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TREE SPECIES DIVERSITY AND COMPOSITON AMONG FOREST FRAGMENTS IN A NORTH-EASTERN NIGERIA FOREST RESERVE

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ABSTRACT

The study was conducted to study tree species composition and diversity among fragments at various attitudes in Bagale Forest Reserve, Adamawa State, North East Nigeria. Tree species composition was 308 individuals made up of 42 trees species in 21 families. Diversity assessments among the fragments and altitudes showed that Tudun Wada Holin, Modire, Lugga and Wurodole had diversity values of 3.22, 1.18, 1.48, 2.12, 1.94 respectively, equally common species (eH1) of 25, 3.27, 4.38, 8.3 and 6.96 respectively. Vitellaria paradoxa had the highest relative density of 14.1% relative dominance of 9.5%, followed by Lannea Kerstingi with 8.6% and Terminalia glaucescence 9.6%.

Keywords: Bagale, Diversity, IVI, Composition, Fragments, Altitude.

1. INTRODUCTION

Floral diversity in the forest refers to the variety of tree species within a region. Mc Gingley (2014) defined floral diversity as a measure of the diversity within an ecological community that incorporates both species richness and the evenness of species abundance.

Many reasons have been adduced for variation in tree species diversity among forest fragments and different altitudes. Some authors, Chen *et al.,* (2011), Malhi *et al.,* (2013), Lippok *et al.,* (2014) suggest that topography strongly influences local endemism of plant species. They also opined that such responses are generally regulated by micro climate gradients. Consistent trends of plant endomism have been reported on larger spatial scales. Huang *et al.,* (2003), Adissu *et al.,* (2015) opine that factors such as climate and topography disturbance, geometric constraints and evolutionary history could be responsible for plant species diversity, species composition and altitudes. However, scientists have notifentified a single patern of species diversity among forest fragments, Katovai *et al.,* (2015), Swignland, (2001).

Disturbance affects diversity and is related to fragment area and habitat heterogeneity. It is a discrete event in time and space which alters the structure of populations, communities or ecosystems causing drastic changes in resource availability. Laurance (2004), Santos and Telleria (2006), Otalora *et al.,* (2011), di Bella *et al.,* (2008).

The main objective of this study is to assess species diversities among forest fragments and altitudes of Bagale Forest Reserve in North-East Nigeria. As these is no published information

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on species composition and abundance in the forest Reserve, result of this study will provide baseline information for subsequent related researches.

2. METHODOLOGY

2.1 Study Location

Bagale Forest Reserve is an old reserve within latitude $9^0$11'N and longitude $12^0$20'E in North East Nigeria (Fig 1) with a total area of about 18,000 hectares.

