Research Article

Phytosociological Assessment and Diversity of Woody Species in Omo Biosphere Reserve, Nigeria.

Oyelowo, O.J*[1], Oladoye, A.O[2], Ojo, E.O.[2], Olubayo, O.O.[2], Sonde, B.[2], Adelani D.O.[3]

[1]Department of Forest Conservation and Protection, Forestry Research Institute of Nigeria.

[2]Department of Forestry & Wildlife Management, Federal University of Agriculture, Abeokuta, Ogun State

[3]Federal College of Forest Mechanization, Afaka, Kaduna

Corresponding author: tayooyelowo@yahoo.com

Abstract

Logging activities, climate change and variation are threatening the sustainability of the entire forest ecosystem. Maintenance and periodic assessment of diverse ecosystems are, therefore, crucial for the long-term survival of human beings. However, baseline data on the resulting depletion of forest ecosystems in Nigeria are insufficient or lacking. The aim of the present study was to assess the phytosociological relationship between species composition and the diversity of woody species at Omo Biosphere Reserve. Three lines of transect were cut apart 200 m far from each other. Each transect has 4 plots of 50 x 50m in an alternate manner at 100m intervals. Trees with e" 10 cm diameter at breast height (DBH) in each plot were measured for height, DBH. The data were analyzed for species composition, richness, diversity, relative density, and relative dominance, Species Importance Value Index (IVI), Species diversity was computed using Shannon's Weaner and Simpson's diversity indices. The Data were analyzed using PAST software Version.3 and Microsoft Excel 2010. The Carl-Pearson correlation coefficient was calculated between various phytosociological parameters. A total of 427 trees representing 57 from 22 families were encountered in Omo Biosphere Reserve. The stocking density of dominant tree species/ha ranges from 0.33 trees/ha to 26.33 trees/ha. For Simpson's similarity between the plots, it varied from 0 % to 77 % for all the plots. The species diversity (Simpson's diversity indices) between the plots varies from 64 % to 93 % for all plots. In conclusion, this study demonstrates the promise of an *in-situ* approach to nature preservation.

Keywords: Phytosociological, Assessment, Diversity, Nigeria, Woody Species, Omo Biosphere

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Resumé

Les activités d'exploitation forestière, les changements et les variations climatiques menacent la durabilité de l'ensemble de l'écosystème forestier. L'entretien et l'évaluation périodique de divers écosystèmes sont donc cruciaux pour la survie à long terme des êtres humains. Cependant, les données de base sur l'appauvrissement des écosystèmes forestiers au Nigéria sont insuffisantes ou absentes. Le but de la présente étude était d'évaluer la relation phytosociologique entre la composition des espèces et la diversité des espèces ligneuses à la réserve de biosphère de l'Omo. Trois lignes de transect ont été coupées à 200 m de distance l'une de l'autre. Chaque transect comporte 4 parcelles de 50 x 50 m en alternance à 100 m d'intervalle. Les arbres avec e" 10 cm de diamètre à hauteur de poitrine (DHP) dans chaque parcelle ont été mesurés pour la hauteur, DHP. Les données ont été analysées pour la composition, la richesse, la diversité, la densité relative et la dominance relative des espèces, l'indice de valeur d'importance des espèces (IVI), la diversité des espèces a été calculée à l'aide des indices de diversité de Shannon Weaner et de Simpson. Les données ont été analysées à l'aide du logiciel PAST Version.3 et de Microsoft Excel 2010. Le coefficient de corrélation de Carl-Pearson a été calculé entre différents paramètres phytosociologiques. Un total de 427 arbres représentant 57 de 22 familles ont été rencontrés dans la réserve de biosphère de l'Omo. La densité de peuplement des espèces d'arbres dominantes/ha varie de 0,33 arbres/ha à 26,33 arbres/ha. Pour la similarité de Simpson entre les parcelles, elle variait de 0 % à 77 % pour toutes les parcelles. La diversité des espèces (indices de diversité de Simpson) entre les parcelles varie de 64 % à 93 % pour toutes les parcelles. En conclusion, cette étude démontre la promesse d'une approche in situ de la préservation de la nature.

Mots-clés : Phytosociologique, Évaluation, Diversité, Nigéria, Espèces ligneuses, Biosphère de l'Omo

(Translated by Google Translate, Revised by editor-in-Chief)

Introduction

Phytosociology is the study of plant communities, their composition and development, as well as the relationships among the species that make up those communities (Ariyo, 2020). It delimitates and characterizes vegetation types based on the complete floristic (species) composition (Jurgen, 2017). It is important to describe the population dynamics of each plant species that occur in each community and understand how other species are in the same community (Mishra *et al.,* 2012). The herbaceous layer composition changes throughout time and space because of a variety of events like grazing, fire and varying intensity and duration rainfall (Shameem, *et al.,* 2010). Species richness is a simple and clear biological diversity statistic (Hillebrand *et al.,* 2018). Communities' species variety is essential since it is typically linked to their functioning and potential for change (Stachowicz *et al.,* 2007; Gamfeldt and Hillebrand, 2008).

