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TREE SPECIES DIVERSITY, COMPOSITION AND STRUCTURE IN OGUN RIVER WATERSHED, SOUTHWESTERN NIGERIA

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ABSTRACT

The community of humans, plants, and animals depend on the watershed ecosystems which in turn are influenced by these biotic agents. With the expansion of agricultural practices, industrial activities and urbanization, the sustainable management of watersheds are being eroded. This study investigated the effects of land use types on tree diversity and structure of Ogun river watershed in order to provide essential information that could enhance its management. Ogun river watershed was stratified into Guinea Savanna (GS), Rainforest (RF) and Swamp Forest (SF) Ecological Zones. Three Land Use Types: Natural Forest (NF), Disturbed Forest (DF) and Farmland (FL) were purposively selected in each of ecological zone. A total of 336 sample plots (25x25 m^2) were obtained through demarcation of study sites proportionate to size. Tree height (m) and diameter at breast height (DBH≥10cm) were measured. Number of trees (NT, ha^{-1}), Shannon-Weiner Index (H´), Simpson's diversity index, Importance Value Index (IVI) and Canopy Structure (CS) were estimated. Data were analysed using descriptive statistics and Analysis of variance. Tree height was highest (44.7±13.1) in RFNF and least (11.3±4.3) in RFDF, while DBH was highest (51.9±6.4) in SFNF and least (24.2±4.8) in SFDF. A total of 89 tree species from 30 families were identified across ecological zones. The number of trees varied from 72.0±19.0 (SFFL) to 1012.0±37.0 (GSNF). The H´ significantly differed among LUTs with highest index (3.0) in GSNF, and least (1.7) in GSFL. Simpson's diversity index was significantly different with highest value (2.9) in GSNF and least (1.4) in GSFL. Upper canopy (Tree height>30-40 m) dominated CS of RFNF (57.7%). Disturbance of Ogun River Watershed through deforestation and farming affected forest structure and flora diversity. Ogun River watershed should be protected from indiscriminate exploitation and encourage enrichment planting in the DF and agroforestry practices on the FL in order to enhance its sustainability.

Keywords: Watershed, Sustainable Management, Natural forest, Disturbed forest, Farm land

INTRODUCTION

A watershed is an area of land that catches all precipitation (such as rain and dew) and drains or allows them to seep into marshes, streams, rivers, lakes or groundwater. These water bodies then provide a channel for the water to drain into oceans. The watershed area acts as a drainage basin funneling all the surface water within the area into a waterway. Each watershed is separated from adjacent watersheds by ridges of high ground. The flow of water over land from small to progressively larger water bodies provide water sources for urban, agricultural, industrial and environmental needs. Thus, the watershed community (humans, animals and plants) depend on the watershed for survival and influence it in many ways. In addition, the flowing water carries organic debris and dissolved organic matters which provide food and shelter for aquatic life. (Mathew, 2008; Enwelu *et al*., 2010).

The process of development continues to undermine the sustainable utilization of watershed resources in many tropical countries including Nigeria. Watersheds have suffered from exceptional rates of change as they are degraded or destroyed by anthropogenic activities such as farming, industrial development and urbanization. Consequently, the conversion of watershed ecosystems to other land use systems have serious impacts on their soils, water quality, floral diversity, structure and population characteristics (Rowe and Abdel-Magid, 1995; Huber *et al*., 2005; Enwelu *et al*., 2010).

As myriad of land use practices expand at the expense of forest and watershed, these have had severe consequences on watershed especially in the tropics. Biodiversity impact has been particularly severe in tropical forest regions and watershed. The biodiversity is being lost at an alarming rate and an appreciable number of forest species are threatened globally as a result of degradation. Human activities had been found as a major driving force with vast implications on changes in watershed ecosystems. (Bamgbose and Arowolo, 2007; Huber *et al*., 2005; MEA, 2005).

Botanical assessments had been found as source of on the extent of plant biodiversity in forest ecosystems and watershed (WCMC, 1992). This study therefore investigated the

effects of land use types (Natural Forest (NF), Disturbed forest (DF) and farm Land (FL) on tree diversity and structure of Ogun river watershed.

The Studies focus on the impacts of forest disturbances on tree diversity and population structure in watershed ecosystems. These are essential for the development of sustainable management strategies and provide an insight into status of vegetation in the area (Moffat *et al*., 2004; Huber *et al*., 2005).

MATERIALS AND METHODS

Study area

Ogun River is located in the Southwestern part of Nigeria, between latitudes 8º 41' N and 9º 10' N and longitudes 3º 28' E and 4º 8' E. The river flows through three South-Western States (Oyo, Ogun, and Lagos) before discharging into the Lagos Lagoon. Ogun River took its source from Igaran Hills at an elevation of about 530m above mean sea level and flows directly southwards over a distance of about 480km before discharging into the Lagos Lagoon. Its major tributaries are the Ofiki and Opeki rivers (Amartya and Akin -Bolaji, 2010) (Fig. 1).

