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Influence of Taungya Agroforestry System on Diversity of Native Woody Species and Soil Physico-Chemical Properties in Nigeria

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Abstract- This study assessed the effects of agroforestry system on diversity of native woody species and soil physico-chemical properties. This was achieved by comparing floristic composition and soil physico-chemical properties in four different *Taungya* agroforestry sites and a natural regrowth forest reserve where active logging has not taken place in Ondo State, Nigeria. Two sample plots of 25 m x 25 m were assessed in each site using systematic sampling techniques. All the plants were identified to species level and categorized into tree, shrub, perennial herb, scrambling shrub, epiphyte, climber and their families were identified. Shannon-Weiner and species evenness indices were used to assess and compare native woody species diversity and abundance. Five soil samples were randomly collected from each agroforest plot and natural regrowth forest at depths of 0-15 cm and 15-30 cm using a soil auger to give a total of one hundred soil samples which were air-dried and sieved using 2.0 mm sieve. The results showed that the study area was richer in arable crops compared to native woody species as there were 54 species distributed into 28 families in the natural regrowth forest, 11 species distributed into 9 families in Aponmu, 19 species distributed into 19 families in Owo, 11 species distributed into 10 families in Idanre, and 8 species distributed into 7 families in Ore. Species density gradually reduced from 1392 ha^{-1} in natural regrowth forest to 1192 ha^{-1}, 848 ha^{-1}, 664 $ha^{-1}$and 432 ha^{-1} in Owo, Idanre, Ore and Aponmu *Taungya* agroforests respectively. More climber species were encountered in natural regrowth forest compared to the *Taungya* agroforest sites. Shrubs species recorded were higher in most of the *Taungya* sites compared to natural regrowth forest. The soil texture of all sites, except Owo *Taungya* were sandy clay loam at the two soil depths. The soil pH ranged from 5.3 to 7.1 for the top soil and from 4.0 to 7.0 for the sub soil. Ore *Taungya* site was significantly higher ($P < 0.05$) in soil organic carbon (2.46 g/kg) and total nitrogen (0.20 g/kg) when compared with other agroforestry sites. The cation exchangeable capacity (6.77 cmol/kg) was highest at Aponmu site. These values however, decreased with depths. This study concluded that *Taungya* agroforest averagely enhanced native plant biodiversity conservation and significantly improved the soil quality of the study area.

Index Terms- Taungya, natural regrowth forest, soil physico-chemical properties, species distribution

I. Introduction

Transformation of forest reserves to other land-uses in recent times has caused many complex changes in the forest ecosystem (Henrik *et al.*, 2010, Awotoye *et al.*, 2013); one of such changes is the emergence of *Taungya* agroforestry practice within the forest reserves in Nigeria. *Taungya* farming is the fore-runner to agroforestry. It is of Burmese origin and means "hill" (*Taung*), "cultivation" (*ya*) (Nair, 1993). According to Adedire (2005), agroforestry is a collective name for land-use systems and practices of deliberately growing or retaining trees or shrubs within an agricultural or pastoral land use system, either under the same form of spatial arrangement or in temporal sequence. Approved *Taungya* is the allocation of land to farmers in forest reserves where tree seedlings and arable crops are planted together (Adekunle and Bakare, 2004), it is considered a management option, as a result of many degradation that has taken place in forest ecosystems which, is beyond their capacity to enhance and conserve native woody species diversity (Brown and Boutin, 2009). The increasing size of the world population has led to a tremendous rise in the demand for food and energy. As a result, more forest reserves in the country are now being converted at high pace to farmland and other uses than ever before. According to Roche (1993) *Taungya* may prove to be one of the cheapest means of establishing forests of all kinds and at the same time supplying food for the general population. *Taungya* farming involves the growing of annual or biennial agricultural crops along with the forest species during the early years of establishment of the forest plantation (Jordan *et al*., 1992). The long-term effect of *taungya* practice on regeneration of native woody plant diversity and soil fertility will however depend on the management practices adopted at the initial time as well as subsequent re-establishment phases (Jordan *et al.*, 1992). Many other factors such as canopy cover percentage, leaf area index and stem density (Hardtle *et al.,* 2003 and Lemenih *et al.,* 2004), substrate quality, litter mass depth (Dzwonko and Gawronski, 2002), land use history (Gachet *et al.,* 2007), management practices (Brown and Boutin 2009) and Farmers attitude (Adekunle and Bakare, 2004) determine the ability of *taungya* system to allow natural regeneration of native woody species. Adekunle and Bakare (2004) reported that, the only species most of the respondents in Ondo State were willing to plant was *Tectona grandis* and those native species retained on farmland are tropical indigenous hardwood species such as *Triplochiton scleroxylon*, *Mansonia altissima*, *Chrysophyllum* *albidum*, *Celtis zenkeri*, *Milicia excelsa*, *Khaya ivorensis*, *Afzelia africana*, *Strombosia pustulata*, *Treculia africana*, etc. It is important to understand that agroforests are not specifically conceived by farmers to allow biodiversity conservation, instead biodiversity restoration in agroforests results mainly from unintentional processes (Michon and de Foresta, 1995). Nevertheless, with the wide practice of *taungya* and many other agroforestry practices, it is important that further studies are carried out to assess the extent to which these methods of land use can provide habitat for indigenous woody species diversity especially in the tropics. Hence this paper seeks to highlight the contribution of *taungya* agroforestry system as a type of land use method adopted in forest reserve management to conserve native woody species diversity and maintain soil fertility.

