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Research article

Phytoecological study of Nzundu massif forest of Imbongo city, Kwilu Province, Democratic Republic of the Congo

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Abstract: Formerly, the Nzundu forest massif covered almost the two third of Kwenge and Imbongo, and a part of Kipuka districts. Nowadays, it is represented by a reduced forest fragment with a surface of about 50 to 70 hectares. The flora inventory was performed on the forest trees at dbh ≥ 10 cm, measured at 1.30 m of high at the breast height trunk, allowed to identify 134 different kinds of plants divided into 109 genera and 31 families. *Fabaceae*, *Malvaceae*, *Rubiaceae*, *Euphorbiaceae*, *Moraceae*, *Meliaceae* and *Sapotaceae* are the most represented families. The value of the basal area got in this forest massif is high or 49.89 $m^2.ha^{-1}$. As to the ecological spectra and phytogeographical distribution, mesophanerophytes, sarcochores, mesophyles and the Congolian-Guinea element are the most numerous. The density of the forest trees listed in this forest massif is of 422 trunks.ha^{-1}. *Brachystegia laurentii* is the species having the highest number of feet or 11.8%. The values of Shannon and of Equitability indices calculated are of 4.7 and 0.9 respectively.
Keywords: Forest ecology - Life forms - Diaspores - Foliar types - Phytogeography.

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INTRODUCTION

The Nzundu forest massif is about ±8 km southeast to Kwilu Bridge on the Kikwit-Mukulu road (Batshamba). The massif in question is derived from a dense forest of Guinean mesophilic semi-deciduous and peri-Guinean mesophilic type predominantly in *Brachystegia laurentii* Louis ex Hoyle. Formerly, this forest covered the low slopes of the left slope overlooking Kwilu River. In the past, it extended between Kwenge sector and Kimbinga Makoloninga village in Imbongo district (Nicolaï 1963).

Currently, this large forest has been reduced to a forest massif, now subjected to an intense human activity (as it was the case with the large forest from which it was derived) because of its proximity not only to Kikwit city with a population estimated at more than 400,000 inhabitants and a majority of small farmers but also to surrounding villages such as Giguidji, Mbundi, Kianga, Kakoy and Mbamba. Its maintenance is only due to its erection as a private farm. Due to the anthropic pressure experienced by this massif, its surface is daily more and more reduced; hence, the need of undertaking a phytoecological inventory. In order to preserve, protect and better manage it, a thorough study of its various components (flora, specific diversity, structure, etc.) is necessary. This concern integrated into the process ($REDD^+$).

That is the reason why this phytoecological study was undertaken. Different parameters considered in this survey were: structure, basal area, density, dominance, frequency as well as ecological and phytogeographic spectra. This survey is significant especially for ecologists at this time where climate change is a global concern. In fact, this massif forest with its florisitic cortege plays somewhat a role in the regulation of temperature which exceeds more than 2°C according to many specialists. Data used to write this paper are based on observations

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made between 2010 and 2012 in a series of studies carried out in various forested areas located in the interland of Kikwit city following a degradation to which they are currently subjected.

MATERIAL AND METHODS

Study area

The Nzundu forest massif is located between Giguidzi-Mbundi and Kianga villages in Imbongo district. It is at least 8 km far from Kwilu Bridge and 3 km upstream of Mwebe bridge (Fig. 1). Physically, this forest massif which already undergoes aggressions from villagers and the population of the semi-rural of Kikwit city is dominated by *Brachystegia laurentii* Louis ex Hoyle along with *Pterocarpus mildbraedii* Harms.

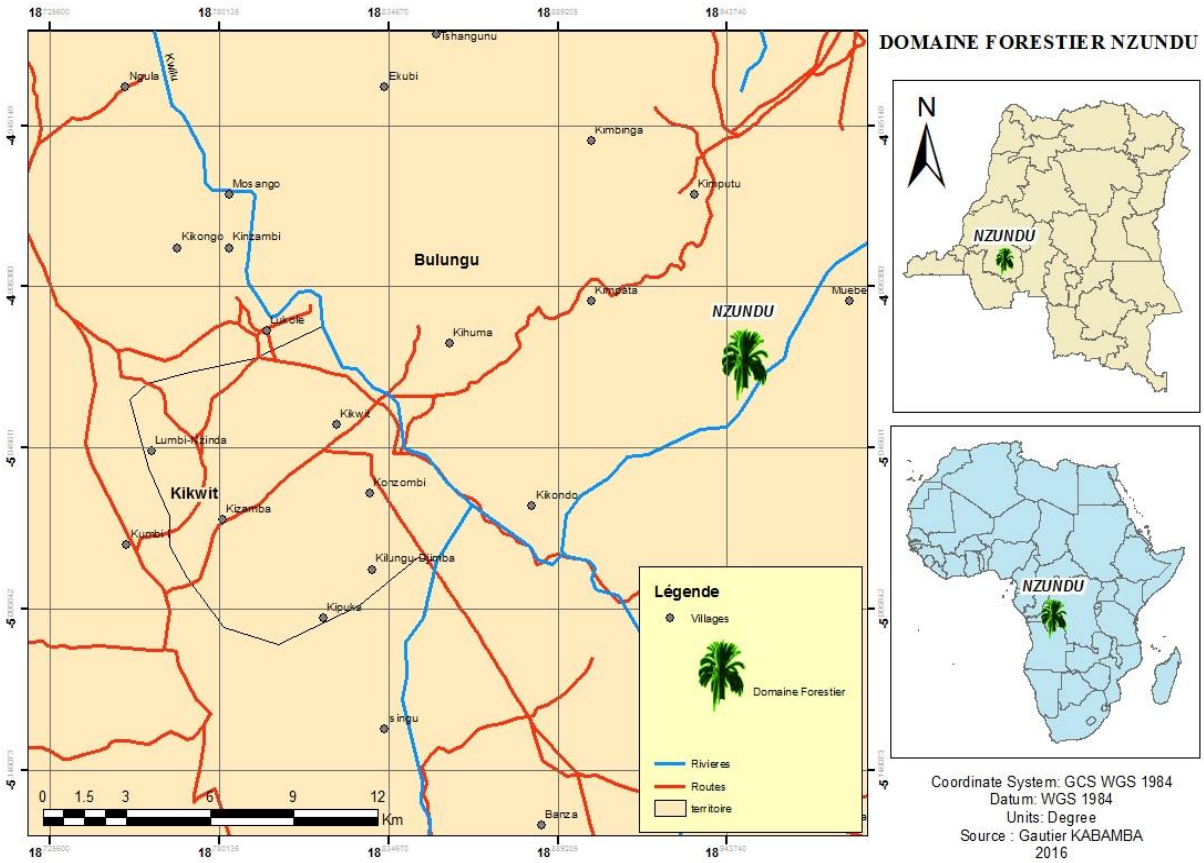

Figure 1. Map showing the location of study area.

Data sampling and analysis

A 1 Km long transect (divided into two sections of 10 m large and 500 m long) was drawn along which, dbh ≥ 10 cm, of trees were measured on both stretches. All species with dbh ≥ 10 cm were inventoried within each delimited portion. The identification of collected specimens was performed using the flora of Central Africa (consisting of 10 volumes and numerous fascicules) and in comparison with concerned herbarium specimens at the Herbarium of the Department of Biology (Faculty of Sciences, University of Kinshasa).

Arborescent tree density was evaluated for all trees having a diameter of 1.30 m at breast height >10 cm, present in various surveys. Basal area (BA), which is the sum of the sections of trunks at 1.30 cm above the ground or 30 cm above tree spur, expressed in m^2/ha, was calculated for all trees having a breast height diameter (dbh) >10 cm, according to the following formula:

$$BA\ (s) = \frac{\pi d^2}{4} \quad (1)$$

The total basal area of phytocenosis and/or any forest is obtained from the sum of areas of all trees of which dbh is greater than a given value (Shaumba *et al.* 2016). In the current study, all trees of dbh >10 cm were considered.