There are two seasons, a dry season (from November to March) and a wet season (from April and October). Mean annual rainfall ranges from 900mm in the north to 2000mm towards the south. The estimates of total annual potential evapotranspiration have been put between 1600 and 1900mm (Ikenweirwe *et al*., 2007).

The three major vegetation zones that the river meanders through include the guinea savannah in the north, the rain forest in the central part and the swamp forests in the southern coastal and flood plains, next to the lagoon (Amartya and Akin -Bolaji, 2010).

The geology is a rock sequence that starts with the Precambrian Basement; which consists of quartzites, biotite schist, hornblende-biotite, granite and gneisses.(Ikenweirwe *et al*., 2007; Jones and Hockey, 1964).

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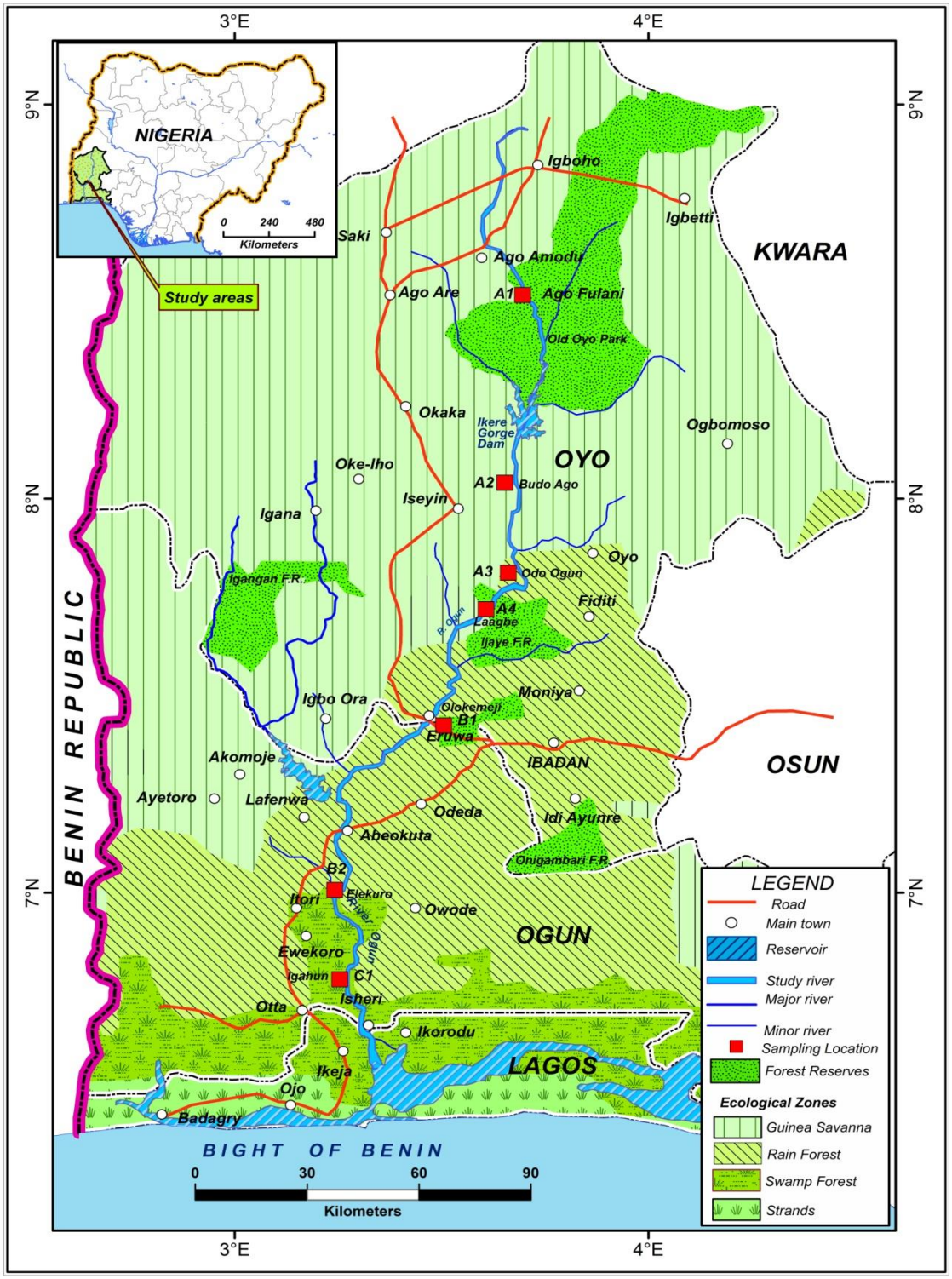