II. Materials and Methods

Study Area

The study was carried out in five locations namely, Idanre (Latitude N 06^0 44 20¹, Longitude E 004^0 46 44¹), Owo (Latitude N 06^0 57.32¹, Longitude E 005^0.37.41.4¹), Aponmu (Latitude N07^{0}14.67¹, Longitude E005^0 02.53¹), Ore (Latitude N 06^0 44. 19¹, Longitude E 004^0 46.43¹) and Natural regrowth forest (Latitude N07^0 15.03¹, Longitude E005^{0}02.39¹). Aponmu in Ondo State, Nigeria. There are two distinct geological regions in the study area. First, is the region of sedimentary rocks in the southern part (i.e Idanre and Ore sites), and secondly, the region of Pre-Cambrian Basement Complex rocks in the northern part (i.e Aponmu and Owo sites), the basement complex is mainly of the medium grained gneisses. These are strongly foliated rocks frequently occurring as out crops. A small proportion of the area, especially to the northeast, overlies the coarse grained granites and gneisses, which are poor in dark ferromagnesian minerals (Smyth and Montgomery, 1962). And the soils derived from the Basement complex rocks are mostly well drained, with a medium texture. The soils, classified as Ondo Association, are of high agricultural value for both tree and arable crops.

The climate of the sites is of the lowland tropical rain forest type, with distinct wet and dry seasons. In the southern part (i.e Idanre and Ore sites), the mean monthly temperature is 27°C, with a mean monthly range of 2°C, while mean relative humidity is over seventy five percent. However, in the northern part (i.e Aponmu and Owo sites), the mean monthly temperature and its range are about 30°C and 6°C respectively. The mean monthly relative humidity is less than seventy percent. In the southern part, rain falls throughout the year, but the three months of November, December and January may be relatively dry. The mean annual total rainfall exceeds 2000 millimetres. However, in the northern part, there is marked dry season from November to March when little or no rain falls. The total annual rainfall in the northern part, therefore, drops considerably to about 1800 millimetres.

The natural vegetation of the sites is of the high forest, composed of many varieties of hardwood timber. The *Taungya* sites were part of forest reserve formerly but now de-reserved.

Survey Method

Four *taungya* agroforestry sites and one natural regrowth forest site were used in order to determine the floristic composition, species diversity and soil physico-chemical properties within each site. Two sample plots of 25 m x 25 m, were mapped out in each site. A *Taungya* agroforest plantation which was established in the year 2007 was used for the whole assessment in each location. All plant species were identified on the field to species level. Those that could not be identified on the field were collected, labelled and brought to Ife Herbarium for proper identification. The woody species were identified and enumerated and their girths at breast height (GBH) cm were measured using girthing tape.

Plant Parameter Measurements

The following parameters were measured in each site:

Plant species density, tree height, girth at breast height (GBH), basal area, Shannon-Weiner diversity index H^1, index of species richness, and Simpson index of similarity.

Plant species density (ha^{-1}): Plant species density (ha^{-1}) was calculated as the number of plant species per plot converted to hectare using the formula below:

$$\text{Plant species density (ha}^{-1}) = \frac{x}{25 \times 25} \times 10{,}000 \quad \ldots\ldots (1)$$

Where x = Number of plant species

Relative density: This was calculated using the formula below:

$$RD = \frac{x}{100} \times 100 \quad \ldots\ldots (2)$$

Where x = number of plant species

Tree height: Tree height of each woody species within each plot was measured using a graduated ranging pole.

Girth at breast height (GBH) and Basal area (m^2): Within each plot, woody plant girths were measured at breast height (GBH) with a tape for trees that were 3m or more tall and at mid-point for those less than 3m tall. The girth measurements were used to calculate the basal area of each tree using the formula below:

$$\text{Basal area } (m^2) = \frac{c^2}{4\pi} \quad \ldots\ldots (3)$$

Where c = girth at breast height in meters

π = constant value of 3.14

The basal area (m^2 ha^{-1}) for each species and all the woody species were calculated for each plot according to equation (3).

