Forest Genetic Resources Training Guide

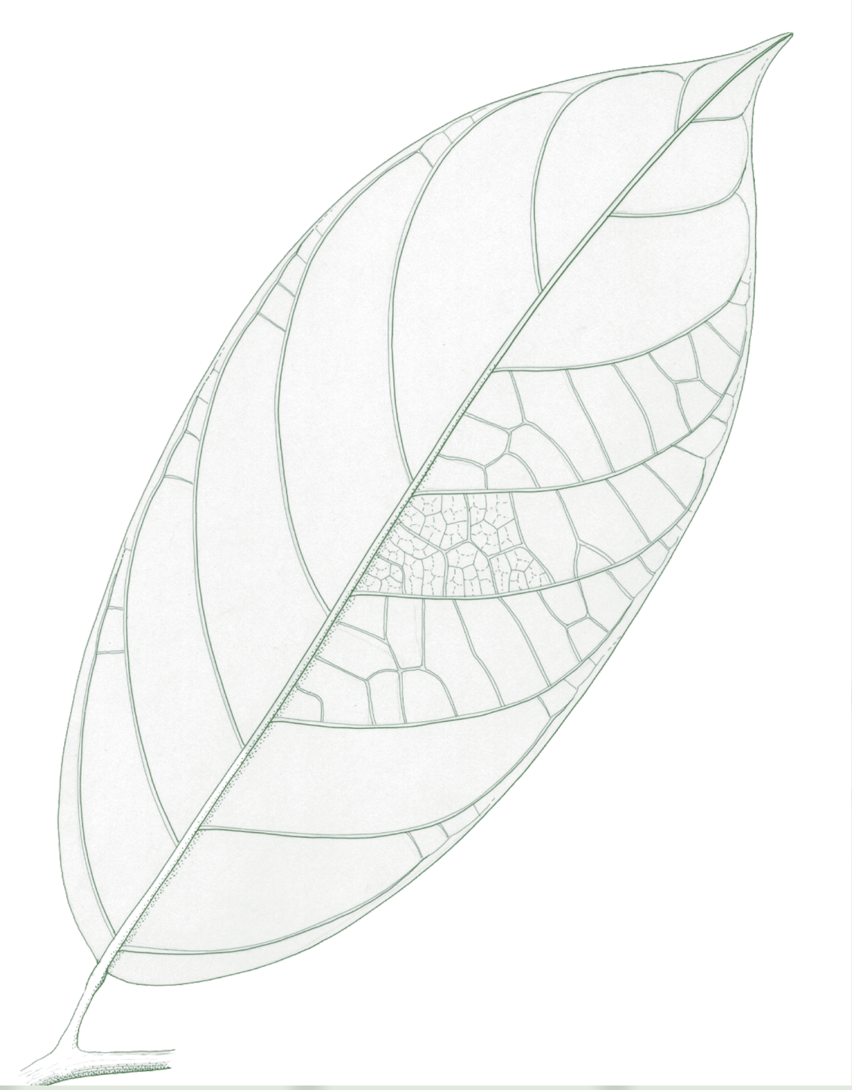
Bioversity International

MODULE 2
Trees outside of forests

Case study 2.1

Conservation of tree species diversity in cocoa agroforests in Nigeria

David Boshier



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Conservation of tree species diversity in cocoa agroforests in Nigeria

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Agroforestry is often viewed as a land-use system that offers solutions to land and forest degradation and to the loss of biodiversity in the tropics. However, systems vary from the simple (e.g. alley cropping, intercropping) to the highly complex and so vary in their capacity to conserve biodiversity. In West Africa (e.g. Côte d'Ivoire (Ivory Coast), Nigeria, Ghana, Cameroon), many smallholder cocoa farms are what have been termed "cocoa agroforests" due to their high levels of plant diversity, including high value timber trees, fruit trees, and food crops.

This case study allows you to explore the role that trees outside of forests may play in conserving tree species diversity. The exercise considers the overall question of '*Can important tree species persist outside of forests and if so, what measures need to be taken to ensure they persist?*' This case study presents information on tree species diversity in cocoa agroforests in the south-west of Nigeria, as well as the background information for the country and cultivation of the crop.

Use the information given here to either: a) present a case for the conservation benefits in terms of tree species diversity in the cocoa agroforests of Nigeria, or b) derive an action plan to ensure optimal conservation benefits in terms of tree species diversity in the cocoa agroforests of Nigeria. In your group discussions you need to think about the following:

- The factors that influence what tree species are maintained in the cocoa farms.
- The scale over which cocoa agroforests occur, densities of individual species and what this means for the viability of individual species.

In your plan/presentation you should cover the following:

- Use the data to summarize the differences between the species found in the cocoa agroforests and the natural forest. Differences may be in the numbers and types of species, e.g. by ecological guild (pioneer, shade bearer), use, level of threat (see IUCN status), native or exotic.
- What information is missing that would help to make more definitive statements or recommendations?
- The extent to which cocoa grown in traditional agroforests affects the diversity of forest tree species.
- How to conserve both the diversity of native tree species and meet the expectations and demands of cocoa farmers.

Introduction

Cocoa (*Theobroma cacao* L. Sterculiaceae) trees evolved in South America, growing in the shade and humidity of the rainforest. However, West Africa now accounts for 70% of the global cocoa supply, with more than two million farmers growing cocoa in Cameroon, Ghana, Côte d'Ivoire, Liberia, and Nigeria. Since its introduction to West Africa, cocoa seedlings have traditionally been planted either under the protective shade of fruit/timber trees, or by removing the forest understorey and thinning the forest canopy. These cocoa agroforests are a good example of multistrata agroforestry, where a range of products, including high quality timber, is available from trees. In areas where forest has been lost, indigenous fruit and timber trees are grown as companion species to provide environmental services (e.g. shade, soil protection) and indigenous fruits.

