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RELATIONSHIP BETWEEN LAND USE TYPES, TREE SPECIES STRUCTURE AND REGENERATION OF WATERSHED OF IJAYE FOREST RESERVES IN SOUTHWESTERN NIGERIA

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ABSTRACT

Conversion of watershed ecosystems to other land use systems has impacts on environment. This study therefore investigated effects of Land Use Types (LUT) on sustainability management of watershed.

The watershed of Ijaye forest reserve was stratified into three LUT: Natural Forest (NF), Disturbed Forest (DF) and Farm land (FL) for floristic survey and regeneration potential investigations. Systematic line transects was used in the laying of the sample plots in NF, DF and FL along the river which meanders through Ijaye Forest Reserve.

A total of 45 tree species from 17 families were identified. The NF had the highest tree density of (1012±37 trees/ha) while FL had the lowest (74±16trees/ha). The NF was dominated by upper canopy (30-40 m) with 56.4% while FL had 1.6% of lower canopy (20- 30 m).

The LUT has important implications on forest structure, species diversity and sustainable management of watershed ecosystems.

Keywords: Land Use Types, Systematic line transect, Species diversity, Natural regeneration.

INTRODUCTION

Watershed can be defined as an area of land that has several tributaries which drain into a larger body of water such as ocean. For instance, Ogun River has vast area of watershed with many tributaries like Ofiki and Opeki rivers. All these tributaries that catches precipitation sewer to Ogun River and eventually drains with interconnecting network of waterways into the Lagos lagoon. By and large, watersheds are more than just drainage areas in and around human communities. They provide habitat for plants and animals, drinking water for people, livestock and wildlife. In addition to these, they provide opportunity for recreation and serene environment. Based on these myriad of opportunity, protection of natural resources cannot be overemphasized. Well managed watersheds are essential to the development and survival of a community and can affect the quality of life of people, contribute to the successful functioning of the ecosystem and sustainable development of the environment.

However, the developmental activities continue 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 (Asinwa, 2018). The conversion of watershed ecosystems to other land use systems have serious impact on their soils, water quality, flora diversity, structure and regeneration potentials.

Different Land Use Types (LUT) such as farming, industrial development, commercial activities and urbanization continue to threaten the sustainability of watershed ecosystems. The chemical residues of fertilizers, pesticides and herbicides pollute soil and water bodies, making them lethal to vegetation and aquatic life. (Rowe and Abdel-Magid, 1995). In addition, the tree species richness and abundance are altered distinctively with the degradation of forest habitats in watershed ecosystem.

Ijaye forest reserve is one of forest reserves in the tropical region of Oyo State. Like other forest reserves in the State such as Olokemeji, Gambari, Osho, Lanlate, Ijaye, Igangan, Olaseyinde, Olla hill, Okoo-Iroo and Opara amongst others constitute natural and artificial plantations which have been depleted due to indiscriminate felling since 1999 (The Nation, 2013). The Ijaye forest reserve watershed which is one tributaries of Ogun River has also been disturbed by various LUTs. The disturbances of this ecosystem cause significant changes in its biodiversity and impede the regeneration potentials (Huber, Bugmann, and Reasoner 2005; Enwelu, Agwu and Igbokwe, 2010).

Natural and anthropogenic disturbances of the watershed hindered regeneration of tree species due to opened canopy which makes forest soil to dry out rapidly and inhibit germination of viable seeds that are in the soil. Furthermore, gap creation in the watershed enhances washing away of soil seed bank and seedlings through run-off. This in turn encourages the growth of invasive weeds and other herbaceous plants which usually interfere with regeneration and impede recovery of trees and shrubs (Simard *et al*., 2001). This study therefore investigated effects of LUT on watershed with a view to providing baseline information towards protection and management of watershed.

MATERIALS AND METHODS

Study Area

Ijaye Forest Reserve is located in Akinyele Local Government Area of Oyo State, Nigeria. It occupies a total land area of 25, 546 ha. The area lies between Latitude 7^0 45' and 7^0 43'N and Longitude 3^0 46' and 3^0 48'E. 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 to 2000mm. The estimates of total annual potential evapotranspiration have been put between 1600 and 1900mm (Ikenweirwe, Otubusin, and Oyatogun, 2007).