Shannon-Weiner diversity index H^1: It was calculated using equation (4):

$$\text{Shannon-Weiner diversity index } (H^1) = -\sum_{i=1}^{s} p_i \ln(p_i) \quad \ldots\ldots$$

Where

H^1 = Shannon-Weiner diversity index

S = total number of species in the plot

P_i = proportion of a species to the total number of plants in the community

ln = natural logarithm

Menhinick's index of species richness: and this was calculated as:

$$d = \frac{s}{\sqrt{n}} \quad \ldots (5)$$

d = Menhinick's index of species richness
s = number of species per plot
n = number of plant per plot

Simpson index of similarity: and this was calculated as:

$$SI = 100 \times \frac{a}{(a+b+c+d+e)} \quad \ldots (6)$$

a = Number of species present in both site under consideration
b = Number of species present in site 1 but absent in site 2
c = Number of species present in site 2 but absent in site 1
d= Number of species present in site 3 but absent in site 1 and 2
e= Number of species present in site 4 but absent in site 1, 2 and 3

Soil Sampling

Five quadrats of 5m x 5m were made within each 25m x 25m plot from where soil samples were randomly collected from each plot of agroforest and natural regrowth forest at depths of 0-15cm and 15-30cm using a soil auger to give a total of one hundred soil samples which were air-dried and sieved using 2.0 mm sieve.

Soil Laboratory Analysis

Water Holding Capacity of the Soil was determined according to the method of Pramer and Schmidt (1964). The soil bulk density was determined by adopting core method (Blake and Hartge, 1986), particle size by hydrometer method (Bouyoucous, 1962), organic matter and carbon by Walkley-Black wet oxidation method (Nelson and Sommers, 1982) as well as total nitrogen by micro-kjeldal digestion method (Bremner *et al.*, 1994). The soil pH was measured electrometrically in water at 1:2 soil/water ratio using pH meter (Rhoades, 1996). Exchangeable acidity was determined by titration method (Mclean, 1965). Available phosphorus was determined by using Bray No.1 method, while exchangeable cations (K^+, Ca^{2+}, Na^+ and Mg^{2+}) was determined using 1M NH_4OAc buffered at pH 7.0 as extractant. Also, the Atomic Absorption Spectrophotometer was used to read the K^+ and Na^+ concentrations in the soil samples. In the data analysis, one way analysis of variance (ANOVA) and Duncan multiple range tests were employed to separate treatment means with a significance level of $P < 0.05$.

III. Results

Vegetation parameters

Density of the Woody Species (per hectare) in all the Five Study Sites.

The density of the woody species (per hectare) in all the five study sites is presented in Table 1. There was a total of 432 plants ha^{-1} consisting of 11 species in Aponmu site where *Cola gigantea* was the native species with the highest density while *Albizia adanthifolia*, *Alchornea cordifolia*, *Antiaris toxicaria*, *Blighia sapida*, *Lecaniodescus cupanioides*, *Margaritaria discoidea* and *Vernonia amygdalina* had the lowest density of 8 plants ha^{-1} each. In Idanre site, 832 individual plants ha^{-1} consisting of 9 species were assessed *Rauvolfia vomitoria* had the highest density of 56 plants ha^{-1} while *Capsicum frutescens* and *Lonchocarpus cyanescens* had the lowest density of 8 plants ha^{-1} each. Owo site had 1176 individual plants ha^{-1} consisting of 17 species where *Ficus exasperata* had the highest density of 24 plants ha^{-1} while *Antiaris toxicaria, Baphia nitida, Cola gigantea, Deinbollia pinnata, Ficus mucoso, Lecaniodescus cupanioides, Mallotus opupositifolius, Markhamia tomentosa, Newbouldia laevis, Ricinodendron heudelotii, Uvaria chamae* and *Vernonia amygdalina* had the lowest density of 8 plants ha^{-1} each. Ore site had 664 individual plants ha^{-1} consisting of 8 species where *Vernonia amygdalina* had the highest density of 56 plants ha^{-1} while *Cola millenii* had the lowest density of 16 plants ha^{-1}. Natural regrowth forest site had 1392 plants ha^{-1} consisting of 49 species where *Cola gigantea* had the highest density of 280 plants ha^{-1} while *Bosqueia angolensis*, *Brachystegia euryoma*, *Deinbollia pinnata, Ficus mucoso, Ficus sur, Lecaniodescus cupanioides, Mallotus oppositifolius, Markhamia tomentosa, Buchholzia coriacea, Cathium spp, Cnestis ferruginea, Cuviera acutiflora, Diospyros menbuttensis, Drypetes gilgiana, Glyphaea brevis, Helalobus monopetalus, Holoptelea grandis, Lecaniodescus cupanioides, Margaritaria discoidea, Myrianthus arboreus, Picralima nitida, Pterocarpus osun, Ricinodendron heudelotii, Stemonocoleus micranthus, Sterculia oblonga, Sterculia rhinopetala* and *Terminalia superba* had the lowest density of 8 plants ha^{-1} each. Overall, site E had the highest native woody species density per hectare (1392 ha^{-1}) while site A had the lowest (432 ha^{-1}).

Table 1: Density of woody species (per hectare) in all five of the study sites.

