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Spatial variation in diversity of woody vegetation species within Kwara State University Malete campus, Kwara, Nigeria

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The roles of woody vegetations and Africa savanna in human development and survival as attracted interest in their conservation to prevent the depletion or loss of those resources. However, there is need for accurate data on species composition, distribution and conservation of woody species in many parts of Africa for adequate planning, monitoring, management and conservation efforts. This study assessed woody species composition, distribution and diversity in Kwara State University, Malete Campus. Simple random sampling technique was applied using plot method which was achieved using geographic information system (GIS) application to overlay the area boundary with grids of cell of 100 x 100 m plots. Data were collected from each plot, all woody species were identified, counted, and trees basal covers were measured. Species frequency, density, abundant, dominance, importance value index (IVI) and diversity were determined. A total of 46 trees and 10 shrubs species belonging to 20 families of tree and 8 families of shrubs were identified. Abundant tree species were *Daniella oliveri* and *Azadirachata indica* while the abundant shrubs species were *Piliostigma thonningii* and *Acacia nilotica*. Shannon diversity index and Shannon measure of evenness revealed that the diversity for trees species was higher (H’=2.4309 and J= 0.6349) than shrubs species (H’=1.1166 and J= 0.4849). There was spatial variation in diversity of trees and shrubs within the university which has more tree species than shrubs species. Hence, university management and community should pay attention to conservation planning and management activities with special consideration on their ecological implication.

Key words: Diversity, tropical forest, savanna ecosystem, humid savanna, *D. oliveri*, *A. indica*, *P. thonningii*.

INTRODUCTION

In recent times, the richness of tropical forest has led to upsurge of interest in conservation of Africa Savanna due to the fact that it harbours three or four times more species than the temperate forest as a result of warm...
climatic change and high primary productivity (Michaela, 2005). Since the first earth summit in Rio de Jeneiro, there has been a sustained global awareness of the importance of the superfluity of biodiversity and natural resources from tropical forests for several purposes. However, tropical forests have been rapidly depleted of natural resources due to increasing urbanization, industrialization, fragmentation, degradation and conversion to other forms of land use (Ayodele, 2005).

Savanna ecosystems of the tropical forest are not left out and are generally described as tropical seasonal ecosystems with a continuous grass layer, mixed with forbs and sedges with a variable cover of trees and shrubs (Khavhagali and Bond, 2008). Savanna ecosystem plays important roles in the welfare and economy of man through the ecosystem services (Ikyaagba et al., 2015). The mean annual rainfall divides savannas into arid and humid/ derived and they reportedly occupy sixty percent vegetation cover of sub-Saharan Africa (Sankaran et al., 2005). This ecosystem is however classified as Derived/Humid, Guinea, Sudan and Sahel Savanna in Nigeria.

Humid savanna is a region of savanna- forest boundary that is ecotone representing the natural limit of distribution of tropical forest and offers an opportunity to understand how the tropical forest responds to climate change and disturbance regimes (Hoffmann et al., 2009). The intermediate disturbance hypothesis shows that communities are likely to contain greatest numbers of species when the quantity of disturbance is neither too high nor too low (Bowman, 2000; Michaela 2005) reported that rain fall patterns, fire and grazing are of great importance and can override other factors at all tropic levels out of all the disturbances in the savanna – climate change, increase in atmospheric CO₂ concentration, fire regimes, grazing by livestock and wild herbivores, rain fall, canopy cover, and soil resources. Ruggiero et al. (2002) however included climate and soil characteristics. Hoffmann et al. (2009) opined that fire is the most universal determinant of savannah forest boundaries worldwide. Bowman (2000) also reported that savanna-forest boundary containing tree species being common to both savanna and forest ecosystem. Resilience however plays a crucial role in the maintenance of savanna ecosystems.

Wood vegetation are made up of plants that produce wood as its structural tissue which include trees, shrubs and lianas and are usually perennial plants whose stems and larger roots are reinforced with wood produced from secondary xylem. Nodza et al. (2014) indicated that Nigeria vegetation is one of the most endowed in Africa, as almost all the vegetation types that exist in other African countries are widely distributed in different geopolitical zones of the country. This is as a result of favourable climate and geographic features, which harbors about 7895 species of plants (Adyeyemi and Ogundipe, 2012). However, the continual existence of this forest is uncertain due to the deforestation rate in the country.