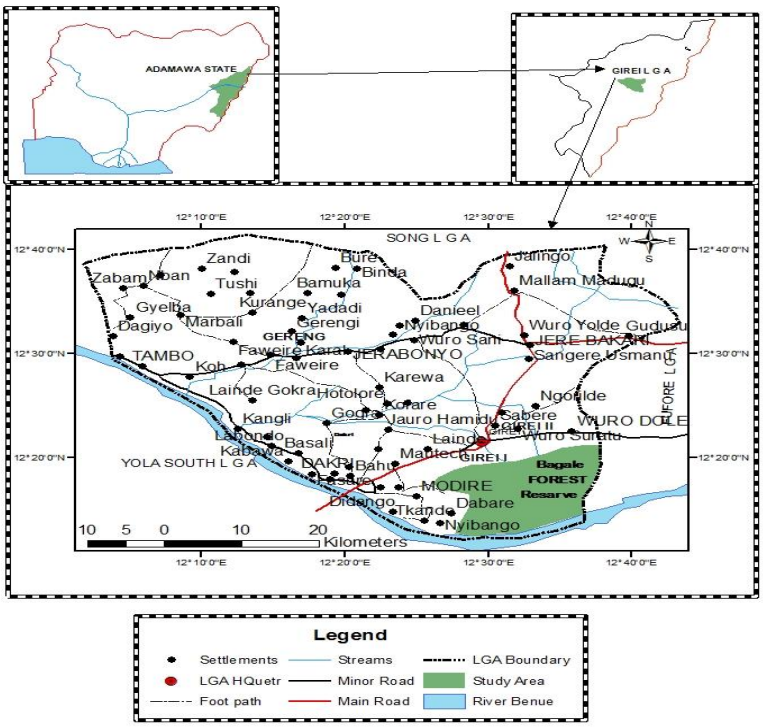

Figure 1: the Study Area

Produce @ GIS Laboratory, Geography Department MAUTECH Yola 2018

Fig. 1: Study Area

The physiography of the reserve is typically undulating, generally of flat plain and a deep to gentle slope surface. The most important land forms are small mountains and flood plains along the River Benue.

The area experiences two distinct seasons-the rainy and dry. (MAUTECH, 2018). There are also two distinct types of temperatures.

The vegetation is savannah woodland, with grass association more or less interspersed with shrubs and trees. It has the characteristics of open biotype with common tree species which include, *Burkea Africana, Tamarindusindica, Acacia senegal, Vitex doniana, Adansonia digitata. Common grasses include Ipomea triloba, Andropogon gayanus, Panicum maximum, Tradax procurmbens, Desmodium salicifolium*, Keay*et al.*, (1964), Naughton and Wolf (1979).

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Digital Maps of the Study Area

A contour map (Fig. 2) and the cross sectional area of the study area (Fig. 3) were produced following polynomial models adopted by Caynela *et al.*, (2006). Elevation above sea level and the distance between plots were measured using a Garmain GPS.