Fig. 1: Map of the study area showing study locations

Sampling procedure and data analysis

The study area was divided into different ecological zones (guinea savannah, rain forest and swamp forests). The guinea savannah covers 68.5% (about 329 km) of the total length of the river while rain forest and swamp forest cover 27.5% (132 km) and 4% (19 km) respectively (Berga, 2006). Based on proportion to size, each ecological zone was purposively sampled by selecting four (4), two (2) and one (1) study locations in the guinea savannah, rain forest and swamp forest ecological zones respectively representing about 1% of coverage area of each ecological zone. Having considered activities on the land cover, each location in the three ecological zones was stratified into Natural Forest (NF: relatively less disturbed forest), Disturbed Forest (DF) and Farm land (FL) for assessment of tree species diversity, composition and structure.

Systematic line transects {described by Osemeobo (1992)} was used in the laying of the sample plots in the selected locations along the river. A set back of 10m from the riverbank was measured and then two transects of 1000m in length parallel on either side of the river were laid. Then, sample plots of 25m x 25m were established in alternate positions along the two transects at 100m interval (8 sample plots per transect and a total of 16 sample plots in each of NF, DF and FL.

In the main plot, all trees were identified and those with Dbh (Diameter at breast height) ≥ 10 cm were measured with a diameter tape, while their total heights were assessed using the Haga altimeter. These trees were classified into four groups based on their height; under storey (< 20 m), lower canopy (20-30 m), upper canopy (30-40 m) and emergent layer (> 40 m) (following Olajuyigbe and Adaja, 2014).

Data Analysis

The data generated were calculated as follows:

Basal Area (BA) Calculation:

The basal area of all trees in the sample plots were calculated using the formulae:

$$BA = \frac{\pi D^2}{4} \quad \text{---------- ------} \quad (l)$$

Where:

BA = Basal Area (m^2)

D = Diameter at breast height (m)

$\pi = 3.142$

The total basal areas for each of the sample plots were obtained by summing of the BA of individual tree in each plot.

Tree Diversity Indices

Frequency of occurrence was obtained for tree species abundance/richness, while the following diversity indices were determined:

a. The species relative density (RD): This was obtained using the Equation 2.

$$RD = \frac{\text{Number of individual species per unit area}}{\text{Total number of individual of all species}} \text{ X } 100 \text{ ---------- (2)}$$

b. Relative Dominance (RDo)

Relative dominance (%) of each species was estimated using the following equation 3

$$RD_o = \frac{(\sum BA_i \; x \; 100)}{\sum BA_i} \text{- - - - - - - - - - - - - - - - (3)}$$

Where RD_o is the relative dominance of the species; Ba_i is the basal area of all the individual trees belonging to a particular species *i*; Ba_n is the basal area of the stand.

c. Shannon –Weiener diversity index (H')

$$H' = \sum_{i=1}^{s} P_i Ln(P_i) \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots (4)$$

d. Pielou's species evenness index (E)

$$E = \frac{H'}{LnS} \text{---} \quad (5)$$

Where: H' is the Shannon Weiener diversity index; S is the total number of species in the community; P*i* is the proportion of S made up of the *ith* species, E is the species evenness, n_i is the number of individual in species and Ln is natural logarithm.

e. Sorensen's species similarity index (SI) between any two sites was calculated using:

$$SI = \frac{2c}{a+b} X100 \quad \text{---------------------------------}(6)$$

Where:

a = number of species at sites a

b = number of species at sites b

c = number of species in sites a and b

RESULTS

Floristic composition of tree species in River Ogun Watershed

A total of 89 tree species from 30 families were identified during the study. The Natural Forest (NF) in the Guinea savannah had the highest tree density of 1012±37 trees/ha while Farm land (FL) in the Swamp Forest had the lowest (72±19trees/ha) (Table 1). Similarly, NF and DF of Swamp Forest zone had the highest (51.71±6.4cm) and the lowest (24.24±4.8 cm) mean dbh respectively. Trees with the highest dbh (174±15.18 cm) were encountered in NF of the Guinea savannah while the lowest dbh (15±4.09cm) were in FL of Guinea savannah (Table 1). Some tree species were present in the Natural Forest of the watershed and absent in disturbed and farmland (Table 2)

Similarity Indices of Tree Species in Ogun River Watershed

The tree species similarities (Shannon-Weiner diversity index) among land use types and ecological zones varied from 0.42 to 0.65 for land use types and 0.88 to 0.96 for the ecological zones. The NF and DF had highest similarity than DF and FL (0.64**)** and NF and FL (0.42) had lowest similarity. The similarity between Guinea savannah and Rain forest ecological zones was the highest (0.96) while Rain forest and Swamp forest had the lowest similarity (0.88) (Table 3a and 3b).

