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CROP-BASED AGROFORESTRY SYSTEMS IN THE BUFFERS OF PROTECTED AREAS: IMPLICATIONS FOR TREE SPECIES CONSERVATİON IN OKOMU NATIONAL PARK, NIGERİA

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ABSTRACT

Woody species inventory was carried out in the traditional agroforestry around Okomu National Park (ONP), Nigeria, to ascertain the conservation of trees/shrubs in the farming systems. Systematic line transects were employed in the laying of Temporary Sample Plots (TSPs) in the existing compartments of ONP forest ecosystem. Two temporary sample plots of 25m x 25m (0.0625ha) in dimension were established in alternate positions along transect at 100m interval, amounting to four (4) temporary sample plots per range and a total of sixteen (16) TSPs within the national park. Total enumeration of live woody species was carried out in each sample plot. Three predominant farming systems were selected from buffer zone and boundary communities. Four (4) farms were purposively selected from each of the farming systems and used as sample plots. All live woody species present on each farm were enumerated and recorded, and diversity indices used to analyze species density and diversity. The density of the tree species identified in the study area include 519, 35, 174 and 80 (ha^{-1}) for ONP, Cassava, Cocoa and Plantain land uses respectively. While diversity indices ONP, Cassava, Cocoa and Plantain land uses were: Shannon's diversity index of (3.431, 1.868, 2.168 and 2.284); Species evenness (0.711, 0.711 0.537 and 0.733); Families Annonaceae, Meliaceae were the richest families identified in ONP while families Moraceae, Mimosoideae were common to the three agroforestry land uses. The analysis of variance of the diversity indices revealed that the biodiversity of the three farming systems differed significantly ($P \leq 0.05$)from ONP. However, all land uses surveyed showed no significant difference in species evenness. The species diversity indicates that traditional farming systems can be effective biodiversity conservation tools in the edges of protected forests and consequently provide environmental sustainability.

Key words: Agroforestry, woody species, conservation, protected area, land uses

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INTRODUCTION

Biodiversity conservation has previously been understood mostly in terms of the management of protected areas and natural forests, without considering the possible role of rural community farms in promoting biodiversity in their subsistence agricultural production systems (Acharya, 2006). Traditional agroforestry systems (TAFS) may be described as an age-long farming practice which are generally devoid of deliberate intensified cultivation of agricultural or forage crops, and have been practiced across the world with varying structure, function, socio economic attributes and ecological services (Viswanath *et al.*, 2018). Creating a natural forest cover semblance through agricultural crops cultivation with tree species, agroforestry areas may serve as biodiversity corridors between protected areas and non-protected remnants of natural vegetation while providing sustainable crop and wood harvests (Gascon *et al*., 2004). Edge effects can be reduced by surrounding forest

edges with agroforestry buffers instead of open pasture or cropland. Although, some authors have described buffer zones around protected areas and parks as a conservation tool; others have explained the socioeconomic benefits of buffer zone agroforestry to surrounding communities. However, very little attention has been paid to the effectiveness of agroforestry practices in buffer zones of protected areas in conservation of biodiversity. This study is therefore set to assess the diversity and abundance of woody species within the traditional farming areas of National Park buffers areas.

MATERIALS AND METHODS

Study Area

Okomu National Park (ONP) covers an area of 202.24 km² (Okomu National Park, 2010). Okomu National Park, formerly known as Okomu Wildlife Sanctuary, is a forest block within**69 - 81** Okomu Forest Reserve (latitudes 6ºN and 6º10'N, and longitudes 5ºE and 5º30'E). The National Park is divided into 78 compartments which are sectioned into four ranges: Iguowan (Range A), Arakhuan (Range B), Julius Creek (Range C) and Baubui Creek (Range D). A number of rural communities surround the Park which consists of about 42 communities, some of which form boundary with the national park. These surrounding communities cultivate arable crops such as cassava, plantain, maize, yam, cocoyam and vegetables including cash crops such as oil palm, cocoa and kola. Vegetation is a tropical lowland rain forest, including areas of swamp-forest, high forest, secondary forest, and open scrub, which supports a unique assemblage of biodiversity. The forest comprises rainforest, fringing/riparian, freshwater and lacustrine ecosystems (White, 1979 cited by Isikhuemen and Ikponmwoba, 2020).