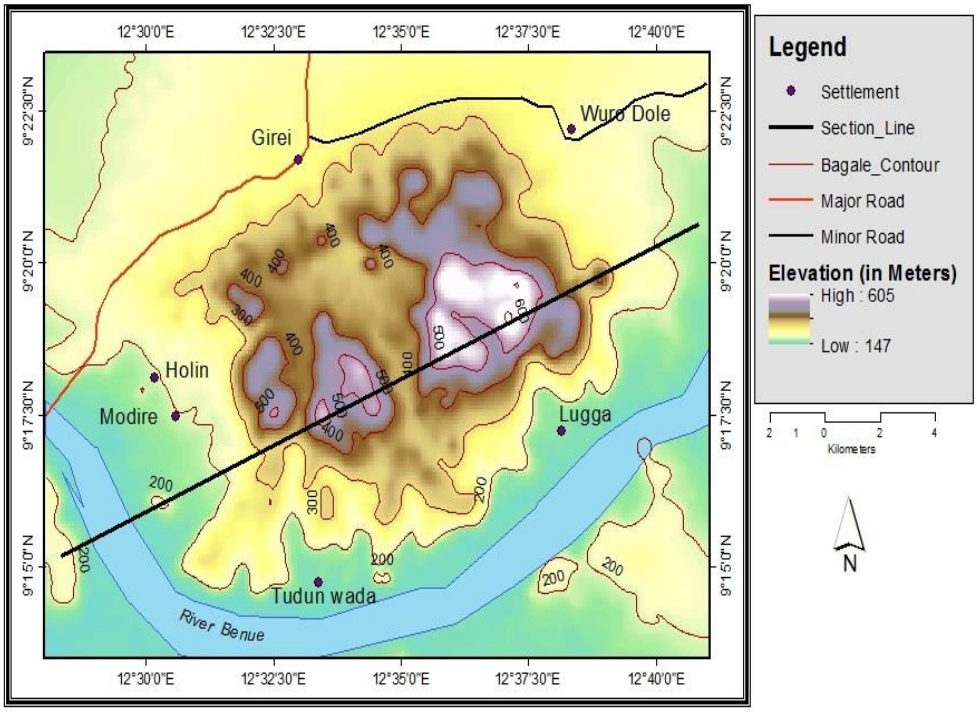

Fig. 2 Contour of the Study Are

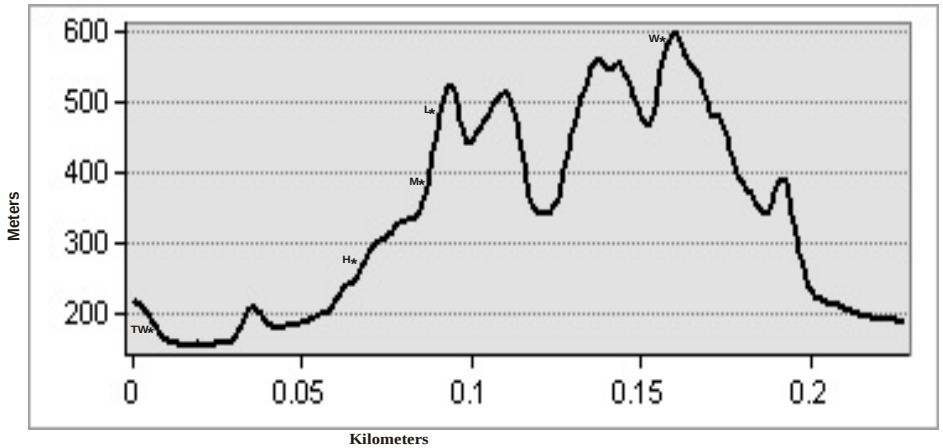

Fig. 5: Cross section of Bagale Hills Forest Reserve along a Section line from SW to NE

T/W=Tudun Wada, H=Holin, M=Modire, L=Lugga, W=Wurodole

Source: Department of Geography, MAUTECH, Yola.

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Fig. 3: Cross Section of the Study Area

The following fragments were selected and sampled: -Tudunwada (<200masl), Holin (200-300masl), Modire (300-400masl), Lugga (400-500masl) and Wurodole (>500masl).

Procedure for Data Collection

3 quadrats (100m x 100m) were laid in each inventory and taxonomic classification of indigenous tree species measuring 10cm and above, Ghate (2007) were done. Double counting of trees was avoided by numbering each tree with red paint before the commencement of inventory, according to Ghazanfar (1989), and Hopkins and Stanfield (1966).

Data Analysis

- Density = $\frac{\text{Total number of species in each quadrat}}{\text{size of quadrat}}$
- Relative frequency, relative density and relative dominance of the species were done using percentages and important values index was also calculated.
- Basal area of each tree was calculated using c = $\frac{c^2}{4\pi r}$.

Where; c = diameter (metres)

$\pi = 3.42$

r = radius.

3.RESULTS

i. Species diversity was calculated using Shannon-Weiner diversity index (Kent and Coker, 1992). $H^1 = -\sum_{i=1}^{s} P_i l_n(P_i)$

Where; H^1 = Shannon-Winer diversity index;
S = Total number of species in the community.
P_i = Proportion of S made up of the i^{th} species.
NL = Natural logarithm.

ii. Species richness or variety index (d) was determined by the formula d = $\frac{S}{\sqrt{N}}$ (Margalef, 1958).
Where S = number of species.
N = number of individuals of all species.

iii. Species relative dominance (RDo) was computed using; RDo = $\frac{(\Sigma Ba_i \times 100)}{\Sigma B_{an}}$. Where; Ba_i = Basal area of individual trees belonging to species I, Ba_n = stand basal area of all species, as adopted by Onyekwelu, (2007).

iv. Species relative density (RD) for each tree species was determined by;

RD (%) = $\left[\frac{n_i}{N}\right]$ x 100.

Where n = number of individual species.
N = total number of species in the entire community.

v. Species evenness was obtained by using the formula,

$$E_H = \frac{Hi}{Hmax} = \frac{\sum Piln(Pi)}{\ln(s)}$$

Plant species composition wad made of 308 individual grouped into 42 trees in 21 families within the reserve. Family *Caesalpinaceae* had the highest number of eight species followed by *Combretacea*e and *Miniosaceae* with four species each, *Moraceae* and *Anacardiaceae* had three species each, *Bombacaceaespecies*, *Annonaceae, Balanitaceae, Tiliaceae, Hymenocardiaceae, Bignoniaceae, Capparaceae, Flacourtaceae, Fabaceae, Steculiaceae, Verbenaceae, Sapotaceae, Olalaceae* and *Papillionaceae* had one species each. (Table 1).

