Biodiversity and Conservation (2022) 31:2259–2296
https://doi.org/10.1007/s10531-021-02348-8

ORIGINAL PAPER

The traditional agroforestry systems of Sierra del Rosario and Sierra Maestra, Cuba

Mauro Agnoletti[1] · Yenia Molina Pelegrín[2] · Alejandro González Alvarez[3]

Received: 6 July 2021 / Revised: 30 November 2021 / Accepted: 5 December 2021 /
Published online: 15 February 2022

Abstract
Traditional coffee cultivation in Cuba is the result of a complex interaction between different flora species creating agroforestry systems widely spread in mountainous area. The systems, product of local traditional knowledge, are mainly devoted to coffee production but, thanks to the interaction with other species, farmers provide different food products both for self-consumption and to be sold. Furthermore, the adoption of shade trees in order to reach a better quality of the coffee cultivated creates particular microclimate conditions favorable for microorganisms, fauna species and also for spontaneous flora species. According to this it is clear the relationships between traditional knowledge and biodiversity preservation which is fundamental also for improving the surrounding environment, avoiding floods or hydrogeological instability damages, concurring to climate change mitigation and carbon storage. Traditional agroforestry systems are one of the best example of coexistence and coevolution between man and nature, being an historical system adopted by local communities to satisfy their needs in total respect of the surrounding environment. Considering this, the promotion and maintenance of this kind of systems and knowledge related might constitute a valid example to actively preserve biodiversity while respecting human needs for food and livelihood security. These systems are also of particular importance considering the importance of coffee as a beverage served in many countries of the world, but often produced in intensive plantations. This paper shows the high sustainability of coffee production under the shade of trees and support a new concept of food quality contributing to preserve local cultures and environments.

Keywords Agroforestry · Coffee · Agrobiodiversity · Traditional knowledge · Agricultural heritage

Communicated by Antonio Santoro.

✉ Mauro Agnoletti
mauro.agnoletti@unifi.it

Extended author information available on the last page of the article

Introduction

Agrobiodiversity is the synergy and interaction between living things, land, technology, and social systems (Long et al. 2003) and conserving it in farming systems could provide direct and indirect benefits necessary for livelihoods and ecosystem functioning (Chirwa et al. 2008). Agroforestry systems are characterized by important elements that can play a significant role in the adaptation to climate change including changes in microclimate structure, protection through provision of permanent cover and opportunities for diversification of the agricultural systems, improving efficiency of use of soil, water and climatic resources, contribution to soil fertility improvement, reducing carbon emissions and increasing sequestration, and promoting gender equity (Rao et al. 2007) while being characterized by high socioeconomic and ecological complexity (Trosper et al. 2011). In addition, it has been exposed that agroforestry systems with greater structural complexity are capable of harboring high biodiversity (Santoro et al. 2020). The biodiversity associated to agroforestry is part of the wider concept of biocultural diversity (Agnoletti and Rotherham 2015) adopted by FAO in the criteria for the designation of agricultural heritage systems among the GIAHS sites (Globally Important Agricultural Heritage Systems).

Coffee cultivation is traditionally based on agroforestry systems considering that shade trees reduce the stress of coffee by ameliorating adverse climatic conditions and nutritional imbalances (Beer et al. 1997). Coffee is an extremely important agricultural commodity, produced in about 80 tropical countries, with an estimated 125 million people depending on it for their livelihoods in Latin America, Africa, and Asia (Krishnan 2017). Over the past 50 years, both production and consumption of coffee have risen considerably but, especially smallholders, who are the main producers, are facing growing challenges derived from climate change and more difficult natural growing conditions (FAO 2015). In Cuba, the culture of coffee has been important in many mountainous areas as a historically key element of the agricultural evolution of its landscapes (Ramírez and Paredes 2003). The first coffee plants were introduced in Cuba from 1748, having place in a farm of Wajay, a town located at the periphery of Havana city in the western geography of the country (Lapique and García 2014); but it is from the Revolution of Haiti that the coffee production in Cuba has had a particular increment (Fernandez 2012). Coffee plantations are predominant as coffee is a commercialized product in the majority of the island farms even if it is not the only species cultivated as it coexists with other cultivated species increasing the crops agricultural diversity being important repositories of biological richness for groups such as trees and epiphytes, mammals, birds, reptiles, amphibians, and arthropods (Moguel and Toledo 1999). Beside this, Cuba has the privilege of having a remarkable wealth of endemic or exclusive flora and fauna. Vales and Vilamajo (2001) highlight Cuba as the island of the Antilles with greater biological diversity, both in total species richness and in the degree of endemism, which considerably increases the value of Cuban biodiversity.

Considering this the present paper takes in consideration two traditional coffee production agroforestry systems located at the opposite extremes of Cuba with the aim of analyzing their structure and the agrobiodiversity related. The two systems considered are Sierra del Rosario and Sierra Maestra, both covering mountainous surfaces and still characterized by traditional practices related to coffee production. The paper aims to stress the importance of presence and maintenance of traditional agroforestry systems for local agrobiodiversity preservation. The agrobiodiversity linked to the presence of traditional practices, in fact, can be fundamental both from an economic and natural point of view providing multiple benefits. In addition, the maintenance of such systems is a valid example of a

sustainable alternative in order to satisfy social-economical needs while preserving the local environment and cultural heritage. The spatial scale chosen for this paper is also aimed at understanding "gamma" diversity, the one at landscape level, considering larger geographic regions compared to small sampling units, including human activity.

Material and Methods

The present study focused on two areas located at the two opposite extremes of the island of Cuba (Fig. 1): Sierra Maestra and Sierra del Rosario. The choice has been made mainly considering the importance of coffee production in both areas history. Furthermore, in both areas the coffee production has been maintained according to the traditional practices creating complex and sustainable agroforestry systems.

The area of Sierra del Rosario, in the north-west of Cuba, covers 80.000 hectares and it is located in Artemisa province. It is 70 km away from the capital, Havana and it is part of a mountainous area with maximum high of 560 m a.s.l.. The eastern portion of the site analyzed is also part of the Sierra del Rosario Biosphere Reserve, included in the official UNESCO list in 1984 and recognized as a reserve showing a complex geological structure, with a great diversity of rocks that produce different and special soils, which in part, determine flora endemism in its landscape (García and Castiñeiras 2006). Sierra del Rosario, according to the Koppen classification (Fig. 3), belongs to the tropical area including both the monsoon (Am) and the savannah (Aw) climate subcategories (Kottek et al. 2006).

Sierra Maestra is set in the opposite side of the island, in the south-east of Cuba. The area considered covers a surface of 494.889 hectares of which 59.066 hectares are characterized by coffee and cocoa cultivation (Fig. 2). It extends across 14 municipalities in Granma, Santiago de Cuba and Guantanamo provinces. The area is set along the Sierra Maestra massif from 240 to 1200 m a.s.l.. According to the Koppen climate classification it belongs to Tropical, both monsoon (Am) and savannah (Aw), and Temperate, no dry

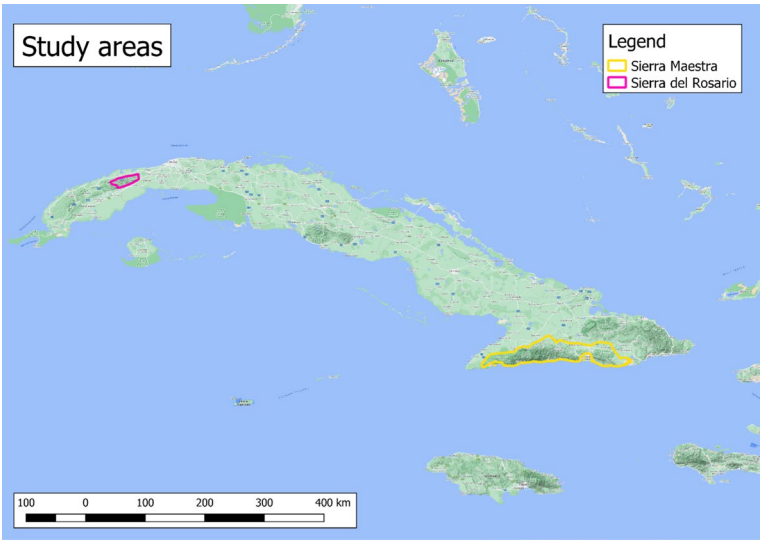

Fig. 1 Localization of the two areas analyzed

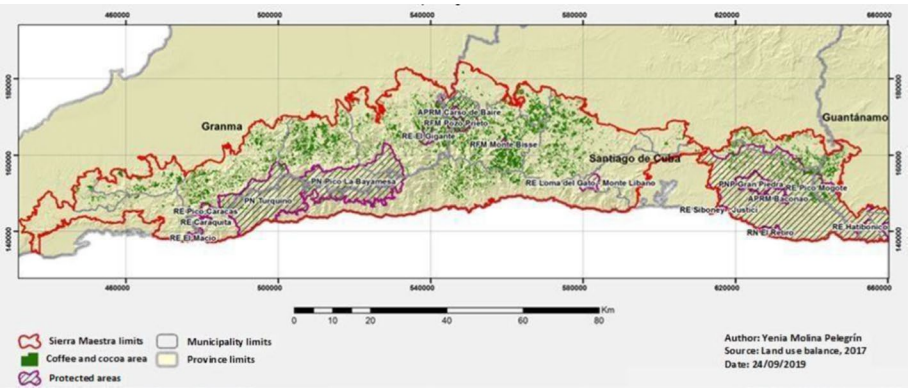

Fig. 2 The map shows the Coffee and Cocoa cultivation distribution in Sierra Maestra as well as it identifies all the protected areas inside the study area boundaries

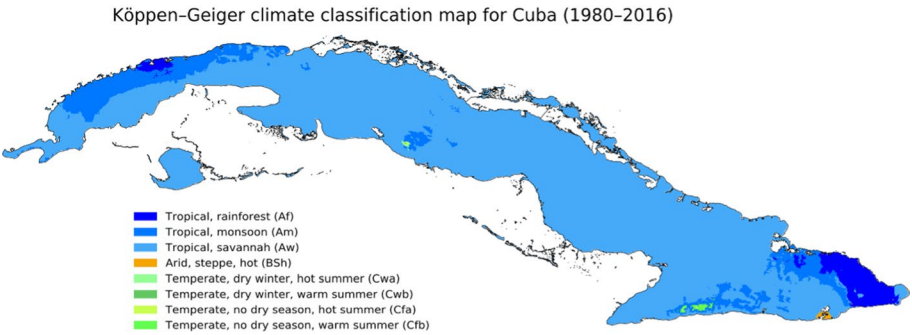

Fig. 3 Koppen climate classification for Cuba Island

season, warm summer (Cfb) classes (Fig. 3). Inside the study area boundaries there are also protected areas, part of the National System of Protected areas which are of as national or local significance (Fig. 2). Furthermore, as in the case of Sierra del Rosario even in this area there is a surface included in UNESCO Biosphere Reserve List from 1987: the Baconao Biosphere Reserve, located in the south of the provinces of Santiago de Cuba and Guantánamo, in the eastern region of Cuba.

The two areas choice has been made according to the recognized importance of traditional coffee cultivation in both of them and because they are, even in the present days, a good example of agroforestry systems sustainable management.