Today, there is an urgent need for conservation measures and adoption of sustainable methods throughout tropical forests to avoid further degradation of the natural resources (Ikyaagba et al., 2015). In Nigeria, for instance, there is limited accurate data on flora composition. Thus species currently perceived as abundant might actually be endangered while those previously perceived as endangered might be nearing extinction (Ikyaagba et al., 2015).

For every proposed development such as establishing a university campus like the case study of this research, the effect of such development may cause habitat degradation, fragmentation and loss, which will affect biodiversity occurrence, distribution, and abundance of species present in such an ecosystem. There is no comprehensive inventory of biodiversity present in the area prior to the establishment of the university campus. Therefore, there is need to account for woody vegetation inventory, which will serve as a baseline information that will identify and evaluate the woody vegetation distribution in the Malete campus.

MATERIALS AND METHODS

Study setting

The study area covers a location known administratively as the Malete Campus of Kwara State University. It lies between Latitudes 8.7284 and 8.6979 N and Longitudes 4.4595 and 4.5030 E with 1,612.60 hectares of land (Figure 1). The area shares boundaries with Malete - Elemere road in the South, Malete - Adio Road in the West, undefined foot path and forest vegetation in the North and East by undeveloped tracts of land. The area lies within the Southern Guinea Savanna ecological zone with rainy season period between April and October and average annual rainfall of 1100 mm/yr while the dry season period is between November and March. Annual mean temperature is 27°C and relative humidity is 89% in the morning and 55% in the evening. The daily minimum temperature is 20°C mostly around December and January, while daily maximum temperature is 33°C and it is the highest in March. The topography information shows that elevation is averagely 300 m and the maximum topographical height is located at the eastern axis with 346 m above sea level. The elevation rises upwards with a gentle slope from South-Western axis to North-Eastern axis where a stream is located. It is therefore characterised by clusters of trees, shrubs and seasonal herb and grass communities with a number of associated animal species.

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**Sampling design and procedure**

The study is a descriptive ecological study that utilized an adaptive simple random sampling technique to establish plots sample of 100 m by 100 m for trees and shrubs species enumeration. The sampling strategy utilized the university land area that was already grouped into: built up, disturbed and undisturbed area. In order to trace out the study area boundary, an image band was combined, geo-referenced and digitized to enable equal distribution and sampling. Identification and species count of trees and shrubs in each selected plot were then carried out after locating the centre point of each plot using Garmin geographic position system (GPS) to capture the geographic coordinates (Latitude, Longitude and Elevation).

In each plot, woody vegetation survey covered 50 m away from the centre point in a square plot of North, South, East, and West. Trees with diameter at breast height 'DBH ≥ 10 cm' were selected for assessment. Tree count, diameter and location coordinate were recorded. Also, shrubs with 'DBH ≥ 5 cm' were identified, counted and location coordinate was recorded. In-situ and ex-situ identification was performed by a plant taxonomist aided by manuals and Floras and were presented in tables and chart that reported relative frequency, relative density and Importance Value Index.

**Data analysis**

**Normalized Difference Vegetation Index (NDVI)**

Normalized Difference Vegetation Index (NDVI) is a remote sensing/GIS technique used to qualitatively and quantitatively evaluate the vegetation covers of an area (Neelima et al., 2013). NDVI can be calculated as:

\[
NDVI = \frac{NIR - R}{NIR + R}
\]

Where NIR is the reflectance in the near infrared region and R is the reflectance in the red region.

**Species Occurrence, Density and Important Value Index (IVI)**

This study adopted techniques described by Nautiyal et al. (2015) to compute frequency, relative frequency, density, relative density, abundance and important value index. IVI of the species was calculated as the sum of species relative density; relative frequency and relative dominance as shown below:

\[
Frequency = \frac{\text{number of sampling units (plot) in which a species occurs}}{\text{Total number of sampled units' studied}} \times 100
\]  

\[
Relative\ frequency\ (RF) = \frac{\text{Number of occurrences of a species}}{\text{Total number of occurrence of all species}} \times 100
\]  

\[
Density = \frac{\text{Total number of individual in all sampling units}}{\text{Total number of sampled units studied}} \times 100
\]  

\[
Relative\ density\ (RD) = \frac{\text{Number of individual of a species}}{\text{Total number of individual of all species}} \times 100
\]  

\[
Relative\ dominance\ (RD_o) = \frac{\text{Total basal cover of individual species}}{\text{Total basal cover of all species}} \times 100
\]  

\[
Abundance = \frac{\text{Total number of individuals in all sampling units}}{\text{Total number of sampling units of occurrence}}
\]  

\[
IVI = RD + RF + RD_o
\]

