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# Floristic Diversity, Composition and Structure of Communal Forests in Cameroon: Case of the Ngomedzap Communal Forest

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**Abstract** **Original Research Article**

Faced with threats to its flora potential, the Cameroonian government's interest in ecologically and economically sustainable management of communal forests is growing. The aim of this study is to analyse the flora diversity, composition and structure of the Ngomedzap communal forest. The methodological approach combines the inventory of woody plants in 25 m x 25 m plots set up in different types of land use. The inventories identified 187 woody species, distributed among 147 genera and 51 families. A floristic similarity was noted between the two types of agroforests, with a coefficient of 54.62 %, and between the two types of forests, with a coefficient of 66.13 %. The values of the Fischer index show that the agroforests are very homogeneous, with coefficients of 13.75 for agroforests with young cacao trees and 9.58 for agroforests with old cacao trees. In contrast to forests, which are highly heterogeneous with values of 48.88 for mature secondary forests and 49.03 for FSJ. Furthermore, the values of the Shannon index show that agroforests are less diverse, with values of 1.19 and 1.24 compared to 4.24 and 4.33 in forests. The study of geographical distribution reveals the dominance of Guineo-Congolian species, with 108 species (57.75% of the total identified species). The overall importance value index shows that the most important species are *Pycnanthus angolensis* (13.47%), *Coelocaryon preusii* (11.47 %) and *Milicia excelsa* (11.15 %). The dominant families are Malvaceae (56.68%), Fabaceae (28.07 %), and Myristicaceae (21.39 %). These results demonstrate the growing importance of agroforests, which are an adaptation strategy and a means of combating climate change. Among the studied flora, 135 species are classified as Least Concern; 29 species are Not Evaluated; 8 species are Near Threatened; 11 species are Vulnerables 2 species are Critically Endangered**:** *Afraegle asso* and *Guibourtia tessmannii*.

**Keywords**: Floristic Diversity, Dynamics, Carbon Stock, Communal Forest, Ngomedzap.



## INTRODUCTION

Cameroon's forests constitute the third-largest forest massif in the Congo Basin, after Gabon and the Democratic Republic of the Congo (DRC). Covering 22.5 million hectares (46% of the national territory), these forests harbour remarkable floral diversity (over 8,000 plant species across 220 families and 1,800 genera) and fauna. They provide nearly eight million impoverished rural Cameroonians with vital nutritional supplements, traditional medicines, domestic energy, and construction materials [1].

Since the 1992 Earth Summit in Rio de Janeiro, all Congo Basin countries have revised their forestry legislation to align with sustainable forest management requirements. Consequently, Cameroon underwent significant reorganisation of its forestry sector, marked by the adoption of a new forestry code and a zoning plan by the Ministry of Environment and Forests. This zoning divides national forests into two categories: the *Permanent Forest Estate* (PFE), comprising state and communal forests, and the *Non-Permanent Forest Estate* (NPFE), designated for non-forest land uses. The PFE forests are themselves subdivided [2].

Cameroon's communal forests occupy approximately 2,330,062 hectares [3]. Under Cameroonian law, a communal forest is a demarcated forest belonging to a municipality, with defined boundaries and a management plan that respects indigenous communities' rights to access forest resources [4]. Municipalities must develop management plans approved by the Ministry of Forestry and Wildlife (MINFOF), and all activities within these forests must comply with the approved plan. However, legislation recognising customary rights to forest resources has inadvertently contributed to vegetation degradation in communal forests [5]. These anthropogenic pressures exacerbate environmental degradation, accelerating climate change [6, 7]. Yet, properly managed, these ecosystems serve as critical carbon sinks [8].

In Cameroon, the Ngomedzap Communal Forest (NCF), spanning 13,820.22 hectares, is a refuge for flora and fauna. It hosts ecosystems rich in endemic species. As a vital carbon sink, it mitigates $CO_2$ emissions while supporting local livelihoods through socio-economic services. Its soils and vegetation regulate water cycles, essential for regional agriculture. However, ecological integrity is threatened by intensifying anthropogenic practices, with poorly documented impacts on flora, vegetation dynamics, and carbon stocks. These include: Shifting cultivation (practised by 80% of households), driving forest fragmentation and biodiversity loss; Selective logging of timber species (e.g., *Entandrophragma* spp.), degrading mature stands; Agroforestry and staple crop expansion (maize, cassava, plantain), encroaching on fallow and mature forest, limiting natural regeneration. Though economically vital, these activities risk undermining ecosystem resilience and essential ecosystem services [9, 10]. Previous floristic studies in Cameroon's communal forests have not addressed Ngomedzap's critical gaps: integrated assessments of floristic diversity, carbon stocks, and land-use impacts (primary forest, fallows, agroforestry, croplands) [11, 12].

This study addresses these knowledge gaps, informing ecosystem-based management policies that prioritise primary forest conservation and sustainable agroforestry as pillars of socio-ecological resilience. The central research question is: what relationship exists between floristic diversity and vegetation dynamics in the Ngomedzap Communal Forest, and how can this guide sustainable management?

The aim of this study was to analyse the floristic diversity, and vegetation dynamics of the Ngomedzap communal forest. More specifically, it involved: assess floristic diversity across NCF land-use types; valuate vegetation structure and **e**stimate correlation beetween biodiversity and Carbone stocks.

## MATERIAL AND METHODS

### *Study Area*

The study was conducted in Ngomedzap Municipality (Nyong et So'o Department, Centre Region, Cameroon), established by Decree No. 230 of 7 june 1955. It lies between 3°26'43"–3°17'29.42"N and 11°14'15"–11°8'41"E (Figure 1), bordered by Akono (north), Biwong Bane (southwest), Mvengue (west), Nkoulmekong/Mengueme (south), and Mengueme (east). The 605 km² municipality comprises 53 third-degree and 4 second-degree traditional chiefdoms. The Commune of Ngomedzap has an equatorial climate with four unevenly distributed seasons: a long dry season from November to mid-March; a short rainy season from mid-March to mid-June; a short dry season from mid-June to mid-August and a long rainy season from mid-August to mid-November. The annual rainfall is 1.200 mm per year. The average temperature in Ngomedzap is 24.7°C. Minimum temperatures range between 19.5°C (December) and 21°C (March), while maximum temperatures vary from 27.1°C (july) to 32.7°C (february). The vegetation of the Commune of Ngomedzap is characterised by a forest rich in marketable timber species and Non-Timber Forest Products (NTFPs). It is composed of four main layers: an upper tree layer, marked by the presence of tall trees and liana species; a middle tree layer, featuring medium-sized trees and liana species; a shrub layer, dominated by shrubs and an herbaceous layer, consisting of a grassy ground cover [13]. The flora is highly diverse.

### Assessment of Woody Diversity in the Ngomedzap Communal Forest

Floristic diversity was evaluated to determine the availability and representativeness of plant species in the study area. This was achieved through an inventory across distinct vegetation formations.

### Data Collection

The sampling protocol followed methods established by prior studies [14, 15]. A total of 26 plots (625 m² each; total 1.625 ha) were surveyed across pre-identified vegetation types, delineated using satellite imagery. Dendrometric measurements targeted all individuals with a Diameter at Breast Height (DBH = 1.30 m above ground) ≥ 10 cm (Figure 2a). For trees with deformities (buttresses/stilt roots), measurements were taken 30 cm above the anomaly. Smaller individuals (DBH < 10 cm) were inventoried in nested 5 m × 5 m subplots at the northwest and southeast corners of each main plot (Figure 2b). Plot allocation was stratified by vegetation type: mature secondary forest (ASFS); young secondary forest (YSFS); old cocoa-based agroforestry systems (≥30 years; SAF) and young cocoa-based agroforestry systems (YCAFS(15–30 years).