Several topographic gradients and climate changes have an impact on plant species diversity. The variables influencing plant species richness and diversity are critical in ecology and conservation biology. The number of species in a forest varies dramatically across its altitudinal range, which is determined by a complicated set of characteristics that describe each species' habitat (Gairola *et al.,* 2011). The loss of diversity is distinct due to population pressure, rapid urbanization, plantation establishment and illicit felling of trees (Oladoye *et al.*, 2013).

According to Lafrankie et al. (2006), tropical rainforests are prone to deforestation and degradation. Population expansion in Nigeria has resulted in a massive increase in human activities, excessive logging, and overexploitation. The available records in the Federal Department of Forestry show that Nigeria has a total of 1,160 constituted forest reserves covering a land area of about 1075 km2. Rural development, encroachment, illegal logging, massive conversion to agriculture and large-scale afforestation projects are some of the problems responsible for the disappearance of this natural forest ecosystem. Illegal logging and encroachment are the greatest threat to SFM today. The natural forest is now disappearing at an alarming rate of 3.5% (about 350,000 – 400, 000 ha) per annum (Oyerinde, 2013). As a result, many of these forest reserves are now merely on paper. Furthermore, the lucrative nature of the wood trade attracted many Nigerians to the industry, resulting in continual timber harvesting in both constituted and unconstrained regions.

According to United Nations (2011), over 70% of Nigerians engage in farming as a means of livelihood. Clearing the forest for logging opens areas of forest that were initially inaccessible to become accessible. This leads to further degradation by fire and farming, affecting the forest species' composition, diversity, and structure. During logging, most of the high-valued timber tree species are selectively felled creating a gap and eventually impeding the survival of some of the shade-loving species that are slow growing. In most cases, gaps created by the felling and evacuation of selectively logged timber trees create easy access for arable crop farmers who clear the forestland year in and year out for food crop production; thereby limiting the chances of some native plant species to survive.

Logging activities are done with little or no consideration for the sustainability of the residual stock and the entire forest ecosystem. The resulting forest depletion has not been adequately quantified. Maintenance and periodic assessment of diverse ecosystems and the whole biological diversity therein are, therefore, crucial for the long-term survival of human beings (Malik *et al.,* 2014). Many non-timber forest products gathered from this forest provide livelihood support for thousands of enclave dwellers and outsiders. Despite its socioeconomic and ecological importance, the forest reserve is being overexploited through unregulated logging and illegal farming activities which have continued to degrade the forest ecosystem. (Adekunle, 2006.). The aim of this study was to determine the woody species' phytosociological assessment and diversity in Omo Biosphere Reserve, a typical conservation area, as benchmarks for monitoring the ongoing impacts of climate change and human activity. Information obtained for this study can be exploited by policymakers to design appropriate measures to enhance forest ecosystem conservation.

Materials and Methods

Study Area

Omo Biosphere Reserve is a conserved area of tropical rainforest in the Nigeria State of Ogun, in the southwest part of the country. It is located about 135 km northeast of Lagos and 80 km east of Ijebu Ode. The reserve falls within $6^0$38 to $7^0$05N and $4^0$19 and $4^0$40E (Fig. 1). The topography of the area is undulating dominated by slopes of up to 15% and elevation reaches between 15m and 150m above sea level. The uneven topography has numerous small hills rising to 300m which are dissected by tributaries of the Omo, Shasha and Oluwa rivers. The mean annual rainfall is about 1750 mm, and the mean relative humidity is 80%. The mean daily temperature is 26.4^{o}C, compared with the mean of 25.8^{o}C. (Ola-Adams, 2014). The land is undulating with occasional hills. A few rock outcrops are observed in parts of the reserve (Chima and Adedire, 2014).

Sampling Procedure and Sample Size

The research employed field survey sampling, using transect and plot sampling measurements, where key aspects of species diversity were determined— that is, species richness (i.e. the number of species present) and the Shannon diversity index (an index that accounts for both the number of species present, i.e. species richness and the abundance of individuals per species), for all plots in each land-use type (Lande 1996, 2003).

Data Types and Collection Methods

A 50×50m plot in an alternate arrangement, each line transect had 4 plots arranged alternately. Trees with e"10cm DBH were measured. DBH, Db,