Importance Value of tree species

The relative frequency, relative density, relative dominance and importance value of tree species in the Bagale hills forest reserve fragments are presented in Table 20. The result shows that the following tree species had these relative frequencies, *Vitellaria paradoxa* (14.1), *lannea kerstingii* (12.1), *Terminalia glaucescens* (11.9), *Tamarindus indica* (7.1), *Anogeissus leiocarpus* (8.0), *Pericopsis laxiflora* (5.8), *Detarium microcarpum* (5.8), *Daniella oliverii* (5.4), *Sclerocarya birrea* (4.2), *Afzelia africana* (8.0), *Prosopis africana* (2.6) *Grewia mollis* (1.60), *Boswellia dalzielii* (.30), *Crossopteryx febrifuga* (0.6), *Entanda africana* (1.30), *Vitex doniana* (1.9), *Terminalia laxiflora* (1.0), *Commiphora africana* (1.0), *Dioscorea species* (0.3), *Hymenocardia acida* (0.96), *Pterocarpus erinaceus* (0.96), *Terminalia laxiflora* (0.96), *Steculia setigera* (0.64), *Maerua angolensis* (0.64), *Oncoba spinosa* (0.64), *Piliostigma thonningii* (0.64), *Isobelina doka* (0.64), *Ficus ingens* (0.64), *Combretum molle* (0.64), *Cassia singueana* (0.64), *Balanite aegyptiaca* (0.64), *Annona senegalensis* (0.3), *Adansonia digitata* (0.64), *Acacia albida* (0.32), *Acacia senegal* (0.32), *Burkea africana* (0.6), *Ceiba pentandra* (0.32), *Ficus abulifolia* (0.32), *Ficus platyphylla (*0.32), *Kigelia africana* (0.32), *Lannea acida* (0.32), *Sarcociphalus lalifolus* (0.6), *Ximenia africana* (0.32).

The tree species had relative densities as follows, *Vitellaria paradoxa* (14.1) *Lannea kerstingii* (12.1), *Terminalia glaucescens* (11.9), *Tamarindus indica* (7.1), *Detarium microcarpum* (5.8), *Daniella oliverii* (5.4), *Pericopsis laxiflora* (5.8), *Prosopis africana* (2.8) *Afzelia africana* (6.0), *Grewia mollis* (1.4) *Vitex doniana* (2.4), *Entanda africana* (1.3), *Boswelii dalzielii* (1.1), *Crossopteryx febrifuga* (0.6).

The importance value of the tree species is as follows; *Vitellaria paradoxa* (9.5) Lannea kerstingii (8.6), *Terminalia glaucescens* (9.6), *Tamarindus indica* (5.1), *Daniella oliverii* (4.8), *Anogeissus leiocarpus* (5.3), *Sclerocarya birrea* (4.8), *Detarium microcarpum* (4.6) *Adansonia digitata* (4.7), *Pericopsis laxiflora* (3.1) *Prosopis africana* (2.8), *Afzelia africana* (6.0), *Terminalia laxiflora* (1.2), *Boswelii dalzielii* (1.1), *Grewia mollis* (1.4), *Entanda africana* (1.3), *Sterculia setigera* (1.0), *Vitex doniana* (2.4), *Dioscorea species* (1.3), *Ficus platyphylla* (2.5), *Crossopteryx febrifuga* (0.6), *Pterocarpus erinaceus* (1.3),

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Table 1: Relative Frequency Density Dominance and Importance Value Index of Tree Species in Bagale Forest Reserve.