Initial field identifications were verified at the National Herbarium of Cameroon (YA) by comparing specimens with reference collections. Consulted resources included: regional floras (*Flore d'Afrique Centrale*, *Flore du Gabon*, *Flore du Cameroun*); illustrated manuals (e.g., *Flora of West Tropical Africa*: Hutchinson & [15]; *La Forêt Dense d'Afrique Centrale*: [16]. *Trees of Nigeria*: [17]). Taxonomic nomenclature follows APG IV (2016), cross-referenced with Lebrun & Stork's (1991–2015) updated database. Ecological traits and phytogeographic distributions were derived from literature.

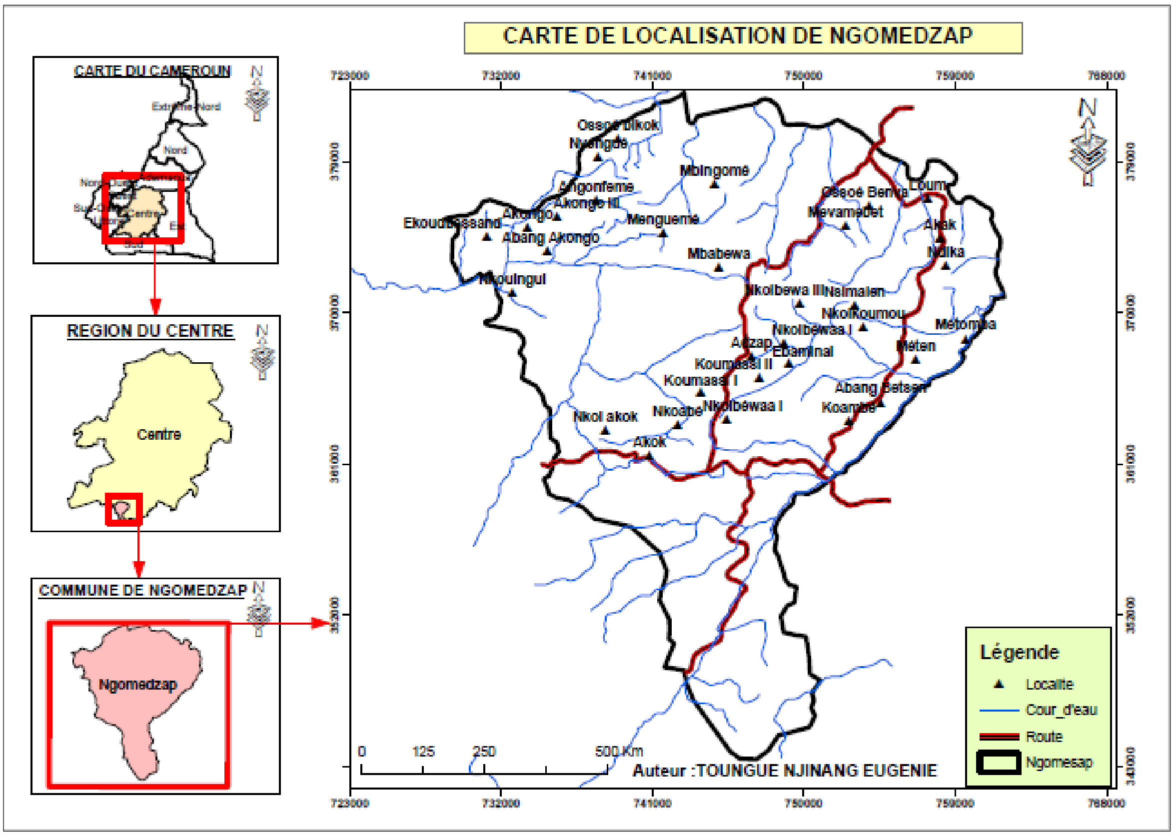


**Fig. 1: Location of the study site (Toungue, 2025)**

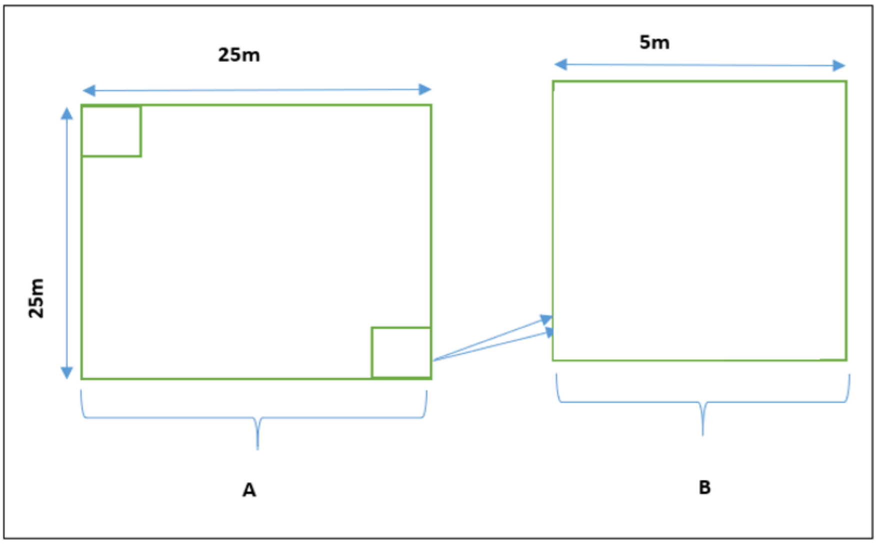


**Fig. 2: Floristic diversity and carbon inventory design**

**Data Analysis**

Several diversity indices were calculated: floristic richness and diversity, the Shannon-Weaver diversity index (*H′*), Simpson's index (*D*), Pielou's evenness index (*E*), and Fisher's Alpha index. These indices provide a more comprehensive assessment of diversity, as they account for species richness and the uniformity of species distribution within the plant community.

Species richness refers to the total number of species (*S*) recorded in a given area. Species diversity, on the other hand, reflects how the total number of individuals (*N*) is distributed among these species.

The Shannon-Weaver Diversity Index (H') is widely used in comparative community studies because it is independent of population size. It quantifies biodiversity heterogeneity within a study area, allowing for the observation of changes over time [18]. Expressed in bits, it is calculated as: $H' = -\Sigma \frac{ni}{N} \ln \frac{ni}{N}$, where H′ = Shannon index, $n_i$ = number of individuals of species, N = total number of individuals across all species.

The value of *H′* ranges from 0 to 5 bits (sometimes slightly higher). A high *H′* value indicates favourable environmental conditions supporting a wide variety of species, reflecting ecosystem stability [19].

Pielou's index (EQ) [20], measures the degree of diversity achieved within a community. It allows for comparisons between plots with differing diversity indices and assesses whether species distribution is uniform or uneven. It is calculated as: $EQ = \frac{H'}{LnS} = \frac{H'}{H'max}$ where E = Pielou's evenness index, H′ = Shannon index, S = total number of species in the plot, ln = natural logarithm. Pielou's evenness ranges from 0 to 1, with higher values indicating a more balanced community [19].

Simpson's index [21, 22], measures the probability that two randomly selected individuals from a community belong to the same species. It is calculated as: $D' = \Sigma(\frac{ni}{N})^2$, where $n_i$ = proportion of individuals belonging to species, N = total number of individuals. The index ranges from 0 to 1, where values closer to 0 indicate high diversity (low dominance) and values closer to 1 indicate low diversity (high dominance). A higher *D* value suggests greater environmental heterogeneity and species diversity.

