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PLANT DIVERSITY AND CONSERVATION CONCERNS IN THE FOREST–SAVANNAH TRANSITION ZONE OF CENTRAL CAMEROON

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ABSTRACT. Although communal forests face threats, their managers continue to neglect conservation, especially in forest–savannah areas, where plant diversity knowledge has been rarely documented. To address these shortcomings, this study aimed to characterise plant diversity and assess the conservation status of the Minta Communal Forest (MCF) in Central Cameroon. To collect data on different land cover/land uses (LC/LUs) that constitute the MCF, floristic inventories were carried out on trees with a diameter ≥5 cm in 37 plots measuring 40 m × 50 m. A total of 1246 stems belonging to 173 species, 121 genera, and 43 families with a generic coefficient of 69.94% were surveyed.

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Mature forests had the highest species richness (130 ± 7), and savannas had the lowest (16 ± 4). The Shannon index (4.38) confirmed the plant diversity richness in the MCF. The density and basal area found were 169 stems/ha and 18.47 m²/ha, respectively. However, they varied significantly in LC/LU function ($p < 0.05$). There were 13 threatened species, including *Entandrophragma candollei*, *Guarea cedrata*, *Milicia excelsa*, and *Irvingia gabonensis*, which are classified as vulnerable species. In addition, *Dialium zenkeri* was as the only species identified as endemic to the South-West Cameroon zone. This study provides useful floristic data, enabling decision-making for the sustainable management of the MCF.

Keywords: floristic inventories; Minta Communal Forest; structural parameters; sustainability; threatened species.

INTRODUCTION

Forest–savanna transition zones (FSTZs) are vast areas where dense forests and savannas meet and interact (Guillet *et al.*, 1996). The landscape diversity of these complex ecosystems makes them unique because they are home to varied biodiversity (Lemoupa, 2015; Mansingh *et al.*, 2025). In Cameroon, forest–savanna transition forests (FSTFs) are located in the orographic zone of the South Cameroon Plateau (Tsalefac *et al.*, 2000). This zone extends approximately 550 km from east to west and 150 km from north to south (MINFOF and WRI, 2012). The landscape of FSTZ is primarily made up of forests, but it also includes grassy savannas, wooded savannas, gallery forests, and semi-deciduous forests with specific climatic and edaphic conditions (Letouzey, 1985; Zekeng *et al.*, 2021). This exceptional ecosystem harbors forest and savanna species based on plant diversity, which means that biodiversity is high within this refuge (Fotso *et al.*, 2019; Mansingh *et al.*, 2025; Ngo *et al.*, 2022). This diversity indicates the presence of complex ecosystems in the area. Despite that a few studies have already been conducted, our understanding of transition zones is limited.

Human communities depend on forests as an important source of ecosystem goods and services (Mapongmetsem *et al.*, 2016; Ngoukwa *et al.*, 2023), providing firewood, timber, food, and drugs and supporting the agricultural and cultural activities of local populations (FAO, 2005). Although their ecological potential has not been fully explored, they constitute a carbon sink that mitigates the effects of climate change; however, research on this subject is still limited (Pinto *et al.*, 2023). In addition, they regulate water and soil and provide a habitat for biodiversity (Dufrene and Maebe, 2017). As a type of forest, FSTFs also contribute to the well-being of human communities. Human activities, such as logging, infrastructural developments, agricultural expansion, overgrazing, and bush fires, negatively affect their functioning and the numerous ecosystem services they provide (Tchoupou *et al.*, 2021; Mounmemi *et al.*, 2023). As a result, FSTFs are losing a significant amount of their biodiversity due to these threats. To remedy this, several initiatives have been implemented at the national and international levels (MINFOF, 2016).

Faced with these threats, the Cameroonian government has implemented initiatives to promote the conservation or sustainable management of its forests. In 1994, it subdivided its forest domain into two main areas, the non-permanent forest domain and the permanent forest domain, which includes communal forests (CFs) (Law, 1994). Article 30 of this law stipulates that a CF is any forest that has been classified or planted by the commune. Classification suggests that the Ministry of Forestry and Wildlife has approved a simple management plan for CFs. The implementation of its national strategy to reduce emissions from deforestation and forest degradation (REDD+) through sustainable forest management, forest conservation, and increased carbon stocks demonstrates Cameroon's commitment to improving the livelihoods of local communities and forest-dependent populations and ensuring sustainable development (MINEPDED, 2018).

The aim of CFs is to unite the aspirations, interests, and practices of local communities to improve their well-being in a sustainable way over time and space (Poissonnet and Lescuyer, 2005) and preserve their ecosystem services (Zekeng *et al.*, 2021). Between 1994 and 2024, the creation of CFs in Cameroon increased steadily from 0 to 73 CFs (MINFOF and WRI, 2024) due to their considerable functions. Although the government is striving to manage these CFs, biodiversity data are still not being considered in the definition of local strategies for the sustainable management of these ecosystems (Zekeng *et al.*, 2021). This is even more concerning for Cameroon's transition forests, particularly in the central region, which is home to an impressive variety of flora according to Letouzey (1985). Unfortunately, human activities have significantly degraded these ecosystems (Fotso *et al.*, 2019; Ngo *et al.*, 2022). In the MCF, it is difficult to define effective conservation strategies due to the lack of in-depth, long-term floristic studies conducted in this CF. From 2010 to 2020, the MCF was exploited, indicating a more than 1% degradation rate for this ecosystem (SIFCAM, 2011). Due to this high degradation rate, we hypothesised that the species richness, biodiversity index, and vegetation structural parameter vary significantly in land cover/land use (LC/LU) function in the MCF. Therefore, this study aimed to characterise the floristic diversity of the MCF located in the FSTZ of Central Cameroon and its role in biodiversity conservation.

