Woody plants species Composition, Richness, Dominance and Diversity in West Bank Forest of International Institute of Tropical Agriculture (IITA) Ibadan, Oyo State, Nigeria.

ABSTRACT

Woody plants species composition, richness, dominance and diversity in west bank forest of International Institute of Tropical Agriculture (IITA) was undertaken to understand the status of the forest. The analysis of tree species, composition, richness and diversity in the forest was carried out with the aim of developing efficient management plan that will ensure biodiversity conservation. Vegetation survey using transects and plot sampling techniques were used to collect data for the study. Three transects of 500 m long each {A (270^0W), B (90^0E), and C (180^0S)} were constructed with the aid of prismatic compass in the forest. 10 sampling plots of 10 m by 10 m each were demarcated along each transect making a total number of 30 sampling plots. In each plot, all woody plants (trees and shrubs) with girth at breast height (gbh) greater than or equal to 10cm (gbh ≥ 10cm) were identified, enumerated and measured. The results showed that 581 woody plants belonging to 65 species and 28 families were encountered in the forest. The most abundant family in the forest was Fabaceae sub families of Caesalpinioidea, Mimisoideae and Palpilinoideae. The forest had Simpson diversity index (D), Shannon-Wiener (H) and Evenness index of 0.012, 0.354 and 0.195 respectively. The total density and basal area of woody plants species in the forest was 1,936.67 individuals' ha-1 and 98.23 m^2 ha−1. *Newbouldia laevis* had the highest density of 190 ha-1 and relative frequency of 9.811% while *Milicia excelsa* had the highest basal area of 40.34 m^2 ha−1, relative dominance of 41.07% and Importance value index of 42.11%. The study concludes that the forest has a reasonably good tree and shrub species composition and richness, dominated by trees and a repository of many indigenous tropical woody plant species. The study recommends in-depth forest inventory, preparation of management plan and promotion of good governance in management of the forest. Also, further studies on regeneration, structure, soil seed bank, seed physiology and herbaceous plant should be carried out in the forest.

Key words: Woody plants, composition, richness, diversity, vegetation survey, transects, sampling plots, density, basal area, inventory

INTRODUCTION

Generally the forest is defined as a tract of land dominated by trees. The United Nation framework convention on climate change defined forest as an area covering at least 0.05 to 1 hectare, containing tree crown cover of more than 10 to 30% with trees that have potential to reach a minimal height of 2 to 5 m at maturity (Nature, 2009). According to Cotě (2003), a forest is an ecosystem characterized by, a more or less dense and extensive tree cover, often consisting of stands varying in characteristics such as species composition, structure, age class and associated processes and commonly including meadows, streams, fish and wildlife. It is a dynamic entity, a renewable resource in which there exists a continuous interaction between the component plants, animals and the surrounding environment.

Globally, forests area covers 4,032,905 hectares or 31% of the world's land total (FAO, 2011). However, these areas are exposed to threats that are mainly caused by human activities where the world population is rising and the global economic expands. The threats include human settlement, infrastructure development, tourism, recreation and resource extraction

Comment [B. B.1]: Diversity is the combination of the species richness (the number of species in the sample plots) and evenness of species (abundance and distribution among species) while species composition is the summation of species identified in terms of density, abundance and frequency of distribution.
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Comment [B. B.3]: Use "woody plant species" instead

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(Chape *et. al*., 2008). Loss of forest cover and biodiversity due to anthropogenic activities is a growing concern in many parts of the world (Hedges and Enters, 2000).

Tropical rainforest accounts for only 7% of earth's dry surface area; rainforests accommodate 70% of animal and plant species in world ecosystems (Jonathan *et. al*., 2007). It is one of the most bio-diverse in the world and provides a wide range of goods and services that are fundamental to human populations locally and globally (Costanza *et. al*., 1997). Tropical forests are currently subject to strong pressure from agricultural expansion, leading to unprecedented deforestation rates (Hansen *et. al*., 2013).

Nigeria is typified by ample forest resources (FAO, 2005): statistics showed that 12.2% of Nigeria's land area of 11,089,000 ha is covered with forests. However, forests in Nigeria are seriously threatened by deforestation and other environmental problems (Ariyo *et. a*l., 2018a). Forest resources commonly found in Nigeria include timber, fuel wood, wildlife, inland fisheries and forage, which are tangible products and have market-determined values. Other benefits derivable from the forests with nonmarket- determined value are recreation, amenity and environmental protection.''In fact, a large percentage of Nigeria's luxurious vegetation has been removed and several species have become extinct (United Nation, 2002)''. The record of WRM (1999) showed that between 70 and 80% of Nigeria's original forest has disappeared and presently the area of its territory occupied by forests is reduced to 12%. Nigeria lost about 2,048,000 ha of forest in the period between 2000 and 2005 (FAO, 2005). ''Nigeria is reported as the fourth leading country in the world and first in Africa having the highest annual forest loss'' (Ariyo *et. a*l., 2018a). A lot of damage has been done to Nigeria's land through the processes of deforestation, notably contributing to the overwhelming trend of desertification (Omofonmwan and Osa-Edoh, 2008). ''The current high level of demand for forest products has outstripped the sustainable level of supply and this situation may deteriorate further unless concrete steps are taken to manage the forests in sustainable ways'' (Ariyo *et. a*l., 2018a). The rapid rate of deforestation in the country (approximately 3.5% per annum (Badejo, 2011) translates into an average loss of 350,000 ha to 400,000 ha every year (Oyebo, 2002). In line with this ugly trend of deforestation (Adeyoju, 2001) sighted in (FAN, 2005) lamented that Nigeria's total forest estate, i.e. areas constituted forest reserves, which stood at 10% of the country's land mass in 1976, had shrunk to less than 6%.