The Sørensen's Similarity coefficient measures floristic similarity between different plots. It compares species lists from two plots to determine their degree of resemblance, calculated as: $Ks = \frac{2C}{A+B} x100$

Where Ks = Sørensen's similarity coefficient, A = species richness in Plot 1, B = species richness in Plot 2 and C = number of shared species between the two plots.

The index ranges from 0 to 100. Higher values (Ks > 50 %) indicate that the compared plots belong to the same plant community. Lower values suggest greater dissimilarity [23].

**Vegetation Structure**

Vegetation structure refers to the spatial arrangement of trees or species, which can be described using mathematical models [24]. Both vertical and horizontal structures were examined.

***Vertical Vegetation Structure (Stratification)***

Stratification was determined based on maximum diameter at breast height (DBH) (Table I), following Letouzey'size classification [25]. In this study, stratification was defined according to the diameter distribution of individuals within a given species population. Four categories (A, B, C, D) were identified. Category A correspond to species with DBH > 100 cm (Upper canopy layer). In category B, species have a DBH between 50 and 100 cm (Middle canopy layer), category C correspond to species with a DBH between 20 and 50 cm (Lower canopy layer) and the category D where species have a DBH between DBH 5 and 20 cm (Shrub layer) and the categorie E where species have DBH less than 5 cm (Herbaceous layer).

Table II. Stratification of the studied forest.

***Horizontal Vegetation Structure***

The key variables used to assess horizontal structure included: stem density; stand diameter distribution: basal area; diameter class distribution and tree distribution per hectare.

The main analytical variables comprised: Stem Density (Stems per Hectare); Relative basal area (Str); Relative density (DeR); Relative Dominance (DoR); Relative Frequency (FrR); Family Importance Value index (FIV) and Importance Value index for species (IVI)

Stem density refers to the total number of individuals of a given species per hectare, calculated as:
$D = \frac{N}{S}$, where: D = Density (stems/ha) NN = Total number of individuals in a sample plot SS = Area of the sample plot (ha).

The basal area (BA) of a tree is the cross-sectional area of its stem at 1.30 m above ground level (or 0.30 m above buttress roots for species that possess them). It represents the area occupied by a tree per hectare and is used to assess a species' relative importance. The formula used is: $ST = \frac{\pi D^2}{4}$, where: BA = Basal area (m²/ha); D = Tree diameter (cm); π = 3.14 (Sonké, 2004)

This refers to the distribution of stems across diameter classes. For this study, all recorded individuals were categorized into 10-cm diameter classes, following [26], who recommend using fixed-width classes (typically 5 or 10 cm) for practical consistency. The classification system was : [0–10 cm]; [10–20 cm]; [20–30 cm], *etc.* The number of stems per hectare per diameter class was used to identify the most ecologically significant size group in the studied stand.

The qualitative analysis of the forest flora was based on structural attributes, including: Importance Value Index (IVI) [27], and Family Importance Value Index (FIV) [28]. Both indices are derived from the sum of: Relative Frequency (FR), Relative Dominance (DoR) and Relative Density (DeR). Formulae: IVI = FR + DoR + DeR [27]; FIV=FR+DoR+DeR [28].

These indices help evaluate the ecological status of the stand and the relative importance of species and families across vegetation layers.

Estimating these indices makes it possible to characterise the stability of a plant population and the relative importance of the different species and families present in the study site [29].

**Analysis of Autoecological Characters or Ecological Spectra**

This refers to the characteristic concept of plant groups in relation to their environment [30]. The analyses are based on comparisons of the relative proportions of the different defined categories. The autoecological characters analysed include phytogeographical distribution types, biological types.

**Conservation Status Assessment**

To establish a conservation status list for high-value species, IUCN Red List categories were applied, supplemented by data from existing floras and monographs [31].

**Statistical Analyses**

Excel 2016 and PAST software were used to analyze inventory data and construct graphs. PAST software was used to calculate biodiversity indices. The Kolmogorov test was used to assessed significance between the different variables (relative density and relative dominance). Arcgis and Envi software were used to perform land use dynamics and locate the study area. The Kolmogorov-Smirnov test was employed to assess the level of dependence and significance between variables at the 95% confidence level.

# RESULTS AND DISCUSSION

## Taxonomic Richness and Diversity Indices in the Different Strata

The inventory identified 2,059 individuals, including 2,013 woody plants, 14 palm trees (*Elaeis guineensis*) and 32 banana trees (*Musa paradisiaca*). This enabled the identification of 187 species, divided into 147 genera and 51 families. The study of floristic diversity for each habitat revealed that Adult Secondary Forests (ASFs) have the highest species richness (130 species divided into 111 genera and 18 families), followed by Young Secondary Forests (YSFs) (118 species divided into 99 genera and 41 families), Young Cocoa Agroforests (YCAFs) (45 species divided into 42 genera and 24 families) and Old Cocoa Agroforests (OCAFs) (39 species divided into 36 genera and 21 families) (Table I). This can be explained by the number of plots inventoried by vegetation type. Indeed, species diversity increases with the number of plots inventoried by vegetation type. In addition, the openings created by logging and tree mortality alter the ecological conditions of the forest and boost the phenomenon of silviculture. These results are lower than findings by [32] in three Annual Cutting Areas (AACs) of the Littoral Region's Forest Management Unit (UFA) 00-004 (203 species) and Higher than [33] in semi-deciduous forests of Central Cameroon (103 species). Discrepancies likely reflect differences in sampled areas.

Overall, the floristic diversity indices in the study area are high (ISH=3.75 bits, D = 0.89 bits, EQ = 0.72, Fisher alpha = 49.96 bits), but vary between the different types of vegetation in the communal forest. The Student's t-test showed significantly higher diversity in mature secondary forest ($p = 0.01 < 0.05$). YSFS and ASFS are the most diverse in the study area with respective Shannon Index values of 4.33 and 4.24 bits, and Simpson Index values of 0.98 and 0.97 bits. In contrast, YCAFS and OCAFS are the least diverse in the studied forest with respective Shannon Index values of 1.90 and 1.24 bits, and Simpson Index values of 0.56 and 0.39 bits. Pielou's evenness is estimated at 0.49 and 0.34 bits in YCAFS and OCAFS respectively, which means that almost all species are very poorly represented in these plant formations. Furthermore, these EQ values are close to 1 (0.87 bits for ASFS and 0.91 bits for YSFS). These values are close to 1, which means that almost all species are more or less equally represented within the plots (Table I).

The Fisher alpha index values are 48.88 bits in ASFSs and 49.03 bits in YSFSs. This confirms that the flora is heterogeneous in these plant formations. This contrasts with OCAFS (9.58 bits) and YCAFS (13.75 bits), where these values are low, indicating that the flora is homogeneous (Table I).

Those high values suggest strong floristic continuity and supports the idea that these vegetation types share a common ecological trajectory in terms of species composition and regeneration processes, as similarly observed in community forests in eastern Cameroon [38].