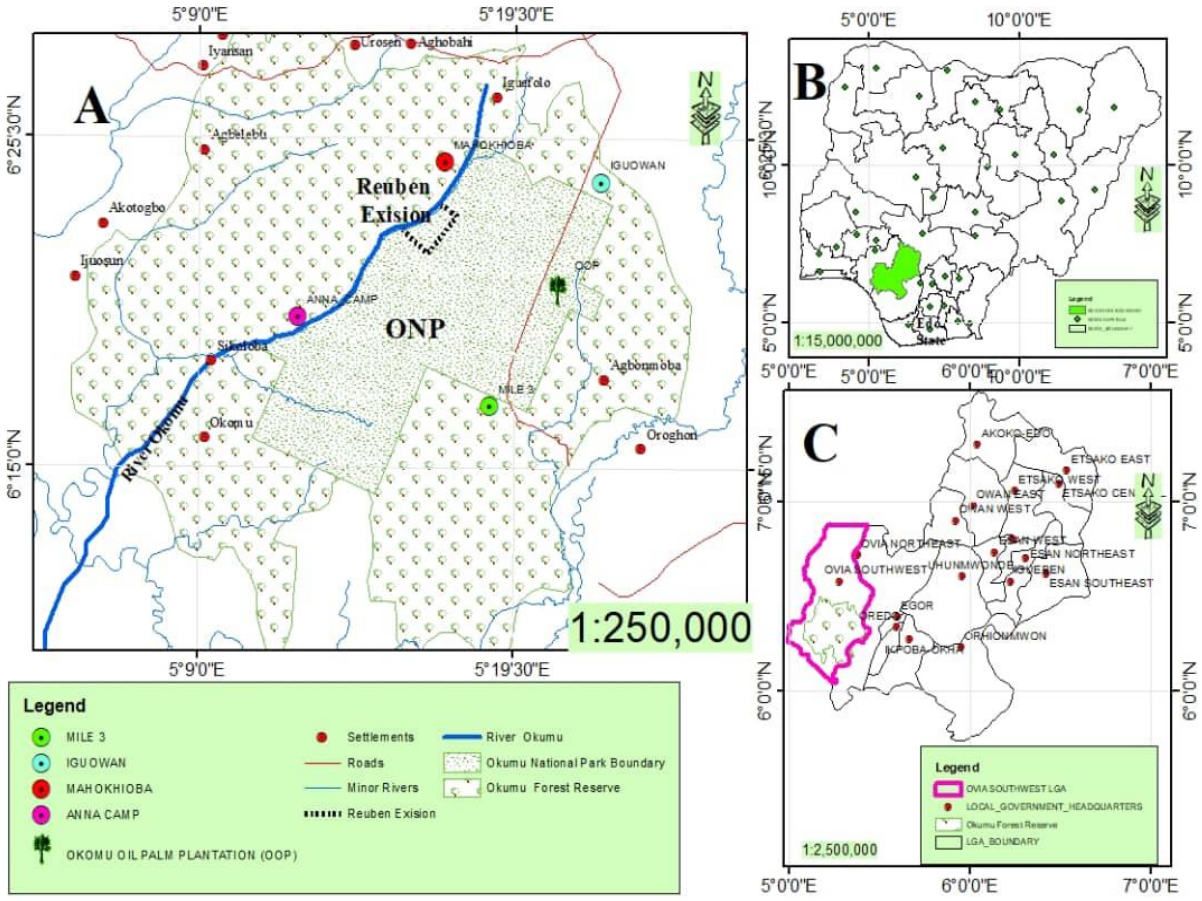

Figure 1. Okomu Forest Reserve (OFR) showing the study areas

Study Procedure

A reconnaissance survey to the Okomu national parkand the adjoining communities was carried out to locate the boundaries of the selected sites and determine the predominant farming systems in the study area. Woody species diversity was carried out within the national park by ten percent sampling to select compartments for the study,

and this resulted in a total of eight compartments. with two compartments purposively selected from each of the four ranges respectively (Figure 2). Systematic line transects as described by Osemeobo (1992) was used in the laying of Temporary Sample Plots (TSPs) in the compartments of ONP forest ecosystem. A set back of 10m was measured where transect of 300m in length was laid in each compartment. Two temporary sample plots of 25m x 25m (0.0625ha) in size was established in alternate positions along transect at 100m interval. This amounted to four (4) temporary sample plots per range and sixteen (16) TSPs within the national park and coordinates of the sample locations were collected accordingly using a GPS.

A 2 km distance was taken between the park boundary and communities (having common boundary with ONP) and used as buffer areas. These communities include Iguowan, Mile 3, Mahokhioba and Anna Camp respectively (Figure 3). The predominant farming practices engaged in by the farmers in the buffer zone and fringe communities were identified, and the three major ones were selected for the woody species inventory. Four (4) farms were purposefully selected from each of the three farming systems (land use) and used as sample plots. All live woody species present on each farm were counted and recorded. Tree and shrub species encountered during the field assessment wereidentified and enumerated with the assistance of an expert field taxonomist. Books such as Nigerian Trees (Kaey, 1989) was consulted for species that were identified in their local names.

Data Analysis

All live woody species identified were classified into families. Woody species density and diversity was analyzed using different diversity indices. Shannon diversity index (H^1), Shannon equitability/evenness index (E), species richness (S), Menhinick's diversity index and Margalef's species richness index (D) were calculated and subjected to analysis of variance (ANOVA). These diversity indices provided important information about rarity and commonness of species in a community.