The major vegetation zones of the reserves include guinea savannah and rainforest. Ogun River meanders through this reserve which makes its watershed to cover about 10% of the total area. (Amartya and Akin -Bolaji, 2010).

METHODS OF DATA COLLECTION

Sampling procedure

The watershed of the forest reserve was stratified into Natural Forest (NF: relatively less disturbed forest), Disturbed Forest (DF) and Farm land (FL) for floristic survey and regeneration potential investigations.

Systematic line transects as described by Osemeobo (1992) was used in the laying of the sample plots in NF, DF and FL along the river which meanders through the forest. A set back of 10m from the riverbank was measured where two transects of 500m in length on either side of the river were laid parallel to the river. Sample plots of 25m x 25m in size were established in alternate positions along the two transects at 100m interval (4 sample plots per transect and a total of 8 sample plots in each of NF, DF and FL) (Fig. 1).

In the main plot, all trees and shrubs 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. 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) (Olajuyigbe and Adaja, 2014).

For assessment of Natural regeneration potentials of tree species, seedlings (20cm- 2m height) and saplings (> 2m in height) were considered as regeneration variables (Devi and Yadava, 2006).

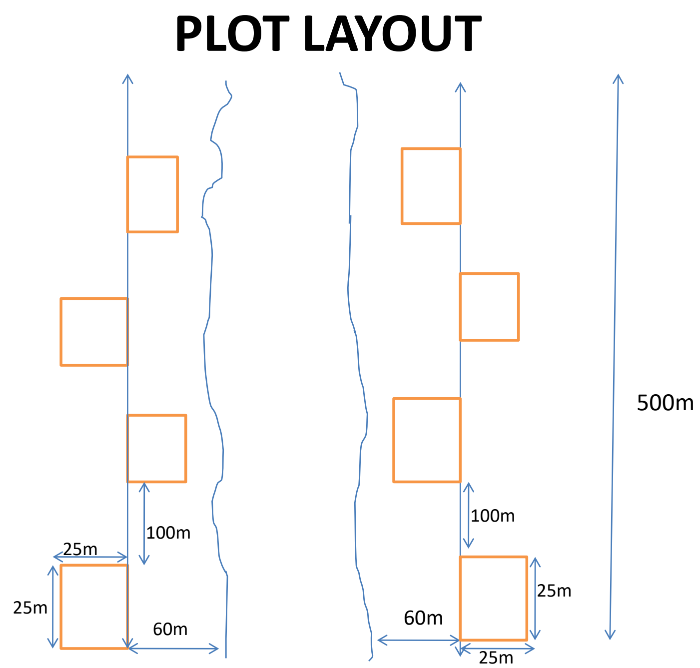

Fig. 1:Plot layout with systematic line transects sampling technique

The data generated were calculated as follows:

Basal Area Calculation:

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

$$BA = \frac{\pi D^2}{4} \quad \text{------------------- ------} \quad (eqn.\ 1)$$

Where:

BA = Basal Area (m^2)

D = Diameter at breast height (cm)

π = Pi = (3.142).

The total basal area for each of the sample plots were obtained by the sum of the BA of all trees in the 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.

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

b. Relative Dominance

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

$$RD_o = \frac{(\sum BA_i\ x\ 100)}{\sum BA_i} \text{- - - - - - - - - - - - - - - - -} (3.9)$$

Where RD_0 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

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

d. Pielou's species evenness index

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

Where: H' is the Shannon Wienner diversity index; S and N_i are the total number of 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:

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

Where:

c = number of species in sites a and b

a, b = number of species at sites a and b

f. **Importance Value Index (IVI)**

The sum of the RD and RD_0 divided by 2 gave the importance value of index for each species (Brashears *et al.*, 2004, Yang *et al.*, 2008). This was used to express the share of each species in the tree community (Rajumar and Parthasarathy, 2008).

$$IVI = \frac{RD\ x\ RD_O}{2} \text{- - - - - - - - - - - - } (6)$$

RESULTS

Floristic Composition and Similarity Indices of Tree species in Ijaye Forest Reserve watershed

