

Floristic Diversity in Forest Management Units: Implications for Biodiversity Conservation in FMU 09-025

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Abstract

The assessment of floristic composition and diversity is very important in forest management units. This study sets out to determine the species diversity and implications for biodiversity conservation in FMU 09-025 of the Campo Ma'an National park, South Region of Cameroon. Due to human activities in the area, the study site was divided into two Blocks (A and B). The transect method was employed in data collection. A total 14 long transects were established parallel to each other in blocks at a distance of 3 km apart, 8 transects in Block A and 6 Transects in Block. In each transect, plots of 20 × 500 m were established at intervals of 500 m. Within each plot, all individual trees ≥ 10 cm were identified, measured, and recorded. The DBH of all trees were measured at 1.3 using the DBH meter tape. The height of trees was measured through estimation (average estimates of all field researchers). Results revealed a total of eight thousand one hundred and twenty four (8124) individual plants with DBH ≥ 10 cm in the entire study area. From this number, 5113 tree stems ≥ 10 cm were identified and measured in Block A. This belongs to 216 species in 47 families. In block B a total of and 5011 stems were identified and measured. This belongs to 239 species in 47 families. Fabaceae, Annonaceae, Euphorbiaceae and Rubiaceae were found to be the most dominant plant families in the study site. *Erythrophleum ivorense*, *Lophira alata*, *Dialium bipindense*, *Musanga cecropioides*, *Alstonia boonei*, *Pterocarpus soyauxii*, *Guibourtia ehie*, *Staudtia kamerunensis*, *Desbordesia glaucescens*, *Sacoglottis gabonensis* were found to be the most dominant

plant species. 41 species are of conservation concern according to the IUCN global Red List 2023 and IUCN local status. These species are considered species with high-priority for conservation. We have 6 endangered species, 11 near Threatened species, and 25 vulnerable species. There was no significant difference in species diversity in the two Blocks.

Keywords

Composition, Floral Diversity, FMU, Conservation Concern

1. Introduction

Biodiversity conservation in forest management units is one of the challenges of man today. Biodiversity is the degree of variation of life forms within a given ecosystem, biome, or entire planet (Uno et al., 2001). This involves all species of plants, animals and microorganisms, the ecosystem, and ecological processes of which they are parts. Globally, the Amazon basin and the Congo basin have been known as the biodiversity seats when it comes to species diversity. These two basins have the highest number of species with estimated 10,000 species of tropical plants in the Congo Basin of which 30 percent are unique to the region (Harrison et al., 2018) and 50,000 plant species have been estimated in the Amazon basin. It has been noted that biodiversity especially plant plays an important role in ecosystem function, particularly in productivity (Cadotte, 2013). While some studies have not mentioned this, several studies have found positive relationships between biodiversity and productivity, measured through biomass (Coelho de Souza et al., 2019). This linkage has been explained as a function of the added value between plant life strategies and use of resources (Gross et al., 2007). However, the negative relationships between biodiversity and productivity (biomass) result from the selection effect, that is, the caused effect when a set of dominant species excludes those less productive species (Turnbull et al., 2012). In addition, most of the studies have been carried out in grasslands, in which fast-growing species dominate and the structure of the community is less, both types of relationships remain controversial in tropical forest ecosystems (Fraser et al., 2015).

It has been shown that different ecological and geological zones of the world support various types of floristic diversity. This floristic diversity helps in understanding plants richness in more optimal ways (Masroor, 2011; Mwakalukwa et al., 2014). The knowledge and understanding of the factors influencing the spatial variation patterns of diversity, and composition, of species is a challenge in community ecology (Lomolino, 2001). It has been shown that altitude is one of the main drivers on the emergent properties of plant communities (Gaston, 2000; Guo et al., 2013). For instance, changes in forest structure and composition of forests such as the decrease of living biomass in the soil; the increase of stem density with the altitude (Hernández et al., 2012); and a tendency of leaves

to become smaller, thicker, and harder have been observed. For instance a reduction of the number of species as well as productivity was observed (K€orner, 2007). Such changes were influenced by abiotic factors such as temperature, decreasing atmospheric pressure, and solar radiation increases with elevation (Christy & Jonh, 2010). Besides the abiotic factors, biotic factors such as farming, urbanization, wild fire, grazing and logging also affects plant composition (Gaujour et al., 2011).

