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Smallholders at a Crossroad: Intensify or Fall behind? Exploring Alternative Livelihood Strategies in a Globalized World

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ABSTRACT
The chocolate market is experiencing a wave of market differentiation thanks to the emergence of the bean-to-bar movement. Cacao is seeing both a rise in demand for mass markets and a process of market bifurcation into more specialized, high-quality products for wealthy urban consumers. For the specialized market, the quality and origin of the beans are important attributes. Direct trading between chocolate makers and famers seeks to promote the conservation of rare cultivars and traditional agroforestry systems, while lifting farmers out of poverty. Here we assess whether these alternative configurations of the global value chain truly offer smallholders new opportunities, beyond the traditional intensification or marginalization pathways that are generally offered to them. We conducted detailed socio-economic and biophysical surveys with a sample of farms in three of the largest cacao producing provinces of Ecuador. Our results show that, even though smallholders lack the assets needed to join mainstream commodity markets, they have been able to capitalize on the qualities of their traditional varieties to access niche markets. Through strong cooperatives, the knowledge held by buyers about what constitutes a high-quality bean has been transferred to farmers. A unique natural capital may provide smallholders with rewarding pathways to develop their agriculture, exploiting new market opportunities offered by globalization. Copyright © 2018 John Wiley & Sons, Ltd and ERP Environment

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Introduction

SMALLHOLDER AGRICULTURE HAS BEEN IDENTIFIED AS A KEY CONTRIBUTOR TO FOOD SECURITY, THE CONSERVATION OF AGRObiodiversity and key ecosystems, and rural livelihoods (Angelsen *et al.*, 2014; Tscharntke *et al.*, 2012; Zimmerer, 2013). Nevertheless researchers have acknowledged the limitation of traditional smallholder systems to fully engage in global value chains (Gomez *et al.*, 2011; Lee, Gereffi, & Beauvais, 2010) and benefit from the high demand of agricultural products in a globalized world (Rueda & Lambin, 2014). Although smallholders make up a large percentage of the suppliers of globally traded commodities such as palm oil, rubber, cacao and coffee (Byerlee & Rueda, 2015), their insertion in these chains is marked by uneven power relationships (Oya, 2009). Global commodity chains are dominated by large corporate actors, which reap the lion's share of the value generated while smallholders remain disenfranchised, cut out from attractive market outlets and alternative market relationships, and, in some cases, indebted (Elder & Dauvergne, 2015; McMichael, 2013).

There are conflicting perspectives on the role of small-scale farmers in the globalization era (Murphy, 2012). A widely held view among economists is that smallholder agriculture is an anachronism, if not a dead-end: it would be better for smallholders to diversify off farm as large, capital-intensive farms are more productive (Collier & Dercon, 2014). Another view argues that intensification of small-scale production can realize significant returns and contribute to poverty reduction, which requires investments and technology adoption (Timmer, 2009). A third view holds that entrepreneurial smallholders may be in a good position to meet the growing global demand for specialty products by contributing to global supply chains (Murphy, 2012). The case of cacao illustrates these alternatives. Cacao (*Theobroma cacao*), a tropical species from South America, is one of the most globally traded commodities (Tropical Commodity Coalition, 2012). The worldwide demand for cacao has increased since the mid-2000s, leading to an expansion of the crop throughout the tropics (Byerlee & Rueda, 2015). By 2013, annual production amounted to 4.6 million tons (FAO, 2015). Most of the cacao is produced by smallholders, who cultivate highly productive *forastero* cultivars, hybrids and clones. Only a fraction of cacao production comes from the most aromatic traditional cultivars from the upper Amazon and Orinoco basins, and from the Caribbean coast (Motamayor *et al.*, 2008). These rare cultivars constitute a small but growing segment in the specialty chocolate market. Nevertheless, they are at risk of disappearing, given the expanding production for lower-quality, high-yielding clones.

Particularly endangered are the *cacao nacional* cultivars from Ecuador, which have a unique floral aroma and flavor (Gockowski, Afari-Sefa, Bruce Sarpong, Osei-Asare, & Dziwornu, 2011). *Nacional* has gradually been replaced by a clone – the CCN-51 (the Spanish acronym for Colección Castro Naranjal no 51) developed in that country during the 1960s by Homero Castro, an agronomist working at the Naranjal research station in the province of Guayas, Ecuador (Boza *et al.*, 2014). CCN-51 is said to be up to four times more productive than the *nacional* cultivars (Melo & Hollander, 2013) and moderately resistant to witches' broom, a fungal disease that affects cacao plantations across the Americas (Suarez-Capello *et al.*, 2006). However, CCN-51 is criticized by connoisseurs for its unvarying organoleptic properties. The use of the CCN-51 in large-scale plantations, which started in 1985 (Crespo del Campo & Crespo, 1997), has transformed Ecuador's cacao production in dramatic ways. It was estimated that about 20% of the total cacao area in Ecuador was planted with the CCN-51 clone, yielding 40% of total production (Anecacao, 2012).

