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Neighbor Trees: Shade, Intercropping, and Cacao in Ecuador

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Previous studies have shown that shade trees in cacao and coffee are important habitats for inter-American migratory birds. A survey of 21 cacao farmers along the northern, central, and southern Pacific Coast of Ecuador found that shade trees are associated with unirrigated, traditional cacao varieties and low levels of chemical inputs. Farmers stressed the importance of shade for managing soil moisture and soil fertility, and for managing some weeds and diseases. Most of the shade trees were not wild forest trees, but had been planted and protected by the farm families. Many other trees are intercropped with cacao for economic reasons, not related to shade. Chocolate manufacturers, consumers, and environmental activists can encourage farmers to maintain shade canopies by paying a premium for the traditional, shade-loving, high-quality aromatic cocoa varieties.

KEY WORDS: cacao; shade; intercropping; biodiversity; Ecuador; migratory bird habitat.

INTRODUCTION

As globalization brings more tropical farm products into postindustrial economies, scholars, activists, and consumers become more concerned about the social and environmental conditions under which those products originate. For example, Roseberry wonders if it is right to drink coffee while ignoring the plight of the "rural toilers" who pick it (Roseberry, 1996). This is similar to concerns expressed a decade earlier about food and its producers

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in temperate climates. For example, Wendell Berry wrote about the need to see U.S. agriculture not just as the source of products, but as the basis of rural communities (Berry, 1990). Consumers are starting to care about potential environmental damage caused by food production; advocates were influential in closing down the U.S. tuna fishing fleet between 1981 and 1988, aided by public outrage over videos of dolphins being killed in the tuna nets (Constance *et al.*, 1995). The organic agricultural movement was originally organized out of both environmental and consumer safety concerns, but is now rapidly growing and developing a more radical, global militancy (Goodman, 2000; see also Guptill and Wilkins, 2002).

Coffee and Cocoa

Of tropical crops sold on the international market, coffee is the most important and has been the first to attract much attention over environmental and social issues. There are now niche markets for organic, socially responsible ("fair-trade"), and "bird-friendly" coffee (grown under a certain diverse and relatively dense canopy of mature shade trees) (Baker *et al.*, 2001; Raynolds, 2000; van Elzakker, 2001). Like coffee, cocoa is a tropical commodity, grown on plantations but also by many smallholder farmers, and it is often grown under shade (Rice and Greenberg, 2000). Cacao and other agroforestry crops have long been proposed as a less environmentally destructive strategy than, say, cattle ranching in the tropics (Hecht, 1982). However, now scholars are starting to take a closer look at cacao and question whether some types of cacao farming are more environmentally sound than others. In a March 1998 conference in Panama, environmentalists and some cocoa industry representatives discussed the potential of shade-grown cacao in Latin America for enhancing sustainable agriculture and biodiversity. They were concerned over the recent tendency to convert shaded cacao to full sun. They concluded that at least some of the shade trees in cacao are forest remnants while others are planted by farmers and that shade trees are an important habitat for birds, including inter-American migratory species (Greenberg, 1998; Parrish, 1998; Power and Flecker, 1998; Smithsonian Migratory Bird Center, 1998; Whinney, 1998).

Shade Trees in Cacao Enhance Bird Diversity

An appropriate shade in coffee trees has been found to be suitable habitat for migratory birds, including for dwindling species (like the Tennessee warbler and the Baltimore oriole) and sometimes harboring even more species than natural forest (see Botero and Baker, 2001, for an excellent review).[5] Cocoa research is starting to show similar results. Cocoa grown under a diverse, shaded canopy supports greater biological diversity than most other tropical crops (Rice and Greenberg, 2000). In a 1997–98 comparison of birds in forest and on cacao farms in the Talamanca lowlands of Costa Rica, Reitsma *et al.* (2001) found that cacao farms had slightly more individual birds and slightly more species than forest (144 bird species on farms and only 130 in forest). However, cacao groves had significantly fewer forest specialist birds than did the forest, and the Talamanca forest had fewer forest bird species than other forested Caribbean lowland sites. This suggests that cacao plantations cannot substitute for forest, but do provide habitat for a large number of other bird species. Other studies support the notion of shaded cacao as wildlife habitat.

A census of birds in Los Tuxtlas, southern Mexico, counted 22,145 birds of 226 species. Researchers found similar numbers of species in remnants of natural forest as in agroforests (cacao, coffee, citrus, and allspice); 79% of the species were found in forest habitats, and a full 80% in arboreal agricultural habitats. Researchers found only 43% of the bird species in live fences (*Bursera simaruba* and *Gliricidia sepium*) and just 5% in pastures (Estrada *et al.*, 1997).

Although there are fewer studies of the diversity of other organisms in cacao, a study of bat communities in the Selva Lacandona in Chiapas, Mexico, found more bat species and more species of rare bats in cocoa plantations and rain forest than in agricultural fields and secondary forest. In the cocoa plantations studied, part of the original diverse tree canopy was left as shade (Medellin *et al.*, 2000).

Shade From Natural Forest Trees

A canopy of natural forest trees, with some very tall individuals (over 15 m), some like *Ficus* spp. and others that bear fruit for many months, and trees with epiphytes and some dead wood, is better bird habitat than a highly managed anthropogenic grove (Botero and Baker, 2001). Cross-culturally, some of the shade canopy used by cacao farmers is from wild forest trees. Some cocoa farmers in the Ibeku area, Abia State in Nigeria, retained various species of forest trees as canopy when preparing for cocoa planting (Meregini, 1997). A farmer survey in southern Cameroon in December 1987 suggested that almost all of the farmers retain selective wild tree species on

[5] A study of ant diversity in coffee groves and natural forests in Mexico and Costa Rica found a significant and visible drop in species number of ants where shade tree species were eliminated and the coffee planted in monoculture (Vandermeer and Perfecto, 1998).

cropped fields, particularly on cocoa plots, to provide shade (Duguma *et al.*, 1990). Coffee and cocoa are the main cash crops of Cote d'Ivoire, mainly grown by small farmers. The shade trees used are mostly wild forest species (Herzog, 1994). A 500-ha agroforestry farm in Gandhu District in Bahia, Brazil, was managed as a forest community, with a high percentage of useful indigenous tree species. The farmer eliminated some species and introduced some cultivated plants, especially cocoa (Schulz *et al.*, 1994).

Regarding the role of relic trees left over as shade when the forest is cleared for cultivation, all the farmers we spoke to who had cleared their own fields made it clear that they knew at the time that they were settling there permanently—they had come to stay and always intended to leave the farms to their children. This would argue against keeping relic trees, as opposed to replacing them with something more useful (many forest trees are not the best producers of useful fruit or timber) or smaller (larger trees are much harder than smaller to fell and dismantle without damaging the cacao). Some farmers elsewhere in the world do grow cacao in shifting cultivation—clearing, planting, and then, when the "forest rent" of soil fertility is exhausted, moving on and clearing a bit more, as in much of Indonesia, where forest rents are exhausted in virgin forest farms, whereon farmers invade fresh forest, in a rolling process of deforestation. This slash and burn, shifting cultivation was never the idea of people cutting forest for cacao in W. Ecuador, and this is in fact encouraging for sustainability, as their commitment to sustainable production on their current plots is clear. Paradoxically, therefore, the absence of forest relic trees may be an encouraging sign, as indicating a commitment to sustainability rather than the opposite.