**Table I: Species richness and diversity indices for forests and SAFs (ASFS = Adult Secondary Forests, YSFS = Young Secondary Forests, OCAFS = Old Cacao Agroforests, YCAFS = Young Cacao Agroforests); ISH = Shannon Index; D' = Simpson Index; EQ = Piélou Index, TUT: Type of Land Use.**

| TUT | Number of individuals | Number of species | Genera | Families s | ISH | D' | EQ | Fisher_alpha |
|---|---|---|---|---|---|---|---|---|
| ASFs | 664 | 130 | 111 | 38 | 4,24 | 0,97 | 0,87 | 48,88 |
| YSFs | 495 | 118 | 99 | 41 | 4,33 | 0,98 | 0,91 | 49,03 |
| YCAFs | 349 | 45 | 42 | 24 | 1,9 | 0,56 | 0,49 | 13,75 |
| OCAFs | 551 | 39 | 36 | 21 | 1,24 | 0,39 | 0,34 | 9,585 |
| Total | 2059 | 187 | 147 | 51 | 3,75 | 0,89 | 0,72 | 49,96 |

## Floristic Similarities between Different Habitats

Based on the Sørensen similarity coefficient calculated pairwise between the different land-use types, the similarity values ranged from 22.49% to 66.13%. The highest similarities were observed between mature secondary forests (ASFS) and young secondary forests (YSFS) (66.13%) and beetween Old cocoa agroforests (OCAFS) and young cocoa agroforests (YCAFS) (54.76%). Since these values are all above 50%, it can be concluded that these vegetation types belong to the same plant community. This also confirms that the plant communities across these vegetation types are closely related and share a significant number of species.

In contrast, land-use types with Sørensen similarity coefficients below 50% indicate floristic heterogeneity between vegetation types (Table VII). The lowest similarities were recorded between mature secondary forests (ASFS) and raffia palm forests (13.04%), and Cocoa agroforests and raffia palm forests (3.85%). Furthermore, the ecological services provided by each vegetation type should be considered. Recent studies [39, 40]; show that cocoa agroforests, though floristically simplified, can still offer substantial ecosystem services such as carbon storage, soil fertility maintenance, and habitat continuity for fauna. However, this depends on maintaining a minimal level of structural and species complexity-something that is rapidly lost in aging, intensively managed systems

## Stand Structure of the Ngomedzap Communal Forest

### *Stem Density per Hectare and Basal Area*

The basal area in the Ngomedzap forest massif is 203.76 m²/ha, varying across different land-use types (LUTs). Mature secondary forests (ASFS) and young secondary forests (YSFS) had the highest basal areas (79.93 m²/ha and 45.97 m²/ha, respectively), while young cocoa agroforests (YCAFS) and old cocoa agroforests (OCAFS) recorded lower values (39.80 m²/ha and 38.07 m²/ha, respectively) (Table II). The abundance of juvenile species and the presence of large-diameter trees explain the higher basal area values. A Student's t-test revealed a significant difference ($p = 0.026$) between natural forests and agroforests, with natural forests having 1.6× greater basal area than agroforests [34], reported 330–870 stems/ha and 36.54–63.23 m²/ha in Mouloundou (East Cameroon) [32], recorded lower densities (1,114.75 stems/ha) in Littoral AACs. These findings align with those of [38], who reported basal areas ranging from 36.54 to 63.23 m²/ha in community forests of eastern Cameroon, and with [41], who found basal areas below 65 m²/ha in annual logging zones (AACs) in the Littoral Region.

Across all sampled plots, the mean stem density was 1,267.08 stems/ha, ranging between 214.77 and 408 stems/ha depending on the LUT (Table II). ASFS, YSFS, and OCAFS had the highest densities of mature stems (408, 339.69, and 304.62 stems/ha, respectively), while YCAFS had the lowest woody species density (214.77 stems/ha). The Student's t-test indicated a marginally significant difference ($p = 0.03 < 0.05$) between mature secondary forests and cocoa agroforests [35], defined tropical forests as typically having 25–50 m²/ha. Variations may stem from forest type differences.

**Table II: Stem densities and basal area per hectare in the Ngomedzap Communal Forest (YSFS: Young Secondary Forests; ASFS: Mature Secondary Forests; YCAFS: Young Cocoa Agroforests; OCAFS: Old Cocoa Agroforests)**

| Land-Use Type (LUT) | Basal Area (m²/ha) | Density (stems/ha) |
|---|---|---|
| ASFs | 79.93 | 408.00 |
| YSFs | 45.97 | 304.62 |
| YCAFs | 39.80 | 214.77 |
| OCAFs | 38.07 | 339.69 |
| Total | 203.76 | 1,267.08 |

**Diameter Class Distribution in the Ngomedzap Communal Forest**

The woody stand of the Ngomedzap Communal Forest (NCF) is characterised by a predominance of individuals in the [10-20], cm diameter class. This class alone contains 805 individuals, equivalent to 1,007 stems/ha. It is followed, in descending order, by the [0-10[ cm class with 676 individuals (801 stems/ha), the [20-30], cm class with 297 individuals (46.79 stems/ha), and the [30, 40], cm class with 102 individuals (49.05 stems/ha). The smallest diameters are found in the [90-100[ cm class with 3 individuals, the [80-90[ cm class with 6 individuals, and the [60-70[ cm class with 7 individuals.

Across different vegetation types, the diameter classes between 0 and 30 cm also show the highest numbers. These include the [10-20[, [0-10[, and [20-30[ cm classes in young secondary forests ($YSF_s$) with respectively 235 individuals (318 stems/ha), 85 individuals (152 stems/ha), and 97 individuals (172 stems/ha), respectively. In mature secondary forests ($ASF_s$), these classes contain 286 individuals (368 stems/ha), 124 individuals (152 stems/ha), and 143 individuals respectively. In OCAFs, the figures are 180 individuals (202 stems/ha), 298 individuals (192 stems/ha), and 27 individuals (30 stems/ha). In YCAFs, they consist of 104 individuals (120 stems/ha), 169 individuals (192 stems/ha), and 30 individuals (33 stems/ha).

Figure 3 illustrates the diameter structure distribution across the four vegetation types. Overall, the stem distribution by diameter class follows a decreasing trend, displaying an "L"-shaped curve. This indicates a strong dominance of juvenile or future-growth individuals, reflecting ecological vigour and a guarantee of sustainability, as young individuals are expected to replace those that are lost (Figure 3). This diameter structure suggests that the NCF has a high regeneration potential. This pattern, typical of tropical forests, indicates a mature stand with strong regeneration, corroborating [33, 34].

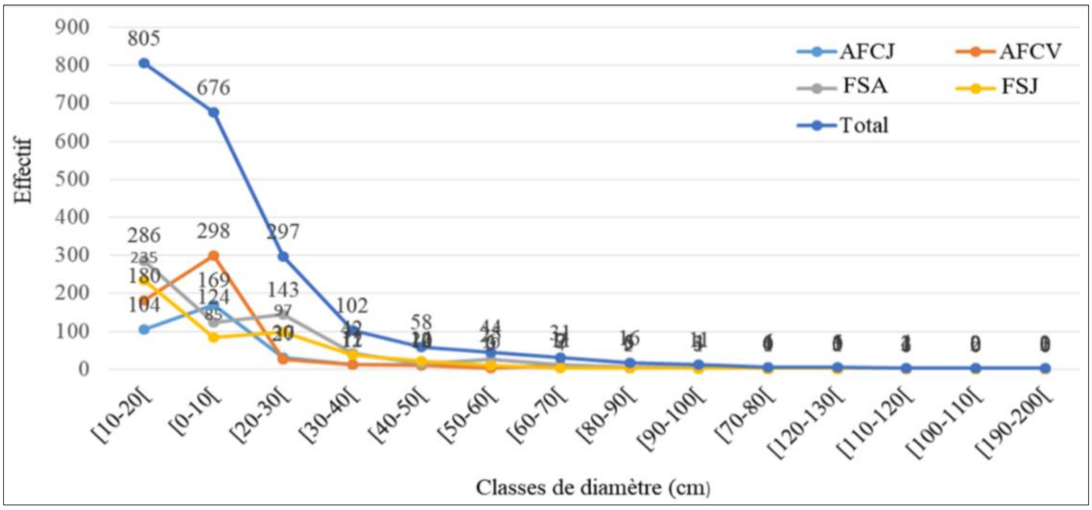


**Fig. 3: Diameter Class Distribution in the Ngomedzap Communal Forest**
**(YSFS: Young Secondary Forests; ASFS: Mature Secondary Forests; YCAFS: Young Cocoa Agroforests; OCAFS: Old Cocoa Agroforests)**