An opportunity for the old cultivars, and for the farmers who grow them, lies in the wave of market differentiation experienced by the chocolate market. As with coffee and tea, demand for cacao is seeing both an unprecedented increase in emerging markets and a process of market bifurcation (Petkova, 2006) into more specialized, high-quality products for wealthier urban consumers around the world (Daviron & Ponte, 2005; Squicciarini & Swinnen, 2015). For these markets, not only the objective attributes of the product are important but also narratives regarding its origin, mode of production and environmental sustainability. In the case of cacao, the demand for differentiated products has helped create a shorter value chain, the bean-to-bar model, based on direct trading between chocolate makers and famers. Under this model, manufacturers engage farmers in shared-value chains (Porter & Kramer, 2011). These arrangements seek to lift them out of poverty through the payment of a market premium that recognizes the high quality of the beans and the provision of technical assistance, while at the same time promoting the conservation of the biological diversity of cacao and the traditional cultivation methods that have ensured the survival of the rare cultivars. Moreover, traditional agroforestry systems have the potential to participate in carbon

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markets, given the tree cover they maintain. Whether these direct trade value chains offer true transformational opportunities for smallholders remains an open question (but see Tampe, 2016, for a discussion on recursive knowledge appropriation as a way of increasing leverage among cacao producers).

This study focuses on Ecuador, home of the *nacional* cacao cultivars, and the largest exporter of fine cacaos in the world. The objectives of our study are threefold. First, we assess whether globalization offers smallholders new opportunities, beyond the traditional intensification or marginalization pathways. Second, we aim to understand whether smallholders are pushed into these new pathways by lack of resources or whether they are being pulled by buyers who seek unique market connections. Last, we identify conditions under which farmers can follow these alternative pathways by means that improve their livelihoods, their bargaining power and their natural capital. We use the case of cacao cultivation in Ecuador as an illustration of these broader questions. Our results inform research on smallholders around the world who grow products for export markets and rely on the agro-biodiversity of their land-holdings.

To conduct our study, we analyze the differences between CCN-51 producers and *nacional* farmers in terms of agricultural practices, access to differentiated value chains, and ecosystem service provision. The contrast between the two production systems helps us understand the economic and environmental characteristics of different livelihood strategies, and assess the contribution of agro-ecological systems to tree biodiversity conservation, carbon sequestration and farmers' participation in high-value chains.

Literature Review

Smallholders' Agriculture and Global Value Chains

Smallholders represent a large majority of producers in many agricultural commodities, from cocoa to coffee to palm oil, particularly in the tropics (Byerlee & Rueda, 2015). The globalization of agricultural systems, together with the growth in population and affluence, has increased the demand for many agricultural commodities, opening markets for smallholders (UNCTAD, 2009). At the same time, the integration of production and distribution, and the liberalization of many agricultural markets around the world, have made these farmers more vulnerable to the volatility of international prices (Naylor & Falcon, 2010; Rueda & Lambin, 2014). Whether smallholders can benefit from their integration in commodity value chains depends on the structure of the industry in their specific product (Bolwig, Gibbon, & Jones, 2009; Bolwig, Ponte, Du Toit, Riisgaard, & Halberg, 2010; Lee *et al.*, 2010), on the organization of the value chain and on the willingness of consumers to pay higher prices for the quality, sustainability, origin and other attributes of the commodity and its mode of production.

Growing interest in sustainable agricultural production among consumers around the world has opened a window of opportunity for smallholders to access differentiated markets. Beginning in the 1970s and 1980s, organic and fair-trade certifications were proposed as alternatives to the conventional production and distribution structures and practices in global agri-food chains dominated by price exchanges and productivity gains that disregarded environmental impacts (Raynolds, 2000). An array of certification schemes surfaced afterwards and is still evolving today. Although barriers to join these differentiated markets are still high (Potts *et al.*, 2014), evidence from field studies indicates that, under some conditions, small farmers might benefit from adopting sustainability standards. Farmers have not only (or mainly) benefited from higher prices, but more importantly they perceive social and environmental benefits, as well as the ability to upgrade to higher value chains (Rueda & Lambin, 2013).

Sustainability standards are not without critics (Bryant & Goodman, 2004; Goodman, Maye, & Holloway, 2010; Gullison, 2003). High costs, low uptake and insignificant changes in the production systems are among the main factors cited by sustainability standards' detractors. Also, standards have been accused of being co-opted by big-brands, serving their interests instead of those of consumers and farmers, and therefore losing their original aim and appeal (Elder & Dauvergne, 2015). The fair-trade and organic movements have been mainstreamed due to high uptake by large corporations (Raynolds, 2004, 2009), raising concern about the alignment between these certifications and their original ethical, alternative purposes. In spite of mainstreaming, fair trade has still a group of 'mission-driven' buyers and a segment of high-quality buyers for whom the seal ensures a reliable supply of high-

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quality coffee, while allowing some technical knowledge transfer that can render these market relationships more egalitarian (Raynolds, 2009). Mainstreaming certification has also meant that only a small fraction of the additional value associated with differentiated products is transferred to producers, as powerful actors along the chain capture most of the value (Elder & Dauvergne, 2015; McMichael, 2013). More recently, a new wave of direct-trade alternatives, pioneered by small roasting companies, such as Intelligentsia coffee, have spread across the coffee and cocoa markets (Holland, Kjeldsen, & Kerndrup, 2016). By going directly to the farmers, these companies claim not only to be able to pay higher prices to farmers, but also to support them in their efforts to improve quality and sustainability. Other examples of alternative business models include shared ownership, such as the Day Company, a social enterprise funded in the late 1990s in which a farmers' coop in Ghana not only supplies the cocoa but owns shares for 47% of the company (Kerrigan, Schaefer, Doherty, & Tranchell, 2007). Divine, the brand of chocolate produced by this company, is 100% fair trade but competes in the mainstream market, not the high-quality one. Whether direct trade supply chains truly deliver on their promise is still to be demonstrated.