Shade Trees Provide Agro-Environmental Services to Cacao Farmers

Birds are not necessarily a high priority for cacao farmers themselves, but shade trees provide several benefits that farmers do appreciate. Shade trees buffer high and low temperature extremes by as much as 5°C. Their litter-fall and pruning residues can contain up to 340 kg of nitrogen per hectare[6] (Beer *et al.*, 1998). West and Central African cocoa cultivation systems have been reported to cause minimum damage to soil, especially when compared with annual food crops (Duguma *et al.*, 2001).

The 500-ha agroforestry farm in Bahia, Brazil (cited above), used little fertilizer, since the forest trees provide much natural mulch. No pesticides have been used, as the system is "self-regulating." The cocoa yields

[6]This high figure represents the nutrient pumping by trees, rather than by nitrogen fixation. N^2 fixation by leguminous shade trees grown at a density of 100–300 trees per hectare may not exceed 60 kg of nitrogen per hectare per year.

from this are similar to those of surrounding cocoa plantations, which do use considerable amounts of fertilizer and pesticides (Schulz *et al.*, 1994). Field trials near Tingo María, Peru, showed that the fungal disease witches' broom *Crinipellis perniciosa* was most severe without shade (Krauss *et al.*, 2001).

However, farmers must prune canopy trees to achieve just the right amount of shade. Excessive shade may increase the incidence of some important diseases (such as *Phytophthora palmivora* in cocoa and *Mycena citricolor* in coffee), but decrease the incidence of others (Beer *et al.*, 1998).

Besides improving the cacao trees' habitat, shade trees and bananas may provide farmers with a joint product they can sell. An economic study of cacao planted under timber (*Cordia alliodora*) and under plantain over 8 years (1990–97) in Panama showed that the expected net incomes from shaded cacao were considerably higher than those from cacao grown as a monocrop. The agroforestry systems were also less risky (Ramírez *et al.*, 2001; Ramírez and Somarriba, 2000; see also Somarriba *et al.*, 2001). Experimental results have shown that rattan (*Calamus zollingeri*) is potentially a valuable intercrop with coffee and cacao. During trials in Sulawesi, Indonesia, rattan survived and grew as well in coffee and cacao agroforests as it did in natural forests (Siebert, 2000). In the Baoule region, Cote d'Ivoire, an inventory of shade trees found that of the 41 tree species, 22 were used as fuelwood and 16 as timber for local construction. Nineteen furnished traditional medicines and 15 had edible parts (fruits, leaves, flowers, palm wine) (Herzog, 1994).

However, in practice, shade trees are not always highly profitable for farmers. A quantitative study of 122 cocoa and coffee farmers in coastal Ecuador (regions of Ventanas, La Troncal, and Babahoyo, where the average area of each farm was 34 ha, showed that the direct income from shade trees was minimal. Even though 57% of all farmers sold wood, it earned them only 2.5% of their income, while the contribution from cacao or coffee was 84%. Between 1982 and 1987, farmers sold 4000 m^3 of timber, an average of 6.6 m^3/year per estate. Most wood (60%) was produced by the medium-sized estates (11–50 ha) (Mussack, 1988).

Not All Intercropped Trees Provide Shade

Besides shade, some other trees, and even annual plants, are intercropped with cacao for other reasons: usually for the direct economic benefits obtained from the intercropped plants themselves. For example, in Ntsan, a village in Cameroon, citrus trees were found in food crop plantings, on fallow land and in backyards, but they were mainly grown as a cacao intercrop. A farmer survey suggested that citrus–cacao agroforests of cocoa diversify the sources of income and help manage the fluctuations in household cash requirements. In other words, they supplement the cash income from cacao, and household members eat some of the citrus fruit (Aulong *et al.*, 2000).

Sapodilla (*Manilkara zapota*) in Grenada is a minor fruit crop, grown mainly by small farmers. Trees are scattered over wide areas as cocoa intercrops and on the edges of fields. Most of the fruit is exported to neighboring Trinidad and to destinations like Canada, Holland, and the United Kingdom (Andall, 1999).

Another reason to intercrop cacao is that the additional crops add income, without harming the cacao. Trials in Nigeria showed that the growth performance of young cocoa planted with annual crops[7] was either superior or comparable with that of cocoa in monoculture. The yield from the arable crops was an added benefit. Weeds were suppressed more in intercropped plots than in pure stands of cocoa (Adeyemi, 1999).

A survey of cocoa farmers in Bendel, Ogun, Ondo, and Oyo States of Nigeria, in 1985, showed that almost all the farmers intercropped their cacao. The intercrops included food crops such as plantain (92.3%), cocoyam (85.7%), cassava (51.3%), yam (41.3%), maize (38.9%), melon (31.4%), cowpea (28.6%), and pineapple (26.0%) and tree crops such as oil palm (71.5%), kola (67.3%), coffee (41.0%), coconut (7.9%), and citrus (7.2%). Other crops were *Sarcophrynium brachystachys* and *Megaphrynium macrostachyum* (45.2%), African walnut (*Tetracarpidium conophorum*) (42.2%), alligator pepper (*Aframomum melegueta*) (31.6%), and *Piper guineense* (20.2%). Guava, mango, pawpaw, and vegetables such as celosia, okra, and *Solanum* spp. were infrequently planted in cacao plots. As many as six or more other crops could be intercropped with cocoa at the same time (Oladokun, 1990). Almost all of the intercrops in the Nigeria study were annual crops, and many were trees that cannot shade cacao (e.g., coffee and citrus are themselves shorter than cacao, and coconut is a tall tree with a fairly small crown).

In Ecuador, farmers were switching from intercropped to monocropped cacao. The rest of this paper describes the historical changes of cacao farming in Ecuador, which has gone through massive expansion, contraction, marketing, and changes in the shade regimes. Then we discuss Ecuadorian farmers' perspectives: Why farmers are eliminating shade trees and how rural Ecuadorians perceive intercropped trees. We offer some suggestions for socially and environmentally responsible ways to encourage farmers to keep shade trees in cacao.

[7] The systems evaluated were (1) cocoa/yam/maize/cowpea, (2) cocoa/cassava/maize/melon, and (3) cocoa/cocoyam/okra/melon.

Hypotheses and Objectives of the Study

The field study tested three hypotheses: first, shade trees in cacao in Coastal Ecuador are wild, forest trees. Second, trees intercropped with cacao in Coastal Ecuador are shade trees. Both of these hypotheses were rejected. A third hypothesis that farmers had a clear and sophisticated understanding of the advantages and disadvantages of using shade trees was supported by the results of the study (i.e., it was not rejected). A related objective was to outline Ecuadorian farmers' reasons for eliminating shade trees in cacao.