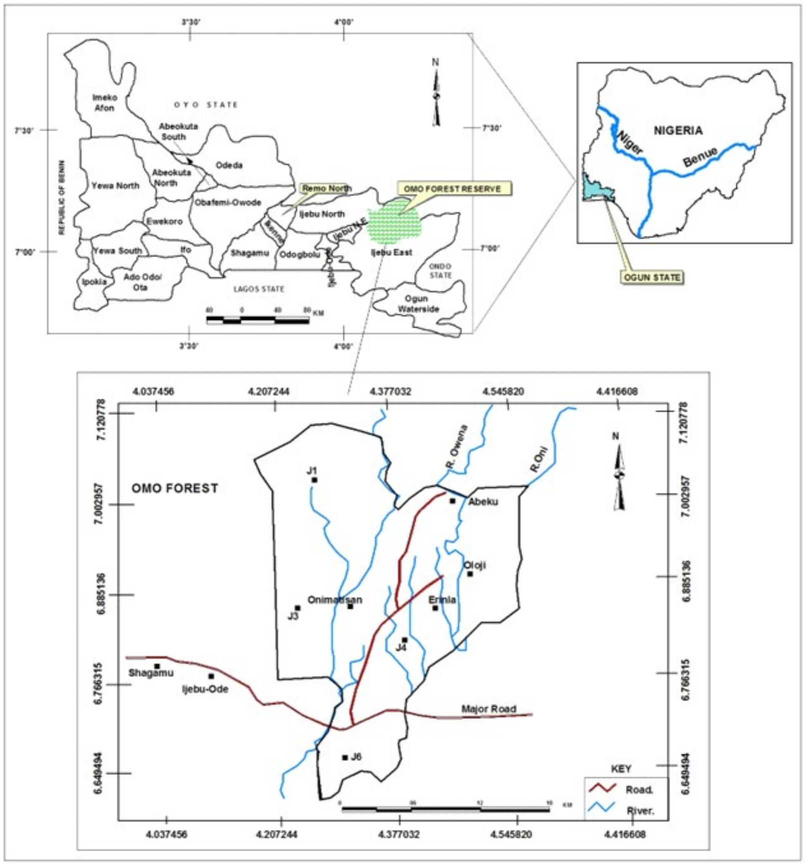

Figure 1. The map of the Omo Biosphere Reserve, Nigeria, showing the study area (Attah *et al.,* 2016).

Dm, Dt. Identification of Species and Measurement of the height. Primary data was collected for this study through a field survey using transects and Plot sampling techniques. To avoid edge error, 20 m were measured inside. Three line transects were cut apart, meaning there were line transects A, B, and C. One line transect was measured 200m far from another. Trees that could not be identified in the field, part of such trees (Leaves, bark, fruits etc) were collected for identification at Forestry Research Institute of Nigeria (FRIN) herbarium, Ibadan.

Species Diversity

The data were analyzed 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 are seen below:

The Simpson's diversity index D was calculated using the formula:

$$D = \sum \left(\frac{n1(n-1)}{N(N-1)}\right) \quad \text{.................................. (i)}$$

Where:

- n = number of individuals of each species
- N = total number of individuals of all species

Shannon's weaner diversity was calculated using the formula:

$$\sum_{i=1}^{s} pi \ln(pi) \quad \text{.................................. (ii)}$$

where:

- S= number of species in the community.
- *pi*= proportion total abundance represented i^{th} species.
- $\sum$ is the sum of the calculations.

The Species Evenness Index (E) was computed with.

$$E = \frac{H\prime}{In(S)} \quad \text{..................... .... (iii)}$$

Where:

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

Phytosociological Parameters

Height $= \frac{RT-RB}{100} \times Distance$ .... (iv)

Volume $= \frac{\pi H(Db^2+4Dm^2+Dt^2)}{24}$ .... (v)

Density $= \frac{Number\ of\ species}{Area\ sampled\ (m^2)}$ ....(vi)

Basal area $= \frac{\pi D^2}{4}$ .... (vii)

Where,π is 3.142 and D is the diameter at breast height.

Relative density$= \frac{number\ of\ species}{total\ number\ of\ individual\ species}$ .... (viii)

Relative frequency (RF) $= \frac{\text{Frequency of a woody plant species}}{\text{Total frequency of woody plant species}} \times 100.$ … (xv)

Species relative dominance will be estimated with the:

Rel. dominance $= \frac{Basal\ area\ of\ a\ species}{Total\ basal\ area\ of\ all\ species} \times 100$ .... (x)

Abundance$= \frac{Total\ number\ of\ individuals\ of\ a\ species\ in\ all\ quadrant}{Total\ number\ of\ quadrant\ in\ which\ the\ species\ occured}$ .... (xi)

Importance Value Index (IVI) = RD+RF+RD_O .... (xii)

Statistical Analysis

The data was analyzed using PAST software Version.3. and Microsoft Excel. Carl-Pearson correlation coefficient was calculated between various phytosociological parameters using Microsoft Excel-2007. Analysis of variance (ANOVA) was carried out to find out the relationship of phytosociological variables with each other and with the environmental factors like altitude and aspect.

Results

Floristic composition and structure of tree species in Omo Biosphere Reserve

A total of 427 trees representing 57 species from 22 families were encountered and identified during the study at the DBH e" 10cm. Euphorbiaceae had the highest number of species (9), Apocynaceae and Meliaceae had 5 species each, Ebenaceae, Fabaceae and, Rubiaceae had 4 species each, Annonaceae, Malvaceae and Sterculiaceae had 3 species each, Cannabaceae, Moraceae and Sapotaceae had 2 species each while Boraginaceae, Chrysobalanaceae, Combretaceae, Cucurbitaceae, Irvingiaceae, Myristicaceae, Olacaceae, Rutaceae, Tiliaceae and Urticaceae had 1 species each (Table 1).