Biodiversity 'pros' and 'cons' of cocoa agroforests

Today, the majority of cocoa production is concentrated in recognized biodiversity hotspots. Cocoa agroforests are suggested as having great potential for conservation of biodiversity, as they can create a forest-like habitat that harbours biodiversity, even in rapidly degrading landscapes, while providing economic and social benefits to small-holder farmers. In fragmented landscapes, they may also provide habitat and resources for animals and plants, while helping to maintain connectivity between forest patches. Benefits also accrue through habitat provision for many migratory bird species that overwinter in the tropics, as well as other rainforest birds, mammals, insects and reptiles, many of which are in decline due to habitat loss. This combination of environmental, social and economic benefits from agroforests has led to their promotion as a 'win-win' land use system for Africa. Marketing of cocoa produced from such agroforests is often based on Fairtrade or organic labels that can give premiums above normal prices for resource-poor farmers (e.g. the Fairtrade premium is an additional $150 per ton of processed beans).

It has been argued that cocoa growing under traditional agroforestry systems has minimal effect on the diversity of forest tree species. However, a review of biodiversity in cocoa agroforests noted a gradual shift in cocoa production towards a management system of lower conservation value than the traditional multistrata cocoa agroforests that harbour diverse forest species. In fact, cocoa agroforests represent a spectrum of management intensity which influences their social, economic and conservation benefits. Shade cocoa habitats are threatened by demand for higher cocoa yields and associated trends to grow cocoa in full sun. Sun-grown cocoa tree varieties are more susceptible to disease, insects, and heat stress, and require extensive use of fertilizers and pesticides to produce viable yields. In Ghana and Côte d'Ivoire, 50% of the total cocoa farm area is under mild shade while 10% and 35% respectively in these countries is managed under no shade.

Thus, although cocoa agroforests are environmentally preferable to many forms of agriculture, they do not equate with primary forests. Detractors claim that planting of cocoa has led to extensive loss of primary rain forest in West Africa. Furthermore, they claim that cocoa agroforests support relatively lower species richness and impair natural species succession and gap dynamics, when compared to floristically and climatically similar secondary or primary forest. As a result, late-succession tree species become rare while pioneer and early secondary species dominate because most regeneration is eliminated by regular cleaning of undergrowth. The extent of benefits will vary depending on the level of shade, intensity of management and hence the stage of agro-ecological succession attained. Given the small size of most cocoa farms, the scale of implementation is also important, and so to benefit biodiversity, appropriate management is required over a large area and hence by a large number of farmers.

Farmer decisions

Of vital importance is the farmers' role in influencing biodiversity in cocoa agroforests. Farmers increase on-farm species diversity to improve agronomic productivity and economic gains, and to spread (minimize) risk. Protecting the tree "shade canopy" is critical to preserving the environment, while timber trees that grow on their farms can serve as timber sources, reducing the pressure on similar resources in other areas. Farmers may retain a particular tree species for their own use (e.g. roofing, doors, furniture) and remove those they do not like or need. Many of the trees retained are highly valued locally, as well as in national and international markets.

Unfortunately, many policies governing naturally occurring high value timber species on cocoa farms discourage farmers from keeping the trees on their farms, or stop them deriving adequate benefits. Across much of West Africa, timber trees are technically owned by governments. Timber companies log trees from cocoa farms, with or without the farmer's permission. In both cases, tree felling causes extensive damage to the cocoa and farmers often feel powerless to prevent this and in addition may suffer a lack of compensation; in many countries they do not legally own, nor can they cut or use the trees that regenerate naturally on their farms. However, despite this, many farmers do maintain timber trees and a diversified shade canopy as a future personal investment.

The Sustainable Tree Crops Program (STCP) is a regional innovation platform in West and Central Africa that aims to improve the economic and social well-being of tree crop farmers and the environmental sustainability of their systems. In Ondo State, Nigeria, participants in STCP's Farmer Field Schools (FFS) discussed their perspectives on preferred trees in cocoa systems. In one area, farmers indicated that their cocoa farms have always used a mixed cropping system, as different crops bring different types of income and there are also positive interactions between various crops. Trees preferred on cocoa farms include both fruit and timber trees (Table 1), but fruit trees are favoured because of the availability of markets. Differences in views were evident depending on land title. One sharecropper preferred fruit trees to timber species as they have no rights to the timber trees (these belong to the landowner). Furthermore, when the landowner fells timber species, substantial damage can be caused to the farm. As a result, the farmer only keeps fruit trees and leaves very few timber species for shade.