Studies of the main tropical forest ecosystems have shown that African rainforests have relatively poor diversity compared to the highest diversity regions of Asia and the Americas. Compared with the American and Asian tropics, there have been very few systematic regional studies of even the basic attributes of African forests such as biomass, species diversity and structure (Malhi et al., 2013). According to UNEP-WCMC (UNEP-WCMC, 2016), ongoing loss of biodiversity in Africa is driven by a combination of human-induced factors that result in deforestation and forest degradation, entailing important land-cover changes. Moreover, the negative impacts of climate change on species and ecosystems are exacerbating the effects of such pressures. Different figures have been published, but the most optimistic calculations indicate a forest loss of 22% across tropical Africa since 1900, whereas the most pessimistic estimates point to 35% - 55%, to which the large-scale forest degradation must be added (Aleman et al., 2017). Consequently, as much as one-third of the tropical African flora is potentially threatened with extinction (Stévert et al., 2019). These poor diversity results from partly due to the neglect to explore the tropical rainforest due to However, based on this overall pattern of diversity, current understanding of the local-scale community-assembly mechanisms for tropical African tree communities is very limited and complicated by previous sampling designs. For instance, inventories based on 1-ha plots spread across a wide area capture fewer than half of the local species, with many represented only by a single individual. In addition, most of these inventories focus on large trees with DBH 10 cm (Hardy & Sonke, 2004) and in some cases only include selected taxa. These small plots limit the identification of habitats at scales that could provide meaningful inferences on plant populations and also preclude comparisons of degrees of habitat specificity with other tropical forests thus having the misconception of poor diversity of the African rainforest. However, Zekeng 2021 worked on plants with DBH greater or equal 10 and vascular plants of 5 cm. He made a remarkable result as a total of 271 species were identified in a semi-deciduous rainforest in Cameroon (Zekeng et al., 2021).

Cameroon is one of the most diverse countries in the African continent in terms of plant, with over 7850 plant species (Onana, 2011). From these species, 815 species are endangered (Onana & Cheek, 2011). The Cameroon heterogeneous landscape presents different vegetation types among which are the Biafran forest with high rainfall, the Congolese forest, and the semi-deciduous forest with low rainfall (Letouzey, 1985). Thus, Cameroon encompasses an intricate mosaic of diverse habitats with moist tropical forest dominating the

south and south-east and covering 54% of the country, mountain forest and savannah in the highlands and sub Sahelian savanna and near desert in the far north. Further studies conducted by Barthlott et al. (1996) ranked Cameroon among the top countries in tropical Africa for plant species diversity per degree square. Similar studies equally confirmed the high diversity of endemism of plant species, as found in the 50 ha plot in central Korup National Park, Cameroon with close to 500 tree species and over 250 liana species (Thomas et al., 2003).

The Forest Management Unit (FMU) 09-025 is found in the Western section of the park has the second largest number of both flora and fauna within the Technical Operation Unit (TOU) of the Campo Ma'an national park. Some of the fauna diversity in the FMU 09-025 forest zone includes: the African elephant (*Loxodonta africana cyclotis*), the lowland gorilla (*Gorilla gorilla*), the chimpanzee (*Pan troglodytes*), the buffalo (*Synerus caffernanus*), the panther (*Panthera pardus*), and the mandrill (*Mandrillus sphinx*). This work is a contribution to the knowledge of the floristic diversity in Forest Management Units and the conservation state of plant species in rainforests to increase the sustainable management of plant biodiversity. More specifically, we: 1) determined the floristic composition FMU 09-025, 2) examine its potential in terms of plant diversity, 3) assessed the conservation status and endemism of plant species within FMU 09-025.