Technology Adoption among Smallholders

A large body of literature exists on the factors that explain smallholders' ability to intensify production at the micro-level (i.e. the household) and the meso-level (i.e. the diffusion process) (Feder & Umali, 1993; Feleke & Zegeye, 2006; Rauniyar & Goode, 1992; Sunding & Zilberman, 2001). Based on these theoretical underpinnings, we expect that economic factors such as percentage of area devoted to the crop, land tenure, availability of inputs (planting material, agrochemicals), labor and credit, as well as access to markets and climatic variables, affect the rate of adoption of higher-yielding technologies (Rauniyar & Goode, 1992). Demographic variables such as age of the farmer and education might also play a role in the decision to adopt a new variety (Feleke & Zegeye, 2006). Also, as technology adoption might follow a spatial diffusion pattern by contagion, we expect farmers living closer to centers of innovation to have higher rates of adoption than those living farther away. Other variables influence farmers' decisions to adopt a new technology or remain in their traditional systems. Issues such as access to information and knowledge of the new technologies and their associated costs (Conley & Udry, 2010; Foster & Rosenzweig, 1996) and risk management strategies may hinder the adoption of more productive, higher-yield technologies. These barriers might be less prominent for large land-holders, thus making the scale of the operation a crucial variable influencing adoption (Collier & Dercon, 2014). We expect farmers who have smaller plots, less education, and less access to capital and labor, and whose income does not depend solely or mainly on cacao, to remain in the *nacional* varieties. Conversely, we expect adopters of the CCN-51 to have larger plots, and higher access to capital and labor.

In sum, smallholders can be *pushed* out of formal markets by their inability to mobilize assets that increase yields. Nevertheless, new economic factors are becoming apparent in globalized markets that might be *pulling* smallholders into higher-value chains, in spite of their lack of access to productive assets.

The Bean-to-Bar Movement

A 'movement' of high-quality chocolate makers has recently emerged in many cities around the world. They not only produce high-quality chocolate, but also claim to source directly from selected farmers, increasing transparency and sharing their profits with the land-holders. Additionally, they engage in the production of the fine bars from scratch, something that had not been done previously in the industry. Pastry chefs and chocolatiers used to buy their base products (butter, powder, liquor, couvertures, etc.) from large manufactures such as Barry Callebaut. Today, thanks to technological innovations and capital investments, many have developed the technology to produce their own chocolate bars in small batches, relying only on their own facilities and know-how. By vertically integrating their production and sourcing directly from farmers, these new chocolate makers claim they can have a higher quality control, a more diverse selection of products and a fairer trade with the farmers who produce cacao. By favoring quality over productivity, the bean-to-bar movement might be a counter force to the adoption of CCN-51, providing alternative economic incentives for farmers to keep the *nacional* cultivars, in spite of their lower productivity. These direct trade value chains may become a pulling force that brings farmers into high-value chains, transfering knowledge from buyers to producers, and changing the nature of the commercial relation between actors.

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Land-Sharing Versus Land-Sparing: The Role of Smallholders in Biodiversity

Shifting to more productive varieties also means changing the agro-biodiversity of the farms and landscapes. It has been argued that land intensification could be an efficient way of increasing yields and incomes for farmers while at the same time sparing land for nature conservation (Tilman, Balzer, Hill, & Befort, 2011). However, rich agroecological systems, especially when surounded by a matrix of preserved forests, can provide high biodiversity value (Melo, Arroyo-Rodríguez, Fahrig, Martínez-Ramos, & Tabarelli, 2013; Tscharntke *et al*., 2012).

Most of the traditional cacao cultivation is done under shade, or at least with several neighboring trees and crops surrounding the plots (De Beenhouwer, Aerts, & Honnay, 2013). Cacao orchards, particularly in small-holders' plots, are thought to be associated with non-cacao tree diversity, in particular when they are located near patches of natural forests (Faria, Laps, Baumgarten, & Cetra, 2006; Rice & Greenberg, 2000). The existence of diverse shade in the plot seems to have benefits for bird diversity (Waldron, Justicia, Smith, & Sanchez, 2012). Shaded cacao agro-forests are less vulnerable to pests and herbivores, although they might be more prone to fungal diseases (Tscharntke *et al*., 2011). Shade trees encompass a variety of uses, such as timber and food, and may be an important source of income (Rice, 2008). Previous studies suggest that shaded cacao systems have higher plant biomass and thus store higher amounts of carbon per hectare than sun-exposed systems (Bisseleua, Missoup, & Vidal, 2009). In contrast, exposed pest resistant hybrids such as CCN-51 are planted as monocrops using more pesticides, fertilizers and irrigation than the *nacional* cacao tree (Ruf, 2011). Thus, the intensification of the production system may have adverse ecological effects, notably on biodiversity and carbon sequestration.

