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Tree Composition and Ecological Structure of Akak Forest Area

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Abstract

Tree composition and ecological structure were assessed in Akak forest area with the objective of assessing the floristic composition and the regeneration potentials. The study was carried out between April 2018 to February 2019. A total of 49 logged stumps were selected within the Akak forest spanning a period of 5 years and 20m x 20m transects were demarcated. All plants species <1cm and above were identified and recorded. Results revealed that a total of 5239 individuals from 71 families, 216 genera and 384species were identified in the study area. The maximum plants species was recorded in the year 2015 (376 species). The maximum number of species and regeneration potentials was found in the family Fabaceae, (99 species) and (31) respectively. *Baphia nitida*, *Musanga cecropioides* and Angylocalyx *pynaertii* were the most dominant plants specie in the years 2013, 2015 and 2017 respectively. The year 2017 depicts the highest Simpson diversity with value of (0.989) while the year 2015 show the highest Simpson dominance with value of (0.013). The year 2013 show a highest Shannon evenness with value of (0.4879). Logged compartment 2015 has a highest fisher alpha with value of 137.7 depicting highest specie richness The Shortest Euclidean distance of 123.44 between year 2013 and 2017 show that they both have many plants species that are similar. Evidently the forest area is very rich in trees in the lower diameter classes, and the structure of the Akak forest area is J reverse indicating that the forest is growing to climax.

Keywords: Floristic Composition, Regeneration Potentials, Species Diversity, Species Similarities

1. Introduction

The sustainable management of the natural resources of the various world ecosystems has been a global concern for many centuries, and in 1990 was stated as an important point in the United Nations' millennium development goals (United Nation [UN],1990). Two years later, the Agenda 21 of the Rio summit placed a specific emphasis on the sustainable management of forest resources worldwide (UN, 1992), because forests constitute the planet's largest terrestrial ecosystems and the richest source of biological diversity. Included amongst these valuable forest ecosystems, the management of which has been a cause of much concern, are the tropical rainforests.

The tropical rainforest has been identified as the most biologically diverse terrestrial ecosystem on earth (Turner, 2001; Gillespie, Brock, & Wright., 2004; Onyekwelu, Mosandl, & Stimm, 2008; Schmitt et al., 2009; FAO, 2010; IUCN, 2010). In terms of tree composition and species diversity, tropical rain forests are Earth‟s most complex ecosystems (Gebreselasse, 2011). Trees are often the most conspicuous plant life form in a typical tropical rainforest. The rainforest act as main repository of the genetic diversity of both flora and fauna.

Natural regeneration of the plant species of a forest is essential for conservation and maintenance of biodiversity (Hossain, Rahman, Hoque, & Khairul, 2004). It helps in the development of plant population of an area over time and space. This is a complex ecological process which involves dispersal of propagating materials, reproduction and establishment of seedlings in relation to environmental factors (Barnes, Zak, Denton, & Spurr, 1998).

Sustainable management of natural forests depends on their ability to regenerate. In this respect, understanding natural regeneration processes and the distribution of recruits is of paramount importance to estimating the future forest structure and composition (Tesfaye, Teketay, & Fetene, 2002; Ceccon, Huante, & Rincon, 2006) and to create or enforce conservation regulations (Schaafsma et al., 2011).

The regeneration status/potential of a species can be assessed from the population dynamics of seedlings and saplings in the forest community (Duchok, Kenyusen, Ashalata, Ashish, & Khan 2005). Several studies have predicted the regeneration status of tree species based on the age and diameter structure of their populations (Pritts & Hancock, 1983; Bhuyan, Khan, & Tripathi 2003). A population structure characterized by the presence of sufficient number of seedlings, saplings and young trees exhibits satisfactory regeneration potential, while an inadequate number of seedlings and saplings is indicative of poor regeneration potential (Saxena & Singh, 1984).

Cameroon is the most biologically rich country known to date on the African continent (Sunderland, Comiskey, Besong, Mboh, Fonwebon, & Dione, 2003). It encompasses an intricate mosaic of diverse habitats with moist tropical forest dominating the south and south-east and covering 54% of the country, mountain forest and savannah in the highlands and sub-Sahelian savannah and near desert in the far north (Sunderland et al., 2003).

These diverse habitats harbour more than 9,000 species of plants, 160 species of which are endemic (Fonge, Tchetcha, & Nkembi, 2013). The majority of the endemic taxa are concentrated around Mount Cameroon and other highland areas (Fonge et al., 2013). During the last few decades, deforestation of tropical forests areas has accelerated at an alarming rate as extensive areas of forest are being cleared every year (Tchouto, 2004). Man affects the forest ecosystem with activities such as agro industries, shifting cultivation, and hunting. There has been an overwhelming concern about the loss of tropical diversity and an emphasis on the identification of biodiversity hot spots in an attempt to optimize conservation strategies (Beentje, 1996).

Several studies indicate that logging directly affects species composition and structure of the forests ecosystem (Silva, De Carvalho, De Lopes, De Almeida, Costa, De Oliveira, Vanclay, & Skovsgaard, 1995; Hall, Harris, Medjibe, & Ashton, 2003; Okuda, Suzuki, Adachi, Quah, Hussein, & Manokaran, 2003; Asase, Asiatokor, & Ofori-Frimpong, 2014). Preserving forest biodiversity without harming economic interests is a big challenge for nations with forests. Local biodiversity loss due to timber extraction activities can disrupt the long-term resilience of forests, which may in turn cascade into an impoverished delivery of ecosystems services, ultimately affecting also human well-being.

Extracting timber or other products changes the tree age structure, composition of tree species and vertical stratification, thereby affecting local temperature, light, moisture, soil, and litter conditions. This results in changes or complete removal of microhabitats (such as dead wood, cavities, root plates or mature trees) that host forest biodiversity. The magnitude of impact on species diversity increases as the forest ecosystem has been under serious pressure from farmland extension (Akinsanmi, 1999).

These changes have caused the loss of some plant species and a decline in the biodiversity conservation status of the Akak forest area. The sustainable management and use of these resources is essential for the nation's economic and environmental security (Akinsanmi, 1999). More over, the Akak forest area serve as buffer zone for most wildlife species moving between Korup region (Korup National Park, Nta ali, Rumpi hills and Ejagham forest reserves). The ecosystem is a centre of high endemism for many taxa (plants, amphibians, mammals, and birds), and its destruction could lead to the local extinction of globally threatened biodiversity (plants, mammals etc.), watershed destruction, and degradation of livelihood systems, property, and lives. conservation.

Diversity studies carried out in Cameroon have covered many parts of the country but left out certain regions despite their richness in plant diversity (Mbolo, 2002). Akak forest area in part of these uncovered areas were there have been relatively few studies on the tree specie composition and diversity. There is a need to provide adequate quantitative and qualitative ecological data to guide forest owners and managers in fashioning out realistic and effective management strategies.

The objectives of this study were to identify tree composition and ecological structure of Akak forest area, specifically: (i) to access the floristic composition (ii) to know the regeneration potentials; and (iii) examine the ecological structure of the Akak forest area. This study is intended to provide baseline information on tree specie composition and diversity in the Akak forest area of Cameroon.

2. Materials and Methods

2.1 Location of the Study Area

The Akak forest area of Cameroon is located between 5°20' –5°25' N latitude and 9° 12'- 9°30' E longitude (Figure 1). Akak is comprised of semi-deciduous lowland rainforest of the Guineo-Congolian type (Kenfack Thomas, Chuyong, & Condit, 2007). Precipitation is unimodal, with an annual average around 4100mm (Nchanji & Plumptre, 2003), with a three-month dry season from December to February (Groenendijk, 2015). The topography is relatively flat. Human interventions, primarily establishing large plantations of cash crops (palm oil, coffee), as well as natural factors, such as elephant disturbance and windfalls, have created large gaps in these forests. Logged forest sites are located in the "heart" of the MPL (Mukete Plantations Limited) concession and the forests of this area have undergone logging, both formal and informal, from 1995 to the present.