A policy framework is needed for tree diversification which encourages, promotes and improves local knowledge specific to prevailing environmental conditions. It must also accommodate farmers tree species preferences and market demands, and ensure widespread availability of improved planting material. Improving cocoa agroforestry practices requires support to farmers in terms of relevant technical knowledge of the dynamics of a system and identifying forest tree species that are both beneficial to farmers and to the environment as neighbour trees (i.e. trees other than the cocoa tree itself). Also, it is necessary to develop a means to register planted and nurtured timber trees on farms so that tree ownership is redefined for the benefit of the farmers. Although farmers are concerned to exploit the full potential of their cocoa agroforests to maximize income and reduce risks, much research has focused only on improvement of the cocoa tree. The result has been research recommendations that act as a barrier to farmer innovation instead of building on local knowledge. For example, in Ghana and Côte d'Ivoire, research produced a long list of tree species claimed to be incompatible with cocoa and consequently to be eliminated from farms as they may act as alternative hosts for cocoa pests and diseases. However, a number of these species were among the most preferred by farmers due to their economic and traditional values. Reorientation of programmes towards development and promotion of shade-tolerant, disease-resistant cocoa varieties could benefit conservation and, at the same time, be economically attractive (e.g. through reduced management costs and improved shade cocoa yields), and more aligned with farmers' aspirations for spreading and reducing risk.

Table 1. Preferred trees species in cocoa agroforests in Nigeria (adapted from Asare 2005)

Preferred species	Native	No of sources mentioning species (n=10)	Reasons for maintaining/ planting	Traditional mode of farmer tree propagation
Elaies guinensis	✓	8	planted for sale and consumption	Natural regeneration, planted seedlings
Milicia excelsa	✓	8	grows naturally, nurtured for shade and timber	Natural regeneration
Citrus sinensis		7	planted for sale and consumption	Planted seedlings
Cola nitida	✓	6	planted for sale and consumption	Natural regeneration, planted seedlings
Irvingia gabonensis	✓	6	planted for sale and consumption	Natural regeneration, planted seedlings
Persea americana		5	planted for sale and consumption	Planted seedlings
Terminalia superba	✓	5	fast growing, used for shade, especially in the dry season and sold as timber	Natural regeneration
Dacryodes edulis	✓	5		Natural regeneration, planted seedlings
Garcinia kola	✓	5	nurtured and planted for sale	Natural regeneration, planted seedlings
Artocarpus altilis		4	seed collected and planted for consumption	Natural regeneration
Cola acuminate	✓	4	planted for sale and consumption	Natural regeneration, planted seedlings
Mangifera indica		4	planted for home consumption	Sown seed
Triplochiton scleroxylon	✓	4	grows naturally and nurtured for shade and timber	Natural regeneration
Anacardium occidentale		3		Sown seed
Lovoa trichilioides	✓	2		Natural regeneration
Antiaris spp.	✓	2		Natural regeneration
Cocos nucifera		2	planted for shade, sales and home consumption	Sown seed
Gmelina arborea		2		Sown seed
Hevea brasiliensis		2	planted for shade and the wood,	Sown seed
Khaya ivorensis	✓	2	nurtured for sale and shade	Natural regeneration
Lophira alata	✓	2	nurtured for shade	Natural regeneration

Biodiversity and bioquality

In assessing the value of cocoa agroforests for conservation of tree biodiversity, it is important to recognize that biodiversity, by its very nature, is a broad concept so that there is no single objective measure of 'how much biodiversity there is'. There are two basic types of biodiversity measure: those which simply count entities, and those which incorporate elements of their differences. So why not simply compare total numbers of species, or numbers of species in certain groups? The first problem with this is that species richness is a function not simply of number of species present, but also the evenness with which individuals are distributed, i.e. their relative abundance among these species.

The following metrics are often used to measure species-level biodiversity, covering species richness or species evenness:

> *Species richness* - the number of species in an ecosystem: this makes no use of relative abundances.
>
> *Species evenness* - the relative abundance or proportion of individuals among the species.
>
> *Simpson index* - takes into account the number of species present, as well as relative abundance of each species. The Simpson index represents the probability that two randomly selected individuals in the habitat belong to the same species.
>
> *Shannon-Weaver index* - takes into account the number of species and the evenness of the species. The index increases either by having additional unique species, or by a greater species evenness.

These examples of more or less sophisticated mathematical metrics of diversity range from simple totals, to indices which also take account of the relative abundance of each species, and so a second problem is: which method is the best? Choice of method influences the result. A third hindrance to objectivity is the fact that taxonomy itself is not entirely objective. These problems alone would not negate a purely numerical approach to assessment but there is a much more serious problem. The main and overriding flaw of standard diversity indices is that they do not reflect even the little consensus that does exist about relative intrinsic value of different species. All species are not of equal rank when used as measures of biotic diversity. Not all species are of equal conservation concern. There is moderate consensus that a decline of three out of 500 species of fruit-fly would be of less concern than a similar decline of one out of two top predators, or of a 'keystone species', on whose presence hangs the existence of a broad web of other species. Furthermore, in any particular area, some species (especially pioneers of disturbed vegetation) may have a wide global distribution whereas others may occur nowhere else (endemic species) and be sensitive to disturbance. Most conservationists would attach more importance to the latter when assessing biodiversity value locally.

Worldwide, the funds available for conservation are limited. It is essential, therefore, that they are spent on those species and ecosystems which are most in need of conservation. If the global funds available for conservation are to be spent for the greatest global good, it can be assumed that the species or ecosystems which most warrant investment are those which are at risk of global extinction. Although individual countries clearly have the right to invest in ensuring that species or ecosystems do not go extinct at a national level, local or national extinctions may be of less global concern if the species in question is still widely represented elsewhere.

An alternative, therefore, is to make some assessment of the ‘bioquality’ of a patch of vegetation (in this case cocoa agroforests) and hence its potential importance for conservation in the context of global biodiversity patterns. Bioquality looks at the proportion of rare species in the vegetation, weighted by their global rarity. Thus a tract of vegetation with many species found in few other parts of the world is defined as being high in bioquality. Bioquality diverts attention away from pure numbers of very common unthreatened species to the identification of priority sites, analogous to the concept of ‘hot spots’ (but on a smaller scale) for establishing conservation priorities.