The circumference of trees was directly measured by considering the cylindrical or conical drums. Using the following mathematical formula, different values of dbh was deduced,

$$C = \pi \times d \quad (2),$$

Henceforth,

$$d = \frac{C}{\pi} \text{ (3)}$$

Where, C = circumference and d: diameter

Relative dominance (expressed in percentage) was calculated using the formula:

$$f(\%) = \frac{BA}{Total\ of\ BA} x\ 100 \text{ (4)}$$

Where, BA= basal area.

We used the following formula to calculate the relative Frequency:

$$f(\%) = \frac{b}{bt} x\ 100 \text{ (5)}$$

Where, b = number of feet / ha for each species; bt = total number of individuals inventoried.

Concerning the relative importance (h) of various species, the following formula was used:

$$h = \frac{e+f+g}{3} \text{ (6)}$$

where, e = relative density; f = relative dominance and g = relative frequency.

As for the diversity of flora, we used the Shannon diversity index for its interpretation:

$$ISH = -\Sigma pi \ln pi \text{ (7)}$$

This formula was given by PAST software where: pi, effective species, i and n total number of species.

Equitability (EQ) was established according to the following mathematical relationship:

$$EQ = \frac{H^+}{H_{max}} \text{ (8)}$$

Where, H^+ = regularity and Hmax = maximum diversity.

Concerning diameter classes, the diameters of all species at dbh > 10 cm, present in the various surveys, were measured using a tape measure and grouped into different classes. Different eco-sociological groups were distinguished on the basis of works of numerous authors (Masens 1997, Shaumba *et al.* 2017). The types of foliar dimensions were defined from the Raunkiaer classification (Habari 2009, Belesi 2009). For the types of phytogeographical distribution, we focused on the major chorological subdivisions of Africa (White 1983, 1992). As for the life forms (LF), we used the Raunkiaer classification adapted to the tropical regions (Habari 2009, Belesi 2009). As far as the types of dissemination of diaspores are concerned, we were inspired by the works of Masens (1997).

RESULTS

Phytodiversity measure

The areal richness of Nzundu forest massif of dbh ≥10 cm species measured at 1.30 m breast height is of 134 woody plant species. Of these, five species have a dbh >70 cm; these are *Brachystegia laurentii* Louis ex Hoyle (1.045 m), *Baillonella toxisperma* Stone (0.757 m), *Bosqueiopsis gilletii De Wild. & Th. Dur.* (0.757 m), *Khaya anthotheca* (Welw.) C. DC. (0.717 m) and *Antiaris toxicaria* Lesch. (0.713 m). Out of these five species, two belong to *Moraceae* family (Table 1). These 134 species are grouped in 31 families and 109 genera. The following families are best supplied with species: *Fabaceae* (30 species), *Malvaceae* (12 species), *Rubiaceae* (11 species), *Euphorbiaceae* (9 species), *Moraceae* (8 species), *Sapotaceae*, *Annonaceae* and *Clusiaceae* with 6 species each. These families alone account for 66.4% of all the species of the studied flora. As for the 23 other families, they contain 33.5% of the total species inventoried in this forest massif. Of these, 16 families are monospecific, representing 11.9% out of the total.

Table 1. Floristic inventory of Nzundu massif forest (Values of different structural parameters).

Plant species	Family	A	B	C	D	E	F	G	H
Allophylus africanus P. Beauv.	*Sapindaceae*	1	2	0.138	0.030	1.48	0.06	0.64	1.75
Amphimas pterocapoides Harms	*Fabaceae*	2	4	0.320	0.321	2.96	0.63	1.28	1.62
Angylocalyx pynaertii De Wild.	*Fabaceae*	2	4	0.302	0.287	2.96	0.06	1.28	1.43
Anisophyllea polynera Floret	*Anisophylleaceae*	1	2	0.243	0.093	1.48	0.19	0.64	1.88
Anonidium mannii (Oliv.) Engl. & Diels	*Annonaceae*	2	4	0.245	0.188	2.96	0.37	1.28	1.54

Anthonotha fragrans (Bak.f) Exell et Hill.	*Fabaceae*	1	2	0.460	0.333	1.48	0.65	0.64	0.92
Anthrocaryon klaineana Pierre	*Annonaceae*	1	2	0.426	0.285	1.48	0.56	0.64	0.89
Antiaris toxicaria Lesch.	*Moraceae*	1	2	0.713	0.798	1.48	1.56	0.64	1.23
Antidesma sp.	*Euphorbiaceae*	1	2	0.239	0.089	1.48	0.18	0.64	0.78
Antidesma vogelianum Müll.-Arg.	*Euphorbiaceae*	1	2	0.484	0.367	1.48	0.72	0.64	0.95
Aphanocalyx margininervatus J.Leonard	*Fabaceae*	2	4	0.566	1.007	2.96	1.97	1.28	2.07
Autranella congolensis (De Wild.) A. Chev.	*Sapotaceae*	2	4	0.607	1.156	2.96	2.27	1.28	2.17
Baillonella toxisperma Pierre	*Sapotaceae*	2	4	0.757	1.803	2.96	3.53	1.28	2.59
Berlinia grandiflora (Vahl.) Mikh. et Dalz.	*Fabaceae*	1	2	0.426	0.285	1.48	0.56	0.64	0.89
Blighia unijugata Bak.	*Sapindaceae*	1	2	0.350	0.192	1.48	0.38	0.64	0.83
Blighia welwitschii (Hiern) Radlk.	*Sapindaceae*	2	4	0.413	0.537	2.96	1.05	1.28	1.77
Bosqueiopsis gilletii De Wild. & Th. Dur.	*Moraceae*	2	4	0.757	1.801	2.96	3.53	1.28	2.59
Brachystegia laurentii Louis ex Hoyle	*Fabaceae*	8	16	1.045	13.739	11.85	26.90	5.13	14.63
Canarium schweinfurthii Engl.	*Burceraceae*	2	4	0.426	0.577	2.96	1.13	1.63	1.91
Carapa grandiflora Sprague	*Meliaceae*	1	2	0.630	0.624	1.48	1.22	0.64	1.11
Carapa procera DC. var. *procera* DC.	*Meliaceae*	1	2	0.331	0.172	1.48	0.34	0.64	0.82
Celtis adolfi-friderici Engl.	*Ulmaceae*	1	2	0.552	0.479	1.48	0.94	0.64	1.02
Celtis durandii Engl.	*Ulmaceae*	2	4	0.502	0.794	2.96	1.55	1.28	1.93
Celtis mildbraedii Engl.	*Ulmaceae*	2	4	0.328	0.337	2.96	0.66	1.28	1.64
Celtis zenkeri Engl.	*Ulmaceae*	2	4	0.300	0.284	2.96	0.56	1.28	1.60
Chrysophyllum lacourtianum De Wild.	*Sapotaceae*	2	4	0.405	0.517	2.96	1.01	1.28	1.75
Coelocaryon botryoides Verm.	*Myristicaceae*	1	2	0.178	0.049	1.48	0.10	0.64	0.74
Cola chlamydantha K.Schum.	*Malvaceae*	1	2	0.280	0.123	1.48	0.24	0.64	0.79
Cola diversifolia De Wild.	*Malvaceae*	1	2	0.111	0.019	1.48	0.04	0.64	0.72
Cola gigantea A. Chev.	*Malvaceae*	1	2	0.292	0.133	1.48	0.26	0.64	0.79
Cola lateritia K. Schum.	*Malvaceae*	2	4	0.128	0.051	2.96	0.10	1.28	1.14
Cola urceolata K. Schum.	*Malvaceae*	1	2	0.283	0.125	1.48	0.25	0.64	0.79
Copaifera mildbraedii Harms	*Malvaceae*	1	2	0.175	0.048	1.48	0.09	0.64	0.55
Corynanthe pachycera K. Schum.	*Rubiaceae*	2	4	0.227	0.162	2.96	0.32	1.28	1.52
Crudia gabonensis Pierre ex Harms	*Fabaceae*	1	2	0.280	0.123	1.48	0.24	0.64	0.79
Cynometra hankei Harms	*Fabaceae*	2	4	0.248	0.193	2.96	0.38	1.28	1.54
Daniellia pynaertii De Wild.	*Fabaceae*	1	2	0.452	0.321	1.48	0.63	0.64	0.92
Desplatsia chrysochlamys (Mildbr. & Bur,) Mildbr.	*Malvaceae*	2	4	0.201	0.127	2.96	0.25	1.28	1.50
Detarium macrocarpum Harms	*Fabaceae*	2	4	0.581	1.599	2.96	3.13	1.28	2.59
Dialium corbisieri Harms	*Fabaceae*	1	2	0.414	0.269	1.48	0.53	0.64	0.88
Dialium pachyphyllum Harms	*Fabaceae*	1	2	0.286	0.128	1.48	0.25	0.64	0.74
Dialium pentandrum Louis ex Stey.	*Fabaceae*	1	2	0.343	0.185	1.48	0.36	0.64	0.83
Dialium tessmannii Harms	*Fabaceae*	3	6	0.289	0.394	4.44	0.77	1.92	2.38
Dichostemma glauscens Pierre	*Euphorbiaceae*	1	2	0.239	0.089	1.48	0.18	0.64	0.77
Diospyros canaliculata De Wild.	*Ebenaceae*	1	2	0.132	0.027	1.48	0.05	0.64	0.73
Duboscia viridiflora (K. Schum.) Mildbr.	*Malvaceae*	3	6	0.217	0.223	4.44	0.44	1.92	2.27
Enantia chloranta Oliv.	*Annonaceae*	1	2	0.229	0.082	1.48	0.16	0.64	0.76
Entandrophragma angolense (Welw.) C. DC.	*Meliaceae*	3	6	0.299	0.422	4.44	0.83	1.92	2.40
Entandrophragma utile Sprague	*Meliaceae*	2	4	0.518	0.844	2.96	1.65	1.28	1.97