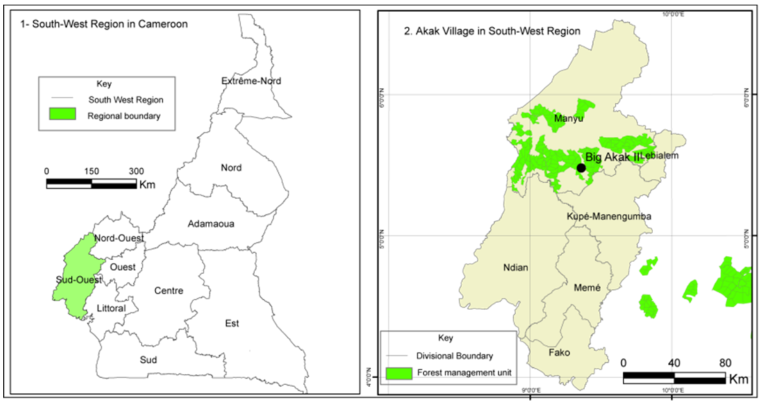

Figure 1. Akak forest area. Source: Adapted from the Cameroon Atlas 2019

2.2 Method

2.2.1 Sampling Plots Establishment for Floristic Survey

A total of 49 logged stumps were selected within the Akak forest spanning a period of 5 years. All three forest compartments had been selectively logged in different year: in 2013, 2015 and 2017. Within each forest compartment, logged stumps were selected randomly, at each stump, a 20 x 20 m transects was demarcated along a disturbance gradient (Figure 2). The transects were demarcated in such manner that the logged stumps will be in the middle and one side of the transects were the highly disturbed side where the tree fell and the other sides was the sides opposite the felling direction, which was least disturbed (Figure 3). A total of 49 transects was created.

Figure 2. Demarcation of transects, Source field work, 2018

Table 1. Sampling transects

Year of logging	Logged stumps
2013	14
2015	20
2017	15
Total	**49**

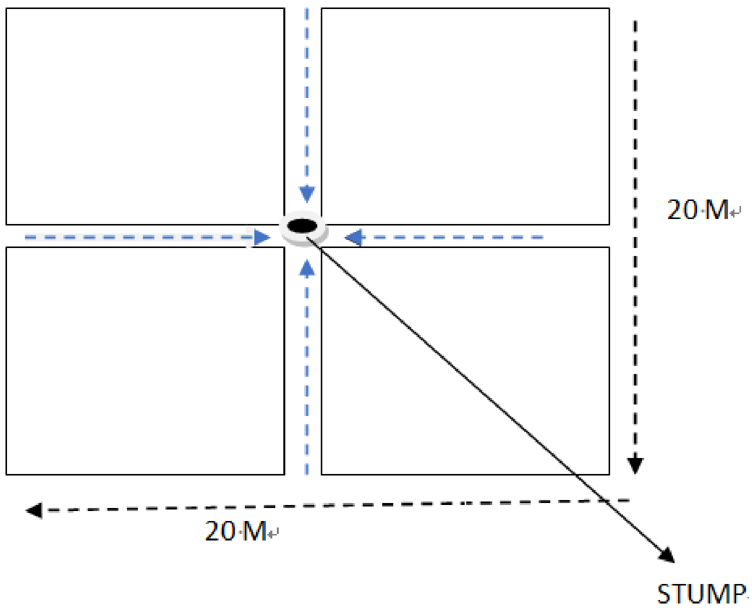

Figure 3. Sampling transects design

2.2.2 Data Collection

All plants taller <2cm were identified to the species level and counted within the 20m x 20m transect. The inventory included tree seedlings were those with diameter size class <2cm as recommended by Luoga and Lejju (2004) saplings were the young trees with diameter size class of (2 - 6cm) small trees (>6–9.9cm), medium-sized trees (10–29.9cm), and large trees (>29.9cm) following a grouping done by Kenfack et al. (2007). The diameter (DBH) of target individuals was recorded at 1.3m stem height, or at 50 cm above buttresses where these were present at 1.3m stem height.

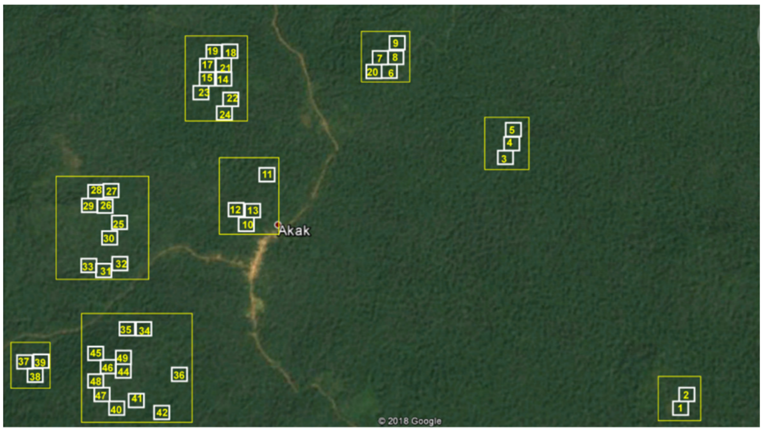

Figure 4. The distribution of sampling transects, source field work, 2018

2.2.3 Data Analysis

Community structure was analyzed through various diversity indices (Shannon-Weaver eveness Indices, Simpson's Indices of diversity and dominance and Fishers' Alpha diversity Index) according to the following formulae:

Data for abundance of species in the transect was first tested for normality, and due to a negative normality test ($p>0.05$) the plots were compared using Kruskal-Wallis non parametric analysis of variance. Following this, the community structure was analyzed through various diversity indices (Shannon-Weaver Evenness Indices, Simpson's Indices of diversity and dominance and Fishers' Alpha Diversity Index) according to the following formulae:

Shannon Index of evenness

Shannon evenness' was calculated as follows:

$$Shannon \quad H = \sum_{i}^{i=1} piLnpi \qquad (1)$$

Where H = the Shannon Index of diversity, pi = relative species abundance, ln = natural logarithm.

Species Evenness:

$$Evenness = \frac{H}{Hmax} \qquad (2)$$

Where Hmax is the maximum possible diversity in the ecosystem.

Simpsons Indices of diversity:

Simpsons Index of dominance:

$$D = \sum_{i}^{i=1} pi^2 \qquad (3)$$

Where pi = relative abundance of species.

Simpsons Index of diversity:

$$\mathbf{1 - D} = (1 - \sum_{i}^{i=1} pi^2) \qquad (4)$$

The value of this index ranges between 0 and 1; the greater the value, the greater the sample diversity. The index represents the probability that two individuals randomly selected from a sample will belong to different species.

Simpsons reciprocal Index

$$\mathbf{1/D} = 1/(\sum_{i}^{i=1} pi^2) \qquad (5)$$

The value of this index starts with 1 as the lowest possible figure. The higher the value, the greater the diversity. The maximum value is the number of species in the sample.