The study carried out is based on the comparison between the two sites. The analysis mainly focuses on the agroforestry systems structure characteristics, the ecological interactions created by the systems themselves and on the traditional practices and agrobiodiversity related. In particular: the first part of the study aims to provide a description of coffee agroforestry system structure, practices and traditional knowledge, focusing on their effects on the surrounding environment, while the second part provides a detailed assessment of coffee agroforestry system agrobiodiversity richness considering the different varieties of species both endemic and cultivated which are deeply related to the maintenance of the systems themselves.

The biodiversity inventories in Sierra del Rosario is the accumulative knowledge resulting of expeditions and field work jointly conducted over the last 35 years between Sierra del Rosario Ecological Station (EESR) and different institutions involved in systematics and taxonomy in Cuba, as is the case of the Cuban National Garden, the Institute of Ecology and Systematics and the National Museum of Natural History. Agricultural diversity has been compiled as the result of field works jointly conducted by INIFAT and EESR since 1999 and recently updated by COBARB project (2012–2019) due to expeditions and surveys conducted among 75 traditional farmers placed in agricultural landscapes.

Results

In Cuba, the introduction of agroforestry system and practices related dates back to the eighteenth century when French settlers introduced coffee cultivation (*Coffea arabica*) in the mountainous areas of the country, where by the first time trees were associated with permanent cultivation, with the goal of obtaining sustained yields in hillside conditions, not forgetting the "conucos" or family parcels, a traditional form of integrated production known as an agrosilvopastoral practice.

In traditional coffee plantations in the mountainous areas of the Sierra Maestra de Cuba, a multiple cultivation method is practiced, since they are established on the same surface, in addition to coffee trees and trees, *Dioscore alata* and *Xathosoma sp*., some varieties of banana are cultivated. Even if coffee is the main source of resources, fruit species are important supplements to the family's daily diet. Currently 57 673.36 ha are dedicated to coffee cultivation in Sierra Maestra.

Sierra del Rosario traditional system is similar to the one of Sierra Maestra: the farms characterized by coffee cultivation of important extension see also the presence of other species also important for farmers livelihood like *Xanthosoma sagittifolium*, *Citrus*, *Pouteria sapota, Manhiot esculenta, Cucurbita moschata* and *Ipomoea batatas.* Coffee cultivation is in fact part of the system diversity being particularly valorized in polycultural systems as when it is mixed with fruit trees as *plátano* (*Musa spp.*), *mamey colorado* (*Pouteria sapota*) and *aguacate* (*Persea americana*) used as shade trees. In addition, the traditional coffee system is characterized by a series of herbaceous species used as food.

The traditional structure of traditional agroforestry system for coffee production is the result of a complex combination of species strongly influencing the agrobiodiversity richness of the system itself (Fig. 4). The farmers use to create shade with species like fruit trees that can contribute to their sustenance but it is also common the utilization of forestry species like *Ficus aurea* and *Trophis racemosa*. Among the species adopted to create shade farmers prefer *Gliricidia sepium* and *Samanea saman* (Gonzalez Alvarez et al. 2016).

From an ecological point of view, in agroforestry systems, nutrients enter through various sources such as rain and organic residues; these can be accumulated either in the shade trees cultivation, soil or litter. At the same time, interactions occur between crop layers such as residue deposition, infiltration, absorption and mineralization; likewise, outputs can occur by crops yields, leaching, runoff, and denitrification processes. The increase in litter shade trees promotes a diversity of decomposer organisms and other species can provide ecosystem services such as pest control (Petite Aldana et al. 2019) (Fig. 5) while protecting the soil from direct insolation, helping maintain organic matter, reducing evaporation and maintaining soil productivity (Siebert 2002).

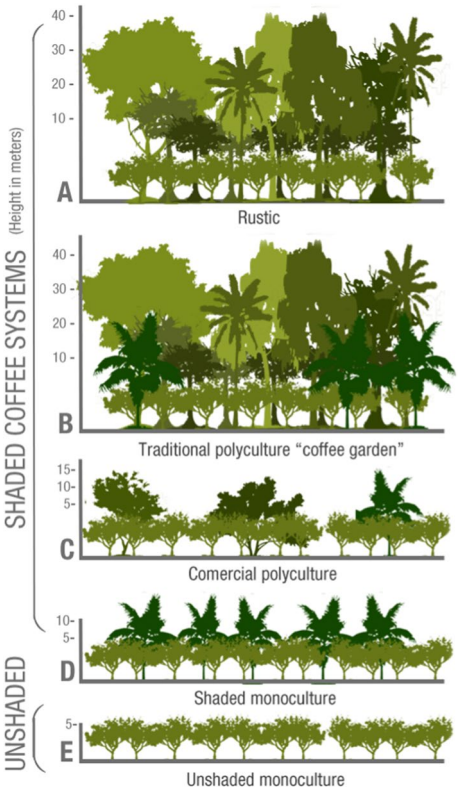

Fig. 4 The traditional polyculture coffee garden is a complex combination of multiple species needed both from an economic and ecological point of view. It is important for farmers' sustenance the presence of different species in the system that contributes to food security and good livelihood conditions but, at the same time, it results fundamental from an environmental point of view providing multiple ecological benefits while improving the agrobiodiversity richness (*from* Moguel and Toledo 1999)

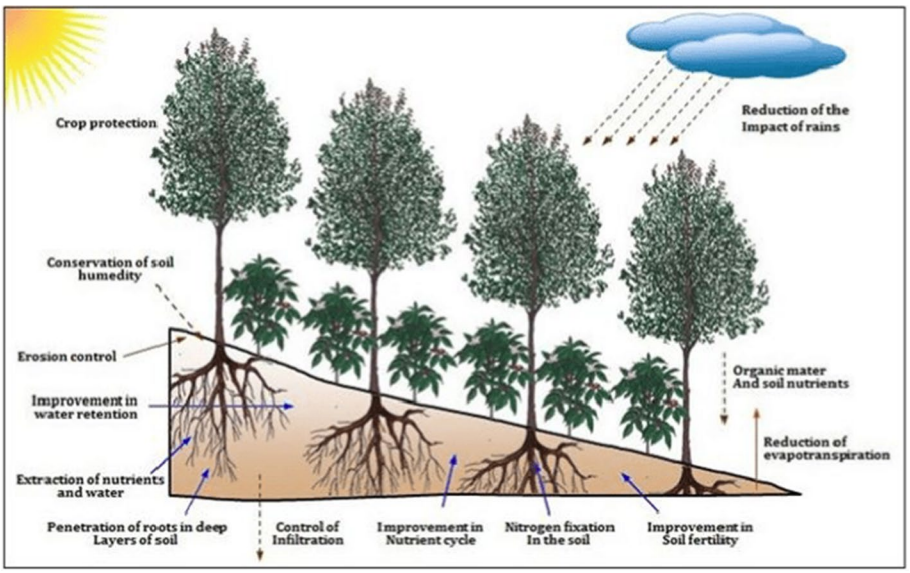

Fig. 5 Ecological interactions in coffee agroforestry system (Petite Aldana et al., 2019)

Fig. 6 Coffee production agroforestry system in Sierra del Rosario

Fig. 7 Coffee production in Sierra Maestra

Besides the ecological functions derived from the system complexity, agricultural diversification is promoted by local farmers as a way to increase options of keep economic inputs in face of extreme climatic impacts. In general, the traditional farms are featured in a high integration of crop production and animal breeding, which is highly desirable under the perspective of agroecology (Figs. 6 and 7).

Sierra del Rosario is recognized for its crop genetic resources with high levels of varietal diversity of coffee (*Coffea* sp), maize (*Zea mays*), lima bean (*Phaseolus lunatus*), common bean (*Phaseolus vulgaris*), chilli (*Capsicum* sp.), etc. (Castiñeiras et al. 2006). The multistate agroecosystems areas can include up to 500 plant species most of which are ornamental and medicinal, followed by fruit and timber species. There is also an amount of plants used and preserved by farmers because of its sacred conditions. Data base of the Ecological Station of RBSR reports a floristic diversity that reaches 889 upper and 281

lower plants, of which 11% are endemic. The richness of Plant Genetic resources of Sierra del Rosario has been object of research and in situ conservation by INIFAT, in collaboration with international partners like Bioversity International (García and Castiñeiras 2006). In this sense, the last project conducted between this organizations (COBARB), budged by 7 GEF and implemented by UNEP, had actualize the inventories of the agrobiodiversity in many traditional systems placed inside or around the RBSR. The actions of this project have been also aware of the landscape peculiarities of the regions (Sánchez et al. 2015).

In the following tables are expressed the species characterizing the systems: the Table 3 is only dedicated to the Sierra del Rosario flora species, Supplementary Material Table 1 to Sierra Maestra species and the last one (Supplementary Material Table 2) contains the species that the two systems have in common.

The fauna diversity is also very rich, both for wild species and livestock. In Sierra del Rosario, among livestock species (Table 1), the most important in terms of number of individuals are pigs. In traditional farms the traditional race of pigs is named "creole". The term "creole" is used academically in reference to the animals considered genetically descendants from those brought to Cuba by Spaniard conquerors. However, the farmers make a broader use of the term; many times they use the word "creole" to name the colored animals or those born in their farms without racial control.

Wild fauna reported at Sierra del Rosario, in studies also conducted at the RBSR, shows a high rate of endemics, among them the best represented groups are Birds (131 species identified including 12 endemics), Reptiles (33 species identified including 27 endemics), Amphibia (16 species identified including 13 endemics), Mammals: (including a remarkable number of bats, with 11 species and among there is very important the presence of two species of genus *Capromys*, commonly known as hutias).

Some of the most charismatic species are reported in the best-preserved areas, but is also possible to observed them in the mountains traditional systems. Ramírez y Paredes and Pupo (2005) remarks that in Sierra del Rosario is not very difficult to see the high flight of the "Gavilán del Monte" (rapacios bird: *Buteo jamaicensis*) or the hummingbird (*Chlorostilbon ricordii*), even in the home gardens, but also other birds like: the national one "Tocororo" (*Plioterus temnurus*), the "Cartacuba" (*Todus multicolor*), the colorful of the "Bijirita" (*Dendroica discolor*) and the Common Bijirita and the familiar and endemic

Table 1 List of livestock species in Sierra del Rosario according to the field work indicated in material and methods

	Livestock species	
	Scientific name	Common Name
1	Sus scrofa domestica	Pigs; Spanish: "cerdo", "puercos"
2	Gallus gallus domesticus	Chickens; Spanish: "pollos", "gallinas"
3	Ovis orientalis aries	Sheep; Spanish: "carneros"
4	Equus ferus caballus	Horses; Spanish: "caballos"
5	Bos primigenius taurus	Caws, Bulls and Oxen; Spanish: "Vacas", "Toros" y "Bueyes"
6	Meleagris gallopavo	Turkeys; Spanish: "Pavos"
7	Ananas platyrhyncos domesticus	Ducks; Spanish: "Patos"
8	Oryctolagus cuniculus	Rabbit; Spanish: "Conejos"
9	Equus africanus x ferux	Mules; Spanish: "Mulos"

Tomeguín del Pinar (*Tiaris canora*), as well as the beautiful and laborious Carpenters: the "Scapular" (*Colaptes auratus*), the "Churroso" (*Colaptes fernandinae*), the "Jobado" (*Centurus superciliaris*) and the "Green" (*Xiphidiopicus percussus*). Population of butterflies such as: *Calisto herophile*, *Eurema larae*, the beautiful *Helicornius charithonius*, *Appias drucilla*, *Utetheisa ornatrix* and *Marpesia chiron*, among many others.

