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Environmental-economic benefits and trade-offs on sustainably certified coffee farms

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ABSTRACT

Coffee with diverse shade trees is recognized as conserving greater biodiversity than more intensive production methods. Sustainable certification has been proposed as an incentive to conserve shade grown coffee. With 40% of global coffee production certified as sustainable, evidence is needed to demonstrate whether certification supports the environmental benefits of shade coffee. Environmental and economic data were taken from 278 coffee farms in Nicaragua divided between non-certified and five different sustainable certifications. Farms were propensity-score matched by altitude, area of coffee and farmer education to ensure comparability between non-certified and certified farms. Farms under all certifications had better environmental characteristics than non-certified for some indicators, but none were better for all indicators. Certified farms generally received better prices than non-certified farms. Farms with different certifications had different investment strategies; C.A.F.E. Practice farms had high investment and high return strategies, while Utz and Organic farms had low investment, low productivity strategies. Tree diversity was inversely related to productivity, price and net revenue in general, but not for certified farms that received higher prices. Certification differentiates farms with better environmental characteristics and management, provides some economic benefits to most farmers, and may contribute to mitigating environment/economic trade-offs.

1. Introduction

The expansion of tropical agricultural commodities, such as coffee, has been seen as one of the major threats to biodiversity (Lenzen et al., 2012; Donald 2004). At the same time, other authors have proposed that promoting sustainable and diverse agricultural landscapes can be part of the solution to conserving biodiversity in hotspots such as Mesoamerica (Harvey et al., 2008). Many authors have presented and promoted the potential of coffee with diverse shade trees to sustain biodiversity of birds, ants, bats and other mammals (e.g. Greenberg et al., 2000; Mas and Dietsch 2004; Estrada et al., 2006). Intensification of traditional coffee production systems, i.e. reduction in use or diversity of shade trees and increased use of agrochemicals, has been seen as a threat to biodiversity in this region (Rice and Ward 1996). Philpott et al. (2008) synthesizing evidence from across Latin America found a consistent trend that both ant and bird species diversity declined (and especially forest species) when shade tree diversity and complexity were reduced. Furthermore, diverse shaded coffee systems have also been deforested and converted to other land uses especially during periods of low coffee prices (e.g. Blackman et al., 2008 in Mexico and Haggar et al., 2013 in Guatemala).

Diverse shaded coffee systems are generally less productive than systems with single species or no shade, and economic incentives may be required to conserve them (Philpott and Dietsch 2003). One way to promote the conservation of diverse shaded coffee is through sustainable certification to access preferential prices among buyers and consumers (Dietsch et al., 2004). The area of certified coffee has grown substantially over the past decade. Potts et al. (2014) estimate that 40% of the volume of global coffee production, although only 12% of sales, is sustainably certified; this comes from approximately 3 million ha or about 30% of global coffee area.

The sustainability standards (e.g. organic, Fairtrade, Rainforest, Utz Certified etc.) differ in the aspects they emphasise (see Milder et al., 2014, a summary is given in the supplementary information), but general they all seek to reduce or eliminate negative environmental and social factors. Each standard has its own way of assessing compliance. In general, there are a limited number of prohibited practices e.g. no use of synthetic agrochemicals in organic, no deforestation under Rainforest Alliance. Additionally, a certain percentage of a larger number of environmental and social criteria need to be met. This

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means that actual compliance with specific criteria can be very variable across farms. For example, while all standards have criteria for shade grown coffee for which farmers gain points, it is in theory possible to be certified under any of the standards without shade if enough other environmental criteria are met.

The conservation of higher carbon stocks in shaded coffee has been claimed as another benefit of sustainably certified coffee. Carbon stocks vary quite widely (from 20 to 150 t ha^{-1} above ground carbon) but generally are found to be intermediate between agricultural and forestry systems (as summarized in Idol et al., 2011). Some sustainability certification bodies, such as Rainforest Alliance, are exploring how to increase the benefits to farmers from the sale of additional ecosystem services, such as carbon sequestration (Rainforest Alliance 2009).

Blackman and Rivera (2011) reviewed studies of the impacts of sustainability standards but found only two studies of the environmental effects of these standards in coffee, and none found evidence of clear benefits. Milder et al. (2014) identified further limitations in previous studies such as the lack of counterfactuals, limited scale of sampling, evaluation of only one dimension of sustainability (e.g. environmental or economic) and indicators based on perception.

The current study addresses some of these limitations through a large-scale survey of 278 farms across Nicaragua, and seeks to determine:

- whether sustainable certification effectively differentiates between coffee farms with different environmental characteristics;
- whether certification provides an economic benefit to the farmer for providing these environmental services;
- whether there are trade-offs between environmental services and productivity or income and if so, whether certification mitigates these trade-offs.