Erismadelphus exsul Mildb.	*Vochysiaceae*	2	4	0.237	0.177	2.96	0.35	1.28	1.53
Erythrophleum suaveolens (Guill. & Perrot) Brenan	*Fabaceae*	1	2	0.595	0.556	1.48	1.09	0.64	1.07
Fernandoaa dolfi-frederici (Gilg & Mildbr.) Heine	*Bignionaceae*	1	2	0.304	0.145	1.48	0.29	0.64	0.80
Ficus lutea Vahl	*Moraceae*	1	2	0.213	0.074	1.48	0.14	0.64	0.76
Ficus sur Welw. ex Ficalho	*Moraceae*	1	2	0.232	0.084	1.48	0.17	0.64	0.76
Ficus thonningii Blume	*Moraceae*	1	2	0.201	0.063	1.48	0.12	0.64	0.75
Filaeopsis discophora Harms	*Fabaceae*	1	2	0.356	0.199	1.48	0.39	0.64	0.84
Funtumia elastica (Preuss) Stapf	*Apocynaceae*	1	2	0.213	0.071	1.48	0.14	0.64	0.75
Gaertnera parvipaniculata Petit	*Rubiaceae*	1	2	0.201	0.063	1.48	0.12	0.64	0.75
Ganophyllum giganteum (A. Chev.) Hauman	*Sapindaceae*	2	4	0.426	0.571	2.96	1.12	1.28	1.79
Garcinia epunctata Stapf	*Clusiaceae*	1	2	0.264	0.109	1.48	0.21	0.64	0.78
Garcinia kola Heckel	*Clusiaceae*	2	4	0.491	0.758	2.96	1.49	1.28	1.91
Garcinia punctata Stapf	*Clusiaceae*	2	4	0.283	0.252	2.96	0.49	1.28	1.58
Gilbertiodendron dewevrei (De Wild.) J. Léonard	*Fabaceae*	2	4	0.283	0.252	2.96	0.49	1.28	1.58
Greenwayadendron suaveolens (Engl. & Diels) Verdc.	*Annonaceae*	1	2	0.439	0.303	1.48	0.59	0.64	0.91
Grewia oligoneura Sprague	*Malvaceae*	1	2	0.178	0.049	1.48	0.10	0.64	0.74
Guarea cedrata (A. Chev.) Pellerg.	*Meliaceae*	1	2	0.277	0.120	1.48	0.24	0.64	0.79
Guibourtia tessmannii (Harms) J. Léonard	*Fabaceae*	1	2	0.286	0.128	1.48	0.25	0.64	0.79
Hannoa klaineana Pierre	*Simaroubaceae*	2	4	0.366	0.421	2.96	0.82	1.28	1.69
Homalium africanum Mast.	*Santalaceae*	1	2	0.416	0.271	1.48	0.53	0.64	0.88
Hua gabonii De Wild.	*Huaceae*	1	2	0.264	0.109	1.48	0.21	0.64	0.78
Hugonia platysepala WelW. ex Oliv.	*Hugoniaceae*	1	2	0.165	0.043	1.48	0.08	0.64	0.74
Khaya anthotheca (Welw.) C. DC.	*Meliaceae*	1	2	0.717	0.807	1.48	1.58	0.64	1.23
Lannea welwitschii (Hiern) Engl.	*Santalaceae*	2	4	0.173	0.094	2.96	0.18	1.28	1.48
Lovoa trichiloides Harms	*Meliaceae*	2	4	0.283	0.252	2.48	0.49	1.28	1.09
Maesobotrya floribunda Benth.	*Euphorbiaceae*	1	2	0.136	0.029	1.48	0.06	0.64	0.73
Mammea africana Sabine	*Clusiaceae*	1	2	0.254	0.102	1.48	0.20	0.64	0.77
Manilkara fouilloyana Aubr. Ex Pellegr.	*Sapotaceae*	1	2	0.214	0.072	1.48	0.14	0.64	0.75
Manilkara koechlinii Aubr.	*Sapotaceae*	1	2	0.242	0.091	1.48	0.18	0.64	0.77
Maranthes chrysophylla (Oliv.) France ex F. While	*Sapotaceae*	2	4	0.120	0.045	2.96	0.09	1.28	1.44
Massularia acuminata (G. Don) Hoyle	*Rubiaceae*	1	2	0.238	0.089	1.48	0.17	0.64	0.77
Memecylon leucocarpum Gilg.	*Melastomataceae*	1	2	0.144	0.032	1.48	0.06	0.64	0.73
Micrococca mercurialis (L.) Benth.	*Euphorbiaceae*	2	4	0.114	0.041	2.96	0.08	1.28	1.44
Milicia excelsa (Welw.) Berg.	*Moraceae*	2	4	0.343	0.370	2.96	0.72	1.28	1.66
Millettia sapinii De Wild.	*Fabaceae*	1	2	0.242	0.091	1.48	0.18	0.64	0.77
Monodora myristica (Gaertn.) Dunal	*Annonaceae*	1	2	0.241	0.091	1.48	0.18	0.64	0.77
Monopetalanthus pteridophyllus Harms	*Fabaceae*	1	2	0.515	0.417	1.48	0.82	0.64	0.98
Nesogordonia kabingensis (K. Schum.) Cap.	*Malvaceae*	1	2	0.394	0.244	1.48	0.48	0.64	0.87
Nesogordonia papaverifera (A. Chev.) Capur.	*Malvaceae*	2	4	0.281	0.247	2.96	0.49	1.28	1.58
Omphalocarpum procerum P. Beauv.	*Sapotaceae*	1	2	0.278	0.121	1.48	0.24	0.64	0.79
Ongokea gore (Hua) Pierre	*Olacaceae*	2	4	0.146	0.067	2.96	0.13	1.28	1.46
Oxyanthus speciosus DC.	*Rubiaceae*	1	2	0.222	0.078	1.48	0.15	0.64	0.76
Panda oleosa Pierre	*Pandaceae*	1	2	0.312	0.152	1.48	0.30	0.64	0.81
Paramacrolobium coeruleum (Taub.) J. Léonard	*Fabaceae*	1	2	0.496	0.387	1.48	0.76	0.64	0.96