A total of 45 tree species from 17 families were identified during the study. The Natural Forest (NF) had the highest tree density of (1012±37 trees/ha) while Farm land (FL) had the lowest (74±16trees/ha) (Table 1). The NF and FL had the highest (47±4.32cm) and the lowest (31.18±7.5 cm) mean dbh respectively. Trees with the highest dbh (174±15.18 cm) were encountered in NF while the lowest dbh (15±4.09cm) were in FL (Table 1). The similarity indices varied from 0.42 to 0.65. The NF and DF had highest (0.65) similarity than DF and FL (0.64**)** and NF and FL (0.42) had lowest similarity. The DF and FL had stronger relationships (0.69**)** and NF and FL (0.46) had weakest relationship as indicated by Principal Component Analysis and Dendogram cluster analysis (Fig. 1 and 2).

Table 1: Diversity Indices of trees in Ijaye Forest Reserve watershed

Indices	NF	DF	FL
Trees/ha	1012±37	263±21	74±16
Species/land use type	43	27	15
Family/ land use type	15	10	8
Mean dbh (cm)	47±4.32	39.83±3.7	31.18±7.5
Max. dbh (cm)	174±15.18	106±11.13	163±14.21
Min. dbh (cm)	25±4.03	19±3.01	15±4.09
Basal Area (m^2/ha)	3.41±0.32	1.86±0.19	1.78±0.14
Shannon-Weiener Diversity Index (H')	2.96	2.16	1.69
Simpson's diversity index (I)	2.89	2.12	1.42
Species Evenness (E_H)	0.89	0.66	0.58

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

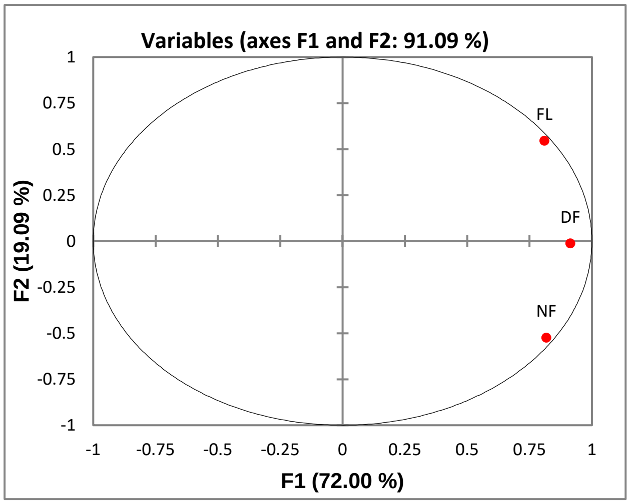

Fig. 1: Principal component analysis of tree spcies in th Land use types of Ijaye Forest Reserve watershed

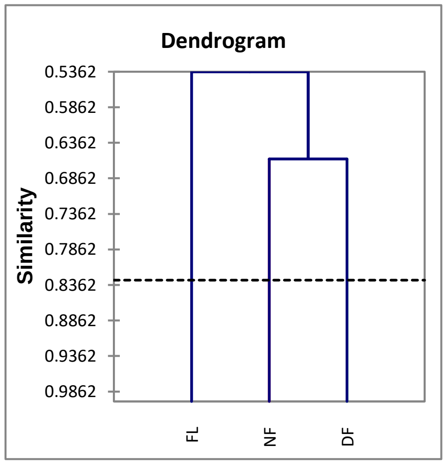

Fig. 2 : Dendrogram of Cluster analysis of tree species (Abundance and Similarity) in the Land use types of Ijaye Forest Reserve watershed

Diversity Indices of tree species in the Land use types of Ijaye Forest Reserve watershed

In the Natural Forest (NF) 43 species from 15 families were observed. The dominant species in NF were *Daniellia oliveri* (123/ha), *Pterocarpus santalinoides* (112/ha), *Brachystegia nigerica* (102/ha) and *Anogeissus leiocarpa* (87/ha). Tree species with low density included *Bridelia ferruginea* (1/ha), *Hildegardia barteri* (1/ha), *Isoberlinia doka* (1/ha), *Lophira lanceolata* (1/ha), *Pachystela brevipes* (1/ha) and *Mitragyna inermis* (1/ha). *Daniellia oliveri* had the highest RD (12.15%), RDo (4.36%) and IVI (19.37%) while *Bridelia ferruginea*, *Hildegardia barteri*, *Isoberlinia doka*, *Lophira lanceolata*, *Pachystela brevipes* and *Mitragyna inermis* had the least RD of 0.10% (Table 2).

