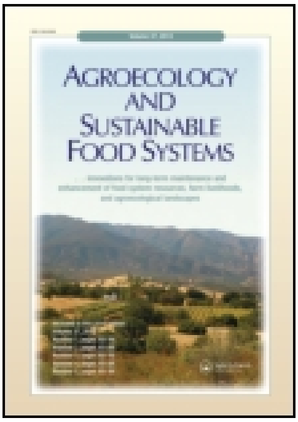


Agroecology and Sustainable Food Systems
Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/wjsa21

Agroecological Transition of Conilon Coffee (Coffea canephora) Agroforestry Systems in the State of Espírito Santo, Brazil

Eduardo Ferreira Sales [a] [b] , V. Ernesto Méndez [c] , Francisco Roberto Caporal [d] & José Cláudio Faria [e]

[a] Instituto Capixaba de Pesquisa Assistência Técnica e Extensão Rural (Incaper), Espírito Santo, Brazil

[b] Universidad de Córdoba, Instituto de Sociología y Estudios Campesinos, Córdoba, Spain

[c] Agroecology and Rural Livelihoods Group, Department of Plant and Soil Sciences, University of Vermont, USA

[d] Departamento de Educação, Universidade Federal Rural de Pernambuco, Brazil

[e] Departamento de Ciências Exatas e Tecnológicas, Universidade Estadual de Santa Cruz, Brazil

Accepted author version posted online: 19 Jul 2012.Published online: 07 Feb 2013.

To cite this article: Eduardo Ferreira Sales , V. Ernesto Méndez , Francisco Roberto Caporal & José Cláudio Faria (2013): Agroecological Transition of Conilon Coffee (Coffea canephora) Agroforestry Systems in the State of Espírito Santo, Brazil, Agroecology and Sustainable Food Systems, 37:4, 405-429

To link to this article: http://dx.doi.org/10.1080/10440046.2012.712633

Agroecology and Sustainable Food Systems, 37:405–429, 2013

ISSN: 2168-3565 print/2168-3573 online
DOI: 10.1080/10440046.2012.712633

Agroecological Transition of Conilon Coffee (*Coffea canephora*) Agroforestry Systems in the State of Espírito Santo, Brazil

EDUARDO FERREIRA SALES,[1,2] V. ERNESTO MÉNDEZ,[3]
FRANCISCO ROBERTO CAPORAL,[4] and JOSÉ CLÁUDIO FARIA[5]

[1]*Instituto Capixaba de Pesquisa Assistência Técnica e Extensão Rural (Incaper), Espírito Santo, Brazil*
[2]*Universidad de Córdoba, Instituto de Sociología y Estudios Campesinos, Córdoba, Spain*
[3]*Agroecology and Rural Livelihoods Group, Department of Plant and Soil Sciences, University of Vermont, USA*
[4]*Departamento de Educação, Universidade Federal Rural de Pernambuco, Brazil*
[5]*Departamento de Ciências Exatas e Tecnológicas, Universidade Estadual de Santa Cruz, Brazil*

Coffee is a very important product in the State of Espírito Santo, Brazil, and most of it is planted as unshaded coffee monocultures, with few growers managing shaded coffee agroforestry systems (AFS). To analyze the opportunities and challenges associated with coffee agroforestry management, we conducted 58 semistructured interviews with coffee growers. In addition, we conducted a field investigation that tested production of Coffea canephora *with the shade trees Australian Cedar (*Toona ciliata*), Jequitibá (*Cariniana legalis*), and Teak (*Tectona grandis*). Of the 58 interviewed farmers, 64% (37) were satisfied with the AFS. One of the main factors that caused satisfaction was obtaining income from sources other than coffee. Unsatisfied farmers mentioned the*

The authors are grateful to the farmers that provided information about their farm, especially to the Dalvi family who allowed for the installation of the investigation with coffee trees on their land; to their extensionist colleagues of the institute that helped obtain information; to the Investigation Foundation of Espírito Santo (Fapes) for the scholarship; to the Consórcio Brasileiro de Pesquisa e Desenvolvimento do Café for the agreement on the investigation on the coffee plantations.

Address correspondence to Eduardo Ferreira Sales, Incaper, CRDR Centro Norte, Rodovia Br 101 Norte Km 151 Caixa postal 62, CEP 29915-140-Linhares, ES, Brazil. E-mail: edufsales@incaper.es.gov.br

competition between shade trees and coffee shrubs. Cedar was the shade tree that grew most and reduced coffee production, while the combination with Jequitibá maintained more stable yields. We conclude that the higher the growth rate of trees, the higher the negative impact on the coffee production in the study areas.

KEYWORDS perception, family farms, competition, agroecology, livelihood, coffee agroforestry

1. INTRODUCTION

Agricultural sustainability has been defined by Gliessman (2007), from an agroecological point of view, as having an ecological base with a capacity for constant renovation. He adds that sustainable agriculture should have very few negative effects on the environment, be dependent on resources generated within the agricultural ecosystem, and maintain or enhance the biodiversity of the landscapes in which it is embedded. Amekawa et al. (2010) compare sustainable agriculture in developed and developing countries, emphasizing characteristics such as self-sufficiency and resilience in situations of economic crisis and low financial inputs. According to these authors, these represent advantages for producers in developing countries. Nevertheless, in the case of coffee and other Brazilian commodities, agriculture is similar to that of developed countries because the farmers compete with and depend on the international market.

According to the International Coffee Organization ([ICO] 2005), in the 10 years between 1980 and 1989, the average consumer price index (CPI) of coffee was US$1.27 per pound, and the coffee producing countries obtained an average annual income of US $10.2 billion through the exportation of coffee. In the years 2000–2004, the average CPI fell to $0.54 per pound and the annual incomes from exportation were reduced to US $6.2 billion. This crash in coffee prices contributed to the increase of poverty in producing countries. This scenario was further aggravated by the strong dependency farmers have on this one product. The economy of the State of Espirito Santo, Brazil, is heavily based on coffee production. When prices are low, unemployment increases and brings along severe socioeconomic consequences. The reduction of the prices also increases pressure on the environment. In order to compensate for a decrease in their income, farmers may feel forced to take other measures that will allow them to survive. Many farmers abandon their traditional coffee growing methods, in particular shaded cultivation. The need to introduce high-profit varieties in order to face the competition with low-cost producers leads to the intensive use of agrochemicals and a reduction of biodiversity (Perfecto et al. 1996; De Muner et al. 2007). According to Wolf (1978), the problem of the peasantry consists of balancing the demands of the outside world with the household needs. To solve this essential problem, farmers can opt for one of two strategies: to increase their production or to reduce their consumption.

Agroecology studies the ecology of agricultural systems, including social, economic and ecological dimensions (Francis et al. 2003; Sevilla Guzmán 2006). It examines the interactions between the means of life of producers, local knowledge and environmental preservation in agricultural landscapes (Guzman Casado and Alonso Mielgo 2007). An agroecological principle discussed by Ewel (1999) and Gliessman (2007) argues for the design of sustainable land use systems using natural ecosystems as models. Agroforestry systems (AFS) are models with ecological advantages that could help to preserve water and forestry resources, but they can be knowledge and labor intensive (Nair 1997). The use of AFS helps to preserve soil and water, as well as the species of flora and fauna. At the same time, it also serves as a natural microclimate moderator (Perfecto et al. 1996). The challenge of creating sustainable AFS lies in how to retain characteristics from natural ecosystems while maintaining adequate levels of production. As Ewel (1999) points out, AFS can imitate natural forests in structure and function through a combination of annual and perennial crops. However, Pretty (1995), Ewel (1999), and Krishnamurthy et al. (2002) admit that there is still much less knowledge and support about technologies that preserve natural resources than there is for conventional agricultural systems.

The search for alternatives through agroforestry options in the production of coffee has drawn the attention of farmers, national and international nongovernment organizations (NGOs) (Nowotny 1997; Agenda 21 2011; Millennium Ecosystem Assessment 2003), and the government sector (Novo Pedeag 2010).