Some scholars differ from this view, arguing that increases in cocoa density cause only minor quantitative changes in biodiversity (Steffan-Dewenter *et al*., 2007). Unlike other agroforestry systems, such as shade-grown coffee, where coffee bushes and trees share the same plot (Philpott *et al*., 2008), cacao farms are usually divided into specialized plots, in a landscape matrix of cocoa plots, non-permanent fields (such as rice or maize), and fruit and timber trees *neighboring* cacao plots (Bentley, Boa, & Stonehouse, 2004). In this scenario of a mixed landscape, the wide adoption of CCN-51 would not have a large impact on biodiversity and biomass accumulation *inside* the cacao plot. Farmers who consider shifting to more productive varieties also need to take into consideration changes in provision of ecosystem services associated with the abandonment of traditional production systems – particularly pest and disease control, provision of food, fodder and other materials, and organic matter.

Methods

Study Area

Ecuador is the second largest producer of cacao in Latin America, with about 3% of global production (FAO, 2015). However, Ecuador's cocoa production accounts for about 70% of the world's fine cacao (Anecacao, 2012). Around 2010, cacao occupied about 521 091 ha in Ecuador, of which 406 552 ha are in the coastal regions (INEC, 2012).

This study was conducted in three of the largest producing provinces: Guayas, Manabí and Los Ríos, in southern Ecuador, responsible for about 78% of the total coastal production (INEC, 2012) (Figure 1). These three provinces provide a gradient in practices, as the adoption of the CCN-51 clones followed a diffusion pattern from Guayaquil, where it was developed, to the northern regions of Los Ríos and Manabí.

Socio-Economic Data Collection and Analysis

We collected data on a random sample of 148 farms in the three regions. Of these farms, 10 were planting exclusively high-quality clones, provided by the INIAP (the Ecuadorian Institute for Agricultural Research, acronym in Spanish), and 28 had mixed strategies, with no predominant type of crop material. The remaining 110 farms were classified as either CCN-51 producers when more than 80% of the production was in CCN-51 clones, or *nacional* producers when more than 80% of production was of the *nacional* variety. A total of 39 CCN-51 producers and 71

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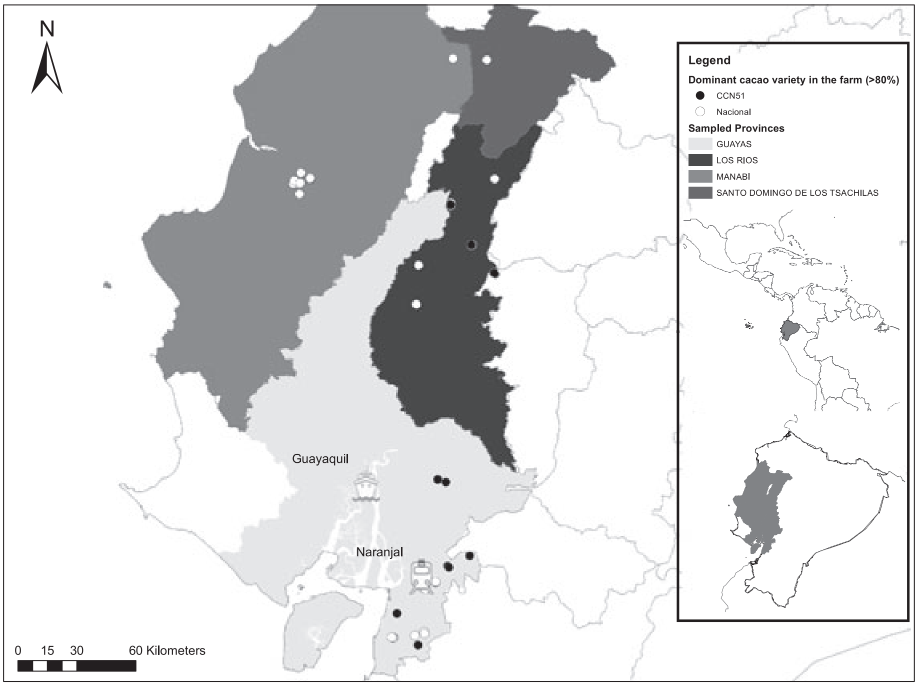

Figure 1. Map of sampled area in Ecuador

nacional producers were surveyed. The survey was conducted to address three main questions. (i) What socio-economic conditions determine whether a farmer plants the *nacional* or CCN-51 (or a combination of both)? (ii) What are the economic outlets and price differences obtained from each production system? (iii) Are biodiversity and carbon sequestration potential different for the two systems?

We compared the distributions of the two sub-samples – i.e. the farmers planting predominantly CCN-51 and predominantly *nacional* – using non-parametric statistics (Fisher exact test for binary variables and Kruskal–Wallis test for continuous variables) to test whether the two sub-samples could be considered as belonging to the same population.

Bio-Physical Data Collection and Analysis

In addition to the socio-economic survey, we surveyed a total of 75 transects in 57 of the 148 farms interviewed. Of these, 18 transects were in CCN-51 farms and 32 transects in *nacional*. Using a stratified random sampling design, we measured non-cacao tree species richness, composition, canopy cover and strata, as well as soil cover. We wanted to test whether plots of *nacional* varieties held larger tree biodiversity and carbon stocks than plots of the CCN-51 cultivar. On each farm surveyed, we randomly established one or two transects (depending on farm size and production system) of 20 m by 50 m. In addition, the northwest and southeast corners of the plot were demarcated into 10 m by 10 m quadrants. Within each of the 10 m quadrants, we measured the diameter at breast height (dbh, a standard forestry measure to estimate the timber volume in a tree) of each non-sapling tree (height at bifurcation > 2 m), classifying each tree by species and abundance within the quadrants. We classified saplings (woody-stemmed plants with bifurcation < 2 m) by species and abundance only. While present, saplings may not represent an ecologically relevant future population, as cacao farmers may clear weeds, bushes, and saplings that compete with their cacao trees.