Tree diameter class distribution revealed that a larger proportion of trees were in the 30 - < 40 cm diameter class in Natural Forest (NF) of Guinea savannah (198 trees) while > 40cm diameter class was least in DF of Rain Forest and Swamp Forest (3 trees) The patterns of population structure in DF is an inverted J – sloped type which indicates a normal population distribution with a high number of individuals in the lower size classes and only few in the higher size classes. In NF the tree population decreased with increase in diameter classes from 30 - < 40 cm diameter class to > 5 0cm. The pattern of population structure was a bell-shaped diameter structure (Fig. 2).

Tree population and canopy structure in Ogun River Watershed

Tree Population and Canopy Structure in the Land Use types of Guinea Savannah in Ogun River Watershed showed that Natural Forests (NF) was dominated by upper canopy (30-40 m) with more than half of the tree population (56.3%) with bell-shaped population structure. The Disturbed Forest (DF) was dominated by under-storey canopy (< 20 m) of 14.8% while emergent layer (> 40m) was absent. The Farmland had 1.6% of lower canopy (20- 30 m) without existence of emergent layer (> 40m) (Fig. 3). In the Rain Forest, NF was dominated by upper canopy (30-40 m) (57.7%) while DF was dominated by under-storey canopy (< 20 m) with 8.8% without upper and emergent canopy (Fig. 3). There was no existence of upper and emergent canopy in the FL that had more of lower canopy (20- 30 m) of 1.8% (Fig. 3). The Natural Forest of SF had 56.3% of upper canopy (30-40 m), there were no upper and emergent canopy in the DF which was dominated by 9.2% of lower canopy (20- 30 m). The FL had 2.1% of upper canopy (30-40 m) and no emergent canopy (Fig. 3).

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Table 1: Diversity Indices of trees from Ogun River watershed in Southwestern Nigeria

Indices	Guinea savannah			Rain Forest			Swamp Forest		
	NF	DF	FL	NF	DF	FL	NF	DF	FL
Trees/ha	1012±37	263±21	74±16	714±24	114±30	46±22	541±29	181±23	72±19
Species/land use type	43	27	15	38	25	17	51	33	24
Family/ land use type	15	10	8	17	12	7	22	20	15
Mean dbh (cm)	47±4.32	39.83±3.7	31.18±7.5	45.33±5.1	39.83±3.1	33.31±2.1	51.71±6.4.	24.24±4.8	29.39±2.1
Max. dbh (cm)	174±15.18	106±11.13	163±14.21	166±10.19	100±9.15	168±16.22	171±15.07	110±10.14	143±13.12
Min. dbh (cm)	25±4.03	19±3.01	15±4.09	20±3.10	17±2.19	16±3.04	24±4.08	21±3.10	19±3.09
Basal Area (m^2 /ha)	3.41±0.32	1.86±0.19	1.78±0.14	3.76±0.41	1.99±0.17	1.11±0.09	3.43±0.40	2.17±0.26	1.46±014
Shannon-Weiener Diversity Index (H')	2.96	2.16	1.69	2.87	2.21	1.76	2.85	2.08	1.77
Simpson's diversity index (I)	2.89	2.12	1.42	2.84	2.18	1.68	2.79	1.98	1.54
Species Evenness (E_H)	0.89	0.66	0.58	0.78	0.67	0.62	0.77	0.71	0.62

Source: Field Survey 2015

NF = Natural Forest, DF = Disturbed Forest, FL = Farm Land, DBH = Diameter at Breast Height.

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Table 2: Tree species present in the various Land Use Types and Ecological zones of Ogun River Watershed (+: indicates species presence, -: indicates species absence.