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The IITA forest is not spared from this ugly trend of deforestation. The forest has suffered anthropogenic disturbance over the years by people living in the adjoining villages of the perimeter fence of IITA. The villagers are allowed into the forest to collect non- timber forest products such as firewood, bamboo, medicinal plants etc. The anthropogenic disturbance also includes illegal hunting, land clearing for experiment, construction of physical structure, firewood, stakes/ poles removal by the IITA staff for experimental fields and poaching activities by hunters who jumped over the perimeter fence and cut young growing trees for club to bring down bat that hung on the tree and occasional but illegal felling of timber in the forest (Ariyo, 2007, Ariyo *et. al*., 2012). The species diversity and composition of woody plants in the forest have been shaped in many ways by human beings, and it is believed no part of it remains absent of human influence (Ariyo, 2018b). Knowledge of the extent to which tree and shrub diversity have been shaped is inadequate. Though the forest is under active protection by the rangers at the moment but there is a need to generate relevant information in order to understand the status of the forest in terms of tree species, composition, richness and diversity, with the aim of developing efficient management plan that will ensure biodiversity conservation, as the forest will serve as a seed source. The objective of the present study was to assess the woody plants species composition, richness,

dominance and diversity in west bank forest of International Institute of Tropical Agriculture (IITA) Ibadan, Oyo State, Nigeria.

Materials and Methods

Description of the Study Area: The study area is the West Bank forest of International Institute of Tropical Agriculture (IITA), Ibadan, Oyo State, Nigeria. IITA is located at longitude 7^0 30' 8''N, latitude 3^0 54' 37''E and 243m above sea level (Tenkouano and Baiyeri, 2007).

Land use history: Prior to the acquisition of land by IITA through the Federal Government of Nigeria, the most extensive land use pattern in the area was arable and tree crop farming and about 3000 people lived in about twenty eight villages scattered in this area.

Climate: The site falls within humid tropical lowland region with two distinct seasons: the longer wet season and shorter dry season. The wet season last for eight months and it extends from March to October while the dry season last for four months from November to February. The rainfall pattern is bimodal with an annual total which ranges from 1,300-1,500mm most of which falls between May and September. The average daily temperature ranges between 21^0C and 23^0C while the maximum is between 28^0C and 34^0C. Radiation is about 5285MJ/m^2/year. Mean relative humidity is in the range of 64% to 83% ((Tenkouano and Baiyeri, 2007).

Vegetation: The area is a mosaic of abandoned villages and farmland at various stages of forest regrowth. The plots that were under cultivation before the acquisition fifty three years ago are now mainly a thicket of *Chromolaena odorata*. It is interesting that although some tree saplings are now pushing through this undergrowth, there is so far little sign of the structure and diversity of the original forest becoming re-established. On the other hand, it is remarkable to note that many of the forest species of plants and animals have managed to survive or even flourish in this extended "bush fallow". The natural vegetation in this area could be classified as tropical semi-deciduous forest with various pockets of vegetation types ranging from derived savanna, secondary forest and riparian types. According to Ezealor (2002), the area resembles mature Guinea-Congo lowland rainforest with scattered emergence of trees which include *Ceiba*, *Milicia* and *Terminalia* spp. Large clumps of bamboo (*Bambusa vulgaris)* are common; stands of *Raphia farinifera* are found along watercourses while scattered oil-palms *Elaeis guineensis* grow in both low-lying and the relatively better-drained upland areas. Thickets of climbers grow in openings where the secondary nature of the forest is most apparent. The main canopy trees, many of which are buttressed at the base, have tall straight trunks, almost un-branched until they form an umbrella-shaped crown, some 30m or more above the ground. Some trees are deciduous, losing all or most of their leaves at the height of dry season. Trees in the lower storey tend to be evergreen and are often heavily overgrown with creepers and lianas. In the forest regrowth the lower stratum tends to be a dense, impenetrable thicket of shrubs, climbers and tree seedlings. Among the climbers are two particular species: *Pararistolochia goldieana* produces a dark red, trumpet-shaped flower with a diameter up to 40cm. It grows in clumps within the forest and is pollinated by flies. It flowers between March and June. *Caesalpinia bonduc* is a spiny woody vine with shiny grey seeds that are used for the "ayo" game. Outside the forest is an extensive area of derived savanna supporting fallow fields and experimental agriculture plots.

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Forest Inventory: Forest inventory was conducted to understand tree and shrub species diversity, their distribution and estimate the available stock in the west bank forest. Forest inventory is defined as the procedure for obtaining information on the quantity and quality of the woodland resources and other characteristics of the land on which the trees and shrubs are growing (Malimbwi, 1997). The actual inventory was preceded by a reconnaissance survey which involved establishing transects and plot laying-out on the map of west bank forest reserve. To cover the whole woodland area and variation between vegetation cover. Systematic sampling design was adopted in this study. In this study, systematic sampling design ensured an even spread of the samples throughout the woodland area and thus increase the chances of including all vegetation types in the woodland (Philip, 1994). This study adopted a sampling intensity of 0.1% which is equivalent to 30 sample plots. Reasons behind this include limited finances and time constraint. Synnot (1979) recommended sampling intensity within a range of 0.5% to 0.7% for tropical natural forest inventories. However, according to Malimbwi and Mugasha (2002) and Malimbwi *et. al*.. (2005), financial and time constraints and purpose of the forest inventory may dictate the sampling unit to be as low as 0.01%.

Techniques of Data Collection: The techniques of data collection for this study was based on vegetation survey using transect and plot sampling techniques (Wolda, 1983, Onyekwelu *et. al*., 2005, Lawal and Adekunle, 2011, Ariyo, *et. al.*, 2011, 2012, Onefeli, *et. al*., 2013).

Vegetation Transect: The vegetation transects were established to obtain a representative sample of the woody vegetation of the study area as well as to understand the species assemblage of trees, and shrubs in their various habitats (forest composition) at the beginning of the study (base line data). Transects were established with minimal disruption to the environment and marked with flagging tape at every 10m (fig. 1).