Family	Species	Freq.	RF	DS	RD (%)	BA M^2	RBA	IVI
Mimosaceae	Faidherbiaalbida	1	0.32	1	0.32	.03	1.25	0.63
Bombacaceel	Adanoniadigitata	2	.64	2	.64	.36	12.8	4.7
Caesalpinaceal	Afzelia Africana	25	8.0	25	8.0	.05	1.9	6.0
Combretaceae	Anogeissusleiocarpus	19	6.1	19	6.1	.10	3.7	5.3
Annonaceae	Annona senegalensis	2	.64	2	.64	.02	.55	.61
Mimosaceae	Acacia Senegal	1	.32	1	.32	.04	1.5	.71
Balanitaceae	Balanitesacgyptiaca	2	.64	2	.64	.03	1.0	.76
Burseraceae	Boswelliadalzielii	1	.3	1	.3	.05	1.8	.80
Caesalpinaceae	Burkea Africana	1	.32	1	.32	.05	1.6	0.76
Burseraceae	Commiplora Africana	3	.96	3	.96	.03	1.4	1.1
Bombacaceae	Ceibapentandra	1	.32	1	.32	.01	.34	.33
Rubriaceae	Crossopteryxfebrifiga	2	.64	2	.64	.02	.61	.63
Combretaceae	Combretummolk	2	.64	2	.64	.05	.17	.99
Caesalpinaceae	Senna singueana	2	.64	2	.64	.02	.72	.67
Caesalpinaceae	Detariummicrocarpum	18	5.8	18	5.8	.07	.24	4.6
Caesalpinaceae	Daniella oliverii	17	.645.	17	.645.	.09	.34	4.8

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			4		4			
Mimosaceae	Entanda Africana	4	1.3	4	1.3	.04	1.3	1.3
Moraceae	Ficusingens	2	.64	2	.64	.03	.90	.73
Moraceae	Ficusabutiffolia	1	.32	1	.32	.02	.82	.49
Moraceae	Ficusplatyphylla	1	.32	1	.32	.19	6.8	2.5
Tiliaceae	Grewiamollis	5	1.6	5	1.6	.03	1.0	1.4
Hymenocardiaceae	Hymenocardiaacida	3	.96	3	.96	.04	1.5	1.1
Caesalpinaceae	Isobelinadoka	2	.64	2	.64	.01	.37	.55
Bignoniaceae	Kigelia Africana	1	.32	1	.32	.07	2.5	1.0
Anacardiaceae	Lanneaacida	1	.32	1	.32	.06	2.2	.95
Anacardiaceae	Lanneakerstingii	38	12.2	38	12.2	.04	1.6	8.6
Capparaceae	Maeruaangolensis	2	.64	2	.64	.03	1.0	.76
Flacourtiaceae	Oncobaspihesa	2	.64	2	.64	.07	2.7	1.3
Mimosaceae	Prosopis Africana	8	2.6	8	2.6	.09	3.1	2.8
Caesalpinaceae	Piliostigmathenningi	2	.64	2	.64	.04	1.5	0.9
Fabaceae	Pterocarpuserinacaeas	3	1.0	3	1.0	.05	1.8	1.3
Rubiaceae	Sarcociophalusesculentus	2	.64	2	.64	.04	1.5	.9
Steculiaceae	Steculiasetigera	2	.64	2	.64	.05	1.7	1.0
Combretaceae	Terminalia glaucescens	37	11.9	37	11.9	.14	5.1	6.9
Caesalpinaceae	Tamarindusindica	22	7.1	22	7.1	.03	1.1	5.1

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Verbenaceae	Vitexdoniana	6	1.9	6	1.9	.09	3.2	2.4
Sapotaceae	Vitellariaparadoxa	44	14.1	44	14.1	.09	.34	9.5
Olacaceae	Ximenia Americana	1	.3	1	.3	.06	2.0	0.9
Combretaceae	Terminalia loxiflora	3	1.0	3	1.0	.05	1.7	1.2
Anacardiaceae	Sclerocaryabirrea	13	4.2	13	4.2	.17	6.0	4.8
Papilionaceae	Pericopsislaxifilora	1	.3	1	.3	.06	2.2	.95
Bombacaceae	Bombaxcostatum	3	1.0	3	1.0	.04	1.5	1.1
Σ		308		308		2.69m^2		