**Species diversity and evenness**

Trees and shrub composition in the University campus were estimated using Shannon-Wiener indices of diversity and evenness (Ikyagga et al., 2015). This index considered species richness and proportion of each species in the sample plots. It was noted...
that, the value of $H'$ obtained from empirical data usually falls between 1.5 and 3.5, and rarely surpasses 4 (Magurran, 2004) which can be obtained as:

$$H' = - \sum_{i=1}^{S} Pi \ln Pi$$

Where $H'$ is Shannon-Wiener diversity index, $P_i$ is Proportion of individuals in the $i^{th}$ species and $\ln P_i$ is the Natural logarithm of $P_i$. An index of evenness ($J'$) can be derived from the Shannon Wiener index. This index of evenness range between 0 and 1 which can be defined as:

$$J' = \frac{H'}{H'_{\text{max}}}$$

Where $H'$ is the Shannon Wiener diversity index, $H'_{\text{max}}$ is $\ln S$ and $S$ is the number of species in the community.

Spatial variation mapping of species diversity using ordinary kriging interpolation

Kriging is a type of spatial interpolation that uses complex mathematical formulas to estimate values at unknown points, based on the values at known points. The values of known points are the grids/plot visited. Shannon index of species diversity was used to calculate the spatial diversity of the whole area. There are different types of Kriging, which include Ordinary, Universal, Co-Kriging, and Indicator Kriging. In this research, Ordinary kriging was used for interpolation; it assumes that the constant mean is unknown. This is a reasonable assumption except there is a scientific reason to reject it (Childs, 2004).

$$\hat{Z}(S_o) = \sum_{i=1}^{N} \lambda_i Z(S_i)$$

Where:
Z(S_i) = the measured value at the ith location
\( \lambda_i \) = an unknown weight for the measured value at the ith location
S_o = the prediction location
N = the number of measured values

RESULTS

NDVI and land cover map

NDVI results show the area distribution of the university vegetation. NDVI value range from 0 to 9; and the higher the value the more vegetative the area. Figures 2 and 3 below show the map revealing NDVI values and the respective corresponding land cover of University Campus:

Woody species composition

A total of 46 trees and 10 shrub species were identified within the university campus, amounting to a total of 56 woody species (trees and shrubs) encountered during the study. The trees belonged to 20 families and 33 genera, while the shrubs belonged to 8 families and 10 genera. Trees were the most dominant woody species identified in the studied area.

The results shown in Figure 4 reveals that 13 of the families were represented by one species each while the dominant family was Fabaceae with 12 species followed by Moraceae, Combretaceae, Meliaceae and Myrtaceae with 5, 4, 4 and 4 species, respectively for tree species, while Figure 5 reveals that 7 families were represented by one species each for shrubs species, with family Fabaceae the only family with multiple species representation.

Woody species occurrence, abundance and IVI

In the sample units of tree species studied, *Azadirachta indica* is the most frequent (11.47), most dominant (24.57) and the most important species with IVI of 58.41/300 but *Daniellia oliveri* (11.01) is the most abundant (22.04) with the highest density (26.89) tree species in the vegetation; while 10 species of trees were the least abundant species (1) with relative frequency of 0.46 among which *Ficus spp* is among the least dominant (0.02) and least dense (0.05) as well the least important tree species (0.52/300).

Among the Shrubs, *Piliostigma thonningii* is the most frequent (92.86) and abundant (19.77), while *Olax subcordata* with the least density (10.71) is the least important shrub species with relative frequency of 0.01.
abundant (1) shrub. Table 1 shows the individual trees species composition with their scientific, family/common names and IVI. Table 2 shows individual shrubs species composition with their Scientific, Family/Common names, frequency, abundance and density.