Parinari excelsa Sabine	*Chrysobalanaceae*	3	6	0.232	0.254	4.44	0.50	1.92	2.29
Parkia filicoidea Welw. ex Oliv.	*Fabaceae*	1	2	0.213	0.071	1.48	0.14	0.64	0.75
Pausinystalia macrocera (K. Schum.) Pierre ex Dup.	*Rubiaceae*	1	2	0.280	0.123	1.48	0.24	0.64	0.79
Pavetta sp.	*Rubiaceae*	1	2	0.144	0.032	1.48	0.06	0.64	0.73
Penianthus preussii Miers	*Menispermaceae*	1	2	0.159	0.039	1.48	0.08	0.64	0.73
Pentacletra macrophylla Benth.	*Fabaceae*	1	2	0.204	0.065	1.48	0.13	0.64	0.75
Pentadesma butyracea Sabine	*Clusiaceae*	2	4	0.248	0.193	2.96	0.38	1.28	1.54
Pentadesma excelliana Staner	*Clusiaceae*	2	4	0.343	0.369	2.96	0.72	1.28	1.66
Petersianthus macrocarpus (Beauv.) Liben	*Lecytidaceae*	3	6	0.284	0.380	4.44	0.75	1.92	2.37
Piptadeniastrum africanum (Hook.) Brenan	*Fabaceae*	3	6	0.456	0.979	4.44	1.92	1.92	2.76
Plagiostyles africana (Müll.-Arg.) Prain.	*Euphorbiaceae*	2	4	0.206	0.134	2.96	0.26	1.28	1.50
Prioria balsaminfera (Vermoesen) Breteler	*Fabaceae*	4	8	0.326	0.670	5.93	1.31	2.56	3.27
Psydrax arnoldiana (De Wild.) Brid.	*Rubiaceae*	2	4	0.243	0.186	2.96	0.36	1.28	1.54
Pterocarpus mildbraedii Harms	*Fabaceae*	5	10	0.180	0.255	7.41	0.50	3.21	3.70
Pterocarpus soyauxii Taub.	*Fabaceae*	1	2	0.267	0.112	1.48	0.22	0.64	0.78
Pterocarpus tinctorius Welw.	*Fabaceae*	2	4	0.487	0.745	2.96	1.46	1.28	1.90
Pycnanthus angolensis (Welw.) Ekell.	*Myristicaceae*	3	6	0.192	0.173	4.44	0.34	1.92	2.24
Quassia africana (Baill.) Baill.	*Simaroubaceae*	2	4	0.130	0.053	2.96	0.10	1.28	1.45
Ricinerodendron heudelotii (Baill.) Pierre ex Heckel	*Euphorbiaceae*	1	2	0.175	0.048	1.48	0.09	0.64	0.74
Sacoglottis gabonensis (Baill.) Urb.	*Humiriaceae*	2	4	0.426	0.571	2.96	1.12	1.28	1.79
Santiria trimera (Oliv.) Aubr.	*Burceraceae*	1	2	0.114	0.020	1.48	0.04	0.64	0.72
Sarchocephalus diderichii (De Wild.)	*Rubiaceae*	1	2	0.191	0.057	1.48	0.11	0.64	0.74
Sarchocephalus pobenguini (Hua ex Pob.) Merril.	*Rubiaceae*	1	2	0.199	0.062	1.48	0.12	0.64	0.75
Schrebera arborea A. Chev.	*Oleaceae*	1	2	0.235	0.087	1.48	0.17	0.64	0.76
Schumanniophyton magnificum (K. Schum.) Harms	*Rubiaceae*	2	4	0.246	0.190	2.96	0.37	1.28	1.54
Scorodophoeus zenkeri Harms	*Fabaceae*	2	4	0.430	0.583	2.96	1.14	1.28	1.80
Scyphocephalium mannii (Benth. & Hook. f.) Warb.	*Myristicaceae*	1	2	0.200	0.062	1.48	0.12	0.64	0.75
Spondianthus preussi Engl.	*Euphorbiaceae*	1	2	0.197	0.061	1.48	0.12	0.64	0.75
Staudtia kamerunensis Warb.	*Myristicaceae*	4	8	0.204	0.026	5.93	0.51	2.56	3.00
Sterculia tragacantha Lindl.	*Malvaceae*	1	2	0.477	0.358	1.48	0.70	0.64	0.94
Strombosia grandiflora Hook.f.	*Olacaceae*	2	4	0.191	0.057	2.96	0.11	1.28	1.45
Strombosia majuscula Hook. f.	*Olacaceae*	2	4	0.334	0.350	2.96	0.69	1.28	1.64
Synsepalum stipulatum De Wild.	*Sapotaceae*	3	4	0.235	0.173	2.96	0.34	1.92	1.74
Tetrapleura tetraptera (Schum. & Thon.) Taub.	*Fabaceae*	1	2	0.191	0.057	1.48	0.11	0.64	0.74
Treculia africana Decne	*Moraceae*	1	2	0.181	0.051	1.48	0.10	0.64	0.74
Trichalisia crepiniana De Wild. & Th. Dur.	*Rubiaceae*	1	2	0.181	0.051	1.48	0.10	0.64	0.74
Trichilia welwitschii C. DC.	*Meliaceae*	2	4	0.178	0.099	2.96	0.20	1.28	1.48
Trilepisium madagascariense DC.	*Moraceae*	2	4	0.175	0.096	2.96	0.19	1.28	1.48
Uapaca sp.	*Euphorbiaceae*	1	2	0.211	0.070	1.48	0.14	0.64	0.75
Xylopia chrysophylla Louis ex Bout.	*Annonaceae*	1	2	0.121	0.022	1.48	0.04	0.64	0.72
Zanthoxylum leprieuri Guill. & Perr.	*Rutaceae*	1	2	0.168	0.044	1.48	0.09	0.64	0.74

Note: **A** = total number of trunks in transect for each species; **B** = number of trunks/hectares for each species, or a × 2; **C** = average dbh (m); **D** = basal area (m^2); **E** = relative density (%); **F** = relative dominance (%); **G** = relative frequency (%); **H** = relative importance (%).

Basal area

The basal area values of trunk sections at dbh ≥10 cm, calculated over a total surface of 1 ha are 49.89 m^2. The most important basal area values were obtained from the following woody species: *Brachystegia laurentii* Louis ex Hoyle (13.739 m^2), *Baillonella toxisperma* Pierre (1.803 m^2), *Bosqueiopsis gilletii* De Wild. & Th. (1.801 m^2), *Detarium macrocarpum* Harms (1.599 m^2), *Autranella congolensis* (De Wild.) A. Chev. (1.156 m^2) and *Aphanocalyx margininervatus* J.Leonard (1.007 m^2). The lowest basal area values were observed in five plant species amongst which are *Cola diversifolia* De Wild., *Staudtia kamerunensis* Warb. and *Xylopia chrysophylla* Louis ex Bout 0.019, 0.026 and 0.022 $m^2.ha^{-1}$ (Table 1). Altogether, the basal area of the upper structural unit is of 26.37 $m^2.ha^{-1}$ while that of the low and medium structural units is of 23.46 $m^2.ha^{-1}$.