HISTORICAL SKETCH OF CACAO IN ECUADOR

Cacao may have been grown in pre-Hispanic times along the coastal riverbanks of lowland Pacific Ecuador. It was certainly grown there by the early sixteenth century, most notably by Jesuit missionaries. Cacao was exported legally to Spain, and illegally to Spanish colonies, including Mexico and the Philippines. By the nineteenth century, Ecuador was the world's main producer of cacao, which was exported as a tablet for making into hot chocolate. Ecuadorian cacao farms were large estates clustered along the Pacific Slope rivers, where boats could load for shipment to coastal ports, especially Guayaquil. In the mid-nineteenth century, European chemists created chocolate candy, and the demand for cocoa skyrocketed. Ecuador responded by expanding production north, i.e., into the dryer coastal regions, and away from the rivers, for shipment via roads to Guayaquil and newer ports. Ecuador became "a money-making machine" (Arosemena, 1991), to the point that many landowners could afford to move their families to fashionable homes in Paris.

By 1910, world cacao prices began to decline, in part because production was catching up with demand. Ecuadorian producers benefited by the opening of the Panama Canal in 1913, which facilitated shipment to the Eastern United States and Europe. During World War I the U.S. government commissioned chocolate bars for the troops. Despite this, between 1900 and 1963, cacao went from being the mainstay of Ecuador's economy to a mere 3.8% of the value of the country's agricultural production. One reason was competition from vast amounts of cacao grown in British West Africa, especially after 1930, planted in part from material collected in Ecuador by British agricultural scientists. Disease (witches' broom[8] and

[8] Caused by the fungus *Crinipellis perniciosa*, which originated in the Amazon Basin and is now found in most of the Neotropics (Willson, 1999).

frosty pod rot[9]) destroyed 60% of the cacao in Ecuador between 1916 and 1931. Cacao production in Ecuador dropped from 48,955 tons to 13,646 tons. The large owners were ruined. They sold their estates to banana companies and to Ecuadorian smallholder farmers, who kept the cacao tradition alive and who now produce most of Ecuador's cacao.

During the 1940s, 50s, and 60s, Ecuadorian, British, and North American plant pathologists gradually developed ways of controlling witches' broom and frosty pod rot, especially by regulating shade: pruning or removing some shade trees to create a dryer environment in the groves, which was less conducive to fungal diseases (Arosemena, 1991). This is not to be confused with a later trend, mentioned below, in which shade trees were eliminated entirely, in a package with fertilization, irrigation, and high-yielding varieties (HYVs).

General Socioeconomic Trends in Ecuador

Ecuador was experiencing severe economic crisis by the late 1990s. The 1995 border war with Peru and falling oil and coffee prices led to inflation and government insolvency. Another contributing factor was the nepotism and corruption of President Abdalá Bucaram, elected in 1996 and deposed when the Congress of Ecuador ruled in 1997 that he was "mentally incompetent to govern." The country abandoned its own currency in 2000, converting to the U.S. dollar. The government froze personal bank accounts in 1999, to stave off a collapse of the banking system. Some agronomists and development specialists began to see cacao as a possible option for earning much-needed foreign exchange. The Ministry of Agriculture continued to fund extension in cacao, and research on modern HYVs and on ways to salvage old groves and to preserve germplasm of traditional varieties (Quiroz, 1997). A European Union project (ECU-B7-3010/93/176) began in 1995 to improve quality, teaching farmers appropriate technology for fermenting and storing top-quality cacao for export. The Bolsa de Productos (a private corporation) began to reestablish a quality certification system for cacao.

METHOD

In April of 1999, the authors interviewed 21 cacao farmers in Ecuador (April 5–23). The interviews were semistructured. After introducing

[9] Also known as monilia, water pod rot or Quevedo disease. It is caused by the fungus *Moniliophthora roreri*. The disease probably originated in the Quevedo area of Ecuador and has spread to Peru, Colombia, parts of Venezuela and Panama (Willson, 1999).

ourselves, we explained that we were interested in cacao farming, and that we would like to learn about their work. The farmers usually explained the bulk of their farm ecology, including the role of cacao and intercropped trees, with little further prompting from us. We were usually accompanied by an extension agent, and often by other Ecuadorian colleagues. The farmer was often accompanied by neighbors or family members, and was usually on friendly terms with the extension agent. The farmers were generally relaxed and self-confident during the interviews.[10] Sampling of farms was opportunistic and not random, but was biased towards small and medium family farms.

About the Farm Families

One family we interviewed was indigenous (Native American), and the others were Hispanic. All of them spoke Spanish and the interviews were held in Spanish. The 21 farms were located in all of the major cacao-producing areas of Coastal Ecuador, including the provinces of Pichincha, Manabí, Los Ríos, Bolívar, Guayas, Cañar, and El Oro (Fig. 1).

The farms we visited in Coastal Ecuador are highly diverse, family farms. Besides citrus and many other trees and plants intercropped with the cacao (discussed below), farmers also cultivate separate plots of annual crops, e.g., coffee, rice, maize, and manioc. In the south, important crops include bananas for export and plantains for consumption within Ecuador. Small herds of cattle are common. Some of the cash earned from cacao, coffee, and fruit is used to buy food. A previous study of four provinces in the study area (El Oro, Guayas, Los Ríos, and Manabí) found that the average cacao farmer had 22 ha of land, of which 9.6 ha was in cacao. On average, the other land was used for coffee (0.7 ha), bananas (0.2 ha), plantain (0.4 ha), rice (2.0 ha), maize (0.7 ha), soybeans (0.8 ha), pasture (5.3 ha), others (1.2 ha), and fallow (1.0 ha) (Proyecto Cacao, 1997).

Small wooden stores are common along the narrow asphalt highways, and shopkeepers occasionally buy cacao and sell pasta, baked goods, sugar, cooking oil, tinned meats, and other staple manufactured foods. Plantains are a major part of the local diet, and have been since at least 1796, when the colonial governor of Ecuador ordered (large-scale) cacao growers to plant 150 plantain plants for every 10,000 cacao trees, stating that plantains were "the bread of the poor" (Arosemena, 1991). Slightly mashed, fried green plantains (*patacones*) are a favorite main dish on the coast of Ecuador.

[10] A full, final technical report (Boa *et al.*, 2000) is available on request from e.boa@cabi.org.