**Woody species diversity**

Trees and shrubs species present in the vegetation sample are 46 and 10, respectively, per 30 hectare. Proportion Pi was obtained for individual trees and
Shrubs species while H measure (P ln Pi). Thus, Shannon H' is given as $\sum_{i=1}^{S} (P \ln Pi) - (-2.4309) = 2.4309$ for Shannon index of trees species and also for shrubs species – (-1.1166) = 1.1166. Hence, Shannon index of evenness of species in the community ranging between 0 and 1 is $J' = (H'/\ln S) = 0.6349$ and 0.4849 for trees and shrubs species in the community, respectively. Tables 3 and 4 show Shannon index with respect to individual species for trees and shrubs, respectively.

**Spatial variation mapping of trees and shrubs species diversity using ordinary kriging interpolation**

Figures 6 and 7 show the spatial variation mapping of trees and shrubs species diversity using ordinary kriging interpolation. Shannon indices were used to map out variation of trees and shrubs within the vegetation. The map of Shannon index for woody species shows that the dark green colour areas have the highest species diversity while grey colour areas have the least species diversity within the community.

The map reveals that the highest diversity of trees species are mostly in North East (NE) part of the studied area while North West area have the lowest diversity. For shrub species, areas with highest diversity of species are mostly in the North West (NW) while North East (NE) areas have the lowest diversity. Figures 6 and 7 below show the spatial variation maps of trees and shrubs species diversity in the community.

**DISCUSSION**

Forty- Six (46) trees species and Ten (10) shrubs species
Table 1. List of Trees Species and their Corresponding IVI.