S/N	SPECIES	FAMILY	Density ha-1 Aponmu	Idanre	Owo	Ore	Natural forest
1	*Albizia adanthifolia*	Mimosoideae	8	16	-	-	-
2	*Albizia zygia*	Mimosoideae	-	-	-	-	16
3	*Alchornea cordifolia*	Euphorbiaceae	8	16	-	-	-
4	*Antiraris toxicaria*	Moraceae	8	-	8		16
5	*Baphia nitida*	Papilionaceae	-	24 ± 8	8	16	24±8
6	*Blighia sapida*	Sapindaceae	8	-	24 ±8	-	32±16
7	*Bosqueia angolensis*	Moraceae	-	-	-	-	8
8	*Brachystegia euryoma*	Caesalpiniodeae	-	-	-	-	8
9	*Buchholzia coriacea*	Capparaceae	-	-	-	-	8
10	*Capsicum frutescens*	Solanaceae	-	8	-	-	-
11	*Cathium spp*	Compositae	-	-	-	-	8
12	*Celtis mildbraedii*	Ulmaceae	-	-	-	-	16
13	*Celtis zenkeri*	Ulmaceae	-	-	-	-	40±8
14	*Chrysophyllum albidum*	Sapotaceae	-	-	-	-	32
15	*Cleistopholis patens*	Annonaceae	-	-	-	-	16
16	*Cnestis ferruginea*	Connaraceae	-	-	-	-	8
17	*Cola gigantea*	Sterculiaceae	16	-	8	-	280
18	*Cola millenii*	Sterculiaceae	-	-	-	8	48
19	*Cuviera acutiflora*	Rubiaceae	-	-	-	-	8
20	*Deinbollia pinnata*	Sapindaceae	-	-	8	-	-
21	*Diospyros dendo*	Ebenaceae	-	-	-	-	64
22	*Diospyros menbuttensis*	Ebenaceae	-	-	-	-	8
23	*Diospyros soubreana*	Ebenaceae	-	-	-	-	80±16
24	*Drypetes chevalieri*	Euphorbiaceae	-	-	-	-	64
25	*Drypetes gilgiana*	Euphorbiaceae	-	-	-	-	8
26	*Enanthea chlorantha*	Annonaceae	-	-	-	-	16
27	*Faraga macrophylla*	Rutacea	-	-	-	-	16
28	*Ficus mucoso*	Moraceae	-	-	8	-	8
29	*Ficus exasperate*	Moraceae	-	-	24 ±8	-	-
30	*Ficus sur*	Moraceae	-	-	-	-	-
31	*Funtumia elastica*	Apocynaceae	-	-	-	16	104±24
32	*Glyphaea brevis*	Tiliaceae	-	-	-	-	8
33	*Helalobus monopetalus*	Annonaceae	-	-	-	-	8
34	*Holoptelea grandis*	Ulmaceae	-	-	-	-	8
35	*Lannea welivitschii*	Anacardiaceae	-	-	-	-	16
36	*Lencaniodescus cupanioides*	Sapindaceae	8	-	8	-	8
37	*Lonchocarpus cyanescens*	Papilionaceae	-	8	-	-	-
38	*Lonchocarpus sericeus*	Papilionaceae	-	-	-	-	16
39	*Mallotus oppositifolius*	Euphorbiaceae	-	-	8	-	72±8
40	*Manihot esculentum*	Euphorbiaceae	64 ± 16	456± 24	608±96	352±48	-
41	*Mansonia altissima*	Sterculiaceae	-	-	-	-	40±8
42	*Margaritaria discoidea*	Euphorbiaceae	8	-	-	-	8
43	*Markhamia tomentosa*	Bignomiaceae	-	-	8	-	-
44	*Microdesmis puberula*	Pandaceae	-	-	-	-	32
45	*Milicia excelsa*	Moraceae	-	-	-	-	16
46	*Musa parasidica*	Musaceae	8	-	-	-	-
47	*Musa sapientum*	Musaceae	-	96± 16	224±32	128±16	-
48	*Myrianthus arboreus*	Moraceae	-	-	-	-	8
49	*Newbouldia laevis*	Bignoniaceae	-	-	8	-	-
50	*Picralima nitida*	Apocynaceae	-	-	-	-	8
51	*Pterocarpus osun*	Papilionaceae	-	-	-	-	8
52	*Rauvolfia vomitoria*	Apocynaceae	-	56 ± 8	-	16	-
53	*Ricinodendron heudelotii*	Euphorbiaceae	-	-	8	-	8
54	*Rinorea dentate*	Violaceae	-	-	-	-	24±8
55	*Rothmannia longiflora*	Rubiaceae	-	-	-	-	16

56	*Sorindeia warneckei*	Anacardiaceae	-	-	-	-	24
57	*Stemonocoleus micranthus*	Caesalpinioideae	-	-	-	-	8
58	*Sterculia oblonga*	Sterculiaceae	-	-	-	-	8
59	*Sterculia rhinopetala*	Sterculiaceae	-	-	-	-	8
60	*Strombosia pustulata*	Olacaceae	-	-	-	-	72±24
61	*Tectona grandis*	Verbenaceae	288 ± 32	152± 24	200±24	72±24	-
62	*Terminalia superba*	Combretaceae	-	-	-	-	8
63	*Trichilia prieuriaria*	Meliaceae	-	-	-	-	24
64	*Uvaria chamae*	Annonaceae	-	-	8	-	-
65	*Vernonia amygdalina*	Asteraceae	8	-	8	56±24	-
	Total		432	832	1176	664	1392

* ± Standard Error.