Forest ecosystems represent efficient systems with closed nutrient cycles that have high proportions of recycling and low levels of losses from the system and of inputs into the system, which is a characteristic related to sustainability (Nair 1997; Gliessman 2007). The conventional agricultural systems are often open or "leaky," meaning that the recycling within the system is relatively low and the losses as well as the inputs are comparatively high. The nutrient cycle in AFS is situated somewhere in between these two extremes.

According to Nair and Dagar (1991), sustainable AFS must have the following attributes: productivity (maintaining or increasing the production), sustainability (preservation of the potential of production of the resource base), and social acceptability (acceptation by the community of farmers). Social acceptability is also important as it relates to one aspect of successful AFS: the consideration of the farmer's knowledge into the production process.

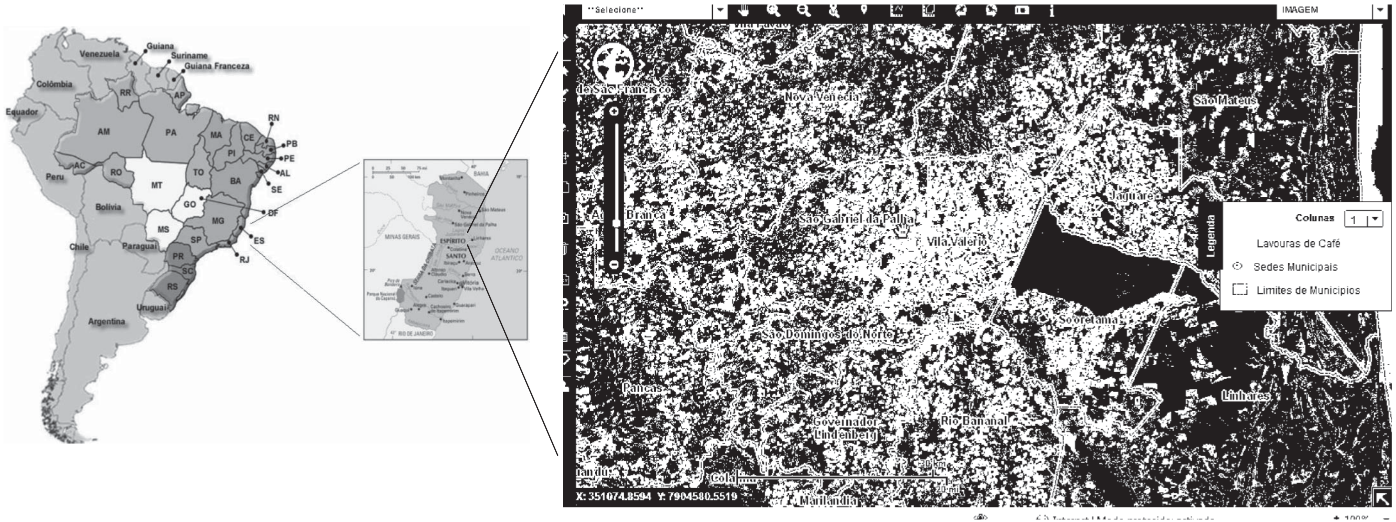
AFS can contribute in various ways to the conservation and provision of ecosystem services. These include the provision of ecological corridors for the conservation of fauna and flora, carbon sequestration, microclimate regulation, as part of the visual quality of the landscape and production of wood, fruit, firewood, and latex (Montagnini 2005). By analyzing services provided by ecosystems in Quebec, Canada, Radesepp-Hearne et al. (2010) found that the majority of the services interact with each other. The results showed compensations at the landscape level between provisioning and regulation services and they found that a higher diversity of ecosystem services was correlated positively with overall ecosystem service provision. This is an important consideration if we are seeking to design and manage AFS with the goal that they contribute to provide multiple ecosystem services.

For example, in the State of Espírito Santo, the dry periods that take place are associated with the southeast and northeast winds, which cause a lot of stress to crops. In August, the harvested coffee trees are still suffering the impacts of the wind, which provokes leaf loss. To mitigate this, while producing timber and conserving soil, the incorporation of shade trees into the system can serve to minimize adverse side effects of the wind and to diversify production and income (DaMatta et al. 2007).

In El Salvador and Nicaragua, Méndez and Bacon (2005) found that coffee farmers are interested in preserving the trees in their plantations, as long as they can keep on extracting the products and benefits they are getting at the moment. One great advantage is that the farmers have maintained this biodiversity on their own and without any financial or technical support. This indicates a clear degree of compatibility between the maintenance of a certain level of arboreal biodiversity and local ways of life. Méndez et al. (2010) found a total of 123 and 106 species of shade trees in El Salvador and Nicaragua, respectively.

In Brazil, the Ministry of Environment has placed emphasis on establishing ecological corridors in order to protect biodiversity at the scale of biomes. Ecological corridors seek to strengthen and connect protected areas within the corridor area by stimulating low impact uses of the land, such as forestry and agroforestry. The concept of ecological corridors symbolizes an alternative approach to conventional ways of preservation of the biological diversity, which is at the same time more inclusive and decentralized (Ministério do Meio Ambiente 2002). Figure 1 shows the forestry reserves in Espírito Santo that are part of ecological corridors surrounded by coffee plantations. The introduction of agroforestry practices in buffer zones around protected areas has been suggested as a technological option that could not only reduce the pressures on forest resources, but even improve the livelihoods of that rural population (Nair 1997).

The insertion of trees in coffee plantations comprises a step for redesigning the coffee system and can have positive effects in terms of ecological, productive and socioeconomic aspects. It is a working proposal that values the natural resources and ecosystem services within coffee landscapes.



Source: Geografic Interface.Geobases/Incaper/Cafeicultura (2012)

FIGURE 1 Location of municipalities in the north of the State of Espírito Santo. Shows in white the areas of coffee cultivation and black the forestry reserves. (Source: Geografic Interface. Geobases/Incaper/Cafeicultura 2012.)

This differs from the predominant Green Revolution approaches used in the majority of coffee plantations in Brazil, as well as in the Espírito Santo. These plantation models use high levels of synthetic fertilizers and pesticides and grow the coffee in full sun or unshaded systems.

According to Costabeber (2007), the fundamental characteristic of the agroecological transition process would be the ecologization of agriculture, whereby considerations of environmental and biophysical character assume an active role in the determination of agricultural practices, marked by a better integration between agronomy and ecology. An agroecological transition requires that the agricultural production process respects the specificities, potentialities and limitations of the ecosystem in which it is embedded. This makes the ecologization a dynamic, continuous, multilinear process, leading to a constant adaptation in order to optimize conditions in time and space.

In most cases, the first step toward the agroecological transition takes the form of conversion to organic agriculture (Gliessman and Rosemeyer 2010). Lyngbaek et al. (2001) analyzed conventional and organic coffee farmers for a period of three years in Costa Rica. The conventional coffee farmers think that market-based alternatives and stabilization of the international coffee market can improve their conditions. The organic growers mention self-sufficiency and the improvement of weed and disease preventing techniques as their main concerns. The majority of organic coffee farmers had twice as many trees in their plantations and the production over the three years of study was 22% lower than on the conventional plantations. However, excluding the certification for organic production, the benefits of both groups were similar, although the prices obtained by the organic growers were 38% higher.

In the State of Espírito Santo, some farmers that tried to make the change to an organic system with trees were not successful. They did not receive better prices. The certification and sales of Conilon coffee (*Coffea canephora*) did not obtain positive results since the demand for this kind of organic coffee is low. Conilon coffee is used to make soluble coffee or to be mixed in small amounts with Arabica coffee (*Coffea arabica*) (Silva and Leite 2000), therefore, being of little value for the organic markets.

Throughout history, in the 19th century, the so-called "Capitania coffee" in the State of Espirito Santo was sown in the proximity of trees on the coastline (*Atlas do ecossistema do Espírito Santo* 2008). However, this system did not prosper and nowadays unshaded coffee crops predominate. Some families still maintain simple agricultural systems in combination with the coffee plantations, for example rubber trees (*Hevea brasiliensis*), some timber-yielding species and fruit trees (Sales and Araujo 2005).