In the areas where calcareous rocks predominate, it is easy to find several species of mollusks, with showy shapes and colors, from the *Zachrycia rangelina*, the largest terrestrial mollusk in the region, but also the species *Emoda sagraiana* and *Emoda marginata*, *Helicina adspersa*, *Plicathyrella assimilis*, and *Vianas regina* Morelet, among other twenty-three species reported. This diversity is consistent with the character of Cuba as a world center of diversity of mollusks.

In the case of Sierra del Rosario, as the result of the field visits conducted by COBARB project, there were observed examples of the use of wild animal used for feeding, as is the case of shrimps and hutias, which are endemic species. In the case of the Cuban *majá* (*Epicrates angulifer*) the biggest snake of the island, which is also an endemic, it is reported the use of its fats for medical purposes. In the case of bees, there are either the species "abeja europea" (*Apis mellifera*) and "abeja de la tierra" (*Melipona beecheii*) that can be managed. Even when both bees are considered as introduced, there are wild populations of these species which are present in the forest or agroforestry areas of the landscapes.

Also Sierra Maestra has a remarkable endemic fauna (Tables 2, 3 and 4).

Among all the species in particular the mollusks could be highlighted considering their multiple uses in Sierra Maestra where they have been used as jewels and personal ornaments, for their color and beauty, including the species: *Zachrysia bayamensis* and *Coryda lindoni*. In addition, also lepidopterans perform various functions such as forming part of food chains and participating in the pollination of many plants. In the ecosystems of the Sierra Maestra can be see *Greta cubana, Virbia hero*s (restricted to the Nipe-Sagua-Baracoa and Sierra Maestra mountain ranges), *Calisto isnaeli*. In Sierra Mastra there is also a great diversity of amphibians and reptiles, in particular the species *Eleutherodactylus albipes, Eleutherodactylus cubanus, Eleutherodactylus jaumei* are endemic of the Sierra Maestra.

Discussion

Coffee culture, as part of mixed systems, tends to be more important in the south of Sierra del Rosario range system while livestock, mainly cows and pigs, tend to be predominant in the more rural farms at the northern side of the range system. The production of coffee seems to be not very high in traditional farms in terms of gross production or productivity. This is in concordance with the arguments of Ospina (2008) pointing that what is remarkable in these ecological coffee systems is the kaleidoscope of food products and ecosystems service. However, in the case of the traditional systems of Sierra del Rosario, there is a surplus of coffee production that is placed in the national markets by different ways, but mainly because of State´s purchases. In the traditional farms placed in Sierra del Rosario, agricultural typologies vary according to differences in topography. For example, is very notable the nonuse of the slopes for practicing the agriculture when the availability of cropping areas in valleys is enough for food requirements. This conducts to differences in the cultures of managing these areas diversifying the traditional practices.

Table 2 Fauna list in Sierra Maestra

Fauna list species		
Apodidae	*Parulidae*	39. Eleutherodactylus rocordii (Dumeril y Bibron)
1. Chorostivon riicordis	20. Dendroica caerulenscens	40. Eleutherodactylus cuneatus (Cope)
Ardidae	21. Dendroica tigrina	41. Eleutherodactylus auriculatus (Cope)
2. Bubulcus ibis	22. Mniotilta varians	42. Eleutherodactylus ronaldi Schwartz
3. Butoride virescens	23. Seiurus motacilla	43. Eleutherodactylus dimidiatus (Cope)
Colunvidae	24. Setofhaga ruticilla	44. Osteopilus septentrionalis (Dumeril y Bibrón)
4. Columbina passerina Linnaeus	*Turdidae*	*Polychorotidae*
5. Patagioenas leucocephala	25. Turdus plumbeus Linnaeus	45. Anolis anfiloquiois
6. Patagioenas squamosa	*Tyrannidae*	46. Anolis equestris
7. Zenaida aseatica	26. Contopus caribaeus	47. Anolis porcatus
Cuculidae	27. Tyrannus caudifaciatus	48. Anolis sagrei
8. Cooyzus americanus	28. Tyrannus dominicensis	49. Anolis allogus
9. Crotophaga ani Linnaeus	*Vireonidae*	50. Anolis baracoae
10. Aurothera merlini d'Orbigny	29. Vireo antiloquus	51. Anolis argenteulus
Accipitridae	*Picidae*	52. Anolis angusticeps
11. Accipiter striatus Vieillot	30. Melanerpes superciliaris Tenminck	*Teidae*
12. Buteo platypterus	31. Sphyrapicus varius	53. Ameiva auberi
13. Cyrcus cyaneus	32. Xiphidiopicus percussus Temminck	*Tropiduridae*
Falconidae	*Cathartidae*	54. Leyocephalus macropus
14. Falco sparverius Linnaeus	33. Cathartes aura Linnaeus	55. Leyocephalus raviceps
Iteridae	*Trogonidae*	*Capromyidae*
15. Dives atroviolacea d'Orbigny	34. Priotelus temnurus Temminck	56. Capromys pilorides Say
16. Icterus dominicensis Linnaeus	*Bufonidae*	
17. Quiscalus niger	35. Bufo spp.	
18. Molothrus bonoriensis	36. Eleutherodactylus varleyis Dunn	
Mimidae	37. Eleutherodactylus atkinsi Lynch	
19. Mimus polyglottos Linnaeus	38. Eleutherodactylus simulans Díaz y Fong	

As has been pointed out, there is a diversity of sources of incomes for the traditional farming systems, condition that can be considered a guarantee of resilience. It is hypothesized that shade promotes slower and more balanced filling and uniform ripening of berries, thus yielding a better-quality product than unshaded coffee plants (Muschler 2001). In addition, the multiplicity of agricultural activities and the traditional knowledge is an opportunity for keeping the functioning in the system itself when a stressing situation occurs. The multifunctionality of many biological resources is also a distinctive attribute of the traditional systems still present in Sierra del Rosario. A very iconic example is the case of Cuban national tree (*Roystonea regia*), a forest resource with multiple uses and cultural signification. The species is a source of traditional materials for buildings, food for humans and animals, and also row materials for packaging. In this sense the petioles of the royal palm are very demanded in the elaboration of boxes for transportation of tobacco leaves.

Even when coffee and fruits trees are very important components of the traditional systems of Sierra del Rosario, other crops species like annual crops are important as complement of the systems. As Brown and Hodgkin pointed (2007), there are three categories of plant species make up plant biodiversity in the rural landscape:

1. The plant species that are deliberately cropped or tended and harvested for food, fiber, fuel, fodder, timber, medicine, decoration, or other uses.
2. At the other extreme, wild species that occur in natural communities and benefit the agricultural environment by providing protection, shade, and groundwater regulation
3. Between these extremes, the wild related species of domesticates that can interbreed with and contribute to the genepool of their crop cousins, that survive autonomously, that share many of the pests and diseases of crops, and that sometimes are eaten to relieve famine

Regarding the Sierra Maestra, it represents one of the main nucleus of biodiversity in Cuba. The system traditional structure, today maintained, results to be a tool for the conservation and management of biodiversity, inside or outside protected areas or where the habitat is very disturbed. The use of forest trees as a shadow of coffee and cocoa cultivation has proven to be sustainable over three centuries creating also a favorable scenario to increase biodiversity. Forest trees are not the only one used to create shade in coffee cultivation, it is, in fact, easy and common to find fruit trees that apart from the function as shade and crop protection, also provide additional food products so that coffee and cocoa systems in Sierra Maestra not only generate coffee and cocoa as a product, but also high quality wood, fruits and agricultural products. Moreover, diversified coffee and cocoa plantations that look like a natural forest are ideal for protecting the soil, conserving water and maintaining high biodiversity constituting excellent wildlife habitat sites.

As seen from the result of the present study traditional agroforestry systems, as the ones in Sierra del Rosario and Sierra Maestra, have the potential to hold high species richness and constitute a valuable tool that could be used to complement conservation effort while being designed to improve farmers' livelihoods by generally increasing productivity, profitability and sustainability.

According to the World Bank (2008), improving these three aspects of small-scale agriculture is a key way out of poverty, emphasizing the potential of agroforestry practices to alleviate shortages. In addition, it has been exposed that agroforestry systems with greater structural complexity are capable of harboring high biodiversity and in particular the functional biodiversity, which can increase productivity and ecological resilience. For example,

Table 3 Flora species list of Sierra del Rosario

	Species	Common name
1	*Abildgaardia mostachya*	Vigueta Naranjo
2	*Abrus precatorius*	Peonía
3	*Acrocomia armentalis*	Corojo
4	*Adianthus capillus veneris*	Culantrillo de Pozo
5	*Agalinis albida*	Fernandina Blanca
6	*Alchornea latifolia*	Aguacatillo
7	*Allium cepa*	Cebolla
8	*Allium cepa var aggregatum*	Cebolla corojo
9	*Allium chinense*	Ajo porro
10	*Allium fistulosum*	Cebollino, Ajo de jardín
11	*Allium sativum*	Ajo criollo
12	*Allium tuberosum*	Cebollino
13	*Alternanthera sp.*	Tapón
14	*Ambrosia artemisiifolia*	Artemisa
15	*Amyris balsamifera*	Cuaba
16	*Andira jamaicensis*	Yaba
17	*Andropogon glomeratus*	Rabo de zorra
18	*Arachys hypogea*	Maní
19	*Argemone mexicana*	Cardo Santo
20	*Artemisa absinthium*	Ajenjo
21	*Arthrostylidium capillifolium*	Tibisi
22	*Asclepias curassavica*	Flor de la calentura
23	*Asclepias nivea*	Flor de la calentura blanca
24	*Averrhoa bilimbi*	Pepinillo
25	*Bahuinia cumanensis*	Bejuco de Tortuga

Table 3 (continued)

	Species	Common name
26	*Bahuinia divaricata*	Pata de Vaca
27	*Blechum browneii*	Mazorquilla
28	*Boconia frutescens*	Yagrumita
29	*Bourreria crassinifolia*	Hierro de sabana
30	*Brassica juncea*	Mostaza
31	*Byrsonima spicata*	Peralejo de Pinar
32	*Caesalpinia pulcherrima*	Guacamaya
33	*Caesalpinia vesicaria*	Brasil
34	*Calophyllum pinetorum*	Ocuje
35	*Calyptrantes capitulata*	Guairaje
36	*Canavalia ensiformis*	Nescafé
37	*Capsicum annuum*	Ají angolano
38	*Capsicum chinense*	Ají cachucha
39	*Capsicum frutescens*	Ají chile
40	*Casearia hirsuta*	Raspalengua
41	*Cassia diphylla*	Maní cimarrón
42	*Catharanthus roseus*	Vicaria
43	*Cayaponia racemosa*	Brionia
44	*Celtis iguanea*	Zarza Blanca
45	*Celtis trinervia*	Hueso
46	*Cinnamomum aromaticum*	Canela china
47	*Cissus verticillata*	Bejuco ubí
48	*Citharexylum caudatum*	Penda
49	*Citrullus lunatus*	Melón de agua
50	*Citrus bergamia*	Bergamota

Table 3 (continued)