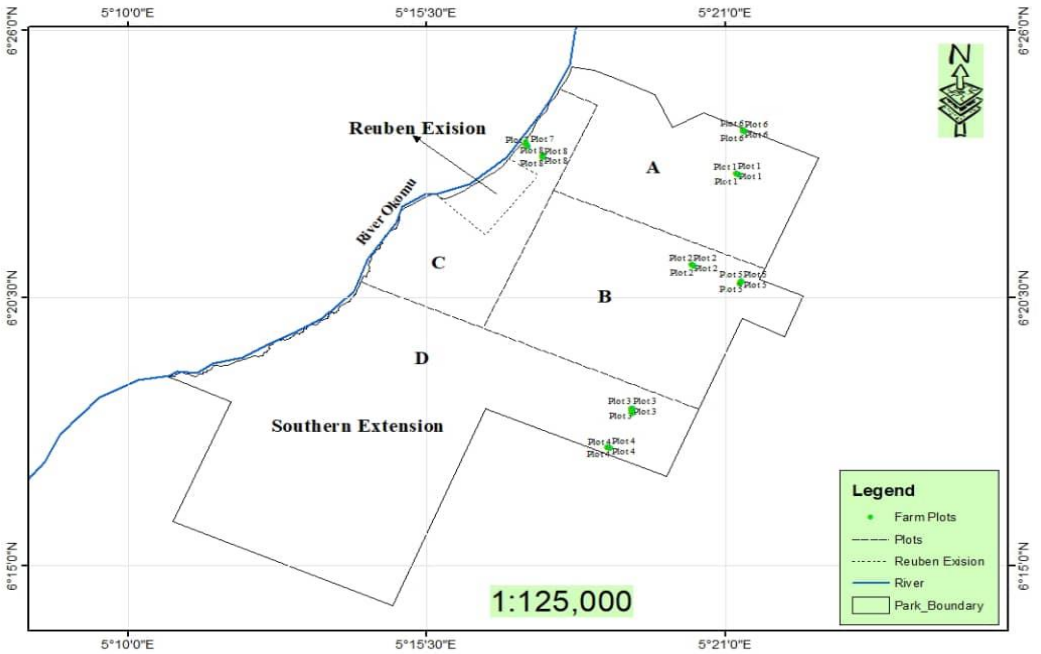

Figure 2: Map of ONP showing sample plots within the four ranges A, B, C and D.

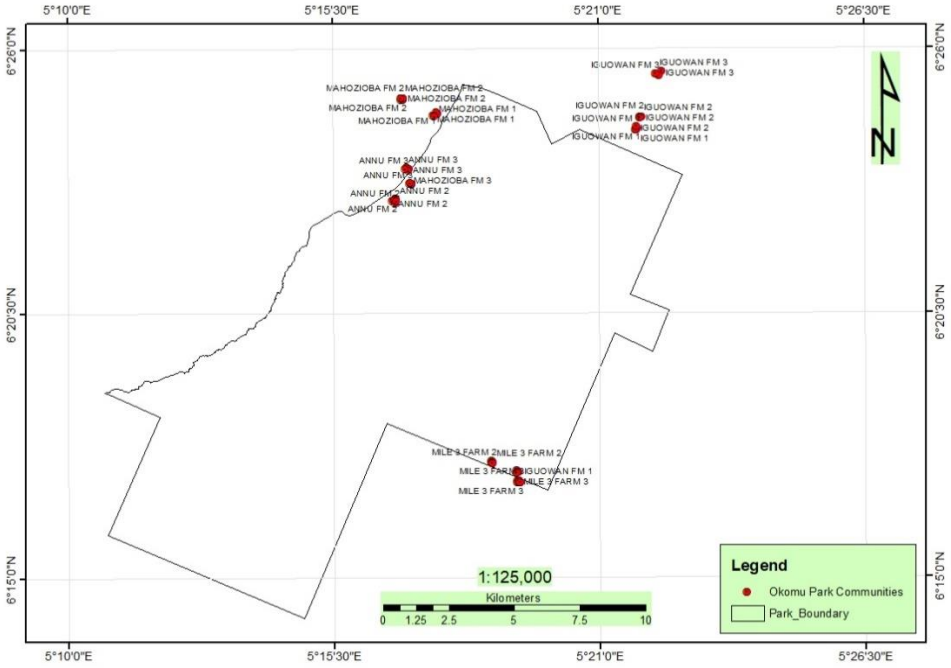

Figure 3. Map of ONP showing agroforestry sample plots for biodiversity study

RESULTS

Tree Species Density and Diversity in Okomu National Park (ONP) and Adjoining Farmlands

All live tree/shrubs in the sampling plots of the four land uses surveyed(ONP, Cassava, Cocoa and Plantain farming systems) are presented below. However, only non-cocoa species were inventoried in the Cocoa land use.A total population of 519 individual tree species (ha^{-1}) belonging to 85 species and 32 families were encountered at the natural forest of ONP (Table 1). Annonaceae and Meliaceae were the richest families each having 7 species. The predominant species were *Eribromaoblanga*, *Strombosiagrandifolia*, *Strombosiapostulata*, *Celtiszenkeri*.

The mean number of individual trees and shrubs $Ha^{-1}$of the four Cassava farms visited was 35 (Table 2). The number of species recorded in the sample plots was 32 belonging to 20 families. The richest family recorded was Euphorbiaceae, Mimosoideae and Moraceae which had four species each. The predominant species identified were *Elaeis guineensis*, *Distemonanthus benthamianus*, *Alstoni aboonei* and *Albizia adianthifolia*.

Also, density and diversity of the Cocoa farmlands (Table 3) shows that mean number of individual trees and shrubs $Ha^{-1}$of the four sample farms was 174 belonging to 42 species and 22 families. The family Moraceae was the richest, having 6 species. The predominant species in the land use include *Elaeis guineensis, Eribroma oblanga, Gmelina arborea, Musanga* cecropoides.

The results of Plantain farm land use (Table 4) revealed that the mean number of individual trees and shrubs Ha^{-1} was 80 belonging to 44 species and 27 families. Family Euphorbiaceae was the richest species with five species. *Alstoniaboonei, Albiziazygia, Psydraxarnoldiana, Elaeis guineensis, Macarang abarteri, Cleistopholis patens, Musangace cropoides, Albizia adianthifolia* were the predominant species present in the Plantain agroforestry.

Differences in the diversity indices of ONP, Cassava, Cocoa and Plantain Land uses

The result of the mean diversity indices of the various land use subjected to analysis of variance (ANOVA) is presented in Table 5. ONP land use served as the control treatment for the study. The other treatments include Cassava, Cocoa and Plantain land uses. The mean Shannon weiner value of ONP land use was significantly different ($P \leq 0.05$) from Cassava, Cocoa and Plantain land uses, which has no significant differences. The highest value of 3.431 was recorded by ONP while Cassava land use had the least mean value of 1.868. The Plantain land use had the highest mean evenness (0.734) while the lowest value was recorded in the Cocoa land use (0.537). All

four land uses had no significant differences. The highest mean Simpson's value of 0.956 was recorded in ONP and the lowest mean value of 0.764 was for Cassava land use. The mean Simpson's value of ONP was significantly different ($P \leq 0.05$) from the Cassava land use but did not differ significantly from the Cocoa and Plantain land uses.The results indicate that ONP had the highest value of 6.634 and was significantly different ($P \leq 0.05$) from the other three land uses. The Cassava farms had the highest Menhinick value of 2.057 while the least value of 1.492 was recorded from the Cocoa system. However, there was no significant difference in the Menhinick values of all four land uses surveyed.