**Family Importance Value in the Ngomedzap Communal Forest**

The analysis of FIV (*Family Importance Value*) in the Ngomedzap Communal Forest (NCF) reveals that nine (9) families have an IVF (*Importance Value Index*) ≥ 10. Overall, the families with the highest values are as follows: Malvaceae (56.68%), Fabaceae (28.07%), Myristicaceae (21.39%), Euphorbiaceae (16.47%), Anacardiaceae (15.70%), Apocynaceae (15.22%), Moraceae (12.14%), Meliaceae (11.47%), and Annonaceae (10.47%). Eight (8) families have IVI values between 5% and 10%, while 34 families have IVI values below 5% (Table III). This aligns with [34] in Dimako Communal Forest, who noted the prevalence of Fabaceae and Malvaceae.

Globally, agroforests exhibited lower family diversity compared to natural forests. The Malvaceae family showed exceptional dominance in agroforests (YCAFS/OCAFS), Fabaceae maintained high importance across all forest type and Myristicaceae was particularly significant in secondary forests (ASFS/YSFS). This analysis highlights how different management practices influence the ecological importance of plant families in the Ngomedzap forest ecosystem.

In YCAFS, the most significant families, ranked in descending order, are: Malvaceae (90.52%), Euphorbiaceae (27.96%), Fabaceae (22.99%), Myristicaceae (19.22%), Apocynaceae (18.63%), Anacardiaceae (17.71%), Moraceae (16.31%), Phyllanthaceae (14.75%), and Lecythidaceae (11.77%). Seven (7) families have IVI values between 5% and 10%, and five (5) families have IVI values below 5%. The dominant families in OCAFs are: Malvaceae (123.63%), Moraceae (24.07%), Fabaceae (15.15%), Anacardiaceae (14.13%), Lauraceae (13.42%), Apocynaceae (12.64%), Combretaceae (10.64%), and Bombacaceae (10.20%). Eight (8) families have IVI values between 5% and 10%, while six (6) families have IVI values below 5%. In ASFs, the dominant families are: Fabaceae (33.30%), Myristicaceae (30.20%), Malvaceae (21.13%), Irvingiaceae (19.41%), Euphorbiaceae (17.87%), Annonaceae (16.15%), Anacardiaceae (13.84%), Meliaceae (13.47%), Sapindaceae (12.49%), and Violaceae (10.61%). Additionally, nine (9) families have IVI values between 5% and 10%, and 19 families have IVI values below 5%. In YSF$_s$, the most important families are: Fabaceae (42.99%), Myristicaceae (30.10%), Apocynaceae (24.21%), Anacardiaceae (23.15%), Meliaceae (18.22%), Euphorbiaceae (15.06%), Annonaceae (13.80%), Rubiaceae (11.31%), Malvaceae (10.35%), and Ulmaceae (10.15%). Six (6) families have IVI values between 5% and 10%, while 25 families have IVI values below 5% (Table III).

**Table III: Dominant Plant Families in the Ngomedzap Communal Forest (ASFS: Mature Secondary Forests; YSFS: Young Secondary Forests; YCAFS: Young Cocoa Agroforests; OCAFS: Old Cocoa Agroforests)**

| Families | *Family Importance Value* (FIV) (%) | | | | |
|---|---|---|---|---|---|
| | YCAFs | OCAFs | ASFs | YSFs | GLOBAL |
| Anacardiaceae | 17,71 | 14,13 | 13,84 | 23,15 | 15,70 |
| Annonaceae | 6,27 | - | 16,15 | 13,80 | 10,47 |
| Apocynaceae | 18,63 | 12,64 | 9,08 | 24,21 | 15,22 |
| Burseraceae | 4,83 | 7,76 | 3,16 | 8,54 | 5,54 |
| Combretaceae | 7,29 | 10,64 | 5,10 | 1,51 | 5,34 |
| Euphorbiaceae | 27,96 | 7,48 | 17,87 | 15,06 | 16,47 |
| Fabaceae | 22,99 | 15,15 | 33,30 | 42,99 | 28,07 |
| Irvingiaceae | - | 6,08 | 19,41 | 0,93 | 7,97 |
| Lecythidaceae | 11,77 | - | 4,21 | 3,42 | 4,21 |
| Malvaceae | 90,52 | 123,63 | 21,13 | 10,35 | 56,68 |
| Meliaceae | 7,08 | 4,30 | 13,47 | 18,22 | 11,47 |
| Moraceae | 16,31 | 24,07 | 5,08 | 7,75 | 12,14 |
| Myristicaceae | 19,22 | 4,84 | 30,20 | 30,10 | 21,39 |
| Phyllantaceae | 14,75 | 7,35 | 4,67 | 9,58 | 8,11 |
| Rubiaceae | - | - | 9,61 | 11,31 | 6,72 |
| Rutaceae | 5,10 | - | 1,39 | 1,14 | 1,59 |
| Sapindaceae | - | 2,57 | 12,49 | 5,34 | 6,54 |
| Ulmaceae | 5,17 | 5,44 | 7,23 | 10,15 | 7,14 |
| Violaceae | - | - | 10,61 | 7,33 | 5,92 |

**Ecologically Important Species in the Ngomedzap Communal Forest**

The ecological importance of species (measured by the "Important Value Index" or IVI) was calculated for the different land-use types in the Ngomedzap Communal Forest (FCN). Table X shows that, overall, only one species (*Theobroma cacao*) is dominant in agroforests, with an IVI ≥ 25% (39.58%). Seven (7) species have IVI values between 10% and 5%, namely: *Pycnanthus angolensis* (13.47%), *Lannea welwitschii* (11.70%), *Milicia excelsa* (11.15%), *Coelocaryon preussi* (10.47%), *Petersianthus macrocarpus* (10.06%), *Piptadeniastrum africanum* (10.34%), *Drypetes gossweileri* (9.21%), *Tabernaemontana crassa* (6.01%), and *Phyllanthus discoideus* (5.04%). Additionally, nine species have IVIs between 5% and 10%, while 169 species have IVIs below 5% (Table IV).

The most important species in the YCAFs are as follows: *Theobroma cacao* (84.48%), *Pycnanthus angolensis* (15.92%), *Lannea welwitschii* (13.63%), *Phyllanthus discoideus* (13.09%), *Alstonia boonei* (11.09%), *Discoglypremna caloneura* (10.61%), *Macaranga burifolia* (10.57%), and *Petersianthus macrocarpus* (10.52%). Ten species have IVIs between 5% and 10%, while 23 species have IVIs below 5%. In OCAF$_s$, the dominant species are: *Theobroma cacao* (99.25%), *Triplochiton scleroxylon* (13.81%), *Lannea welwitschii* (12.74%), *Coelocaryon preussi* (12.41%), *Persea americana* (11.98%), *Milicia excelsa* (11.35%), and *Terminalia superba* (10.56%). Additionally, 11 species have IVIs between 5% and 10%, while 22 species have IVIs below 5%.