	Species	Common name
51	*Cladium jamaicensis*	Cortadera
52	*Clematis dioica*	Cabello de Ángel
53	*Clidemia hirta*	Cordobán peludo
54	*Clusia minor*	Copeicillo
55	*Coccoloba retusa*	Uvilla
56	*Coix lacryma jobii*	Santa Juana
57	*Colocasia esculenta*	Malanga
58	*Colubrina ferruginosa*	Bijaguara
59	*Cordia nitida*	Ateje de Costa
60	*Costus sp.*	Caña mexicana
61	*Costus speciosus*	Caña americana, Cañuela santa
62	*Costus spicatus*	Caña mexicana
63	*Cucumis melo*	Melón de Castilla
64	*Cupania glabra*	Guara de costa
65	*Cupania macrophylla*	Guara macho
66	*Cymbopogon citratus*	Caña santa
67	*Cynodon dactylon*	Pasto bermuda
68	*Dalbergia ecastophyllum*	Pendola
69	*Davilla rugosa*	Bejuco colorado
70	*Deherainia cubensis*	Contraguao cimarrón
71	*Dendropanax arboreus*	Víbona
72	*Dichrostachys cinerea*	Marabú
73	*Didymopanax morototoni*	Yagruma macho
74	*Diospyros caribaea*	Tagua
75	*Diospyros crassinervis*	Ebano carbonero

Table 3 (continued)

	Species	Common name
76	*Dovyalis hebecarpa*	Aberia
77	*Drypetes alba*	Hueso
78	*Drypetes serrata*	Chicharrón de costa
79	*Echinochloa colonum*	Grama pintada
80	*Echites umbellata*	Caramagüey Blanco
81	*Ehretia tinifolia*	Roble prieto
82	*Elephantopus scaber*	Lengua de vaca
83	*Enallagma latifolia*	Güira de olor
84	*Eryngium foetidum*	Culantro
85	*Erythroxylon alternifolium*	Arabo Prieto
86	*Erythroxylon areolatum*	Jibá Macho
87	*Eucaliptus resinifera*	Eucalipto
88	*Eugenia glabra*	Guairaje macho
89	*Eugenia maleolens*	Guairaje
90	*Eugenia rigidifolia*	Biriji
91	*Eugenia rimosa*	Guairajillo
92	*Eupatorium capillifolium*	Copal
93	*Eupatorium odoratum*	Rompezaragüey de sabana
94	*Eupatorium villosum*	Albahaca de sabana
95	*Faramea occidentalis*	Nabaco
96	*Ficus aurea*	Jagüey Hembra
97	*Ficus cassinervia*	Jagüey
98	*Ficus combissi*	Jagüey Macho
99	*Ficus laevigata*	Jagüey
100	*Ficus membranacea*	Jagüey

Table 3 (continued)

	Species	Common name
101	*Ficus subscabrida*	Jagüey Macho
102	*Flacourtia indica*	Ciruela gobernadora
103	*Foeniculum vulgare*	Hinojo
104	*Gaya occidentalis*	Botón de Oro
105	*Genipa americana*	Jagua
106	*Gerascanthus coloccocus*	Ateje
107	*Gerascanthus gerascanthioides*	Varía
108	*Gilibertia edulis*	Víbona
109	*Gossypium sp*	Algodón
110	*Guettarda cobsii*	Hueso
111	*Guettarda lindeniana*	Cuero
112	*Guettarda valenzuelana*	Vigueta
113	*Guzmania monostachya*	Curujey Bonito
114	*Gymnanthes lucida*	Yaití
115	*Hamelia patens*	Ponasí
116	*Hedychium coronarium*	Mariposa blanca
117	*Helianthus annuus*	Girasol
118	*Heliotropium indicum*	Alacrancillo
119	*Hibiscus costatus*	Majaguilla
120	*Hibiscus pernambucensis*	Majagua
121	*Hibiscus sabdariffa*	Serení
122	*Hibiscus tiliaceus*	Majagua
123	*Hura crepitans*	Salvadera
124	*Hypharrenia rufa*	Jaragua
125	*Ilex cassine*	Yanilla Blanca

Table 3 (continued)

	Species	Common name
126	*Ilex repanda*	Naranjo Blanco
127	*Imperata brasiliensis*	Yaguna
128	*Ipomoea batatas*	boniato
129	*Ixora floribunda*	Lengua de vaca
130	*Jacquinia brunnescens*	Espuela de Caballero
131	*Jatropha multifida*	Ceibilla
132	*Justicia pectoralis*	Tilo, carpintero
133	*Khaya senegalensis*	Caoba africana
134	*Krugiodendron ferreum*	Carey de costa
135	*Lantana camara*	Filigrana
136	*Lantana involucrata*	Filigrana cimarrona
137	*Laplacea curtyana*	Almendro
138	*Laurentia longiflora*	Revienta caballos
139	*Licaria triandra*	Laurel de la Loma
140	*Lippia alba*	Flor de España
141	*Lippia dulcis*	Orozoz
142	*Lippia micromera*	Oreganillo
143	*Lonchocarpus pentaphyllus*	Guamá de Costa
144	*Lonchocarpus sericeus*	Guamá
145	*Lysiloma sabicu*	Sabicú
146	*Malpighia biflora*	Palo bronco de Monte
147	*Malpighia glabra*	Acerola
148	*Mammea americana*	Mamey de Santo Domingo
149	*Manhiot esculenta*	Yuca
150	*Manilkara albescens*	Acana

Table 3 (continued)

	Species	Common name
151	*Manilkara jaimiqui*	Jaimiquí
152	*Manilkara sapota*	Sapote
153	*Mappia racemosa*	Palo de Cana
154	*Margaritaria nobilis*	Azulejo
155	*Mastichodendron foetidissimum*	Jocuma
156	*Matayba apetala*	Macurije
157	*Matayba oppositifolia*	Macurije
158	*Matricaria recutita*	Manzanilla
159	*Melia azedarach*	Paraíso
160	*Mentha sp.*	Menta
161	*Mentha spicata*	Hierba buena
162	*Mentha x piperita*	Menta
163	*Miconia laeviagata*	Cordobancillo de arroyo
164	*Mikania cordifolia*	Guaco
165	*Mikania hastata*	Guaco
166	*Mikania ranunculifolia*	Guaco
167	*Morinda royoc*	Piñipiñi
168	*Mucuna pruriens*	Pica Pica
169	*Muntingia calabura*	Capulí
170	*Myrcia valenzuelana*	Pimienta cimarrona
171	*Myrica cerifera*	Arraiján
172	*Nectandra earlet*	Boniato amarillo
173	*Neobracea valenzuelana*	Meloncillo
174	*Neurolaena lobata*	Victoriana
175	*Ocimum basilicum*	Albahaca

Table 3 (continued)

	Species	Common name
176	*Ocimum gratissimum*	Orégano cimarrón
177	*Ocimum sanctum*	Albahaca morada
178	*Ocotea cuneata*	Canelón
179	*Ocotea floribunda*	Boniato Laurel
180	*Ocotea leucoxylon*	Aguacatillo
181	*Olyra latifolia*	Tibisí
182	*Origanum majorana*	Mejorana
183	*Oryza sativa*	Arroz
184	*Oxandra lanceolata*	Algarrobo, Yaya
185	*Paspalum conjugatum*	Cañamazo amargo
186	*Passiflora edulis*	Maracuyá
187	*Passiflora sexflora*	Pasionaria de cerca
188	*Passiflora suberosa*	Huevo de Gallo
189	*Pavonia fruticosa*	Tabano
190	*Peltophorum adnatum*	Moruro Abey
191	*Pennisetum purpureum*	King Grass
192	*Phaseolus lunatus*	Frijol caballero
193	*Phaseolus vulgaris*	Frijol comun
194	*Phoebe elongata*	Boniatillo
195	*Picramnia pentandra*	Aguedita
196	*Picramnia plumata*	Palo amargo
197	*Piper auritum*	Anisón
198	*Piscidia piscipula*	Guamá candelón
199	*Pisonia aculeata*	Medicinal
200	*Pithecellobium arboreum*	Moruro Rojo

Table 3 (continued)

	Species	Common name
201	*Moruro Rojo*	Encinillo
202	*Pithecellobium saman*	Algarrobo
203	*Plantago major*	Llantén
204	*Platygine hexandra*	Ortiga
205	*Plectranthus amboinicus*	Orégano francés
206	*Plectranthus sp*	Meprobamato, Mandelamina
207	*Pluchea carolinensis*	Salvia
208	*Potomorphe peltata*	Caisimón de Anís
209	*Potomorphe umbellata*	Caisimón
210	*Pouteria chrysophillifolia*	Sapote culebra
211	*Pouteria dictyoneura*	Vigueta peluda
212	*Pouteria dominigensis*	Sapote culebra
213	*Pouteria sapota*	Mamey colorado
214	*Protium cubense*	Copal
215	*Prunus myrtifolius*	Almendrillo
216	*Prunus occidentalis*	Cuajaní
217	*Prunus persica*	Melocotón
218	*Pseudolmedia spuria*	Macagua
219	*Psychotria grandis*	Tapa caminos
220	*Psychotria horizontalis*	Dagame cimarrón
221	*Psychotria revoluta*	Lengua de vaca
222	*Psychotria undata*	Árbol Plateado
223	*Punica granatum*	Granada
224	*Pyrus malus*	Pyrus malus
225	*Rauvolfia cubana*	Vibona

Table 3 (continued)

	Species	Common name
226	*Rauvolfia nitida*	Malambo
227	*Renealmia aromatica*	Cojate
228	*Reynosia wrightii*	Almendrillo
229	*Rheedia aristata*	Manajú
230	*Rheedia fruticosa*	Manajú
231	*Rheedia roscifolia*	Manajú
232	*Richardiabrasiliensis*	Garro
233	*Rondeletia odorata*	Clavellina
234	*Rosmarinus officinalis*	Romero
235	*Ruta sp*	Ruda
236	*Sabal parviflora*	Palma Cana
237	*Saccharum officinarum*	Caña de Azúcar
238	*Sapindus saponaria*	Jaboncillo
239	*Savia bahamensis*	Icaquillo macho
240	*Savia clusiifolia*	Icaquillo
241	*Securidaca virgata*	Medicinal
242	*Senna alata*	Guacamaya francesa
243	*Senna occidentalis*	Yerba hedionda
244	*Sesamum orientale*	Ajonjolí
245	*Setaria geniculata*	Rabo de gato
246	*Simaruba laevis*	Gavilán
247	*Sinapis alba*	Mostaza
248	*Sloanea amygdalina*	Cresta de Gallo
249	*Smilax dominguensis*	Raíz de China
250	*Smilax havanensis Jacq.*	Bejuco Ñame

Table 3 (continued)

	Species	Common name
251	*Smilax lanceolata* L.	Raiz de China
252	*Smilax mollis Willd.*	Bejuco de Name
253	*Solanum torvum*	Pendejera
254	*Sorghum bicolor*	Millo, sorgo
255	*Spondias purpurea*	Ciruela
256	*Sporobolus indicus*	Espartillo
257	*Stachytarpheta jamaicensis*	Verbena
258	*Stevia rebaudiana*	Estevia
259	*Stygmaphyllum sagreanum*	Bejuco San Pedro
260	*Suberanthus nerifolius*	Caobilla
261	*Sutureja brownei*	Menta
262	*Symplocos strigillosa*	Jibacoa
263	*Syzygium malaccense*	Albaricoque, pera
264	*Tabebuia shaferi*	Roble blanco
265	*Tabernaemontana ambliocarpa*	Lechoso
266	*Tabernaemontana citrifola*	Jazmín café
267	*Tagetes erecta*	Carolá
268	*Tagetes lucida*	Anís
269	*Tapura obovata*	Cagada de aura
270	*Teloxys ambrosioides*	Apasote
271	*Terminalia intermedia*	Chicharrón
272	*Ternstroemia peduncularis*	Copey Vera
273	*Tillandsia usneoides*	Guajaca, Curujey
274	*Tillandsia valenzuelana*	Curujey
275	*Tournefortia hirsotissima*	Nigua