From the beginning, coffee production was developed through slash and burn practices. Because of the coffee price crisis at the end of the 19th and beginning of the 20th century, coffee cultivation in Espírito Santo was substituted by pastures. In the 20th century, from the decade of the 1960s onward, an intense lumber activity initiated in the region, which played an important role in the economy of the state and in the devastation of the Atlantic Rainforest biome (Dean 1996; *Atlas do ecossistema do Espírito Santo* 2008). In that same decade, as a result of a new coffee crisis, the federal government encouraged the substitution of Arabica coffee plantations with Conilon coffee. Conilon coffee production began to expand throughout the entire state, and remains the predominant variety at the present time (De Muner et al. 2007). Coffee plantations occupy 452,527 ha in the state (see http://www.conab.gov.br/conteudos.php?a=1252&t=2), which represents about 10.2% of the total land area. The state's coffee cultivation through AFS covers only 241.7 ha (Sales and Araujo 2005), a very small segment of the total area under coffee cultivation.

Conilon coffee production in Espirito Santo is responsible for almost 20% of the world's production, but this is achieved through a production model that privileges the economic and productive dimension without taking environmental impacts into account (De Muner et al. 2007). Table 1 illustrates the coffee production in the last 5 years in the state.

For 60,558 of the 84,356 farms in the state (Estabelecimentos agropecuários 2011), coffee is the main source of income. Of these, 40.7% are cultivated predominantly with Arabica coffee, and 59.3% with Conilon coffee. Eighty percent of these rural holdings are family farms (Banco de dados agregados 2011). These agricultural systems are made up of small farms run by families, with a mode of production that supports household consumption as well as some sales of agricultural products.

To assist in the transition from monocultures of coffee to a more sustainable agriculture, we sought to learn more about the perceptions of farmers involved in AFS and information about the influence of crops associated with coffee shrubs. In this article, we examine the case of Conilon coffee production in AFS of the State of Espírito Santo, Brazil.

The objectives of this research were: 1) to analyze the perceptions of coffee growers about coffee AFS; and 2) to analyze the effects of competition between different types of shade tree species and coffee shrubs.

TABLE 1 Production of coffee in the State of Espírito Santo, 2007–2011

Coffee production by type (bags of 60 kg; in thousands)	Years				
	2007/2008	2008/2009	2009/2010	2010/2011	2011/2012
Arabica	2167	2867	2603	2792	3079
Conilon	8139	7363	7602	7355	8494
Total	10306	10230	10205	10147	11573

Source: http://www.conab.gov.br/conteudos.phpa=1253&ordem=produto&Pagina_objcmsconteudos=1#A_objcmsconteudos

2. METHODOLOGY

2.1. Characteristics of the State of Espírito Santo

The State of Espírito Santo is situated in the southeast region of Brazil. It has a population of 3,351,669 inhabitants (Contagem da população 2007) and a density of 72 inhabitants per square kilometer. The anthropogenic characteristics of the state have been influenced by the indigenous population, the African slaves that participated actively as labor forces in the economic activities, and the European invaders who enslaved the other ethnic groups and mixed with them (*Atlas do ecossistema do Espírito Santo* 2008).

The climate of the northern region of the state is classified as a "humid tropical climate with dry winter" (Aw), according to the Köppen climate classification. The average annual temperature varies from 21°C to 26°C, with frequent rains from October to March. The dry period is from April to September, with an annual average of 1277 mm and a water deficit of 69 mm, at a latitude of 19°23′59″S and a longitude of 40°04′01″W (Nóbrega et al. 2008). A great part of the areas with Conilon coffee growing tradition in the northeast and north coast of the state have to deal with limited water and need to use irrigation systems (Taques and Dadalto 2007).

The main vegetation formation in the north of the State of Espírito Santo is the low land dense ombrophilous forest, in the typology Tabuleiro Forest, part of the Atlantic Rainforest biome. The forestry reserves in the State of Espírito Santo are part of the Central Corridor of the Atlantic Rainforest. The Atlantic Rainforest is one of the hotspots of the planet identified by Conservation International, with a high priority for preservation. The region is a reserve for biodiversity, the first Red List officially recognized by the state's government, which identified 998 threatened species (222 of fauna and 776 of flora; Critical Ecosystem Partnership Fund 2007).

The largest Conilon coffee plantations in the State of Espírito Santo are in the northern municipalities of Vila Valério with a plantation area of 21,900 ha and a productivity of 1,650 kg ha^{-1}, Jaguaré has 19,000 ha planted and produces 1,750 kg $ha^{-1}$and Sooretama has 16,100 ha and a productivity of 1,800 kg ha^{-1} (Instituto Brasileiro de Geografia e Estatística 2012). These municipalities produce most of the coffee in the state and are neighbors to the large forest reserves, as shown in the map in Figure 1. Sooretama, located in the low region of the State of Espírito Santo at an average of 100 meters above sea level, means "refuge to wild animals" in the indigenous language. It comprises the Sooretama Biological Reserve run by Instituto Brasileiro do Meio Ambiente e Recursos Naturais Renováreis (IBAMA) with more than 24,000 ha of the Tabuleiro Atlantic Forest, and together with the neighboring Vale do Rio Doce private reserve (not declared as a conservation area) constitutes the largest natural forestry mass of the state, totaling 45,787 ha, corresponding to 1% of the entire state territory (Instituto de pesquisas da Mata Atlântica 2005).

The soils in the north are predominantly sedimentary yellow latosol, naturally poor being flat and low permeability, with difficult water and root penetration. They are not appropriate for intensive mechanization, being more adequate for perennial cultivation (*Atlas do ecossistema do Espírito Santo* 2008).

2.2. Preliminary Survey

The first step to obtaining the data was a survey conducted with the farmers who owned coffee plantations managed through AFS. In areas where farmers used AFS or combined coffee cultivation within their smallholdings, structured questionnaires were elaborated and applied by extensionists and researchers of Incaper. The survey was applied in the year 2004 in 10 Conilon coffee producer municipalities. The preliminary data illustrated the cultivated species, the area covered, and the use and localization of the AFS (Sales and Araujo 2005).

2.3. Farmer Interviews

From December 2009 to February 2010 semistructured interviews were conducted with 58 farmers that managed coffee AFS in the state and grouped into three categories by socioeconomic and management characteristics and the type of agriculture they practice, according to van der Ploeg (2008; Table 2).

TABLE 2 Characteristics of interviewed farmers in the State of Espírito Santo, Brazil

	Characteristics				
Type of agriculture	Scale/ importance	Use of capital/ resources	Mode/ function	Labor force	Production vs. market
Peasant	Small, vulnerable/ low	Sustainable use of ecological capital/ limited	Co-produce / multifuncti-nality	Family	Farmer's market
Managerial	Intermediate	Financial and industrial capital	Appro-priation Artificiliality		Specialized for market
Capitalist	Huge/great	Companies	Specialization	Exclusively wage-earners	Maximization of benefits

Source: Characteristics based on van der Ploeg (2008).

Van der Ploeg (2008) states that the basic difference between peasant and capitalist styles of production is in the degree of autonomy inherent to the resource base. Farmers under the peasant style coproduce and integrate with nature and nature is converted into goods and services for human consumption. The peasants are less dependent on the market, characterized by multifunctionality (agro-tourism, water retention, biodiversity, transformation, and commercialization of products) and use family labor.

The capitalist style is opposite to the peasant's and is based on artificiality and specialization, as the presence of nature is reduced. The capitalist style is dependent on the market, growth for export, and hires solely wage labor. The entrepreneurial farming style is somewhere in between these two. The gradual dependence on the market, credit availability, and the scale of production increases from peasant to capitalist style.