Fishers Alpha

$$\boldsymbol{Fishers \quad Alpha = ax, \frac{(ax)^r}{r}, \frac{(ax)^{r2}}{r2}, \dots, \frac{(ax)^n}{n}, \dots} \qquad (6)$$

Importance value Indices of the different species were calculated as follows:

IVI = Relative Dominance + Relative Density + Relative Frequency

Where:

-Relative dominance = Basal Area of each species /Total Basal area of the site;

-Relative density = Abundance of each species/ Total number of individuals at the site;

-Relative Frequency = Frequency of occurrence of each species across the subplots/Total Frequency at the site.

Data on species abundance was plotted across diameter classes to determine the state of the forest (whether the forest is growing of mature and declining).

All these analyses were done in the Minitab Version 17 Statistical Package (Minitab Inc., PA, USA) at α = 0.05.

Similarities of species were calculated using Euclidean and correlation distance.

3. Results

3.1 Floristic Composition of Akak Forest Area

A total of 5239 individuals from 71 families, 216 genera and 384species were identified in the study area (2013, 2015 and 2017) (Table 2). 1249 individuals were seedlings <2cm tall, and 1458 individuals were saplings 2 – 6cm tall, 156 individuals were small trees of >6-9.99cm, 1244 individuals were medium size trees10-29.99cm and 918 individuals were large trees >29.99cm. The individuals in the different years do not differ significantly ($P < 0.05$) (Table 3).

Table 2. Comparison of 0.5ha sample size for the different years (2013, 2015 and 2017)

Variable	2013	2015	2017
Number of species	308	376	351
Number of families	63	65	56
Number of genera	156	183	164
Individuals	1449	1826	1964
Basal area/0.5 ha	0.28	0.27	0.32
Density/0.5 ha	1449	1826	1964

The results revealed that the maximum plants species was recorded in 2015 (376 species), followed by 351 species in 2017 and 308 species in 2013. (Table 4). The plant species in the different years do not differ significantly (Table 21). This means that the Akak forest area has similar plant species.

Table 3. Kruskal Wallis test on taxa and individual versus years

Categories	Year	N	Median	Ave Ranking	Z	H	DF	P
Taxa_S versus Year	2013	14	61.50	23.8	-0.37			
	2015	20	54.00	21.9	-1.25	3.01	2	0.222
	2017	15	69.0	30.2	1.69			
	Overall	49		25.0	-	-	-	-
Individuals versus Year	2013	14	107.50	23.0	-0.62			
	2015	20	94.50	22.4	-1.05	2.99	2	0.225
	2017	15	69.0	30.3	1.72			
	Overall	49		25.0	-	-	-	-

Table 4. The distribution of families, genera and species in the Akak forest area

	2013		**2015**		**2017**			
FAMILY	**GENERA**	**SPECIES**	**GENERA**	**SPECIES**	**GENERA**	**SPECIES**	**Total Genera**	**Total species**
Ancanthaceae	-	-	1	3	1	1	2	4
Anacardiaceae	3	8	4	12	2	9	8	13
Annonaceae	9	15	11	16	10	20	30	51
Apocynaceae	9	13	8	12	7	11	24	39
Araceae	2	2	1	4	2	2	5	8
Arecaceae	2	4	3	8	3	6	8	14
Asparagaceae	-	-	-	-	1	1	1	2
Asteraceae	1	1	1	1	-	-	2	3
Bignoniaceae	1	1	1	1	2	2	4	7
Burseraceae	4	7	5	6	4	6	13	22
Cecropiaceae	2	2	2	4	2	2	6	10
Celastraceae	1	2	1	5	1	3	3	5
Clusiaceae	2	7	1	4	2	7	5	8
Combretaceae	1	1	1	3	1	2	3	5
Commelinaceae	2	3	3	3	-	-	5	8
Connaraceae	1	1	1	3	2	3	4	7
Convolvulaceae	-	-	1	1	-	-	1	2
Cucurbitaceae	-	-	1	2	-	-	1	2
Dichapetalaceae	2	6	2	7	2	6	6	10
Dilleriaceace	-	-	-	-	1	1	1	2
Dioscoreaceae	1	3	1	4	1	1	3	5
Ebenaceae	1	10	1	12	1	14	3	5
Euphorbiaceae	9	14	11	21	1	16	21	33
Fabaceae	20	35	23	33	20	31	63	106
Gentianaceae	1	1	2	3	1	1	4	7

	2013		2015		2017			
FAMILY	**GENERA**	**SPECIES**	**GENERA**	**SPECIES**	**GENERA**	**SPECIES**	**Total Genera**	**Total species**
Gnetaceae	1	1	1	1	-	-	2	3
Huaceace	-	-	1	1	1	1	2	4
Humiriaceace	-	-	-	-	1	1	1	2
Icacinaceae	1	6	2	4	2	2	5	9
Irvingiaceae	2	2	3	4	2	4	7	12
Lamiaceae	1	1	1	4	1	2	3	5
Lauraceae	2	5	2	3	3	5	7	12
Lecythidaceae	1	2	2	5	2	2	5	9
Leguminosae	1	1	-	-	-	-	1	1
Loganiaceae	1	3	1	2	1	3	3	5
Malvaceae	9	21	8	24	10	34	27	45
Marantaceae	1	2	2	5	1	2	4	7
Melastomataceae	-	-	3	6	1	1	4	8
Meliaceae	8	18	7	15	6	14	21	34
Memecylaceae	-	-	1	1	-	-	1	2
Menispermaceae	1	1	1	1	1	1	3	5
Monimiaceae	1	1	1	1	-	-	2	3
Moraceae	6	7	5	11	4	8	15	24
Myristicaceae	4	6	1	2	3	3	8	12
Myrtaceae	1	2	2	3	1	2	4	7
Ochnaceae	4	7	2	2	3	3	9	14
Octoknemaceae	1	1	1	1	1	2	3	5
Olacaceae	4	7	4	8	4	11	12	20
Orchidaceae	-	-	1	1	-	-	1	2
Pandaceae	1	1	1	1	1	1	3	5
Passifloraceae	-	-	1	1	-	-	1	2
Phyllanthaceae	1	2	4	8	4	7	9	17
Piperaceae	-	-	1	1	-	-	1	2
Polygalaceae	1	2	1	1	-	-	2	3
Putranjivaceae	1	10	1	12	1	11	3	5
Rhizophoraceae	-	-	-	-	1	1	1	2
Rhamnaceae	1	1	1	1	-	-	2	3
Rosaceae	1	1	1	1	1	1	3	5
Rubiaceae	11	29	15	35	13	27	39	67
Ruscaceae	1	2	1	2	1	3	3	5
Rutaceae	2	5	2	5	2	4	6	10
Solicaceae	-	-	1	1	-	-	1	2
Sapindaceae	2	2	2	3	3	6	7	12
Sapotaceae	2	4	2	6	3	9	7	12
Tiliaceae	1	1	1	1	1	1	3	5
Ulmaceae	1	3	2	4	2	4	5	9
Urticaceae	1	2	1	1	-	-	2	3
Verbenaceae	1	2	1	1	1	4	3	5
Violaceae	1	6	2	8	1	9	4	7
Vitaceae	1	2			1	3	2	3
Zingiberaceae	2	3	4	10	2	3	8	14
UK,Leguminaceace	-	-	-	-	7	7	7	14
UK,Sapindaceace	-	-	-	-	2	2	2	4
UK,Sapotaceace	-	-	-	-	2	2	2	4
Total	156	308	182	375	164	351	-	-

*UK= Unknown

The maximum number of species was found in the family Fabaceae (99 species) followed by Rubiaceae (91 species), Malvaceae (79 species), Annonaceae and Euphorbiaceae (51 species) each, and Meliaceae (47 species), Apocynaceae and Ebenaceae (36 species each), Putranjivaceae (33 species each) and rest 62 families comprising 28 to 1 species respectively (Table 22). The family Fabaceae for 2013 had the highest number of species (35) followed by 2015 (33 species) and 2017 31 (species), the family Rubiaceae for 2015 had the highest number of species (35) followed by 2013 (29 species) and 27 (species) 2017.