Table 3 (continued)

	Species	Common name
276	*Trichilia havanensis*	Siguaraya
277	*Trichilia hirta*	Cabo de hacha
278	*Trichospermum grewiifolius*	Guasimilla
279	*Trophys racemosa*	Ramón de Caballos
280	*Turnera ulmifolia*	Marilope
281	*Urera baccifera*	Chichicate
282	*Vernonia havanensis*	rompezaragüey
283	*Vigna umbellata*	Frijol picolino, Frijol diablito, Frijol de Navidad
284	*Vigna unguiculata*	Péinate para atrás
285	*Vitis tiliaeflia*	Parra Cimarrona
286	*Vitis vinifera*	Uva
287	*Xanthium strumarium*	Guizazo de caballo
288	*Xanthosoma atrovirens*	Malanga amarilla
289	*Xiphidium caeruleum*	Mandelamina
290	*Zanthoxylon cubense*	Ayúa blanca
291	*Zanthoxylon fagara*	Amoroso
292	*Zea mays*	Maíz
293	*Zuelania guidonia*	Guaguasí

Table 4 Flora species list in Sierra Maestra

	Species						
1	*Acacia magnum*	41	*Campyloneurum phililidis*	81	*Eugenia malccensis*	121	*Polypodium aureum*
2	*Acalypha alopecuroides*	42	*Casearia guainensis*	82	*Eupatorium leptophillum*	122	*Polypodium lycopodioldes*
3	*Achyranthes aspera vari. indica*	43	*Cassia arabiniae*	83	*Euphorbia heterophilla*	123	*Portulaca oleracea*
4	*Acianthera rubroriridis*	44	*Cassia fistula*	84	*Ficus elastica*	124	*Puteria sapota*
5	*Acianthera rubroviridis (Lindl.)*	45	*Cecropia peltata*	85	*Gliricidia sepium*	125	*Regophyllum antillanum*
6	*Adiantum latifolium*	46	*Ceiba pentandra*	86	*Guarea guara*	126	*Ricinus communis*
7	*Adiantum piramidale*	47	*Cenchrus echinatus*	87	*Hibiscus rosa-sinensis*	127	*Rottboellia exaltata*
8	*Adiantum tenerum*	48	*Chamaesyce berteriana*	88	*Inga vera*	128	*Ruellia tuberosa*
9	*Aeschynomene americana*	49	*Chamaesyce hirta*	89	*Ipomoea tiliacea*	129	*Sanseviera guineensi*
10	*Albizzia falcataria L*	50	*Chamaesyce hyssopipholia*	90	*Isochilus linearis*	130	*Sechium edule*
11	*Albizzia lebbeck (L.) Benth*	51	*Chenopodium ambrosioides*	91	*Ixora sp*	131	*Senegalia tenuifolia*
12	*Albizzia procera L. Benth*	52	*Ciclopeltis semicordata*	92	*Jatropha curcas*	132	*Senna robiniifolia*
13	*Alvaradoa arborescens*	53	*Cissus trifoliata*	93	*Khaya nyasica*	133	*Solanum nigrum*
14	*Alysicarpus vaginalis*	54	*Clusia rosea*	94	*Leptochloa panicea*	134	*Solanum nodiflorum*
15	*Amaranthus dubius Mart*	55	*Cnidosculus urens*	95	*Leptochloa virgata*	135	*Solanum verbascofolium*
16	*Amaranthus spinosus*	56	*Commelina erecta*	96	*Lucaena leucocephala*	136	*Sonchus oleraceus*
17	*Anatherum domingense*	57	*Crotalaria incana*	97	*Lucheaplaty pelatia*	137	*Specklinia grisebachiana*
18	*Andropagon pertusus*	58	*Croton lobatus*	98	*Ludwigia erecta L*	138	*Spondias mombin*
19	*Annona reticulata*	59	*Cucumis dipsaceus Ehrenb. ex Spach*	99	*Lycopersicum pimpillenifolium*	139	*Syzygium jambos*
20	*Anthurium cubense*	60	*Cucumis sativus L*	100	*Miconia acuneae*	140	*Thelypteris dentata*
21	*Anthurium fendleri*	61	*Cucurbita pepo L*	101	*Morinda citrifolia*	141	*Thelypteris obliterata*
22	*Apoda prorepentia testaefolia*	62	*Cynodon dactylon*	102	*Mykania alba*	142	*Thelypteris poiteana*
23	*Aralia sp.*	63	*Cyperus iria*	103	*Nephrolepis multiflora*	143	*Theobroma cacao*
24	*Artocarpus altilis*	64	*Cyperus rotundus*	104	*Ochroma pyramidale*	144	*Thouinia trifoliata*
25	*Artocarpus communis*	65	*Delonix regia*	105	*Oncidium luridum Lindl*	145	*Thunbergia alata Bojer*
26	*Belotia grewiaetolia*	66	*Dendrocereus nudiflorus*	106	*Oxalis corniculata L*	146	*Thunbergia fragrants*
27	*Blechum occidentale*	67	*Desmodium canum*	107	*Oxalis violaceae L*	147	*Tillandsia bulbosa*

Table 4 (continued)

	Species						
28	*Borraria laveis*	68	*Dichanthium annulatum*	108	*Panicum maximum*	148	*Tillandsia recurvata*
29	*Bouchea prismatica*	69	*Dichanthium caricasum*	109	*Panicum pilosum*	149	*Tillandsia turquinensis*
30	*Brachiaria extensa*	70	*Dieffebanchia seguine*	110	*Panicum reptans*	150	*Tradescantia zebrina*
31	*Brachiaria fasciculata*	71	*Digitaria adscendens*	111	*Paspalum fimbriatum*	151	*Tragia volubilis*
32	*Brachiaria subquadripara*	72	*Echinochloa colona*	112	*Pedilantus angustipholium*	152	*Trophis recemosa*
33	*Brassia caudata*	73	*Echinochloa cruzgalli*	113	*Petiveria alliacea L*	153	*Utricularia incisa*
34	*Buherhavia erecta L*	74	*Eleusine indica*	114	*Philodendron consanguineum*	154	*Vachellia tortuosa*
35	*Bursera simaruba*	75	*Emilia sonchifolia*	115	*Phyla nodiflora*	155	*Vernonia cinerea*
36	*Cajanus indicus*	76	*Epidendrum nocturnum Jacq*	116	*Pimenta dioica*	156	*Waltheria indica*
37	*Caladium bicolor*	77	*Epidendrum radicans*	117	*Plumeria montana*	157	*Wedelia ehrnbelgii*
38	*Calocarpum sapota*	78	*Eringium phoetidim*	118	*Poeppigia prest*	158	*Xanthosoma cubense*
39	*Calycophillum candidissimum*	79	*Erythrina poeppigiama*	119	*Poeppigiana erythrina*		
40	*Campyloneurum cubense*	80	*Erythrina vellutina*	120	*Polypodium astropelis*		

cross-pollination can increase coffee production by up to 50% compared to self-pollination (Tscharntke et al. 2011) and biological control can reduce outbreaks of plagues or herbivores (Kellerman et al. 2008; Perfecto et al. 2004). Interactions between woody and herbaceous plants in agroforestry systems usually improve the microclimate and nutrient availability in the soil. The belowground presence of trees affects moisture availability and soil temperature and these, in turn, affect transpiration and energy conversion of nearby plants (Rosenberg et al. 1983; Atangana et al. 2014). Biologically complex agroforestry systems often reveal greater ecosystem functioning and a reduced reliance on chemical inputs (Drinkwater and Snapp 2007; Malézieux et al. 2009; Martin and Isaac 2015). Such benefits have been observed from farm to landscape levels of integration, and across temperate and tropical agroecosystems. While these benefits are a key target in future food production landscapes, such success requires well developed diagnostics of the plant-soil continuum (Isaac and Borden 2019).

Conclusions

Agroforestry systems are recognized as an alternative for land use planning on farms and interfluvial areas being considered as a sustainable example for the management of tree, shrub, soil, crops and animals' resources. The system must integrate the function and interaction between its components, otherwise it may be a good association, but hardly adequate to protect the soil-crop-tree and produce sustainably. Many of the alternatives improve soil conditions, others influence water production or relate to crop protection (World Vision 2005). The high diversity in terms of cultivated and spontaneous species characterizing the systems object of the present paper allows a strong resilience of the systems themselves, tested after the impact of devastating hurricanes, changes in rainfall patterns and droughts. In addition, at the genetic, species, and farming systems levels, biodiversity provides valuable ecosystems services and functions for agricultural production (Thrupp 2000).

"Agroforestry" is a relatively new term, the traditional knowledge and practices underpinning these land use systems is ancient, having originated in the ancestral "shifting cultivation" practices of African peoples and indigenous peoples of the Americas (and elsewhere). Landscape structure, field area and margins, and polycultures that are part of the indigenous agricultural strategy appear to increase the biodiversity of traditional agroecosystems (Altieri et al. 1987; Oldfield and Alcorn 1987; Parrotta et al. 2015). Thus, there is increasing evidence that the mosaic structure of landscapes under indigenous management maintains and even improves biodiversity (Gonzalez-Bernaldez 1991; Brown and Brown 1992; Reichhardt et al. 1994), as well as preserving the associated cultural values (Agnoletti 2014; Agnoletti et al. 2015).

Furthermore, the complex system created thanks to the introduction of shade trees and other cultivated species contribute to obtain multiple benefits from both an ecological and economic point of view. In fact, shade trees play an important role in erosion control and in maintaining soil productivity by stimulating the decomposition of residuals while generating additional products, such as wood, firewood and fruits, providing important contributions to farmers' livelihoods, especially in seasons where productivity it is low. It is increasingly clear that shade trees provide direct and indirect benefits, so it is difficult to fully quantify the total benefits. However, these benefits are expected to improve farmers' livelihoods by stabilizing their income and increasing their ability to recover in general. Considering this and the fact that being system with no chemical inputs and completely

sustainable they can mitigate the effects of climate change by propitiating a favorable microclimate and increasing carbon storage it is clear that results important their preservation and protection in order to provide multiple benefits to the environment sustaining local communities. The present study, in this sense, has contributed to give a framework of the traditional structure of agroforestry systems for coffee production in Cuba providing at the same time the list of all the flora and fauna species involved in the systems themselves. This turns to be fundamental to understand the importance of maintaining and promoting traditional knowledge which, in this particular case, is the key to preserve the agrobiodiversity, sustain local communities and implement sustainable economic strategies. These systems are also an important alternative to intensive plantations of coffee, especially when we relate this production to the worldwide market of coffee consumed in many countries, for their sustainability and as an expression of a wider concept of food quality.

Appendix 1: Complete list of the useful species at Sierra Del Rosario, with the botanical family of each species

List of species used for animal feeding.