In the Disturbed Forest (DF), 27 tree species were distributed among 10 families. *Acacia albida* (32/ha) had the highest density followed by *Cleistopholis patens* (27/ha) *Pterocarpus santalinoides* (23/ha) while *Erythrophleum guineense* had the least density of (1/ha). For RDo, *Adansonia digitata* had the highest relative dominance (18.60%), followed by *Kigelia africana* (14.88%) and *Parkia biglobosa* (12.94%). *Terminalia superba* had the least RDo and IVI value of 0.52% and 1.35% respectively. *Acacia albida* had the highest RD of 12.17% followed by *Cleistopholis patens* 10.27% while highest IVI of 20.69% was recorded for *Adansonia digitata* followed by *Parkia biglobosa* (18.36%) (Table 3).

The tree species distribution in the Farm land (FL) showed that 15 tree species were distributed among 8 families. *Parkia biglobosa* had the highest density of 18/ ha, RD (24.32%) and IVI (19.97%). *Kigelia africana* had the highest RDo (17.39%) while *Bombax bounopozense*, *Brachystegia nigerica*, *Ceiba pentandra* and *Morinda lucida* had the least RD (1.35%) (Table 4).

Table 2: Tree Species Diversity Indices of Natural Forest in the Land use types of Ijaye Forest Reserve watershed

Species	Family	D (No. ha⁻¹)	BA (m² ha⁻¹)	RDo (%)	RD (%)	RF (%)	IVI (%)
Adansonia digitata	Bombacaceae	13	0.30	8.58	1.28	0.30	10.16
Acacia albida	Leguminosae	7	0.02	0.50	0.69	0.16	1.35
Afzelia africana	Leguminosae	23	0.06	1.67	2.27	0.53	4.47
Albizia ferruginea	Leguminosae	64	0.02	0.59	6.32	1.49	8.4
Albizia lebbeck	Leguminosae	49	0.06	1.73	4.84	1.14	7.71
Allophylus africana	Sapindaceae	14	0.07	1.93	1.38	0.33	3.64
Anogeissus leiocarpa	Combretaceae	87	0.15	4.30	8.60	2.02	14.92
Antiaris africana	Moraceae	4	0.08	2.24	0.40	0.09	2.73
Bombax bounopozense	Bombacaceae	18	0.12	3.60	1.78	0.42	5.8
Brachystegia nigerica	Leguminosae	102	0.18	5.13	10.08	2.37	17.58
Bridelia ferruginea	Euphorbeacea	1	0.05	1.39	0.10	0.02	1.51
Ceiba pentandra	Bombacaceae	12	0.11	3.19	1.19	0.28	4.66
Cleistopholis patens	Annonaceae	78	0.05	1.50	7.71	1.81	11.02
Cola flavovelutina	Sterculiaceae	8	0.02	0.71	0.79	0.19	1.69
Cola gigantean	Sterculiaceae	9	0.10	3.01	0.89	0.21	4.11
Cola cordifolia	Sterculiaceae	14	0.08	2.24	1.38	0.33	3.95
Daniellia ogea	Leguminosae	47	0.07	2.17	4.64	1.09	7.9
Daniellia oliveri	Leguminosae	123	0.15	4.36	12.15	2.86	19.37
Diospyros dendo	Ebenaceae	11	0.04	1.10	1.09	0.26	2.45
Diospyros mespiliformis	Ebenaceae	7	0.05	1.37	0.69	0.16	2.22
Dialium guineensis	Leguminosae	18	0.12	3.35	1.78	0.42	5.55
Enantia chloranta	Annonaceae	17	0.06	1.69	1.68	0.40	3.77
Erythrophleum guineense	Leguminosae	5	0.04	1.12	0.49	0.12	1.73
Ficus exasperata	Moraceae	7	0.06	1.80	0.69	0.16	2.65
Hildegardia barteri	Sterculiaceae	1	0.06	1.69	0.10	0.02	1.81
Isoberlinia doka	Leguminosae	1	0.05	1.35	0.10	0.02	1.47
Khaya grandifoliola	Meliaceae	3	0.04	1.13	0.30	0.07	1.5
Khaya senegalensis	Meliaceae	23	0.04	1.04	2.27	0.53	3.84
Kigelia africana	Bignoniaceae	7	0.30	8.69	0.69	0.16	9.54
Lecaniodiscus cupanioides	Sapindaceae	68	0.10	2.77	6.72	1.58	11.07