Among the identified tree species during the inventory, *Celtis zenkeri* and *Diospyros dendo* had the highest frequency of 92 each *Diospyros hybridus, Sterculia rhinopatala, strombosia postulate* had 50 each, *Desplastsia lutea, Diospyros mespiliformis, Pycnanthus angolensis* had 42 each, *Ceiba pentandra, Cleistopholis philippensis, Maranthes glabra, Nisanga senegalensis* had 33 each, Among the least frequency (8) was found *Adenopus breviflorus, Alstonia cogenesis, Brachystegia eurycoma, Buchholzia coricea, Celtis mildbraedii, Chrysophyllum albidum, Drypetes grossweileri, Drypetes welwichii, Entandrophragma angolensis* (Table 2).

The stocking density of dominant tree species/ha in Omo Biosphere Reserve ranged from 0.33 trees/ha to 26.33 trees/ha. *Diospyros dendo* had the highest Relative Density (RD) of 18.50 followed by *Diospyros hhybrids* (15.46), and *Celtis zenkeri*. All other trees had less densities as shown in Table 2. The rate at which the tree species dominate the area was also calculated; *Celtis zenkeri* had the highest value of 6.17 followed by *Ceiba pentandra* (2.73), *Diospyros dendo* (2.72), *Ricinodendron heudelotii* (2.59), *Sterculia rhinopatala* (2.50), *Diospyros hybridus* (2.42) while *Cleistopholis patens* and *Xylopia aethiopica* had the lowest dominance value of 0.01 each. *Diospyros dendo* had the highest value of 33.03 for Importance Value Index (IVI) while *Rauvolfia vomitoria* had the lowest value of 0.97 (Table 2).

Table 1: List of tree species encountered, families and abundance in Omo Biosphere Reserve.

Species	Family	Total	Density/Ha	%
Adenopus breviflorus	Cucurbitaceae	1	0.33	0.23
Albizia ferruginea	Fabaceae	3	1	0.7
Alstonia congensis	Apocynaceae	1	0.33	0.23
Brachystegia eurycoma	Fabaceae	1	0.33	0.23
Buchholzia coriacea	Sterculiaceae	1	0.33	0.23
Canthium hispidum	Rubiaceae	3	1	0.7
Ceiba pentandra	Malvaceae	4	1.33	0.94
Celtis mildbraedii	Cannabaceae	3	1	0.7
Celtis zenkeri	Cannabaceae	62	20.67	14.52
Chrysophyllum albidum	Sapotaceae	1	0.33	0.23
Cleistopholis patens	Annonaceae	2	0.67	0.47
Cleistopholis philippensis	Annonaceae	6	2	1.41
Cola gigantean	Sterculiaceae	3	1	0.7
Cordia millenii	Boraginaceae	2	0.67	0.47
Desplatsia lutea	Tiliaceae	16	5.33	3.75
Diospyros canaliculata	Ebenaceae	6	2	1.41
Diospyros dendo	Ebenaceae	79	26.33	18.5
Diospyros hybridus	Ebenaceae	66	22	15.46
Diospyros mespiliformis	Ebenaceae	9	3	2.11
Drypetes floribunda	Euphorbiaceae	10	3.33	2.34
Drypetes gilgiana	Euphorbiaceae	2	0.67	0.47
Drypetes gossweileri	Euphorbiaceae	5	1.67	1.17
Drypetes welwichii	Euphorbiaceae	1	0.33	0.23
Entadrophragma cylindricum	Meliaceae	2	0.67	0.47
Entandrophragma angolensis	Meliaceae	1	0.33	0.23
Fagara indica	Rutaceae	3	1	0.7
Funtumia elastic	Apocynaceae	8	2.67	1.87
Hunteria umbellate	Apocynaceae	7	2.33	1.64
Hylodendron gabonensis	Fabaceae	1	0.33	0.23
Irvingia wombulu	Irvingiaceae	1	0.33	0.23
Khaya ivorensis	Meliaceae	3	1	0.7
Lovoa trichiloides	Meliaceae	1	0.33	0.23
Macaranga barteri	Euphorbiaceae	3	1	0.7
Macaranga grandifolia	Euphorbiaceae	1	0.33	0.23
Macaranga spp	Euphorbiaceae	2	0.67	0.47
Malacantha alnifolia	Sapotaceae	1	0.33	0.23
Maranthes glabra	Chrysobalanaceae	11	3.67	2.58
Massularia acuminate	Rubiaceae	1	0.33	0.23
Milicia excelsa	Moraceae	3	1	0.7
Mitragyna ciliate	Rubiaceae	1	0.33	0.236
Musanga cecropioides	Urticaceae	1	0.33	0.23
Nauclea diderichii	Rubiaceae	3	1	0.7