	Scientific name	Family
1	*Commelina diffusa* Burm. f	Commelinaceae
2	*Cynodon dactylon* (L.) Pers	Poaceae
3	*Dendropanax arboreus* (L.) Decne. & Planch	Araliaceae
4	*Echinochloa colona* (L.) Link	Poaceae
5	*Gerascanthus coloccocus* (L.) Borhidi	Boraginaceae
6	*Guazuma ulmifolia* Lam	Malvaceae
7	*Helianthus annuus* L.	Asteraceae
8	*Hypharrenia rufa* Nees	Poaceae
9	*Pennisetum purpureum* Schumacher	Poaceae
10	*Roystonea regia* (Kunth) O.F. Cook	Arecace
11	*Saccharum officinarum* L.	Poaceae
12	*Samanea saman* (Jacq.) Merr	Leguminosae
13	*Sorghum bicolor* (L.) Moench	Poaceae
14	*Sporobolus indicus* (L.) R.Br	Poaceae
15	*Trophis racemosa* (L.) Urb	Moraceae

List of species used for beverage elaboration.

	Scientific name	Family
1	*Canavalia ensiformis* L.	Leguminosae
2	*Cassia grandis* L. f	Leguminosae
3	*Citrus x aurantifolia* (Christm.) Swingle	Rutaceae
4	*Coffea arabica* L.	Rubiaceae
5	*Coffea canephora* L.	Rubiaceae
6	*Passiflora edulis* Sims	Passifloraceae
7	*Smilax dominguensis* Willd	Smilacaceae

	Scientific name	Family
8	*Smilax havanensis* Jacq	Smilacaceae
9	*Smilax lanceolata* L.	Smilacaceae
10	*Smilax mollis* Willd	Smilacaceae
11	*Vitis tiliifolia* Humb. & Bonpl. Ex Schult	Vitaceae
12	*Vitis vinifera* L.	Vitaceae

List of the species used as condiments.

	Scientific name	Family
1	*Allium cepa* L.	Amaryllidaceae
2	*Allium cepa* var. *aggregatum* G. Don	Amaryllidaceae
3	*Allium chinense* G. Don	Amaryllidaceae
4	*Allium fistulosum* L.	Amaryllidaceae
5	*Allium sativum* L.	Amaryllidaceae
6	*Allium tuberosum* Rottler ex Spreng	Amaryllidaceae
7	*Averrhoa bilimbi* L.	Oxalidaceae
8	*Bixa orellana* L.	Bixaceae
9	*Brassica juncea* (L.) Coss	Brassicaceae
10	*Capsicum annuum* L.	Solanaceae
11	*Capsicum chinense* Jacq	Solanaceae
12	*Capsicum frutescens* L.	Solanaceae
13	*Cinnamomum cassia* (Nees & T. Nees) J. Presl	Lauraceae
14	*Citrus* x *aurantium* L.	Rutaceae
15	*Citrus limon* (L.) Burm	Rutaceae
16	*Eryngium foetidum* L.	Apiaceae
17	*Foeniculum vulgare* Mill	Apiaceae
18	*Lippia micromera* Schauer	Verbenaceae
19	*Ocimum gratissimum* L.	Lamiaceae
20	*Plectranthus amboinicus* (Lour.) Spreng	Lamiaceae
21	*Sinapis alba* L.	Brassicaceae

List of the species used as fruits.

	Scientific name	Family
1	*Anacardium occidentale* L.	Anacardiaceae
2	*Ananas comosus* (L.) Merr	Bromeliaceae
3	*Annona muricata* L.	Annonaceae
4	*Annona squamosa* L.	Annonaceae
5	*Carica papaya* L.	Caricaceae
6	*Chrysophyllum cainito* L.	Sapotaceae
7	*Chrysophyllum oliviforme* L.	Sapotaceae
8	*Citrullus lunatus* (Thunb.) Matsum. Y Nakai	Cucurbitaceae
9	*Citrofortunella microcarpa* (Bunge) Wijnands	Rutaceae
10	*Citrus reticulata* Blanco	Rutaceae
11	*Citrus* x *sinensis* Osbeck	Rutaceae

	Scientific name	Family
12	*Citrus x paradisi* Macfad	Rutaceae
13	*Cocos nucifera* L.	Arecaceae
14	*Cucumis melo* L.	Cucurbitaceae
15	*Dovyalis hebecarpa* (Gardner) Warb	Salicaceae
16	*Flacourtia indica* (Burm. F.) Merr	Salicaceae
17	*Malpighia emarginata* DC	Malpighiaceae
18	*Malus domestica* L.	Rosaceae
19	*Mammea americana* L.	Callophyllaceae
20	*Mangifera indica* L.	Anacardiaceae
21	*Manilkara zapota* (L.) P. Royen	Sapotaceae
22	*Melicoccus bijugatus* Jacq	Sapindaceae
23	*Muntingia calabura* L.	Muntingiaceae
24	*Musa x paradisiaca* L.	Musaceae
25	*Persea americana* Mill	Lauraceae
26	*Pouteria campechiana* Baehni	Sapotacae
27	*Pouteria sapota* (Jacq.) H.E. Moore & Stearn	Sapotaceae
28	*Prunus persica* (L.) Stokes	Rosaceae
29	*Psidium guajava* L.	Myrtaceae
30	*Punica granatum* L.	Lythraceae
31	*Spondias purpurea* L.	Anacardiaceae
32	*Syzygium malaccense* (L.) Merr. & L.M. Perry	Myrtaceae

List of the species used as grains.

	Scientific name	Family
1	*Arachys hypogaea* L.	Leguminosae
2	*Oryza sativa* L.	Poaceae
3	*Phaseolus lunatus* L.	Leguminosae
4	*Phaseolus vulgaris* L.	Leguminosae
5	*Sesamum indicum* L.	Pedaliaceae
6	*Vigna umbellata* (Thunb.) Ohwi & H. Ohashi	Leguminosae
7	*Vigna unguiculata* L. Walp	Leguminosae
8	*Zea mays* L.	Poaceae

List of wood and timber species.

1	Scientific name	Family
2	*Abarema obovalis* (A. Rich.) *Barneby & J.W. Grimes*	Leguminosae
3	*Acrocomia aculeata* (Jacq.) Lodd. ex Mart	Arecaceae
4	*Alchornea latifolia* Sw	Euphorbiaceae
5	*Amphitecna latifolia* (Mill.) A. H. Gentry	Bignoniaceae
6	*Amyris balsamifera* L.	Rutaceae
7	*Andira inermis* (W. Wright) DC	Leguminosae
8	*Boconia frutescens* L.	Papaveraceae
9	*Ehretia cassinifolia* A. Rich	Boraginaceae

1	Scientific name	Family
10	*Buchenavia capitata* (Aubl.) Howard	Combrataceae
11	*Calophyllum antillanum* Britton	Calophyllaceae
12	*Calyptrantes capitulata* C. Wright	Myrtaceae
13	*Casearia hirsuta* Sw	Salicaceae
14	*Cedrela odorata* L.	Meliaceae
15	*Celtis trinervia* Lam	Ulmaceae
16	*Citharexylum caudatum* L.	Verbanaceae
17	*Coccoloba retusa* Griseb	Polygonaceae
18	*Cojoba arborea* (L.) Britton & Rose	Leguminosae
19	*Colubrina arborescens* (Mill.) Sarg	Rhamnaceae
20	*Comocladia dentata* Jacq	Anacardiaceae
21	*Cordia nitida* Vahl	Boraginaceae
22	*Cupania americana* L.	Sapindaceae
23	*Cupania glabra* Sw	Sapindaceae
24	*Cupania macrophylla* C. Mart	Sapindaceae
25	*Deherainia cubensis* (Radlk.) Mez	Primulaceae
26	*Dendropanax arboreus* (L) Decne. & Planch	Araliaceae
27	*Dichrostachys cinerea* (L.) Wight & Arn	Leguminosae
28	*Diospyros caribaea* (A. DC.) Standl	Ebenaceae
29	*Diospyros crassinervis* (Krug &Urb.) Standl	Ebenaceae
30	*Drypetes alba* Poit	Euphorbiaceae
31	*Drypetes serrata* (Maycock) Krug & Urb	Euphorbiaceae
31	*Ehretia cassinifolia* A. Rich	Boraginaceae
33	*Ehretia tinifolia* L.	Boraginaceae
34	*Erythroxylon alternifolium* M. Gomez	Erythroxylaceae
35	*Erythroxylon areolatum* L.	Erythroxylaceae
36	*Eucaliptus resinifera* Sm	Myrtaceae
37	*Eugenia glabra* Alston	Myrtaceae
38	*Eugenia maleolens* Pers	Myrtaceae
39	*Eugenia rigidifolia* A. Rich	Myrtaceae
40	*Eugenia rimosa* C. Wright	Myrtaceae
41	*Ficus aurea* Nutt	Moraceae
42	*Ficus cassinervia* Desf. ex Willd	Moraceae
43	*Ficus citrifolia* Mill	Moraceae
44	*Ficus combissi* Warb	Moraceae
45	*Ficus maxima* Mill	Moraceae
46	*Ficus membranacea* C. Wright	Moraceae
47	*Garcinia aristata* (Griseb.) Borhidi	Clusiaceae
48	*Garcinia serpentini* Borhidi	Clusiaceae
49	*Garcinia ruscifolia* (Griseb.) Borhidi	Clusiaceae
50	*Genipa americana* L.	Rubiaceae
51	*Gerascanthus gerascanthioides*	Boraginaceae
52	*Guarea guidonia* (L.) Sleumer	Meliaceae
53	*Guettarda combsii* Urb	Rubiaceae
54	*Guettarda lindeniana* A. Rich	Rubiaceae
55	*Guettarda valenzuelana* Rich	Rubiaceae

1	Scientific name	Family
56	*Gymnanthes lucida* Sw	Euphorbiaceae
57	*Hibiscus cordifolius* Mill	Malvaceae
58	*Hibiscus elatus* Sw	Malvaceae
59	*Hibiscus tiliaceus* L. var. pernambucensis (Arruda) I.M. Johnst	Malvaceae
60	*Hura crepitans* L.	Euphorbiaceae
61	*Ilex cassine* L.	Aquifoliaceae
62	*Ilex repanda* Griseb	Aquifoliaceae
63	*Juglans jamaicensis* D. DC	Fagaceae
64	*Khaya senegalensis* (Desr.) A. Juss	Meliaceae
65	*Krugiodendron ferreum* (Vahl) Urb	Rhamnaceae
66	*Laplacea curtyana* A. Rich	Theaceae
67	*Licaria triandra* (Sw.) Kosterm	Lauraceae
68	*Lonchocarpus pentaphyllus* (Poir.) D.C	Leguminosae
69	*Lonchocarpus sericeus* (Poir.) Kunth ex DC	Leguminosae
70	*Lysiloma sabicu* Benth	Leguminosae
71	*Malpighia urens* L.	Malpighiaceae
72	*Manilkara albescens* (Griseb.) Cronquist	Sapotaceae
73	*Manilkara jaimiqui* (C. Wright ex Griseb.) Dubard	Sapotaceae
74	*Mappia racemosa* Jacq	Icacinaceae
75	*Margaritaria nobilis* L.f	Phyllantaceae
76	*Matayba oppositifolia* (A.Rich.) Britton	Sapindaceae
77	*Melia azedarach* L	Meliaceae
78	*Micropholis guyanensis* (A. DC.) Pierre	Sapotaceae
79	*Myrcia valenzuelana* (A. Rich.) Griseb	Rubiaceae
80	*Myrica cerifera* L.	Myricaceae
81	*Nectandra coriacea* (Sw.) Griseb	Lauraceae
82	*Nectandra hihua* (Ruiz & Pav.) Rohwe	Lauraceae
83	*Nectandra minima* Rohwer	Lauraceae
84	*Neobracea valenzuelana* (A. Rich.) Urb	Apocynaceae
85	*Ocotea cuneata* (Griseb.) Urb	Lauraceae
86	*Ocotea floribunda* (Sw.) Mez	Lauraceae
87	*Ocotea leucoxylon* (Sw.) Laness	Lauraceae
88	*Peltophorum adnatum* Griseb	Leguminosae
89	*Phoebe elongata* (Vahl) Nees	Lauraceae
90	*Picramnia pentandra* Sw	Leguminosae
91	*Picramnia reticulata* Griseb	Leguminosae
92	*Piscidia piscipula* (L.) Sarg	Leguminosae
93	*Samanea saman* (Jacq.) Merr	Leguminosae
94	*Pouteria dictyoneura* (Griseb.) Radlk	Sapotaceae
95	*Pouteria dominigensis* (C.F. Gaertn.) Baehni	Sapotaceae
96	*Protium cubense* (Rose) Urb	Burseraceae
97	*Prunus myrtifolia* (L.) Urb	Rosaceae
98	*Prunus occidentalis* Sw	Rosaceae
99	*Pseudolmedia spuria* (Sw.) Griseb	Moraceae
100	*Psychotria horizontalis* Sw	Rubiaceae
101	*Psychotria undata* Jacq	Rubiaceae