The density of taxa

The density of woody species in the Nzundu forest massif is of 422 feet per ha. This set is distributed in 366 stems.ha^{-1} for species with dbh ≤49.9 cm and 56 trees for species with dbh ≥50 cm (including 5 to dbh >70 cm). The highest relative density values were obtained from the following species: *Brachystegia laurentii* Louis ex Hoyle (11.85%), *Pterocarpus mildbraedii* Harms (7.41%) and *Prioria balsaminfera* (Vermoesen) Breteler (5.93%). Seven other species have moderately high relative density values.

Emergent trees at dbh >70 cm, the most numerous are *Brachystegia laurentii* Louis ex Hoyle (16 trunk.ha^{-1}), *Pterocarpus mildbraedii* Harms (10 trunk.ha^{-1}), *Prioria balsaminfera* (Vermoesen) Breteler and *Staudtia kamerunensis* Warb. having 8 trunk.ha^{-1} each. The following families have a large number of stems/ha: *Fabaceae* (110 trunk.ha^{-1}), *Malvaceae* (34 trunk.ha^{-1}), *Rubiaceae* and *Sapotaceae* each with 28 trunk.ha^{-1}, *Meliaceae Clusiaceae* and *Euphorbiaceae* with 20 trunk.ha^{-1} each, *Myristicaceae* (18 trunk.ha^{-1}), *Annonaceae* and *Ulmaceae* with 14 trunk.ha^{-1} each (Table 1).

Relative dominance

The highest values obtained with respect to relative dominance for dbh ≥10 cm species measured at 1.30 m were observed in four species, *Brachystegia laurentii* Louis ex Hoyle (26.90%), *Baillonella toxisperma* Stone (3.53%), *Bosqueiopsis gilletii* De Wild. & Th. (3.53%), *Detarium macrocarpum* Harms (3.13%) and *Autranella congolensis* (De Wild.) A. Chev. (2.27%) (Table 1).

Relative frequency

As for the relative frequency calculated for species with dbh ≥10 cm, the most important values obtained are for the following species: *Brachystegia laurentii* Louis ex Hoyle (5.13%), *Prioria balsaminfera* (Vermoesen) Breteler (2.56%), *Pterocarpus mildbraedii* Harms (3.21%) and *Staudtia kamerunensis* Warb. (2.56%) (Table 1).

Relative importance

The highest values of relative importance, calculated for dbh ≥10 cm, were observed in four species (*Brachystegia laurentii* Louis ex Hoyle - 14.63%, *Pterocarpus mildbraedii* Harms - 3.70%, *Prioria balsaminfera* (Vermoesen) Breteler - 3.27% and *Staudtia kamerunensis* Warb. – 3.00%) and the lowest in one species (*Copaifera mildbraedii* Harms with 0.55%).

Distribution of the frequencies of different classes of diameters and the trend of the basal area

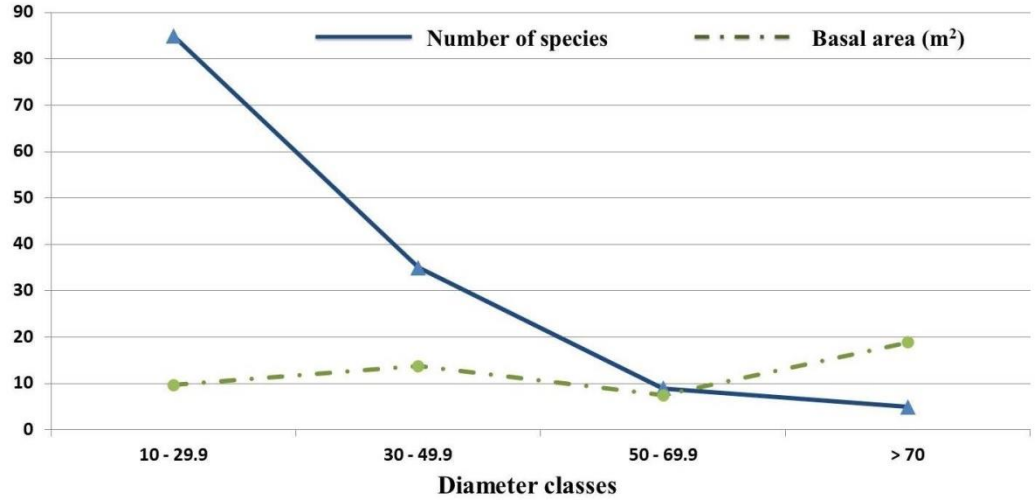

Figure 2. Shows the trunk distribution by diameter classes and the basal area values obtained for each class.

The considered diameter classes (grouped from table 1), collect the values in dbh groups of 20 cm intervals, *i.e.* 10–29.9 cm; 30–49.9 cm; 50–69.9 cm; >70 cm. Fig. 2 shows that the curve of the species obtained has a hyperbolic appearance with a decrease in the number of trunks for the high dbh classes. The curve representing the trend of the basal area as a function of the diameter classes has a curvilinear shape. It is observed that the highest values of this basal area were obtained in the emergent and the smallest in the dbh range between 10 and 29.9 cm.

Ecological spectra

Table 2. Ecological spectra, phytogeographical types and phytosociological status of listed species.