Transects and plots designs: Three transects {A (270^0W), B (90^0E), and C (180^0S) were constructed with the aid of prismatic compass in West bank forest of IITA (fig. 1). The transects were established with minimal disruption to the environment and marked with flagging tape at every 10m. Each transect was 500m long. 10 sampling plots of 10m by 10m each were demarcated along each of the transect making a total number of 30 sampling plots (3 transects by 10 plots). A distance of 40m was left between each of the plot to minimize repetition of plant species while 20m was left at the beginning and at the end of each transect as the border row to minimize edge effects. In each plot, all woody plants (trees and shrubs) with girth at breast height (gbh) greater than or equal to 10cm (gbh ≥ 10cm) were identified, enumerated and measured. The identification of plant species were carried out with the assistance of retired taxonomist form Forestry Research Institute of Nigeria (FRIN). Samples of woody plants that cannot be identified on the field were coded and taken to the Forestry Research Institute of Nigeria, Ibadan (FRIN) herbarium for proper identification. The information that was recorded from each sample plot includes: woody plants (tree and shrub) species names, number of individual of each species, total number of each species, Geographical Positioning System (GPS) readings of coordinate of the plots and transects, this was plotted on the GPS arc view to know the exact position of each transect within the forests and to obtained the study location map (fig. 2).

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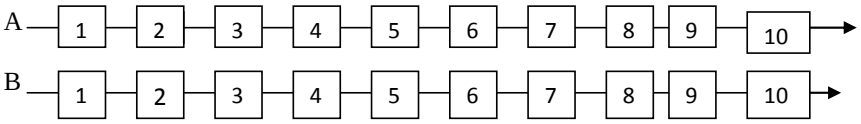
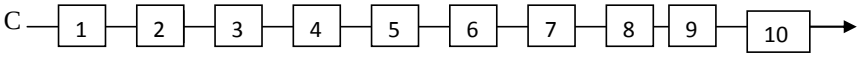
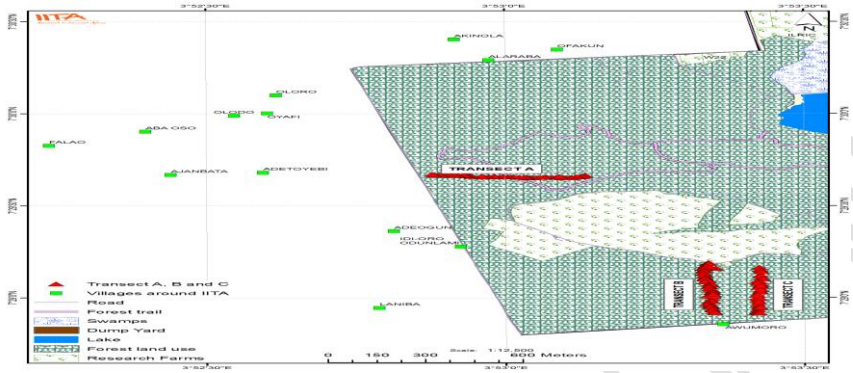




Legend: - Each line A, B, and C, are 500m long transect while 1, 2, 3, --------10 are plots of 10m by 10m each.
Figure 1: Transects and plots design



Source: Field Survey, 2016

Figure 2: Map of West Bank Forest showing the location of transect A, B, and C

Data Analysis: The data were analysed for species composition, richness, diversity, relative density, and relative dominance, Species Importance Value or Coverage Index (IVI). Ecologically, Species diversity was computed using Shannon's Weaner and Simpson's diversity indices. The expressions of these indices were seen below:

The Simpson's diversity index D (Simpson, 1949) was calculated using the formula:

$$D = \sum ni\,(ni-1)/\,N\,(N-1) \quad \text{..... 1}$$

Where ni is total number of each species, N is total number of all the species.

The Shannon and Weaner index (H') was computed from the formula as modified by Shannon and Weaner (1964).

$$H' = -3.3219\,\Sigma\, ni/N \log\,(ni/N) \quad \text{..... 2}$$

Where ni is total number of each species, N is total number of all the species.

The Evenness (E) was computed from Pielou's index (Pielou, 1969)

$$E = H'/\,In\,S \quad \text{..... 3}$$

Where, H'= Shannon and Weaner diversity, and In S is natural log of the total number of species recorded.

Species relative density (RD) was computed following Brashears *et. al.*, (2004)

$$RD = (ni/N) * 100 \quad \text{..... 4}$$

Where RD (%) is the species relative density, ni is number of individuals of a species i and N is the total number of individual of all the species of woody plant.

Relative frequency (RF) = Frequency of a woody plant species/ Total frequency of woody plant species * 100..... 5

vi. Species relative dominance was estimated with RDo = ($\sum Ba_i$ * 100) / $\sum Ba_n$ 6

Where Ba_i, is the basal area of all individual trees belonging to a particular species i, Ba_n is the stand basal area. The basal area was calculated using the formulae

BA= πD^2/ 4. Where BA is Basal area, π is 3.142 cm and D is diameter at breast height The girth at breast height (gbh) (1.3m above the ground level) of woody plants was converted into diameter with the following relationships:

C = 2πr..... 7
r = d/2..... 8
C = 2πd/2..... 9
C = πd..... 10
d = C/π..... 11
Where C = circumference (gbh) of the woody plants, r = radius, d = diameter and π= 3.142

vii Importance Value Index (IVI) or coverage index (CI) of each tree species was computed as indicated in Mueller Dombois and Ellenberg (1974) using a composite equation

IVI = Relative density (RD) + Relative frequency (RF) + Relative dominance (RDO)..... 12

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RESULTS AND DISCUSSION

Floristic Composition

A total number of 581 woody plants comprising of trees and shrubs with the (gbh) ≥10 cm belonging to 65 species and 28 families were encountered in the forest, out of these, trees constituted 75.38% species and shrubs had 24.62% species with frequency of 85.71% and 14.29% respectively (Table 1). This is in line with the findings of Akinyemi *et. al*., (2004) which found 289 individual trees distributed among 44 different tree species and 18 families in one hectare of Omo forest reserve. Also, Akinsanmi and Akindele, (2002) recorded 88 tree species with dbh ≥ 20 cm in 32 plots of 0.25ha per plot at Oluwa forest reserve.