Nauclea diderichii	Rubiaceae	3	1	0.7
Nesogordonia papaverifera	Malvaceae	1	0.33	0.23
Nisanga senegalensis	Meliaceae	6	2	1.41
Picralima nitida	Apocynaceae	3	1	0.7
Pterygota macrocarpa	Malvaceae	2	0.67	0.47
Pycnanthus angolensis	Myristicaceae	7	2.33	1.64
Rauvolfia vomitoria	Apocynaceae	1	0.33	0.23
Ricinodendron heudelotii	Euphorbiaceae	8	2.67	1.87
Sterculia rhinopatala	Sterculiaceae	15	5	3.51
Strombosia postulate	Olacaceae	31	10.33	7.26
Terminalia superb	Combretaceae	2	0.67	0.47
Tetraptera tetraplura	Fabaceae	1	0.33	0.23
Treculia odorata	Moraceae	2	0.67	0.47
Trichilia monadelpha	Meliaceae	2	0.67	0.47
Uapaca togoensis	Euphorbiaceae	2	0.67	0.47
Xylopia aethiopica	Annonaceae	3	1	0.7
Total		427	142.33	99.936

Table 2: Density, relative density, frequency relative frequency relative dominance, abundance, and Importance Value Index (IVI) in Omo Biosphere Reserve

Species	Density/ha	R.D	Frequency	R.F	Dominance	R.Do	IVI	Abundance
Adenopus breviflorus	0.33	0.23	8.33	0.69	0.18	0.45	1.38	0.23
Albizia ferruginea	1	0.7	25	2.07	0.07	0.17	2.94	0.7
Alstonia congensis	0.33	0.23	8.33	0.69	1.43	3.65	4.58	0.23
Brachystegia eurycoma	0.33	0.23	8.33	0.69	0.53	1.35	2.27	0.23
Buchholzia coriacea	0.33	0.23	8.33	0.69	0.05	0.14	1.06	0.23
Canthium hispidum	1	0.7	25	1.38	0.12	0.31	2.39	0.7
Ceiba pentandra	1.33	0.94	33.33	1.38	2.73	6.96	9.27	0.94
Celtis mildbraedii	1	0.7	8.33	0.69	0.09	0.22	1.61	0.7
Celtis zenkeri	20.67	14.52	91.67	7.59	6.17	15.75	37.86	14.52
Chrysophyllum albidum	0.33	0.23	8.33	0.69	0.21	0.54	1.47	0.23
Cleistopholis patens	0.67	0.47	16.67	1.38	0.01	0.03	1.88	0.47
Cleistopholis philippensis	2	1.41	33.33	2.76	0.81	2.07	6.24	1.41
Cola gigantean	1	0.7	16.67	1.38	0.98	2.5	4.58	0.7
Cordia millenii	0.67	0.47	16.67	1.38	0.96	2.44	4.29	0.47
Desplatsia lutea	5.33	3.75	41.67	3.45	1.31	3.33	10.53	3.75
Diospyros canaliculata	2	1.41	16.67	1.38	0.12	0.3	3.08	1.41
Diospyros dendo	26.33	18.5	91.67	7.59	2.72	6.94	33.03	18.5
Diospyros hybridus	22	15.46	50	4.14	2.42	6.18	25.77	15.46
Diospyros mespiliformis	3	2.11	41.67	3.45	0.53	1.36	6.92	2.11
Drypetes floribunda	3.33	2.34	25	2.07	0.75	1.9	6.32	2.34
Drypetes gilgiana	0.67	0.47	16.67	1.38	0.14	0.35	2.2	0.47
Drypetes gossweileri	1.67	1.17	8.33	0.69	0.2	0.51	2.37	1.17
Drypetes welwichii	0.33	0.23	8.33	0.69	0.07	0.17	1.1	0.23
Entadrophragma cylindricum	0.67	0.47	16.67	1.38	0.3	0.76	2.61	0.47
Entandrophragma angolensis	0.33	0.23	8.33	0.69	0.23	0.59	1.51	0.23
Fagara indica	1	0.7	25	2.07	0.51	1.29	4.06	0.7
Funtumia elastic	2.67	1.87	25	2.07	0.35	0.88	4.83	1.87
Hunteria umbellata	2.33	1.64	25	2.07	0.29	0.73	4.44	1.64
Hylodendron gabonensis	0.33	0.23	8.33	0.69	0.07	0.18	1.1	0.23
Irvingia wombulu	0.33	0.23	8.33	0.69	0.12	0.31	1.23	0.23
Khaya ivorensis	1	0.7	25	2.07	1.21	3.08	5.85	0.7
Lovoa trichiliodes	0.33	0.23	8.33	0.69	0.03	0.08	1.01	0.23
Macaranga barteri	1	0.7	16.67	1.38	0.15	0.38	2.46	0.7