Tree species diversity in agroforests in Nigeria

The tree conservation value of cocoa agroforests was assessed in Ondo State (lat. 5°45´–8°15´N, long. 4°45´–6°00´E), an important area of cocoa and timber production in Nigeria. In Ondo State, deforestation for agriculture, including cocoa, is a serious concern and in an attempt to curb indiscriminate felling of trees and forest, forest reserves were gazetted across the state. However, these reserves continued to shrink under the pressure of rapid population growth and the related increased rate of conversion to agriculture. Although there are few reliable data, it is clear that a large proportion of forest has been converted into cocoa farms, with associated threats to remnant forest cover. The climate is a tropical monsoon type with two distinct seasons: rainy (April–October) and dry (November–March). The soils of the study area are a ferruginous tropical soil (Alfisol) on crystalline rock.

Three villages, close to each of three forest reserves (Idanre, Owo, and Ala Forest Reserves), were randomly selected as they are within the main cocoa producing areas. Tree diversity was assessed in sample plots within each reserve, and also on cocoa farms from each of the selected villages. Three sample plots of 25x25 m were demarcated along transect lines in each reserve and all trees identified. All timber species were counted within each plot, and diameter at breast height (dbh) measured for all trees greater than 10 cm dbh. One productive cocoa farm was selected from each of the three selected villages. The area of each selected farm was measured and all trees inside the farm, other than cocoa, were identified, counted and measured in the same way as for the forest. Basal area and volume of all measured trees in the sample plots and cocoa farms were calculated. Rarefaction, a method that allows comparisons of the number of species found in two areas when sampling effort differs, was used to generate the expected number of species in cocoa agroforests and natural forest, with confidence intervals for species richness.

Four hundred and eighty seven trees belonging to 45 species and 24 families were identified in the 21 ha of cocoa agroforests surveyed (Table 2), with the predominant 10 species accounting for 77% of the total. Edible fruit species topped the list with *Elaeis guineensis*, followed by *Cola nitida, Citrus sinensis, Mangifera indica, Anacardium occidentale, Psidium guajava and Persea americana*. Overall, 413 edible fruit trees belonging to 17 species in 13 families were recorded in the 21 ha of cocoa agroforests, of which 39.7% of trees and 52.9% of species were indigenous (Table 2). Non-fruit tree species that were present in substantial proportions were *Alstonia congensis, Ceiba pentandra, Triplochiton scleroxylon* and *Milicia excelsa*. There were also indications that some farmers were making deliberate efforts to plant some timber tree species on their farms, especially *Terminalia* spp. In the 0.56 ha of forest surveyed, 163 trees from 62 species and 29 families were found (Table 2). The dominant tree species were *Celtis mildbraedii, Piptadeniastrum africanum, Afzelia africanum, Antiaris africana, Entandrophragma cylindricum, Brachystegia euricoma, Canarium schweinfurthii, C. pentandra* and *A. congensis*.

Tree diversity in the natural forest was higher than in the cocoa agroforests, both in terms of the number of species and by Shannon's index (Table 3). Rarefaction curves indicate cocoa agroforests support lower species richness than a floristically and climatically similar site of native forest (Fig. 1). Basal area and density of non-cocoa trees in the cocoa agroforests were also low compared to the natural forest (Table 3).

Table 2. Diversity of non-cocoa tree species (>10 cm dbh) in 21 ha of cocoa agroforests and 0.56 ha of native forest reserve in Ondo State, Nigeria (NPLD – Non-pioneer light demander, NA – no classification available, exotics are not classified for ecological guild. IUCN status based on 1994 categories as assessments are from 1996-2000 that have not been converted to revised system, EN–Endangered, VU–Vulnerable, LR–Lower risk; see appendix for details)

Species	Family	Farm freq in 21 ha	Farm density per ha	Forest freq in 0.56 ha	Forest density per ha	Native	Edible fruit	Ecological guild	IUCN status Category
Acacia sieberiana A.Chev	Mimosoideae			2	3.4	✓		NA	
Afzelia africana Sm.	Caesalpinioideae	1	0.05	8	13.6	✓		NPLD	VU
Albizia zygia J.F. Macbr	Mimosoideae			1	1.7	✓		NPLD	
Alstonia congensis Engl.	Apocynaceae	10	0.48	5	8.5	✓		Pioneer	
Anacardium occidentale Linn	Anacardiaceae	39	1.86				✓		
Anopyxis klaineana (Pierre) Engl	Rhizophoraceae			1	1.7	✓		NPLD	VU
Anthocleista vogelii Planch	Loganiaceae			1	1.7	✓		Shade bearer	
Anthonotha macrophylla P. Beauv	Caesalpinioideae			1	1.7	✓		Shade bearer	
Antiaris toxicaria Lesch.	Moraceae	3	0.14	5	8.5	✓		NPLD	
Antidesma laciniatum Muell. Arg	Euphorbiaceae			2	3.4	✓		Shade bearer	
Berlinia spp. Hook f & Benth	Caesalpinioideae			3	5.1	✓		NA	
Bligha sapida Konig	Sapindaceae	2	0.1	3	5.1	✓	✓	NPLD	
Bombax buonopozense P.Beauv	Bombacaceae	2	0.1			✓		Pioneer	
Bosqueia angolensis Ficalho	Moraceae			3	5.1	✓		NPLD	
Brachystegia eurycoma Harms	Caesalpinioideae	1	0.05	5	8.5	✓		NPLD	
Caloncoba glauca (P.Beauv.) Gilg	Flacourtiaceae			2	3.4	✓		Shade bearer	
Canarium schweinfurthii Engl	Burseraceae	1	0.05	5	8.5	✓		NPLD	
Ceiba pentandra (Linn) Gaertn	Bombaceae	8	0.38	5	8.5	✓		Pioneer	