Comparison of Vegetation Variables of the Five Study Sites.

The comparative analysis of the vegetation parameters which include, density per hectare, mean GBH, mean height, most abundant family, most abundant species, habit, Shannon-Weiner index of diversity, index of species richness, basal area, Sorenson index of similarity is presented in Table 2. There was considerable variation in the plant species composition and abundance in all the five study sites. The most abundant plant species encountered in Aponmu *Taungya* agroforest and in natural regrowth forest was the *Cola gigantea* and in Idanre, Owo and Ore (*Taungya* agroforests) *Rauvolfia vomitoria*, *Ficus exasperata* and *Vernonia amygdalina* were the most abundant plant species encountered. The most abundant family encountered in Aponmu *Taungya* agroforest was the family Verbenaceae and in Idanre, Owo and Ore (*Taungya* agroforests) the family Euphorbiaceae was the most abundant family encountered, while the most abundant family encountered in Natural regrowth forest was the family Sterculiaceae. The species diversity index was found to be highest in Natural regrowth forest (H^1 = 3.43), low in Aponmu *Taungya* site (H^1 = 1.27). The assessment of similarity between the five study sites using Sorenson's index of similarity (Table 3) showed that, Idanre and Ore *Taungya* sites had the highest similarity (90.5 %) closely followed by Owo and Ore *Taungya* sites (90.1 %). The lowest similarity was found between Ore *Taungya* site and Natural regrowth forest (1.4 %) while Aponmu and Idanre *Taungya* sites had (80.0 %), Idanre and Owo *Taungya* sites (87.5 %), Aponmu *Taungya* and Natural regrowth forest sites (21.5%), Ore and Aponmu *Taungya* sites (75.8 %), Owo and Aponmu *Taungya* sites (77.8 %), Owo *Taungya* and Natural regrowth forest sites (20.4%), Ore *Taungya* and Natural regrowth forest sites (10.51%). Highest species density of 1488 plants $ha^{-1}$was encountered in the natural forest site while the lowest species density of 432 plants ha^{-1} was encountered in Aponmu *Taungya* sites. The comparison in terms of the basal area revealed that Natural regrowth forest had the highest basal area (25.89 m^2 ha^{-1}) and Ore *Taungya* agroforest had the lowest basal area (1.67 m^2 ha^{-1}). The composition of plants in terms of their habit also revealed that Natural regrowth forest had the largest tree species (1176 ha^{-1}) while Ore Taungya had the lowest (334 ha^{-1}). Owo *Taungya* agroforest site, had the largest shrub species (648 ha^{-1}) and Aponmu *Taungya* agroforest site, had the lowest shrub species (80 ha^{-1}). Owo *Taungya* agroforest also had the largest perennial herb species (224 ha^{-1}) and Natural regrowth forest had the lowest (0 ha^{-1}). Scrambling shrubs were not present in all the sites except in Natural regrowth forest and Idanre *Taungya* agroforest where three and one species per hectare of scrambling shrubs were encountered respectively. The natural regrowth forest had a dense growth of trees and climbers than the *Taungya* agroforest sites. Epiphytes were not present in all the sites except in Owo and Idanre *Taungya* agroforests where eight species per hectare of epiphytes was encountered (Table 2).

Table 2. Summary of the vegetation comparing the five study sites

SPECIES VARIABLES	APONMU	IDANRE	OWO	ORE	NATURAL REGROWTH FOREST	TOTAL
Number of family	9	10	11	7	28	62
Number of species	11	11	19	8	54	98
Density (ha^{-1})	432	848	1192	664	1488	4624
Mean basal area	10.44	3.23	9.07	1.67	25.89	50.29
Total mean GBH	234.6	120.5	414.97	80.83	1241.1	2029
Total mean height	53.3	37.7	81.3	37.18	405.3	614.78
Most abundant family	Verbenaceae	Euphorbiaceae	Euphorbiaceae	Euphorbiaceae	Sterculiaceae	
Most abundant native woody species	*Cola gigantea*	*Rauvolfia vomitoria*	*Ficus exasperate*	*Vernonia amygdalina*	*Cola gigantea*	
HABIT DESCRIPTION						TOTAL
Tree	334	168	312	112	1176	2112
Shrub	80	560	648	424	192	1904
Perennial herb	8	96	224	128	0	456
Scrambling shrub	0	8	0	0	24	32
Epiphyte	0	8	8	0	0	16
Climber	0	8	0	0	96	104
Shannon-Weiner	1.26623	1.49451	1.58448	1.42582	3.4326	

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Table 3: Sorenson Species Index of Similarity (%)

SITES	Aponmu	Idanre	Owo	Ore	Natural Regrowth Forest
Aponmu	-	-	-	-	-
Idanre	80.0	-	-	-	-
Owo	77.8	87.5	-	-	-
Ore	75.8	90.5	90.1	-	-
Natural Regrowth Forest	21.5	1.4	20.4	10.51	-

Soil Parameters

(a) Particle size distribution

Owo *Taungya* agroforest site had the highest sand content (70 % and 69 %) at both 0-15 cm and 15-30 cm depths respectively and *Taungya* agroforest at Aponmu site had the lowest sand (46 % and 45 %). These values were significantly different ($P < 0.05$). The sand fraction is also significantly higher than silt and clay in all the sites (Table 4). The textural classification revealed that the soil of all the study sites at 0-15 cm were sandy clay loam except the *Taungya* agroforest in Owo site which was loam sand while at 15-30 cm all the five study sites were sandy clay loam.