Table 5. Akak forest area population structure of tree individuals along girth class frequencies (DBH classes in (cm) / 0.5ha)

DBH classes	Number of individual's in 2013	Number of individual's in 2015	Number of individual's in 2017	Total	Percentage of individual in the Akak forest area
<10	794	1078	1092	2964	56.5
11-20	239	285	338	862	16.4
21-30	150	156	190	496	9.4
31-40	73	74	93	240	4.5
41-50	49	44	77	170	3.2
51-60	25	41	36	102	1.9
61-70	22	47	34	103	1.9
71-80	14	22	15	51	0.9
81-90	6	16	23	45	0.8
91-100	12	29	22	63	1.2
>100	65	34	44	143	2.7
	1449	**1826**	**1964**	**5239**	**100**

Population density of tree species across girth class interval in Akak forest area showed that around 56.5% of individuals belonged to <10 cm DBH (Table 5). The highest number of species was also observed in the same category; the study area represents stands with good regeneration.

3.2 Overall Importance of Plant Species in Akak Forest Area

Table 6. Important value index (IVI) of plants species in 2013

Family	*Genera*	*Scientific name*	Frequency	Rel. Density	Rel. Dominance	IVI
Fabaceae	*Baphia*	*Baphia nitida*	13	3.588682	5.215358	21.80
Ochnaceae	*Lophira*	*Lophira alata*	6	1.449275	11.9965	19.45
Fabaceae	*Angylocalyx*	*Angylocalyx pynaertii*	11	5.383023	1.381469	17.76
Malvaceae	*Cola*	*Cola rostrata*	8	1.725328	6.672505	16.40
Euphorbiaceae	*Plagiostyles*	*Plagiostyles africana*	9	2.829538	4.50127	16.33
Myristicaceae	*Staudtia*	*Staudtia kamerunensis*	10	1.173223	2.955489	14.13
Burseraceae	*Pseudospondias*	*Pseudospondias sp.1*	7	1.035197	5.205741	13.24
Dichapetalaceae	*Dichapetalum*	*Dichapetalum angolense*	9	1.311249	2.422935	12.73
Ebenaceae	*Diospyros*	*Diospyros sp.1*	9	1.10421	2.510208	12.61
Clusiaceae	*Garcinia*	*Garcinia mannii*	9	1.794341	1.734889	12.53
Fabaceae	*Calpocalyx*	*Calpocalyx sp.1*	8	2.00138	2.496233	12.50
Malvaceae	*Cola*	*Cola millenii*	11	1.449275	0.027519	12.48
Rubiaceae	*Tricalysia*	*Tricalysia sp.1*	7	2.415459	2.486708	11.90
Putranjivaceae	*Drypetes*	*Drypetes sp.3*	10	1.311249	0.077583	11.39
Marantaceae	*Halopegia*	*Halopegia sp.1*	8	1.035197	1.990345	11.03
Icacinaceae	*Lasianthera*	*Lasianthera africana*	10	0.966184	0.026705	10.99
Anacardiaceae	*Sorindeia*	*Sorindeia macrophylla*	7	2.622498	1.358843	10.98
Lecythidaceae	*Napoleonaea*	*Napoleonaea sp.2*	9	1.173223	0.001787	10.18
Arecaceae	*Elaeis*	*Elaeis guineensis*	1	0.414079	8.580546	9.99
Annonaceae	*Greenwayodendron*	*Greenwayodendron sp.1*	6	0.89717	2.638314	9.54

Top fifteen dominant tree species that are found in 2013 logged compartment in Akak forest area based on the Important Value Index (IVI) is shown in the (Table 6) The most dominant one is *Baphia nitida* followed by *Lophira alata*.

Table 7. Important value index of plants species in 2015

Family	*Genera*	*Scientific name*	Frequency	Rel. Density	Rel. Basal Area	IVI
Cecropiaceae	*Musanga*	*Musanga cecropioides*	12	6.626506024	7.084100042	25.71061
Fabaceae	*Angylocalyx*	*Angylocalyx pynaertii*	11	4.709748083	1.878068508	17.58782
Euphorbiaceae	*Macaranga*	*Macaranga sp.1*	10	3.669222344	2.97462525	16.64385
Moraceae	*Treculia*	*Treculia obovoidea*	9	1.971522453	4.699689944	15.67121
Fabaceae	*Baphia*	*Baphia nitida*	11	1.807228916	0.671558059	13.47879
Sapindaceae	*Chytranthus*	*Chytranthus sp.1*	11	1.040525739	0.702699968	12.74323
Myristicaceae	*Pycnanthus*	*Pycnanthus angolensis*	10	1.040525739	0.896888243	11.93741
Ebenaceae	*Diospyros*	*Diospyros suaveolens*	6	0.657174151	5.248817899	11.90599
Burseraceae	*Canarium*	*Canarium schweinfurthii*	9	1.588170865	0.947089694	11.53526
Putranjivaceae	*Drypetes*	*Drypetes sp.1*	8	0.985761227	2.336333512	11.32209
Malvaceae	*Cola*	*Cola millenii*	9	1.588170865	0.675565761	11.26374
Lecythidaceae	*Napoleonaea*	*Napoleonaea sp.2*	9	0.711938664	0.450184909	10.16212
Rutaceae	*Zanthoxylum*	*Zanthoxylum sp.1*	7	1.150054765	1.957885512	10.10794
Apocynaceae	*Voacanga*	*Voacanga sp.1*	8	1.369112815	0.557664961	9.926778
Putranjivaceae	*Drypetes*	*Drypetes molunduana*	8	1.423877327	0.38989974	9.813777
Meliaceae	*Trichilia*	*Trichilia sp.1*	9	0.766703176	0.021563054	9.788266
Anacardiaceae	*Sorindeia*	*Sorindeia macrophylla*	8	1.204819277	0.259804833	9.464624
Euphorbiaceae	*Plagiostyles*	*Plagiostyles africana*	8	0.766703176	0.450138313	9.216841
Icacinaceae	*Lasianthera*	*Lasianthera africana*	8	1.150054765	0.050213212	9.200268
Burseraceae	*Santiria*	*Santiria tremari*	7	0.492880613	1.366860133	8.859741

Top fifteen dominant tree species that are found in 2015 logged compartment in Akak forest area based on the Important Value Index (IVI) is shown in the (Table 7) The most dominant one is *Musanga cecropioides* followed by *Angylocalyx pynaertii*.