MATERIALS AND METHODS

Study area

This study was conducted in the MCF located in the municipality of Minta, Haute-Sanaga department, Centre region, Cameroon. The municipality of Minta is located at 4°33'34" North latitude and 12°49'52" East longitude (*Figure 1*). The topography of Minta is dominated by plateaus with varying degrees of ruggedness, ranging from 640 to 680 m in altitude. The hydrography is dominated by rivers, such as the Tia, Ngbwadjé, Dja, Longé, and Nyamendouga. The soils are ferralitic with a red texture and are poor in nutrients with little humus. The vegetation is that of dense semi-deciduous forests with Ulmaceae and Malvaeae (Letouzey, 1985). The MCF is located in the transition zone between forests and northern savannas with vast expanses of savanna and numerous fairly rich forest galleries along watercourses (SICFAM, 2011). The climate is equatorial Guinean with four seasons, two dry seasons and two rainy seasons, with rainfall sometimes reaching 1440 mm/year. Temperatures vary between 21 and 30°C throughout the year. The MCF was classified by Decree No. 2010/2579/PM on September 17, 2010. It covers an area of 41,087 ha (PCD Minta, 2015).

Data collection

The sampled plots were randomly arranged for the inventory of individuals larger than 5 cm in diameter based on the LC/LU types that were identified in the field during our previous studies based on satellite image treatment in the MCF. The MFC is constituted by six LC/LUs: farms (Fars), mature forests (MFs), swamp forests (SwFs), secondary forests (SFs), fallows (Fals), and savannas (Sas). Plant inventories were recorded in these LC/LUs based on the sampling design recommended by Hairiah *et al.* (2011), which consists of establishing a 2000 m² plot (50 m × 40 m) randomly within each LC/LU. Woody species with a diameter at 1.30 m greater than 30 cm were sampled in the plots, and those with a diameter at 1.30 m height between 5 and 30 cm were sampled in a sub-plot of 200 m² (5 m × 40 m) positioned in the center of each plot.

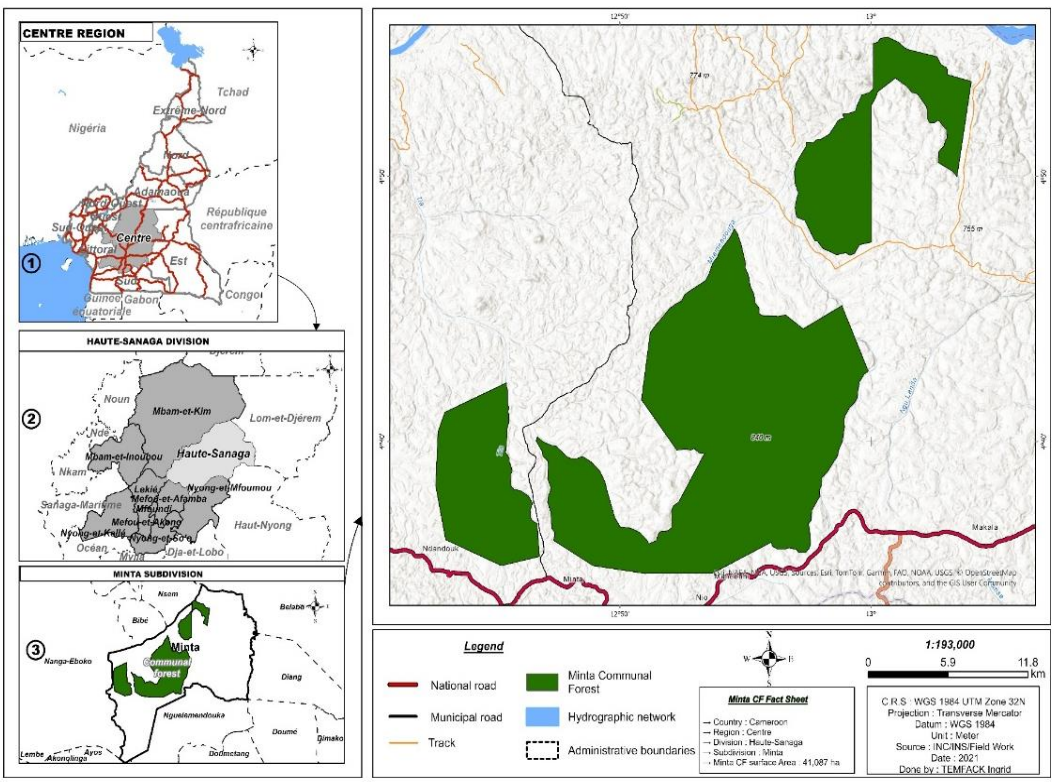

Figure 1 – Localisation of the Minta communal forest

In each plot, the following data were collected: the scientific or vernacular/common name of the woody species present, their uses, and other information that could aid identification. For species that could not be identified in the field, their identification was confirmed at the National Herbarium in Yaounde, Cameroon based on samples collected in the field, preserved in 70% alcohol, and dried.