Species	Family	Farm freq in 21 ha	Farm density per ha	Forest freq in 0.56 ha	Forest density per ha	Native	Edible fruit	Ecological guild	IUCN status Category
Celtis mildbraedii Engl	Ulmaceae	3	0.14	8	13.6	✓		Shade bearer	
Celtis zenkeri Engl.	Ulmaceae	1	0.05	1	1.7	✓		NPLD	
Chrysophyllum albidum G. Don	Sapotaceae	4	0.19	1	1.7	✓	✓	Shade bearer	
Citrus paradisi Macfad	Rutaceae	14	0.67				✓		
Citrus reticulata Blanco	Rutaceae	24	1.14				✓		
Citrus sinensis (L.) Osbeck	Rutaceae	50	2.38				✓		
Cleistopolis patens (Benth) Engl & Diels	Annonaceae	1	0.05	4	6.8	✓		Pioneer	
Cocos nucifera Linn	Palmae	14	0.67				✓		
Cola nitida (Vent) Schott & Endl	Sterculiaceae	53	2.52			✓	✓	Shade bearer	
Cordia millenii Bak.	Boraginaceae			3	5.1	✓		Pioneer	LR/lc
Dacroydes edulis (G. Don.) H.J. Lam	Burseraceae	8	0.38			✓	✓	Savanna	
Daniella ogea (Harms) Rolfe ex Holl	Caesalpinioideae			2	3.4	✓		Pioneer	
Deplatsia dewevrei De Wild & Th Dur	Tiliaceae			2	3.4	✓		Shade bearer	
Diallium guineense Willd	Caesalpinioideae	2	0.1			✓	✓	Savanna	
Diospyros mespiliformis Hochst	Ebenaceae			1	1.7	✓	✓	Shade bearer	
Dracaena manii Bak.	Agaraceae	1	0.05	1	1.7	✓		Pioneer	
Drypetes gossweileri S. Moore	Euphorbiaceae	1	0.05	4	6.8	✓		Shade bearer	
Elaeis guineensis Jacq	Palmae	60	2.86			✓	✓	Pioneer	
Entandrophragma cylindricum (Sprague)	Meliaceae	1	0.05	5	8.5	✓		NPLD	VU
Erythrophleum africanum (Benth) Harms	Caesalpinioideae			3	5.1	✓		NPLD	
Ficus exasperata (Vahl)	Moraceae	2	0.1	2	3.4	✓		Pioneer	
Funtumia elastica (Preuss) Stapf.	Apocynaceae	2	0.1	4	6.8	✓		NPLD	
Garcinia kola Heckel	Guttiferae	5	0.24			✓	✓	Shade bearer	
Gilbertiodendron dewevrei De Wild	Caesalpinioideae			3	5.1	✓		Shade bearer	
Gossweilerodendron balsamiferum (Verm) Harms	Caesalpinioideae	1	0.05	3	5.1	✓		NPLD	EN
Harungana madagascarensis Lam	Guttiferae			4	6.8	✓		Pioneer	