	Code	Guinea savannah			Rain Forest			Swamp Forest		
Species		NF	DF	FL	NF	DF	FL	NF	DF	FL
Adansonia digitata	ADDI	+	+	+	+	+	+	-	-	-
Acacia albida	ACAL	+	+	+	+	-	-	-	-	-
Afzelia africana	AFAF	+	+	-	+	+	-	-	-	-
Albizia ferruginea	ALFE	+	+	-	+	+	+	-	-	-
Albizia lebbeck	ALLE	+	+	-	+	+	+	-	-	-
Allophylus africana	ALAF	+	+	-	+	-	-	-	-	-
Alstonia boonei	ALBO	-	-	-	-	-	-	+	+	+
Alstonia congnensis	ALCO	-	-	-	-	-	-	+	+	+
Aningeria robusta	ANRO	-	-	-	-	-	-	+	+	-
Anogeissus leiocarpa	ANLE	+	+	-	+	-	-	-	-	-
Anonidium manni	ANMA	-	-	-	-	-	-	+	-	-
Anthocleista vogelii	ANVO	-	-	-	-	-	-	+	+	-
Anthonotha macrophylla	ANTMA	-	-	-	-	-	-	+	+	+
Antiaris africana	ANAF	+	-	-	+	-	-	-	-	-
Artocarpus altilis	ARAL	-	-	-	-	-	-	+	+	+
Avicennia africana	AVAF	-	-	-	-	-	-	+	-	-
Baphia nitida	BANI	-	-	-	-	-	-	+	+	-
Barteria fistulosa	BAFI	-	-	-	-	-	-	+	-	-
Berlinia confuse	BECO	-	-	-	-	-	-	+	+	-
Blighia unijugata	BLUN	-	-	-	-	-	-	+	+	-
Bombax bounopozense	BOBO	+	+	+	+	+	+	-	-	-
Brachystegia eurycoma	BREU	-	-	-	-	-	-	+	+	+
Brachystegia nigerica	BRNI	+	+	+	+	+	+	+	+	+
Bridelia ferruginea	BRFE	+	-	-	+	-	-	+	-	-
Bridelia micrantha	BRMI	-	-	-	-	-	-	+	+	+
Cananga odoranta	CAOD	-	-	-	-	-	-	+	+	-
Carapa procera	CAPR	-	-	-	-	-	-	+	-	-
Cassia siamea	CASI	-	-	-	+	+	+	-	-	-
Ceiba pentandra	CEPE	+	+	+	+	-	-	-	-	-
Celtis brownie	CEBR	-	-	-	-	-	-	+	+	+
Celtis milbreadii	CEMI	-	-	-	+	-	-	+	-	-
Cleistopholis patens	CLPA	+	+	-	+	-	-	+	+	+
Cola flavovelutina	COFL	+	+	-	+	+	-	-	-	-
Cola gigantean	COGI	+	+	-	+	-	-	-	-	-

Cola cordifolia	COCO	+	+	-	+	+	-	+	-	-
Cordia milenii	COMI	-	-	-	-	-	-	+	-	-
Cylicodiscus gabonensis	CYGA	-	-	-	-	-	-	+	+	+
Daniellia ogea	DAOG	+	-	-	+	-	-	-	-	-
Daniellia oliveri	DAOL	+	+	-	+	-	-	-	-	-
Diospyros dendo	DIDE	+	-	-	+	+	-	+	-	-
Diospyros mespiliformis	DIME	+	-	-	+	+	+	-	-	-
Diospyros piscatorial	DIPI	-	-	-	-	-	-	+	-	-
Diospyros suaveolens	DISU	-	-	-	-	-	-	+	+	-
Dialium guineensis	DIGU	+	+	+	+	+	+	-	-	-
Enantia chloranta	ENCH	+	+	+	+	+	+	-	-	-
Erythrophleum guineense	ERGU	+	+	-	+	-	-	-	-	-
Ficus exasperata	FIEX	+	+	+	-	-	-	-	-	-
Gmelina arborea	GMAR	-	-	-	-	-	+	-	-	-
Guarea cedrata	GUCE	-	-	-	-	-	-	+	+	-
Guarea kunthiana	GUKU	-	-	-	-	-	-	+	-	-
Harungana madagascariensis	HAMA	-	-	-	+	-	-	-	-	-
Hildegardia barteri	HIBA	+	-	-	+	+	-	+	+	+
Isoberlinia doka	ISDO	+	-	-	-	-	-	-	-	-
Khaya grandifolia	KHGR	+	-	-	+	-	-		-	-
Khaya ivorensis	KHIV	-	-	-	-	-	-	+	-	-
Khaya senegalensis	KHSE	+	-	-	+	-	-	-	-	-
Kigelia africana	KIAF	+	+	+	-	-	-	-	-	-
Laguncularia racemosa	LARA	-	-	-	-	-	-	+	+	+
Lecaniodiscus cupanioides	LECU	+	+	+	+	+	+	+	+	+
Lonchocarpus sericeus	LOSE	-	-	-	+	+	-	+	+	+
Lophira alata	LOAL	+	-	-	+	+	-	+	-	+
Lophira lanceolata	LOLA	+	-	-	+	+	-	+	+	-
Lovoa trichilioides	LOT	-	-	-	-	-	-	+	-	-
Malacantha alnifolia	MAAL	-	-	-	+	+	-	+	+	-
Millettia thonningii	MITH	+	+	-	+	+	+	-	-	-
Mitragyna ciliata	MICI	-	-	-	-	-	-	+	+	+
Mitragyna inermis	MIIN	+	-	-	+	-	-	+	-	-
Mitragyna ledermannii	MILE	-	-	-	-	-	-	+	-	-
Morinda lucida	MOLU	+	+	+	-	-	-	-	-	-
Monodora myristica	MOMY	-	-	-	+	+	+	+	+	-
Morus mesozygia	MOME	-	-	-	+	+	+	+	+	-
Pachystela brevipes	PABR	+	-	-	-	-	-	+	-	-
Parinari robusta	PARO	-	-	-	+	+	-	+	-	-
Parkia biglobosa	PABI	+	+	+	+	-	-	-	-	-
Pentachletra macrophylla	PEMA	-	-	-	-	-	-	+	+	+
Piliostigma thonningii	PITH	+	+	-	+	-	+	+	+	-
Piptadeniastrum africanum	PIAF	-	-	-	+	+	+	+	+	+