2. Materials and Method

2.1. Study Area

The FMU 09-25 found in the Western section of the Campo Man National Park has the second largest number of elephants within the Technical Operation Unit (TOU) of the Campo Ma'an national park as shown in **Figure 1**. It is located between Latitude 2°13'30 to 2°34'30 and longitude 9°50'00 to 10°10'00, in the South region of Cameroon. Soils in the FMU 09-25 area are generally classified as Ferrasols and Acrisols. They are strongly weathered, deep to very deep and clayey in texture (except at the seashores and in river valleys where they are mainly sandy), acid and low in nutrients with pH values generally around 4 (Tchouto et al., 2006). The area has a typical equatorial climate with two distinct dry seasons (November-March and July to mid-August) and two wet seasons (April-June and mid-August to October). The average annual rainfall generally decreases with increasing distance from the coast, ranging from 2800 mm in Campo. The average annual temperature is about 25°C and there is little variation between years. Generally, the area has a low population density of about 10 inhabitants per square kilometer and is sparsely populated with most people living around Kribi, along the coast, and in agro-industrial and logging camps. Despite the low population density, there are several activities that are carried out in the area with varying ecological impacts on the forest ecosystem, these activities include industrial plantation agriculture, logging, poaching and hunting.

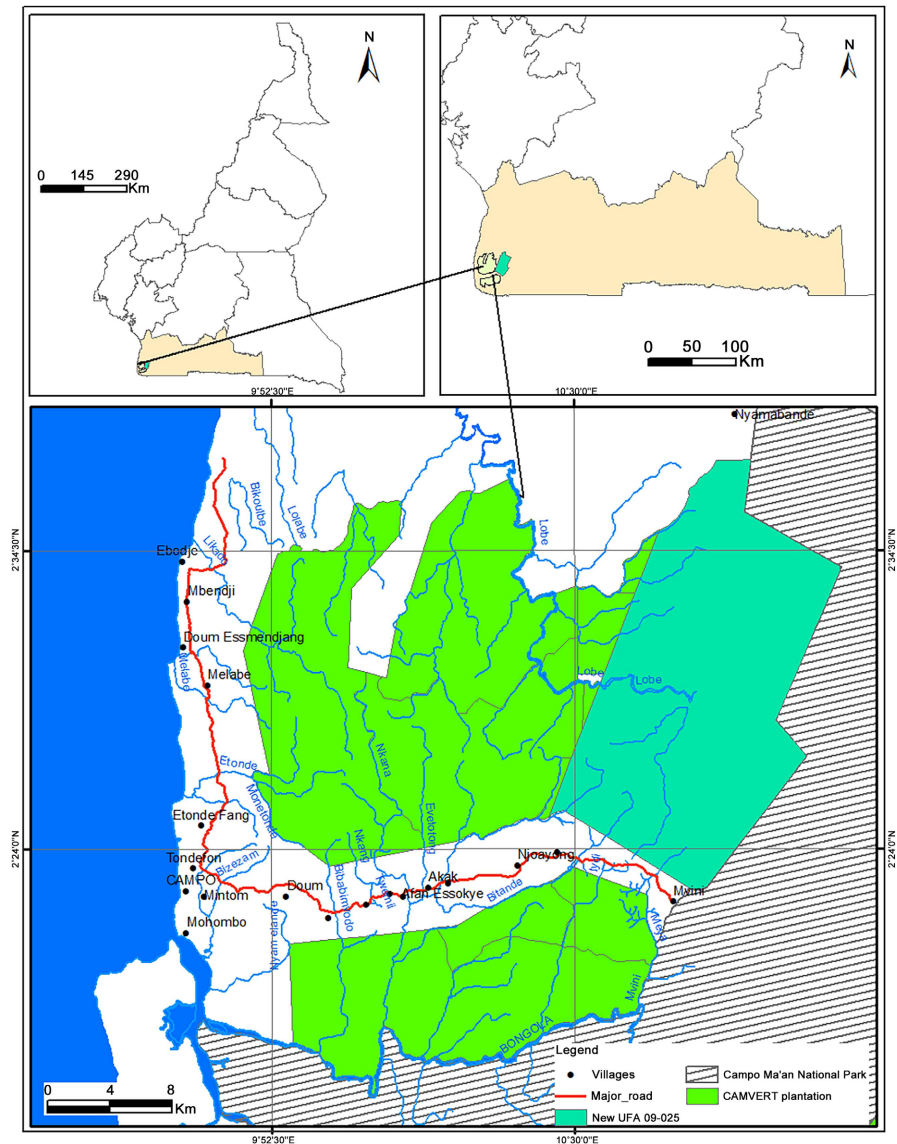


Figure 1. Map of the study area.

2.2. Study Design

The FMU was divided into two blocks (A and B). This was due to the present of human activities in the area, the study site was divided into two Blocks in each block, the transect method as described by Tchouto (2004) and Buckland *et al.* (2007) was established. A total 14 long transects were established parallel to each other in blocks at a distance of 3 km apart, 8 transects in Block A and 6 Transects in Block B as shown in Figure 2. In each transect, plots of 20 × 500 m were established at intervals of 500 m. The quadrates along transects were placed in an alternate manner (that is, if quadrate one is on the left of the transect, quadrate two is placed at the right). A total of fourteen 20 × 500 quadrates were sampled giving 28 ha of total land covered.

We sampled all plants ≥ 10 cm stem diameter in all quadrants Identification of plants was done in the field using various methods. The trees were identified