Table 1. Tree Species Diversity in Okomu National Park (ONP)

S/No.	Species Name/Authority	Family	DHa^{-1}	RD
1	*Aframomum melegueta* K. Schum.	Zingiberaceae	9	1.74
2	*Albizia adianthifolia* (Schum.) W.F. Wight	Mimosoideae	5	0.97
3	*Alchornea cordifolia* (Schum. &Thonn.) Muell.Arg.	Euphorbiaceae	5	0.97
4	*Allanbackia floribunda* Oliv.	Guttiferae	9	1.74
5	*Alstonia boonei* De Wild	Apocynaceae	3	0.58
6	*Anonidium mannii (Oliv.)* Engl. And Diels.	Annonaceae	14	2.70
7	*Anthonotha macrophylla* P.Beauv.	Caesalpiniodeae	7	1.35
8	*Antiaris Africana* Engl.	Moraceae	2	0.39
9	*Antrocrayon micraster*	Anacardiaceae	2	0.39
10	*Baphia nitida* Lodd.	Papilionoideae	7	1.35
11	*Baphia pubescens* Hook. F	Papilionoideae	3	0.58
12	*Barteria fistulosa* Mast.	Passifloraceae	1	0.19
13	*Berlinia auriculata* Benth.	Caesalpinioideae	1	0.19
14	*Berlinia coriacea* Keay	Caesalpiniodeae	14	2.70
15	*Blighia sapida* Konig	Sapindaceae	3	0.58
16	*Bosqueia angolensis* Ficalho	Moraceae	2	0.39
17	*Brachystegia eurycoma* Harms	Caesalpinoideae	2	0.39
18	*Brenania brieyi* (De Wild.) Pefit	Rubiaceae	3	0.58
19	*Buchholzia coriacea* Engl.	Capparidaceae	3	0.58
20	*Calamus deerratus* G. Mann & H. Wendl.	Palmae	2	0.39
21	*Celtis mildbraedii* Engl.	Ulmaceae	3	0.58
22	*Celtis zenkeri* Engl.	Ulmaceae	20	3.86
23	*Cleistopholis patens* (Benth.) Engl. & Diels	Annonaceae	12	2.32
24	*Cola millenii* K. Schum.	Streculiaceae	1	0.19
25	*Cola nitida* (Vent.) Schott &Endl.	Streculiaceae	6	1.16
26	*Combretum racemosum* (P.Beauv.) Keay	Combretaceae	2	0.39
27	*Cordia millenii* Bak.	Boraginaceae	1	0.19
28	*Cycliodiscus gabunensis* Harms.	Mimosoideae	2	0.39
29	*Danielia ogea* Rolfe ex Holl.	Caesalpiniodeae	8	1.54
30	*Desplatsia chrysochalamy* Mildbr. &Burret	Tiliaceae	1	0.19
31	*Desplatsia subericarpa* Bocq.	Tiliaceae	1	0.19
32	*Diospyros barteri* Ramaswami	Ebenaceae	1	0.19
33	*Diospyros crassiflora* Hiern	Ebanaceae	1	0.19
34	*Diospyros dendo* Welw.	Ebanaceae	4	0.77
35	*Diospyros suaveolens* Gurke	Ebenaceae	17	3.28
36	*Elaeis guineensis* Jacq.	Palmae	2	0.39
37	*Enantia chlorantha* Oliv.	Annonaceae	2	0.39
38	*Entandrophragma angolense* (Welw.) C.DC.	Meliaceae	11	2.12
39	*Entandrophragma cylindricum* (Sprague) Sprague	Meliaceae	3	0.58
40	*Eribroma oblanga* Mast.	Sterculiaceae	50	9.65
41	*Gambeya albida* (G. Don) Aubrev. &Pellegr.	Sapotaceae	1	0.19
42	*Guarea cedrata (A. Chev.)* Pellegrin	Meliaceae	14	2.70
43	*Guarea thompsonii* Sprague & Hutch.	Meliaceae	6	1.16
44	*Harungana madagascariensis* Lam. ex Poir.	Guttiferae	1	0.19
45	*Homalium letestui* Pellegr.	Flacourtiaceae	2	0.39
46	*Homalium macropterum* Gilg	Flacourtiaceae	1	0.19
47	*Khaya ivorensis* A. Chev.	Meliaceae	1	0.19
48	*Lannea welwitschia* (Hiern) Engl.	Anacardiaceae	5	0.97
49	*Lonchocarpus cyanescens* Perkin	Papilionoideae	1	0.19
50	*Lophira alata* Banks ex Gaertn.	Ochnaceae	17	3.28
51	*Macaranga barteri* Müll.-Arg.	Euphorbiaceae	11	2.12