| S/N | Species           | Family Name | Common Name                        | Abundance | Relative Frequency | Relative Density | Relative Dominance | IVI  |
|-----|-------------------|-------------|------------------------------------|-----------|-------------------|------------------|-------------------|------|
| 1   | Acacia spp        | Fabaceae    | Gum acacia                         | 3.22      | 4.13              | 1.47             | 0.96              | 6.56 |
| 2   | Acacia spp        | Fabaceae    | Wattles, Acacias                   | 2.67      | 1.38              | 0.41             | 0.22              | 2.01 |
| 3   | Adansonia digitata| Malvaceae   | Macaw-fat                          | 1         | 1.38              | 0.15             | 1.16              | 2.69 |
| 4   | Afzelia Africana  | Fabaceae    | Afzelia, African mahogany          | 53        | 0.46              | 2.69             | 1.97              | 5.12 |
| 5   | Albizia lebbeck   | Mimosaceae  | Indian siris                       | 1         | 0.46              | 0.05             | 0.08              | 0.59 |
| 6   | Anacardium occidentale | Anacardiaceae | Cashew                           | 7.17      | 2.75              | 2.19             | 3.2               | 8.14 |
| 7   | Annona squamosa   | Annonaceae  | Sugar-apple                        | 1         | 0.46              | 0.05             | 0.02              | 0.53 |
| 8   | Angeissus leiocarpus | Combretaceae | Axle-wood tree                  | 18.09     | 5.05              | 10.12            | 8.8               | 23.96|
| 9   | Azadirachta indica| Meliaceae   | Neem                               | 17.6      | 11.47             | 22.37            | 24.57             | 58.41|
| 10  | Bambusa vulgaris  | Poaceae     | Bamboo                             | 3.5       | 0.92              | 0.36             | 0.07              | 1.34 |
| 11  | Bauhinia tomentosa| Fabaceae    | Yellow baumnia, Yellow bell orchid tree | 3.5   | 0.92              | 0.36             | 0.65              | 1.93 |
| 12  | Blighia sapida    | Sapindaceae | Akee                               | 3         | 0.92              | 0.31             | 0.11              | 1.33 |
| 13  | Bridelia ferruginea| Phyllanthaceae | Bridelia, Coast goldleaf         | 3.67      | 2.75              | 1.12             | 0.96              | 4.83 |
| 14  | Bridelia micrantha| Phyllanthaceae | Bridelia, Coast goldleaf         | 11        | 0.46              | 0.56             | 0.29              | 1.31 |
| 15  | Daniellia oliveri | Fabaceae    | West african copal tree           | 22.04     | 11.01             | 26.89            | 15.52             | 53.42|
| 16  | Dialium guineense | Fabaceae    | Velvet tamarind                    | 6         | 1.83              | 1.22             | 0.55              | 3.6  |
| 17  | Dillenia spp      | Dilleniaceae|                                   | 9         | 0.46              | 0.46             | 0.22              | 1.14 |
| 18  | Eleais guineense  | Arecaceae   | African oil palm                   | 5         | 0.46              | 0.25             | 0.26              | 0.97 |
| 19  | Erythrina gigantea| Fabaceae    | Coral tree, Flame tree             | 1         | 0.46              | 0.05             | 0.07              | 0.58 |
| 20  | Eucalyptus camadulasis | Myrtaceae | Red gum                           | 10.67     | 1.38              | 1.63             | 1.3               | 4.31 |
| 21  | Eucalyptus globulus| Myrtaceae   | Blue gum                           | 7         | 0.46              | 0.36             | 0.2               | 1.02 |
| 22  | Eucalyptus spp    | Myrtaceae   |                                   | 3         | 0.46              | 0.15             | 0.06              | 0.67 |
| 23  | Eucalyptus torelliana| Myrtaceae | Cadagi tree                       | 1         | 0.46              | 0.05             | 0.02              | 0.53 |
| 24  | Ficus capensis    | Moraceae    | Wild fig                           | 1         | 0.46              | 0.05             | 0.02              | 0.53 |
| 25  | Ficus macrophylla | Moraceae    | Moreton bay fig                    | 4         | 0.46              | 0.2              | 0.25              | 0.91 |
| 26  | Ficus mucuso      | Moraceae    | Doumbourou                          | 5.5       | 5.5               | 3.36             | 1.89              | 10.76|
| 27  | Ficus spp         | Moraceae    |                                   | 1         | 0.46              | 0.05             | 0.02              | 0.52 |
| 28  | Ficus sur         | Moraceae    | Wild fig                           | 3.2       | 2.29              | 0.81             | 0.76              | 3.86 |
| 29  | Khaya ivorensis   | Meliaceae   | Red mahogany                       | 1.5       | 0.92              | 0.15             | 0.13              | 1.19 |
| 30  | Khaya senegalensis| Meliaceae   | Mahogany                           | 1.5       | 0.92              | 0.15             | 0.08              | 1.15 |
| 31  | Mangifera indica  | Anacardiaceae| Mango                            | 2.6       | 2.29              | 0.66             | 1.02              | 3.97 |
| 32  | Pamari spp        | Chrysobalanaceae | Cork tree, Hissing tree        | 3         | 1.38              | 0.46             | 0.25              | 2.09 |
| 33  | Parkia biglobosa  | Fabaceae    | African locust bean tree           | 6.96      | 11.01             | 8.49             | 22.1              | 41.6 |
| 34  | Poga oleosa       | Anisophylleaceae | Ovoga                       | 1         | 0.46              | 0.05             | 0.02              | 0.53 |
Table 1. Cont’d

| S/N | Species               | Family name | Common name         | Abundance | Relative frequency | Relative density |
|-----|-----------------------|-------------|---------------------|-----------|-------------------|-----------------|
| 35  | Prosopis africana    | Fabaceae    | Guele               | 1.33      | 1.38              | 0.2             | 0.11            | 1.69            |
| 36  | Pterocarpus erinaceus| Fabaceae    | African rosewood    | 14        | 0.46              | 0.71            | 0.37            | 1.54            |
| 37  | Pterocarpus soyauxii | Fabaceae    | African padouk, Barwood, African coral | 1.5 | 0.92 | 0.15 | 0.08 | 1.15 |
| 38  | Tabebuia spp         | Bignoniaceae| Trumpet trees, Roble| 8         | 0.46              | 0.41            | 0.23            | 1.1             |
| 39  | Tamarindus spp       | Fabaceae    | Tamarind            | 4.5       | 0.92              | 0.46            | 0.26            | 1.64            |
| 40  | Terminalia spp       | Verbenaceae | Teak                | 1         | 0.92              | 0.1             | 0.05            | 1.07            |
| 41  | Tectona grandis      | Combretaceae|                     | 4         | 0.46              | 0.2             | 0.08            | 0.74            |
| 42  | Terminalia laxiflora | Combretaceae| Stage tree         | 1         | 0.46              | 0.05            | 0.02            | 0.53            |
| 43  | Terminalia radii     | Combretaceae|                     | 2         | 0.46              | 0.1             | 0.11            | 0.87            |
| 44  | Trichilia emetica    | Meliaceae   |                     | 3.33      | 2.75              | 1.02            | 0.75            | 4.52            |
| 45  | Vitellaria paradoxa  | Sapotaceae  | Shea butter tree    | 6.5       | 11.01             | 7.93            | 9.43            | 28.37           |
| 46  | Vitex doniana        | Lamiaceae   | West african plum, African oak | 2.71 | 3.21 | 0.97 | 0.69 | 4.87 |
|     | **Total**            |             |                     | **275.26**| **100**           | **100**         | **100**         | **300**         |