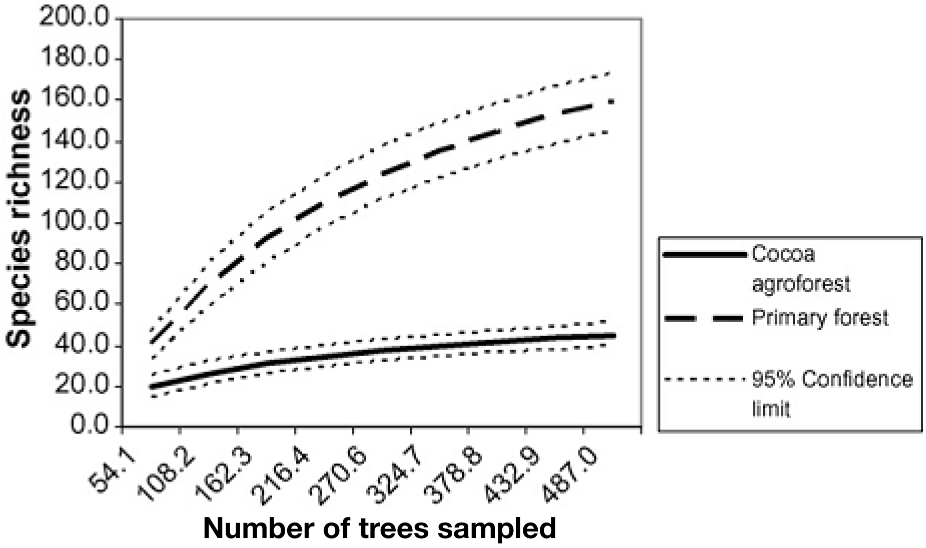
Species	Family	Farm freq in 21 ha	Farm density per ha	Forest freq in 0.56 ha	Forest density per ha	Native	Edible fruit	Ecological guild	IUCN status Category
Holarrhena floribunda (G. Don) Dur & Schinz	Apocynaceae	2	0.1			✓		Pioneer	
Holoptelia grandis (Hutch) Mildbr	Ulmaceae			1	1.7	✓		Pioneer	
Khaya ivorensis A.Chev	Meliaceae			2	3.4	✓		NPLD	VU
Lannea welwitschii (Hiern) Engl.	Anacardiaceae			3	5.1	✓		Pioneer	
Lecaniodiscus cupanioides Planch ex Benth	Sapindaceae			2	3.4	✓		Shade bearer	
Lophira alata Banks ex Gaertn f.	Ochnaceae			1	1.7	✓		Pioneer	VU
Lovoa trichilioides Harms	Meliaceae			4	6.8	✓		NPLD	VU
Mangifera indica Linn	Anacardiaceae	43	2.05				✓		
Mansonia altissima A. Chev	Sterculiaceae			1	1.7	✓		NPLD	
Microdesmis puberula Hook f. ex planch	Pandaceae	1	0.05			✓		Shade bearer	
Milicia excelsa (Welw) C.C. Berg	Moraceae	7	0.33	4	6.8	✓		Pioneer	LR/nt
Mitragyna ciliate Aubrev & Pellegr	Rubiaceae			2	3.4	✓		Swamp	
Mitragyna stipulosa (DC) Kuntze	Rubiaceae			1	1.7	✓		Swamp	
Musanga cecropoides R. Br. Ex. Tedlie	Moraceae	3	0.14	4	6.8	✓		Pioneer	
Nesogodonia papaverifera (A.Chev) R. Capuron	Sterculiaceae			1	1.7	✓		Shade bearer	VU
Pachystela brevipes (Bak.) Baill	Sapotaceae			2	3.4	✓		Swamp	
Parinari curatellifolia Planch ex Benth	Chrysobalanaceae			1	1.7	✓	✓	NPLD	
Penthaclethra macrophylla Benth	Mimosoideae			2	3.4	✓		NPLD	
Persea americana Mill	Lauraceae	32	1.52				✓		
Phyllanthus discoideus (Baill.) Muell. Arg.	Euphorbiaceae	1	0.05			✓		Pioneer	
Phyllanthus physocarpus Muell Arg.	Euphorbiaceae			1	1.7	✓		Shade	
Piptadeniastrum africanum (Hook. F.) Brenan	Mimosoideae	1	0.05	8	13.6	✓		NPLD	
Psidium guajava Linn	Myrtaceae	33	1.57				✓		
Pterocarpus erinaceus Poir.	Papilionoideae			2	3.4	✓		NPLD	

Species	Family	Farm freq in 21 ha	Farm density per ha	Forest freq in 0.56 ha	Forest density per ha	Native	Edible fruit	Ecological guild	IUCN status Category
Pterocarpus santalinoides L'Herit ex DC	Papilionoideae			1	1.7	✓		Swamp	VU
Pterygota macrocarpa K. Schum	Sterculiaceae	6	0.29	2	3.4	✓		NPLD	VU
Pycnanthus angolensis (Welw) Warb.	Myristicaceae			3	5.1	✓		NPLD	
Ricinodendron heudelotii (Baill) Heckel	Euphorbiaceae	25	1.19	2	3.4	✓	✓	Pioneer	
Spathodea campanulata P.Beauv	Bignoniaceae	3	0.14	2	3.4	✓		Pioneer	
Spondias mombin Linn	Anacardiaceae	5	0.24			✓	✓	Swamp	
Sterculia rhinopetala K. Schum	Sterculiaceae			1	1.7	✓		NPLD	
Sterculia tragacantha Lindl.	Sterculiaceae	1	0.05	1	1.7	✓		Pioneer	
Terminalia ivorensis Engl & Diels	Combretaceae			1	1.7	✓		Pioneer	VU
Terminalia superba Engl & Diels	Combretaceae	1	0.05	1	1.7	✓		Pioneer	
Triplochiton scleroxylon K. Schum	Sterculiaceae	8	0.38	2	3.4	✓		Pioneer	LR/lc
Uapaca heudelotii Baill	Euphorbiaceae	1	0.05			✓		Swamp	
Zanthoxylum gilletii (De Wild.) Waterman	Rutaceae			2	3.4	✓		Pioneer	

Table 3. Density, basal area, volume and diversity indices of non-cocoa trees in cocoa agroforests and natural rainforest in Ondo State, Nigeria (differences significant at *P*< 0.05)

Parameters	Cocoa agroforest	Native forest
Density (trees/ha)	23.2	276.3
Basal area (m^2/ha)	6.2 ± 2.1	44.2 ± 7.3
Volume (m^3/ha)	119.9 ± 31.0	730.9 ± 112.3
Shannon diversity index	2.71	3.58

Figure 1. Tree species richness in cocoa agroforests and primary forest (forest reserve) in Ondo State, Nigeria. Individual rarefaction curves and confidence intervals



Nigeria background

Cocoa was introduced in 1874 to Nigeria and plays a significant socio-economic role in the country. Nigeria used to be the second largest producer in the world, but a combination of factors (e.g. civil war in the mid 1960s, the oil boom) led to the neglect of cocoa, and reduced production. It is currently the fifth largest producer after Côte d'Ivoire, Ghana, Indonesia, and Brazil. The average West African cocoa farm is three to seven hectares in size, and supports a family of eight to ten people. Cocoa currently occupies a total area of 700 000 ha in Nigeria, with an average farm size of only 1.7 ha. Sixty per cent of cocoa tree stock is more than 30 years old. There are no labour shortages, but there are severe problems with black pod disease which reduces production by up to 70%. Cultivation is confined to three main ecological zones:

- Ideal cocoa climate – Ondo, Ekiti, parts of Oshun States in Ilesha Region. Rainfall 2000-2500 mm per year.
- Ideal cocoa soil – Cross River State (deep soil). Rainfall is in excess of 4000 mm per year.
- Marginal (Southern Guinea Savannah) – Ibadan, Kwara, Ogun, and large parts of Oshun States. Rainfall 1000-1500 mm per year.