S/No.	Species Name/Authority	Family	DHa^{-1}	RD
52	*Microdesma oleosa*	Pandaceae	1	0.19
53	*Monodoramyristica* (Gaertn.) Dunal	Annonaceae	1	0.19
54	*Musangacercopioides* R.Br. &Tedlie	Moraceae	9	1.74
55	*Nauclea diderrichii* (De Wild. &T.Durand) Merr.	Rubiaceae	1	0.19
56	*Omophlacarpum procerum* P. Beauv.	Sapotaceae	4	0.77
57	*Palisota hirsuta* (Thunb.) K. Schum.	Commelinaceae	1	0.19
58	*Pausinystalia yohimbe* (K. Schum.) Pierre ex.	Rubiaceae	2	0.39
59	*Pausinystatia macroceras* (K. Schum.) Pierre ex.	Rubiaceae	1	0.19
60	*Pentaclethra macrophylla* Benth.	Mimosoideae	9	1.74
61	*Pentadesma butyracea* Sabine	Guttiferae	7	1.35
62	*Petersianthus macrocarpus* P. Beuav.	Lecythidaceae	2	0.39
63	*Phyllanthus discoideus* (Baill.) Müll.Arg.	Euphorbiaceae	2	0.39
64	*Piptadeniastrum africanum* (Hook.f.) Brenan	Mimosoideae	16	3.09
65	*Psydrax arnoldiana* (De Wild & Th. Dur.) Bridson	Rubiaceae	5	0.97
66	*Pycnanthus angolensis* (Welw.) Warb.	Myristicaceae	8	1.54
67	*Rauvolfia vomitoria* Afzel.,	Apocynaceae	8	1.54
68	*Rinorea dentata* (P. Beauv.)	Violaceae	2	0.39
69	*Rinorea welwitschii* Oliv. Kuntze	Violaceae	4	0.77
70	*Rothmannia hispida* (K Schum.) Fagerlind	Rubiaceae	7	1.35
71	*Sterculia rhinoptala*	Streculiaceae	5	0.97
72	*Sterculia oblonga* Mast.	Streculiaceae	1	0.19
73	*Strombosia grandifolia* Hook.f.	Olacaceae	37	7.14
74	*Strombosia pustulata* Oliv.	Olacaceae	29	5.60
75	*Tabenaemontana pachysiphon* Stapf	Apocynaceae	3	0.58
76	*Tebenaemontana penduliflora* K. Schum.	Apocynaceae	4	0.77
77	*Treculia africana* Decne.	Moraceae	1	0.19
78	*Trichilia lanata* A.Chev.	Meliaceae	1	0.19
79	*Trichilia monodelpha* (Thonn.) JJ de Wilde	Meliaceae	10	1.93
80	*Triplochiton scleroxylon*K Schum.	Sterculiaceae	9	1.74
81	*Xylopiaacutiflora* (Dunal) A. Rich.	Annonaceae	6	1.16
82	*Xylopia aethiopica* (Dunal) A. Rich.	Annonaceae	3	0.58
83	*Xylopia quintasii* Pierre ex Engl. & Diels	Annonaceae	3	0.58
84	*Zanthoxylum gilleti* (De Wild.) P.G. Waterman	Rutaceae	4	0.77
85	*Zanthoxylum zanthoxyloides* (Lam.) Zepern. &Timler	Rutaceae	7	1.35
	No of Trees (ha^{-1})		**518**	**100.0**

Table 2. Tree Species Diversity in Cassava (*Manihot esculenta*)farming System

S/No.	Species Name/Authority	Family	DHa^{-1}	RD
1	*Albizia adianthifolia* (Schum.) W Wight	Mimosoideae	12	8.5
2	*Albizia zygia* (DC.) JF Macbride	Mimosoideae	1	0.7
3	*Alchornea cordifolia* (Schum. &Thonn.) Müll.-Arg	Euphorbiaceae	1	0.8
4	*Alstonia boonei* De Wild	Apocynaceae	16	11.3
5	*Amphimas pterocarpoides* Pierre ex Harms	Papilionoideae	3	2.1
6	*Antiaris Africana* Engl.	Moraceae	2	1.5
7	*Baphia nitida* Lodd.	Papilionoideae	1	0.8
8	*Bombax buonopozense* P. Beauv.	Bombacaceae	2	1.5
9	*Canarium schweinfurthii* Engl.	Burseraceae	1	0.8
10	*Cleistopholis patens* (Benth.) Engl. & Diels	Annonaceae	4	2.8
11	*Distemonanthus benthamianus* Baill.	Caesalpinioideae	24	17.0
12	*Elaeis guineensis* Jacq.	Palmae	25	17.6
13	*Entandrophragma cylindricum* (Sprague) Sprague	Meliaceae	2	1.6
14	*Eribroma oblanga* Mast.	Streculiaceae	4	3.1
15	*Ficus exasperata* Vahl	Moraceae	4	3.1
16	*Irvingia wombulu* Vermoesen.	Irvingiaceae	1	0.8
17	*Khaya ivorensis* A. Chev.	Meliaceae	1	0.8
18	*Leucaena leucocephala* (Lam.) de. Wit)	Fabaceae	2	1.5
19	*Macaranga barteri* Müll.-Arg.	Euphorbiaceae	3	2.1
20	*Maesobotrya barteri* (Sc. Elliot) Keay	Euphorbiaceae	1	0.7
21	*Musanga cecropioides* R.Br. &Tedlie	Moraceae	3	2.1
22	*Myrianthus arboreus* P. Beauv.	Moraceae	1	0.8
23	*Napoleonaea vogelii* (Shrub)	Lecythidaceae	5	3.9
24	*Nauclea diderrichii* De Wild. &T.Durand) Merr.	Rubiaceae	2	1.6