The contacts of the first informants were collected from a previous research, and this information was later completed by means of the snowball technique, which consists of asking the interviewees who else could be contacted to be interviewed about the topic of AFS. The interviews were recorded with a digital recorder and later transcribed. The final number of interviewed persons was reached when a "theoretical saturation" occurred; that is, there were no additional observations. In the conversations with farmers, the stance of the qualitative interviewer was adopted, allowing people to talk about their perspectives and experiences without structuring the conversation, or defining what they should say (Taylor and Bogdan 1986). In the interview process, the intention was to capture the perception of farmers and their families in changing the production system. Farmers who cultivate other species along with the coffee had the opportunity to talk about their experiences and presented their views on the coffee AFS. The farmers were asked about their satisfaction in relation to the AFS with coffee trees and their living conditions at the moment of the interview (economic, emotional, etc.). Next, the farmers were classified as satisfied or unsatisfied, in accordance with these perceived aspects.

2.4. Agroforestry Field Investigation

The results of the preliminary survey showed an extensive use of Teak trees (*Tectona grandis*) and Australian Cedar (*Toona ciliata*), covering an area of 30 and 55.8 ha, respectively. Based on the information of the survey, we chose shade trees to be evaluated in a field investigation designed through principal components analysis. Our research was done in the municipality of Sooretama, where the owner of an agroforestry coffee plantation allowed for the establishment of the investigation plot. In this study we evaluated the interaction between the Conilon coffee shrubs and three species of timber trees: Australian Cedar, Jequitibá (*Cariniana legalis)* and Teak.

Jequitibá, a native species, was chosen because of its importance in the Atlantic Rainforest biome and the quality of its wood. Teak is originally from the East Indies and Cedar of South Asia and Australia (Nair 1997).

The coffee shrubs were planted in October 2004, with a spacing of 4 m between rows of coffee plants and one meter between plants within rows on flat ground. At the same time, the shade trees were arranged in an 8-×-8 m spacing as shown in Figure 2. Irrigation and fertilization were applied to the plots according to observed necessity.

Conilon coffee yields (kilograms per coffee tree) were collected for a 4-year period (2007, 2008, 2009, and 2010). Tree measurements (diameter at breast height [DBH] and height) were carried out every year after planting. The relationships between different variables were evaluated through principal components analysis using data for Conilon coffee yields of external coffee trees. Coffee yield data were collected from coffee shrubs representing numbers 1–12, as shown in Figure 2. Production coffee plants were used to observe the gradient of influences between trees and coffee shrubs. Regression analysis was used to investigate the competitive effects of shade trees on coffee production, using yields as the dependent variable as a function of distance to the timber trees as the independent variable.

Replicates					123…12	
	ccccccccc	T6	cccccccc	T12	cccccccccccccccccc	coffee row with timber tree
R1	ccccccccc		cccccccc		cccccccccccccccccc	coffee row without timber tree
	ccccccccc	T5	cccccccc	T11	cccccccccccccccccc	
	cxcxcxcx		cxcxcxcx		cxcxcxcxcxcxcxcxcx	
	ccccccccc	T4	cccccccc	T10	cccccccccccccccccc	coffee row with timber tree
R2	ccccccccc		cccccccc		cccccccccccccccccc	coffee row without timber tree
	ccccccccc	T3	cccccccc	T9	cccccccccccccccccc	
	cxcxcxcx		cxcxcxcx		cxcxcxcxcxcxcxcxcx	
	ccccccccc	T2	cccccccc	T8	cccccccccccccccccc	coffee row with timber tree
R3	ccccccccc		cccccccc		cccccccccccccccccc	coffee row without timber tree
	ccccccccc	T1	cccccccc	T7	cccccccccccccccccc	

C clonal Conilon coffee shrubs (individuals originated from one and the same plant, through vegetative propagation)
T Teak tree
cxcxc pollination line (mix of individuals)
* The same design was used for the observational data with Jequitiba and Australian Cedar.

FIGURE 2 Diagram of investigation design showing position of the Conilon coffee plants and Teak trees in an agroforestry system in the State of Espírito Santo, Brazil.*

Observational data were examined with the statistical program R Project for Statistical Computing. The biplot graphical representing the principal components was used to show the multivariate analysis (Gabriel 1971).

3. RESULTS

3.1. Farmer Perceptions of the Agroforestry System

Out of the 58 farmers interviewed in this study, 37 were satisfied and 21 were unsatisfied with the AFS. The interviewed growers revealed information about products (rubber, timber, spice, heart of palm and fruits) and services (nutrient cycling, windbreak, and insecticide; Tables 3 and 4). Among the satisfied farmers, there were 19 peasant, 17 entrepreneurial, and 1 capitalist. According to them, the covering of the soil with crop residues offers protection and holds humidity for a longer period of time. There was also a clear preference for fast growing trees which give farmers a quicker return for their work and enable them to obtain other income than the one gained from coffee. Eight of the satisfied farmers had systems characterized by the intensive use of synthetic inputs in combination with cultivations of coconut palms (*Cocos nucifera*), rubber trees, timber trees, cacao trees (*Theobroma cacao*), and other species. These farmers had an entrepreneurial style and reported that they sold all of their production.

Among the 21 farmers who were unsatisfied, there were 11 peasant, 9 entrepreneurial, and 1 capitalist. They showed various reasons for their dissatisfaction with the AFS and stated that due to the negative effects of the competition between the combined species they would not continue to manage their coffee as an AFS. Eight of the farmers that tried the AFS (5 peasant and 3 entrepreneurial) had a low production which led to negative perceptions regarding the AFS. These eight growers began to use methods similar to those of conventional farmers, using chemical inputs. Four farmers insisted that the AFS did not work out in their region due to the climate conditions in the north of the state which are very hot and irregular.

TABLE 3 Production of interviewed farmers in the State of Espírito Santo, Brazil

Style of agriculture	Total number of farms	No. satisfied	No. Dissatisfied	Production			
				*/ coconut	*/ rubber	*/ timber	*/Nutrient cycling
Peasant	30	19	11	1/6	4/4	0/7	2/11
Entrepreneurial	26	17	9	2/6	3/3	3/14	1/1
Capitalist	2	1	1	0/0	0/1	1/1	0/0

Relation */production = number of simple systems with only one species with coffee shrubs/number of mix systems with several species.

TABLE 4 Associate species to coffee shrubs found more than once in the interviews

No.	Common name	Plant species	Frequency	Product and/or service
1	Açai	*Euterpe oleracea*	2	Heart of palm and fruit
2	Caju	*Anacardium occidentale*	4	Fruit
3	Aroeira	*Schinus terebinthifolius*	2	Spice
4	Banana	*Musa sp.*	6	Fruit
5	Cacau	*Theobroma cacao*	9	Fruit
6	Seringueira	*Hevea brasiliensis*	15	Rubber
7	Cedro	*Cedrela fissilis*	2	Timber
8	Cedro Australiano	*Toona ciliata*	5	Timber
9	Citrus	*Citrus sp.*	3	Fruit
10	Coco	*Cocos nucifera*	15	Fruit and windbreak
11	Cupuaçu	*Teobroma grandiflorum*	3	Fruit
12	Eucalipto	*Eucalyptus sp*	3	Timber
13	Gliricidia	*Gliricidia sepium*	9	Nutrient cycling
14	Inga	*Inga sp.*	4	Nutrient cycling
15	Jaca	*Artocarpus integrifolia*	2	Fruit
16	Kobi	*Albizia polycephala*	2	Nutrient cycling
17	Louro da Costa Rica	*Cordia alliodora*	2	Timber
18	Neem	*Azadirachta indica*	3	Insecticide
19	Mamão	*Carica papaya*	2	Fruit
20	Pimenta do reino	*Piper nigrun*	3	Spice
21	Pupunha	*Bactris gasipaes*	2	Heart of palm
22	Teca	*Tectona grandis*	6	Timber

Aside from the uncertainty concerning prices, costs, droughts, and excessive rains, there was also the legislation issue for the tree harvest, as exemplified by one of the interviewed growers: “I’m not going to plant trees in the coffee plantations anymore, because later I won’t be allowed to cut the trees. Besides, like this the area turns out to be unusable for agriculture in the future.”

These opinions are due to the environmental regulations in place or the farmer’s perception about them. In reality the law prohibits the cutting of species that belong to one and the same biome, but it is allowed to cut exotic ones. Still, there is the fear that the terrain will be unfit for sowing. In addition, farmers mentioned as a negative factor, that there was uncertainty about the prices of the timber products of the species that were tested.