Family Distribution of Woody Plant Species in the West bank forest of IITA

The distribution into families of all woody plants species encountered in west bank forest was shown in table 2. Among the 28 families Fabaceae with sub families of Caesalpinioidea, Mimisoideae and Palpilinoideae was found to be the most abundant family. It had the highest number of species represented by *Albizia ferruginea*, *Albizia zygia*, *Baphia nitida*, *Delonix regia*, *Leucaena leucocephala*, *Lonchocarpus sericeus*, *Millettia* sp. and *Millettia thonningii*. It had family relative density of 12.29% and species frequency relative density7.40%. This was followed by Meliaceae and Moraceae which had 10.77% and 9.23% family relative density and species frequency relative density of 11.70% and 15.32%, Apocynaceae and Euphorbiaceae had equal family relative density of 7.69% and species frequency relative density of 8.26% and 6.37% respectively. Also, Rubiaceae, Sapindaceae and Ulmaceae, Rutaceae and Sapotaceae had 4.62% and 3.08% family relative density and species frequency relative density of 0.69%, 9.98%, 4.82%, 0.69% and 3.44% respectively. The dominant families in the study area were similar to those reported for tropical rainforest ecosystems in south western Nigeria (Adekunle, 2006; Onyekwelu *et al.*, 2008, Aigbe *et al*., 2014; Aigbe and Omokhua, 2015). For example, Onyekwelu *et al*. (2008) noted that members of the

Euphorbiaceae, Sterculiaceae, Meliaceae, Mimosoideae and Apocynaceae families are dominant in three rainforest ecosystems in south western Nigeria, Adekunle *et. al.,* (2002) and Akinyemi *et al*. (2004) in a study at Omo Forest Reserve however listed Euphorbiaceae among the commonest families with the greatest number of individual stems per hectare. Adekunle *et al.* (2013) also reported that Caesalpinioideae, Sterculiaceae, Meliaceae and Moraceae families are dominant in Strict Nature Reserve, within Akure Forest Reserve in Ondo State, Southwest, Nigeria. The most threatened families in the forest were those families represented by only one species (Oguntala, 1981).

Species Richness, Diversity and Evenness in the forest

Species diversity is a combination of the number of species and their relative abundance. The values of species diversity depend upon levels of species richness and evenness (Molles, 2007). A measure of species diversity is an important parameter of a plant community that plays a vital role in ecology and conservation biology. The knowledge of species diversity is useful for establishing the influence of biotic disturbance, and the state of succession and stability in the environment (Misra, 1989). This species diversity index increases with the number of species in the community (Krebs, 1989). The species diversity of woody plants in the west bank forest of IITA in table 3 showed that transect A had the highest Simpson's diversity, Shannon Weaner and Evenness index of 0.043, 0.471 and 0.276. This was followed by transect B with 0.060, 0.498 and 0.295 respectively while transect C had 0.084, 0.519 and 0.324. However, west bank forest had Simpson's diversity index of 0.012, Shannon Weaner index of 0.354 and Evenness index of 0.195 respectively. The intra species richness of woody plant (alpha diversity) showed that transect A had the highest alpha diversity of 51 species, this was followed by transect B which had 49 plant species while transect C had 40 species of woody plants. In term of Gama diversity (number of individual) Transect A also had the highest value of 245 individual woody plants, followed by transect B and C with the value of 199 and 137 individual woody plants respectively. This showed that transect A was richer in terms of woody plants species and composition than transect B and C. The forest had a total richness of 65 plants species, Simpson diversity index (D), Shannon-Wiener (H) and Evenness index of 0.012, 0.354 and 0.195 respectively. The high number of species richness in the forest could be attributed to climatic, edaphic variability and anthropogenic activities. Mishra *et. al*., (2004) reported that moderately or slightly disturbed tropical forest ecosystem tends to support more number of plant species in comparison with a forest which is dense and undisturbed. According to Isichei (1996), succession restores and increase diversity of life in an area after disturbance. Also Ayodele and Lameed (1999) stated that species diversity is well correlated with the annual amount of rainfall with the water areas tending to be rich in species diversity in the southern parts of Nigeria. The abundance of woody plants species in the west bank forest may be due to the combined effects of favourable climatic conditions and protection from anthropogenic activities over many years which enhance regeneration.

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Density and Frequency of Woody Plant Species

Density and frequency of a species measure the distribution of a species within the population. The density of each woody plant and total density of woody plant species encountered in the west bank forest was shown in table 4.The total density of woody species in West Bank forest of IITA was 1,936.67 individuals ha-1. It was higher than those reported from DAFs like Yegof forest (1,768.13 individuals ha-1) (Mesfin *et. al*., 2018), Dodola (761 individuals ha-1) (Hundera *et. al*. 2007), Adelle (898 individuals ha-1) and Boditi (498 individuals ha-1) (Yineger *et al*. 2008), Hugumburda (1,218 individuals ha-1) (Aynekulu