Lophira alata	Ochnaceae	7	0.04	1.04	0.69	0.16	1.89
Lophira lanceolata	Ochnaceae	1	0.03	0.89	0.10	0.02	1.01
Pachystela brevipes	Sapotaceae	1	0.07	1.93	0.10	0.02	2.05
Millettia thonningii	Leguminosae	3	0.04	1.16	0.30	0.07	1.53
Mitragyna inermis	Rubiaceae	1	0.05	1.35	0.10	0.02	1.47
Morinda lucida	Rubiaceae	**7**	0.04	1.26	0.69	0.16	2.11
Piliostigma thonningii	Leguminosae	4	0.04	1.08	0.40	0.09	1.57
Pterocarpus erinaceus	Leguminosae	3	0.11	3.14	0.30	0.07	3.51
Pterocarpus santalinoides	Leguminosae	112	0.13	3.88	11.07	2.60	17.55
Terminalia superba	Combretaceae	7	0.06	1.80	0.69	0.16	2.65
Vitex doniana	Verbanaceae	11	0.08	2.22	1.09	0.26	3.57
Uapaca togoensis	Euphorbiaceae	5	0.09	2.56	0.49	0.12	3.17
Xylopia aethiopica	Annonaceae	9	0.06	1.77	0.89	0.21	2.87

D. = Density, BA = Basal area, RDo = Relative Dominance, RD = Relative Density, RF = Relative Frequency, IVI = Important Value Index

Table 3: Tree Species Diversity Indices of Disturbed Forest in the Land use types of Ijaye Forest Reserve watershed

Species	Family	D. (No. ha^{-1})	BA (m^2)	RDo (%)	RD (%)	RF (%)	IVI (%)
Adansonia digitata	Bombacaceae	5	0.35	18.60	1.90	0.19	20.69
Acacia albida	Leguminosae	32	0.01	0.64	12.17	1.19	14
Albizia ferruginea	Leguminosae	10	0.02	0.93	3.80	0.37	5.1
Albizia lebbeck	Leguminosae	19	0.05	2.50	7.22	0.70	10.42
Allophylus africana	Sapindaceae	3	0.06	3.13	1.14	0.11	4.38
Anogeissus leiocarpa	Combretaceae	7	0.01	0.62	2.66	0.26	3.54
Bombax bounopozense	Bombacaceae	4	0.08	4.20	1.52	0.15	5.87
Brachystegia nigerica	Leguminosae	5	0.04	2.18	1.90	0.19	4.27
Ceiba pentandra	Bombaceae	7	0.06	3.13	2.66	0.26	6.05
Cleistopholis patens	Annonaceae	27	0.03	1.54	10.27	1.00	12.81
Cola flavovelutina	Sterculiaceae	3	0.02	0.88	1.14	0.11	2.13
Cola gigantean	Sterculiaceae	2	0.08	4.36	0.76	0.07	5.19
Cola cordifolia	Sterculiaceae	4	0.07	3.94	1.52	0.15	5.61
Daniellia oliveri	Leguminosae	18	0.01	0.79	6.84	0.67	8.3
Dialium guineensis	Leguminosae	8	0.07	3.63	3.04	0.30	6.97
Enantia chloranta	Annonaceae	9	0.04	2.07	3.42	0.33	5.82
Erythrophleum guineense	Leguminosae	1	0.04	1.97	0.38	0.04	2.39
Ficus exasperata	Moraceae	11	0.07	3.76	4.18	0.41	8.35
Kigelia africana	Bignoniaceae	4	0.28	14.88	1.52	0.15	16.55
Lecaniodiscus cupanioides	Sapindaceae	18	0.02	0.87	6.84	0.67	8.38
Morinda lucida	Rubiaceae	7	0.03	1.71	2.66	0.26	4.63
Parkia biglobosa	Leguminosae	13	0.24	12.94	4.94	0.48	18.36
Piliostigma thonningii	Leguminosae	8	0.04	2.26	3.04	0.30	5.6
Pterocarpus santalinoides	Leguminosae	23	0.03	1.40	8.75	0.85	11
Terminalia superba	Combretaceae	2	0.01	0.52	0.76	0.07	1.35
Vitex doniana	Verbanaceae	9	0.07	3.73	3.42	0.33	7.48
Xylopia aethiopica	Annonaceae	4	0.05	2.84	1.52	0.15	4.51