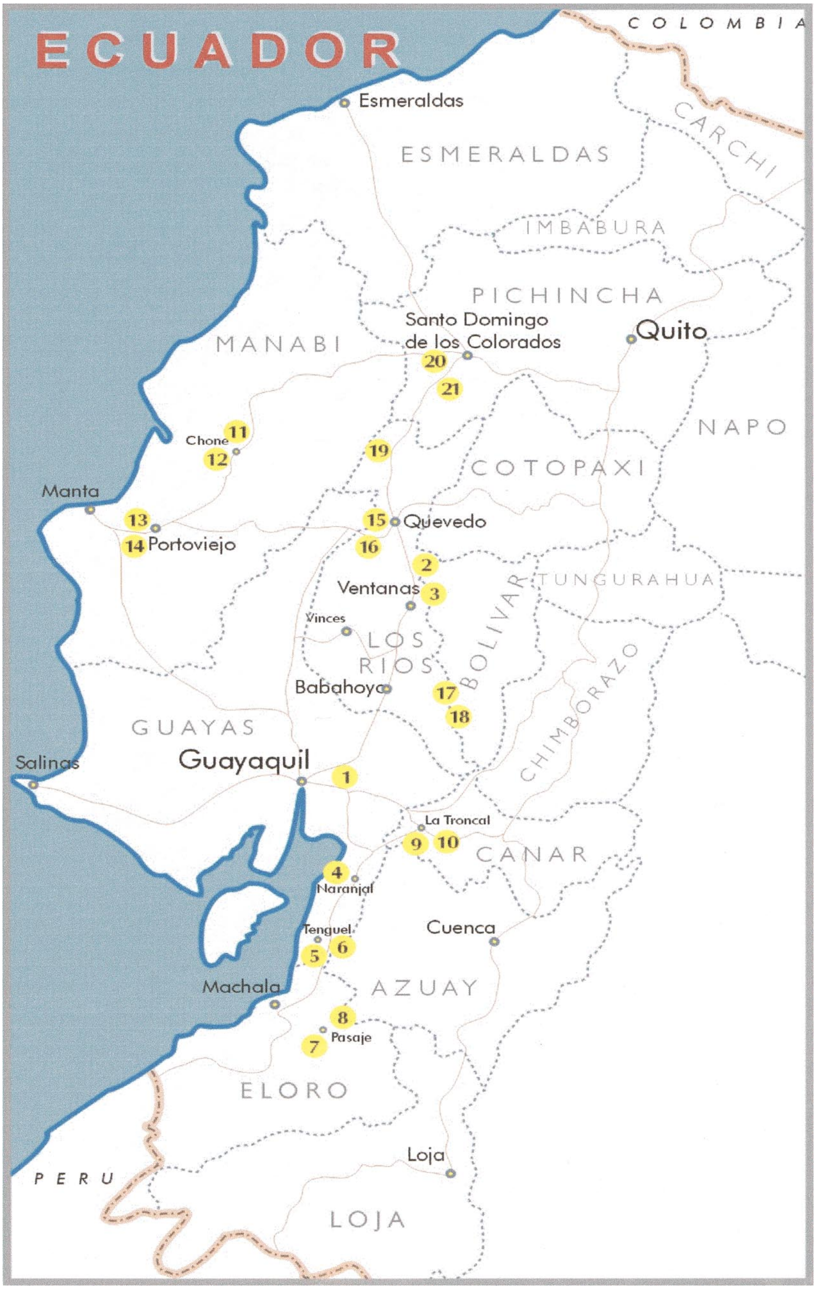

Fig. 1. Location of study sites in Coastal Ecuador.

SHADE TREES ARE NOT FOREST REMNANTS

It is commonly assumed that shade trees are forest remnants (Rice and Greenberg, 2000). An earlier study of cacao in Coastal Ecuador went so far as to say that most shade trees were "native to the area, of an advanced age, without market value, and without utilization value" (Mussack, 1988, p. 54). However, we only visited one farm where the shade trees were survivors from the natural forest. On all other farms, cacao was grown either in full sun or in the shade of trees that the farmers had planted. Some of the planted shade trees were quite large, and looked (superficially) like natural forest, especially when grown on steep, boulder-covered slopes (Fig. 2). But the farmers were quick to point out that they had planted the trees—as much as 40 years previously—lined up in rows, columns and even diagonally, to allow maximum wind passage (or as one farmer called it: by all four winds, *por los cuatro vientos*). Some of these large shade trees were planted decades after the natural forest had been cut. Some of the farms had first been cleared of natural trees, then planted in banana, sugarcane, or some other field crop for many years before being replanted in anthropogenic forest (see Table I).

Fig. 2. Heavily shaded cacao can look like a forest, at least superficially. Photo by E. Boa.

Table I. Clearing Land for Cacao and Establishing Neighbor Trees

Farm[a]	Farmer statement
ECF2	The farmers I know in this region have planted their (neighbor) trees. They are not left behind when the forest is cleared
ECF3	There has not been high forest hear for 35 years but there are still many native trees—they plant themselves
ECF8	The farmers that I know leave very few native trees standing [when they plant cacao]. They use some laurels left over from the forest clearing
ECF17	My farm was completely cleared of trees originally. The big trees you see here, which are now 40 years old, were originally volunteers
ECF18	I cut down all trees on my farm. I encouraged volunteer trees such as laurel, like my neighbor [ECF17]
	Above my farm is still natural forest. It is a bit dangerous because of snakes but it is exploited for bush meat. The natural forests are now largely stable
	I have lately cut down all the mature trees in my plot. They originally started as volunteers. I still have a guayacón of 27 years which will be very valuable. I am leaving this for my children to cut down in 30–35 years time. [We suspect more practical reasons of time and effort were the reason the timber trees were still there]
ECF19	Here is my piece of forest. This 12 year old bantano was cut down ten years ago and has grown again. (It is now about 60 cm in diameter.) I made a table with the wood. Bantano is not worth as much as laurel on the market
	The spacing of my zapote and avocado trees is different from cacao. They are 12 m apart whilst the cacao is 4 m. That is why the fruit trees do not appear in a precise line—unless you ignore the lines of cacao and look more carefully! Do I have to plan for fruit trees when planting my cacao? No. The fruit trees can be fitted in to any cacao tree spacing. [There may be patterns to fruit trees that are not obvious to the casual observer]

Note. Authors' comments are in square brackets
[a] ECF (Ecuador Cacao Farm) is a field code for each farm. See Fig. 1 for locations.

A common shade strategy was to plant guabo (*Inga edulis*),[11] a fast-growing tree, to shade cacao when the grove is first planted. Often, farmers use an ingenious strategy of using annual crops and trees in relays. They plant maize, manioc, bananas, or some other crop among the cacao to provide shade for the 1st year, until the *Inga* grows tall enough to cast shade on the cacao. After 3–5 years, the cacao (especially the modern varieties) can withstand sun, and the farmers begin cutting off guabo branches and ringing the trees, which then die, and eventually decompose in the field.

Management Strategies

Shaded cacao in Ecuador tends to be used with traditional cacao varieties (Table II). The HYVs thrive in full sun, especially after the trees are

[11] A legume tree, not to be confused with the fruit tree guava (*Psidium guajava*), which is called *guayabo*, in Spanish.

Table II. Technologies Associated with Cacao Grown in Shade and in Full Sun

Shade	Full sun
Traditional cacao varieties (e.g., *nacional*, *trinitario*)	Modern, high yielding varieties, especially CCN51
Little or no chemical fertilizer. Organic fertilizer provided by shade trees	Some chemical fertilizer
Not usually irrigated	Irrigated
Intercropped with other trees, besides shade	Often grown as a monocrop

Source: authors' interviews and Proyecto Cacao (1997).

mature (Fig. 3). Beer (1987) notes that shade trees compete for cacao for some soil nutrients, and that cacao trees have a lower response to fertilizer if the grove is shaded.