Plant species	Family	LF	PhgD	DTD	TFD	PhSt
Allophylus africanus P. Beauv.	*Sapindaceae*	MsPh	At	Sar	Me	H
Amphimas pterocapoides Harms	*Fabaceae*	MgPh	GC	Bal	Me	SP
Angylocalyx pynaertii De Wild.	*Fabaceae*	MsPh	GC	Bal	Me	SP
Anisophyllea polynera Floret	*Rhizophoraceae*	MsPh	CG	Sar	Me	SP
Anonidium mannii (Oliv.) Engl. & Diels	*Annonaceae*	MsPh	CG	Sar	Me	SP
Anthonotha fragrans (Bak.f) Exell et Hill.	*Fabaceae*	MsPh	CG	Bal	Me	SP
Anthrocaryon klaineana Pierre	*Anacardiaceae*	MgPh	CG	Sar	Me	SP
Antiaris toxicaria Lesch.	*Moraceae*	MgPh	GC	Sar	Me	MT
Antidesma sp.	*Euphorbiaceae*	MsPh	-	Sar	Me	SP
Antidesma vogelianum Müll.-Arg.	*Euphorbiaceae*	MsPh	At	Sar	Me	SP
Aphanocalyx margininervatus J.Leonard	*Fabaceae*	MsPh	CG	Bal	Me	SP
Autranella congolensis (De Wild.) A. Chev.	*Sapotaceae*	MsPh	At	Sar	Me	SP
Baillonella toxisperma Pierre	*Meliaceae*	MgPh	CG	Sar	Me	SP
Berlinia grandiflora (Vahl.) Mikh. et Dalz.	*Fabaceae*	MsPh	GC	Bal	Me	SP
Blighia unijugata Bak.	*Sapindaceae*	MsPh	At	Sar	Me	SP
Blighia welwitschii (Hiern) Radlk.	*Sapindaceae*	MgPh	GC	Sar	Me	SP
Bosqueiopsis gilletii De Wild. & Th. Dur.	*Moraceae*	MsPh	GC	Sar	Me	SP
Brachystegia laurentii Louis ex Hoyle	*Fabaceae*	MgPh	CG	Bal	Me	SP
Canarium schweinfurthii Engl.	*Burseraceae*	MgPh	GC	Sar	Me	SP
Carapa grandiflora Sprague	*Meliaceae*	MgPh	GC	Sar	Me	SP
Carapa procera DC. var. *procera* DC.	*Meliaceae*	MsPh	FC	Sar	Me	SP
Celtis adolfi-friderici Engl.	*Ulmaceae*	MsPh	GC	Sar	Mi	SP
Celtis durandii Engl.	*Ulmaceae*	MsPh	GC	Sar	Mi	SP
Celtis mildbraedii Engl.	*Ulmaceae*	MgPh	GC	Sar	Mi	SP
Celtis zenkeri Engl.	*Ulmaceae*	MsPh	CG	Sar	Mi	SP
Chrysophyllum lacourtianum De Wild.	*Sapotaceae*	MgPh	CG	Sar	Me	SP
Coelocaryon botryoides Verm.	*Myristicaceae*	MsPh	FC	Sar	Me	SP
Cola chlamydantha K.Schum.	*Malvaceae*	MsPh	CG	Sar	Me	SP
Cola diversifolia De Wild.	*Malvaceae*	MsPh	FC	Sar	Me	SP
Cola gigantea A. Chev.	*Malvaceae*	MsPh	CG	Pté	Me	SP
Cola lateritia K. Schum.	*Malvaceae*	MsPh	CG	Sar	Me	SP
Cola urceolata K. Schum.	*Malvaceae*	MsPh	CG	Sar	Me	SP
Copaifera mildbraedii Harms	*Fabaceae*	MgPh	CG	Bal	Me	SP
Corynanthe pachycera K. Schum.	*Rubiaceae*	MsPh	GC	Sar	Me	SP
Crudia gabonensis Pierre ex Harms	*Fabaceae*	MsPh	CG	Bal	Me	SP
Cynometra hankei Harms	*Fabaceae*	MgPh	GC	Bal	Me	SP
Daniellia pynaertii De Wild.	*Fabaceae*	MgPh	GC	Bal	Me	SP
Desplatsia chrysochlamys (Mildbr. & Bur,) Mildbr.	*Malvaceae*	MsPh	GC	Sar	Me	MT
Detarium macrocarpum Harms	*Fabaceae*	MgPh	CG	Sar	Me	SP
Dialium corbisieri Harms	*Fabaceae*	MsPh	FC	Sar	Me	SP

Dialium pachyphyllum Harms	*Fabaceae*	MgPh	CG	Sar	Me	SP
Dialium pentandrum Louis ex Stey.	*Fabaceae*	MsPh	FC	Sar	Me	SP
Dialium tessmannii Harms	*Fabaceae*	MsPh	CG	Sar	Me	SP
Dichostemma glauscens Pierre	*Euphorbiaceae*	MsPh	CG	Sar	Me	SP
Diospyros canaliculata De Wild.	*Ebenaceae*	McPh	At	Sar	Me	SP
Duboscia viridiflora (K. Schum.) Mildbr.	*Malvaceae*	MsPh	CG	Sar	Me	SP
Enantia chloranta Oliv.	*Annonaceae*	MsPh	GC	Sar	Me	SP
Entandrophragma angolense (Welw.) C. DC.	*Meliaceae*	MgPh	GC	Pté	Me	SP
Entandrophragma utile Sprague	*Meliaceae*	MgPh	GC	Pté	Me	SP
Erismadelphus exsul Mildb.	*Vochysiaceae*	MgPh	CG	Sar	Me	SP
Erythrophleum suaveolens (Guill. & Perrot) Brenan	*Fabaceae*	MgPh	GC	Bal	Me	SP
Fernandoaa dolfi-frederici (Gilg & Mildbr.) Heine	*Bignoniaceae*	MsPh	CG	Pté	Me	SP
Ficus lutea Vahl	*Moraceae*	MsPh	At	Sar	Me	MT
Ficus sur Welw. ex Ficalho	*Moraceae*	MsPh	At	Sar	Me	MT
Ficus thonningii Blume	*Moraceae*	MsPh	At	Sar	Me	MT
Filaeopsis discophora Harms	*Fabaceae*	MgPh	GC	Bal	Me	MT
Funtumia elastica (Preuss) Stapf	*Apocynaceae*	MsPh	GC	Scl	Me	MT
Gaertnera parvipaniculata Petit	*Rubiaceae*	MsPh	CG	Sar	Me	SP
Ganophyllum giganteum (A. Chev.) Hauman	*Sapindaceae*	MgPh	CG	Sar	Me	SP
Garcinia epunctata Stapf	*Clusiaceae*	MgPh	GC	Sar	Me	SP
Garcinia kola Heckel	*Clusiaceae*	MgPh	GC	Sar	Me	SP
Garcinia punctata Stapf	*Clusiaceae*	MgPh	GC	Sar	Me	SP
Gilbertiodendron dewevrei (De Wild.) J. Léonard	*Fabaceae*	MgPh	GC	Bal	Me	SP
Greenwayadendron suaveolens 'Engl. & Diels) Verdc.	*Annonaceae*	MsPh	GC	Sar	Me	SP
Grewia oligoneura Sprague	*Malvaceae*	MsPh	CG	Sar	Me	SP
Guarea cedrata (A. Chev.) Pellerg.	*Meliaceae*	MgPh	GC	Sar	Me	SP
Guibourtia tessmannii (Harms) J. Léonard	*Fabaceae*	MgPh	CG	Bal	Me	SP
Hannoa klaineana Pierre	*Simaroubaceae*	MgPh	GC	Sar	Me	SP
Homalium africanum Mast.	*Flacoutiaceae*	MsPh	GC	Sar	Me	MT
Hua gabonii De Wild.	*Huaceae*	MsPh	FC	Sar	Me	MT
Hugonia platysepala WelW. ex Oliv.	*Menispermaceae*	MsPh	GC	Sar	Me	MT
Khaya anthotheca (Welw.) C. DC.	*Meliaceae*	MgPh	GC	Bal	Me	SP
Lannea welwitschii (Hiern) Engl.	*Santalaceae*	MsPh	GC	Sar	Me	H
Lovoa trichiloides Harms	*Meliaceae*	MgPh	GC	Scl	Me	SP
Maesobotrya floribunda Benth.	*Euphorbiaceae*	McPh	FC	Sar	Me	SP
Mammea africana Sabine	*Clusiaceae*	MgPh	GC	Sar	Me	SP
Manilkara fouilloyana Aubr. Ex Pellegr.	*Sapotaceae*	MgPh	CG	Sar	Me	SP
Manilkara koechlinii Aubr.	*Sapotaceae*	MgPh	FC	Sar	Me	SP
Maranthes chrysophylla (Oliv.) France ex F. While	*Sapotaceae*	MsPh	CG	Sar	Me	SP
Massularia acuminata (G. Don) Hoyle	*Rubiaceae*	McPh	GC	Sar	Me	SP
Memecylon leucocarpum Gilg.	*Melastomataceae*	McPh	FC	Sar	Mi	SP
Micrococca mercurialis (L.) Benth.	*Euphorbiaceae*	McPh	GC	Sar	Me	MT
Milicia excelsa (Welw.) Berg.	*Moraceae*	MgPh	GC	Sar	Me	MT
Millettia sapinii De Wild.	*Fabaceae*	McPh	FC	Bal	Me	SP
Monodora myristica (Gaertn.) Dunal	*Annonaceae*	MsPh	CG	Sar	Me	SP
Monopetalanthus pteridophyllus Harms	*Fabaceae*	MgPh	FC	Bal	Me	SP
Nesogordonia kabingensis (K. Schum.) Cap.	*Malvaceae*	MsPh	GC	Pté	Me	SP
Nesogordonia papaverifera (A. Chev.) Capur.	*Malvaceae*	MsPh	GC	Pté	Me	SP
Omphalocarpum procerum P. Beauv.	*Sapotaceae*	MgPh	GC	Sar	Me	SP