In ASF$_s$, the dominant species are: *Pycnanthus angolensis* (19.21%), *Milicia excelsa* (15.35%), *Coelocaryon preussi* (13.48%), and *Piptadeniastrum africanum* (13.74%). Twelve species have IVIs between 5% and 10%, and 115 species have IVIs below 5%. In YSF$_s$, the most significant species are: *Lannea welwitschii* (17.77%), *Pycnanthus angolensis* (17.25%), *Tabernaemontana crassa* (13.44%), *Coelocaryon preussi* (10.65%), *Trichilia dregeana* (10.57%), and *Petersianthus macrocarpus* (10.06%). Eight species have IVIs between 5% and 10%, and 105 species have IVIs below 5%.

**Table IV**: **Ecological importance of the most representative species across vegetation types (ASFS: Mature Secondary Forests; YSFS: Young Secondary Forests; YCAFS: Young Cocoa Agroforests; OCAFS: Old Cocoa Agroforests)**

| Espèces végétales | Importance Value Index (IVI) (%) | | | | |
|---|---|---|---|---|---|
| | YCAFs | OCAFs | ASFs | YSFs | GLOBAL |
| *Theobroma cacao* | 84,48 | 99,25 | - | - | 39,58 |
| *Pycnanthus angolensis* | 15,92 | 1,95 | 19,21 | 17,25 | 13,47 |
| *Lannea welwitschii* | 13,63 | 12,74 | | 17,77 | 9,70 |
| *Tabernaemontana crassa* | - | - | 7,25 | 13,44 | 6,01 |
| *Coelocaryon preussi* | 3,89 | 12,41 | 13,48 | 10,65 | 11,47 |
| *Phyllanthus discoideus* | 13,09 | 6,63 | - | 6,26 | 5,04 |
| *Trichilia dregeana* | 3,01 | - | 4,56 | 10,57 | 4,88 |
| *Rinorea welwitschii* | - | - | 8,77 | - | 4,81 |
| *Terminalia superba* | 6,45 | 9,56 | 4,48 | - | 4,57 |
| *Blighia welwitschii* | - | 2,21 | 8,31 | 3,07 | 4,25 |
| *Polyalthia suaveolens* | - | - | 5,59 | 6,63 | 3,98 |
| *Desbordesia glaucescens* | - | - | 8,34 | 3,39 | 3,97 |
| *Bombax buonopozense* | - | 9,48 | 5,81 | - | 3,96 |
| *Alstonia boonei* | 11,09 | 6,38 | - | - | 3,88 |
| *Triplochiton scleroxylon* | 2,93 | 13,81 | 10,76 | - | 6,75 |
| *Erythrophleum ivorense* | - | - | 7,00 | 5,96 | 3,72 |
| *Celtis zenkeri* | 4,33 | - | 4,24 | 5,58 | 3,67 |
| *Discoglypremna caloneura* | 10,61 | 6,75 | - | 2,22 | 3,66 |
| *Petersianthus macrocarpus* | 10,52 | | - | - | 3,61 |
| *Milicia excelsa* | 1,83 | 11,35 | 15,35 | - | 11,15 |
| *Piptadeniastrum africanum* | 5,82 | - | 13,74 | 8,74 | 10,34 |
| *Drypetes gossweileri* | - | 9,56 | 9,73 | - | 9,21 |
| *Funtumia elastica* | 7,35 | 5,54 | | - | 3,09 |
| *Hylodendron gabonense* | - | - | 7,51 | - | 3,07 |
| *Eribroma oblongum* | - | 7,82 | - | - | 3,02 |
| *Persea americana* | 2,13 | 11,98 | - | - | 2,42 |
| *Distemonanthus benthamianus* | - | - | - | 8,32 | 2,33 |
| *Macaranga burifolia* | 10,57 | - | - | - | 2,13 |
| *Croton* sp. | 8,47 | - | - | - | 2,10 |
| *Millettia sanagana* | 5,39 | 8,98 | - | - | 2,04 |
| *Klainedoxa microphylla* | - | - | 5,81 | - | 1,75 |
| *Elaeis guineensis* | 5,87 | 1,92 | - | 2,59 | 1,67 |
| *Rauvolfia macrophylla* | - | - | - | 5,93 | 1,65 |
| *Dacryodes edulis* | 4,00 | 6,68 | - | - | 1,45 |
| *Ficus exasperata* | 6,27 | 2,76 | - | - | 1,37 |
| *Fillaeopsis discophora* | 7,66 | - | - | - | 1,33 |

**Morphological Types and Vertical Stratification of Flora**

The analysis of morphological types in this study reveals that the shrub layer (Category D) dominates cocoa-based agroforests, with 675 species (representing 74.94% of the recorded flora), followed by the lower tree layer with 102 species (11.36%), the herbaceous layer with 79 species (8.80%), and the middle tree layer with 41 species (4.57%). This distribution is typical of regenerating tropical forests, where successional dynamics gradually restore complexity through the recruitment of shade-tolerant and late-successional species [42]. The presence of upper canopy species, although minimal (0.90%), indicates the beginning of structural maturity and biomass recovery in these forests [43].

Ultimately, while cocoa agroforests support high species richness in the shrub layer, they lack vertical complexity. Strategies that encourage vertical diversification—such as the integration of native tree species and reduced pruning intensity—could enhance both biodiversity and ecosystem services in these landscapes [44]. In secondary forests, the shrub layer remains dominant overall, comprising 653 species (56.20%) of the studied forest flora. This is followed by the lower tree layer **(**355 species, 30.60%**),** the herbaceous layer **(**75 species, 6.50%), and the middle tree layer **(**68 species, 5.90%). The upper canopy layer shows very low coverage, with only 3 species (0.33%) in agroforests and 10 species (0.90%) in the studied secondary forests (Figure 4).

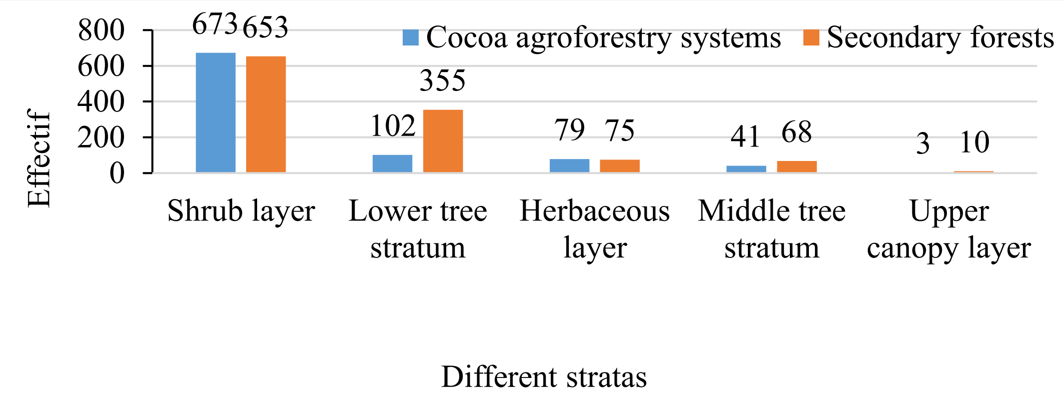


**Fig. 4: Vertical stratification of the studied flora**

**Ecological and Chorological Spectra, Plant Functional Groups**

The morphological, biological, phytogeographical, and ecological characteristics of the species were compiled from various theses, scientific articles, and reference works. Juvenile-stage species were not included in these graphical representations.