Traditional aromatic varieties are common and are generally unirrigated. Farmers use some chemical fertilizer on traditional varieties, but the only farmers who fertilize heavily are those with the modern variety CCN51. Epiphytes (air weeds) have to be cleaned off by hand, but are more common in traditional, shaded cacao. Full-sun cacao, especially CCN51, encourages ground weeds and farmers tend to use more herbicides with it. Farmers use fungicides and insecticides only sporadically (see Table III).

Fig. 3. Harvesting cacao in full sun. Note the dense ground weeds (photo by E. Boa).

Table III. Management Practices on Study Farms

Farm	Cacao variety	Irrigation	Fertilizer	Weed control	Pest management
ECF2	*Nacional* (about 10 ha)	No	No	Air weeds: removed when cacao price is high	No pesticides. Manual control
ECF3	*Nacional* (about 10 ha)	No	Yes, urea	Air weeds: removed by hand. Ground weeds: controlled by shade	No pesticides. Manual control. Suggested that urea application helps reduce disease impact
ECF4	*Nacional* (about 10 ha)	Yes	Yes	Air weeds: removed by hand. Ground weeds: controlled by shade	No information
ECF9	Venezolana + CCN51 (15 ha total)	Yes, intensive	No — "too expensive"	Applies cocktail of 3 herbicides, every 2 months. Air weeds: removed during cacao harvest	Applies malathion twice a year against ants
ECF10	CCN51 (35 ha)	Yes, "essential"	Yes, including foliar fertilizer	Intensive. "CCN51 needs more herbicides." One application will last 6 months if dry when sprayed	Removes leaf cutters with gasoline. They also spray against the *cochinilla* and *gusanos* (scale insects and caterpillars). Spray against "sandwich maker" (a leaf-rolling caterpillar) only when damaging; we do not want to kill pollinators"
ECF11	Trinitario, Venezolana, *Nacional* (10–20 ha)	Yes, 2–4 times a year	No, cannot afford	Controls ground weeds with machete. Too costly to spray. Air weeds have to be cleaned by hand	No pesticides used on cacao. Applied to coconut insect pest
ECF12	*Nacional* + Trinitario (50 ha) CCN51: (1 ha)	Yes. Owns pump	Yes, urea very occasionally	Hand weeds four times a year. They "clean" cacao during 1st year, later every 2 years	Gets rid of the leaf cutters. Does not control termites, "nobody worries about them"

ECF16	*Nacional* complex (about 10–15 ha)	No, cannot afford	Yes, urea occasionally	Cuts air weeds by hand. Has few ground weeds. Uses "liquid, Gramoxone or Aminapá"	Removes diseased material by hand. Used to spray against witches broom. Uses malathion or DDT against termites
ECF17	*Nacional* + Venezolana (15 ha)	No	No	Air weeds: if not removed trees will not yield for a year Ground weeds: hand removed 3–4 times a year	Use lacquer to reduce risk of mal de machete. Asked for chemicals to control Monilia. Cuts out witches' broom
ECF18	*Nacional* (30 ha)	No	No	All weeds removed by hand. Air weed removal is "biggest task around here"	Manual control. Witches broom said to be declining as a result of successful removal
ECF19	*Nacional* (10 ha)	No	No	Where shade is heavy, weed one a year by hand; twice a year in younger groves. No herbicides used	No pesticides. Some neighbors use for young cacao but he's not sure why
ECF21	CCN51 (30 ha)	No	On soil 3 × per year; also uses foliar fert	Weeding requires much labor. Use machete and herbicide, 3 times a year	Uses insecticides and fungicides

EMIC CONCEPTS OF ADVANTAGES AND DISADVANTAGES OF SHADE

The Ecuadorian farm families were aware that shade managed soil moisture, soil fertility, and some weeds and diseases. However, they realized that shade encouraged other weeds and diseases. Farmers were keenly aware of which species were good for shade (e.g., Fernán Sánchez) and which were not (e.g., citrus). The farmers had the most to say about *Inga* spp., and although their comments were generally quite positive, there were some less favorable statements, probably because of local differences in climate, and because unless it is pruned occasionally, *Inga* can give too much shade (see Table IV).

Shade Helps to Manage Soil Moisture

Many of the farmers with large, mature shade trees said they chose shade because they did not have irrigation. Shaded ground stays moist longer, and cacao requires some soil moisture. However, farmers with irrigation said they could clear the shade trees, as long as the cacao was 3–5 years old and could withstand full sun. These conclusions were similar to those reached by Beer (1987) in a review of the technical literature of cacao and shade.

Shade Trees Improve Soil Fertility

Nine of the farmers emphasized how shade trees, especially guabo, improve soil fertility (see Table IV). One farmer mentioned that guabo is a legume, but all of the others were aware that the leaf litter, decomposing branches and discarded cacao husks were organic fertilizers. It is possible that the shade-tree-as-fertilizer idea was reinforced by agricultural extensionists. We spoke with one researcher who said that agronomists were promoting guabo for cacao because it fixes nitrogen. Ecuadorian cacao farmers have received many visits from extension agents, and current farmer knowledge is a hybrid of local and outside information, as Iskandar and Ellen (2000) describe for the Baduy of Java. Whether it is farmers' own idea or a blend of local and outsider knowledge, farmers do appreciate crop residues and leaves, branches, and even the decaying roots of shade trees as forms of fertilizer.

Shade Helps Suppress Ground Weeds

Farmers said that shade helps to suppress weeds (*monte*); Beer *et al.* (1998) reached the same conclusion. In this paper, we refer to grasses and

Table IV. Role of Named Neighbor Trees in Relation to Cacao

Scientific name	Local name	Role reported by farmers
Cedrela odorata	Cedro	Soil Improvement • good fertilizer
Ceiba ?pentandra	Ceibo (bototillo)	Shade: • removed—no good for shade [possibly gives too much shade]
Citrus sp.	Cítrico	Shade • provides little shade • not grown for shade • (mandarins) are not for shade • citrus is not shade; it sucks the soil and gives nothing back • (mandarin and orange) are not shade
Cordia ?alliodora	Laurel	Shade • yes, it provides shade • affects cacao little as shade [seen as a positive service by one farmer] • soil improvement • feeds cacao with its leaves
Inga edulis	Guabo bejuco	Shade • yes; best shade • soil improvement • especially keeps the soil new
Inga edulis	Guabo	Shade • most important • good for young cacao • bad for shade and takes the "sap from the earth." [May refer to another *Inga* sp.] • best one for [young] shade, but removed after 3 years because they provide too much shade • no good for shade because it falls apart and damages the cacao • if planted too close to cacao it shades it [Santo Domingo—cloudy region with lower light levels] • weeds • throws out lots of stuff which prevents the weeds from growing • soil improvement • improves the soil; is a great fertilizer; feeds the soil; keeps the earth new
Inga spectabilis	Guabo de machete	Shade • is not good for shade • weeds • air weeds (parasitic plants) grow on it and can kill [Guabo was not specifically mentioned as a source of the air weeds found on cacao]
Maclura tinctoria	Moral fino	Shade • not good
Mangifera indica	Mango	Shade • also grown for shade • provides shade but takes long time to establish • weeds • parasitic plants "spill off" of mango trees onto cacao
Quararibea cordata	Zapote	Shade • not for shade
Schizolobium parahybum	Pachaco	Shade • too high and thin to provide shade • gives some shade [seen as a neutral service]
Triplaris cumingiana	Fernán Sánchez	Shade • provides shade

Note. Bulleted lists are used to distinguish comments made by different farmers. Authors' comment are in square brackets.

flowering annuals as "ground weeds" to distinguish them from air weeds (discussed below). Ground weeds thrive in the sun (see Table IV). Farmers relied mostly on household labor and hand tools to clear the dense weeds from the ground below cacao trees. Weeding with a machete is tedious and has the further disadvantage that if a person accidentally nicks the bark of a cacao tree with a machete, the wound can become infected with the disease known as *mal de machete*.[12] Two of the farmers we interviewed mentioned using herbicides. This is consistent with responses to a 1996 questionnaire, where 6% of the farmers interviewed claimed to use herbicides (Proyecto Cacao, 1997).