Among the interviewees, there were 10 leaders of social movements, worker unions, or associations. Half of them were satisfied with the AFS. The polled leaders are or were part of a permanent mobilization toward agroecology. The farmers that adopted this posture often left their cultivations to participate in meetings, which left their farming systems abandoned or as secondary activities. In some cases they remembered the past with a certain nostalgia and they somehow complained about the lack of support for the realization of the work in the organization. One of these farmers that participated very intensively, said: "I wasn't a farmer anymore, all my time was taken by the organizational process." They spoke with pride about having participated as "heroes of the resistance" or about the fact that they received many visitors, even from abroad. The decline in production of these local leader farmers caused a negative impression on the proposal for AFS but this process served as learning for the construction of more feasible proposals.

Six peasants that were beneficiaries of agrarian reforms were also interviewed, half of whom were satisfied with the AFS. Out of the farmers that sold their production directly at fairs or at farmer's markets (8), 6 affirmed to be pleased with the AFS. They also stated that they did not have time to pay special attention to the coffee shrubs, since they also were dedicated to other products like fruits and vegetables that would have a better economic return. Some of them also sold their products to public institutions with the help of state initiatives, which guaranteed a relatively steady income. Finally, we found that more peasant farmers preferred nutrient cycling species (13) and more entrepreneurial farmers (17) preferred timber species (Table 3). Also, 16 peasant farmers used clonal Conilon compared to 24 entrepreneurial farmers, and 3 teak growers and 2 cedar growers thought that there was competition between these two tree species in relation to the coffee plantations.

3.2. Agroforestry Field Investigation

In the agroforestry field investigation, coffee production varied with the harvest year and the timber tree species. The results after four consecutive harvests show that the system with cedar trees had a negative effect on production related to the harvest year and the presence or the absence of this tree in the cultivation lines (Table 5 and Figure 3).

Figure 4 shows the principal component analysis of our data (Table 6) with a biplot graphic. There was a negative relationship between rows of coffee with timber tree (TT) species within the same row and the height and DBH of the trees; that is, the greater the rate of growth of trees in rows planted with coffee, the lower the production of coffee (coffee with timber

TABLE 5 Mean coffee production, tree height, and diameter at breast height (DBH) for 2009 in the agroforestry investigation, Espirito Santo, Brazil

Species	Coffee rows without timber trees (kg/plant)	Coffee rows with timber trees (kg/plant)	Tree height (m)	DBH (cm)
Australian Cedar	8.34	7.36	11.92	24.65
Brazilian Jequitibá	7.83	8.05	5.52	8.54
Teak	7.87	7.15	10.61	14.72

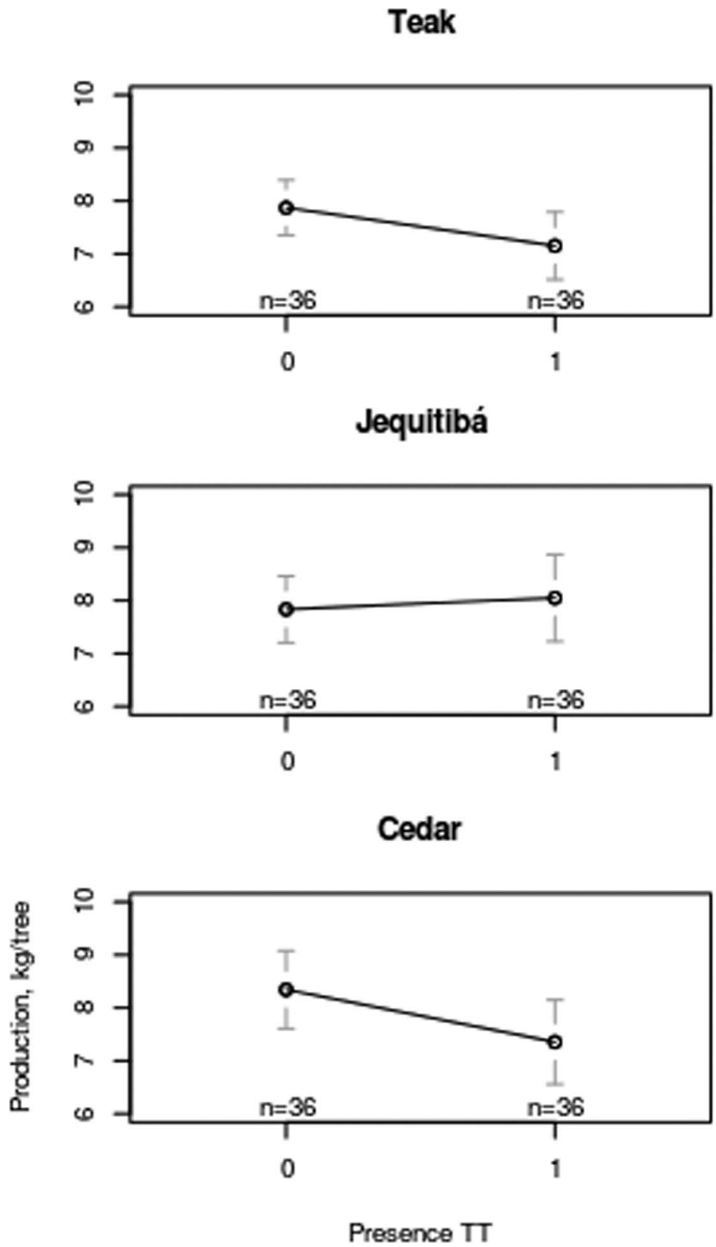


FIGURE 3 Mean production of coffee cherries in four harvests (2007–2010) for coffee agroforestry systems combined with Teak, Jequitibá, Cedar (1) and without timber trees (TT) (0) in Espirito Santo, Brazil.

species in the same row). The first principal component (PC1) retained 81.5% of the total variance of the data and is essentially a contrast between variables such as only coffee versus the timber tree species with coffee, height and DBH of timber tree species.

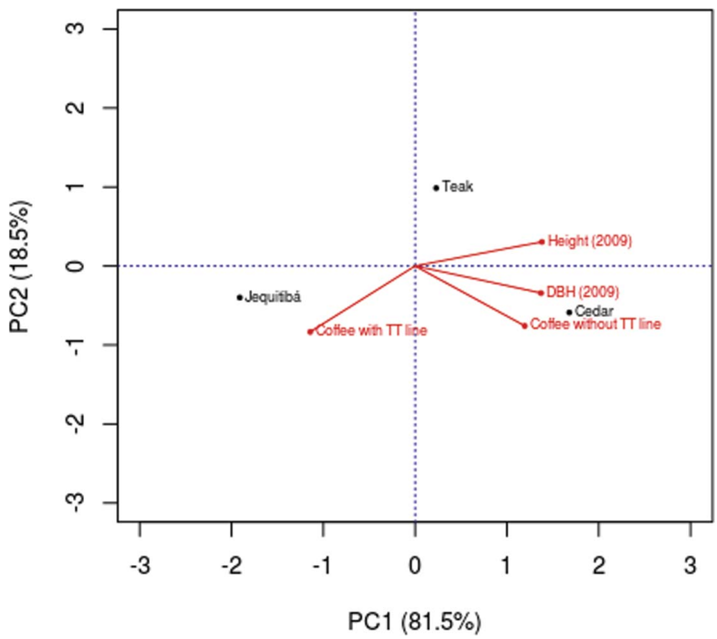


FIGURE 4 Biplot of the principal component analysis represents the interrelation between Conilon coffee yields with and without timber trees (TT), and biometry of trees (Teak, Australian Cedar and Jequitibá) height and diameter at breast height (DBH) in Sooretama, State of Espírito Santo, Brazil (color figure available online).

TABLE 6 Coffee yields and biometry of trees: coordinates for the variables observed in principal component (PC) analysis

		Eigenvalues (numeric property)	
		PC1 ($\lambda1 = 2.55344$)	PC2 ($\lambda2 = 1.21654$)
Eigenvectors (directional property)	Coffee plantation without trees	0.47	−0.62
	Coffee plantation with trees	−0.45	−0.69
	Height (2009)	0.54	0.25
	Diameter at breast height (2009)	0.54	−0.28
Variation retained (%)	Partial	81.5	18.5
	Accumulated	81.5	100

Figure 5 shows data from the model coffee production. The Teak and Cedar trees had an impact on the production but the Jequitibá trees were of little influence.