***Phytogeographical Distribution***

The study of geographical distribution reveals the dominance of Guineo-Congolian species, with 108 species (57.75% of the total identified species). These are followed by afrotropical species (27 species; 14.44%), palaeotropical species (15 species; 8.02%), pantropical species (12 species; 6.42%). The phytogeographical analysis of the flora reveals a strong predominance of Guineo-Congolian species (57.75%), reflecting the typical composition of humid tropical forests of Central Africa. This dominance is consistent with the ecological characteristics of the study area, which lies within the core of the Guineo-Congolian phytogeographical region, known for its high biodiversity, floristic endemism, and structural complexity [45, 46]. The significant presence of Afrotropical (14.44%) and Palaeotropical (8.02%) taxa further supports the notion of biogeographical connectivity across Africa's tropical forests. Afrotropical species, which extend beyond the Guineo-Congolian core, illustrate the transitional nature of some forest components and the overlap with other African bioregions [47]. The Pantropical group (6.42%), encompassing species found across several tropical continents, highlights either ancient lineages with Gondwanan origins or the result of more recent long-distance dispersal events [48]. Overall, the dominance of Guineo-Congolian elements and the relative scarcity of extrazonal species confirm the ecological integrity of these ecosystems and their alignment with regional phytogeographic classifications. These results emphasize the importance of conserving forest remnants and agroforest systems that maintain native floristic identity while accommodating certain useful exotics [45]. Introduced/cultivated species and cosmopolitan species are represented by 9 and 8 species, respectively, accounting for 4.81% and 4.28%. Sudano-Zambezian species are poorly represented, with only 5 species (2.67%), as are Afro-Malagasy species, with just 3 species (1.60%) (Figure 5).

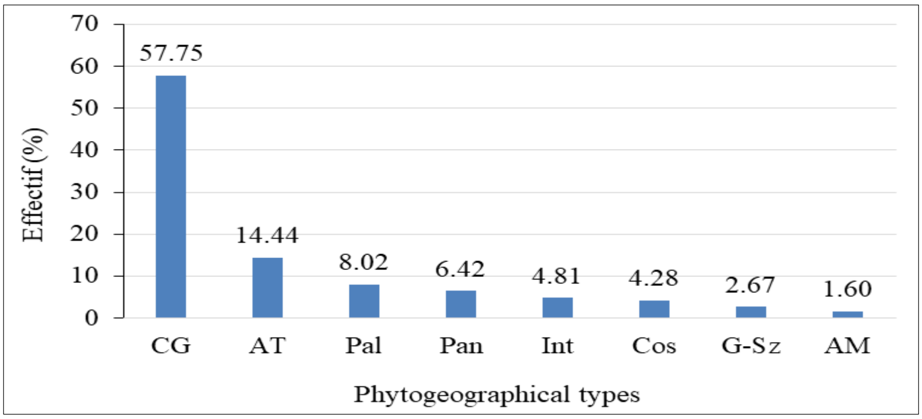


**Fig. 5: Phytogeographical types distribution**

(CG: Guineo-Congolian species, AT: Afrotropical, PAL: Palaeotropical, PAN: Pantropical, Int: Introduced/Cultivated species, Cos: Cosmopolitan, G-Sz: Sudano-Zambezian; AM: Afro-Malagasy)

***Biological Spectrum***

The analysis of life forms (biological types) within the surveyed plots reveals a striking dominance of phanerophytes (169 species; 90.37%), comprising megaphanerophytes (47 species; 25.13%) - tall trees >30m, mesophanerophytes (29 species; 15.51%) - medium trees 8-30m, microphanerophytes and Nanophanerophytes (29 species each; 15.51% each) - small trees 2-8m and shrubs <2m respectively. Lianas are represented by 10 species (5.35%), while hemicryptophytes show exceptionally low coverage (8 species; 4,28%). This spectrum reflects a characteristic mature tropical forest structure, where woody plants dominate across multiple canopy strata. The minimal presence of hemicryptophytes suggests limited development of herbaceous ground cover, typical of closed-canopy systems (Figure 6).

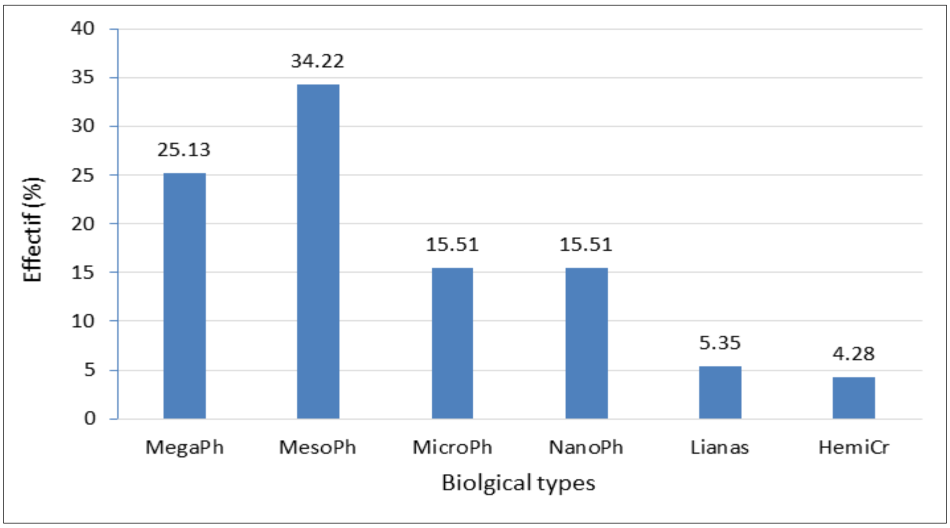


**Fig. 6: Biological Spectrum repartition**
(Megaph: Megaphanerophytes, Mesoph: Mesophanerophytes, Microph: Microphanerophytes, Nanoph: Nanophanerophytes, Hemicr: Hemicryptophytes)

***Diaspore Types***

The analysis of diaspore types reveals a clear dominance of sarcochores (42.25%; 79 species) and sclerochores (24.06%; 45 species). Together, these two categories account for 124 species (66.31%), reflecting a strong reliance on zoochory (seed dispersal by animals), a characteristic feature of tropical rainforest ecosystems.

The remaining diaspore types are less represented: Barochores (14.44%; 27 species), which rely on gravity for dispersal, Pogonochores (8.56%; 16 species), adapted for wind dispersal, Ballochores (5.88%; 11 species), which exhibit explosive dispersal mechanisms, Acanthochores (4.81%; 9 species), equipped with hooks or spines for epizoochory (external animal dispersal) (Figure 7). Zoochory facilitates seed movement over long distances and into favorable microsites, enhancing gene flow and colonization success, particularly for species with fleshy or hard-coated diaspores adapted to ingestion or attachment [49]. The strong representation of sarcochores aligns with the abundance of fleshy-fruited species that attract vertebrate dispersers, while sclerochores reflect species whose hard-coated seeds are often ingested and later deposited by animals [50]. The low prevalence of ballochores and acanthochores suggests that passive and mechanical dispersal strategies are less common in this ecosystem compared to animal-mediated dispersal.

The predominance of zoochory as the primary dispersal mode, accounting for a combined endozoochory and epizoochory, underscores the critical role of animal vectors in shaping seed dispersal dynamics within tropical ecosystems. This dominance aligns with findings from other humid tropical forests, where frugivores and other animals are pivotal for effective seed transport and subsequent forest regeneration [51]. Endozoochory, involving internal seed dispersal through ingestion, facilitates long-distance dispersal and genetic exchange, while epizoochory allows seeds to hitchhike on animal fur or feathers, extending dispersal potential [49].

Understanding the relative importance of these dispersal modes provides critical insights for conservation and restoration initiatives, highlighting the need to maintain healthy animal populations to support natural regeneration and forest dynamics.