2011), Wof Washa (698.8 individuals ha-1) (Fisaha *et. al*. 2013) and woodlands (376.86 individuals ha-1) (Adamu *et. al*. 2012) in Ethiopia. However, its density was found to be lower than Tara Gedam (3,001 individuals ha-1), Abebaye (2,850 individuals ha-1) (Zegeye *et al*. 2011) and Zengena (2,202 individuals ha-1) (Tadele *et al*. 2014) forests. Variations in density distributions can be attributed to differences in topographic gradients and habitat preferences of different tree and shrub species forming the forest as well as the degree of anthropogenic influences (Whittaker *et. al*., 2003). However, based on individual woody plants, *Newbouldia laevis* had a relative density of 9.81% and density of 190 ha-1 and was the most abundant woody plant in the west bank forest. *Trichilia monadelpha*, *Antiaris toxicaria*, *Funtumia elastica*, *Trilepisium madagascariense* and *Blighia sapida* had densities of 146.67 ha-1, 133.33 ha-1, 123.33 ha-1, 116.67 ha-1 and 113.33 ha-1, relative densities of 7.57%%, 6.89%, 6.37%, 6.37%, 6.02% and 5.85% respectively. Other species had values ranges between 76.67 and 3.33/ ha, 3.96% and 0.17%. This is similar to the finding of Ariyo (2007) and Ariyo *et. al*., (2011) which found *Funtumia elastica* as the most abundant woody plant followed by *Lecaniodiscus cupanioides*, *Newbouldia laevis*, *Albizia zygia* and *Antiaris toxicaria* have the same abundance and *Trilepisium madagascariense* in IITA forest reserve. Onyekwelu *et. al*., (2005) recorded high relative density for *Diospyros mespiliformis*, *Strombosia pustulata*, *Funtumia elastica*, *Napoleonaea imperialis* and *Sterculia rhinopetala* in Queen's Forest and *Diospyros mespiliformis*, *Strombosia pustulata*, *Celtis zenkeri*, *Pycnanthus angolensis*, and *Buchholzia coriacea* at Oluwa Forest. According to Brashears *et. al*., (2004) and Onyekwelu *et. al*., (2005) relative density is an index for assessing species relative distribution, thus apart from *Newbouldia laevis* and *Trichilia monadelpha* with high relative distribution in west bank forest, other species are variously distributed within the forest. Species such as *Albizia ferruginea*, *Alstonia boonei*, *Canthium venosum*, *Blighia unijugata*, *Keetia venosa*, *Bridelia micrantha*, *Psydrax parviflora*, *Diospyros mespiliformis*, *Cola nitida*, *Entandrophragma angolense*, *Entandrophragma sp*., *Garcinia cola*, *Morus mesozygia*, *Maesopsis eminii*, *Napoleona vogelii*, *Rauvolfia vomitoria*, *Olax subscorpioidea*, and *Synsepalum dulcificum* among others were low in abundance with their densities and relative densities ranging between 3.33/ ha and 6.67/ ha, 0.17% and 0.34% respectively. Other species such as *Albizia ferruginea*, *Canthium venosum*, *Keetia venosa*, *Celtis philipensis*, *Diospyros mespiliformis*, *Entandrophragma angolense*, *Entandrophragma sp*., *Maesopsis eminii*, *Millettia* sp., *Rauvolfia vomitoria*, *Synsepalum dulcificum*, *Trichilia monadelpha*, *Voacanga africana* and *Zanthoxylum rubescens* were encountered once in the west bank forest and had the density of 3.33 ha-1 and relative density of 0.17%. Such species may be regarded as rare in the forest. These results are similar to the earlier findings of Richard (1952), Oguntala (1981) and Etukudo (2002) that although there are usually several species in the tropical rainforest ecosystem some may have only one representative per hectare. The presence of invasive species such as *Delonix regia* and *Leucaena leucocephala* recorded densities of 0.00067and 0.00033, relative densities of 0.34% and 0.17% respectively. Furthermore, some of the species in the forests grow in the understory and their growth may be retarded because felling of trees is not allowed in the forest (Ariyo, 2018b).

Frequency is an indicator of homogeneity and heterogeneity of a given vegetation type (Lamprecht, 1989). The higher number of species in higher frequency classes and lower number of species in lower frequency classes show homogeneity in forest composition. And the low number of species in higher frequency classes shows heterogeneity of species. The present study also revealed *Newbouldia laevis* is the most frequent woody plants occurring in the forest. This might be attributed to its higher density and occurrence in a wide range within the forest. Other species commonly occurring across the forest were *Trichilia monadelpha*, *Antiaris toxicaria*, *Funtumia elastica*, *Trilepisium madagascariense* and *Blighia sapida*.

Variation in the frequency of species might be attributed to habitat preferences among species, species characteristic for adaptation, degree of disturbance and availability of suitable conditions for regeneration (Rey *et al*. 2000). Some species of woody plant were encountered once or twice in the forest, indicating that these species might be under threat of extinction due probably to anthropogenic factor. FORMECU (1999) reported that tropical tree species with frequency of less than 10 individuals per hectare is endangered. Ihenyen *et. al.,* (2010) and Alamu and Agbeja (2011) also reported that one tree species per hectare is endangered.

Basal Area

Basal area provides the measure of the relative importance of the species rather than simple stem count (Lamprecht, 1989). The basal area of woody plants in the forest is found on table 4. Species with higher basal area could be considered as the most important species in the study vegetation. *Milicia excelsa* had the highest basal area of 40.34 m^2 ha−1; this was followed by *Alstonia boonei*, *Triplochiton scleroxylum* and *Margaritaria discoidea* with 6.75 m^2 ha−1, 6.63 m^2 ha−1 and 4.55 m^2 ha−1respectively. Other species of woody plants had between 3.63 m^2 ha−1 to 0.027 m^2 ha−1. The total basal area of woody plant species encountered in the west bank forest was 98.23 m^2 ha−1. This value is much higher than 18.42 m^2 ha−1 and 28 m^2 ha−1 obtained for Oluwa forest reserve and tropical rainforest area in Trinidad (Akinsanmi and Akindele, 2002; Clubbe and Jhilmit, 1992). Generally, the basal area values obtained in this study are higher than those reported in many other forest types in Nigeria (Adekunle *et. al*., 2002). This suggests that the west bank forests have better growth and potential to retain higher biomass. In this study, basal area analysis across individual species revealed that there was high domination by very few or small woody species. This also indicates that most of the species with high relative density (RD) were not among those with high relative dominance (RDo) in the forest; this is in line with the report of Onyekwelu, *et. al*., (2005) and Bekele, (1994).