Khaya ivorensis	1	0.7	25	2.07	1.21	3.08	5.85	0.7
Lovoa trichiliodes	0.33	0.23	8.33	0.69	0.03	0.08	1.01	0.23
Macaranga barteri	1	0.7	16.67	1.38	0.15	0.38	2.46	0.7
Macaranga grandifolia	0.33	0.23	8.33	0.69	0.3	0.76	1.69	0.23
Macaranga spp	0.67	0.47	8.33	0.69	0.03	0.09	1.24	0.47
Malacantha alnifolia	0.33	0.23	8.33	0.69	0.14	0.35	1.28	0.23
Maranthes glabra	3.67	2.58	33.33	2.76	0.35	0.9	6.23	2.58
Massularia acuminata	0.33	0.23	8.33	0.69	0.03	0.08	1	0.23
Milicia excels	1	0.7	25	2.07	0.47	1.19	3.97	0.7
Mitragyna ciliate	0.33	0.23	8.33	0.69	0.06	0.16	1.08	0.23
Musanga cecropioides	0.33	0.23	8.33	0.69	0.04	0.1	1.02	0.23
Nauclea diderichii	1	0.7	16.67	1.38	1.71	4.37	6.45	0.7
Nesogordonia papaverifera	0.33	0.23	8.33	0.69	0.02	0.05	0.97	0.23
Nisanga senegalensis	2	1.41	33.33	2.76	0.31	0.78	4.95	1.41
Picralima nitida	1	0.7	16.67	1.38	0.16	0.41	2.49	0.7
Pterygota macrocarpa	0.67	0.47	16.67	1.38	0.68	1.72	3.57	0.47
Pycnanthus angolensis	2.33	1.64	41.67	3.45	0.67	1.72	6.81	1.64
Rauvolfia vomitoria	0.33	0.23	8.33	0.69	0.02	0.05	0.97	0.23
Ricinodendron heudelotii	2.67	1.87	25	2.07	2.59	6.62	10.56	1.87
Sterculia rhinopatala	5	3.51	50	4.14	2.5	6.38	14.03	3.51
Strombosia postulata	10.33	7.26	50	4.14	1.94	4.96	16.35	7.26
Terminalia superba	0.67	0.47	16.67	1.38	0.83	2.12	3.96	0.47
Tetraptera tetraplura	0.33	0.23	8.33	0.69	0.06	0.16	1.09	0.23
Treculia odorata	0.67	0.47	8.33	0.69	0.06	0.16	1.32	0.47
Trichilia monadelpha	0.67	0.47	16.67	1.38	0.03	0.07	1.91	0.47
Uapaca togoensis	0.67	0.47	8.33	0.69	0.26	0.66	1.82	0.47
Xylopia aethiopica	1	0.7	25	2.07	0.01	0.03	2.8	0.7
	142	100	1233	100	39	100	300	100

Similarity And Diversity Indices of Tree Species in Omo Biosphere Reserve

Table (3) shows the species similarities (Simpson's Similarity indices) between the plots, which vary from 0 % to 77 % for all plots in the Omo Biosphere Reserve. Plots 5 & 1 had the highest similarity indices of 77 %, plots 3 & 2 had 74 %, plots 5 & 4 had 64 %, plots 4 & 1 and plots 4 & 2 had 63 % each, plots 5 & 3 had 51 %, plots 12 & 5 had 10 % while plot 9 & 2, 9 & 3, 9 & 5 and 9 & 6 had no similarity at all 0 % (Table 3). The higher the value of the similarity indices between the plots, the more related they are in species composition. This implies that plots 5 & 1 are more related floristically than plots 12 & 5.

Table 4 presents the species diversity (Simpson's diversity indices) between the plots, which varies from 64 % to 93 % for all plots in Omo Biosphere Reserve. Plots 8&12 had the highest diversity of 93 %, plot 9 had 91 %, plot 7&10 had 89 %, plot 11 had 86 %, plot 2 had 79%, plot 1 had 78%, plot 3&6 had 73 %, plot 4 had 71 %, while the least is diversity value is recorded in plot 5 which had 64 % (Table 4)

Dominance value ranges from 0.07 to 0.36. Plot 5 had the highest dominance value of 0.36, plot 4 had 0.29, plots 3 & 6 had 0.27 each, plot 1 had 0.22, plot 2 had 0.21, plot 11 had 0.14, plots 7 & 10 had 0.11 each, plot 9 had 0.09 while the least value of 0.07 is found in plot 8 & 12.

Table 3: Species similarities (Simpson's Similarity Indices) between the plots in Omo Biosphere Reserve.

	Plot1	Plot2	Plot3	Plot4	Plot5	Plot6	Plot7	Plot8	Plot9	Plot10	Plot11	Plot12
Plot1	1.00											
Plot2	0.55	1.00										
Plot3	0.47	0.74	1.00									
Plot4	0.63	0.63	0.59	1.00								
Plot5	0.77	0.60	0.51	0.64	1.00							
Plot6	0.42	0.58	0.62	0.55	0.51	1.00						
Plot7	0.10	0.15	0.18	0.18	0.12	0.21	1.00					
Plot8	0.10	0.06	0.07	0.12	0.05	0.10	0.41	1.00				
Plot9	0.04	0.00	0.00	0.03	0.00	0.00	0.25	0.35	1.00			
Plot10	0.07	0.11	0.17	0.11	0.08	0.13	0.24	0.43	0.16	1.00		
Plot11	0.13	0.13	0.15	0.16	0.11	0.12	0.29	0.41	0.44	0.32	1.00	
Plot12	0.11	0.13	0.16	0.13	0.10	0.20	0.26	0.28	0.36	0.34	0.37	1.00

Table 4: Species diversity (Simpson's diversity indices) between the Plots in Omo Biosphere Reserve.