Pterocarpus erinaceus	PTER	+	-	-	+	-	-	-	-	-
Pterocarpus santalinoides	PTSA	+	-	-	+	-	-	-	-	-
Raffia palm	RAPA	-	-	-	-	-	-	+	+	+
Rhizophora mangle	RHMA	-	-	-	-	-	-	+	+	+
Rhizophora racemosa	RHRA	-	-	-	-	-	-	+	+	+
Tectona grandis	TEGR	-	-	-	-	-	+	-	-	-
Terminalia superba	TESU	+	+	-	+	-	-	+	-	-
Trema orientalis	TROR	-	+	+	-	+	+	-	+	+
Uapaca togoensis	UATO	+	-	-	-	-	-	-	-	-
Vitex doniana	VIDO	+	-	+	+	-	-	-	-	-
Vitellaria paradoxa	VIPA	-	-	+	-	-	-	-	-	-
Xylopia aethiopica	XYA	+	+	+	-	-	-	-	-	-

Source: Field Survey 2015

NF = Natural Forest, DF = Disturbed Forest, FL = Farm Land

Table 3a: Similarity Indices of Tree Species among Land use types in Ogun River Watershed

	NF	DF	FL
NF	1		
DF	0.65	1	
FL	0.42	0.64	1

Table 3b: Similarity Indices of Tree Species among Ecological Zones in Ogun River Watershed

	GS	RF	SF
GS	1		
RF	0.96	1	
SF	0.91	0.88	1

Source: Field Survey 2015

NF = Natural Forest, DF = Disturbed Forest, FL = Farm Land, GS = Guinea Savannah, RF = Rain Forest, SF = Swamp Forest

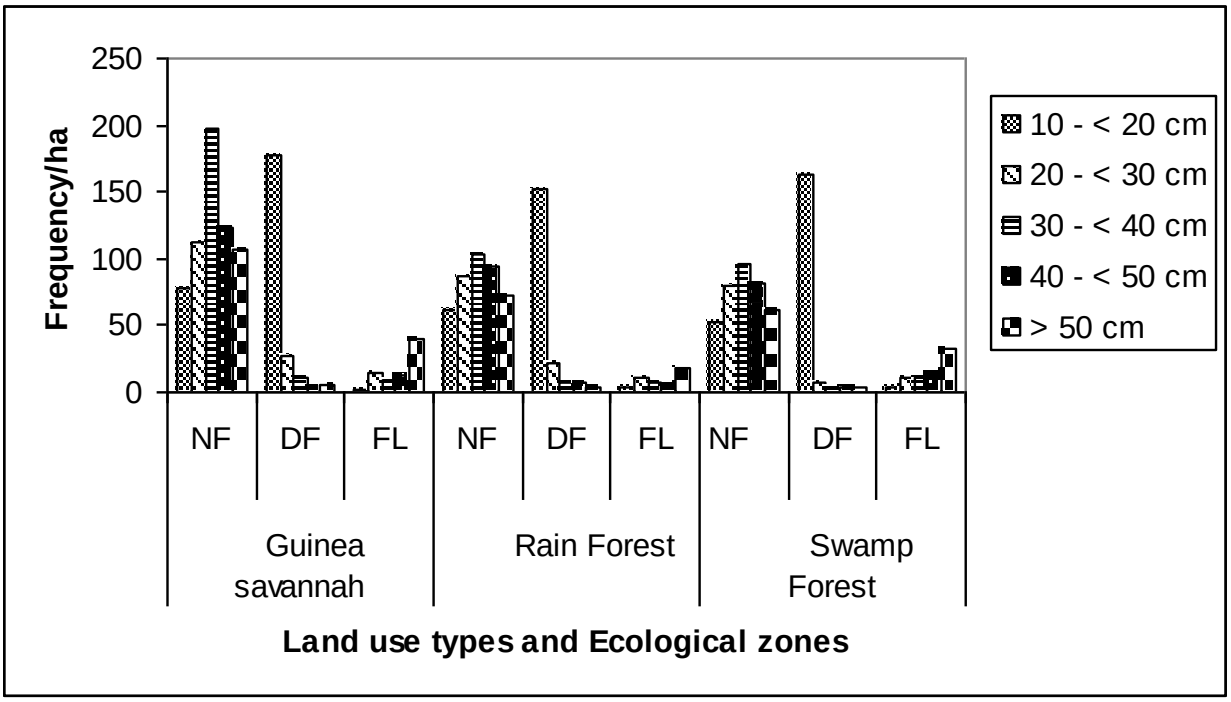

Figure 2: Tree diameter class distribution in Land use types and Ecological Zones of Ogun River Watershed