In addition to tree species diversity, we estimated complexity of forest structure by indicating the presence/absence of four height strata (<0.5 m, 0.5. to 1.5 m, 1.5 to 3 m and 3 m+) using a modified Relevé method (Mueller-Dombois, 2001). A stratum was marked as 'present' when foliage covered at least 20% of the surface area

DOI: 10.1002/bse

of the 10 m × 10 m plot. Within the larger 20 m × 50 m transect, we assessed tree species richness by counting the number of different tree species within the entire transect area. In order to assess ground cover, we classified a point every 0.5 m along the transects' longitudinal midline (100 points total), with the following categories: leaf litter, weeds and/or plants, bare soil and other. This gave us a proportional estimation of ground cover composition.

Normality tests for all variables showed that only leaf litter was normally distributed. We thus conducted a Student t test to evaluate the effect of production system on leaf litter and a Wilcoxon test (which relaxes the normality assumption) for all other variables. We also studied the dependence between the production system and the canopy structure of the agroforest. Since the contingency table has more than 20% of the expected values below 5 (50%), we performed a Fisher exact test for independence for tables of more than 2 × 2, as implemented in the R software (R Core Team, 2013). We simulated the p-value with 10 000 replicates.

To compute above ground biomass (AGB) and total carbon sequestration, we obtained allometric equations for the species encountered in this study from several sources (Table 1), using equations that do not require tree height. The AGB was estimated for both cacao trees and non-cacao species and was compared between the two types of production system (dominated by *nacional* and CCN-51) using a Wilcoxon test. In the case of cacao trees, as noted by previous authors, we found no allometric equations based only on dbh (Isaac, Timmer, & Quashie-Sam, 2007; Kongsager, Napier, & Mertz, 2013) so we used a general tropical-region equation (Pearson *et al.*, 2013).

Results

Socio-Economic Characteristics and Land Use

Most of the farms surveyed were small or medium in size: 47% had 5 hectares or less, while 44% had between 5.1 and 30 hectares, and only 9% had more than 50 hectares. This distribution reflects the overall composition of cacao farm holdings in Ecuador (Useche & Blare, 2013).

CCN-51 adopters have similar demographic characteristics – age, education, size of the household – to *nacional* farmers (Table 2 Panel A). However, CCN-51 adopters differ in significant ways on several other characteristics (Table 2 Panel B): they have larger and younger plantations, with more land devoted to cocoa as a proportion of their farm. Producers of CCN-51 have very different land use practices as well: they use irrigation, pesticides and non-organic fertilizer in larger proportions than *nacional* producers. In terms of self-reported floristic biodiversity, the number of non-cacao tree species and the diversity of these species are significantly higher for *nacional* producers

Species (common name) or plant type	Equation for AGB (in Kg)	Source
Bactris gasipaes (chontilla)	$6.8414\ dbh^{2.086} + 2.7340\ dbh^{2.1837} + 2.7402\ dbh^{1.9408}$	Ares *et al.* (2002)
Carapa guianensis (figueroa)	$e^{(0.76+0.00015\ dbh^2)}\ x\ 10^3$	Segura and Kanninen (2005)
Cecropia spp	$e^{(-2.5118\ +\ 2.45257\ \log\ (dbh))}$	Nelson *et al.* (1999)
Coffea sp. (coffee)	$0.281\ dbh^{2.06}$	Pearson, Walker, and Brown (2013)
Cordia alliodora	$10^{(-0.755\ +\ 2.072\ \log\ (dbh))}$	Segura & Kanninen, 2005
Fruit trees	$10^{(-1.11\ +\ 2.64\ \log\ (dbh))}$	Somarriba *et al.* (2013)
Guadua angustifolia	$e^{[\log(2.6685)\ +\ 0.9879\ \log\ (dbh)\ -\ 0.0508/2\ ]}$	Rojas Quiroga, Li, Lora, and Andersen (2013)
Musa spp (banana)	$0.030\ dbh^{2.13}$	Pearson et al. (2013)
Phytelephas aequatorialis (Palma de tagua)	$e^{(-3.348\ +\ 2.7483\ \log\ (dbh))}$	Goodman *et al.* (2013)
Schizolobium parahybum (Pachaco)	$(7.692 + 0.015\ dbh^2)^2$	Alvarez (2008)
Timber trees	$21.3 - 6.95\ dbh + 0.74\ dbh^2$	Brown and Iverson (1992)
Theobroma cacao (cocoa)	$e^{[-2.289+2.649+\log\ (dbh)-0.021\ \log(dbh^2)]}$	Pearson *et al.* (2013)