The scientific name used in this study was determined according to the Phylogenetic Classification of Angiosperms APG IV.

Endemism and conservation status of plant species inventoried

This study draws on the studies of White (1983, 1986), Sonké (1998), Tchouto (2004), Momo (2009), Kabelong *et al.* (2018a), and Mounmemi *et al.* (2023) to characterise the plant species according to their endemism centers, as follows: Afro-American (AA); Afro-Malagasy (AM); Cameroon and Gabon (CaGab); Guineo-Congolese region (GC); Guineo-Congolese-Sudano-Zambesian region (GCZ); Guinea zone (Gu); introduced species (Int); center of endemism undetermined (Ind); Lower Guinea (LG); paleo-tropical (Paleo); pantropical (Pan); South-West Cameroon (Sw-Cam); tropical Africa (AT); and western Guinea (OGC).

The conservation status of species was determined according to the International Union for Conservation of Nature Red List (https://www.iucnredlist.org), with the following categories: extinct (EX), critically endangered (CR), endangered (EN), vulnerable (VU), near threatened (NT), least concern (LC), data deficient (DD), and not evaluated (NE).

Data analysis

Botanical data were collected in an MS Excel 2016 file and imported to R 4.4.1. software for data analysis. The analyses involved calculating biodiversity indices and vegetation structural parameters, and comparing the results using statistical analyses. The biodiversity indices used in this study were selected because they quantify biodiversity, monitor its changes, assess the pressures on the ecosystem, and inform decision-making regarding the management measures to be implemented. With biodiversity index and vegetation structural parameters calculated for each LC/LU, a Shapiro–Wilk normality test was used before statistical analysis to determine if the data followed a normal distribution. For data that were not normally distributed, such as the species richness, number of genera and families, and Shannon, Margalef, Piélou, Simpson, and Fisher Alpha Indices, the Kruskal–Wallis and Wilcoxon tests were used to assess the significant differences between LC/LUs, and for two by two comparisons (using Wilcoxon test), when Kruskal–Wallis test has shown a significant difference. For tree density, basal area, and the regeneration index, which had a normal distribution, parametric tests, namely analysis of variance (ANOVA) and Tukey's test, were used to identify significant differences between LU/LUs.

Floristic diversity

Inventory data were used to characterise the flora of the MCF and its LC/LUs based on the following diversity parameters. Species richness was estimated by counting the number of species identified in each LC/LU and for the MCF as a whole and calculating the Margalef index. This index estimates and provides a quantitative measure of diversity to enable habitat comparisons, assess ecosystem changes over time, and monitor environmental pressure. A high value (> 6) for this index indicates high species richness and/or good species evenness, a low value (< 3) suggests low diversity, and a value between 3 and 6 indicates moderate species richness (BonobosWorld, 2025). It was calculated as follows (*Equation 1*):

$$\mathrm{RMg} = \frac{\mathrm{S} - 1}{\ln(\mathrm{N})} \qquad (1)$$

where S is the number of species, and N is the number of individuals.

The generic coefficient designates the ratio of the number of species to the number of genera. Flora is diverse when it contains fewer large multi-species genera (Aké Assi, 1984) (*Equation 2*).

$$\text{Generic coefficient} = \frac{\text{Number of genders}}{\text{Number of species}} \times 100 \qquad (2)$$

The Shannon–Weaver diversity index assumes that individuals are randomly sampled or distributed from an indefinitely large population and that all species are represented in the sample. It is the most widely used index because it gives more importance to rare species (Shannon and Weaver, 1949). It was calculated as follows (*Equation 3*):

$$\mathrm{H}' = -\Sigma \frac{\mathrm{Ni}}{\mathrm{N}} \times \ln \frac{\mathrm{Ni}}{\mathrm{N}} \qquad (3)$$

where Ni is the number of individuals of species i, and N is the total number of individuals of all species.

Simpson's diversity index (Simpson, 1949) measures the distribution of individuals among species in a given population. Simpson's index was calculated using the following formula (*Equation 4*):

$$\mathrm{D} = \frac{\mathrm{ni}\,(\mathrm{ni} - 1)}{\mathrm{N}\,(\mathrm{N} - 1)} \qquad (4)$$

where D is the Simpson index; ni is the number of individuals of species i; and N is the total number of individuals of all species.

Pielou's equitability is used to assess the even or uneven distribution of species in different ecosystems (Dajoz, 1982) and was calculated using the following formula (*Equation 5*):

$$\mathrm{EQ} = \frac{\mathrm{H}'}{\log 2\ \mathrm{N}} \qquad (5)$$

where H' is the Shannon index, and N is the total number of individuals of all species.

Fisher's alpha index considers rare species and is stable depending on the number of individuals. It was calculated using the following formula (*Equation 6*):

$$\mathrm{S} = \alpha \ln(1 + \mathrm{N}/\alpha) \qquad (6)$$

where S is the specific richness; N is the number of individuals; and α is Fisher's alpha index.