	Species	Individuals	Dominance_D	Simpson_1-D	Evenness_e^H/S	Equitability_J
plot1	11	63	0.22	0.78	0.54	0.74
plot2	9	32	0.21	0.79	0.67	0.82
plot3	6	22	0.27	0.73	0.72	0.82
plot4	8	32	0.29	0.71	0.60	0.75
plot5	4	52	0.36	0.64	0.76	0.80
plot6	7	23	0.27	0.73	0.69	0.81
plot7	14	33	0.11	0.89	0.78	0.91
plot8	20	36	0.07	0.93	0.82	0.93
plot9	19	38	0.09	0.91	0.78	0.92
plot10	15	25	0.11	0.89	0.80	0.92
plot11	13	43	0.14	0.86	0.72	0.87
plot12	18	28	0.07	0.93	0.89	0.96

Tree species ordination for tree species in Omo Biosphere Reserve

Species ordination by Detrended Correspondence Analysis (DCA) of tree species e”10 cm diameter at DBH in the 12 plots within the study area represents 117.53 % (axis 1 79.89 %; axis 2 37.55 %) of variance accounted for by the first four ordination axes (Fig. 4). High eigen value shows that the species are becoming endemic, which is an indication of a stable environment. About 60 % of the species are in quadrant 4, which implies high interaction within the site. The length of axes ranges from -60 to 420. All the species falls into the first quadrant on the positive side of the axis (Fig. 4)

Discussion

In this study, a total of 427 trees representing 57 species from 22 families encountered in Omo Biosphere Reserve is higher when compared with 10 tree species in 8 families recorded by Ibe *et al.* (2014) in Ohaji/Egbema Watershed in Imo State. However, relatively high compared to 80 species/ha recorded by Vordzogbe *et al.,* (2005) and lesser when compared with the value of 102 species belonging to 35 families reported by Edet *et al.*, (2011) for Afi Mountain Wildlife Sanctuary. Asinwa *et. al* (2019) also reported that the Natural Forest of Ijaye Forest Reserve in Oyo State was more diverse with high tree species diversity compared with degraded forest and fallow land.

Euphorbiaceae dominated the plots with 9 numbers of species followed by Apocynaceae and Meliaceae with 5 species each, Ebenaceae, Fabaceae, and Rubiaceae had 4 species each, Annonaceae, Malvaceae and Sterculiaceae had 3 species each. Similar results were observed at neo- tropical forests (Martin and Aber, 1997) and Shervarayan hills (Kaduvul and Parthasarathy, 1999). Adeyemi (2020) reported similar species of Sterculiaceae and Euphorbiaceae in Old Oyo National Park.

Relative stand density (RD) indicates how fully the trees occupy a site. It is a measure of the number and average size of trees growing in a stand compared to the maximum possible number of trees of the same average size that the site could support (a biological limitation). It tells us how crowded the trees are and measures the intensity of competition. The stocking density of dominant tree species/ha in Omo Biosphere Reserve ranged from 0.33 trees/ha to 26.33 trees/ha (Table 2). The Relative Density (RD) of *Diospyros dendo* was the highest RD of 18.50 which is similar to the RD of 20.35 recorded by Salami *et al.,* (2018). This could be a result of sustained human disturbance and encroachment and climatic conditions.

Nath *et. al.* (2005) noted that similarity indices provide quantitative bases for two or more assemblages used on their species composition. Simpson’s similarity between the plots varies from 0 % to 77 % for all plots in Omo Biosphere Reserve, Plots 5 & 1 had the highest similarity indices of 77 %, plots 3 & 2 had 74 %, while plots 9 & 2, 9 & 3, 9 & 5 and 9 & 6 had no similarity at all 0 % (Table 3). The higher the value of the similarity indices between the plots, the more related they are in species composition. This implies that there are stronger relationships of tree species between plots 5 & 1 than between plots 12 & 5. The similarity and relationship in plots 5 & 1 could be due to the influence of the nutrients and other biotic factors. The floristic composition, stand density, basal area, vertical stratifications, and community kinds are all included in the structural study of vegetation. While the diversity offers details on the abundance of species, their distribution, and the rate at which species composition is changing (Adekunle, 2013).