Table 1. Allometric equations used to compute AGB for each species

DOI: 10.1002/bse

Panel A. Household characteristics	CCN51	Nacional	p-value†
	Median values/percentage		
HH head age (years)	50.5	56.0	0.32
HH head education (years)	6.00	6.00	0.14
Household size (number of people)	5.00	5.00	0.72
Highest education in the household (years)	12.00	14.00	0.29
Cocoa as main income (% yes)	0.68	0.51	0.10
Hire workers (% yes)	0.66	0.62	0.83
Panel B. Agricultural practices			
Total area (ha)	7.50	5.00	0.04*
Cocoa area (ha)	4.70	3.00	0.00***
Farm age (years)	9.00	33.0	0.00***
Density of cacao trees (trees/ha)	1100	700	0.00***
Density of non-cacao trees (trees/ha)	11.5	25	0.02*
Diversity of non-cacao species (species/ha)	4	5	0.07**
Apply pest-control products (% yes)	0.71	0.30	0.00***
Apply fungicide (%yes)	0.16	0.04	0.06
Apply insecticide (%yes)	0.45	0.18	0.00**
Use of organic fertilizers (%yes)	0.36	0.23	0.07
Use of chemical fertilizers (%yes)	0.50	0.14	0.00***
Use water for irrigation (%yes)	0.84	0.46	0.00***
Panel C. Market conditions			
Belongs to an association (%yes)	0.31	0.45	0.20
Premium for certification (%yes)	0.34	0.38	0.83
Premium for quality (%yes)	0.05	0.37	0.00***
Access to credit (%yes)	0.37	0.20	0.07**
Distance from Guayaquil (km)	60.77	148.52	0.00***

Table 2. Survey data measured in both farm categories
†Variables showing a significant effect of the type of producer have an asterisk according to the Wilcoxon rank-sum test for continuous variables and the Fisher exact test for dichotomous variables
*Significant at 0.1,
**significant at 0.05,
***significant at 0.001

than for CCN-51 producers. Finally, CCN-51 producer are located significantly closer to Naranjal, the place where CCN-51 was developed, compared with their *nacional* counterparts.

The Role of Higher Prices in Household Livelihoods

The Ecuadorian National Institute for Normalization (INEN) established the physical characteristics of each type of cacao bean for export (INEN, 2000). The norm distinguishes between four types of cacao *nacional* and CCN-51. Exporters and buyers negotiate the differential for Ecuadorian cacao above the international price of reference based on this norm. Exporters interviewed quoted a differential between US$20 and US$200/ton exported for the *nacional* cacao (i.e. between 0.7% and 7% of the base price). This differential has eroded over time, and the gap between *nacional* and CCN-51 has also closed (Melo & Hollander, 2013). At the level of producers, there is no formal market for high-quality beans, nor a set price for farmers who comply with the norm. Farmers who sell their beans to cooperatives might receive premiums either for quality (i.e. selling only *nacional*) or for eco-certification (i.e. selling fair trade or organic). Smallholders only participate in these markets through cooperatives. If they sell to an informal buyer, they receive no premium for either quality or sustainability, even if they produce only *nacional* varieties. Large holders who have their own certificate could sell directly to an exporter. If they only grow *nacional*

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(or recent clones of *nacional*), they may have a client overseas who is willing to pay for *nacional* beans and thus receive a higher price.

Nacional producers in the sample are shown to use different commercial channels than their CNN-51 counterparts. *Nacional* farmers in Manabí belong to Fortaleza del Valle, a buying coop that has developed strong market connections with high-quality chocolate makers, improving farmers' access to price premiums, stable contracts, technical assistance and market shares (Tampe, 2016). Fortaleza was created in 2006 and today has over 600 members. It holds both the organic and fair-trade certifications and has been able to reach high-quality buyers with whom it has developed strong collaboration for quality control. Similarly, many of the *nacional* producers in Los Ríos and Guayas have been supported by the Fundación Maquita Cushunchic (MCCH), a Catholic NGO that provides technical support and has an exporting company – Agromaquita – through which farmers sell certified and high-quality cacao to clients around the world (Marcos, 2013). By integrating the technical assistance, purchasing and exporting activities, MCCH has been able to appropriate key knowledge regarding pricing, quality and market outlets. Its engagement in ethical trade initiatives has been instrumental in the success of its marketing efforts (Nelson, Tallontire, & Collinson, 2002). According to the survey, producers of cacao *nacional* do not seem to rely more on cooperatives than producers of CCN-51 but they do receive higher prices for quality in a significantly larger proportion than producers of CCN-51 (Table 2 Panel C). The average value of the quality differential was US$16.2/quintal, equivalent to 17.7% of the base price paid during 2013 (Sinagap, 2013), much larger than the price differential reported by the exporters.

Biodiversity Estimates

We identified a total of 30 non-cacao tree species in the farms, 70% of them native and 30% introduced. The introduced species are commercial crops (coffee and banana) and fruits for domestic consumption. The native species are used for fruit, timber and trees kept for medicinal purposes and sources of materials (Table 3).

The type of producer was a significant predictor of the percentage of weeds, the percentage of leaf litter, the number of non-cacao species of more than 2 m height in the farm, the number of non-cacao species in the transect and the number of cacao trees in the transect (Table 4). Compared with *nacional* producers, CCN-51 farms had fewer non-cacao species in the farm, higher percentage of leaf litter, lower percentage of weeds, and more cacao trees in the cultivated area (a median of 9.5 cacao trees per quadrant in CCN-51 dominated quadrants versus 6.5 per quadrant on the *nacional* counterparts). We also found that cacao trees have significantly bigger dbh on farmlands with *nacional* varieties than on CCN-51-dominated farms. *Nacional* plantations are older than those planted with CCN-51 clones (Table 4).