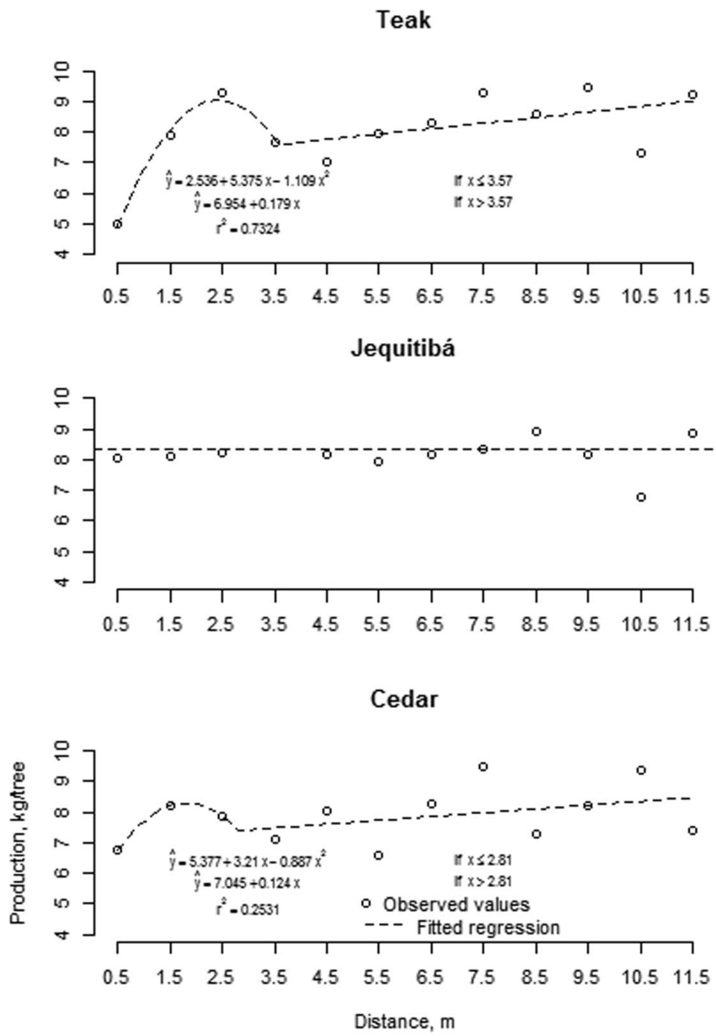


FIGURE 5 Coffee production as a function of distance from timber trees in an agroforestry experiment in Espirito Santo, Brazil (mean of 4 years).

7. DISCUSSION

During the recording of the interviews, the farmers addressed many issues: competition in the coffee plantations with intercropping, uncertainty of the agricultural products prices, the transition process, and the difficulties with earnings and daily work.

According to the interviewed farmers, there was a conflict between the more immediate economic benefits they obtain by using agrochemicals and the fact that they may be causing socioenvironmental problems by using them. Many farmers felt they needed to prioritize the economic aspect. The reduced labor inputs needed by the conventional agriculture model are an attractive factor for farmers who use pesticides and chemical fertilizers to increase coffee production, incomes and their labor capacity. The AFS are seen by producers as a risk, which implies the need to implement incentives as motivators.

Farmers also brought up the question of herbicides. They spoke of the difficulties of working with a hoe compared to herbicides and referred to both the economic side of the matter as well as the ergonomic question. And in periods of high temperatures and intense rains, the presence of shrubs increased labor needs even more strenuous.

As stated in the introduction, some farmers in Espírito Santo took the first step of transitioning to an AFS by changing to an organic system with trees. The transition occurred abruptly, with the suspension of the application of chemical fertilizers and pesticides and the incorporation of the trees all at the same time. Coffee production decreased to such a low level that some farmers decided to return to the conventional management of their lands. No measures were taken in this transition process to improve the use of traditional practices, nor were the chemical inputs being substituted by organic ones, as indicated by Gliessman (2007). Perhaps, the implementation of the proposal of AFS lacked more discussion and caution. The failure was also the technical advice of focusing all efforts on the mobilization and training of a few farmers. Working with leaders only was a historic mistake made by rural extension and international cooperation programs. The leader farmers ended up overloaded with work and the goals of programs were never achieved. The technological issue did not seem to be the most important one according to the farmers. Instead, the market is inexorable, because when the farmers subject their production to sales with intermediates, their probability of success is even smaller. Moreover, there is no difference in price between an agroecological coffee and a conventional one, which does not reward anybody for leaving the use of synthetic inputs behind and starting an agroecological transition process.

If the farmers are willing to reduce their more immediate economic benefits temporarily and instead obtain timber of good quality or other product, this could be a good diversification option for the coffee grower as well as for the environment. However, other issues arise, such as whether there is a market for the other products. For example, on-farm research on AFS conducted in the state of Chiapas, Mexico, by Soto-Pinto et al. (2000) concluded that production of coffee may decrease under shade cover more than 50%. However, the system promotes conservation of natural resources and landscape diversity. The results in Mexico suggest that producers may continue keeping coffee shade cover and 460 trees per ha (60% trees/40% shrubs) with no significant decrease in yields, and with the added economic benefits derived from other products extracted from the plantations.

In other coffee producing countries, the process of agroecological transition has made some progress. According to Jaffe and Bacon (2008) an important step is to create an alternative network of coffee trade to overcome some of the limitations of the conventional market. In this case, some gains were made through a partnership including coffee farmer cooperatives, researchers, students, and consumers who came together in working with Mesoamerican coffee growers. However, in this case, farmers were producing and selling high quality Arabica coffee, which is able to gain much better prices at the market and is in demand through certified channels.

In a study led by Delgado (2008), the adoption of organic agriculture by farmers of the agrarian reform in Brazil is perceived as a risky and very expensive option. For that reason, many farmers continue working in conventional agriculture. In the case of the use of AFS, the risk of reduction of benefits due to competition between crops is perceived as the biggest threat to transition. However, half of the six interviewed farmers still chose to operate their system as organic because they were leaders and technicians and had a different perception. The agroecology perspective considers several things, not only production.

In our case study in Espírito Santo, the introduction of trees into the coffee plantation was used to jumpstart the agroecological transition process, and, in some cases, it jeopardized coffee production. This has created discouragement, but some farmers have chosen to continue with the transition, when aware about the time needed to adjust to the AFS composition. As Souza et al. (2010) state, in a transition process whereby trees were inserted into the Arabica coffee plantations of the Atlantic Forest Zone in Minas Gerais State, Brazil, in the beginning of the AFS adoption, coffee growers utilized some trees incompatible with coffee. Another study pointed out that several exotic tree species that were found in the AFS in 1993–1994 (initial phase) were no longer present in the AFS when monitored in 2007 (Souza et al. 2011). The coffee growers preferred the native tree species anyway. But, for that, considering that time is precious for the agroecological transition, technicians, farmers and institutions organized criteria and indicators for the selection of best trees to intercrop. The main local criteria for tree selection were the compatibility with the coffee shrubs, the amount of biomass produced by the trees, and the level of input and labor resources that were needed to maintain the trees. In the case of Espírito Santo State the farmers avoid the species of the same biome. According to testimonies from the northern region of the State of Espírito Santo, the trees compete with the coffee plants mostly during drought periods. In the years of excessive drought, this condition is even worse from April to September, coinciding with the harvest of the coffee.

Based on Santos et at. (2012) in the region of Forest Zone in Minas Gerais State, Brazil, some shade coffee production systems presented extremely low yield and have become economically unsustainable for family coffee farmers. In this study, water availability during the dry season was one important factor in determining coffee yield. This research demonstrates the importance of proper management is necessary for AFS to succeed. In another study in this region, one of the criteria pointed out by the farmers to select the trees to use in agroforestry coffee systems is the root systems. If the roots of the intercropped trees explore different layers of the soil, the competition will be less (Carvalho 2011).