The Family Importance Value Index (FIV) and Species Importance Value Index (IVI) provide information on the ecological importance of the species and families studied. The IVI described by Cottam and Curtis (1959) was used in this study. The relative frequency, which represents the frequency of a species corresponding to the number of sampling units containing that species, was calculated according to Reitsma (1988) and expressed as a percentage (*Equation 7*).

$$\text{Relative frequency} = \left(\frac{f}{\mathrm{F}}\right) \times 100 \qquad (7)$$

where f is the number of occurrences of species i, and F is sum of occurrences of all species.

The relative dominance is derived from the basal area and considers the size of individuals to highlight the taxa that occupy part of the forest. It was calculated as the proportion of the basal area of a species or family in relation to the total basal area and expressed as a percentage (*Equation 8*).

$$\text{Relative dominance} = \left(\frac{BA}{\text{S}}\right) \times 100 \qquad (8)$$

where BA is the basal area of a species, and S is the total basal area of all species.

The relative density was calculated as the number of stems of a species or family (ni) divided by the total number of stems (N) and multiplied by 100 (*Equation 9*).

$$\text{Relative density} = \left(\frac{ni}{\text{N}}\right) \times 100 \qquad (9)$$

IVI helps to identify the tree species that have the greatest ecological impact on the forest. It is calculated using the following formula (*Equation 10*):

$$\text{IVI} = \text{Relative Frequency} + \text{Relative Dominance} + \text{Relative Density (for species)} \qquad (10)$$

FVI helps to identify the main families that play a significant ecological role in the functioning of the forest. It is calculated using the following formula (*Equation 11*):

$$\text{FVI} = \text{Relative Frequency} + \text{Relative Dominance} + \text{Relative Density (for families)} \qquad (11)$$

Structural parameters of MCF

The following structural parameters were calculated: average stem density, average basal area, regeneration index, and diameter class distribution.

The average stem density was the average number of trees counted in a unit area. In this study, density corresponded to the average number of individuals per hectare and was calculated as follows (*Equation 12*):

$$\text{D} = \frac{N}{\text{S}} \qquad (12)$$

where N is the total number of individuals in a sample plot, and S is area of the sample plot (ha).

The average basal area (BA) refers to trees whose diameter was measured at 1.30 m above ground level and 0.30 m above any defects, where applicable. The following formula was applied to the entire plot (*Equation 13*):

$$\text{BA} = -\sum \frac{\pi\text{D2}}{4} \qquad (13)$$

where π is 22/7 (Sonké, 2004), and D is the tree diameter (cm). The extrapolation factor to hectares was 5.

The distribution by diameter class grouped the trees inventoried into diameter classes of 10 cm, highlighting the diameter structure.

The regeneration index (RI) provides information on the natural regeneration capacity of species in a given ecosystem as a percentage ratio between the total number of individuals with a diameter of less than 10 cm at 1.30 m above the ground and the total number of individuals counted (Hakizimana *et al*., 2011). RI was calculated as follows (*Equation 14*):

$$\text{IR} = \frac{\text{Number of stems measured}}{\text{Total number of stems}} \times 100 \qquad (14)$$

RESULTS

A total of 37 sampling plots were recorded in the MCF and were distributed as follows: 5 Fars, 13 MFs, 4 SwFs, 4 SFs, 6 Fals, and 5 Sas. This represents a total sampled area of 7.4 ha.

Species richness and biodiversity indices

The study area contained 1246 stems belonging to 173 species, 121 genera, and 43 families with a generic coefficient of 69.94%. The greatest species richness was observed in MF (130 ± 7), and the lowest in Sa (16 ± 4). The same trend was observed for the number of genera and families for different LC/LUs. Kruskal–Wallis and Wilcoxon tests showed a significant difference between the number of species in MF and SF and that in Fal, SwF, Far, and Sa. The Margalef index was 24.13 for the study area, indicating high species richness. Kruskal–Wallis and Wilcoxon tests showed a significant difference between MF and the rest of the LC/LUs. However, there was no significant difference in the species richness of SF, Fal, and SwF. The Shannon index for the study area was 4.38 with a high value in MF (4.39) and SF (3.69), confirming the rich biodiversity of some LC/LUs constituting the FSTZ of Central Cameroon. Kruskal–Wallis and Wilcoxon tests showed a significant difference among MF, SF, and Fal. The Simpson index was 0.97, indicating that randomly selected individuals belong to the same species. This value indicates that FSTFs are balanced and diversified. Statistical analyses showed no significant differences between Far and Sa, but they were significantly different from MF, SF, Fal, and SwF.

The study area had an equitability of 0.85, indicating that individuals were evenly distributed among all species and that the population of this CF was balanced. A similar trend was observed among different LC/LUs. However, the statistical test (p = 0.05) revealed no significant difference between indices for MF and SF. Similarly, no significant difference was observed among indices for Far, Sa, and Fal.

Fisher’s alpha of 54.55 showed that there were few rare species and that the environment was relatively stable. Apart from Far (9.71cde) and Sa (8.7cde), in which this index was below 10, the values in the other LC/LUs indicate environmental stability.