The data showed that the complexity of the agro-forest (measured as presence/absence of four vertical strata) was not equivalent between the two production systems (Figure 2). In particular, we observe an excess of single-stratum presence in CCN-51 farms and an excess of highly complex (four-vertical-strata forests) quadrants in farms with *nacional* varieties.

Biomass and Carbon Stock Estimates

We produced estimates of carbon storage for 11 farms dominated by CCN-51 and 24 farms dominated by *nacional*. There is a significant difference in the amount of carbon stored in *nacional* quadrants. Most of this difference is attributed to the cacao trees, since the amount of carbon stored by non-cacao species is not significantly different between the two groups. Although *nacional* plots tend to have fewer cacao trees per hectare, these trees are much older than the cacao trees planted in CCN-51 farms (Table 4).

Discussion

Cacao farmers in Ecuador have a diverse array of crops and livelihood strategies. In our study, cacao represents about 80% of total farmland. Our analysis shows that farmers with larger plots, greater access to capital and living

DOI: 10.1002/bse

Species	Local name	Use	Origin
Sloanea sp.	achiotillo	medicinal	native
Persea americana	aguacate	food (fruit)	Mexico
Musa sp.	banano/guineo	commercial crop	Asia
Coffea sp.	café	commercial crop	Africa
Guadua angustifolia	caña guadua	timber	native
Cedrela montana	cedro blanco	timber	native
Bactris gasipaes	chontilla	food (fruit)	native
Carapa guianensis	figueroa	timber	native
Artocarpus altilis	fruta de pan	food (fruit)	native
Inga spectabilis	guaba	food (fruit)/shade	native
Inga ornifolia	guabo de mico	food (fruit)/shade	native
Cecropia obtusifolia	guarumo	shade/medicinal	native
Cecropia sp.	guarumo huasmo	shade/medicinal	native
Psidium guajaba	guayaba	food (fruit)	native
Guaiacum sanctum	guayacan blanco	timber	native
Cordia alliodora	laurel	timber	native
Citrus aurantifolia	limon	food (fruit)	Asia
Mammea americana	mamey	food (fruit)	native
Citrus reticulata	mandarino	food (fruit)	Asia
Mangifera indica	mango	food (fruit)	Asia
Codiaeum variegatum	mango de jardín	ornamental	Asia
Ficus jacobii	matapalo	ornamental	native
Crescentia cujete	mate	utensil	native
Cydonia oblonga	membrillo	food (fruit)	Asia
Maclura tinctoria	moral fino	dye	native
Citrus sinensis	naranja	food (fruit)	Asia
Schizolobium parahybum	pachaco	timber/medicinal	native
Phytelephas aequatorialis	palma de tagua	household materials/handcrafts	native
Carica papaya	papaya	food (fruit)	native
Matisia cordata	zapote	food (fruit)	native

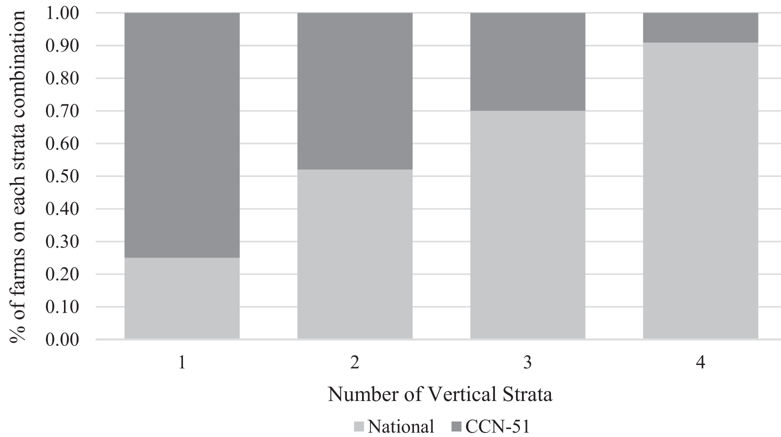
Table 3. Non-cacao species recorded in the CCN51 and *nacional* plantations with common and scientific names, use and origin

	CCN51	Nacional	
	Median values/percentage		p-value[†]
Farm age	10.0	40.0	0.00***
Number of non-cacao species in the transect	0.50	1.00	0.02*
Number of non-cacao individuals in the transect	4.00	6.00	0.33
Percentage of weeds	6.05	30.00	0.00**
Percentage of leaf litter	79.00	64.00	0.02*
Bare soil percentage	5.00	2.50	0.10
Percentage of other plants in the transect	1.00	0.50	0.84
Above ground biomass non-cacao trees (kg)	52.30	188.90	0.51
Above ground biomass cacao trees (kg)	101.50	286.30	0.00**
Above ground biomass all trees (kg)	103.80	457.00	0.00**
Cacao dbh in the transect (cm)	6.10	8.90	0.00***

Table 4. Transect data measured in both farm categories

[†]Variables showing a significant effect of the type of producer have an asterisk according to the Wilcoxon rank-sum test for continuous variables except the percentage of leaf litter, which was tested using the Student t test. The Fisher exact test was used for dichotomous variables

DOI: 10.1002/bse



Notes: Four strata were measured as present/absent (Level 1 between 0 and 50 cm, Level 2 between 50 cm and 1.5 m, Level 3 between 1.5 and 3 m and Level 4 more than 3 m). The figure shows the presence of one, two, three or four strata in any combination; CCN51 farms are in dark grey and *nacional* farms in light grey. The test of independence of forest complexity and type of farm rejected the independence hypothesis with a p-value of 0.0487.