1	Scientific name	Family
102	*Rauvolfia cubana* A. DC	Apocynaceae
103	*Rauvolfia nitida* Jacq	Apocynaceae
104	*Reynosia wrightii* Urb	Rhamnaceae
105	*Richardia brasiliensis* Gomes	Rubiaceae
106	*Sabal parviflora* Becc	Arecaceae
107	*Sapindus saponaria* L.	Sapindaceae
108	*Savia bahamensis* Britt	Euphorbaceae
109	*Savia clusiifolia* Griseb	Euphorbaceae
110	*Schefflera morototoni* (Aubl.) Maguire, Steyerm. & Frodin	Araliaceae
111	*Sideroxylon foetidissimum* Jacq	Sapotaceae
112	*Simarouba glauca* DC	Simaroubaceae
113	*Suberanthus neriifolius* (A. Rich.) Borhidi & M. Fernández	Rhamnaceae
114	*Swietenia macrophylla* King	Meliaceae
115	*Swietenia mahagoni* (L.) Jacq	Meliaceae
116	*Symplocos martinicensis* (Krug & Urb.) Mai	Symplocaceae
117	*Tabebuia shaferi* Britton	Bignoniaceae
118	*Tabernaemontana citrifolia* L.	Apocynaceae
119	*Tapura obovata* Britton & Wilson	Dichapetalaceae
120	*Tectona grandis* L.	Verbenaceae
121	*Terminalia catappa* L.	Combretaceae
122	*Ternstroemia peduncularis* DC	Penthapylaceae
123	*Trema micrantha* (Roem. & Scult.) Blume	Ulmaceae
124	*Trichilia havanensis* Jacq	Meliaceae
125	*Trichilia hirta* L.	Meliaceae
126	*Trichospermum grewiifolius* (A.Rich.) Kosterm	Malvaceae
127	*Zanthoxylon cubense* P. Wilson	Rutaceae
128	*Zanthoxylon elephantiasis* Macfad	Rutaceae
129	*Zanthoxylon fagara* (L.) Sarg	Rutaceae
130	*Zanthoxylon martinicense* (Lam.) DC	Rutaceae
131	*Zuelania guidonia* (Sw.) Britton & Millsp.	Salicaceae

List of medicinal species.

	Scientific Name	Family
1	*Abrus precatorius* L.	Leguminosae
2	*Adenoropium multifidum* (L.) Poh	Euphorbiaceae
3	*Adianthus capillus veneris* L.	Adianthaceae
4	*Agalinis albida* Britton & Pennell	Orobanchaceae
5	*Ageratum conyzoides* L.	Asteraceae
6	*Allophyllus cominia* (L.) Sw	Sapindaceae
7	*Aloe vera* (L.) Burm.f	Xanthorrhoeaceae
8	*Alternanthera caracasana* Kunth	Amaranthaceae
9	*Ambrosia artemisiifolia* L.	Asteraceae
10	*Andropogon glomeratus* (Walter) Britton	Poaceae
11	*Argemone mexicana* L.	Papaveraceae

	Scientific Name	Family
12	*Artemisa absinthium* L.	Asteraceae
13	*Arthrostylidium capillifolium* Griseb	Poaceae
14	*Asclepias curassavica* L.	Asclepiadaceae
15	*Asclepias nívea* L.	Asclepiadaceae
16	*Bahuinia cumanensis* Kunth	Caesalpinaceae
17	*Bahuinia divaricata* L.	Caesalpinaceae
18	*Banksea speciosa* J. König	Proteaceae
19	*Bidens pilosa* L.	Asteraceae
20	*Blechum pyramidatum* (Lam.) Urb	Acanthaceae
21	*Byrsonima spicata* (Cav.) DC	Malpighiaceae
22	*Caesalpinia vesicaria* L.	Leguminosae
23	*Caesalpinia pulcherrima* (L.) Sw	Leguminosae
24	*Cassia diphylla* (L.) Greene	Leguminosae
25	*Catharanthus roseus* (L.) G. Don	Apocynaceae
26	*Cayaponia racemosa* (Mill.) Cogn	Cucurbitaceae
27	*Cecropia schreberiana* Miq	Urticaceae
28	*Celtis iguanea* (Jacq.) Sarg	Ulmaceae
29	*Chromolaena odorata* (L.) R.M. King & H. Rob	Asteraceae
30	*Cissus verticillata* (L.) Nicolson & C.E.Jarvis	Vitaceae
31	*Citrus x bergamia* Risso & Poit	Rutaceae
32	*Cladium jamaicensis* Crantz	Cyperaceae
33	*Clematis dioica* L.	Ranunculaceae
34	*Clidemia hirta* (L.) D.Don	Melastomataceae
35	*Clusia minor* L	Clusiaceae
36	*Coix lacryma-jobi* L.	Poaceae
37	*Costus sp.*	Costaceae
38	*Costus scaber Ruiz & Pav*	Costaceae
39	*Crescencia cujete* L.	Bignoniaceae
40	*Cymbopogon citratus* (DC) Stapf	Poaceae
41	*Dalbergia ecastaphyllum* (L.) Taubert	Leguminosae
42	*Davilla rugosa* Poir	Dilleniaceae
43	*Echites umbellatus* Jacq	Apocynaceae
44	*Elephantopus scaber* L.	Asteraceae
45	*Erigeron quercifolius* Lam	Asteraceae
46	*Faramea occidentalis* (L.) A.Rich	Rubiaceae
47	*Gaya occidentalis* (L.) Sweet	Malvaceae
48	*Gossypium sp*	Malvaceae
49	*Guzmania monostachya* Rusby ex Mez	Bromeliaceae
50	*Hamelia patens* Jacq	Rubiaceae
51	*Hedychium coronarium* J. Koening	Zyngiberceae
52	*Heliotropium indicum* L.	Asteraceae
53	*Hibiscus sabdariffa* L.	Malvaceae
54	*Hippobroma longiflora* (L.) Don	Campanulaceae
55	*Hohenbergia penduliflora* (A. Rich.) Mez	Bromeliaceae
56	*Imperata brasiliensis* Trin	Poaceae
57	*Ixora floribunda* (A. Rich.) Griseb	Rubiaceae

	Scientific Name	Family
58	*Jacquinia brunnescens* Urb	Primulaceae
59	*Justicia pectoralis* Jacq	Acanthaceae
60	*Koanophyllon dolicholepis* (Urb.) R.M. King & H. Rob	Asteraceae
61	*Lantana camara* L.	Verbenaceae
62	*Lantana involucrata* L.	Verbenaceae
63	*Lepidium virginicum* L.	Brassicaceae
64	*Lippia alba* (Mill.) N.E. Br. Ex Britton & Wilson	Verbenaceae
65	*Matricaria recutita* L.	Asteraceae
66	*Mentha sp.*	Lamiaceae
67	*Mentha spicata* L.	Lamiaceae
68	*Mentha x piperita* L.	Lamiaceae
69	*Miconia laeviagata* (L.) D.Don	Melastomataceae
70	*Mikania cordifolia* (L. f.) Willd	Asteraceae
71	*Mikania hastata* (L.)Willd	Asteraceae
72	*Mikania ranunculifolia* A. Rich	Asteraceae
73	*Mimosa pudica* L.	Leguminosae
74	*Momordica charantia* L.	Cucurbitaceae
75	*Morinda royoc* L.	Rubiaceae
76	*Mucuna pruriens* (L.) DC	Leguminoseae
77	*Neurolaena lobata* (L.) R.Br. ex Cass	Asteraceae
78	*Ocimum basilicum* L.	Lamiaceae
79	*Ocimum sanctum* L.	Lamiaceae
80	*Olyra latifolia* L.	Poaceae
81	*Origanum majorana* L.	Lamiaceae
82	*Oxandra lanceolata* (Sw.) Baill	Lauraceae
83	*Parthenium hysterophorus* L.	Asteraceae
84	*Paspalum conjugatum*	Poaceae
85	*Paspalum notatum* Fluggé	Poaceae
86	*Passiflora sexflora* Juss	Passifloraceae
87	*Passiflora suberosa* L.	Passifloraceae
88	*Pavonia fruticosa* (Mill.) Fawc. & Rendle	Malvaceae
89	*Petiveria alliacea* L.	Phytolacaceae
90	*Phylla scaberrima* (Trevir.) Moldenke	Verbenaceae
91	*Piper aduncum* L.	Piperaceae
92	*Piper auritum* Kunth	Piperaceae
93	*Piper peltatum* L.	Piperaceae
94	*Piper umbellatum* L.	Piperaceae
95	*Pisonia aculeata* L.	Nyctaginaceae
96	*Plantago major* L.	Plantaginaceae
97	*Platygine hexandra* (Jacq)	Euphorbiaceae
98	*Plectranthus sp*	Lamiaceae
99	*Pluchea carolinensis* (Jacq.) G. Don	Asteraceae
100	*Pleopeltis polypodioides* (L.) E. G. Andrews & Windham	Polypodiaceae
101	*Psychotria grandis* Sw	Rubiaceae
102	*Psychotria revoluta* DC	Rubiaceae
103	*Renealmia aromatica* L.f	Zingiberaceae

	Scientific Name	Family
104	*Rondeletia odorata* Jacq	Rubiaceae
105	*Rosmarinus officinalis* L.	Lamiaceae
106	*Ruta graveolens* L.	Rutaceae
107	*Securidaca virgata* Sw	Polygalaceae
108	*Senna alata* (L.) Roxb	Leguminosae
109	*Senna occidentalis* (L.) Link	Leguminosae
110	*Setaria geniculata* (Lam.) Beauv	Poaceae
111	*Sida aculeata* Burm	Malvaceae
112	*Sida rhombifolia* L.	Malvaceae
113	*Sloanea curatelifolia* Griseb	Elaeocarpaceae
114	*Solanum torvum* Sw	Solanaceae
115	*Stachytarpheta jamaicensis* (L.) Vahl	Verbenaceae
116	*Stevia rebaudiana* (Bert.) Bertoni	Asteraceae
117	*Stygmaphyllum sagreanum* A. Juss	Malpighiaceae
118	*Satureja brownei* (Sw.) Briq	Lamiaceae
119	*Tabernaemontana citrifola* L.	Apocynaceae
120	*Tagetes erecta* L.	Asteraceae
121	*Tagetes lucida* Cav	Asteraceae
122	*Dysphania ambrosioides* (L.) Mosyakin et Clemonts	Amaranthaceae
123	*Tillandsia usneoides* (L.) L.	Bromeliaceae
124	*Tillandsia valenzuelana* A. Rich	Bromeliaceae
125	*Tournefortia hirsutissima* L.	Boraginaceae
126	*Tradescantia spathacea* Sw	Commelinaceae
126	*Turnera ulmifolia* L.	Passifloraceae

List of species used as roots and tubers.