Ecological importance of families

In the MCF, the following families had a high FVI: Fabaceae (44.70), Urticaceae (23.44), Arecaceae (19.98), Cannabaceae (17.88), Annonaceae (17.20), Myristicaceae (16.62), Apocynaceae (15.00), Euphorbiaceae (13.86), Malvaceae (12.41), and Phyllanthaceae (11.20). These families play a key role in the physiognomy and organisation of this CF. The LC/LU data showed that most families with a high overall FVI also played a major role in the dynamics of the different LC/LUs. However, their influence varied from one stratum to another (*Table 2*).

Ecological importance of species

Overall, the species with high IVI values were *Musanga cecropioides* R. Br. (21.99), *Elaeis guineensis* Jacq (12.22), *Albizia zygia* (11.95), *Celtis tessmannii* (10.53), *Petersianthus macrocarpus* (9.15), *Funtumia elastica* (Preuss) Stapf. (8.86), *Coelocaryon preussi* Warb. (8.47), *Pycnanthus angolensis* (7.39), *Piptadeniastrum africanum* (7.00), and *Pterocarpus soyauxii* (6.58). The representation of IVI by LC/LUs highlighted the influence of several species in their specific ecosystems, such as *Annona senegalensis* Pers, which was essentially a savanna species (*Table 3*).

Density, basal area and regeneration index

The MCF had a low tree density of 169 stems/ha, indicating ecosystem degradation. However, Tukey's test showed that these densities were significant in strata, such as MF (245 stems/ha) and SF (215 stems/ha). ANOVA and the Tukey test showed no significant difference between the average densities of Far and Sa, but the densities of Far and Sa were significantly different from those of MF, SF, Fal, and SwF. The average basal area of the MCF was 18.47 m²/ha, showing that this forest was disturbed. Based on ANOVA and the Tukey test ($p > 0.05$), there was a significant difference in the basal area between MF and all other LC/LUs. However, no significant differences were found among SF, Fal, SwF, Far, and Sa.

The MCF had a regeneration index of 24.15%, which was less than 50%, indicating that this forest had a low potential for ensuring its own natural regeneration. The highest regeneration index was found in Far (60%) and the lowest in MF (17.63%). ANOVA showed a significant difference in the index between Far and other LC/LUs. However, there was no significant difference between Sa and Fal (*Table 4*).

Table 1 – Species richness and biodiversity indices per LC/LU

Floristic parameters	LC/LU					
	MF	SF	Fal	SwF	Far	Sa
Number of species	130[a]	54[ab]	48[bc]	32[bcd]	19[d]	16[d]
Number of genera	100[a]	57[ab]	43[abc]	32[bcd]	18[cd]	6[e]
Number of families	41[a]	25[ab]	24[abc]	23[abcd]	12[bcde]	5[e]
Margalef index	19,99[a]	10,03[b]	8,77[bc]	6,45[bcd]	4,41[cde]	3,91[de]
Shannon index	4.39[a]	3.69[b]	3.01[c]	2.46[d]	2.42[de]	2.33[e]
Simpson index	0.98[a]	0.96[b]	0.88[c]	0.77[d]	0.83[e]	0.84[e]
Pielou Equitability	0.90[a]	0.92[a]	0.77[bcd]	0.71[d]	0.82[bc]	0.84[ab]
Fisher Alpha index	49.49[a]	27.06[b]	19.34[bc]	14.12[cd]	9.71[cde]	8.7[cde]

Farm (Far), Mature Forest (MF), Swamp Forest (SwF), Secondary Forest (SF), Fallow (Fal), Savannah (Sa)

Table 2 – Family value index in the MCF

LC/LU	Families	FVI	LC/LU	Families	FVI
Far	Fabaceae	91.72	SF	Fabaceae	87.04
	Rubiaceae	42.90		Euphorbiaceae	28.54
	Anacardiaceae	35.12		Annonaceae	24.49
	Arecaceae	29.24		Cannabaceae	19.77
	Lauraceae	23.51		Apocynaceae	19.15
MF	Fabaceae	38.00	Fal	Urticaceae	90.66
	Cannabaceae	24.15		Fabaceae	33.62
	Myristicaceae	22.97		Arecaceae	28.46
	Annonaceae	16.66		Apocynaceae	18.52
	Lecythidaceae	15.27		Anacardiaceae	17.68
SwF	Arecaceae	78.78	Sa	Annonaceae	128.56
	Urticaceae	38.39		Phyllanthaceae	89.69
	Myristicaceae	20.82		Moraceae	48.82
	Araliaceae	18.70		Araliaceae	23.14
	Fabaceae	17.99		Fabaceae	9.18

Farm (Far), Mature Forest (MF), Swamp Forest (SwF), Secondary Forest (SF), Fallow (Fal), Savannah (Sa)