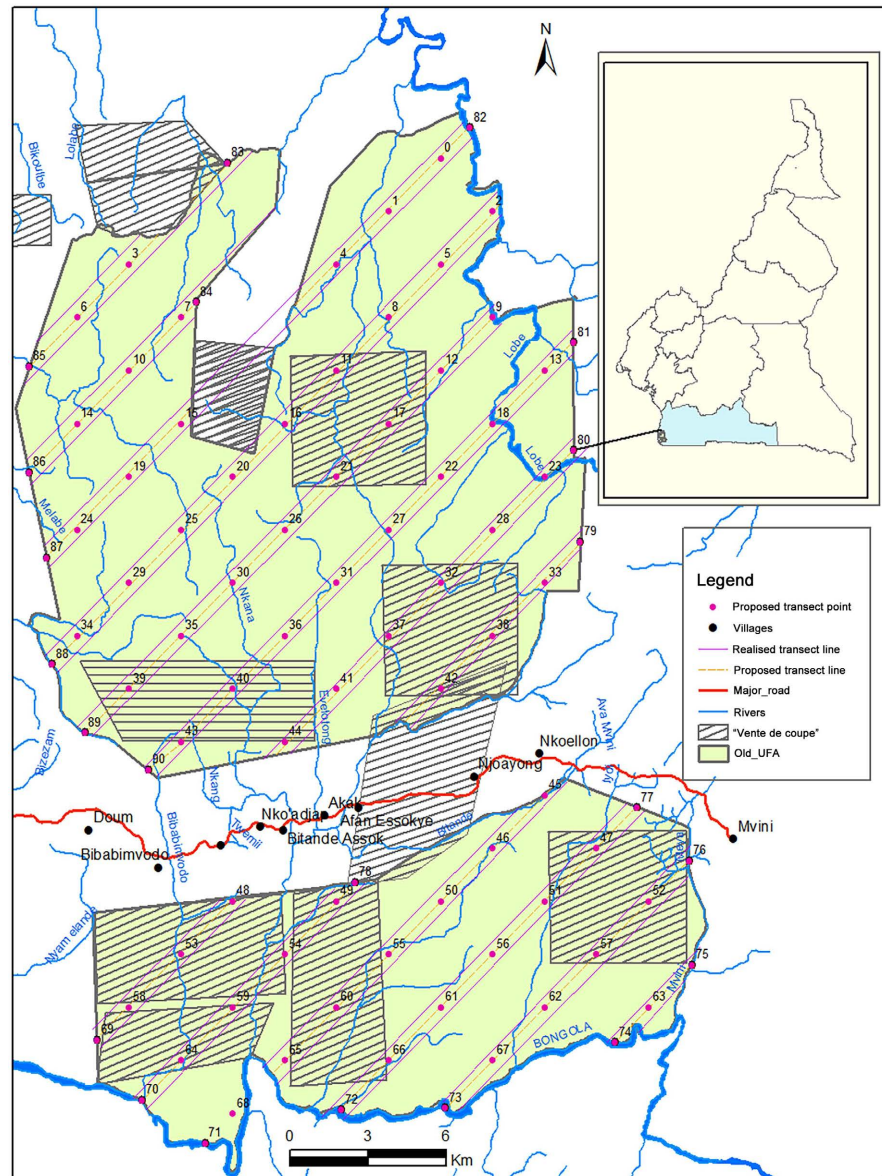


Figure 2. Study design.

using a combination of characters such as the general form of the tree (buttresses, roots systems, bark texture; slash colour, smell and exudates, leaf type and shape) as well as the flowers, and fruits of the trees. In each transect, records of all species of vascular plants, excluding tree dwelling epiphytes were taken. For trees that were unable to be identified, the leaves were collected and put in a plant press for the Limbe Botanic Garden herbarium. Tree structural data were collected and recorded in each quadrat using a datasheet file. Each leaf and dead tree within the plot was identified and was measured at 1.3 m DBH. The DBH of all trees were measured using the DBH meter tape. The height of trees were measured using the hypsometer (Vitax) and also by estimation (average estimates of all field researchers). Some trees generally posed a lot of difficulties in

measuring the DBH at 1.3 m, due to the configuration of their buttresses, lines and stems at 1.3 m. In such a situation, the DBH was measured at a distance either above or below 1.3 m. Field manuals, field books, text books all on plants were used to help in the identification of the plants/trees in the field.

2.3. Data Analysis

Data Analysis Field data were compiled using Microsoft Excel version 20 package and analysis was done using the PC ORD package Version 7. For vegetation structure, the quantitative characteristics such as Plant Diversity, Relative Density (RD), Dominance (D), Relative Frequency (RF), Relative Dominance (RD), Important Value Index (IVI) were calculated.