D. = Density, BA = Basal area, RDo = Relative Dominance, RD = Relative Density, RF = Relative Frequency, IVI = Important Value Index

Table 4: Tree Species Diversity Indices of Farm land in the Land use types of Ijaye Forest Reserve watershed

Species	Family	D. (No. ha^{-1})	BA (m^2)	RDo (%)	RD (%)	RF (%)	IVI (%)
Adansonia digitata	Bombacaceae	3	0.31	17.56	4.05	0.20	21.81
Acacia albida	Leguminosae	4	0.01	0.78	5.41	0.27	6.46
Bombax bounopozense	Bombaceae	1	0.11	6.40	1.35	0.07	7.82
Brachystegia nigerica	Leguminosae	1	0.13	7.52	1.35	0.07	8.94
Ceiba pentandra	Bombaceae	1	0.12	6.50	1.35	0.07	7.92
Daniellia oliveri	Leguminosae	8	0.02	1.32	10.81	0.53	12.66
Dialium guineensis	Leguminosae	8	0.11	6.00	10.81	0.53	17.34
Enantia chloranta	Annonaceae	4	0.04	2.02	5.41	0.27	7.7
Kigelia africana	Bignoniaceae	4	0.31	17.39	5.41	0.27	23.07
Lecaniodiscus cupanioides	Sapindaceae	2	0.07	3.73	2.70	0.13	6.56
Morinda lucida	Rubiaceae	1	0.06	3.58	1.35	0.07	5
Parkia biglobosa	Leguminosae	18	0.28	15.61	24.32	1.20	41.13
Vitex doniana	Verbanaceae	4	0.07	4.16	5.41	0.27	9.84
Vitellaria paradoxa	Sapotacea	11	0.08	4.66	14.87	0.73	20.26
Xylopia aethiopica	Annonaceae	4	0.05	2.78	5.41	0.27	8.46

D. = Density, BA = Basal area, RDo = Relative Dominance, RD = Relative Density, RF = Relative Frequency, IVI = Important Value Index

Population dynamics and canopy structure of trees in different Land use types of Ijaye Forest Reserve watershed

The Natural Forests (NF) was dominated by upper canopy (30-40 m) with 56.4% of the tree population having bell-shaped population structure (Fig.3). The Disturbed Forest (DF) was dominated by under-storey canopy (< 20 m) (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).