The Shannon diversity obtained for the study site indicates that Plots 8&12 had the highest diversity of (0.93), followed by plot 9 (0.91), while the least value was obtained in plot 5 which had (0.64)

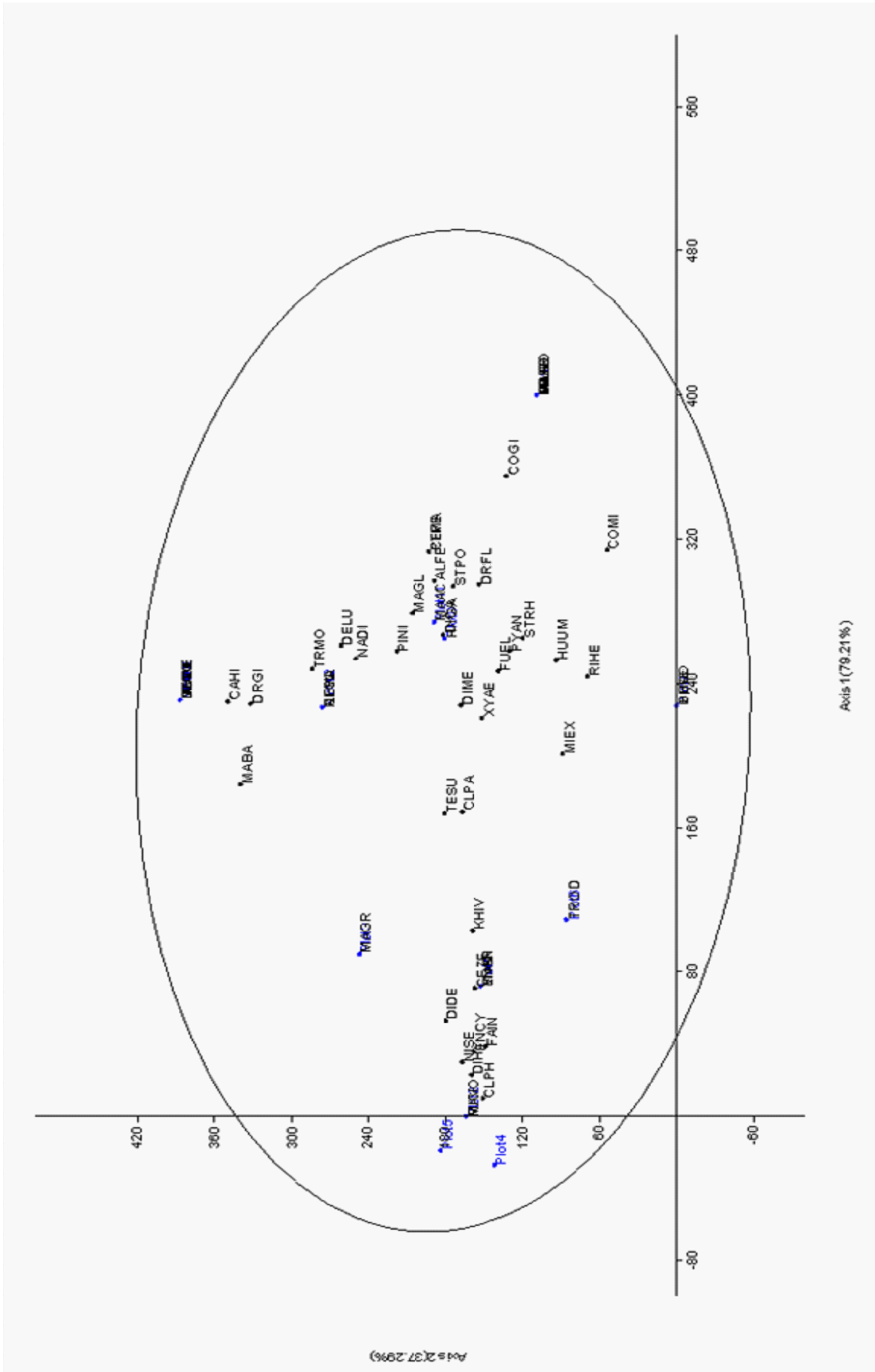

Figure 4: Detrended Ordination for Omo Biosphere Reserve.

(Table 4). The higher diversity indices results could also mean that the community structure is more stable (Isango, 2007). Equitability for all 12 plots ranged from 0.64 to 0.93, which indicates that between 64.0 and 93.0% of the trees were distributed evenly among species/plots (Magurran and Henderson, 2003; Pappoe *et al*., 2010). This showed that the site was able to support high heterogeneity of tree species. High diversity indices obtained in the site are an indication of the difference in the dominance of the most common species. The high evenness in the study site, (Table 4) indicated little dominance by any single species and repeated coexistence of species overall plots. The species diversity (Simpson's diversity indices) between the plots varies from 64 % to 93 % for all the plots.

Dominance is the degree of influence of one species over another in an ecosystem. Its value ranges from 0.07 to 0.36. Plot 5 had the highest dominance value of 0.36, plot 4 had 0.29, plots 3 & 6 had 0.27 each, plot 1 had 0.22, plot 2 had 0.21, plot 11 had 0.14, plots 7 & 10 had 0.11 each, Plots 9 had 0.09 while the least value of 0.07 is found in plot 8 & 12.

Conclusions

This study's findings demonstrated the promise of an *in-situ* approach to nature preservation. In comparison to other similar forest ecosystems, particularly those found in global biodiversity hotspots, the phytosociological assessment, as well as the species diversity and abundance, were favourable. Therefore, these forests are a potential hotspot for biodiversity that needs better conservation and management efforts as well as in-depth analysis of all the biodiversity indicators.

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