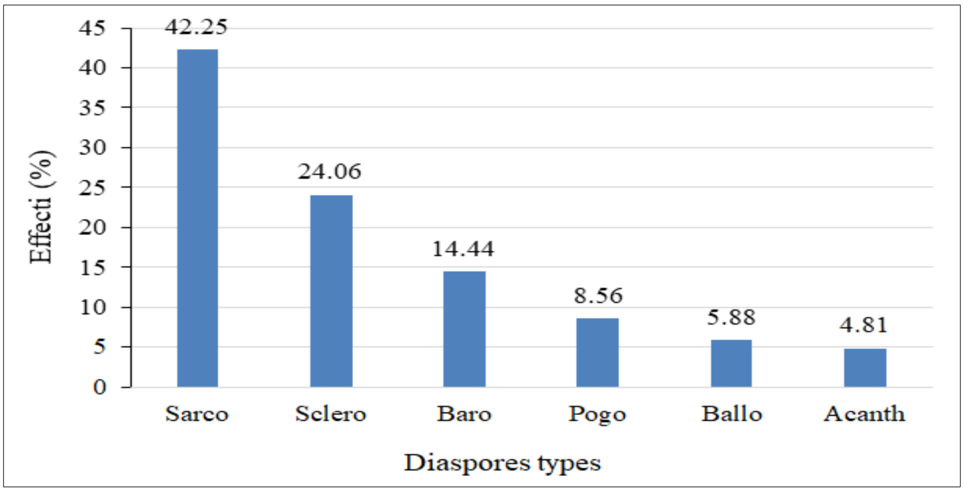


**Fig. 7: Diaspores repartition**
(Sarco: Sarcochores, Scléro: Sclérochores, Baro: Barochores, Pogo: Pogonochores, Ballo: (Ballochores, Acanth: Acanthochores)

***Dispersal Modes***

The most prevalent dispersal strategy is zoochory, comprising: Endozoochory (64 species; 34.22%) – seeds dispersed internally by animals through ingestion, Epizoochory (43 species; 22.99%) – seeds transported externally on animal fur or feathers his is followed by: anemochory (64 species; 34.22%) – wind dispersal, barochory (21 species; 11.23%) – gravity-dependent dispersal, autochory (14 species; 7.49%) – self-dispersal (e.g., explosive mechanisms) and anthropochory (9 species; 4.81%) – human-mediated dispersal (Figure 8). The high prevalence of zoochory (57.21% combined) underscores the ecological significance of animal vectors in this system, while anemochory represents a secondary but equally important dispersal pathway. The limited role of anthropochory suggests relatively low human influence on natural dispersal dynamics.

Priority conservation actions should focus on these vulnerable and critically endangered species, including habitat protection, sustainable management, and restoration efforts. Integrating local community participation and agroforestry practices that favor the regeneration of these species could enhance conservation outcomes [47.]

This study highlights the critical importance of continuous monitoring and updating of conservation status assessments, especially in biodiversity-rich but understudied tropical regions. Strengthening the integration of conservation science with land-use management will be essential to safeguard both species diversity and ecosystem services in the face of accelerating anthropogenic pressures [45].

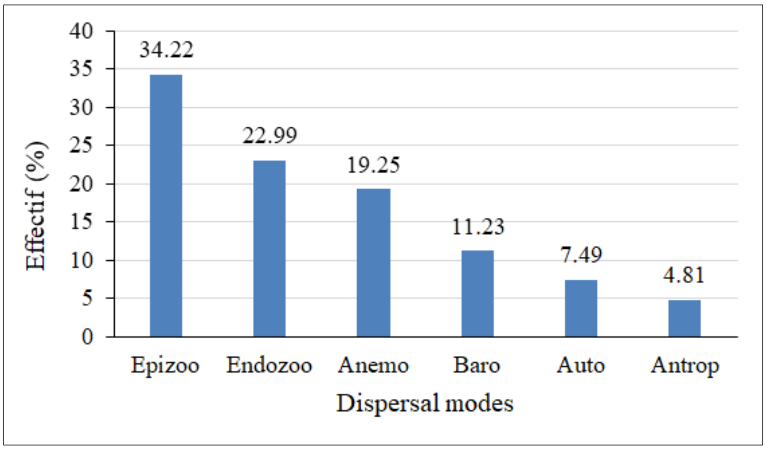


**Fig. 8: Dispersal Modes repartition**

(Epizoo: Epizoochorie, Endozoo: Endozoochorie, Anemo: Anémochorie, Baro: Barochorie, Auto: Autochorie, Anthrop: Anthropochorie)

***Conservation Status of the Studied Flora***

The conservation status of species in this study was determined using the IUCN Red List categories and criteria. The threatened species identified fall into six categories: Least Concern (LC)**,** Not Evaluated (NE)**,** Vulnerable (VU)**,** Near Threatened (NT)**,** Critically Endangered (CR)**,** and Data Deficient (DD)**.** Among the recorded species in the studied flora, 135 species are classified as Least Concern (LC)**;** 29 species are Not Evaluated (NE)**;** 8 species are Near Threatened (NT) (*Cola argentea*, *Entandrophragma angolense*, *E. congoense*, *Guarea cedrata*, *Irvingia gabonensis*, *Milicia excelsa*, *Nauclea diderrichii*, and *Piptostigma preussii*); 11 species are Vulnerable (VU) (*Anopyxis klaineana*, *Antrocaryon micraster*, *Aucoumea klaineana*, *Dacryodes igaganga*, *Diospyros crassiflora*, *Drypetes preussii*, *Entandrophragma cylindricum*, *Garcinia kola*, *Khaya ivorensis*, *Nesogordonia papaverifera*, and *Odyendyea gabonensis*); 2 species are Critically Endangered (CR)**:** *Afraegle asso* and *Guibourtia tessmannii*; 1 species is classified as Data Deficient (DD)**:** *Mangifera indica* (Figure 9). Priority conservation required for 11 vulnerable and 2 critically endangered species.

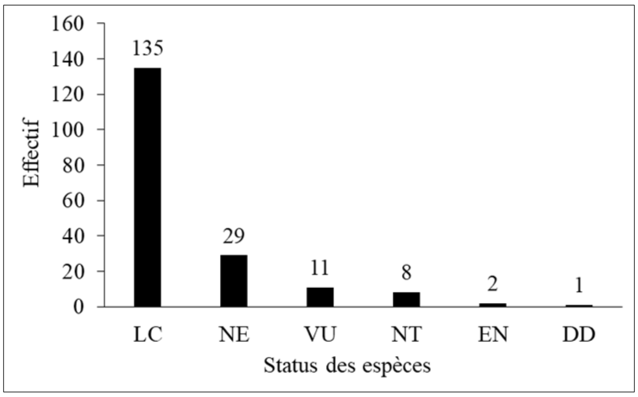


**Fig. 9: Distribution of threatened species by IUCN categories**

(LC = Least Concern; NE = Not Evaluated; VU = Vulnerable; NT = Near Threatened; CR = Critically Endangered; DD = Data Deficient)

## CONCLUSIONS

This study was initiated with the aim of assessing floristic diversity and carbon stocks in the Ngomedzap forest massif. To achieve this, a floristic inventory was conducted across 26 plots, each measuring 625m², to record dendrometric parameters. Floristic Diversity recorded 2,059 individuals, representing 187 species distributed across 147 genera and 51 families in the Ngomedzap communal forest. The calculation of diversity indices Shannon (3.75 bits), Pielou (0.72), and Simpson (0.89 bits) indicates that the vegetation in the Ngomedzap communal forest massif is rich and diverse. Tree density ranges between 398 and 826 stems/ha, with the highest density observed in the adult secondary forests, which recorded the largest number of mature stems at 826 stems/ha (predominantly adult trees).

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