Remaining forest cover in West Africa constitutes only one-fifth of its original extent. This partially indicates the beginning of the end of cocoa farm expansion into forested areas. Efforts to increase production depend more on the rehabilitation of neglected cocoa orchards than increasing the area under cocoa. Nigeria's national economy has never depended on cocoa production as heavily as those of Ghana and Côte d'Ivoire. Therefore government policies did not prioritize cocoa production to the same extent leading to cocoa farmers neglecting their farms and shifting labour to other sectors of the economy. As a consequence, cocoa farms in Nigeria are classified as having medium shade levels with high numbers of forest tree species in contrast to Ghana and Côte d'Ivoire which are classified as having low shade levels. The challenge for policy makers in Nigeria at the moment is how to enhance cocoa agroforestry production but at the same time conserve its biodiversity. Research and development have focused on reducing shade and increasing production, while diversifying through the incorporation of indigenous fruit trees with a strong demand in national and regional markets. Much work has also gone into the domestication of indigenous fruit trees, with virtually no work on the forest timber species that farmers also prefer. New propagation methods for some indigenous fruit trees (e.g. *Dacryodes edulis, Irvingia gabonensis, Ricinodendron heudelotti* and *Garcinia kola*) have resulted in shorter gestation periods, reduced height and relatively smaller canopy. The changes bring them into the same stratum as the cocoa tree, giving rise to concern that competition between species will be increased rather than decreased.

Institutions and cocoa in Nigeria

Cocoa Research Institute of Nigeria (CRIN): a government-appointed institution with a mandate to conduct research on the following tree crops: oil palm, cocoa, cashew, coffee, tea and cola (both *Cola nitida* and *C. acuminata*). CRIN works on cocoa establishment, soil nutrition, cocoa farm rehabilitation, and sustainable cocoa systems. Since the 1960s, CRIN has studied the adaptability of these crops in association with cocoa.

Cross River State Cocoa Board: conducting research since 1988 in collaboration with the Forestry Development Department in a 'cocoa taungya[1]' plantation (Cross River State North Forest Reserve Cocoa Project) where cocoa trees are planted in combination with timber trees, plantain and cassava shade. The research studies the synergistic effect of *Triplochiton scleroxylon, Tectona grandis, Nauclea diderrichii* and *Terminalia ivorensis* on cocoa establishment and yield.

Tree Crop Unit, Ondo State Ministry of Agriculture: has a government mandate to produce and distribute planting materials for tree crops such as oil palm, cola (*C. nitida/C. acuminata*), cocoa, cashew, and rubber. Operations are carried out by establishing community nurseries and facilitating distribution of material to farmers. Cocoa plants are raised from seed produced by hand pollination, as prescribed by CRIN.

Sustainable Tree Crop Programme (STCP)-Nigeria: has worked with national partners to demonstrate innovative approaches to improve productivity of cocoa farms in environmentally friendly and socially responsible ways. Farmers (4559) were trained through a Farmer Field School (FFS) training approach, and 10 722 farmers trained by the FFS trainees through guided farmer-to-farmer diffusion. In all, FFS farmers received training on topics related to integrated crop and pest management, quality improvement, and farm safety. STCP works in collaboration with CRIN to promote the concept of active cocoa agroforestry, serving as a platform for the dissemination of research results on cocoa shade trees, encouraging farmers to protect, plant and harvest timber trees, and to help improve soil conservation.

1 A Burmese word derived from the words taung, a hill, and ya, cultivation. Now widely used to describe the practice, used in many countries, of establishing tree plantations together with food crops. Food cropping is ended after the initial 1–2 years of tree establishment.

Information sources

This case study is based on the following papers:

Asare R. 2005. Cocoa agroforests in West Africa: a look at activities on preferred trees in the farming systems. In: Forest & Landscape Working Papers, development and Environment. No.6-2005. Available from: http://curis.ku.dk/ws/files/20497370/workingpapersno6.pdf. Date accessed: 28 September 2012.

Asare R. 2006. A review on cocoa agroforestry as a means for biodiversity conservation. In: Forest & Landscape, Conference paper, May 2006. Available from: http://www.icraf.com/treesandmarkets/inaforesta/documents/agrof_cons_biodiv/Cocoa_review_biodiversity.pdf. Date accessed: 28 September 2012.