Shade Encourages Air Weeds

Cacao is attacked by weeds growing directly on the crop plant. The epiphytes include bromeliads[13] (called by various regional names: *piñuela*, *chupayo*, and *lechuga*) and parasitic plants[14] (regional names: *hierba de pájaro*, *pajarito*, *comida de pájaro*, *solda*, and *lentejilla*). Air weeds take root on the cacao branches and within a year or two can blanket the tree. The air weeds form a mat and accumulate soil, fallen leaves, and a lot of water, which can be quite heavy. The cacao branches bend under the weight of the air weeds.[15] Farmers strip these air weeds off of the slippery cacao branches every year or two. It is time-consuming and uncomfortable. Farmers complain that when weeding the branches, they damage the cacao buds, and so lose much of the following crop. Farmers claimed that air weeds thrived on shaded cacao more than on full-sun cacao, and that some of the shade trees themselves provided habitat for air weeds (see Table VII).

Shade and Cacao Disease

Farmers offered a complex of ideas about the relationship between shade and cacao diseases. Some said that there was a higher disease incidence

[12]Caused by the fungus *Ceratocystis fimbriata*, which attacks cacao, coffee, and other crops. The fungus enters through wounds in the bark (CABI, 1999; Willson, 1999).
[13]*Tillandsia complanata, Guzmania monostachia, Aechmea angustifolia.*
[14]Various genera of mistletoe parasitize cacao, including *Phoradendron*, *Pihivusa*, and *Psittacanthus* (Willson, 1999).
[15]We propose the term "air weed" to describe epiphytic weeds, following the term "air plant" to describe wild epiphytes in Neotropical forests (Kricher, 1989). We are unsure if there is an emic terms for air weeds. Most farmers referred to ground weeds as weeds (*monte*) and called air weeds by the individual names for bromeliad and mistletoe. However, we did meet one farmer, Griserio Pinos, who called ground weeds "lower weeds" (*monte de abajo*) and air weeds "upper weeds" (*monte de encima*). Extension agents have popularized the phrase *poda sanitaria* (cleansing pruning) to describe the weeding of air plants.

Table V. Effect of Neighbor Trees and Shade on Pest Impact

Pest type	Farmer statements
Diseases	Full-sun reduces/shade increases
	With full sun (no shade) there is less disease
	Too much shade and rain leads to more Monilia
	Cacao diseases are worse when cacao is grown with other trees
	Shade reduces
	With *nacional*, shade reduces pest impact, particularly Monilia
	Too much shade is bad since air movement is reduced
	Shade reduces witches broom
	No relation
	There is no relation between the amount of shade or sun and pest impact
	Increase in pest not associated with move from shade to full sun
Weeds	Shade beneficial
	Shade controls weeds. Shade removes weeds
	Cacao self-shading
	Older cacao shades out its own weeds and less (neighbor tree) shade is needed
	When cacao canopy closes weeds are eliminated
	CCN51 needs more herbicide protection than traditional varieties[a]
	No effect of shade
	Air weeds (bromeliads) are the same whether shade or full sun

[a]Because CNN51 casts less shade than traditional varieties, so weeds grow under it more easily.

in shaded cacao. Other said there was less. Farmers said there were more of most diseases in shaded cacao, especially in dense shade, but that there was less witches' broom (a serious disease) under shade (see Table V). Most Ecuadorian cacao was densely shaded until the 1920s and 30s, when agricultural scientists began to encourage less shade—which lets in more air and light (Arosemena, 1991). The dryer cacao leaves and branches support lower populations of disease-causing fungi, especially witches' broom and frosty pod rot. The shade one sees in contemporary Ecuadorian cacao, even in densely shaded groves, is probably less than what was common in the nineteenth century.

No Price Premium for Aromatic Cacao

Farmers were emphatic about the more pleasant taste and aroma of traditional cacao varieties, but the modern varieties (e.g., CCN51) were higher yielding. Farmers also observed that traditional varieties live longer. Cacao growers suggested they would be more willing to grow traditional (shaded) varieties if there was a price reward for doing so. Farmers complained that buyers bought all cacao at the same price, whether it was a modern HYV or a traditional aromatic (see Table VI for some farmer statements about varieties).

Table VI. Farmer Choice of Cacao Variety

Farm	Farmer statement
ECF3	My father and I are fond of *nacional*, the original variety of the country. We don't want to see it die out, and the flavor is superior to that of CCN51, although the prices of the two are now pretty much the same. We hope that in the future the price of *nacional* will rise because of its better flavor
	Nobody can understand why there is no price differential already, as the superiority of *nacional*'s flavor is universally acknowledged
ECF8	*Nacional* is recommended here. The root mat strength is important on these steep and broken slopes with thin and fragile soils. *Nacional* roots much better than CCN51
ECF9	We apply fertilizer to a young plant of CCN51 so it will produce more. But we old-timers say, what happens to this plant if we make it produce a lot while it is young? The old plants of *nacional* are still alive. With shade, they live to be 100 years old
	CCN51 is only 10–12 years old and we do not know how long it will live. A cacao plant will have to live 20–30 years to be profitable because it takes so much to establish it. Anything less is not worth while
ECF10	I think CCN51 could live for more than 50 years[a]
ECF18	My farm (*nacional*) is 40 years old and could be good for another 40 years
ECF20	CCN51 lasts productively for 15–20 years. After this it loses its strength and has to be replaced. Yes, *nacional* will yield for 40 years but CCN51 produces more

Source: Authors' survey.
[a]This would appear highly unlikely (authors' comment).

Until the 1960s, Ecuador had a complex system of named quality grades of cacao. The better cacao fetched higher prices. North American manufacturers, the main buyers, required a certain volume, at a standard quality, and were not very interested in buying the higher grades. Buyers began catering to the manufacturers, mixing grades, and selling all Ecuadorian cacao at the same price. The quality grading system collapsed, which led to general decadence in the quality of Ecuadorian cacao and paved the way for the adoption of full-sun, high-yielding, nonaromatic cacao (Arosemena, 1991).