Ongokea gore (Hua) Pierre	*Olacaceae*	MgPh	GC	Sar	Me	SP
Oxyanthus speciosus DC.	*Rubiaceae*	McPh	At	Sar	Me	SP
Panda oleosa Pierre	*Pandaceae*	MgPh	GC	Sar	Me	SP
Paramacrolobium coeruleum (Taub.) J. Léonard	*Fabaceae*	MsPh	At	Bal	Me	MT
Parinari excelsa Sabine	*Chrysobalanaceae*	MgPh	GC	Sar	Me	SP
Parkia filicoidea Welw. ex Oliv.	*Fabaceae*	MsPh	At	Sar	Me	SP
Pausinystalia macrocera (K. Schum.) Pierre ex Dup.	*Rubiaceae*	MsPh	GC	Sar	Me	SP
Pavetta sp.	*Rubiaceae*	McPh	-	Sar	Me	SP
Penianthus preussii Miers	*Menispermaceae*	NnPh	GC	Sar	Me	MT
Pentacletra macrophylla Benth.	*Fabaceae*	MsPh	GC	Bal	Me	MT
Pentadesma butyracea Sabine	*Clusiaceae*	MsPh	GC	Sar	Me	SP
Pentadesma excelliana Staner	*Clusiaceae*	MsPh	GC	Sar	Me	SP
Petersianthus macrocarpus (Beauv.) Liben	*Lecytidaceae*	MgPh	GC	Pté	Me	MT
Piptadeniastrum africanum (Hook.) Brenan	*Fabaceae*	MgPh	GC	Bal	Me	SP
Plagiostyles africana (Müll.-Arg.) Prain.	*Euphorbiaceae*	MsPh	CG	Sar	Me	SP
Prioria balsaminfera (Vermoesen) Breteler	*Fabaceae*	MgPh	CG	Bal	Me	SP
Psydrax arnoldiana (De Wild.) Brid.	*Rubiaceae*	MgPh	CG	Sar	Me	SP
Pterocarpus mildbraedii Harms	*Fabaceae*	MgPh	GC	Pté	Me	SP
Pterocarpus soyauxii Taub.	*Fabaceae*	MgPh	GC	Pté	Me	SP
Pterocarpus tinctorius Welw.	*Fabaceae*	MgPh	At	Pté	Me	SP
Pycnanthus angolensis (Welw.) Ekell.	*Myristicaceae*	MsPh	GC	Pté	Me	MT
Quassia africana (Baill.) Baill.	*Simaroubaceae*	McPh	GC	Sar	Me	SP
Ricinerodendron heudelotii (Baill.) Pierre ex Heckel	*Euphorbiaceae*	MgPh	GC	Sar	Me	MT
Sacoglottis gabonensis (Baill.) Urb.	*Humiriaceae*	MsPh	GC	Sar	Me	SP
Santiria trimera (Oliv.) Aubr.	*Burseraceae*	MsPh	GC	Sar	Me	SP
Sarchocephalus diderichii (De Wild.)	*Rubiaceae*	MgPh	GC	Sar	Me	SP
Sarchocephalus pobenguini (Hua ex Pob.) Merril.	*Rubiaceae*	MsPh	GC	Sar	Me	H
Schrebera arborea A. Chev.	*Oleaceae*	MsPh	GC	Pté	Me	SP
Schumanniophyton magnificum (K. Schum.) Harms	*Rubiaceae*	MsPh	GC	Sar	Ma	SP
Scorodophoeus zenkeri Harms	*Fabaceae*	MgPh	CG	Bal	Me	SP
Scyphocephalium mannii (Benth. & Hook. f.) Warb.	*Myristicaceae*	MsPh	GC	Sar	Me	SP
Spondianthus preussi Engl.	*Anacardiaceae*	MsPh	CG	Pté	Me	SP
Staudtia kamerunensis Warb.	*Myristicaceae*	MsPh	CG	Sar	Me	SP
Sterculia tragacantha Lindl.	*Myristicaceae*	MsPh	CG	Pté	Me	SP
Strombosia grandiflora Hook.f.	*Olacaceae*	MsPh	GC	Sar	Mi	SP
Strombosia majuscula Hook. f.	*Olacaceae*	MsPh	GC	Sar	Me	SP
Synsepalum stipulatum De Wild.	*Sapotaceae*	MsPh	GC	Sar	Me	SP
Tetrapleura tetraptera (Schum. & Thon.) Taub.	*Fabaceae*	MsPh	GC	Bal	Me	MT
Treculia africana Decne	*Moraceae*	MsPh	At	Sar	Me	MT
Trichalisia crepiniana De Wild. & Th. Dur.	*Rubiaceae*	MsPh	CG	Sar	Me	SP
Trichilia welwitschii C. DC.	*Meliaceae*	MsPh	CG	Scl	Me	SP
Trilepisium madagascariense DC.	*Moraceae*	MsPh	GC	Sar	Me	MT
Uapaca sp.	*Euphorbiaceae*	MsPh	-	Sar	Me	H
Xylopia chrysophylla Louis ex Bout.	*Annonaceae*	MsPh	CG	Sar	Me	SP
Zanthoxylum leprieuri Guill. & Perr.	*Rutaceae*	MsPh	GC	Sar	Me	SP

Note: LF = Life forms (McPh = Microphanerophytes; MgPh = megaphanerophytes; MsPh = mesophanerophytes; NnPh = nanophanerophytes); **PhgD** = Phytogeographical distributions (At = Afro-tropical; CG = Congolian-Guineo; FC = foreign-Congolian; GC = Guineo-Congolian); **DTD** = Dissemination types of diaspores (Bal = Ballochores; Pté = Pterochores; Sar = sarcochors; Scl = Sclerochores); **TFD** = Types of foliar dimensions (Me = Mesophyl; Mi = Microphyl) and **PhSt** = Phytosociological status (H = *Halleeteae*; MT = *Musango-Terminalietea*; SP = *Strombosio-Parinarietea*).

The analysis of life forms shows the predominance of mesophanerophytes (MsPh) species (56%); followed by megaphanerophytes (MgPh) species (36.6%) but Microphanerophytes (McPh) and nanophanerophytes (NnPh) are poorly represented as 6.7% and 0.7% respectively. With regard to the dissemination of diaspores, sarcochors (Sar) form the most abundant group (70.1%); then come next H and far behind this group, Ballochores (Bal) and Pterochores (Pte) with 17.2 and 10.4% respectively of the total. Sclerochores (Scl) are very poorly represented (2.2%). As for the types of the foliar dimensions, the mesophyl (Me) species predominate and constitute ~94% of the total of the inventoried plants. On the other hand, microphyl (Mi) species are very poorly represented (~5%) (Table 2). The Shannon index (ISH) calculated for all the 134 species listed is of 4.77 and the Equitability is of 0.97 (Table 3).

Table 3. Biodiversity index values.

Indices	Values
Regularity (H+)	4.77
Maximum diversity (Hmax)	4.90
Equitability (J)	0.97

Types of phytogeographical distribution

The Guinean base element (GC, CG and FC) is the most abundant; it accounts 90.1% of the total of species listed. In this basic element, Guineo-Congolian (GC) species are the most numerous (51.9%) followed by CG (29.8%) and FC (8.4%). Afro-tropical (At) species are relatively well represented (9.9%). This shows the sign of degradation of this forest massif. Three taxa could not be determined to the species (Table 2).