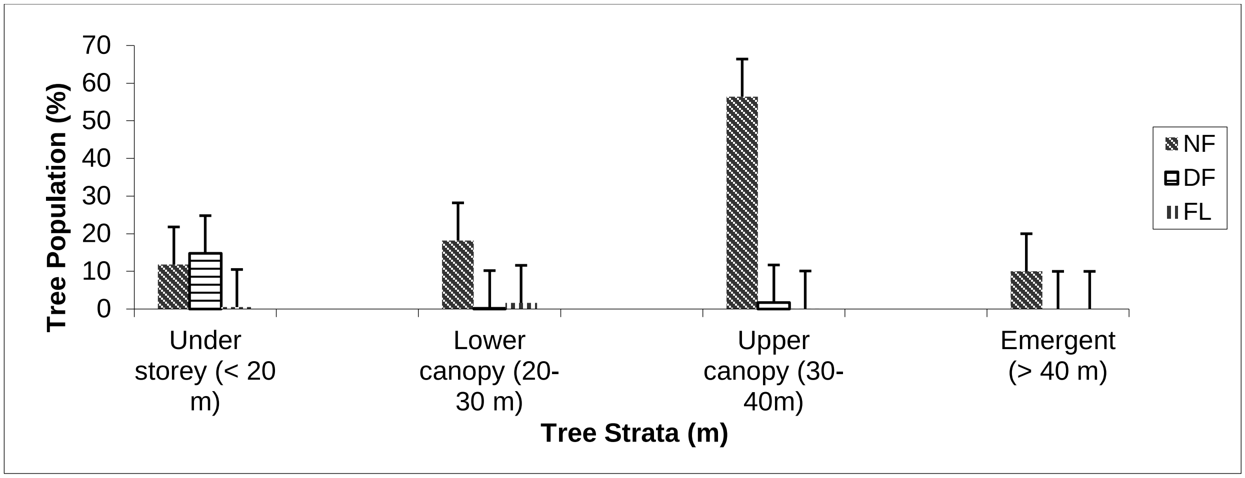

Fig. 3: Population dynamics and canopy structure of trees in the Land use types of Ijaye Forest Reserve watershed

Diameter class distribution of trees in the Land use types of Ijaye Forest Reserve watershed

Diameter class distribution of trees revealed that the highest number of trees were in the 30 - < 40 cm diameter class in Natural Forest In NF the tree population decreased with increase in diameter classes from 30 - < 40 cm diameter class to > 50 cm. The pattern of population structure was a bell-shaped diameter structure**.**

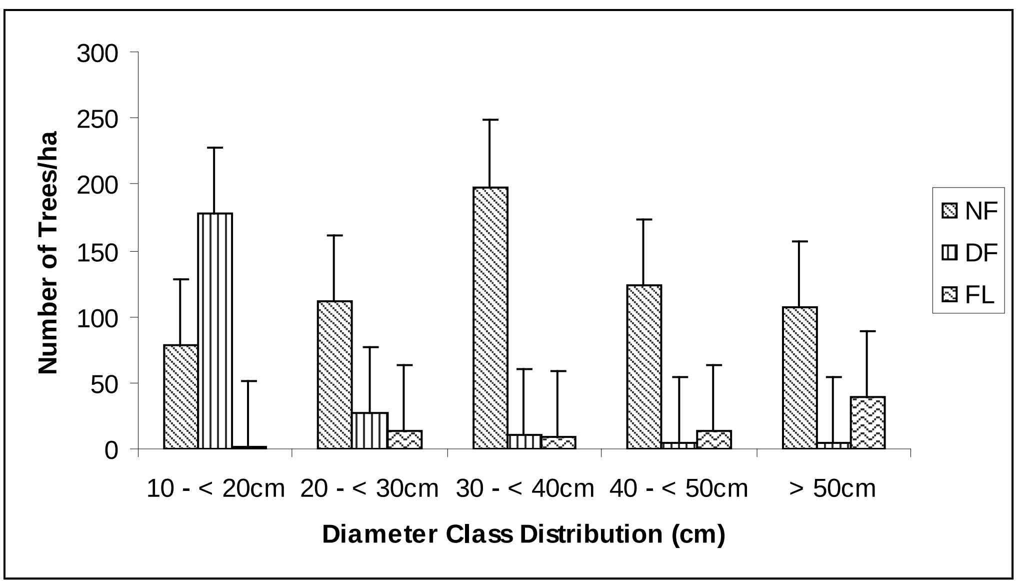

Fig. 4: Diameter class distribution of trees in different Land use types of Ijaye Forest Reserve watershed

Natural Regeneration Potentials of different Land use types of Ijaye Forest Reserve watershed

As shown in Table 5, the highest mean density of seedlings were recorded in DF (1221±17.11 Plants/ha) and the least mean density of seedlings were recorded in FL with 67±3.38 Plants/ha. In the same vein, DF had the highest mean density of saplings.(1010±11.08 Plants/ha) while FL had the least number of saplings of 13±1.38 Plants/ha. The NF had 680±13.25 Plants/ha seedlings and 587±9.31 Plants/ha saplings.