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Table 4: Particle size distribution of the soil in all the sites under consideration

	0-15 cm depth				15-30 cm depth			
Land use type	Sand %	Silt %	Clay %	Textural Class	Sand %	Silt %	Clay %	Textural Class
Natural regrowth forest (NRF)	64^{d}	21^{c}	15^{b}	Sandy clay loam	62^{c}	20^{c}	19^{c}	Sandy clay loam
Taungya Agroforest Idanre (TID)	52^{b}	17^{b}	31^{d}	Sandy clay loam	50^{b}	18^{b}	20^{c}	Sandy clay loam
Taungya Agroforest Ore (TOR)	62^{c}	15^{a}	23^{c}	Sandy clay loam	61^{c}	16^{a}	24^{d}	Sandy clay loam
Taungya Agroforest Owo (TOW)	70^{e}	19^{bc}	11^{a}	Loam sand	69^{d}	20^{c}	10^{a}	Sandy clay loam
Taungya Agroforest Aponmu (TAP)	46^{a}	39^{d}	15^{b}	Sandy clay loam	45^{a}	40^{d}	16^{b}	Sandy clay loam

*Values followed by the same letter in the same column are not significantly different at $P < 0.05$ Level according to Duncan multiple range test.

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(b) Soil pH

Aponmu *Taungya* agroforest site had the highest pH value (7.1) at 0-15 cm, closely followed by Owo *Taungya* agroforest site (7.0) while the Ore Taungya agroforest site had the lowest pH value (5.3). The *Taungya* agroforests at Aponmu and Owo sites were significantly higher ($P < 0.05$) than other three sites (Table 5). The two sites also had the highest pH value (7.0) at 15-30 cm while Ore *Taungya* agroforest site had the lowest pH value (4.0). *Taungya* agroforest Aponmu and *Taungya* agroforest Owo sites were also significantly higher ($P < 0.05$) than other three sites (Table 6).

(c) Water holding capacity

Aponmu *Taungya* agroforest site had the highest water holding capacity value (57.0) at 0-15 cm and Ore *Taungya* agroforest site had the lowest water holding capacity value (42.0). *Taungya* agroforest Aponmu site was significantly higher at ($P < 0.05$) than other four sites (Table 5). Aponmu *Taungya* agroforest site also had the highest water holding capacity value (58.0) at 15-30 cm and Ore *Taungya* agroforest site had the lowest water holding capacity (44.0). The water holding capacity of the soil in Aponmu *Taungya* agroforest site was also significantly higher ($P < 0.05$) than other four sites (Table 6).

(d) Organic matter content

Ore *Taungya* agroforest site had the highest organic matter content (4.28) at 0-15 cm while Owo *Taungya* agroforest site had the lowest organic matter content (2.95). Ore *Taungya* agroforest site was significantly higher ($P < 0.05$) than other four sites (Table 5). Ore *Taungya* agroforest site also had the highest organic matter content (4.23) at 15-30 cm and Owo *Taungya* agroforest site had the lowest organic matter content (1.21). Ore *Taungya* agroforest site was also significantly higher ($P < 0.05$) than other four sites (Table 6).

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Table 5: Chemical characteristics of the top soil at 0-15 cm in the entire site under consideration

Land use type	pH	WHC %	Om g/kg	OC g/kg	TN g/kg	P mg/kg	Ca cmol/kg	Mg cmol/kg	K cmol/kg	Na cmol/kg	EA cmol/kg
NRF	6.2^{c}	48.5^{c}	3.82^{c}	2.22^{c}	0.166^{d}	7.93^{a}	4.63^{c}	0.7^{d}	0.29^{b}	0.2^{a}	0.7^{c}
TID	5.7^{b}	48.3^{c}	3.56^{b}	2.07^{b}	0.158^{c}	13.99^{d}	3.13^{a}	0.5^{c}	0.19^{a}	0.17^{b}	0.4^{b}
TOR	5.3^{a}	42^{a}	4.28^{d}	2.46^{d}	0.201^{e}	9.33^{c}	4.0^{b}	0.4^{bc}	0.21^{a}	0.16^{c}	0.15^{a}
TOW	7^{d}	46.6^{b}	2.95^{a}	1.72^{a}	0.142^{a}	9.56^{c}	4.63^{c}	0.3^{a}	0.2^{a}	0.16^{c}	0.3^{ab}
TAP	7.1^{d}	57.0^{d}	3.56^{b}	2.07^{b}	0.151^{b}	8.86^{b}	6.0^{d}	0.3^{a}	0.31^{c}	0.16^{c}	0.25^{a}