Comment [B. B.11]: Give space

Relative Dominance and Importance value/ Coverage Index of Woody Plants

Table 4 also revealed the relative dominance and important value/ coverage index of woody plants in west bank forest. *Milicia excelsa* had the highest relative dominance of 41.07% followed by *Alstonia boonei* and *Triplochiton sceleroxylum* with a value of 6.87% and 6.75%. *Margaritaria discoidea* had 4.63%. *Cola nitida* and *Zanthoxylum rubescens* had equal relative dominance of 3.70% each, while *Entandrophragms angolense* had 3.45%. Other woody plants had relative dominance of 0.03% to 2.98%. The dominant species reported was similar to Adekunle *et. al.,* (2013), who reported *Mansonia altissima* and *Triplochiton scleroxylon* as the dominant species in Akure Forest Reserve but different from Aigbe *et. al.,* (2014), who reported *Pycnathus angolensis and Staudtia stipitata* as the dominant species in Afi River Forest Reserve.

Importance value or coverage index provides knowledge on important species of a plant community. It indicates the structural importance of a species within a stand of mixed species. And it is used for comparison of ecological significance of species in which high IVI value indicates that the species sociological structure in the community is high. It is crucial to compare the ecological significance of species (Lamprecht, 1989). It was also stated that species with the greatest importance value are the leading dominant of specified vegetation (Senbeta, 2006). In terms of Importance value or coverage index, *Milicia excelsa* also had the highest value of 42.11%. This was followed by *Newbouldia laevis*, *Trichilia monadelpha*, *Antiaris africana*, *Funtumia elastic*, *Trilepisium madagascariense*, *Blighia sapida*, *Triplochiton sceleroxylum*, *Albizia zygia* with 19.75%, 15.42%, and 14.42%, 13.03%,

12.97%, 11.85%, 10.20% and 9.22% respectively. Other species of woody plants had values ranging between 0.37% and 7.98%. The importance value index rank species in a way as to give an indication on which species come out as important element of the woody plants in west bank forest. Importance value or coverage index can also be used to set conservation priority among plant species in the study area (Shibru & Balcha 2004). Therefore, species with low IVI values such as *Synsepalum dulcificum, Rauvolfia vomitoria, Canthium venosum, Trichilia roka, Keetia venosa, Celtis philipensis, Diospyros mespiliformis, Voacanga africana, Morus mesosygia* and *Garcinia kola* should be prioritized for conservation measures in the study area. *Milicia excelsa* had the highest IVI value that could be attributed to its higher basal area.

CONCLUSION

The study revealed that the West Bank forest reserve of IITA has a reasonably good tree and shrub species composition and richness. The forest was dominated by trees and a repository of many indigenous tropical woody plant species. It has a total richness (alpha diversity) of 65 woody plant species and Gama diversity of 581 individual woody plants from 28 families. The most abundant family in the forest was Fabaceae with sub families of Caesalpinioidea, Mimisoideae and Palpilinoideae. The total density of woody species in the forest was 1,936.67 individuals ha-1. Species noted to be most frequent and most abundant are *Newbouldia laevis, Trichilia monadelpha,, Antiaris toxicaria, Funtumia elastica, Trilepisium madagascariense* and *Blighia sapida* while the highest basal area and relative dominance species are *Milicia excelsa, Alstonia boonei* and *Triplochiton sceleroxylum*. The total basal area of woody plant species encountered in the forest was 98.23 m^2 ha−1. In terms of Importance value or coverage index, *Milicia excelsa Newbouldia laevis, Trichilia monadelpha, Antiaris africana, Funtumia elastic, Trilepisium madagascariense, Blighia sapida, Triplochiton sceleroxylum, Albizia zygia* had the highest value. Species richness for some timber tree species such as *Antiaris toxicaria, Celtis zenkeri, Celtis wightii, Triplochiton sceleroxylum, Pycnanthus angolensis, Diospyros monbuttensis, Lannea welwitchiii* and *Margaritaria discoidea* were relatively high due to protection which the forest has undergone over the years. However, species with low IVI values such as *Synsepalum dulcificum, Rauvolfia vomitoria, Canthium venosum, Trichilia roka, Keetia venosa, Celtis philipensis, Diospyros mespiliformis, Voacanga africana, Morus mesosygia* and *Garcinia kola* should be prioritized for conservation measures in the study area. Invasive species such as *Delonix regia* and *Leucaena leucocephala* were also observed in the forest. Adequate protection of the site should be a priority to prevent loss of diversity of plants from the reserve.

RECOMMENDATION

The study recommends in-depth forest inventory, preparation of management plan and promotion of good governance in management of West Bank forest of IITA. Also the present study was limited to composition; richness and diversity of woody plant species, thus further studies on regeneration, structure, soil seed bank, seed physiology and herbaceous plant are needed in the area.

DATA AVAILABILITY STATEMENT

Raw (Primary) data were generated for this study; the primary data was collected from the West bank forest of International Institute of Tropical Agriculture (IITA) forest. The data that

support the findings of this study are available from the author (Ariyo, O. C), upon reasonable request.