Table 2: Species Diversity in the Altitudes/Fragments

Altitude	Species richness	H^1	I	e^{H^1}
<200	0.95	3.22	0.54	25
200-300	1.30	1.18	1.06	3.27
300-400	5.0	1.48	0.76	4.38
400-500	1.17	2.12	2.82	8.3
>500	0.77	1.94	0.61	6.96

H^1 = Shannon-Weiner index
I = Species evenness
e^{H^1} = Commonly common species
<200 = Tudunwada, 200-300 = Holin, 300-400 Modire, 400-500 = Lugga, >500 = Wurodole
*metres above sea level.

Vitellariaparadoxa had the highest relative density of 14.1%, and relative dominance of 9.5%, followed by *Lannea Kerstingii* with relative frequency of 12.2% and relative dominance of 8.6%, *Burkeaafricanna*, *Ficusingens* and *Kigelia Africana* had relative frequencies, and dominance of

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0.32%, 0.64%, 0.32%, 0.76%, 0.64%, 0.32%, 0.76%, 0.64%, 0.32% 0.76%, 0.73%, 1.0% respectively, (Table 1).

Species diversity among the fragments and altitudes showed that *Tudunwada, Holin, Modire, Lugga* and *Wurodale* has diversity value of 1.30, 0.95, 5.0, 1.17 and 0.77 as species richness; 3.22, 1.18, 1.48, 2.12 and 1.94 as Shannon-Weiner values (H^1); 1.06, 0.54, 0.76, 2.82, 0.61 as evenness; 25, 3.27, 4.38, 8.3, 6.97 as equally common species (e^{H^1}) respectively (Table 2).

4.DISCUSSION

The distribution and abundance of different tree species over a landscape is what constitutes diversity in respect of tree species. Species diversity is one of the analytical tools applied in determining the degree of variability of species within a community or a region. It is a count of the different species present in an area (Kumar *et al.,* 2010). Species richness is essentially a measure of the number of species in a defined sampling unit, and it is the basic component of diversity of any community, while species evenness refers to relative abundance or proportion of individuals among the species (Bello, *et al.,* 2013).

A total of 312 trees stands were encountered within the fifteen randomly sampled plots in the study area. Thirty six different tree species distributed within eighteen genera and into nineteen families were found within the reserve. The species and families of tree encountered in Bagale Forest Reserve gave a vegetation close to what Mu'azu (2010) found in neighbouring Kuyambana Forest Reserve, Maru in Zamfara Stste which was described as Sudan Savannah with a transition to Guinea Savannah. The dominance of Caesalpiniceae, Mimosaceae, and Combretaceae families in Bagale is almost with his findings. The thirty six different tree species of Bagale are higher than that of Zamfara Forest Reserve which stood at 21 and 24 as documented by Malami (2005), and also twice higher than that of Isah *and Shamaki* (2012) where they recorded only 11 tree species at Dabagi Forest Reserve in the Sudan Savannah of North-western Nigeria. These variations may largely be as a result of differences in climatic as well as edaphic factors that characterize each ecological zone. These results also differ comparatively from the findings of Ihenyen *et al.,* (2009) in Ehor Forest Reserve in Edo State which is in a high forest zone, of Southern Nigeria where 2, 062 tree stands were identified in just 3 compartments of the forest reserve, belonging to 99 different species distributed into 87 genera and 36 families.

These differences confirm variability in terms of weather and climate between the two ecological zones of the forest sites as the major factors dictating the distribution and abundance of varieties of different floral species as described by Causton (1988). Among the thirty six different tree species found within the reserve, Table (20) showed the relative density (RD), Relative Dominance (RD_o) and importance value indices of these species.