Although about 94% of the cacao groves in Ecuador are of traditional varieties, this is changing rapidly. Only about half (52%) of the area in new cacao (under 5 years) is planted in traditional aromatic varieties, and the other half is planted in modern high-yielding clones, especially CCN-51. However, most of the groves still being planted in traditional varieties are blends of Nacional and Trinitario; less than 1% of new groves are planted in the endogenous Nacional variety.[16] New groves on the larger estates especially are based almost exclusively on full-sun, HYV cacao (Proyecto Cacao, 1997).

NEIGHBOR TREES

While shade trees may be bird-friendly, especially if they are natural forest remnants, we found that many of the trees intercropped with cacao are not shade trees at all, but are grown only for fruit or other products. We suggest the term "neighbor trees" to describe any tree growing as an intercrop with cacao. We follow Odum's observation that ecological terms are often extensions of human roles (Odum, 1959). In this case, a neighbor tree is one that lives near cacao, in the same community.

Neighbor trees include, but are not limited to shade trees. Niches of neighbor trees include the following:

1. *Timber* trees, Fernán Sánchez (*Triplaris cumingiana*), laurel (*Cordia alliodora*), pachaco (*Schizolobium* sp.), and others, grown for the value of their timber and because they have small canopies, so in theory they can be cut down while doing relatively minor damage to the cacao (Fig. 4). Farmers pay contract loggers to harvest timber trees intercropped in cacao. However, although four farmers showed us timber trees intercropped with cacao, the timber trees were large and looked like they would be difficult to harvest without also damaging cacao trees. We saw few examples of timber trees that had been grown to maturity and harvested from within a cacao grove. Timber trees may be grown as more of an old age pension, to be harvested when the cacao trees are cut down, but this is a topic for future research. Beer *et al*. (1998) also report that timber harvesting damages cacao trees.
2. *Fruit* trees like mango (*Mangifera indica*) and guava are not grown in sufficient numbers to shade a whole grove. They provide fruit for household members and occasionally for small sales.
3. *Commercial citrus* was grown on 19 of the 21 farms we visited. Most citrus trees are shorter than the cacao trees themselves, and compete with the cacao, but are grown for fruit, especially for sale.
4. *Gap and understory trees*. when individual cacao trees die prematurely, some farmers fill in the gap with other species, often coffee

[16]The government of Ecuador is concerned about this loss of germplasm and is attempting to prevent genetic erosion with a gene bank and by developing technologies to encourage the maintenance of old groves, supported in part by the European Union, through the Project "Reactivation of the Production and Improvement of the Quality of Cacao" (Quiroz, 1997).

Fig. 4. Laurel timber drying next to a cacao grove (photo by E. Boa).

plants. In some groves, farmers plant coffee as an understory to cacao, so the cacao is actually the shade tree for the coffee.

5. *Palms*. Some palms, like coconut, are grown in the groves, but farmers point out that they are too thin to cast much shade.
6. *Others*. There are many perennial plants that are not technically trees: papaya, bananas, and bamboo, which farmers plant between the rows of cacao. Some farmers grow a common species of bamboo (*Guadua angustifolia*) and use it to make various things, including the poles for harvesting cacao.

Farmers plant neighbor trees in a highly ordered pattern. For example, there may be one row of citrus between each row of cacao, or one coconut per every nine cacao trees. We saw few cases of trees planted at irregular distances, or on nongeometric patterns (for a list of other neighbor trees, see Table VII).

Farmers plant neighbor trees that are specifically not for shade, e.g., citrus, for the same reason that farmers intercrop in general: to increase returns to land (Netting, 1993; Wilken, 1987). Farmers plant many trees with cacao not because the cacao needs neighbors, but because cacao can tolerate them. Modern HYV cacao is planted in full sun, without other neighbor trees as well. This may be because the HYV–sun–chemical fertilizer combination

Table VII. Neighbor Trees Observed on 21 Cacao Farms in Ecuador

Local name (# of farms)	Scientific name	General notes	Some farmer comments on neighbor tree
Aguacate/Palto (5)	*Persea* americana	Avocado	Grown for fruit. The foliage is denser at the time of cacao flowering and fruiting
Amargo (2)	*Simarouba amara*		Sold for timber
Balsa (2)	*Ochroma pyramidale*		Sold for timber
Caucho (2)	*Castilla elastica*	Caucho also = *Ficus elastica*	Dries up the earth. Sold for timber
Cauje (2)	*Pouteria caimito*		The fruit can be sold. Rots when there is too much water
Cítrico (19)	*Citrus* spp	Includes mandarins (4) and tangerines (1); some farms had more than one kind of citrus	Both can grow well with cacao and they give fruit to sell. Mandarin combines well with cacao. It is not a shade tree
Fernán Sánchez (6)	*Triplaris cumingiana*		Good for timber and shade
Fruto de pan (5)	*Artocarpus altilis*	Breadfruit (Fig. 5)	Makes too much leaf litter which clogs cacao branches. Attracts humidity and can grow well with cacao and other fruit trees. Parasitic plants thrive on it. The fruit is fed to pigs
Guabo (also known as Guabo bejuco) (6)	*Inga edulis*	The most common shade tree used by farmers	It is more rooted, and during droughts it dries out soil further. People don't use guabo in the area around Chone. Guabo is least valuable as a product tree though some use for firewood. It is a great fertilizer
Guabo de machete (5)	*Inga spectabilis*	= Guaba vaina de machete	Makes shade. Parasitic plants cover it
Guaya/Guayacán/ Guayacón (5)	*Tabebuia* sp	Guaya interpreted as a contraction of guayacán	Planted for fruit and timber
Laurel (11)	Cordia alliodora	Laurel de puna = *Cordia alliodora*, laurel fino = *C. macrantha*	Blows over in wind and destroys cacao. Causes less damage than other timber trees when felled. Affects cacao very little. Does not cast too much of a shadow. Grown for timber and light shade
Mamey (3)	*Mammea americana* or *Manilkara zapota*	Mamey Cartagena = *Mammea americana*; mamey colorado = *Manilkara zapota*	Grown for the fruit

Table VII. (*Continued*)

Local name (# of farms)	Scientific name	General notes	Some farmer comments on neighbor tree
Mango (7)	*Mangifera indica*		Drought tolerant, withstands flooding. When it gets too big it falls apart and damages the cacao. A big tree can destroy 3–4 cacao trees. Foliage is denser at the time of cacao flowering and fruiting. Gets a lot of parasitic plants. It is shade, but it takes too long to grow
Pachaco (6)	*Schizolobium parahybum*		Fast growing timber tree, too thin to give much shade. More damaging than either laurel or Fernán Sánchez when felled
Zapote (7)	*Quararibea cordata*		Fruit tree. Less tolerant of drought and flooding than mango. Combines well with cacao and does not impede flowering or fruiting
Teca (3)	*Tectona grandis*	Teak	Good shade