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Table 1: **Woody plant species Composition and Forms in the forest**

Form	**NOS**	**% NOS**	**SF**	**SF %**
Shrub	16	24.62	83	14.29
Tree	49	75.38	498	85.71
Total	**65**	**100**	**581**	**100**

Source: Computed from Vegetation Survey Data, 2016

NOS: Number of species, % NOS: Percentage number of species, SF: Species frequency, SF%: Species frequency percentage

Table 2: Family Distribution of woody plant species in West Bank forest of IITA

S/N	**Families**	**NOS**	**RD %**	**SF**	**SFRD %**
1	Anacardiaceae	2	3.08	13	2.24
2	Annonaceae	1	1.54	5	0.86
3	Apocynaceae	5	7.69	48	8.26
4	Bignoniaceae	1	1.54	57	9.81
5	Bombacaceae	1	1.54	4	0.69
6	Caricaceae	1	1.54	2	0.34
7	Dichapetalaceae	1	1.54	6	1.03
8	Ebenaceae	2	3.08	8	1.38
9	Euphorbiaceae	5	7.69	37	6.37
10	Guttiferae	1	1.54	2	0.34
11	Lecythidaceae	1	1.54	2	0.34
12	Fabaceae- Caes.	1	1.54	2	0.34
13	Fabaceae- Mim.	3	4.62	23	3.96
14	Fabaceae- Pap.	4	6.15	18	3.10
15	Meliaceae	7	10.77	68	11.70
16	Moraceae	6	9.23	89	15.32

17	Myristicaceae	1	1.54	9	1.55
18	Olacaceae	1	1.54	2	0.34
19	Palmae	1	1.54	10	1.72
20	Pandaceae	1	1.54	23	3.96
21	Rhamnaceae	1	1.54	1	0.17
22	Rubiaceae	3	4.62	4	0.69
23	Rutaceae	2	3.08	4	0.69
24	Sapindaceae	3	4.62	58	9.98
25	Sapotaceae	2	3.08	20	3.44
26	Malvaceae	4	6.15	34	5.85
27	Tiliaceae	1	1.54	4	0.69
28	Ulmaceae	3	4.62	28	4.82
	Total	**65**	**100**	**581**	**100**

Source: Computed from Vegetation Survey Data, 2016

NOS: Number of species, RD%: Relative density in percentage, SF: Species frequency, SF%: Species frequency in percentage, SFRD: Species frequency relative density

Table 3: Woody Plants Species Diversity in West Bank Forest of IITA

Transect	n	N	D	H	E
A	51	245	0.043	0.471	0.276
B	49	199	0.060	0.498	0.295
C	40	137	0.084	0.519	0.324
WBF	65	581	0.012	0.354	0.195

Source: Computed from Vegetation Survey Data, 2016

Table 4: Density (D) in ind. ha-1, Frequency (F), Basal Area (BA) in m^2 ha-1, Relative Density (RD), Relative Frequency (RF), Relative Dominance (RDom.) and Important Value Index (IVI) of woody species in West Bank forest of IITA.

S/n	Scientific name	Family	Form	D/ ha	F	BA/ha (m^2)	RD%	RF%	RDom%	IV
1	*Albizia ferruginea*	Fabaceae- Mim	Tree	3.333	1	0.272	0.172	0.172	0.277	0.621
2	*Albizia zygia*	Fabaceae- Mim	Tree	70.000	21	1.959	3.614	3.614	1.995	9.223
3	*Alchornea laxiflora*	Euphorbiaceae	Shrub	76.667	23	0.059	3.959	3.959	0.060	7.978
4	*Alstonia boonei*	Apocynaceae	Tree	6.667	2	6.747	0.344	0.344	6.870	7.558
5	*Antiaria africana*	Apocynaceae	Tree	133.333	40	0.640	6.885	6.885	0.652	14.422
6	*Baphia nitida*	Fabaceae- Pap	Shrub	13.333	4	0.158	0.688	0.688	0.161	1.537
7	*Blighia sapida*	Sapindaceae	Tree	113.333	34	0.145	5.852	5.852	0.148	11.852
8	*Blighia unijugata*	Sapindaceae	Tree	6.667	2	0.056	0.344	0.344	0.057	0.745
9	*Bombax buonopozense*	Bombacaceae	Tree	13,333	4	2.007	0.688	0.688	2.044	3.42
10	*Bridelia micrantha*	Euphorbiaceae	Shrub	6.667	2	0.077	0.344	0.344	0.078	0.766
11	*Canthium venosum*	Rubiaceae	Shrub	3.333	1	0.060	0.172	0.172	0.061	0.405
12	*Keetia venosa*	Rubiaceae	Shrub	3.333	1	0.111	0.172	0.172	0.113	0.457
13	*Psydrax parviflore*	Rubiaceae	Shrub	6.667	2	0.060	0.344	0.344	0.061	0.749
14	*Carica papaya*	Caricaceae	Tree	6.667	2	0.458	0.344	0.344	0.476	1.164
15	*Celtis philipensis*	Ulmaceae	Tree	3.333	1	0.223	0.172	0.172	0.227	0.571
16	*Celtis wightii*	Ulmaceae	Tree	33.333	10	0.159	1.721	1.721	0.162	3.604
17	*Celtis zenkeri*	Ulmaceae	Tree	56.667	17	0.914	2.926	2.926	0.931	6.783
18	*Chrysophyllum albidum*	Sapotaceae	Tree	63.333	19	0.713	3.270	3.270	0.726	7.266
19	*Cola millenii*	Malvaceae	Tree	36.667	11	0.168	1.893	1.893	0.171	3.957
20	*Cola nitida*	Malvaceae	Tree	6.667	2	3.631	0.344	0.344	3.697	4.385
21	*Delonix regia*	Fabaceae- Caes.	Tree	6.667	2	0.239	0.344	0.344	0.243	0.931
22	*Dichapetalum madagascareniense*	Dichapetalaceae	Shrub	20.000	6	0.036	1.033	1.033	0.037	2.103
23	*Diospyros monbuttensis*	Ebenaceae	Shrub	23.333	7	0.055	1.205	1.205	0.056	2.466
24	*Diospyros mespiliformis*	Ebenaceae	Shrub	3.333	1	0.325	0.172	0.172	0.331	0.675
25	*Elaeis guineensis*	Palmae	Tree	33.333	10	2.787	1.721	1.721	2.848	6.290