*Values followed by the same letter in the same column are not significantly different at $P < 0.05$ according to Duncan multiple range test.
TAP (SITE A): Taungya Agroforest Aponmu
TID (SITE B): Taungya Agroforest Idanre
TOW (SITE C): Taungya Agroforest Owo
TOR (SITE D): Taungya Agroforest Ore
NRF (SITE E): Natural regrowth forest

Table 6: Chemical characteristics of sub soil at 15-30 cm in the entire site under consideration

Land use type	pH	WHC %	Om g/kg	OC g/kg	TN g/kg	P mg/kg	Ca cmol/kg	Mg cmol/kg	K cmol/kg	Na cmol/kg	EA cmol/kg
NRF	6.0^{c}	48.8^{c}	2.15^{b}	1.25^{a}	0.093^{b}	10.73^{b}	3.50^{c}	0.5^{b}	0.17^{c}	0.18^{c}	0.6^{d}
TID	4.7^{b}	50.0^{b}	2.63^{c}	1.52^{b}	0.119^{d}	14.92^{d}	1.88^{a}	0.5^{b}	0.16^{bc}	0.16^{b}	0.4^{c}
TOR	4.0^{a}	44.0^{a}	4.23^{d}	2.46^{d}	0.192^{e}	15.39^{e}	3.25^{b}	0.6^{c}	0.15^{b}	0.16^{b}	0.3^{b}
TOW	7.0^{d}	49.7^{b}	1.21^{a}	1.70^{c}	0.061^{a}	12.59^{c}	3.25^{b}	0.4^{a}	0.13^{a}	0.16^{b}	0.2^{a}
TAP	7.0^{d}	58.0^{d}	2.15^{b}	1.25^{a}	0.11^{c}	8.63^{a}	4.38^{d}	0.9^{d}	0.24^{d}	0.13^{a}	0.3^{b}

*Values followed by the same letter in the same column are not significantly different at P value of 5% Level according to Duncan multiple range test.

Legend
TAP (SITE A): Taungya Agroforest in Aponmu
TID (SITE B): Taungya Agroforest in Idanre
TOW (SITE C): Taungya Agroforest in Owo
TOR (SITE D): Taungya Agroforest in Ore
NRF (SITE E): Natural regrowth forest

IV. Discussion

Floristic Composition

Studies on the floristic composition and structure are instrumental in sustainability of forest since they play a major role in the conservation of plant species and in management of ecosystem as a whole (Tilman 1988; Ssegawa and Nkuutu, 2006). Measurement of species diversity is an indicator that helps to determine the well being of an ecological system (Magurran, 1988). Shannon-Weiner index of species diversity indices recorded, revealed that natural regrowth forest had the highest index (3.43), coupled with highest number of individual species (54) and families (28). The value of Shannon-Weiner index (H) of diversity is normally found to fall between 1.5 and 3.5, if the value is close to five it implies high diversity of a particular species (Michael, 1984; Mittermeier *et al*., 1998). Comparatively, Owo agroforest site had the highest species diversity index (1.58) among the *taungya* sites, closely followed by Idanre (1.49) and Ore (1.43), while the least was Aponmu agroforest site (1.27). The implication of this is that the natural regrowth forest is more diverse, than all the *taungya* sites investigated. Generally in terms of plant species density in all the sites examined there is variation in the plant species distribution. The result of the study revealed that natural regrowth forest had the highest native woody plant species density, when compared with the agroforest sites.