Table 8. Important value index of plants species in 2017

Family	*Genera*	*Scientific name*	Frequency	Rel. Density	Rel. Basal Area	IVI
Fabaceae	*Angylocalyx*	*Angylocalyx pynaertii*	13	5.49898167	5.889832928	24.38881
Myristicaceae	*Staudtia*	*Staudtia kamerunensis*	12	1.578411405	2.374044478	15.95246
Moraceae	*Treculia*	*Treculia obovoidea*	11	2.545824847	2.370822708	15.91665
Malvaceae	*Cola*	*Cola millenii*	12	1.985743381	0.570541027	14.55628
Anacardiaceae	*Sorindeia*	*Sorindeia macrophylla*	10	2.036659878	2.379226046	14.41589
Violaceae	*Rinorea*	*Rinorea dentata*	8	1.069246436	5.065841073	14.13509
Lecythidaceae	*Napoleonaea*	*Napoleonaea sp.1*	12	1.578411405	0.522226154	14.10064
Icacinaceae	*Lasianthera*	*Lasianthera africana*	12	1.476578411	0.041221527	13.5178
Euphorbiaceae	*Plagiostyles*	*Plagiostyles africana*	9	1.985743381	2.513852952	13.4996
Putranjivaceae	*Drypetes*	*Drypetes molunduana*	10	2.138492872	1.325387039	13.46388
Dichapetalaceae	*Tapura*	*Tapura africana*	10	1.731160896	0.794181287	12.52534
Fabaceae	*Baphia*	*Baphia nitida*	8	0.916496945	3.459618809	12.37612
Icacinaceae	*Lavigeria*	*Lavigeria sp.1*	11	0.610997963	0.495053311	12.10605
Sapotaceae	*Gambeya*	*Gambeya africanum*	8	0.712830957	2.737865704	11.4507
Rubiaceae	*Corynanthe*	*Corynanthe sp.1*	9	1.069246436	0.915642933	10.98489
Clusiaceae	*Garcinia*	*Garcinia mannii*	9	1.018329939	0.900804273	10.91913
Fabaceae	*Calpocalyx*	*Calpocalyx sp.1*	8	1.018329939	1.732376611	10.75071
Lauraceae	*Homalium*	*Homalium sp.1*	9	0.967413442	0.683218623	10.65063
Huaceae	*Afrostyrax*	*Afrostyrax lepidophyllus*	8	1.425661914	1.06909645	10.49476

Rutaceae	*Zanthoxylum*	*Zanthoxylum sp.1*	4	0.509164969	5.835968322	10.34513

Top fifteen dominant tree species that are found in 2017 logged compartment in Akak forest area based on the Important Value Index (IVI) is shown in the (Table 8) The most dominant one is *Angylocalyx pynaertii* followed by *Staudtia kamerunensis*.

3.3 Ecological Structure of the Akak Forest Area

3.3.1 Diversity

Different biological indices, such as Shannon evenness (e^H/S) index's, Simpson's diversity index (1-D), Dominance (D) and Fisher_alpha, were evaluated for Akak forest area to reveal the natural regeneration status of recorded plant species (Table 9). The year 2017 depicts a higher diversity with value of (0.989) and least dominance with value of (0.010) while 2015 show the least diverse with value of (0.9869) and a higher dominance with value of (0.013), they differed significantly among the different years for both Dominance (P = 0.032) and diversity Simpson_1-D (p =0.033) (Table 10). The year 2013 show a higher evenness with value of (0.4879) while the year 2015 show the lowest evenness with value of (0.4640) and did not differ significantly among the different years (Table 10). Logged compartment 2015 has a higher fisher alpha with value of 137.7 depicting higher specie richness while the year 2013 has the least specie richness with value of 120.9.

Table 9. Comparison of 0.5ha sample size for the different years (2013, 2015 and 2017)

Variable	2013	2015	2017
Dominance_D	0.012	0.013	0.010
Simpson_1-D	0.9879	0.9869	0.9892
Evenness_e^H/S	0.4908	0.4640	0.4817
Fisher_alpha	120.9	137.7	126.1

Table 10. Kruskal-Wallis test on Dominance, Simpson and Evenness versus years

Categories	Year	N	Median	Ave Ranking	Z	H	DF	P
Dominance_D versus Year	2013	14	0.02999	29.0	1.24			
	2015	20	0.03145	28.3	1.32	6.91	2	0.032
	2017	15	0.02380	16.9	2.62			
	Overall	49		25.0				
Simpson_1-D versus Year	2013	14	0.9700	21.0	-1.24			
	2015	20	0.9686	21.8	-1.30	6.80	2	0.033
	2017	15	0.9762	33.0	2.60			
	Overall	49		25.0				
Evenness_e^H/S versus Year	2013	14	0.7652	23.3	-0.53			
	2015	20	0.7979	26.3	0.51	0.35	2	0.837
	2017	15	0.7787	24.9	-0.02			
	Overall	49		25.0				

3.3.2 Species Similarity

In analysing the similarities between species and years Figure represents a dendrogram showing similarities between the three different logged compartments. The shortest Euclidean distance of (Figure 5) 123.44 between year 2013 and 2017 (Table 11) show that they both have many plants species that are similar. The longest Euclidean distance of 179.11 between 2015 and 2107 depicts they both have less similar plants species.

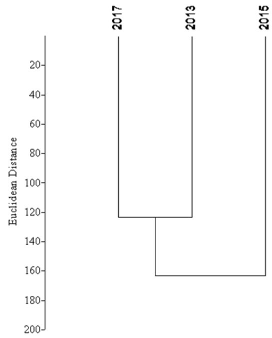

Figure 5. Euclidean Distance

Table 11. Similarities and distances

Year	2013	2015	2017
2013	0	147.26	123.44
2015	147.26	0	179.11
2017	123.44	179.11	0

The structure of the Akak forest area is J reverse showing that the forest is growing to climax with (Figure 6) many individuals as recruits (2856 individuals).

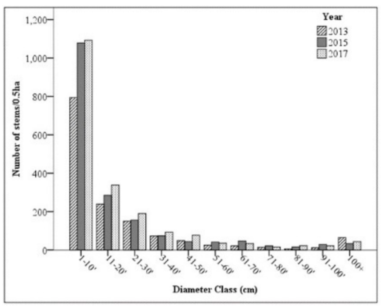

Figure 6. Structure of Akak forest area

3.4 Regeneration Potential in Akak Forest Area

Table 12. The status of regeneration potentials in Akak forest (+) means presence and (–) means absence

Family	Scientific name	2013	2015	2017
Acanthaceae	*Justicia sp.1*	-	+	-
Anacardiaceae	*Antrocaryon sp.1*	+	+	-
	Lannea welwitschii	+	+	-
	Sorindeia macrophylla	+	+	+
	Sorindeia sp.1	+	+	-
	Sorindeia sp.3	+	+	-
	Sorindeia sp.4	+	+	-
	Sorindeia sp.5	-	+	-
	Sorindeia sp.6	-	+	-
	Sorindeia sp.7	-	+	-
	Sorindeia thompsonii	-	+	-
Annonaceae	*Annickia chlorantha*	-		+
	Anona sp.1	-	+	-

	Anonidium mannii	-	+	-
	Anonidium sp.1	+	+	-
	Cleistopholis glauca	+	+	+
	Cleistopholis patens	+	+	+
	Cleistopholis sp.1	-	+	+
	Greenwayodendron sp.1	+	+	+
	Monodora myristica	-	-	+
	Pachypodianthium staudtii	+	+	-
	Pachypodianthium sp.1		+	-
	Polyanthia suaveolens	+	+	-
	Uvaria sp.1	+	+	-
	Uvariodendron sp.1	+	-	+
	Uvariopsis sp	-	-	+
	Xylopia aethiopica	+	+	+
	Xylopia quintasii	+	+	+
	Xylopia staudtti	-	-	+
Apocynaceae	*Alstonia boonei*	+	-	-
	Eglandulosa sp.1	+	+	-
	Holarrhena floribunda	+	-	-
	Picralima nitida	+	-	+
	Pleiocarpa sp.1	+	+	+
	Rauvolfia vomitoria	+	+	+
	Tabernaemontana crassa	+	+	+
	Tabernaemontana sp.1	+	+	-
	Voacanga sp.1	-	-	+
	Voacanga sp.2	-	+	-
Araceae	*Raphidophora sp.1*	+	-	+
	Rektophylum mirabilis	+	+	-
	Rektophylum sp.1	+	-	-
	Raphidophora sp.2	-	+	-
	Recktophylum sp.2	-	+	-
Arecaceae	*Elaeis guineensis*	+	+	-
	Elaeis sp.1	-	+	-
	Elaeis sp.2	-	+	-
	Raphia sp.1	-	+	-
	Calamus sp.1	+	-	-
	Calamus sp.2	+	-	-
	Calamus sp.3	+	-	-
Asparagaceae	*Anthericum sp.1*	+	+	+
Asteraceae	Chromolaena odorata	+	-	-
Begoniaceae	*Begonia meyeri-johannis*	-	+	-
	Newbouldia laevis	+	-	+
	Spathodia campanulata	-	-	+
Burseraceae	*Canarium schweinfurthii*	+	+	+
	Dacryodes edulis	+	+	-
	Dacryodes klaineana	-	+	-
	Pseudospondias sp.1	+	+	+
	Santiria tremari	+	+	-
	Santiria sp.1	+	-	-
Cecropiaceae	*Musanga cecropioides*	+	+	-
	Musanga sp.1	-	+	-
	Myrianthus arboreus	-	+	-
	Myrianthus sp.1	+	+	-
Celastraceae	*Salacia sp.1*	+	+	+
	Salacia sp.2	+	+	-
	Salacia sp.3	-	+	-