Table 2. List of shrubs species and their corresponding frequency, abundance and density.

| S/N | Species       | Family name | Common name                              | Abundance | Relative frequency | Relative density |
|-----|---------------|-------------|------------------------------------------|-----------|-------------------|-----------------|
| 1   | Acacia nilotica | Fabaceae    | Scented-pod acacia                       | 11.88     | 35.82             | 31.53           |
| 2   | Acalypha wilkesiana | Euphorbiaceae | Red acalypha                            | 9         | 1.49              | 1               |
| 3   | Annona senegalensis | Annonaceae | African custard-apple, Wild soursop    | 1.67      | 4.48              | 0.55            |
| 4   | Balanites aegyptiaca | Zygophyllaceae | Desert date                          | 2         | 2.99              | 0.44            |
| 5   | Entada gigas   | Fabaceae    | Monkey-ladder , Sea bean                | 4.5       | 5.97              | 1.99            |
| 6   | Ficus benjamina | Moraceae    | Ficus benjamina, Ficus tree            | 53        | 1.49              | 5.86            |
| 7   | Nauclea latifolia | Rubiaceae | African peach                           | 4         | 1.49              | 0.44            |
| 8   | Olax subcordata | Olacaceae   |                                         | 1         | 4.48              | 0.33            |
| 9   | Piliostigma thonningii | Fabaceae  | Camel's foot tree, Monkey bread       | 19.77     | 38.81             | 56.86           |
| 10  | Rauvolfia vomitoria | Apocynaceae | Swizzle-stick                           | 4.5       | 2.99              | 1               |
|     | **Total**      |             |                                          | **111.32**| **100**           | **100**         |