Table 3 – Species importance value index in the MCF

LC/LU	Scientific name	IVI	LC/LU	Scientific name	IVI
Far	*Coffea canephora*	41.78	SF	*Albizia zygia*	30.52
	Elaeis guineensis	27.00		*Piptadeniastrum africanum*	26.99
	Pterocarpus soyauxii	26.83		*Macaranga hurifolia*	20.82
	Cylicodiscus gabonensis	22.72		*Albizia glaberrima*	15.90
	Persea americana	22.39		*Pterocarpus soyauxii*	11.77
MF	*Celtis tessmannii*	14.86	Fal	*Musanga cecropioides*	87.12
	Petersianthus macrocarpus	13.62		*Elaeis guineensis*	25.45
	Coelocaryon preussi	13.49		*Albizia glaberrima*	12.36
	Musanga cecropioides	11.35		*Funtumia elastica*	11.89
	Albizia zygia	10.14		*Albizia adianthifolia*	10.56
SwF	*Raphia sp*.	70.79	Sa	*Bridelia ferruginea*	78.59
	Musanga cecropioides	35.97		*Annona senegalensis*	67.81
	Pycnanthus angolensis	19.61		*Ficus mucuso*	42.32
	Terminalia superba	16.99		*Polyscias fulva*	18.83
	Polyscias fulva	16.89		*Indéterminé 16*	10.79

Farm (Far), Mature Forest (MF), Swamp Forest (SwF), Secondary Forest (SF), Fallow (Fal), Savannah (Sa)

Table 4 – Density, basal area, and regeneration index of the MCF

Parameters layers	Average density (number of stems/ha)	Basal area (m^2/ha)	Regeneration index (%)
MF	245^{a}	70.43^{a}	17.63^{de}
SF	215^{ab}	15.03^{b}	23.83^{cd}
Fal	177^{bc}	12.97^{bc}	32.07^{bc}
SwF	153^{bc}	7.16^{bcd}	19.67^{cde}
Far	59^{d}	$4.73b^{cde}$	60^{a}
Sa	46^{d}	$0.54b^{cde}$	43.47^{b}
Global	169	18.47	24,15

Farm (Far), Mature Forest (MF), Swamp Forest (SwF), Secondary Forest (SF), Fallow (Fal), Savannah (Sa)

Diametric structure

This forest showed a decreasing exponential diameter structure, indicating that this CF had the capacity to regenerate naturally. In the LC/LUs, the diametric structure was almost similar to the overall structure. However, the 20–30 class showed a significant drop in the number of stems, suggesting that there is some activity with a significant impact on the stems in this class (*Figure 2*).

Regional centers of endemism and species conservation status

Analysis of endemicity centers showed that 131 species were endemic to the following areas: GC (27%), OGC (19%), Ind (15%), and LG (17%). Species endemic to Guinea and Congo zone predominated in the study area. *Dialium zenkeri* was the only species identified as endemic to the geographical area of south-west Cameroon. The distribution of species according to their conservation status was as follows: DD (0.78%), LC (74.5%), NE (14.11%), NT (5.88%), and VU (4.7%). The majority of species were of minor concern and have not been assessed. However, 4% of species, or 13 vulnerable species, were included in the categories of threatened species (*Table 5*).