$$\text{Tree Basal Area (TBA)} = (1/2\text{DBH})^2 \times \pi$$

$$\text{Stem density (stems/ha)} = \frac{\text{Tree in plot (stems)}}{\text{Plot area (ha)}}$$

$$\text{Percentage (\%) Dominant species} = \frac{\text{Number of species at that elevation}}{\text{Total number of species at that elevation} \times 100}$$

$$\text{Relative Density} = \frac{\text{Number of Individuals of species} \times 100}{\text{Number of individuals of all species}}$$

$$\text{Basal Area (BA)} = (1/2\text{DBH})^2 \times \pi$$

$$\text{Relative Basal Area} = \frac{\text{BA of species} \times 100}{\text{BA of all species}}$$

$$\text{Relative Frequency} = \frac{\text{Frequency of a species} \times 100}{\text{Frequency of all species}}$$

$$\text{Important value index (IVI)} = \text{CVI} + \text{Relative Frequency}$$

Measures of species diversity were done using the Shannon-Weiner index (H') and Simpson's index (DS) (Shannon & Weiner, 1963) which have been shown to be more representative of diversity in larger areas. Shannon's index is a measure of uncertainty, providing the probability of picking a dominant species at random.

Comparison was made possible by bringing the plot under the same level, in each block. $H' = -\sum p_i \ln p_i$, where p_i is the proportion of individuals of species (Relative density of species/100), and \ln is the natural logarithm.

The maximum value of H' is the natural logarithm of the number of species ($\ln S$). Evenness (E) describes the distribution among species, reaching a value of 1 when all species have equal numbers of individuals.