Figure 2. Forest complexity measured as number of strata present

closer to the place of release of the clone have been the main adopters of CCN-51. Since the clone demands more inputs, only those with some financial capital have adopted CCN-51. Smallholders have, for the most part, kept their trees in *nacional*, helped by their participation in cooperatives that can sell the cacao at a price that reflects the high quality of the beans, which is then transferred to producers. When asked about the reasons for keeping their varieties, farmers mention cultural and cost-saving reasons. Having access to the differentiated market that actually pays a higher price gives them one more reason to stay. Therefore, even though smallholders lack the assets needed to join mainstream commodity markets, they have been able to capitalize on the intrinsic qualities of their traditional varieties to access niche markets. Thanks to their natural capital, they have not been excluded from globalization but are instead pulled into global markets by the new wave of niche-commodity outlets (Le Polain & Lambin, 2012).

By forming strong cooperatives, the knowledge held by buyers about what constitutes a high-quality bean has been transferred to farmers via training, facilities and constant collaboration. Today, cooperatives control the cacao processing (and even exporting business), capture the value derived from such activities and transfer the gains to their members.

In terms of biodiversity, cacao plots are dominated by the cacao trees, but non-cacao trees are also present. Farmers who have established CCN-51 plots have a significantly lower percentage of in-plot tree diversity, not only in terms of the absolute number of non-cacao trees per area but also the alpha species diversity of their plots. The space that non-cacao trees occupy in *nacional* plots is used to plant a higher number of cacao trees under the CCN-51 plantations. As a whole, CCN-51 plots have one-third of the diversity of non-cacao species of the *nacional* producers. *Nacional* producer have more species of timber and fruits that contribute to the household's income and sustenance, most of them native. If cacao remains a commodity market in which farmers' sustainability or quality efforts are ignored, one can expect farmers to continue their adoption of CCN-51, intensifying their plots and simplifying their agroforestry systems, with profound implications for biodiversity, food security and livelihoods. Farmlands with CCN-51 clones have more intensive practices – using more pesticides, fertilizer and irrigation. They also seem to have a higher amount of labor devoted to these and other maintenance tasks such as weeding.

Nacional farms have greater carbon stocks than their CCN-51 counterparts. This condition provides a greater opportunity for farmers in traditional agroforestry systems to enter carbon markets. Our estimates need to be improved in light of more accurate measurements as they are based on the application of allometric equations to the tree inventory. Uncertainty in these estimates, from tree measurement to the generality of the allometric equations, is a limitation of this methodology (Chave *et al.*, 2004). More specifically, our carbon stock estimates may be biased by the lack of tree height information and the impossibility of using species-specific allometric equations in all cases (Chave *et al.*, 2004).

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Conclusion

There has been a large transformation of the Ecuadorian landscape since the introduction of CCN-51. Farms planted in CCN-51 tend to be more homogeneous and more intensively managed. Access to land, capital and irrigation seems to be the determinants of farm conversion toward CCN-51. Smallholders who lack access to these productive factors have remained in the *nacional* varieties and have found an attractive market to sell their products. The conditions that have allowed farmers to thrive in this niche market relate to (i) the organizational capabilities to improve quality and scale, strengthening their bargaining position with buyers, (ii) the willingness of buyers to collaborate with cooperatives in transferring knowledge and value to farmers, securing a stable supply of high-quality beans, (iii) the transfer of quality-related prices to farmers who remain loyal to cooperatives, delivering the agreed upon quality and quantity, and (iv) the diversification of the production system, which enhances ecosystem service provision for farms and creates opportunities for market differentiation to satisfy consumers who value agro-diverse systems high in biodiversity and carbon storage.

Higher prices have assisted farmers who sell to cooperatives in maintaining a large proportion of the *nacional* trees. Participation in these niche markets has, in turn, helped preserve the genetic diversity of the crop and the diverse composition of their farms. As Ecuador becomes a more affluent country, farmers may gain access to technology, capital and other services, thus jeopardizing the survival of the *nacional* varieties. Manufacturing companies interested in the niche market of high-quality cacao cannot expect that these native cultivars will survive at the expense of the wellbeing of the Ecuadorian farmers who grow them. Migration to urban centers, under-funded agronomic research in the countries of origin and the impacts of global environmental change all threaten the survival of these cultivars and the livelihood of the farmers who grow them. The trade relationships, no matter how direct and value enhancing, cannot by themselves address all these issues. Hence, creating market incentives for traditional cacao varieties and investing in the wellbeing of small cacao producers are essential for the conservation of the most aromatic, traditional cultivars.

This case study illustrates how globalization may offer new opportunities to smallholders, beyond Ecuadorian cacao producers. Fine cacao varieties are found throughout the Orinoco and Amazon basin, the Antilles, Central America, Mexico and even Madagascar. Smallholders in these and other agro-diverse production systems may be pulled into new differentiated markets to meet the demand of the urban elites in rich and emerging economies. Their unique natural capital may provide them with rewarding pathways to develop agriculture beyond the traditional options of productivity increases through technology adoption or being left out of high-value export markets.

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