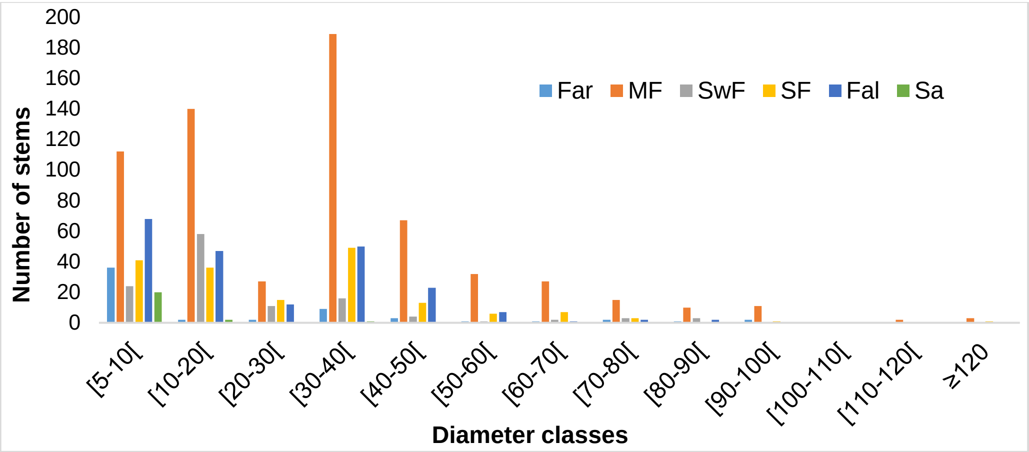

Figure 2 – Diameter structure of the different vegetation layers

Table 5 – Regional centers of endemism and species conservation

N°	Families	Species	Chorology	UICN Status
1	Anacardiaceae	*Pseudospondias macrocarpa*	AT	VU
2	Annonaceae	*Anonidium mannii*	LG	VU
3	Araliaceae	*Polyscias fulva*	GCZ	NT
4	Clusiaceae	*Allanblackia floribunda*	GC	VU
5	Ehretiaceae	*Cordia platythyrsa*	AT	VU
6	Euphorbiaceae	*Mallotus oppositifolius*	AM	VU
7	Fabaceae	*Afzelia bipindensis*	LG	VU
8	Fabaceae	*Afzelia pachyloba*	LG	VU
9	Fabaceae	*Albizia ferruginea*	OGC	NT
10	Gentianaceae	*Anthocleista schweinfurthii*	GC	VU
11	Irvingiaceae	*Irvingia gabonensis*	OGC	NT
12	Malvaceae	*Nesogordonia papaverifera*	LG	VU
13	Malvaceae	*Pterygota macrocarpa*	OGC	VU
14	Meliaceae	*Entandrophragma candollei*	OGC	VU
15	Meliaceae	*Guarea cedrata*	OGC	NT
16	Meliaceae	*Guarea thompsonii*	OGC	NT
17	Moraceae	*Milicia excelsa*	OGC	NT
18	Olacaceae	*Strombosia pustulata*	OGC	NT
19	Putranjivaceae	*Drypetes preussii*	LG	VU
20	Rubiaceae	*Nauclea diderrichii*	OGC	NT
21	Rhizophoraceae	Anopyxis klaineana	GC	VU

(AA: Afro-American, AM: Afro-Malagasy, AT: Afro-tropical, CaGab: Cameroon and Gabon, GC: Guineo-Congolese, GCZ: Guineo-Congo-Sudano-Zambézian; Gu: Guinea; Int: Introduced; Ind: Undetermined; LG: Lower Guinea; Pal: Palaeo-tropical; Pan: Pantropical; Sw-Cam: South-West Cameroon OGC: Western Guinean Zone; VU: Vulnerable, NT: Near Threatened)

DISCUSSION

Floristic inventories remain key tools for understanding species composition, forest diversity, and forest conditions (Gonmadje *et al.*, 2011; Phillips *et al.*, 2003), providing vital information for forest conservation (Gordon *et al.*, 2006). One of the main characteristics of tropical forests is their species richness (Tarakeswara *et al.*, 2018). Mbolo *et al.* (2016), Sonké (2004), and Tchaleu *et al.* (2022) maintained that the correct interpretation of biodiversity indices enables better flora characterisation, which was achieved in this study. This study included trees with diameters of 5 cm or greater, whereas earlier studies in the Congo Basin were limited to large-diameter trees (diameters > 10 cm) (Djuikouo *et al.*, 2010; Gonmadje *et al.*, 2011; Lejoly, 1995; Tabué *et al.*, 2016).

FSTZ is an important habitat that hosts 173 species. Comparing the specific richness of LC/LU functions, the least affected areas or LC/LUs, such as MF and FS, were mostly diversified as a result of anthropogenic activities, in particular logging, mining, and agriculture (PCD, 2015; Tchaleu *et al.*, 2022). Forests were destroyed to make way for farms, leading to biodiversity loss. This could explain the low species richness of farms compared to other LC/LUs (Mounmemi *et al.*, 2023). This is a strong call to action for MCF managers to take urgent measures to curb these threats. If these activities continue at such a pace, it will lead to the destruction of this forest and, consequently, global biodiversity loss. Furthermore, these results demonstrate the ability of FSTF ecosystems to withstand anthropogenic and climatic pressures due to the high species richness of the ecosystems. This supports the assertion by Lemoupa (2015), who argued that this area serves as a refuge for savanna and forest species.

Compared to other studies, this study showed a higher species richness (173 species) than other types of dense tropical forests. Mounmemi *et al.* (2023) recorded 171 species in the dense semi-deciduous forests of Dimako, and Kabelong *et al.* (2018a) identified 115 species in the dense evergreen forests of Campo Ma'an. Compared to the results for savannas (16 woody species), the number of recorded species were higher than the 7 species recorded in the savannas of Makénéné by Fomekong *et al.* (2023). This difference may be due to the fact that most of these studies focused either solely on dense forest or savanna areas. Consequently, the species that were recorded were specific to these ecosystems. However, the present study, which was conducted in a mixed area of forests and savannas, recorded a wider range of species, demonstrating the importance of FSTZs in biodiversity conservation due to the environmental conditions present there that facilitate forest progression into savannas (Youta *et al.*, 2003).

A forest is considered rich if its Shannon index is greater than or equal to 3.5 (Kent and Coker, 1992). The MCF, with a Shannon index of 4.38, was rich and diverse from a floristic perspective. The values obtained for biodiversity indices, such as the Simpson index (0.97), Pielou's equitability (0.85), and Fisher's alpha (54.55), revealed a large, diverse population that was evenly distributed among species and balanced in space.

These results differ from those of Honvou *et al.* (2021) and Kengne *et al.* (2018), who estimated that species are evenly distributed in undisturbed environments. However, this CF has suffered and continues to suffer the effects of agriculture, logging, livestock farming, and mining. The presence of these factors demonstrates that human activities play a major role in the dynamics of land cover in the MCF.

The families with the highest FVI in the study area were Fabaceae, Urticaceae, Arecaceae, Cannabaceae, Annonaceae, Myristicaceae, Apocynaceae, Euphorbiaceae, Malvaceae, and Phyllanthaceae. Fabaceae now includes Caesalpiniaceae and Mimosaceae, according to the APG IV classification, explaining its dominance. The importance of Arecaceae, mainly represented by *Elaeis guineesis*, is due to disturbances caused by agriculture, as this species has been found in plantations and fallows. Some species of Myristicaceae are planted or left by populations because of their nutritional, medicinal, and cosmetic properties, explaining their abundance; very few species of this family are exploited. Due to their strong adaptability to progressively anthropised (Sewale and Mammo, 2022) and dry environments as well as to varying altitudes, these species have found favorable conditions for their proliferation in the FSTZ (Zekeng *et al.* 2020; Nyongo and Kimengsi, 2025).