S/No.	Species Name/Authority	Family	DHa^{-1}	RD
25	*Pentaclethra macrophylla* Benth.	Mimosoideae	1	0.7
26	*Piptadeniastrum africanum* (Hook.f.) Brenan	Mimosoideae	3	2.3
27	*Pycnathus angolensis* (Welw.) Warb.	Myristicaceae	5	3.9
28	*Rauvolfia vomitoria* Afzel.,	Apocynaceae	3	2.1
29	*Ricinodendron heudelotii* (Baill.) Pierre	Euphorbiaceae	2	1.4
30	*Spondias mombin* Linn.	Anacardiaceae	1	0.8
31	*Terminalia ivorensis* A. Chev.	Combretaceae	1	0.8
32	*Trema guineensis* (Schumach. &Thonn.) Ficalho	Ulmaceae	1	0.8
	Total No of Trees		**138**	**100**
	Mean No of Trees (ha^{-1})		**35**	

Table 3. Tree Species Diversity in Cocoa (*Theobroma cacao*) Farming System

S/No	Species Name/Authority	Family	D/Ha	RD
1	*Albizia adianthifolia* (Schum.) W Wight	Mimosoideae	4	0.6
2	*Allanblackia floribunda* Oliv.	Guttiferae	6	0.9
3	*Alstonia boonei* De Wild	Apocynaceae	29	4.2
4	*Amphimas pterocarpoides* Pierre ex Harms	Papilionoideae	23	3.3
5	*Anthonotha macrophylla* P. Beauv.	Caesalpinioideae	12	1.7
6	*Blaghia sapida* Konig.	Sapindaceae	4	0.6
7	*Bombax buonopozense* P. Beauv.	Bombacaceae	4	0.6
8	*Buchholzia coriaceae*Engl.	Capparidaceae	4	0.6
9	*Ceiba pentandra* (L.) Gaertn.	Bombacaceae	3	0.5
10	*Cola acuminata* Schott. &Endl.	Streculiaceae	86	12.3
11	*Cola nitida* (Vent.) Schott &Endl.	Streculiaceae	13	1.9
12	*Distemonanthus benthamianus* Baill.	Caesalpinioideae	1	0.1
13	*Elaeis guineensis* Jacq.	Palmae	166	23.9
14	*Entandrophragma angolense. (*Welw.) C.DC.	Meliaceae	4	0.6
15	*Eribromaoblanga* Mast.	Streculiaceae	38	5.5
16	*Ficus camptoneura* Mildbr.	Moraceae	8	1.1
17	*Ficus exasperata* Vahl	Moraceae	10	1.4
18	*Ficus mocoso* Ficalho	Moraceae	4	0.6
19	*Ficus sur* Forssk.	Moraceae	1	0.1
20	*Funtumia elastica* (Precess) Stapf	Apocynaceae	13	1.9
21	*Gmelina arborea* Roxb,	Lamiaceae	68	9.8
22	*Harungana madagascariensis* Lam.	Guttiferae	3	0.4
23	*Hylodendron gabunense* Taub.	Caesalpinioideae	4	0.6
24	*Irvingia wombulu* Vermoesen.	Irvingiaceae	7	1.0
25	*Lannea welwitschii* (Hiern) Engl.	Anacardiaceae	4	0.6
26	*Macaranga barteri* Müll.-Arg.	Euphorbiaceae	16	2.3
27	*Morinda lucida* Benth.	Rubiaceae	1	0.1
28	*Musanga cecropioides* R.Br. &Tedlie	Moraceae	41	5.9
29	*Myrianthus arboreus* P. Beuav.	Moraceae	3	0.5
30	*Pentaclethra macrophylla* Benth.	Mimosoideae	7	1.0
31	*Piptadeniastrum africanum* (Hook.f.) Brenan	Mimosoideae	13	1.8
32	*Psydrax arnoldiana* (De Wild & Th. Dur.) Bridson	Rubiaceae	6	0.9
33	*Pycnanthus angolensis* (Welw.) Warb.	Myristicaceae	15	2.2
34	*Rauvolfia vomitoria* Afzel.,	Apocynaceae	9	1.3
35	*Ricinodendron heudelotii* (Baill.) Pierre	Euphorbiaceae	10	1.4
36	*Spathodea campanulata* P. Beauv.	Bignoniaceae	3	0.5
37	*Strombosia pustulata* Oliv.	Olacaceae	11	1.6
38	*Tectona grandis* L. f.	Lamiaceae	30	4.4
39	*Terminalia ivorensis*A. Chev.	Combretaceae	3	0.5
40	*Terminalia superba* Engl. & Diels	Combretaceae	7	1.0
41	*Trema guineensis* (Schumach.&Thonn.) Ficalho	Ulmaceae	3	0.5
42	*Trichilia monadelpha* (Thonn.) JJ de Wilde	Meliaceae	1	0.1
	Total No of Trees		**696**	100
	Mean No of Trees(ha^{-1})		**174**	