were identified in Malete Campus, Kwara State University. The number of tree species recorded is quite close to the one recorded (52) by Ikyaaagba et al. (2015) in Federal university of Agriculture Makurdi, Nigeria in Guinea Savanna. This is in contrast with 67 woody species recorded by Nodza et al. (2014) in Akoka Campus Lagos state and 26 recorded by Iwara et al. (2012) in Ugep Cross-river state, as a result of difference in
| S/N | Species                          | Pi     | LnPi   | H      |
|-----|---------------------------------|--------|--------|--------|
| 1   | Acacia spp                      | 0.0147 | -4.217 | -0.0622|
| 2   | Acacia spp                      | 0.0041 | -5.5048| -0.0224|
| 3   | Adansonia digitata              | 0.0015 | -6.4857| -0.0099|
| 4   | Afzelia africana                | 0.0269 | -3.614 | -0.0974|
| 5   | Albizia lebbeck                 | 0.0005 | -7.5843| -0.0039|
| 6   | Anacardium occidentale          | 0.0219 | -3.8231| -0.0836|
| 7   | Annona squamosa                 | 0.0005 | -7.5843| -0.0039|
| 8   | Anogeissus leiocarpus           | 0.1012 | -2.291 | -0.2318|
| 9   | Azadirachta indica              | 0.2237 | -1.4975| -0.335 |
| 10  | Bambusa vulgaris                | 0.0036 | -5.6384| -0.0201|
| 11  | Bauhinia tomentosa              | 0.0036 | -5.6384| -0.0201|
| 12  | Blighia sapida                  | 0.0031 | -5.7925| -0.0177|
| 13  | Bridelia ferruginea             | 0.0112 | -4.4932| -0.0503|
| 14  | Bridelia micrantha              | 0.0056 | -5.1864| -0.029 |
| 15  | Daniellia oliveri               | 0.2689 | -1.3133| -0.3532|
| 16  | Dialium guineense               | 0.0122 | -4.4062| -0.0538|
| 17  | Dillenia spp                    | 0.0046 | -5.387 | -0.0246|
| 18  | Eleais guineensis               | 0.0025 | -5.9748| -0.0152|
| 19  | Erythrina gigantica             | 0.0005 | -7.5843| -0.0039|
| 20  | Eucalyptus camadulasis          | 0.0163 | -4.1185| -0.067 |
| 21  | Eucalyptus globulus             | 0.0036 | -5.6384| -0.0201|
| 22  | Eucalyptus spp                  | 0.0015 | -6.4857| -0.0099|
| 23  | Eucalyptus torelliana           | 0.0005 | -7.5843| -0.0039|
| 24  | Ficus capensis                  | 0.0005 | -7.5843| -0.0039|
| 25  | Ficus macrophylla               | 0.002  | -6.198 | -0.0126|
| 26  | Ficus mucuso                    | 0.0336 | -3.3946| -0.1139|
| 27  | Ficus spp                       | 0.0005 | -7.5843| -0.0039|
| 28  | Ficus sur                       | 0.0081 | -4.8117| -0.0391|
| 29  | Khaya ivorensis                 | 0.0015 | -6.4857| -0.0099|
| 30  | Khaya senegalensis              | 0.0015 | -6.4857| -0.0099|
| 31  | Mangifera indica                | 0.0066 | -5.0193| -0.0332|
| 32  | Parinari spp                    | 0.0046 | -5.837 | -0.0246|
| 33  | Parkia biglobosa                | 0.0849 | -2.4663| -0.2094|
| 34  | Poga oleosa                     | 0.0005 | -7.5843| -0.0039|
| 35  | Prosporis africana              | 0.002  | -6.198 | -0.0126|
| 36  | Pterocarpus erinaceus           | 0.0071 | -4.9452| -0.0352|
| 37  | Pterocarpus soyauxii            | 0.0015 | -6.4857| -0.0099|
| 38  | Tabeulla spp                    | 0.0041 | -5.5048| -0.0224|
| 39  | Tamarindus spp                  | 0.0046 | -5.387 | -0.0246|
| 40  | Terminalia spp                  | 0.0016 | -6.8911| -0.007 |
| 41  | Tectona grandis                 | 0.002  | -6.198 | -0.0126|
| 42  | Terminalia laxiflora            | 0.0005 | -7.5843| -0.0039|
| 43  | Terminalia radii                | 0.001  | -6.8911| -0.007 |
| 44  | Trichilia emetic                | 0.0102 | -4.5885| -0.0467|
| 45  | Vitellaria paradoxa              | 0.0793 | -2.5344| -0.201 |
| 46  | Vitex doniana                   | 0.0097 | -4.6398| -0.0448|
|Total|                                | 1.0000 | -248.6922| -2.4309|

Thus, Shannon Index (H') for trees = - (H), Therefore : - (-2.4309) which is 2.4309.
Table 4. Shannon weiner diversity index for shrubs species.

| S/N | Species                     | Pi    | lnPi   | H     |
|-----|-----------------------------|-------|--------|-------|
| 1   | Piliostigma thonningii      | 0.5686| -0.5646| -0.321|
| 2   | Olax subcordata             | 0.0033| -5.7082| -0.0189|
| 3   | Acacia nilotica             | 0.3153| -1.1543| -0.3639|
| 4   | Annona senegalensis         | 0.0055| -5.1974| -0.0287|
| 5   | Nauclea latifolia           | 0.0044| -5.4205| -0.024 |
| 6   | Acalypha wilkesiana         | 0.01  | -4.6096| -0.0459|
| 7   | Ficus benjamina             | 0.0586| -2.8365| -0.1663|
| 8   | Rauvolfia vormitoria        | 0.01  | -4.6096| -0.0459|
| 9   | Entada gigas                | 0.0199| -3.9165| -0.078 |
| 10  | Balanites aegyptiaca        | 0.0044| -5.4205| -0.024 |
|     | Total                       | 1.0000| -39.4377| -1.1146|

Thus, Shannon Index (H') for shrubs = - (-H), therefore: – (-1.1146) which is 1.1146.

Figure 7. Showing spatial variation in shrubs species diversity.

species richness in a tropical rain forest compared to a savanna ecosystem of our present study.

