martínez-Sánchez (2008). Here, most growers use rustic practices and few chemical inputs (Rice and Ward 1996).

Finally, our study has looked at the impact of certification on various management practices, not on ecological indicators like bird diversity, the focus of studies by Philpott et al. (2007) and Martínez-Sánchez (2008). Presumably, certification can alter management practices more easily than it can generate changes in ecological indicators.

What are the policy implications of our findings? They suggest that commodity certification schemes that require adherence to well-defined stringent standards, are enforced at the individual farm level by independent third-party monitors, and are implemented in areas where producers do not already adhere to these standards can have significant environmental benefits. That said, certification schemes meeting these criteria may have an important disadvantage: they are likely to entail significant costs for producers. Absent high price premiums or other benefits from certification, these costs will discourage certification. Indeed, the relatively small number of certified organic producers in our sample (1 percent) likely reflects this phenomenon.

References

Aakvik, A. 2001. Bounding a matching estimator: The case of a Norwegian training program. *Oxford Bulletin of Economics and Statistics* 63(1): 115–43.

Adams, M., and A. Ghaly. 2007. Maximizing sustainability of the Costa Rican coffee Industry. *Journal of Cleaner Production* 15: 1716–29.

Asociación de Productores Orgánico de Turrialba (APOT). 2001. Normas para la Producción Orgánica: Establecidas y aprobadas por los productores de APOT. August.

Arnould, E., A. Plastina, and D. Ball. 2009. Does fair trade deliver on its core value proposition? Effects on income, educational attainment, and health in three countries. *Journal of Public Policy and Marketing* 28(2): 186–201.

Babbar, L., and D. Zak. 1995. Nitrogen loss from coffee agroecosystems in Costa Rica: Leaching and denitrification in the presence and absence of shade trees. *Journal of Environmental Quality* 24: 227–33.

Blackman, A., and J. Rivera. 2010. The evidence base for environmental and socioeconomic impacts of "sustainable" certification. Discussion Paper 10-17: Washington, DC: Resources for the Future.

Blackman, A., B. Lahiri, B. Pizer, M. Rivera Planter, and C. Muñoz Piña. 2010. Voluntary regulation in developing countries: Mexico's Clean Industry Program. *Journal of Environmental Economics and Management* 60(3): 182–92.

Bolwig, S., P. Gibson, and S. Jones. 2009. The economics of smallholder organic contract farming in tropical Africa. *World Development* 37(6): 1094–104.

Caliendo, M., and S. Kopeining. 2008. Some practical guidance for the implementation of propensity score matching. *Journal of Economic Surveys* 32: 31–72.

Calo, M., and T.A. Wise. 2005. Revaluing peasant coffee production: Organic and Fair Trade markets in Mexico. Global Development and Environment Institute, Tufts University. October.

de Lima, A., A. Novaes Keppe, M. Corrêa Alves, R. Fernando Maule, and G. Sparovek. 2008. Impact of FSC forest certification on agroextractive communities of the state of Acre, Brazil. Instituto de Manejo e Certificação Florestal e Agrícola (Imaflora), University of São Paulo, Entropix Engineering Company.

Dehejia, R., and S. Wahba. 2002. Propensity score-matching methods for nonexperimental causal studies. *Review of Economics and Statistics* 84(1): 151.

Ferraro, P. 2009. Counterfactual thinking and impact evaluation in environmental policy. In M. Birnbaum and P. Mickwitz (eds.), *Environmental Program and Policy Evaluation: New Directions for Evaluation* 122: 75–84.

Frondel, M., and C. Schmidt. 2005. Evaluating environmental programs: The perspective of modern evaluation research. *Ecological Economics* 55(4): 515–26.

Giovannucci, D., and S. Ponte. 2005. Standards as a new form of social contract? Sustainability initiatives in the coffee industry. *Food Policy* 30: 284–301.