Eco-sociological groups

Three eco-sociological groups have been identified. Among them, the species of *Strombosio-Parinarietea* (SP) are the most abundant. They make up 81.3% of all the species listed in the Nzundu forest bulb. The species belonging to *Musango-Terminalietea* (MT) are relatively well represented (15.7%). Their significant presence already demonstrates sufficiently the state of degradation that currently characterizes this forest. Those of *Halleeteae* (H) are very weakly represented (3%) (Table 2).

DISCUSSION

The Nzundu forest massif is part of the Guinean and Peri-guinian semi-deciduous tropical rainforests. It differs from that of Kamaba (Masens 2015) by the high frequency of *Brachystegia laurentii* and the total absence of certain noble species like *Millettia laurentii* However, these two forest massifs share a number of plant species: *Celtis mildbraedii*, *Piptadeniastrum africanum*, *Prioria balsamifera*, *Pterocarpus mildbraedii* etc. Unlike the Kamaba forest which gathered 155 different plant species while the Nzundu forest massif has only 134 species. The 134 species are divided into 31 families and 109 genera. *Fabaceae* (25 genera), *Rubiaceae* (10 genera), *Euphorbiaceae* (8 genera), *Sapotaceae* (7 genera), *Annonaceae*, *Malvaceae*, *Meliaceae* and *Moraceae* with 6 genera each. The most supplied genera in species are: *Cola* (5 species), *Celtis* and *Dialium* with each 4 species and 4 genera each have 3 species. These include *Ficus*, *Garcinia*, *Pentadesma* and *Pterocarpus*. Compared to what was observed in some forests studied in the tropics; these results are in the same order of magnitude as those obtained in these various plant formations (Bosanza *et al.* 2017). Species of Kamaba phytocenosis have a high proportion of trees with dbh measured at 1.30 m at breast height >30 cm. Thus, it presents a curve with concavity facing downwards and the shape of this curve would undoubtedly explain a rather remarkable presence of heliophilous species (Rollet 1969), while those of the Nzundu forest massif show a large proportion of large trees at dbh ≥50 cm. Their distribution follows a curve of which concavity is oriented upwards. According to the same authors, this demonstrates the presence of a large number of shade species. Therefore, it is possible to paraphrase some authors (Lomba *et al.* 2017) that the dbh of Nzundu phytocenosis trees, measured at 1.30 m, increases with the evolution of vegetation. Among the families listed in this forest massif, we have *Fabaceae*, *Malvaceae*, *Rubiaceae*, *Euphorbiaceae*, *Meliaceae*, *Moraceae*, *Sapotaceae*, *Annonaceae* and *Clusiaceae* which are the most supplied in plant species (Table 2). Apart from *Myristicaceae* family, these results are similar to those obtained by Masens (2015) in the Kamaba forest massif in the lower Kasaï vegetation in the Democratic Republic of the Congo (Belesi 2009). According to Kambale *et al.* (2017), the basal area is a parameter commonly used to distinguish plant formations from the mainland. The basal area values of the trunks measured at 1.30 m in Nzundu phytocenosis was significantly higher (49.89 $m^2.ha^{-1}$) than in

the Kamaba forest (20.0 $m^2.ha^{-1}$). This very significant difference could be explained by the high proportion of trees with large trunks characterizing the Nzundu forest.

The basal area value obtained in this phytocenosis ranges from 23 to 50 $m^2.ha^{-1}$. It is clear that the basal area values obtained in different equatorial and subequatorial forests are included in this interval (Mosango 1990). Moreover, this value is relatively less than the tropical forests of Panama (59.6 $m^2.ha^{-1}$) as observed by Golley *et al.* (1969), India (59.6 $m^2.ha^{-1}$) as observed by Bajpai *et al.* (2012) and slightly higher than the one obtained by Mosango (1990) in the evergreen rainforest (Kongolo island/Kisangani).

For biological spectra, chorological types and phytogeographic status, mesophanerophytic and megaphanerophytic species predominate (92.4%). The sarcochorous and mesophyl species are the most abundant, with 70.1 and 94.8% respectively; the Guinean base element being the most predominant, accounting for ~90% of all inventoried species. All these results are in the same order of magnitude as those obtained in various tropical and intertropical forests as described in previous studies (Lejoly 1995, Belesi 2009, Masens 2015, Shaumba *et al.* 2017, Lomba *et al.* 2017).Concerning the relative frequency, *Brachystegia laurentii* reaches 5.1% followed by three other species: *Pterocarpus mildbraedii* (3.2%), *Prioria balsamifera* and *Staudtia kamerunensis* with 2.5% each.

As for relative dominance, *Brachystegia laurentii* is the most important (26.9%). *Baillonella toxisperma* and *Bosqueiopsis gilletii* had a relative dominance of more than 3%. It is again the species *Brachystegia laurentii* which reaches a value of the highest relative importance (14.6%), followed by three other species: *Pterocarpus mildbraedii*, *Prioria balsamifera* and *Staudtia kamerunensis* gave values above 3% (Table 1). These results go along with those obtained in the Ngoto forest (Lejoly 1995). It is clear that *Brachystegia laurentii* is the only species that has exhibited large proportions of the values of different parameters considered in this study, contrary to what was observed in the Kamaba forest massif (Masens 2015).

Finally, the high values of Shannon and Equitability indices can mean either a high specific richness due to a high presence of rare species (species having only one individual) or diversity due to a regular distribution of individuals between species or a high number of individuals in the observed distribution. The value of the calculated Shannon index is 4.77. This value approximates the maximum diversity (4.90), which means that diversity is important. That of Equitability is 0.97, which reflects the regularity in terms of the distribution of individuals within the species. These values are in the same order of magnitude as those found by Sokpon (1995) in the *Strombosia glauscens* and *Triplochiton scleroxylon* and *Dialium guineense* and *Triplochiton scleroxylum* forests in Benin.

CONCLUSION

The study on the floristic inventory and some ecological parameters carried out in Nzundu forest massif showed that this phytocenosis presents a moderately appreciable specific richness (134 species). The regressive evolution observed within this phytocenosis is triggered with extreme rapidity by the slaughter and the reckless clearing of trees more or less isolated and/or grouped and this by severe depredations, which are currently inflicted on them. Even if these degradable practices had always existed in the past, they had never, according to villagers surveyed, reached such a degree of acuity due to the high concentration of the population around this forest massif. Considering woody species, species with dbh $\leq$ 49.9 cm showed a high specific richness compared to trees with dbh $\geq$ 50 cm. The diameter distribution of species in this forest ecosystem is of the hyperbolic type and having high basal area (49.89 $m^2.ha^{-1}$), located at the extreme top of the range of 23–50 $m^2.ha^{-1}$ established for Equatorial forests. This basal area was 23.46 $m^2.ha^{-1}$ for trees at dbh $\leq$ 49.9 cm and 26.37 $m^2.ha^{-1}$ for emerging species at dbh $\leq$ 50 cm. In view of this basal area value, we can ascertain that Nzundu phytocenosis was in the recent past a mature and reworked forest. Currently this forest is under unprecedented pressure because of its proximity to the urban-rural city of Kikwit. The population of this city and its surroundings, composed of 2/3 of the farmers and charcoal burners, has largely destroyed this forest leaving only a few hundred hectares of m^2.

The density of species measured at 1.30 m was of 422 trunks.ha^{-1}, divided into 366 trunks.ha^{-1} for trees at dbh $\leq$ 49.9 cm and 56 trunks.ha^{-1} for dbh $\geq$ 50 cm. *Fabaceae*, *Malvaceae*, *Rubiaceae* and *Euphorbiaceae* were the syntaxa accounting for the largest number of species and in addition to these families, *Sapotaceae*, *Meliaceae*, *Moraceae* and *Clusiaceae*, collected a large number of trunks.ha^{-1}. The calculated Shannon and Equitability indices for this phytocenosis oscillated around 4.77 for the first and 0.97 for the second.

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