Among the species identified in the study area as having a high IVI, several were pioneer species, such as *Musanga cecropioides*, *Elaeis guineensis*, *Funtumia elastica*, and *Coelocaryon preussi*. The ecological importance of these species indicates a degree of environmental degradation of about 5% as a result of multiple anthropogenic activities taking place without the implementation of a reforestation strategy (PCD Minta, 2015). This corroborates the results of Zekeng *et al.* (2021), who found similar results in the semi-deciduous forests of Cameroon, reflecting the current state of most forests in the Congo Basin (Hourticq *et al.*, 2013).

Based on the results obtained in the LC/LUs, with an overall IVI of 1.38, *Annona senegalensis* could be considered rare or of little influence, but considering its main habitat, which is the savanna, it has an IVI of 67.81. This species is highly valued by local populations for its nutritional value and is the most abundant woody species (11-fold) recorded in savannas of the MCF. This highlights the importance of considering the natural habitat when assessing the ecological significance of a species (Sewale and Mammo, 2022). A program aiming to promote *Annona senegalensis* it should consider that it is primarily a savanna species.

The average stem density in the SF of the study area was 215 stems/ha, which is low compared to the 775 stems/ha found in the secondary forests on the outskirts of Deng-Deng National Park by Kabelong *et al.* (2018b). This difference could be explained by the missions and management strategies of each area. This study was conducted in a CF, which is a production forest in which sustainable forest management strategies are promoted. In contrast, Deng-Deng National Park is a protected area, where the focus is on the integral conservation of biodiversity. The sampling method used in this study was based on 2000-m² quadrats, whereas Kabelong *et al.* (2018b) sampled 25-km transects.

For several decades, legal and illegal logging has been rampant in the study area. Despite this, the MCF has an average basal area of 18.47 m^2/ha, which is higher than the 5.15 m^2/ha found by Fomekong *et al.* (2023) in the forests of Makénéné. This difference may be due to the fact that these authors took samples on the outskirts of cocoa-based agroforests, indicating some disturbance to the environment, whereas in the present study, the inventory was carried out in the middle of the forest and at least 2 km from communication axes. The fact that these areas are remote to human activities would be beneficial for conservation areas, as natural regeneration would occur more quickly.

A significant decrease in the number of individuals in the 20–30 cm diameter class was observed in all LC/LUs, indicating that individuals in this class are highly sought after by local inhabitants, as they show some signs of maturity and are easier to fell than individuals with larger diameters (PCD Minta, 2015). With a regeneration index of less than 50% in almost all LC/LUs, MCF managers must implement stricter monitoring measures to limit the pressure exerted by loggers and other stakeholders on the CF. It must also urgently undertake reforestation activities to support the current low regeneration potential of the MCF. This is an essential activity for ensuring ecosystem sustainability.

The conservation status assessment identified 13 threatened species in this study. This result supports the idea that CFs, particularly those located in the forest-savanna transition zone due to their significant floristic potential, require special attention to ensure biodiversity conservation through compliance with sustainable management rules. This idea is consistent with the findings of Zekeng *et al.* (2021), who recommended that production forests should be taken into account in biodiversity conservation. This is evidenced by the presence of the 13 threatened species recorded in the study area. Therefore, communal forest managers should prioritize the preservation of this ecosystem to prevent the complete loss of their original biodiversity.

The presence of endangered, near-threatened, and other species listed in this study provides data that the municipality can use to guide specific biodiversity conservation programs. Municipal authorities could therefore enter into partnerships with organizations working to protect endangered species in order to prevent their extinction. It is well established that the creation of anthropized ecosystems is responsible for biodiversity loss (Mounmemi *et al.*, 2023; Tchoupou *et al.*, 2021). The study revealed that there are no endangered species on farms or even on fallow land in the MCF. In this context, promoting agroforestry in the area could help to address this biodiversity loss through the production and distribution of seedlings of threatened species to farmers, as well as the use of green manure. In addition, practices such as slash-and-burn agriculture in CF should be avoided because it poses a significant threat to biodiversity.

CONCLUSIONS

This study aimed to characterise the floristic diversity of the MCF located in the FSTZ of Central Cameroon and its role in biodiversity conservation. The plant diversity was abundant and varied with a wealth of 173 species, indicating the ecological health, habitat diversity, and complexity of biological interactions within this forest, despite the numerous pressures it faces. Based on the results of this study, agriculture appears to be the main driver of degradation given the low species richness and biodiversity indices observed. These forests are generally in a degraded state due to their average density of 169 stems/ha and low regeneration index of 24.15%. In addition, 13 species were identified as being of high conservation interest. The majority of these species are endemic to the GC zone and require special attention to preserve and manage the MCF sustainably. This study has also made it possible to assess the floristic potential of the CFs in the FSTZ and to understand their role in the conservation of national biodiversity. It is therefore recommended that this zone be considered when planning national strategies for the conservation and/or sustainable management of forests as well as dense evergreen and semi-deciduous forests.

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