Note. The scientific names come from Valverde (1998) and Gentry (1996) and are based on the common names farmers gave us. The following tree species were recorded from only one farm: Badeia [*Passiflora quadrangularis*]; Bantano [*Pithecellobium macradenium*]; Beldaco [*Pseudobombax guayasense*]; Cadi [*Phytelephas* sp.]; Caña de guadua [*Guadua angustifolia*]; Canelón [*Swartzia littlei*]; Canuto [*Cecropia* sp.?]; Cedro [*Cedrela odorata*]; Cadi; Ceibo (bototillo) [*Ceiba ?pentandra* (poss. *C. trichistandra*)]; Cereza [*Bunchosia* sp.]; Guachapelí [*Albizia guachapele*]; Guanábana [*Annona muricata*]; Guayacón blanco [*Tabebuia* sp.?]; Guayava [*Psidium guajava*]; Guabo colorado [*Inga* sp. ?]; Guabo mico [*Inga vera*]; Matapalo [*Ficus* sp.]; Moral fino [*Maclura tinctoria*]; Yuca de ratón [*Gliricidia sepium*]. No scientific name equivalent was found for these local names. All were recorded from one farm only. Chontilla; Pechicho, Pijao; Porotá/Porotú, Quinceañera; Visola. The following are often not grown in direct association with cacao. They include [# farms]: Carambola = *Averrhoa carambola* [2]; Coco = *Cocos nucifera* [2+]; Papaya = *Carica papaya* [2]; Poma rosa = *Syzygium jambos*].

is heavily influenced by extension agents, who tend to take a dim view to intercropping.

People said they grew neighbor trees for the fruit, for fertilizer, and for managing soil humidity. Farmers were generally quite pleased with the neighbor trees, even though they did not use the word “shade” very often unless the interviewers mentioned it first (see Table VIII). Some farmers (e.g., ECF19, see Table VIII) were not sure if they considered their cacao shaded or not. On the other hand, concerned environmentalists use the word “shade” frequently when describing the trees grown in cacao (for example, see the Smithsonian Migratory Bird Center website http:// natzoo.si.edu/smbc/). When environmentalists begin talking more

Fig. 5. Breadfruit trees cast dense shade, and the heavy leaves lodge in cacao branches (photo by E. Boa).

with farmers, activists will need to be aware that not all trees intercropped with cacao are for shade, and that many are domesticated or at least managed, and are not all wild forest trees.

Table VIII. Influence of Neighbor Trees on Management of Cacao

Farm	Farmers' attitudes about neighbor Tree	Farmer statement
ECF9	Neutral	When pests increase we do not think this is because the shade in our cacao has been removed to give full-sun production
		Mandarin, orange and zapote combine well with the cacao and do not harm it. They are not shade. Mango is shade but it takes a long time (to grow)
ECF10	Neutral	There is no relationship between the amount of shade or full sun in groves and pest problems, or the way in which we manage the cacao
	Positive	Trees are often put in rows down the edges of the main cacao plots. The main purpose of these other trees is, in order of importance, fertilization of the soil, to provide us with products and also for humidity control. For shade? This is not really worth a mention
	Positive, mostly	Guabo does give fruit—here, try some. It produces wood for firewood. We take the guabo out after 3 years, because they have grown so fast they overshadow the cacao. The other trees are left longer [Guabo = *Inga edulis*, a fast growing tree which fixes nitrogen.]
ECF11	Positive	Why do I have all these trees together with cacao? Soil improvement is important. You can't overfeed the soil
ECF13	Positive	Rotting down of my other (shade) tree leaves for fertilizer is important. Coconut takes longer than most others—a frond will take up to a year to rot down, less if wet. Whereas banana leaves are pretty much rotted down in 2 months
ECF16	Positive, mostly	We plant laurel and other timber trees here and there. We also plant caucho but it dries up the earth. The guabo, especially guabo de bejuco, keeps the earth new. We removed one mango tree because it made too much shade [Guabo = *Inga* spp., Caucho = rubber, Laurel = *Cordia alliodora*]
ECF19	Neutral	See how the breadfruit and citrus and the cacao are so close together, yet all give fruit? They don't interfere with each other
	Negative	Fruit trees receive more from the cacao than they give back in leaf fertilizer
	Positive	I believe my farm is shaded. [This was not the first farmer to be confused when asked about the shade cast by other trees on cacao.] I am not sure what different management practices I would need to use if my cacao was in full sun but I expect I would need chemical fertilizers most. I do not use them at the moment
		I say that shade in *nacional* improves production because there are fewer pests and diseases, particularly monilia. One of my neighbors disagrees and says that ventilation and air movement are important. Of course, you can have too much shade, but you also got the benefit from other trees growing with cacao
		Yes, it is possible that cacao tolerates other trees, and that these give an opportunity to increase production. However, I still believe that cacao benefits from other trees and that shade is one of these benefits. I cannot say whether shade is more important than the other benefits

Note. Authors' comments in square brackets.

Diversity of Birds

We asked some farmers about the relationship between birds and shade. The farmers did not quite scoff at the question, but they thought it was trivial. One farmer, Tomás Olmedo, pointed out that, after all, the cacao plant itself is a tree, and that parrots nest in the holes of the larger, older cacao trees. Mr Olmedo further observed that the traditional varieties live to be 80 or 100 years old and become large trees, which are attractive to birds. But the modern HYV cacao was only introduced in the 1980s, so farmers are unsure how long the trees will live.[17] The authors observed that HYV cacao shows few signs of being able to live to be 100; they are shorter trees with thinner branches, and not as likely to harbor birds.

Farmers' lack of interest in birds may be related to the common local perception that birds spread parasitic plants, by eating their fruits, then perching on cacao trees and defecating the seeds, which stick to the cacao bark.[18] While farmers may have few concerns over biodiversity, they are anxious to preserve the value of their land for their children and grandchildren, even though they do not refer to the notion as "sustainability."

One of the more troubling losses of agrodiversity (Conelly and Chaiken, 2000) is the decline in the populations of old, traditional cacao varieties. The old varieties are shade-loving, low-input cacao, once used to make the highest quality of chocolate. Some of the groves still survive, in part because they can be productive until they are 80 or older, but unless farmers start to plant new groves of aromatic cacao, this genetic material will be endangered.

CONCLUSIONS

Few shade trees in coastal Ecuador are forest remnants. Besides shade trees, farmers plant many other kinds of tree in cacao, for fruit, timber, and poles. All of these intercropped trees, shade and others, make up a complex of neighbor trees. Shade and other neighbor trees are crops, which farmers carefully plant and manage. Sun cacao is part of a package that includes modern HYVs, chemical fertilizer, irrigation, and monocropping. Farmers are aware that shade trees preserve soil moisture and soil fertility, and that they suppress ground weeds. Farmers also understand that properly regulated shade helps manage some cacao diseases, but stress that shade encourages air weeds. Farmers are more likely to use shade with traditional, aromatic varieties of cacao that are slowly disappearing. Preserving the agrodiversity

[17] Plant breeders suggest that the trees will give high yields until they are about 25 years old.
[18] Willson (1999) writes that birds eat mistletoe and the seeds stick to their beaks, which the birds wipe off onto trees, planting the weeds on cacao.

of Neotropical cacao (traditional cacao varieties, shade and other neighbor trees) would be easier if farmers received a price reward for aromatic cacao.

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