	Salacia sp.4	-	+	-
	Salacia sp.5	-	+	-
Clusiaceae	*Allanblackia sp.1*	+	-	-
	Garcinia mannii	+	+	-
	Garcinia ovalifolia	+	-	-
	Garcinia sp.1	+	+	+
	Garcinia sp.2	-	+	-
	Garcinia sp.4	+	+	-
Combretaceae	*Terminalia ivorensis*	+	-	-
Commelinaceae	*Commelina sp.1*	+	+	-
	Palisota sp.1	+	+	-
Connaraceae	*Rourea sp.3*	-	+	+
Dichapetalaceae	*Dichapetalum angolense*	+	+	+
	Dichapetalum sp.1	+	+	-
	Dichapetalum sp.2	+	+	-
	Dichapetalum sp.3	+	+	-
	Dichapetalum sp.4	-	+	-
	Dichapetalum sp.5		+	-
	Tapura africana	+	+	+
Dilleniaceae	*Tetracera podotricha*	-	-	+
Ebenaceae	*Diospyros sp.4*	+	+	-
	Diospyros crassiflora	+	+	+
	Diospyros hirsuta	+	+	-
	Diospyros hoyleana	+	+	-
	Diospyros mouloundouana	+	+	+
	Diospyros sp.1	-	+	-
	Diospyros hirsuta	+	+	+
	Diospyros sp.2	-	+	-
	Diospyros sp.3	+	+	+
	Diospyros sp.6		+	
	Diospyros suaveolens	+	+	+
	Diospyros zenkeri	+	+	-
Euphorbiaceae	*Alchornea sp.1*	+	-	-
	Discoglypremna caloneura	-	+	-
	Discoglypremna sp.1	-	+	+
	Klaineanthus sp.1	+	+	-
	Macaranga sp.1	+	+	-
	Macaranga monandra	+	+	-
	Macaranga sp.2	+	+	-
	Macaranga sp.3	-	+	-
	Maesobotrya sp.1	+	+	-
	Manniophyton fulvum	+	+	-
	Mareyopsis sp.1	-	+	-
	Plagiostyles africana	+	+	-
	Ricinodendron heudelotii	+	+	+
	Ricinodendron heudelotii	-	+	-
	Sapium ellipticum	-	-	+
	Tetracarpidium sp.1	-	-	+
@Fabaceae	*Angylocalyx pynaertii*	+	+	+
	Afzelia sp.1	+	+	+
	Afzelia sp.2	+	+	+
	Albizia adianthifolia	+	+	+
	Albizia sp.1	-	+	-
	Amphimax pterocarpoides	-	-	+
	Anthonotha fragrans	-	+	-
	Anthonotha macrophylla	+	+	+

	Baphiopsis sp.1	+	-	-
	Baphia nitida	+	+	+
	Brachystegia sp.2	+	-	-
	Calpocalyx sp.1	+	+	+
	Calpocalyx sp.2	+	+	-
	Calpocalyx sp.3	+	+	-
	Cylicodiscus gabunensis	+	+	-
	Cynometra hankei	+	+	-
	Dialium bipindense	+	+	-
	Dialium guineense	+	-	-
	Dialium lopense	+	+	-
	Distemonanthus benthamianus	+	+	-
	Detarium microcarpum	-	+	-
	Erythrophleum guineense	-	+	-
	Guibourtia sp.1	+	+	+
	Hylodendron gabunense	+	+	-
	Millettia sp.1	+	+	+
	Monopetalanthus sp.1	-	+	-
	Millettia sp.2	-	+	-
	Parkia bicolor	-	+	-
	Pentaclethra macrophylla	+	+	+
	Piptadeniastrum africana	+	+	+
	Pteropcarpus soyau+ii	+	+	-
	Tetrapleura tetraptera	-	+	-
Flacourtiaceae	*Scotellia coriacea*	-	-	+
Gentianaceae	*Anthocleista nobilis*	-	+	-
	Anthocleista sp.1	+	+	-
Gnetaceae	*Gnetum africanum*	+	+	-
Huaceae	*Afrostyrax lepidophyllus*	-	-	+
Icacinaceae	*Lasianthera africana*	+	+	-
	Lavigeria sp.1	+	+	+
Irvingiaceae	*Desbordesia sp.1*	-	+	-
	Desbordesia glaucescens	+	-	+
	Irvingia gabonensis	+	+	-
Lamiaceae	*Vitex grandifolia*	-	+	-
	Vitex micrantha	-	+	+
	Vitex sp.1	-	+	-
	Vitex sp.2	-	+	+
Lauraceae	*Beilschmiedia sp.1*	-	-	+
	Homalium letestui	-	+	+
	Homalium sp.1	+	+	-
	Hypodaphnis zenkeri	+	+	-
Lecythidaceae	*Napoleonaea sp.1*	+	+	-
	Napoleonaea sp.2	+	+	+
	Napoleonaea sp.3	-	+	-
	Petersianthus sp.1	-	+	+
Leguminosae	Cylicodiscus gabunensis	+	-	-
Leptaulaceae	*Leptaulus sp.1*	-	-	+
Malvaceae	*Ceiba pentandra*	+	+	-
	Christiana sp.1	-	-	+
	Cola accuminata	-	+	+
	Cola cauliflora	+	+	+
	Cola digitata	-	+	+
	Cola lateritia	+	+	+
	Cola millenii	-	+	+
	Cola rostrata	+	+	+