Table 5: Mean density (Plants/ha) in the Land use types of Ijaye Forest Reserve watershed

Land uses	Density (Plants/ha)	
	Seedlings (20cm-2m height)	Saplings (> 2m in height)
NF	680±13.25	587±9.31
DF	1221±17.11	1010±11.08
FL	67±3.38	13±1.38

DISCUSSION

Tree species composition and diversity in the Land use types of Ijaye Forest Reserve watershed

There were differences in species diversity and richness among the land use types in the of Ijaye Forest Reserve (IFR) watershed. The Natural Forest (NF) was the most diverse land use with high tree species diversity. This could be attributed to little or no human interference on NF. According to MEA (2005); Alcott, Ashton and Gentry, (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 and development of livelihoods. This implies that anthropogenic activities in the watershed 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 trees for fuelwood and timber products as well as conversion of forest to other land use. This had negative impacts on the species composition and richness of the ecosystem (Abagai, 2011).

Majority of the trees in NF were in the 30-< 40 cm diameter classes while DF was dominated by trees in 10-< 20 cm diameter class. 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 that of Steffen *et al.* (2015) who found that human interference in watershed affected the population structure of tree species and richness. The high density 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 *et al.* (2009) who observed that anthropogenic activities impede healthy tree structure of moist forest and wet evergreen forests. The 'bell shape' DBH distribution in NF does not follow common trend obtained in natural forests where stem densities decreased 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 in class diameter are generally said to show active regeneration and recruitment (Jew *et al.*, 2016). This implies that this disturbed watershed community has potential to recover over time and enhance environmental sustainability, provided the perturbation is stopped (Nath *et al., 2005*; Adekunle, Olagoke and Ogundare, 2013; Olajuyigbe and Adaja, 2014).

Similarity Indices of Tree Species in the Land use types of Ijaye Forest Reserve watershed

Similarity indices provide quantitative bases for two or more assemblages based on their species composition (Nath *et al.,* 2005). The stronger relationships of tree species between DF and FL for tree species 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 (Festus *et al.,* 2015).

Important Value Index (IVI) which determines the overall niche of each species in plant community is the function of summation of relative density, relative density and relative dominance. Plant species vary in their response to environmental and edaphic factors which considerably influences the Important Value Index (IVI). They have different degrees of tolerance to environmental variables, such as light, temperature, moisture, and nutrients. At the community level, these differences in tolerances will cause various species to have competitive advantages, depending on the nature of those environmental factors (Smith and Smith, 2001). According to Cox, Kantz and Gilbert (1994); Abdullahi (2010) and Abba, (2013), high IVI of a species indicated its dominance and ecological success as well as its good power of regeneration and greater ecological amplitude. Species like *Parkia biglobosa* and *Adansonia* were found dominating FL in the study area with appreciable IVI probably because of their role in rural livelihood and soil fertility enhancer which earned their protection (Ikyaagba, 2008; Athua and Pabi, 2013). In the same vein, low IVI recorded for some of the species in the study areas could be attributed to the over exploitation and low regeneration potentials. On the other hand, high IVI of *Daniellia oliveri* and *Anogeissus leiocarpa* in the Natural Forest (NF) which are economic timber species could be as a result of good regeneration potential, couple with favourable and sustainable environmental conditions.

Population dynamics and canopy structure of trees in the Land use types of Ijaye Forest Reserve watershed

The trees in the upper canopy layer (30-40 m) of the NF constituted more than half of the population in the study area. 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). Natural Forest 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. On the contrary, Disturbed forest (DF) 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 the menace of unsustainable human activities is controlled.

CONCLUSION

The Natural Forest (NF) was found to be the most diverse land use, having high tree and ground flora species 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, healthy watershed ecosystems and sustainable development of environment. The differences among plant communities as affected by different land use types in the 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 recommended 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. Then, indiscriminate tree exploitations for timber, poles or charcoal production must be discouraged. This will in turn result into sustainability of the environment at large.

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