Table 4. Tree Species Diversity in Plantain (*Musa paradisca*) Farming System

S/No.	Species Name/Authority	Family	DHa^{-1}	RD
1	*Albizia adianthifolia* (Schum.) W Wight	Mimosoideae	14	4.4
2	*Albizia zygia* (DC.) JF Macbride	Mimosoideae	32	10.0
3	*Allanblackia floribunda* Oliv.	Guttiferae	2	0.7
4	*Alstonia boonei* De Wild	Apocynaceae	22	6.9
5	*Amphimas pterocarpoides* Pierre ex Harms	Papilionoideae	3	0.9
6	*Anthocleista vogelii* Planch.	Longaniaceae	2	0.7
7	*Baphia nitida* Lodd.	Papilionoideae	2	0.7
8	*Blighia sapida* Konig.	Sapindaceae	2	0.7
9	*Bombax buonopozense* P. Beauv.	Bombacaceae	3	0.9
10	*Brenania brieyi* (De Wild.) Petit	Rubiaceae	6	1.9
11	*Ceiba pentandra* (L.) Gaertn.	Bombacaceae	2	0.7
12	*Cleistopholis patens* (Benth.) Engl. & Diels	Annonaceae	11	3.4
13	*Dacryodes edulis* (G. Don) H. J. Lam	Burseraceae	10	3.1
14	*Diospyros dendo* Welw.	Ebenaceae	2	0.7
15	*Diospyros suaveolens* Gurke	Ebenaceae	9	2.7
16	*Distemonanthus benthamianus* Baill.	Caesalpinioideae	4	1.4
17	*Drypetes chevalieri* Beille	Euphorbiaceae	2	0.7
18	*Elaeis guineensis* Jacq.	Palmae	32	10.0
19	*Entandrophragma utile* (Dawe & Sprague) Sprague	Meliaceae	2	0.7
20	*Eribroma oblanga* Mast.	Streculiaceae	9	2.7
21	*Ficus camptoneura* Mildbr.	Moraceae	2	0.7
22	*Ficus exasperata*Vahl	Moraceae	2	0.7
23	*Funtumia elastica* (Precess) Stapf	Apocynaceae	2	0.7
24	*Hevea brasiliensis* Müll.Arg.	Euphorbiaceae	10	3.1
25	*Humalium letestui* Pellegr.	Flacourticeae	2	0.7
26	*Irvingia wombulu* Vermoesen.	Irvingiaceae	2	0.7
27	*Jatropha curcas* L.	Euphorbiaceae	10	3.1
28	*Macaranga barteri* Müll.-Arg.	Euphorbiaceae	29	8.9
29	*Milicia excelsa* (Welw.) C.C. Berg	Moraceae	2	0.7
30	*Morinda lucida* Benth.	Rubiaceae	2	0.7
31	*Musanga cecropioides* R.Br. &Tedlie	Moraceae	11	3.4
32	*Newbouldia laevis* Seem.	Bignoniaceae	5	1.5
33	*Pentaclethra macrophylla* De Wild. &T.Dur and) Merr.	Mimosoideae	6	1.9
34	*Psydrax arnoldiana* (De Wild & Th. Dur.) Bridson	Rubiaceae	11	3.4
35	*Pycnathus angolensis* (Welw.) Warb.	Myristicaceae	10	3.1
36	*Rauvolfia vomitoria* Afzel.,	Apocynaceae	2	0.7
37	*Ricinodendron heudelotii* (Baill.) Pierre	Euphorbiaceae	5	1.5
38	*Strombosia pustulata* Oliv.	Olacaceae	2	0.7
39	*Tectona grandis* L. f.	Lamiaceae	7	2.2
40	*Terminalia superba* Engl. & Diels	Combretaceae	10	3.0
41	*Theobroma cacao* L.	Malvaceae	9	2.7
42	*Trema guineensis* (Schumach.&Thonn.)Ficalho	Ulmaceae	5	1.5
43	*Trichilia monadelpha* (Thonn.) JJ de Wilde	Meliaceae	2	0.7
44	*Zanthoxylum zanthoxyloides* (Lam.) Zepern. &Timler	Rutaceae	2	0.7
	Total No of Trees		**321**	**100.00**
	Mean No of Trees(ha^{-1})		**80**	

Table 5: The mean vegetation diversity indices of ONP, Cassava, Cocoa and Plantain land uses

	Diversity Indices					
Land Use	**Dominance _D**	**Simpson_ 1-D**	**Shannon _H′**	**Evenness _e^H/S**	**Margalef (*MI*)**	**Menhinick**
ONP	$0.044^{a} \pm 0.002$	$0.956^{b} \pm 0.002$	$3.431^{b} \pm 0.041$	$0.711^{a} \pm 0.011$	$6.834^{b} \pm 0.233$	$1.945^{a} \pm 0.129$
Cassava	$0.236^{b} \pm 0.067$	$0.764^{a} \pm 0.068$	$1.868^{a} \pm 0.288$	$0.711^{a} \pm 0.124$	$3.031^{a} \pm 0.827$	$2.057^{a} \pm 0.446$
Cocoa	$0.182^{ab} \pm 0.027$	$0.818^{ab} \pm 0.027$	$2.168^{a} \pm 0.120$	$0.537^{a} \pm 0.018$	$3.231^{a} \pm 0.226$	$1.492^{a} \pm 0.264$
Plantain	$0.147^{ab} \pm 0.039$	$0.853^{ab} \pm 0.039$	$2.284^{a} \pm 0.278$	$0.734^{a} \pm 0.042$	$3.214^{a} \pm 0.761$	$1.714^{a} \pm 0.339$

Values in each cell signifies mean ± standard error; Values with the same letter indicates no significant difference at ≤ 0.05

Table 6. Summary of Tree Species Abundance and Diversity Indices of ONP, Cassava, Cocoa and Plantain land uses

				Diversity Indices					
Land Use	**Mean plot sizes Ha^{-1}**	**No of Species**	**Density of Trees Ha^{-1}**	**Dominance _D**	**Simpson _ 1-D**	**Shannon _H′**	**Evenness _e^H/S**	**Margalef (*MI*)**	**Menhinick**
ONP	1.00	85	519	0.04	0.96	3.43	0.71	6.83	1.95
Cassava	1.40	32	35	0.24	0.76	1.87	0.71	3.03	2.06
Cocoa	0.64	42	174	0.18	0.82	2.17	0.54	3.23	1.49
Plantain	0.45	44	80	0.15	0.85	2.28	0.73	3.21	1.71

DISCUSSION

Okomu national park had the highest species richness and diversity indices while the lowest diversity index was recorded in the Cassava agroforestry land use. The results of the Shannon index and other indices of ONP show that the tropical rainforests are a mix of rich species diversity. The three crop-based agroforestry practices surveyed were characterized with different trees and shrubs which were indigenous and exotic species. This was an indication that some tree species were deliberately cultivated in those farms. The woody species richness was highest for ONP (85 species), which is the protected area and the lowest number was obtained from the Cassava agroforestry systems (32 species).