	Cola sp.1	-	+	+
	Cola sp.2	+	+	+
	Duboscia macrocarpa	+	+	-
	Grewia coriacea	+		+
	Leptonychia sp.1	-	+	-
	Leptonychia sp.2	-	+	+
	Leptonychia sp.3	-	+	-
	Scaphopetalum sp.1	+	+	+
	Scaphopetalum sp.2	+	+	
	Sterculia tragacantha	-	+	+
	Theobroma cacao	+	-	-
	Sterculia tragacantha	-	+	-
Marantaceae	*Morantochloa sp.1*	-	+	+
Melastomataceae	*Dissotis sp.1*	-	+	-
	Memecylon warnekii	-	+	-
	Memecylon sp.1	-	+	-
	Memecylon sp.2	-	+	-
Meliaceae	*Carapa procera*	+	-	-
	Carapa sp.1	-	+	+
	Entandrophragma candollei	+	-	-
	Entandrophragma sp.1	+	+	-
	Guarea cedrata	+	+	-
	Guarea sp.1	+	+	+
	Guarea sp.2	+	+	-
	Khaya sp.1	-	+	-
	Trichilia rubescens	+	+	-
	Trichilia sp.1	+	+	-
	Trichilia welwitschii	+	-	-
	Trichoscypha abut	-	+	-
	Trichoscypha acuminata	+	+	-
	Turreanthus sp.1	+	+	-
Memecylaceae	*Mamecylum sp.1*	-	+	-
Menispermaceae	*Stephania sp.1*	-	+	+
Monimiaceae	*Glossocalyx sp.1*	+	+	-
Moraceae	*Chlorophora excelsa*	+	+	-
	Dorstenia sp.1	+	+	+
	Ficus elasticum	+	+	-
	Ficus mucuso	-	+	-
	Ficus sp.1	-	+	-
	Ficus subsargitata	-	+	-
	Ficus sur	-	+	-
	Treculia africana	-	-	-
	Treculia obovoidea	+	+	+
	Treculia sp.1	-	+	-
	Trilepisium sp.1	-	-	+
	Trilepisium madagascariense	+	-	-
Myristicaceae	*Coelocaryon sp.1*	+	-	+
	Pycnanthus angolensis	+	+	+
	Staudtia kamerunensis	+	+	+
Myrtaceae	*Eugenia sp.1*	-	+	-
	Syzygium guineense	+	-	+
	Syzygium sp.1	+	-	-
Ochnaceae	*Campylospermum sp.1*	+	+	+
	Lophira alata	+	+	-
	Ochna sp.1	+	-	-
Octoknemaceae	*Octoknema sp.1*	+	-	+

	Diogoa zenkeri	+	-	-
	Olax sp.1	+	+	+
Olacaceae	*Strombosia grandifolia*	+	+	-
	Strombosia pustulata	+	+	-
	Strombosia zenkeri	-	+	-
	Strombosiopsis tetrandra	+	+	+
Pandaceae	*Microdesmis sp.1*	-	+	+
Passifloraceae	*Barteria fistulosa*	-	+	-
	Antidesma sp.1	-	+	+
	Bridelia sp.1	-	-	+
Phyllanthaceae	*Magaritaria sp.1*	-	+	
	Uapaca guineensis	-	+	+
	Uapaca staudtii	-	-	+
Polygalaceae	*Carpolobia sp.1*	+	+	-
	Drypetes molunduana	+	+	-
	Drypetes sp.1	+	+	+
	Drypetes sp.2	-	+	-
	Drypetes sp.3	-	+	+
	Drypetes sp.4	+	+	+
Putranjivaceae	*Drypetes sp.5*	+	+	-
	Drypetes sp.6	-	+	+
	Drypetes sp.7	+	+	-
	Drypetes sp.8	+	+	+
	Drypetes sp.9	+	+	-
	Drypetes sp.10	-	+	-
	Drypetes sp.11	-	+	-
Rhizophoraceae	*Anopyxis kleneanna*	-	-	+
Rosaceae	*Pyracantha sp.1*	+	+	-
	Belonophora sp.1	-	+	+
	Belonophora sp.2	-	+	-
	Canthium sp.1	+	-	+
	Shumanniophyton magnificum	+	-	+
	Corynanthe sp.1	-	+	+
	Ixora sp.1	-	+	+
	Massularia acuminata	+	+	-
	Massularia sp.1	+	-	-
	Morinda lucida	-	+	-
	Mitragyna sp	-	-	+
Rubiaceae	*Oxyanthus sp.1*	-	+	-
	Pauridiantha sp.1	+	+	-
	Pavetta sp.1	-	+	-
	Rothmania hirpida	+	+	+
	Rothmania sp.1	+	+	-
	Rothmania sp.2	+	+	-
	Rothmannia talbotii	+	+	+
	Rothmania sp.3	-	+	-
	Rothmania sp.4	-	+	-
	Shebournia sp.1	-	+	+
	Tricalysia sp.1	+	-	+
Ruscaceae	*Dracaena arborea*	+	+	-
	Dracaena sp.1	+	+	-
	Fagara sp.1	+	-	-
Rutaceae	*Zanthoxylum sp.1*	+	+	+
	Zanthoxylum sp.2	+		+
Salicaceae	*Phyllobotryon sp.1*	-	+	-
Sapindaceae	*Blighia sp.1*	+	+	-

	Chytranthus sp.1	+	+	+
	Chytranthus talbotii	-	+	+
	Laccodiscus sp.1	-	-	+
	Baillonella toxisperma	-	-	+
Sapotaceae	*Gambeya africanum*	+	+	+
	Gambeya sp.2	+	-	-
	Omphalocarpum sp.1	+	-	-
Tiliaceae	*Desplatsia dewevrei*	+	+	-
	Celtis sp.1	+	+	+
Ulmaceae	*Celtis sp.2*	+	+	-
	Trema guineensis	-	+	+
	Rinorea dentata	+	+	+
	Rinorea oblongifolia	+	-	+
Violaceae	*Rinorea sp.1*	+	+	-
	Rinorea sp.2	+	+	-
	Rinorea sp.3	+	+	-
	Rinorea sp.4	-	+	-
Vitaceae	*Cissus dinklagei*	+	-	-
Zingiberaceae	*Hydrychium sp.1*	-	+	-
	Renealmia sp.1	-	+	-

Result show that the family Fabaceae species have the highest presence of regeneration regenerating species (31) followed by the family Rubaceae with (21) species (Table 12).

Most of the regenerating species in Akak forest are between the size class 1-4.9 (Figure 7) with the year 2015 having the highest number of recruits (1014 individuals) (Table 12).

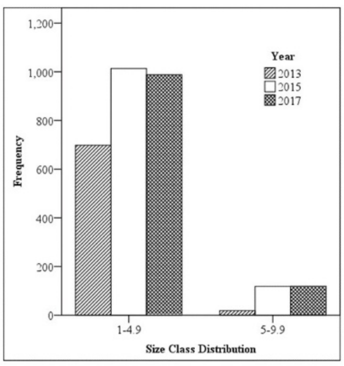

Figure 7. Regeneration potentials

4. Discussion

4.1 Floristic Composition of Akak Forest Area

Tropical forest ecosystems are one of the richest terrestrial ecosystems which support a variety of life forms and maintain huge global biodiversity (Shi & Singh, 2002). The forests of southwestern Cameroon are generally known to be rich in species diversity because they are located within the high rainfall zone of the Guinean equatorial tropical forest. (Fonge et al., 2013). Numbers of species, genera, families, were higher in the in 2015 logged compartments compared to the 2017 and 2013 this can be due to the increase in densities of seedlings. These findings are consistent with the general notion that the recovery of forests after logging normally takes years and the resulting forest differ considerably in species composition, and structure from the original forest (Johns, Barreto, & Uhl, 1996; Kinjanjui, Karachi, & Kennedy, 2013; Wiafe, 2014). Felton, Felton, Wood and Lindenmayer (2006) found significantly higher proportion of regenerated pioneers in logged sites in a Bolivian subtropical forest. Following disturbances, pioneers and Non Pioneer Light demanding densities are expected to increase whilst those of shade-bearers decline with time until the canopy closes (Duah-Gyamfi, Kyereh, Adam, Agyeman, & Swaine 2012). The higher numbers of species, genera, families in 2015 logged compartments compared to 2017 and 2013 can be attributed to the openings of canopy gaps and higher incidence of sunlight on the forest floors as a result of logging disturbance and the time for pioneers to colonise the environment (Hawthorne, 1993; Swaine, Agyeman, & Adam, 1998; Molino & Sabatier, 2001). This result is also in line with the observations by Tchouto et al. (2004) in Cameroonian forest that herbaceous species, pioneer species and climbers increase with the degree of disturbances. Similarly, the relatively higher numbers of species, genera, families recorded in compartment logged 3 years (2015) ago compared to compartment logged 1 year (2017) suggest that more time may be required for the expected compositional of shade tolerant seedlings. The slight decrease in numbers of species, genera, families in 2013 as compared to 2015 is similar to Duah-Gyamfi et al. (2012) reported a reduction in the proportion of understory pioneer species after 33 months of selective logging in Pra Anum Forest Reserve of Ghana. The greater basal area of species in 2017 compared to 2015 may be due immediately after logging there is still a grater number of plants stands but will eventually change with time since the mortality rate of plants adapted to low light levels will eventually increase. Other investigators have reported higher basal areas following disturbances in different forests (Latty, Canham, & Marks, 2004; Sefah, unpublished). Sefah (unpublished), for example, found significantly higher mean basal area of seedlings and saplings in heavily disturbed forests forest types in Ghana, and concluded that this might be due to the sufficient light availability resulting from the low canopy cover.