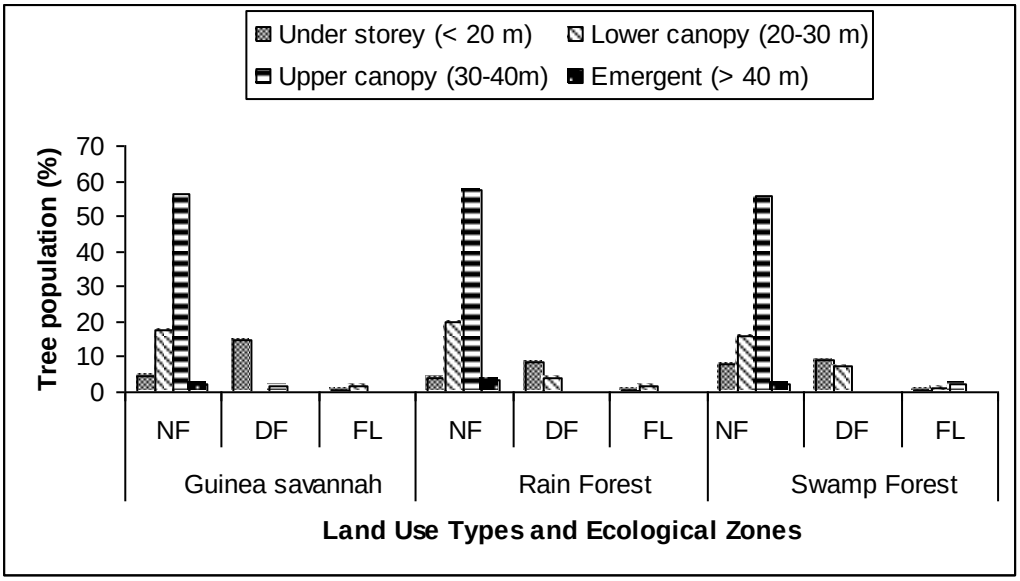

Fig. 3: Tree population and canopy structure in Ogun River Watershed

DISCUSSION

Floristic composition of tree species in River Ogun Watershed

One of the known characteristics of watershed as in typical tropical forests is the plant diversity and richness, which is number of different plant species per unit area (Peters, 1996). In this study, differences in species diversity and richness were observed among the land use types in the three ecological zones. The Natural Forest (NF) was the most diverse land use with high tree species diversity of 43 species/ha compare to Farm land (FL) (15 species/ha). This could be attributed to little or no human interference on NF. According to MEA, (2005); *Alcott et al.*, (2013) and Steffen *et al.*,(2015) deforestation and other anthropogenic activities have important implications on forest structure, species diversity, healthy watershed ecosystems and the sustainability of livelihoods.

The total of 89 tree species encountered across the land use types of Ogun river watershed indicated the biodiversity nature of the ecosystem. The density of tree species in NF was higher than what Agbo-Adediran *et al.*, (2017) reported (14 tree species) in Asanmagbe Watershed of Forestry Research Institute of Nigeria. This could be as a result of extent of area covered by the watershed and establishment of plantation of fewer species in the ecosystem. This implies that anthropogenic activities on watershed as in any forest estate lead to reduction of species richness, diversity and consequently affects the ecosystem. In Kagoro/Tsonje watershed in Kaduna State, decrease in number of trees in disturbed forest and farmland was ascribed to overexploitation of fuelwood and timber which eventually paved way for farming activities. This in turn led to negative impacts on species composition richness (Abagai, 2011)

Tree diameter class distribution in Ogun River Watershed

Majority of the trees in NF were in the diameter classes (30- < 40 cm) while DF was dominated by trees in diameter class (10- < 20 cm) (Fig. 2). According to Kimaro and Lulandala, (2013) and Akinyemi *et al., (*2002), felling of mature trees for timber, clearing of land for farming, collection of fuelwood and other non-timber forest products, as well as farmers encroachment most likely have affected species quantity and quality in many