Heckman, J., H. Ichimura, J. Smith, and P. Todd. 1998. Characterizing selection bias using experimental data. *Econometrica* 66: 1017–98.

Holdridge, L. 1979. *Life Zone Ecology*. San José, Costa Rica: IICA.

Holland, P. 1986. Statistics and causal inference. *Journal of the American Statistical Association* 99(467): 854–66.

International Federation of Organic Agriculture Movements (IFOAM). 2010. Principles of organic agriculture. Available at http://www.ifoam.org/about_ifoam/principles/index.html (accessed January 13, 2009).

Instituto del Café de Costa Rica (ICAFE). 2007. Report on Costa Rican coffee production. XXXVI National Congress on Coffee Production. December 2.

Kilian, B., C. Jones, L. Pratt, and A. Villalobos. 2004. Can the private sector be competitive and contribute to development through sustainable agricultural business? A case study of coffee in Latin America. *International Food and Agribusiness Management Review* 7(3): 21–45.

List, J., D. Millimet, P. Fredriksson, and W. McHone. 2003. Effects of environmental regulations on manufacturing plant births: Evidence from a propensity score matching estimator. *Review of Economics and Statistics* 85(4): 944–52.

Loria, J. 1992. Coffee poses environmental headache for Costa Rica. *Reuter Washington Report* 21, September.

Martínez-Sánchez, J.C. 2008. The role of organic production in biodiversity conservation in shade coffee plantations. Ph.D. dissertation. Department of Biology, University of Washington, Seattle.

Morgan, S., and D. Harding. 2006. Matching estimators of causal effects: Prospects and pitfalls in theory and practice. *Sociological Methods and Research* 35(1): 3–60.

Philpott, S., P. Bichier, R. Rice, and R. Greenberg. 2007. Field testing ecological and economic benefits of coffee certification programs. *Conservation Biology* 21(4): 975–85.

Quispe Guanca, J.L. 2007. Caracterización del impacto ambiental y productivo de las diferentes normas de certificación de café en Costa Rica. Master's thesis. Centro Agronómico Tropical de Investigación y Enseñanza (CATIE).

Rametsteiner, E., and M. Simula. 2003. Forest certification: An instrument to promote sustainable forest management? *Journal of Environmental Management* 67(1): 87–98.

Rice, R., and J. Ward. 1996. Coffee, conservation and commerce in the western hemisphere: How individuals and institutions can promote ecologically sound farming and forest management in northern Latin America. Washington, DC: Smithsonian Migratory Bird Center.

Rivera, J., and de Leon, P. 2004. Is greener whiter? The Sustainable Slopes Program and the voluntary environmental performance of western ski areas. *Policy Studies Journal* 32(3): 417–37.

Rivera, J., P. de Leon, and C. Koerber. 2006. Is greener whiter yet? The Sustainable Slopes Program after five years. *Policy Studies Journal* 34(2): 195–224.

Rosenbaum, P. 2002. *Observational Studies*, 2nd ed. New York: Springer-Verlag.

Rosenbaum, P., and D. Rubin. 1983. The central role of the propensity score in observational studies for causal effects. *Biometrika* 70: 41–55.

Rubin, D.B. 1974. Estimating causal effects of treatments in randomized and nonrandomized studies. *Journal of Educational Psychology* 66: 688–701.

Soto, G. 2009. Research Professor, Agroecology, Tropical Agricultural Research and Higher Education Center (CATIE), Turrialba, Costa Rica. Personal communication with authors. August 6.

Van der Vossen, H. 2005. A critical analysis of the agronomic and economic sustainability of organic coffee production. *Experimental Agriculture* 41: 449–73.

Wehrmeyer, W., and Y. Mulugetta (eds.). 1999. *Growing Pains: Environmental Management in Developing Countries.* Sheffield, UK: Greenleaf Publishing.