4.2 Overall Importance of Plant Species in Akak Forest Area

In the study area, the most dominant family was the Fabaceae (99) species this is in line with Sainge (2016) who reported a similar situation in the kimbi fundong park. Fabaceae always fall among the three most dominant families in the world. Fabaceae is the most diverse plant family in the world with a wide distribution of sort, registering 770 genera and 19,500 sorts, and considered the third largest family of angiosperms in species numbers (Beech, Rivers, Oldfield, & Mith, 2017; Azani et al., 2017) the second most dominant family is Rubiaceae, with 91 species. This is inline with (Ndam, Nkefor, & Blackmore, 2001) and Fonge et al. (2011) who reported that the Rubiaceae was the most dominant tree family in the Mount Cameroon region and Kenfack et al. (2007) also report Rubiaceae to be the most dominant tree family in the Korup National Park. Nevertheless, Rubaiaceae could be the most dominant tree family in the Guinean equatorial forest as reported by Fonge et al. (2013).

It is an established fact that few species dominate forest ecosystems that experience prolonged absence or frequent occurrences of high intensity disturbances (Cornell, 1978; Sheil & Burslem, 2003; Kinjanjui, Karachi, & Kennedy, 2013). This pattern was evident in the results of the present study, which showed a much higher importance value for the fifteen most dominant species in the 2013 logged compartment as compared to compartment logged in 2017 and 2013. Similar results have been observed in the tropics (Todaria, Uniyal, Pokhriyal, Dasgupta, & Bhatt, 2010; Nartey, 2013 unpublished; Wiafe, 2014), though other studies have produced contradictory results (Muhanguzi, Obua, & Oryem-Origa, 2007; Chazdon et al., 2010). With time, the importance of the dominant species diminished in the studied habitats this is evident in our study sites were logged sites of 2017 had higher IVIs for the fifteen most dominant species than sites logged in the year 2015.

Resistance is the inherent ability of a forest to remain unaffected or absorb moderate disturbances (Thompson, Mackey, Mcnulty, & Mosseler, 2009). According to Belote, Jones, & Weiboldt (2012), forest resistance decreases with increasing timber-harvesting disturbance when these researchers found that compositional stability was lower in most disturbed plots of forests in the Appalachian Mountains of North America. Thus, the dominance of similar species in the 2013, 2015 and 2017 sites by the same families in the present study reflects high resistance to logging disturbance, coupled with their relatively high diversity. According to Thompson et al. (2009), resistance is enhanced by increase diversity of a forest ecosystem. The dominance of *Angylocalyx pynaertii, Staudtia kamerunensis, Cola millenii, Drypetes molunduana, Tapura Africana, Baphia nitida, Sorindeia macrophylla and Musanga cecropioides* in at least two sites in terms of importance in most species are either pioneers or non-pioneer light demanding species (Duah-Gyamfi, Kyereh, Adam, Agyeman, & Swaine, 2012).

4.3 Ecological Structure of the Akak Forest Area

Generally, the Akak forest area has a high diversity. The higher species diversity in the 2017 as opposed 2013 and 2015 This is in agreement with Young and Swiacki (2006) who stated that diversity was made up of the variety of species present and the relative abundance of those species. The higher the values, the higher the diversity (Ojo, 2004). The Simpson's Index indicates that the diversity of the reserve is high and it is an indicative of a healthy reserve when compared to the other years. The specie richness index obtained was higher in 2015 (137.7) than in the other years which indicate high species richness this contradicts Fonge et al. (2013) who had a poor specie richness in her studies on Plants in Lewoh-Lebang in the Lebialem Highlands of Southwestern Cameroon.

4.4 Regeneration Potential in Akak Forest Area

Recruitment of viable seedling and saplings can be indicators of the regeneration status of a plant community. The processes involved in tree regeneration can be influenced by disturbance regimes and other factors, such as predation, canopy openness, soil moisture availability, as well as biological features of the species, such as their life cycles and behavior. The absence of some regeneration species in some years such as *Lophira alata* in the year 2017, *Terminalia ivorensis* in the year 2015 and *Tetrapleura tetraptera* in 2017 can be attributed excessive selective logging of this species for commercial purposes. other factors, such as environmental gradient, as well as species-specific regeneration patterns together with disturbance regimes contributed to the non presence of these species. The presence of abundant seedlings of the other species (*Afrostyrax lepidophyllus, Pentaclethra macrophylla, Ricinodendron heudelotii and Scorodophloeus zenkeri*) is consistent with a previous report from tropical rainforests (Whitmore, 1996). their characterized by sufficient numbers of seedlings, saplings and adults, indicate that they are regenerating successfully. for *Afrostyrax lepidophyllus* and *Pentaclethra macrophylla*, their superior natural regeneration can be linked to their good fruiting efficiency and germination capacity. in addition, the high fruit predation of Afrostyrax lepidophyllus by small mammals ensures the dissemination of seeds throughout the forest. *Pentaclethra macrophylla* has fruits that explode at maturity, scattering seeds at great distances from seed tree, which reduces the density-dependent mortality that occurs when too many seeds germinate at the same time under a seed tree. *Ricinodendron heudelotii*, is a gap opportunist and fast-growing pioneer tree (Plenderleith, 2000) that regenerates rapidly in open canopy forest and very poorly under closed canopies. its high regeneration observed in this study can be attributed to the high degree of disturbances in the forest.

5. Conclusion

The Akak forest area important in terms of plant biodiversity with 71 families and 384 species recorded in the study area and also considered as important destination point for rich timber resources such as *Diospyros crassiflora, Petersianthus macrocarpus, Entandrophragma cylindricum, Khaya ivorensis, Piptadeniastrum africanum, Milicia excelsa, Lophira alata, Strombosia pustulata* etc are found. Hence, it is very crucial to protect these important forests for biodiversity, sustainable management and environmental perspectives. The forest has a high diversity and richness with *Angylocalyx pynaertii, Staudtia kamerunensis, Cola millenii, Drypetes molunduana, Tapura Africana, Baphia nitida, Sorindeia macrophylla and Musanga cecropioides* figuring out as dominant species found Akak forest area. The Akak forest area currently displays signs of recovery. Evidently, the forest area is very rich in trees in the lower diameter classes, which is an indication of a healthy and vigorous stand. The structure of the forest tells us that there is high species diversity and the relative richness in plant species of the and it is in the process of recovering.

Conflict of interests

The authors declare that there is no conflict of interests regarding the publication of this paper.

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