forested area. This finding is in agreement with findings of Abagai, (2011) who found that human interference in Kagoro/Tsonje watershed in Kaduna State declined population structure of tree species and richness. The high frequency of trees in the lower diameter classes coupled with the fewer trees in >50 cm diameter category, buttressed the high level of disturbance and degradation. This is in agreement with (Nath *et al.*,2005 and Addo-Fordjour *e tal.*,2009) who observed that anthropogenic activities impede healthy tree structure of moist forest and wet evergreen forests respectively. The 'bell shape' DBH distribution in NF does not follow common trend obtained in natural forests where stem densities decrease with increasing diameter trees. This agrees with assertion of Kimaro and Lulandala, (2013) that some stable tree populations may not show inverse "J" shaped curve DBH distribution pattern due to differences in growth rates among size classes. The disturbed forest with this inverse "J" shaped are generally said to show active regeneration and recruitment (Jew *et al.*, 2016). This implies that this disturbed forest community has potential to recover over time provided the perturbation is stopped (Nath *et al*,.2005; Adekunle *et al.*, 2013; Olajuyigbe and Adaja, 2014).

Similarity Indices of Tree Species in Ogun River Watershed

Similarity indices provide quantitative bases for comparison of species composition in two or more assemblages (Nath *et al.*, 2005). The stronger relationships between DF and FL (0.64) and Guinea savannah and Rain forest (0.96) revealed the close connections among their species compositions. These similarities and relationship between the communities might be due to influence of factors such as nutrients, biotic and abiotic factors along the water course. The nutrient composition of a typical watershed ecosystem depends on the geology of the area, precipitation, groundwater input, run-off and soil chemical composition which all influence distribution of plant species (Cronk and Fennessy, 2001). This implies that areas with similar climatic and edaphic factor accommodate similar species. On the other hand, low similarity indices and weak relationship indicate the heterogeneity in species composition of land use types. Some differences among plant communities result from landscape, exposure, erosion and biotic factors. In this study, the Guinea savannah and

Rainforest zones were closer floristically than Guinea savannah and Swamp forest as well as Rainforest and Swamp forest. This is in accordance with the assertion of Festus *et al*., (2015) who observed and attributed the homogeneity of plant species in different ecological zones in Mau riparian forest in Kenya to low level of disturbances. The similarity index for Guinea savannah and Rainforest zones agrees with Ojo *et al.*, (1999) who reported a similarity index of 60.9% between two ecological zones (Rainforest and Swamp forest) in South Western Nigeria. The human activities on FL had resulted in the removal of many trees and thus changed the landscape completely from what was observed in NF. This corroborate the findings of Festus *et al*., (2015); Malik and Hussain (2008) and Badshah *et al*., 2010 who observed in their different studies that human disturbances of forested areas play critical roles in land degradation.

Tree population and canopy structure in Ogun River Watershed

The trees in the upper canopy layer (30-40 m) of the NF constituted more than half of the population in the three ecological zones. Height distribution in this land use type (NF) in Guinea savannah (GS), Rain forest (RF) and Swamp forest (SF) follows the pattern for the vertical structure of a tropical forest, with more trees in upper canopy and emergent layer. The vertical and horizontal structure is peculiar to mature natural forests which are ecosystems with a recognized ability to maintain both structure and floristic diversity that is stable over time through the dynamic balance of mortality, recruitment and growth of plants (Saiter *et al*., 2011).

In Natural Forest of the three ecological zones, every stratum had the highest number of trees per hectare compared to other land use types. This agrees with findings of Saiter *et al*., (2011) that mature forest with insignificant human interference is composed of trees in various layers and a closed canopy. In contrary, disturbed forest (DF) in GS, RF and SF did not follow the pattern for the vertical structure with more trees in understorey layers and lower canopy and no trees in the emergent layer. This reveals the high impact of logging (disturbance and degradation) and probably the state of recovery of the tree population (Olajuyigbe and Adaja, 2014). Addo-Fordjour *et al.*(2009) and Anning *et al*. (2009) reported

that when number of trees in the lower layers (understorey and lower canopies) were higher than those in the upper strata, it suggests the young age of the secondary forest which implies that rejuvenation could be possible if menace of unsustainable human activities are controlled.

CONCLUSIONS

Assessment of floristic composition, tree diversity and structure in Ogun river watershed ecosystems has provided essential information towards its sustainable management.

The Natural Forest (NF) was found to be the most diverse land use, having high tree diversity with more of the trees in higher diameter classes and upper canopy. This gives an indication of little or no human interference which has important implications on forest structure, species diversity and healthy watershed ecosystems. The differences among plant communities as affected by different land use types in Ogun river watershed ecosystems was found to be under influence of nutrient composition, geology, precipitation, groundwater input, run-off and soil chemical composition of the ecosystems. It is therefore suggested that Sustainable urban and agricultural irrigation practices in addition to agroforestry practices in watershed must be encouraged, with more efforts on increasing the number of browse plants along the water course and development of an action plan for establishment of range land where there will be controlled grazing of livestock.

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