The density of the native woody species (Trees and Shrubs) varied considerably in the different sites under consideration; the shrubs were significantly high in most of the *Taungya* sites compared to the natural regrowth forest. Perennial herbs were encountered in the four *Taungya* agroforest sites, but completely absent in the Natural regrowth forest. This was in agreement with White (1983) who noted that, in a forest the ground layer is often sparse or absent; grasses are absent and if present are localized or inconspicuous. Scrambling shrubs were only present in both natural regrowth forest and Idanre *Taungya* agroforest site. The natural regrowth forest had a dense growth of trees and climbers than the *Taungya* agroforest sites. Continuous clearing of vegetation for arable and tree crops had caused reduction in plant diversity in the *Taungya* agroforest sites because it reduces the regeneration of woody trees and climbers. The most abundant native plant species encountered in Aponmu Taungya agroforest site was *Cola gigantea,* while other economic species such as *Albizia adanthifolia, Antiaris toxicaria, Lecaniodescus cupanioides* and *Blighia sapida* were also present but in smaller numbers. This supports the position of Michon and de Foresta (1995) that agroforests help to conserve biodiversity and this is the assurance of agroforest production and reproducibility. The success recorded in Aponmu *Taungya* agroforest site was also enhanced by effective monitoring of the forest by the forest officers, due to the proximity of the forest to the state capital. In all the *Taungya* agroforest sites examined, *Tectona grandis* were the dominant species encountered and this corroborates Adekunle and Bakare (2004) who reported that the only species most of the respondents in Ondo State are willing to plant is *Tectona grandis* since, it is a fast growing exotic species with commercial and timber values, and this indicated that Teak plantation strive well when it is planted with food crops on the same site. In Idanre, Owo and Ore *Taungya* agroforest sites, agricultural crops such as *Manihot esculentum w*as the most abundant plant species encountered this is because farmers are more interested in their agricultural crops rather than the government owned trees and native woody species. This corroborates Michon and de Foresta (1991) that simple agroforestry (i.e *Taungya* agroforests) is often dominated by agricultural crops like maize, cassava, rice, cocoa, coffee, and hence are of more interest to the agriculturists. *Manihot* spp happens to be the most planted agricultural crop in these areas due to its high yield and demand for *Manihot* products such as Gari, Fufu and others. The most abundant tree species encountered in the Natural regrowth forest were tree species (*Cola gigantea, Funtumia elastica, Diospyros species)* in *Sterculiaceae, Apocynaceae* and *Ebenaceae* families. These three families were among the most abundant families encountered by Adekunle (2006) in Shasha forest reserve that fall within lowland rainforest ecosystem of Nigeria, just like the sites investigated here. *Cola gigantea* and *Funtumia elastica* have characteristics for conspicuous seed and easy dispersal by wind. This must have enhanced their spread in the areas investigated.

Overall result for the girth size distribution showed that natural regrowth forest had the highest number of woody species per hectare in the largest girth size (81 cm and above) and followed by Aponmu *taungya* agroforestry site. The other three (3) agroforestry sites had no woody species in the largest girth size. The implication of this is that most of the big trees might have been selectively removed by the farmers which are evidenced by the presence of many plants in the small girth sizes dominated by non-timber species. This is an indication that the original vegetation of the study sites might have been altered by some illegal activities of forest utilization and it also shows that the trees are generally immature and far below stipulated minimum girth approved for exploitation by law. It is also an indication that the forest plots are degraded.

Sorenson's index of similarity however revealed that the *taungya* sites were not significantly different from one another. This may be due to the fact that they were all established in the same year, and they had the same tree-crop combination. However, they were significantly different from the Natural regrowth forest site. This may be attributed to the intentional removal of other plant species considered to be weeds by the farmers, since they were only paying attention to the native woody species rather than their arable crops.

Soil Properties

The species composition can have significant effect on soil physical properties, which in turn can reflect the soil fertility of a given area. The particle size distribution of the soil in all the sites under consideration revealed that the soils were sandy clay loam in all the sites at both depths except Owo *Taungya* site which was loam sand at 0-15 cm. This agrees with Oloyede (2008) that depending upon the pre-existing soil conditions, tree species, rate of growth, time since establishment and plantations on agricultural land have the potential to change soil properties, either positively or negatively or many have no effect at all.

The chemical properties of the soil in all the sites under consideration showed that, the pH in all the sites examined ranged from slightly acidic to neutral (6.0 - 7.1) and therefore good for plant growth and development. Although soil pH is often considered as the master variable of soil, its importance in nutrition management cannot be understated. The soil pH is comparatively higher in Aponmu and Owo sites compared to the other three sites. This may be due to leaching of the base elements. Juo and Manu (1996) found that growing vegetation tend to decrease soil pH, with low nutrient stocks. Brandy and Weil (1999) have reported that soil pH is strongly influenced by the nature of the vegetation and the amount of organic matter in the soil especially in the tropical environment. Natural regrowth forest had the highest exchangeable acidity value, coupled with highest sodium and magnesium content at both 0-15 cm and 15-30 cm soil depth compared to the other agroforest sites. This might not be unconnected with the fact that *Tectona grandis* is not a nitrogen fixing tree and instead demand for available nutrients competitively with the planted crops. It is reported that these variation in acidity may be explained from differences in the degree of neutralization of the soil exchange complex (Rhoades and Binkley, 1996). Significantly higher values of organic matter coupled with organic carbon and total nitrogen were recorded in Ore agroforest site and relatively low in Owo *taungya* site at both soil layers compared to other sites. This observation could be attributed to the role of agroforest inconsistent addition of organic matter to the soil through dead and decaying roots. Available phosphorus was significantly higher in Idanre and Ore at both soil surface layers compared to the other sites. This might not be unconnected with the presence of phosphorus fixing species such as *Alchornea cordifolia* in these two sites. This is in conformity with the reports of Kang *et al.* (1984) that some species such as *Alchornea cordifolia* and *Gliricidia sepium* have high phosphorus content and have the potential of fixing phosphorus when present in the soil. Water holding capacity was significantly low in Ore *taungya* site compared to the other sites at both soil layers. This might be as a result of the textural class which are not significantly different in both depths coupled with high organic matter. Overall, the result of soil properties in all the sites examined showed that there is significant difference between the Natural regrowth forest and the four *taungya* agroforest sites.

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