Rosemeyer (2010) affirms that during the agroecological transition process there is a reduction of benefits in developed countries but, in general, an increase of benefits in developing countries when farmers were using fewer agrochemicals and external inputs before starting a transition process. In the case of the coffee growers in the State of Espírito Santo, we found mixed results depending on the management regime used by growers before transitioning. The growers who were using high levels of external inputs experienced a severe decrease in coffee production due to the transition to organic systems. On the contrary, farmers that were not using very many inputs experienced an easier transition and less yield reduction.

Farmers in favor of the AFS expressed that shade trees provide a more favorable environment to undertake their tasks. If the management of the AFS is performed through selective pruning of the trees, a correct application of fertilizers and an adequate distance between the trees and the crops, the coffee growers testify positively about the system. There are laws and initiatives that encourage the AFS. For example, the Atlantic Forest law (Lei da Mata Atlântica 2010) and state initiatives for diversification and commercialization of agricultural products on the institutional markets in the Food Acquisition Program (Peraci and Bittencourt 2010) help the farmers that possess AFS and represent favorable means to avoid failure of the system.

Various researches have proven that the diversity and structure of the shade canopy affects the biodiversity conservation potential in coffee plantations (Perfecto et al. 1996; Moguel and Toledo 1999; Méndez et al. 2007). In the case of the State of Espírito Santo, where the majority of the coffee plantations have no trees, simple systems or perennial commercial cultivations combined with the coffee crops could provide a significant increase in the biodiversity conservation potential of the coffee areas.

The field investigation showed that the competition between the trees and the coffee is insignificant in the case of the Jequitibá and small in the case of Teak trees. The production of coffee in combination with Jequitibá also remained stable over 4 years. In the agroforestry system combined with Cedar, the competition was higher during the last two years. Nevertheless, if the farmer is willing to wait until the trees have reached the age to be cut down, there is also a prospect for remuneration in this case.

The results draw attention to the complementarities between farmer's and technician's knowledge. There was concordance between technical knowledge and the perception of farmers in relation to the competition about teak and cedar with coffee shrubs.

8. CONCLUSION

The interviews with the farmers about intercropping trees with coffee show their direct utility for obtaining additional income and products. Indirectly they also provide environmental services within the agroecosystem. An important aspect is the fact that 64 percent of total farmers surveyed were satisfied with the AFS, even with all the problems presented.

According to the statistical analyses presented, there is slight competition between the trees and the coffee shrubs. However, in situations of low coffee prices combined cultivation can guarantee better income. It was observed that the higher the growth rate of trees in the plantations, the lower the production of coffee. Shaded coffee plantations can help in the agroecological transition process and reduce the uncertainty in relation to AFS. The investigation in the intercropping with coffee can provide parameters to quantify the interference of the trees in the cropping systems.

The strong presence of the market, that encourages farmers and their families to try to obtain high outputs of coffee and other products, constantly conflicts with the need for auto consumption, environmental preservation, and diversification with other food products. The farmers' families prefer to stay with the incomes stemming from coffee, which restricts the initiatives for livelihood and the sales of extra harvests from diversified cropping.

In the State of Espírito Santo, the AFS provide an opportunity to introduce a forestry component, spices or fruit that can support environmental services, produce quality wood for carpentry and diversify agricultural activities. Overall, the strategy has great potential to contribute to the promotion of a better balance between production and farmers' needs.

REFERENCES

Agenda 21. 2012. *Conservation & Management of Resources for Development*, ch. 12. http://www.un.org/esa/dsd/agenda21/res_agenda21_12.shtml (accessed January 20, 2012).

Amekawa, Y., H. Sseguya, S. Onzere, and I. Carranza. 2010. Delineating the multifunctional role of agroecological practices: Toward sustainable livelihoods for smallholder farmers in developing countries. *Journal of Sustainable Agriculture* 34: 202–228.

Atlas do ecossistema do Espírito Santo. 2008. Vitória: SEMA, Viçosa: Universidade Federal de Viçosa.

Banco de dados agregados. 2011. http://www.sidra.ibge.gov.br/bda/tabela/protabl.asp?c=1109&z=p&o=2&i=PTabe (accessed December 19, 2011).

Carvalho, A. F. 2011. Agua e radiação em sistemas agroflorestais com café no território da Serra do Brigadeiro-MG. Ph.D. thesis. Universidade Federal de Viçosa.

CONAB. 2013. Séries históricas. http://www.conab.gov.br/conteudos.php?a=1252&t=2 (accessed January 17, 2013).

Contagem da população. 2007. Instituto Brasileiro de Geografia e Estatística—IBGE. http://www.ibge.gov.br/home/estatistica/populacao/contagem2007/contagem.pdf (accessed October 19, 2010).

Costabeber, J. A. 2007. Transição agroecológica: do produtivismo à ecologização. In *Agroecologia e extensão rural: contribuições para a promoção do desenvolvimento rural sustentável*, eds. F. R. Caporal and J. A. Costabeber, 17–48. Brasília: MDA/SAF/DATER.

Critical Ecosystem Partnership Fund. 2007. *Assessing five years of CEPF investment in the Atlantic forest biodiversity hotspot, Brazil*. http://www.cepf.net/Documents/final_atlanticforest_assessment.march07.pdf (accessed January 20, 2012).

DaMatta, F. M., C. P. Ronchi, E. F. Sales, and J. B. S. Araujo. 2007. O café Conilon em Sistemas Agroflorestais. In *Café conilon*, eds. R. G. Ferrão, A.F.A. Fonseca, S.M. Bragança, M.A.G. Ferrão and L.H. De Muner, 374–389. Vitória: Incaper.

De Muner, L. H., F. R. Caporal, M. J. Fornazier, M. P. Padovan, and H. C. Schmidt. 2007. Sustentabilidade da cafeicultura do conilon no Espírito Santo. In *Café conilon*, eds. R. G. Ferrão, A.F.A. Fonseca, S.M. Bragança, M.A.G. Ferrão and L.H. De Muner, 623–647. Vitória: Incaper.

Dean, W. 1996. *A ferro e fogo: a história da devastação da Mata Atlântica brasileira*. São Paulo: Companhia das Letras.

Delgado, A. 2008. Opening up for participation in agro-biodiversity conservation: The expert-lay interplay in a Brazilian social movement. *Journal of Agricultural & Environmental Ethics* 21: 559–577.

Estabelecimentos agropecuários. 2011. http://www.ibge.gov.br/home/estatistica/economia/agropecuaria/censoagro/brasil_2006/tab_brasil/tab5.pdf (accessed December 3, 2011).

Ewel, J. J. 1999. Natural systems as models for the design of sustainable systems of land use. *Agroforestry Systems* 45: 1–21.

Francis, C. D. Rickerl, G. Lieblein, R. Salvador, S. Gliessman, M. Wiedenhoeft, T. A. Breland, S. Simmons, ET al. 2003. Agroecology: The ecology of food systems. *Journal of Sustainable Agriculture* 22(3): 99–18.

Gabriel, K. R. 1971. The biplot-graphic display of matrices with application to principal component analysis. *Biometrika* 58: 453–467.

Geografic Interface. Geobases/Incaper/cafeicultura. 2012. http://www.geobases.es.gov.br/sistema/AcessoNavegador.aspx?id=115 (accessed April 26, 2012).

Gliessman, S. R. 2007. *Agroecology: The ecology of sustainable food system*s, 2nd ed. Boca Raton, FL: CRC Press/Taylor & Francis.

Gliessman, S. R., and M. Rosemeyer. 2010. *The conversion to sustainable agriculture: principles, processes, and practices*. Boca Raton, FL: CRC Press.

Guzman Casado, G. I., and A. M. Alonso Mielgo. 2007. La investigacion participativa en agroecologia: una herramienta para el desarrollo sustentable. *Ecosistemas* 16: 24–36.