	Scientific Name	Family
1	*Colocasia esculenta* (L.) Schott	Araceae
2	*Dioscorea alata* L.	Dioscoraceae
3	*Ipomoea batatas* (L) Lam	Convolvulaceae
4	*Manhiot esculenta* Crantz	Euphorbiaceae
5	*Xanthososma sagittifolium* (L.) Schott	Araceae

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1007/s10531-021-02348-8.

Author contributions MA: conceptualization; YMP, AGA: methodology; YMP, AGA: investigation; MA: writing; MA: supervision.

Funding This research is part of the "GIAHS Building Capacity" project, funded by the Italian Agency for Development Cooperation (AICS) and by the Department of Agriculture, Food, Environment and Forestry (DAGRI) of the University of Florence.

Data availability Not applicable.

Code availability Not applicable.

Declarations

Conflict of interest The authors declare that they have no conflict of interest.

Ethical approval Not applicable.

Consent to participate Not applicable.

Consent for publication Not applicable.

References

Agnoletti M (2014) Rural landscape, nature conservation and culture: Some notes on research trends and management approaches from a (southern) European perspective. Landsc Urban Plan 126:66–73

Agnoletti M, Rotherham ID (2015) Landscape and biocultural diversity. Biodivers Conserv 24:3155–3165. https://doi.org/10.1007/s10531-015-1003-8

Agnoletti M, Tredici M, Santoro A (2015) Biocultural diversity and landscape patterns in three historical rural areas of Morocco, Cuba and Italy. Biodivers Conserv 24:3387–3404. https://doi.org/10.1007/s10531-015-1013-6

Altieri M, Merrick L, Anderson MK (1987) Peasant agriculture and the conservation of crop and wild plant resources. Conserv Biol 1(1):49–58

Atangana A, Khasa D, Chang S, Degrande A (2014) Ecological interactions and productivity in agroforestry systems. In: Atangana A (ed) Tropical agroforestry. Springer, Dordrecht

Beer J, Muschler R, Kass D, Somarriba E (1997) Shade management in coffee and cacao plantations. Agrofor Syst 38(1):139–164

Brown KS, Brown GG (1992) Habitat alteration and species loss in Brazilian forests. In: Whitmore TC, Sayer JA (eds) Tropical deforestation and species extinction. Chapman & Hall, New York

Brown AH, Hodgkin T (2007) Measuring, Managing and Maintaining crop genetic diversity on farm. In: Jarvis DI, Padoch C, Cooper HD (eds) Managing biodiversity in agricultural ecosystems. Columbia University Press, New Yok, pp 13–33

Castiñeiras L, Barrios O, Fernández L, León N, Cristóbal R, Shagarodsky T, Fuentes V, Fundora Z, Moreno V (2006) Catálogo de cultivares tradicionales y nombres locales en fincas de las regiones occidental y oriental de Cuba. Agrinfor. La Habana, Cuba, 64 pp.

Drinkwater LE, Snapp SS (2007) Nutrients in agroecosystems: rethinking the management paradigm. Adv Agron 92:163–186

Fernández AH (2012) Sistema de asentamiento de las haciendas cafetaleras en la Sierra dl Rosario (1790 1850), Artemisa. Cuba Cuba Arqueológica Año V 1:12–19

Food and Agriculture Organization (2015) FAO statistical pocketbook coffee 2015. Food and Agriculture Organization, Rome

García M, Castiñeiras L (2006) La diversidad agrícola en reservas de la biosfera de Cuba. Editorial Academia, La Habana, pp 10–20

Gonzalez-Bernaldez F (1991) Diversidad biológica, gestión de ecosistemas y nuevas políticas agrarias. In: Pineda FF, Casado MA, de Miguel JM, Montalvo J (eds) Diversidad biológica. Fundación R Areces, Madrid

Gonzalez Alvarez A, Rodríguez YS, Delgado DA, Zamora JL (2016) Agrobiodiversidad en La Sierra Del Rosario, Cuba: El Café (Coffea Arabica L.) y otras claves de su configuración, Agrotecnia de Cuba 40(2):3–8

Kellermann JL, Johnson MD, Stercho AM, Hackett SC (2008) Ecological and economic services provided by birds on Jamaican Blue Mountain coffee farms. Conserv Biol 22(5):1177–1185
Kottek M, Grieser J, Beck C, Rudolf B, Rubel F (2006) Rubel F (2006) World Map of the Köppen-Geiger climate classification updated. Meteorol Z 15(3):259–263
Krishnan S (2017) Sustainable coffee production. Oxford research encyclopedia of environmental science. Oxford University Press, Oxford. https://doi.org/10.1093/acrefore/9780199389414.013.224
Isaac ME, Borden KA (2019) Nutrient acquisition strategies in agroforestry systems. Plant Soil 444:1–19. https://doi.org/10.1007/s11104-019-04232-5
Lapique Z, García L (2014) La Periferia Habanera. Rev Bimestre Cubana 41(2):89–102
Long CL, Li H, Ouyang Z, Yang X, Li Q, Trangmar B (2003) Strategies for agrobiodiversity conservation and promotion: a case from Yunnan, China. Biodivers Conserv 12:1145–1156. https://doi.org/10.1023/A:1023085922265
Malézieux E, Crozat Y, Dupraz C, Laurans M, Makowski D, Ozier-Lafontaine H, Rapidel B, Tourdonnet S, Valantin-Morison M (2009) Mixing plant species in cropping systems: concepts, tools and models: a review. Agron Sustain Dev 29:43–62
Martin AR, Isaac ME (2015) Functional traits in agroecology: a blueprint for research. J Appl Ecol 52:1425–1435
Muschler RG (2001) Shade improves coffee quality in a sub-optimal coffee-zone of Costa Rica. Agrofor Syst 51:131–139. https://doi.org/10.1023/A:1010603320653
Moguel P, Toledo VM (1999) Biodiversity conservation in traditional coffee systems of Mexico. Conserv Biol 13(1):11–21
Oldfield M, Alcorn JB (1987) Conservation of traditional agroecosystems. Bioscience 37(3):199–208
Ospina A (2008) Aproximación a la conservación de especies vegetales nativas con bosque ecológico con sombrío. Cali, Colombia. Consulted at www. agroforesteriaecologica.com. Accessed 26 Aug, 2019
Parrotta JA, Dey de Pryck J, Darko Obiri B, Padoch C, Powell B, Sandbrook C (2015) The Historical, Environmental and Socio-Economic Context of Forests and Tree-Based Systems for Food Security and Nutrition. Chapter 3 (pp. 71–134) In: Vira B, Mansourian S, Wildburger C (eds) forests and food: addressing hunger and nutrition across sustainable landscapes. Open Book Publishers, Cambridge, UK. http://dx.doi.org/https://doi.org/10.11647/OBP.0085
Chirwa PW, Akinnifesi FK, Sileshi G, Syampungani S, Kalaba FK, Ajayi OC (2008) Opportunity for conserving and utilizing agrobiodiversity through agroforestry in Southern Africa. Biodiversity 9(1–2):45–48. https://doi.org/10.1080/14888386.2008.9712881
Petit-Aldana J, Rahman MM, Parraguirre-Lezama C, Infante-Cruz A, Romero-Arenas O (2019) Litter decomposition process in coffee agroforestry systems. J For Environ Sci 35(2):121–139. https://doi.org/10.7747/JFES.2019.35.2.121
Perfecto I, Vandermeer J, Bautista G, Nunez G, Greenberg R, Bichier P, Langridge S (2004) Greater predation in shaded coffee farms: The role of resident neotropical birds. Ecology 85:2677–2681
Thrupp LA (2000) Linking agricultural biodiversity and food security: the valuable role of agrobiodiversity for sustainable agriculture. Int Aff 6(2):265–281. https://doi.org/10.1111/1468-2346.00133
Trosper L, Parrotta AJ, Agnoletti M et al (2011) The unique charachter of traditional forest-related knowldege: threats and challanges ahead. In: Parrotta JA, Trosper RL (eds) Traditional forest-related knowledge. Springer, Dordrecht
Ramírez Pérez JF, Paredes Pupo FA (2005) Cuba, paisaje a la naturaleza. Las Terrazas. Pinar del Río, 29 pp.
Rao KPC, Verchot LV, Laarman J (2007) Adaptation to climate change through sustainable management and development of agroforestry systems. J SAT Agric Res 4(1):1–30
Reichhardt L, Mellink E, Nahan GP, Rea A (1994) Habitat heterogeneity and biodiversity associated with indigenous agriculture in the Sonoran desert. Etnoecológica 3:21–36
Rosenberg NJ, Blad BL, Verma DB (1983) Microclimate: the biological environment. Wiley and Sons, New York
Sánchez Y, González A, Kauffman M, Zamora JL, Pérez HM (2015) Family farming and its landscape imbrication. An assessment in Sierra del Rosario and Cuchillas del Toa biosphere reserve. Agrotec De Cuba 5:73–85
Santoro A, Venturi M, Bertani R, Agnoletti M (2020) A review of the role of forests and agroforestry systems in the FAO Globally Important Agricultural Heritage Systems (GIAHS) programme. Forests 11:860. https://doi.org/10.3390/f11080860
Siebert SF (2002) From shade to sun-grown perennial crops in Sulawesi, Indonesia: implications for biodiversity conservation and soil fertility. Biodivers Conserv 11:1889–1902
Tscharntke T, Clough Y, Bhagwat SA, Buchori D, Faust H, Hertel D, Wanger TC (2011) Multifunctional ****shade-tree management in tropical agroforestry landscapes—a review. J Appl Ecol 48(3):619–629

Vales MA, Vilamajo D (2001) Biodiversidad biológica cubana, conservación y uso sostenile. Ciencia Innov y Desarro 6(1):39–44
World Vision International (2005). Annual report.
World Bank (2008) The World Bank annual report 2008: year in review. World Bank, Washington DC, USA. https://openknowledge.worldbank.org/handle/10986/7524.

Authors and Affiliations

Mauro Agnoletti[1] · Yenia Molina Pelegrín[2] · Alejandro González Alvarez[3]

Yenia Molina Pelegrín
yenia.molina@nauta.cu

Alejandro González Alvarez
alejandrotransito84@gmail.com

[1] Department of Agriculture, Food, Environment and Forestry (DAGRI), University of Florence, via San Bonaventura 13, 50145 Florence, Italy

[2] Agroforestry Research Institute, Victorino Road, La Soledad Locality, Guisa, Granma, Cuba

[3] Instituto de Investigaciones Fundamentales en Agricultura Tropical "Alejandro de Humboldt" (INIFAT), calle 188, Santiago de las Vegas, Boyeros, La Habana, Cuba