These questions respond to two areas identified by Milder et al. (2014) as priorities for understanding the interactions of sustainability standards and conservation: the effects on ecosystems services, and the nature of conservation/productivity trade-offs.

2. Methods

2.1. Economic and environmental evaluation of farms

We used the Committee for Sustainability Assessment (COSA) method for multi-criteria assessment of sustainability in coffee (Giovannucci and Potts 2008) to evaluate environmental characteristics and production costs and farm income on farms with different sustainability certifications in Nicaragua. This method seeks to use indicators that can be evaluated by trained evaluators but non-specialists (i.e. people with a technical training but not economists nor environmental scientists). It also aims for a method that can be implemented in between half to one day per farm; while this limits the depth of evaluation it also permits larger samples sizes to be undertaken. While we recognize the importance of assessing outcomes (Milder et al., 2014), and the indicators chosen were as close to the outcome as feasible, in the case of soil and water conservation the only viable option found was to assess practices that should lead to outcomes (e.g. assessing how potential water contaminants are treated rather than assessing the water quality). Nevertheless, this evaluation still serves to confirm whether there is differential implementation of good management practices between non-certified and certified farms, especially as many of these practices are not mandatory, but contribute to a score across a larger number of the standard criteria.

Nicaragua was chosen as having a relatively compact and homogenous coffee production area that allows comparison of certifications under similar environmental and socioeconomic conditions. Although a small coffee producer (less than 2% of global production) it has been one of the pioneering countries in organic and Fairtrade certification (Bacon, 2005) and both small-scale and large-scale farmers use the major certification standards.

We conducted surveys across the main coffee producing departments of Central-Northern Nicaragua (Esteli, Jinotega, Madriz, Matagalpa and Nueva Segovias). We aimed to survey 80 non-certified farms plus 40 farms from each of five certifications: C.A.F.E. Practices, Fairtrade, organic (also Fairtrade certified), Rainforest Alliance and Utz certified (a summary of the main characteristics of each is provided in the Supplementary Information). Cooperatives or coffee traders provided lists of certified farms; non-certified coffee farms of similar size were identified in the same communities as the certified farms by asking local traders or the farmers themselves. The sampling of non-certified farms from the same community as the certified was to facilitate the matching using propensity scoring (see Section 2.2) by increasing the likelihood of the farms being under comparable conditions, but presence in the same community was not the basis for the matching. Due to availability of certified farms, surveys were conducted on 81 non-certified farms and between 35 and 48 farms for each certification, with a total of 294 farms evaluated. Two surveyors experienced in farm verification processes conducted the farmer questionnaires. We provided training and constant revision and feedback on the content and quality of the questionnaire to ensure consistency in application of the criteria for evaluation. The questionnaire covered general farm and environmental characteristics, productivity, production costs and revenue. General farm characteristics included farm size, area in coffee production, farm altitude, farmer educational level, and years of experience of the farmer producing coffee, amongst others.

Due to the large number of farms and time that could be dedicated evaluation of the farms consisted of visual observation or simple field measurements to assess environmental characteristics and management. The evaluation only considered the area of the farm under coffee plantation; other aspects of land-use on the farm were not included.

Environmental services were evaluated in four aspects.

- Habitat quality in terms of number of trees per ha, the total number of tree species in the coffee plantation and the number of tree strata were assessed by surveyors making visual counts or estimates in the field but also validating with the farmer's knowledge. Tree diameter was also measured for a small sample of trees (see carbon stock estimation below). These indicators show how similar the shade-tree structure is to a forest and are derived from those used by the Smithsonian Migratory Bird Centre (SMBC, no date) to determine bird-friendly coffee shade systems based on research by Greenberg et al. (1997). The number of tree species is obviously dependent on the area under coffee production. To take this into account we used an adaptation of the Margalef diversity index (Magurran 2004) which compensates for the degree of sampling effort by dividing the number of species − 1 by the log of the number of individuals sampled. In our case, we considered the area of the coffee plantation to be more accurate as a measure of sampling effort than the estimated tree population (tree population is affected by tree planting of 1 or 2 species by the farmers, while species richness is affected occurrence of wild trees which we consider a function of area). Additionally, to avoid negative logs, as some areas are less than 1 ha, ln(area + 1) was used as the denominator in the following equation:

$$\text{Tree diversity} = (\text{spp-1})/\ln(\text{area} + 1)$$

While both the Margalef index and this adaptation may be limited by the assumption of a natural log based relationship of species richness to population or area, the index has advantages over other diversity indices in being more heavily weighted to species richness (our primary