S/n	Scientific name	Family	Form	D/ ha	F	BA/ha (m^2)	RD%	RF%	RDom%	IV
26	*Entandrophragma angolense*	Meliaceae	Tree	3.333	1	3.387	0.172	0.172	3.448	3.792
27	*Entandrophragma cylindricum*	Meliaceae	Tree	13.333	4	1.044	0.688	0.688	1.063	2.439
28	*Entandrophragma sp.*	Meliaceae	Tree	3.333	1	0.077	0.172	0.172	0.078	0.422
29	*Ficus exasperata*	Moraceae	Tree	16.667	5	0.429	0.861	0.861	0.436	2.158
30	*Ficus mucoso*	Moraceae	Tree	13.333	4	1.512	0.688	0.688	1.539	2.915
31	*Funtumia elastic*	Apocynaceae	Tree	123.333	37	0.291	6.368	6.368	0.296	13.032
32	*Garcinia kola*	Guttiferae	Tree	6.667	2	0.038	0.344	0.344	0.039	0.727
33	*Glyphaea brevis*	Tiliaceae	Shrub	13.333	4	0.054	0.688	0.688	0.055	1.431
34	*Holarrehena floribunda*	Apocynaceae	Tree	23.333	7	1.186	1.205	1.205	1.207	3.617
35	*Khaya grandifoliola*	Meliaceae	Tree	13.333	4	0.048	0.688	0.688	0.049	1.425
36	*Lannea welwitchiii*	Anacardiaceae	Tree	20.000	6	0.797	1.033	1.033	0.812	2.878
37	*Lecaniodiscus cupanioides*	Sapindaceae	Tree	73.333	22	0.166	3.787	3.787	0.169	7.743
38	*Leucaena leucocephala*	Fabaceae- Mim.	Tree	3.333	1	0.255	0.172	0.172	0.260	0.604
39	*Lonchocarpus sericeus*	Fabaceae- Pap.	Tree	16.667	5	1.623	0.861	0.861	1.286	3.008
40	*Maesopsis eminii*	Rhamnaceae	Tree	3.333	1	1.573	0.172	0.172	1.601	1.945
41	*Mallotus oppostifolus*	Euphorbiaceae	Shrub	10.000	3	0.060	0.516	0.516	0.061	1.093
42	*Margaritaria discoidea*	Euphorbiaceae	Tree	16.667	5	4.552	0.861	0.861	4.634	6.356
43	*Microdesmis puberula*	Pandaceae	Shrub	76.667	23	0.049	3.959	3.959	0.050	7.968
44	*Milicia excelsa*	Moraceae	Tree	10.000	3	40.341	0.516	0.516	41.073	42.105
45	*Millettia sp.*	Fabaceae- Pap.	Tree	3.333	1	0.068	0.172	0.172	0.069	0.413
46	*Millettia thonningii*	Fabaceae- Pap.	Tree	26.667	8	0.223	1.377	1.377	0.227	2.981
47	*Monodora tenuifolia*	Annonaceae	Tree	16.667	5	0.455	0.861	0.861	0.463	2.185
48	*Morus mesosygia*	Moraceae	Tree	6.667	2	0.029	0.344	0.344	0.030	0.718
49	*Napoleona vogelii*	Lecythidaceae	Shrub	6.667	2	0.081	0.344	0.344	0.083	0.771
50	*Newbouldia laevis*	Bignoniaceae	Tree	190.000	57	0.128	9.811	9.811	0.131	19.753
51	*Olax subscorpioidea*	Olacaceae	Shrub	6.667	2	0.086	0.344	0.344	0.087	0.775
52	*Pycnanthus angolensis*	Myristicaceae	Tree	30.000	9	1.304	1.549	1.549	1.327	4.425

S/n	Scientific name	Family	Form	D/ ha	F	BA/ha (m^2)	RD%	RF%	RDom%	IV
53	*Rauvolfia vomitoria*	Apocynaceae	Shrub	3.333	1	0.052	0.172	0.172	0.053	0.397
54	*Ricinodendron heudelotii*	Euphorbiaceae	Tree	13.333	4	2.924	0.688	0.688	2.977	4.353
55	*Synsepalum dulcificum*	Sapotaceae	Shrub	3.333	1	0.027	0.172	0.172	0.027	0.371
56	*Spondia mombin*	Anacardiaceae	Tree	23.333	7	0.866	1.205	1.205	0.882	3.292
57	*Steculia tragacantha*	Malvaceae	Tree	36.667	11	0.535	1.893	1.893	0.545	4.331
58	*Trichilia monadelpha*	Meliaceae	Tree	146.667	44	0.270	7.573	7.573	0.275	15.421
59	*Trichilia prieuriana*	Meliaceae	Tree	43.333	13	0.193	2.238	2.238	0.197	4.673
60	*Trichilia roka*	Meliaceae	Tree	3.333	1	0.086	0.172	0.172	0.087	0.431
61	*Trilepisium madagascariense*	Moraceae	Tree	116.667	35	0.904	6.024	6.024	0.920	12.968
62	*Triplochiton sceleroxylum*	Malvaceae	Tree	33.333	10	6.633	1.721	1.721	6.754	10.196
63	*Voacanga Africana*	Apocynaceae	Tree	3.333	1	0.325	0.172	0.172	0.331	0.675
64	*Xanthoxylum zanthoxylloides*	Rutaceae	Tree	10.000	3	0.198	0.516	0.516	0.202	1.234
65	*Zanthoxylum rubescens*	Rutaceae	Tree	3.333	1	3.631	0.172	0.172	3.697	4.041
	Total			**1,936.667**	**581**	**98.216**	**100**	**100**	**100**	**300**

Source: Computed from Vegetation Survey Data, 2016