Fabaceae family was majorly represented accounting for twelve (12) and three (3) trees and shrubs species, respectively (Ikyaaqba, 2008). This corroborates the affirmation of other Nigeria studies like Erhenhi and Obadoni (2016) in Urhonigbe forest reserve in Edo State, and Bello and Musa (2016) in Shika, Zaria. John et al. (2013) in Northern Botswana and Elizabeth (2011) studied in Kumasi, Ghana also reported family Fabaceae as the most represented family. This is due to similarity in species recorded and close geographical characteristic with similar ecological distribution. Though, this is not in agreements with Athua and Pabi (2013) in Ghana and Ikyaaqba (2008) in Nigeria whose studies postulated that Mimosoideae, Combretaceae, Euphorbiaceae are the most represented families.

D. oliveri and A. indica were the two (2) most frequency while Afzelia africana had the highest abundance value (53) for trees species. P. thonningii and Acacia nilotica were the two (2) with most frequency; while Acalypha wilkesiana and Rauvolfia vormitoria were the least frequent for shrub species. The result also indicated that O. subcordata have the lowest abundance value out of the shrubs species. This result is in agreement with Oyedepo et al. (2016) whose study reported that D. oliveri have the highest frequency. In contrast with this, Bello and Musa (2016) in Shika, Zaria Nigeria revealed that Isoberlinia doka was the most abundant species.

IVI result revealed that A. indica and D. oliveri have the highest IVI value of 58.41 and 53.42, respectively per 300 which indicated their ecological importance while Seven (7) species: Annona squamosa, Eucalyptus spp, Eucalyptus torelliana, Poga oleosa, Tectona grandis, Terminalia laxiflora and Ficus spp have IVI values less than 0.54 per 300. Bello and Musa (2016) in their study in Shika, Zaria Nigeria and John et al. (2013) in their study in Northern Botswana also utilized IVI value to determine the most importance species.

The overall diversity and evenness of woody species was much higher in trees species ($H' = 2.4309$ and $J = 0.6349$) than shrubs species ($H' = 1.1166$ and $J = 0.4849$),
which may be a consequence of high species richness in tree species. It has been noted that the value of $H'$ obtained from empirical data usually falls between 1.5 and 3.5, and rarely surpasses 4 (Magurran, 2004). This implies that the diversity of woody shrubs falls at the lowest values of diversity range while the diversity of woody trees falls at the highest value of diversity range indicating the extent of tree species diversity in the woody population. Bello and Musa (2016) in their study in Shika, Zaria Nigeria obtained Shannon diversity values of 2.441, 2.331, and equitability of 0.733, 0.685 for trees and shrubs species, respectively which therefore highlighted close diversity evaluation of tree species in the savanna ecosystem of Nigeria.

Result of spatial variation map of woody species diversity using ordinary kriging interpolation indicates that, spatial diversity is higher in some region and lowers in some region within the community for both trees and shrubs species. The North East (NE) region had the highest diversity while the North West (NE) region had the lowest diversity of trees species. For shrubs species the reverse was the case, highest diversity was in the North West (NW) while the lowest diversity was in the North East region. This result can be attributed to high disturbances in terms of concentration of built up area in the North Western region of the University Campus due to clear cutting of vegetation before building structures compared to North Eastern region with low concentration of built up areas.

Conclusion

The university has more trees species richness and diversity than shrubs species with forty-six (46) tree species (33 genera and 20 families) and ten (10) shrubs species (10 genera and 8 families) identified. D. oliveri and A. indica occurred mostly with high density and therefore highlighted as the two most ecologically important woody trees while P. thonninii and A. nilotica are the most abundant shrubs in the vegetation. There is spatial variation in distribution of woody species across the community: the North- East part of the vegetation has the highest trees diversity while the North- West part has the highest shrubs diversity.

Hence, there is need for University management and the entire community to pay attention to conservation planning and management activities that will put ecological implication into consideration. Maps on forest ecology of Malete Campus, Kwara State University should be widely circulated and made easy to interpret which will be readily available to the institution and local communities. This research, being a base line study, has opened up space for further researches; hence it is recommended that more researches should be carried out on the identified species in order to ascertain their morphological, anatomical, phyto-chemical characteristics, ethnobotanical and economic importance.

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CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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