Appendix A. Organic Producers' Association of Turrialba Standards for Organic Production (APOT 2001)

1. Soil conservation

a. Must use soil conservation practices: drains , canals, terraces, contour planting, contamination barriers, and overflow ditches.

b. Must not use herbicides, pesticides, or synthetic goods that damage the soil.

c. Must use diverse shade (legumes, fruits, *leñosas,* Musacaeas, etc.) that will be shade useful to the family, coffee and nature.

d. Must not permit the soil to be exposed to the sun, using soil cover, such as shade, coffee, grass or dead cover. It is recommended to use dead cover in the case of specialty vegetables.

e. Must use wind breaks when necessary, with preference for species that are useful for the family and the farm.

f. Must incorporate organic material in the soil, such as bocashi, compost, lombricompost, etc.

g. Must give preference to always using the resource of the farm, but when necessary it is permissible to use external inputs of natural original, such as: products mineral like lime, *la rotoca fosforical*, *cal dolomita*, K-Mg, zinc sulfate, and magnesium sulfate, in cases of documented deficiency

h. If cultivation requires it and conditions permit, it's permitted to use a plow.

i. It is permitted to plant without contours only in already-established plantings, but in new plantations, contour planting is required.

2. Protection and management of water

a. Must take care to ensure there is good management of water in the farm: reforestation around the rivers, *acequias o quegbradas,* to avoid erosion and contamination of the waters with agrochemicals and trash.

b. Must manage water rationally when irrigation is used.

3. Care of biodiversity

a. Must take care the farm has a variety of trees, birds, plants, and insects to protect nature and aid in the control of natural pests.

b. Must have diversity in the foods in the farms for animals and humans.

c. Must have biodiversity that permits having different income/inputs for the producer and his family in different seasons of the year.

d. Must have diversity of cultivation for example rotation of crops in the case of *cultivos temporales, cultivos intercalados, etc.*

e. Using the coffee variety “catimor” is not permitted for new planting and replanting coffee.

4. Care of farm animals

a. Must provide the animals space that is sufficient, ventilated, and clean. They cannot be in stables all the time.

b. Must provide animals with clean organic food.

c. Must have diversity of food for farm animals.

d. Must have a good management of the animal wastes of the farm: must avoid contamination.

e. Must use natural control of disease, medicinal plants, and natural control of parasites.

5. Management of pests and sicknesses

a. Must favor diversity of cultivation that aids in the natural control of pests and sicknesses.

b. Must manage the soil with a diversity of organic material.

c. The cases where deemed necessary, and with previous authorization of the local inspector, it is permitted to use *sulfato de cobre o caldo bordeles* but it’s not permitted to apply more than 6.2 kg/ha/year.

d. It is not permitted to use gasoline for burning of *zomopas.*

6. Contamination of the farm

a. It’s not permitted to throw wastes of containers of agrochemicals in the farm or in sources of water.

b. It is not permitted to apply synthetic agrochemicals 36 months before the harvest.

c. Must maintain the distance and the live barrier necessary to avoid contamination that comes from neighboring lots that use agrochemicals.

7. Post harvest management practices

a. Must only take fresh, mature coffee to the mill.

b. Must not use sacks contaminated with synthetic agrochemicals.

c. Cannot mix organic product with transitional product.

d. In cases where growers are producing organic coffee and coffee in transition, they must carefully label the organic coffee to avoid mixing it with other types of coffee.

e. The transport of organic products must be clean and free of contamination.

8. General care of the farm

a. Must plan the farm well and have roads that do not promote erosion.

b. The organic producer must not grow conventional and organic in the same cultivated field in (parallel production).

c. The organic producer that already has conventional parcels on which crops other than coffee are grown must have a plan for converting the entire farm to organic within the next five years.

d. Must use live barriers to clearly separate organic lots and conventional lots.

9. Norms for the management of the quality of life of producers

a. The organic producer must understand the principles of organic agriculture.

b. The organic producer must undertake training periodically.