Instituto Brasileiro de Geografia e Estatística. 2012. Cidades. Lavouras permanentes. Vila Valério, Jaguaré e Sooretama—ES. http://www.ibge.gov.br/cidadesat/topwindow.htm (accessed January 16, 2012).

Instituto de pesquisas da Mata Atlântica. 2005. *Conservação da Mata Atlântica no Estado do Espírito Santo: cobertura florestal e unidades de conservação*. Vitória: Ipema.

International Coffee Organization. 2005. ICO submission to UN General Assembly Summit to review the Millennium Development Goals. http://dev.ico.org/documents/ed1966e.pdf (accessed January 20, 2012).

Jaffe, R., and C. M. Bacon. 2008. From differentiated coffee markets toward alternative trade and knowledge networks. In *Confronting the coffee crisis: Fair trade, sustainable livelihoods and ecosystems in Mexico and Central America*, eds. C. M. Bacon, V. E. Méndez, S. R. Gliessman, D. Goodman, and J. A. Fox, 311–336. Cambridge, MA: MIT Press.

Krishnamurthy, L., A. Buendía Nieto, M. A. M. Valente, and M. U. Gómez. 2002. Caracterización del sistema tradicional agrisilvícola café-plátano-cítricos en el municipio Tlapacoyan, Veracruz. In *Tecnologías agroforestales para el desarrollo rural sostenible*, eds. L. Krishnamurthy and M. U. Gómez, 18–48. México: Programa de las Naciones Unidas para el Medio Ambiente.

Lei da Mata Atlântica. 2010. http://www.planalto.gov.br/ccivil_03/_Ato2004-2006/2006/Lei/L11428.htm (accessed December 8, 2010).

Lyngbaek A. E., R. G. Muschler, and F. L. Sinclair. 2001. Productivity and profitability of multistrata organic versus conventional coffee farms in Costa Rica. *Agroforestry Systems* 53: 205–213.

Méndez, V. E., and C. M. Bacon. 2005. Medios de vida y conservación de la biodiversidad arbórea: las experiencias de las cooperativas cafetaleras en El Salvador y Nicaragua. *LEISA Revista de Agroecología* 20: 27–30.

Méndez, V. E., C. M. Bacon, M. Olson, K. S. Morris and A. Shattuck. 2010. Agrobiodiversity and shade coffee smallholder livelihoods: A Review and synthesis of ten years of research in Central America. *The Professional Geographer* 62: 357–376.

Méndez, V. E., S. R. Gliessman, and G. S. Gilbert. 2007. Tree biodiversity in farmer cooperatives of a shade coffee landscape in western El Salvador. *Agriculture, Ecosystems and Environment* 119: 145–159.

Millennium Ecosystem Assessment. 2003. *Ecosystems and human well-being: A framework for assessment*. Washington, DC: Island Press. http://www.maweb.org/en/Condition.aspx#download (accessed January 20, 2012).

Ministério do Meio Ambiente. 2002. *Projeto Corredores Ecológicos*. Programa Piloto para Proteção das Florestas do Brasil PPG7. Brasília: MMA.

Moguel, P., and V. M. Toledo. 1999. Biodiversity conservation in traditional coffee systems of Mexico. *Conservation Biology* 13: 11–21.

Montagnini, F. 2005. *Environmental services of agroforestry systems*. New York: Food Products Press.

Nair, P. K. R. 1997. *Agroforestería*. México: Univesidad Autonoma de Chapingo.

Nair, P. K. R., and J. C. Dagar. 1991. An approach to developing methodologies for evaluating agroforestry systems in India, *Agroforestry Systems* 16: 55–81.

Nóbrega, N. E. F., J. G. F. Silva, H. E. A. Ramos, and F. S. Pagung. 2008. Balanço hídrico climatológico e classificação climática de Thornthwaite e Köppen para o município de Linhares—ES. In *Congresso Nacional de Irrigação e Drenagem*, 18. São Mateus: Associação Brasileiro de Irrigação e Drenagem.

Novo PEDEAG. 2010. Plano Estratégico de Desenvolvimento da Agricultura: Novo PEDEAG 2007–2025. http://www.seag.es.gov.br/pedeag/livro.htm (accessed October 23, 2010).

Nowotny, K. 1997. *Sistematização do programa de agrossilvicultura*. Vitória: Associação de Programas em Tecnologias Alternativas.

Peraci, A. S., and G. A. Bittencourt. 2010. Family farming and price guarantee programs in Brazil: The Food Acquisition Program (PAA). In Silva, J. G., M. E. Del Grossi, and C. G. França, *The Fome Zero (Zero Hunger) Program: The Brazilian experience*, 193–223. Brasília: MDA. http://www.grazianodasilva.org/wp-content/uploads/2011/06/Zero-Hunger-Book-ENGLISH_full.pdf (accessed January 20, 2012).

Perfecto, I., R. A. Rice, R. Greenberg, and M. E. Vand der Voort. 1996. Shade coffee: A disappearing refuge for biodiversity, *BioScience* 46: 598–609.

Pretty, J. 1995. *Regenerating agriculture: policies and practices for sustainability and self-reliance*. London: Earthscan.

Radesepp-Hearne, C., G. D. Peterson, and E. M. Bennett. 2010. Ecosystem service bundles for analyzing tradeoffs in diverse landscapes. *Proceedings of the National Academy of Sciences of the United States of America* 107:5242–5247.

Rosemeyer, M. E. 2010. What do we know about the conversion process? Yields, economics, ecological process and social issues. In *The conversion to sustainable agriculture: principles, processes and practices*, eds. S. R. Gliessman and M. E. Rosemeyer, 15–48, Boca Raton, FL: CRC Press.

Sales, E. F., and J. B. S. Araujo. 2005. Levantamento de árvores consorciadas com cafeeiros no Estado do Espírito Santo. In *Congresso Brasileiro de Agroecologia,* 3. Florianópolis, Brazil: ABA, [DC-Room].

Santos, R., L. Rodrigues, C. Lima, and C. Jaramillo-Botero. 2012. Coffee yield and microenvironmental factors in a native tree agroforestry system in southeast Minas Gerais, Brazil, *Journal of Sustainable Agriculture*, 36: 54–68.

Sevilla Guzmán, E. 2006. *De la sociología rural a la Agroecología*. Barcelona: Icaria Editorial.

Silva, O. M., and C. A. Leite. 2000. Competitividade e custos do café no Brasil e no exterior. In *Café: produtividade, qualidade e sustentabilidade*. ed. L. Zambolim, 27–50. Viçosa: Universidade Federal de Viçosa.

Soto-Pinto, L. L., I. Perfecto, J. Castillo-Hernandez, and J. Caballero-Nieto. 2000. Shade effect on the coffee production at the northern Tzeltal zone of the state of Chiapas, Mexico. *Agriculture, Ecosystems & Environment* 80: 61–63.

Souza, H. N., I. M. Cardoso, J. M. Fernandes, F. C. P. Garcia, V. R. Bonfim, A. C. Santos, A. F. Carvalho and E. S. Mendonça. 2010. Selection of native trees for intercropping with coffee in the Atlantic Rainforest biome. *Agroforestry Systems* 80:1–16.

Souza, H. N, J. de Graaff, and M. M. Pulleman. 2011 Strategies and economics of farming systems with coffee in the Atlantic Rainforest Biome. *Agroforestry Systems*. DOI:10.1007/s10457-011-9452-x

Taques, R. C., and G. G. Dadalto. 2007. Zoneamento agroclimático para a cultura do café Conilon no Estado do Espírito Santo. In *Café conilon*, eds. R. G. Ferrão, A. F. A. Fonseca, S. M. Bragança, M. A. G. Ferrão, and L. H. De Muner, 51–63. Vitória: Incaper.

Taylor, S. J., and R. Bogdan. 1986. *Metodología de las ciencias sociales*. Buenos Aires: Paidos Studio.

Van der Ploeg J. D. 2008 *Camponeses e imperios alimentares: sustentabilidade na era da globalização*. Porto Alegre: Editora UFRGS.

Wolf, E. R. 1978. *Los campesinos*, 3rd ed. Barcelona: Editorial Labor.