Annonaceae, Meliaceae, Rubiaceae, and Sterculiaceae families were the most prominent families in the national park; families Moraceae and Mimosoideae were the dominant species common to the three-agroforestry land uses inventoried. The Euphorbiaceae family was present in the protected area but was a prominent family in the farming systems. These families have been reported among the dominant families in most studies carried out in some tropical rainforest's ecosystems by Adekunle (2006); Onyekwelu*et al*. (2008); Salami and Akinyele (2018). However, Euphorbiaceae was the richest family recorded in the Cassava and Plantain faming systems. Some authors have listed the family Euphorbiaceae as a major dominant family in rainforest diversity studies (Ifo*et al*., 2016; Onyekwelu*et al*., 2008). Also, the dominant tree species in the protected areas include *Eribroma oblanga*, *Strombosia grandifolia*, while the dominant species common to the three agroforestry land uses are *Elaeis guineensis*, *Alstonia boonei* and *Albizia adianthifolia*. The occurrence of different dominant species across the different sites could be attributed to the effect of forest degradation (Onyekwelu*et al*., 2008).

The results of the species diversity indices revealed that the biodiversity did not vary greatly among the threefarming systems inventoried but significantly differed from the diversity and abundance of ONP. The mean Shannon-Weiner diversity of ONP (3.43) showed that ONP was most diverse, and this can be attributed to the national park being a protected area. Similar result of 3.656 and 3.342 was obtained by Adekunle (2006) for Shasha Forest Reserve and Omo Forest Reserve respectively. Although, the Shannon-Weiner value was lowest in the Cassava farming system (1.868), the value was not significantly different from the other farming systems. Oke and Jamala (2013) explained that agroforestry plots surveyed may have contained a variety of woody species but Shannon index indicated that they show a lower species diversity than the natural forest. Going further, the Simpson's index for ONP, Cassava, Cocoa and Plantain land uses indicated that species diversity was high in all land uses inventoried. Adekunle (2006) obtained a similar Simpson's

value of 0.914, 0.908 and 0.900 for Shasha, Ala and Omo Forest Reserves respectively. Also, Naidu *et al*. (2018) had a similar value of 0.97 - 0.98 in the tropical forest inventory carried out in Ghats, India.

The four land uses surveyed had no significant difference in terms of species evenness indicatiing there was similar distribution of the different woody species present on the farming systems. Evenness, according to Morris *et al*. (2014), represents the degree to which individuals are split among species with low values indicating that one or a few species dominate, while high values indicate that relatively equal numbers of individuals belong to each species.The three agroforestry land uses surveyed had no significant difference in the diversity indices analyzed. Molla and Kewassa (2015) obtained a contrary result which provided theat there was a significant difference in diversity indices among the different traditional agroforestry settlements surveyed in Dellomenna District of Southeastern Ethiopia. Although the Plantain agroforestry system had more species richness than the Cassava systems, the species composition in both systems had some similarities. *Elaeis guineensis, Alstoniaboonei, Albizia adianthifolia* were the dominant species common to both farming systems. Cocoa agroforestry recorded the highest population of *Elaeis guineensis*. This was followed by *Cola acuminata*. *E. guineensis* (Oil Palm) was the most common species in the traditional cocoa farming system surveyed by Oke and Odebiyi (2007) in Ondo State, Nigeria. The retention of *E.guineensis*, Cola species on farmlands by farmers can be attributed to the economic value of the species. Farmers in South West Nigeria, and West Africa countries like Cameroon retained useful economic trees in their cocoa farms which also provided shades for the cocoa trees (Oke and Odebiyi, 2007; Gockowski*et al*., 2004). Furthermore, the cocoa farm was a mix of a total of 42 different tree species ranging from timber to fruit trees, giving the cocoa farms diversity similar to forest ecosystem. Several studies have shown that these species are usually associated with cocoa farming in Nigeria. Also, the complex, structural diversity observed in the Cocoa farms indicates that the system supports the conservation of some forest tree species. Alves (1990), described the Cocoa agroforestry in Southern Bahia, as a system that allows economic development while maintaining a portion of the original forest diversity and thus preserving wildlife. The results of the cocoa and plantain diversity showed that both land uses held a biodiversity structure therefore can effectively serve as a transition zone between the forest and open crop lands to reduce edge effects,as an environment similar to forest habitats will be created.

CONCLUSION

The information obtained from the inventory studies indicate the diversity - Shannon, Simpson's and Margalef - indices for this study shows that ONP was the richest and most diverse of all land uses surveyed. However, there was no significant difference in the species evenness of the four systems. The Shannon values of the three agroforestry farms were significantly different from the value of ONP indicating that species richness, eveness and abundance decrease as forest degradation and farming activities increase. In addition, the species diversity of the cocoa and plantain agroforestry systems implies that conservation of important tree species is possible in such systems, which suggests that agroforestry systems around protected areas area potentially effective strategy for in situ conservation of some rare tropical forest species. Therefore, practice of agroforestry should be encouragedowing to the successful practice recorded in the study area, as it also provides an ecosystem similar to the neighboring forest.

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