The results indicated that *Vitellaria paradoxa* had the highest relative density of and dominance 14.4% and 13.9%, followed by Lannea kerstingii with 12.2% and 7.7%, and Terminalia glaucescens with 11.5% and 7.1% respectively. Many species had low relative densities and relative dominance. Some of them include *Ximenia Americana* 0.32% and 0.17%, *Sarcociphalus*

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lalifolus 0.32%, 0.08%, *Lannea acida* 0.32%,0 .10% respectively. At Kuyanbana *Isobelina doka* had the highest relative density followed by *Prosopis africana* and *Anogeissus leiocarpus* which may be as a result of the ecological variation or over-exploitation of the woody genetic resources as reported by Mu'azu (2010) at Kuyanbana Forest Reserve. Consequently, *Vitellaria paradoxa* taking the lead in terms of relative dominance and density at Bagale Forest Reserve, may be as a result of heavy or excessive logging of some other species due to high demand and economic value. *Acacia albida, Acacia senegal, Ceiba pentandra, Ficus abutilifolia, Ficus platyliphylla, Kigelia africana, Lannea acida* and *Ximenia americana*, recorded one stand each with the least relative density and *Sarcociphalus lalifolius* recorded the least relative dominance followed by *Ceiba pentandra, Piliostigma thonningii, Annona senegalensis*. This signifies that *Piliostigma thonningii, Annona senegalensis,* and *Daniella oliverii* were at the top of the list of vulnerable tree species under threat of extinctions from the reserve which may be as a result of over-exploitation, competition or edaphic factors, agreeing with the findings of Bello *et al.,* (2013) from his studies carried out in Kogo Forest Reserve, North-western Nigeria.
Shannon-weiner diversity index (H^1) value stood at approximately 2.00. Since diversity, varies with locations depending on the species available within an ecological zone, Bagale Forest Reserve is replete with a moderate diversity index, which lies within the general limits of 1.5 – 3.5 as stipulated by Kent and Coker (1992). These figures can be compared with what was found by Dikko (2012) at Dabagi Forest Reserve who recorded a H^1 value of 1.45 which is very low, but even higher than that of Kumar *et al.,* (2010) who in 30 sites of tropical dry deciduous forest of Western India recorded Shannon-weiner index (H^1) values of 0.67 to 0.79. Moreover, in the low land humid tropical rainforest region of Nigeria, Onyekwelu *et al.,* (2007) obtained Shannon-weiner diversity values of 3.12, 3.31 and 2.82 at Oluwa, Queens and Elephants Forests.

This implies that climate favours diversity and may be partly responsible for the diversity index obtained at Bagale. This is also in line with the findings of Bhat and Kaveriappa (2013) obtained among the fresh water swamp forests of Kulathupazha, Anchal, Shendurney, Kathalkani, Pilarkan and Charmady, Karnataka, where H^1 of 2.53, 3.69, 2.46, 4.04, 3.25 and 4.90 respectively were obtained. This confirms that diversity or richness in terms of species and their distribution could be largely dictated by climatic and ecological conditions.

Species evenness (EH) as a measure of equitability of spread, according to Maguiran (1988) was valued at 1.2 which is a bit higher than that of Dabagi forest reserve(0.74) as recorded by Dikko (2012). Indicating the available tree species were fairly and evenly distributed within the forest sites may be due to less competition for space among the trees considering the characteristic nature of the ecological zones. This is line with the findings of Rad *et al.,* (2009) who in four different experimental forests of University of Tehran recorded EH of 0.64, 0.76, 0.71 and 0.65 of which despite proximity still noticed variability among the different forested areas. Species richness (d) is the basic component of diversity of any community, Aparajita (2007). Bagale Forest Reserve had a species richness of 1.80 which is comparatively low compared to 1.92, 1.85 and 2.16 for that of Oluwa, Queen's and Elephant forests of low land humid tropical rainforest region of Nigeria a reported by Onyekwelu *et al.,* (2007). This may be due to more favourable

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environment of the tropical forest zone compared to extreme Northern Guinea Savannah ecological zone as well as level of encroachment on the reserve.

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