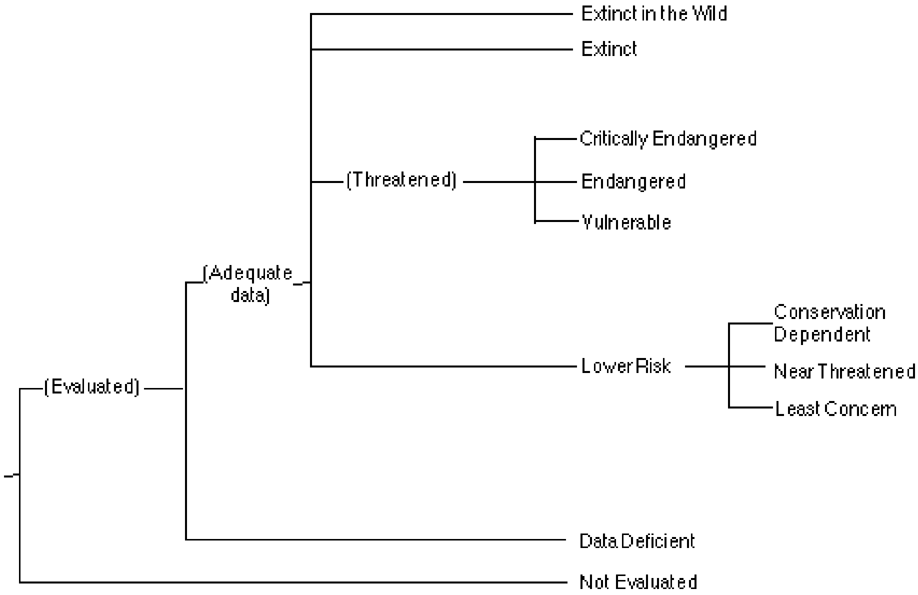
Hawthorne WD. 1995. Ecological profiles of Ghanaian forest trees. TFP 29 Oxford Forestry Inst.

Oke DO, Odebiyi KA. 2007. Traditional cocoa-based agroforestry and forest species conservation in Ondo State, Nigeria. Agriculture, Ecosystems & Environment 122:305-311.

Appendix: IUCN threatened species categories

NB: IUCN categories were revised in 2007. The 1994 categories are presented here as those directly relevant to this study – see Table 2.

Figure A1. Structure of the IUCN 1994 categories



EXTINCT (EX) - A taxon is Extinct when there is no reasonable doubt that the last individual has died.

EXTINCT IN THE WILD (EW) - A taxon is Extinct in the wild when it is known only to survive in cultivation, in captivity or as a naturalized population (or populations) well outside the past range. A taxon is presumed extinct in the wild when exhaustive surveys in known and/or expected habitat, at appropriate times (diurnal, seasonal, annual), throughout its historic range have failed to record an individual. Surveys should be over a timeframe appropriate to the taxon's life cycle and life form.

CRITICALLY ENDANGERED (CR) - A taxon is Critically Endangered when it faces an extremely high risk of extinction in the wild in the immediate future, as defined by any of the criteria (A to E) as described below.

ENDANGERED (EN) - A taxon is Endangered when it is not Critically Endangered but is facing a very high risk of extinction in the wild in the near future, as defined by any of the criteria (A to E) as described below.

VULNERABLE (VU) - A taxon is Vulnerable when it is not Critically Endangered or Endangered but is facing a high risk of extinction in the wild in the medium-term future, as defined by any of the criteria (A to E) as described below.

LOWER RISK (LR) - A taxon is Lower Risk when it has been evaluated, does not satisfy the criteria for any of the categories Critically Endangered, Endangered or Vulnerable. Taxa included in the Lower Risk category can be separated into three subcategories:

1. **Conservation Dependent (cd)** Taxa which are the focus of a continuing taxon-specific or habitat-specific conservation programme targeted towards the taxon in question, the cessation of which would result in the taxon qualifying for one of the threatened categories above within a period of five years.
2. **Near Threatened (nt)** Taxa which do not qualify for Conservation Dependent, but which are close to qualifying for Vulnerable.
3. **Least Concern (lc)** Taxa which do not qualify for Conservation Dependent or Near Threatened.

DATA DEFICIENT (DD) - A taxon is Data Deficient when there is inadequate information to make a direct, or indirect, assessment of its risk of extinction based on its distribution and/or population status. A taxon in this category may be well studied, and its biology well known, but appropriate data on abundance and/or distribution is lacking. Data Deficient is therefore not a category of threat or Lower Risk. Listing of taxa in this category indicates that more information is required and acknowledges the possibility that future research will show that threatened classification is appropriate. It is important to make positive use of whatever data are available. In many cases great care should be exercised in choosing between DD and threatened status. If the range of a taxon is suspected to be relatively circumscribed, if a considerable period of time has elapsed since the last record of the taxon, threatened status may well be justified.

NOT EVALUATED (NE) - A taxon is Not Evaluated when it is has not yet been assessed against the criteria.

Forest Genetic Resources Training Guide

MODULE 1 Species conservation strategies

1.1 *Leucaena salvadorensis*: genetic variation and conservation
1.2 *Talbotiella gentii*: genetic variation and conservation
1.3 *Shorea lumutensis*: genetic variation and conservation

MODULE 2 Trees outside of forests

2.1 Conservation of tree species diversity in cocoa agroforests in Nigeria
2.2 Devising options for conservation of two tree species outside of forests

MODULE 3 Tree seed supply chains

3.1 Genetic bottlenecks in the restoration of *Araucaria nemorosa*
3.2 Tree planting on farms in East Africa: how to ensure genetic diversity?

MODULE 4 Forest management

4.1 Impacts of selective logging on the genetic diversity of two Amazonian timber species
4.2 Does selective logging degrade the genetic quality of succeeding generations through dysgenic selection?
4.3 Conserving *Prunus africana*: spatial analysis of genetic diversity for non-timber forest product management

MODULE 5 How local is local? – the scale of adaptation

5.1 Selecting planting material for forest restoration in the Pacific north-west of the USA
5.2 Local adaptation and forest restoration in Western Australia

Other modules to be published among the following:
Plantation forestry, Tree domestication, Forest restoration, Genetic modification