Pielou's evenness is described by the following equation: $E = H'/\ln S$. The Simpson's index was introduced in 1949 by Edward Simpson to measure the degree of concentration when individuals are classified into various types. The formula for calculating Simpson's index is: $D = \frac{1}{\sum (n_i - 1) / (N(N-1))}$ where N = the total number of all organisms n_i = the numbers of individuals of each individual species.

3. Results

3.1. Species Diversity in the FMU09-025

Results from the data revealed a total of eight thousand one hundred and twenty four individual (8124) trees with DBH of ≥ 10 cm in the entire study area (that is FMU 09-025). From this, a total of five thousand and eleven (5011) individual stems were measured in Block A and three thousand one hundred and thirteen (3113) stems of DBH ≥ 10 cm were measured and identified in Block A. These individual plants belong to 276 species in 47 families. From the 276 species found in the entire FMU 216 were found in Block A and 239 species found in Block B. This means that 60 species were found in Block B that were not found in Block A and 37 species were found in Block A that were not found in Block B.

The rarefaction curve, showing the tree species richness in the FMU sample is increasing gradually towards the end as shown in **Figure 3**. This means that the forest trees species composition is considered satisfactorily sampled. It was found that, the number of species per plot varied from 81 to 123 species for the whole tree community. Variation of between 77 and 106 species was found among the FMU for the large tree diameter class. The areas sampled in each of the 28 1-ha plots showed a variation of 34 to 60 species for medium trees and 19 to 29 species for small stems in the FMU plots.

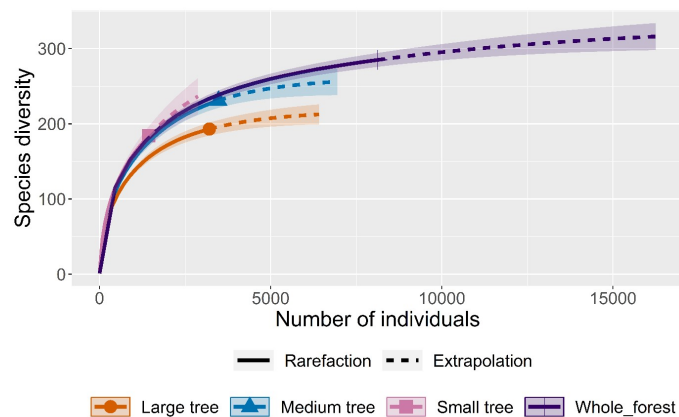


Figure 3. Rarefaction curve showing species richness of the a – whole tree community and b – tree size classes for the FMU.

The Shannon-Weaver index for the whole tree community (4.05 ± 0.15) as well as for large trees (3.99 ± 0.19) did not vary too much, in contrast to medium trees (3.53 ± 0.27) and small stems (2.79 ± 0.26). The same trends were found for the Simpson and the Fisher- α index. However, for small stems, it was found that the values of the Simpson index were low (0.91 ± 0.04), with greater variation ($CV \geq 3.96$) among the plots than the other trees classes ($CV \leq 3.41$). For the α -Fisher index, it was found that small stems had low values (17.55 ± 5.65) and more marked variation ($CV \geq 32.17$) among plots than the other tree size classes (**Table 1**).

Table 1. Average values and coefficient of variation for species richness and diversity for FMU09-025 tree community and tree size classes in the FMU09-025.

Estimate parameters	Whole tree community	Large trees	Medium trees	Small stems
Average \pm Standard error				
Richness	82.8 \pm 49.1	52 \pm 23.8	58.2 \pm 28.5	34.6 \pm 21.6
Shannon-Weaver	4.01 \pm 0.11	3.76 \pm 0.636	3.612 \pm 0.366	2.94 \pm 0.234
Simpson	0.9608 \pm 0.011	0.9608 \pm 0.011	0.9596 \pm 0.0058	9.157 \pm 0.454
Fisher-α	33.2 \pm 16	31.2 \pm 13	32.5 \pm 9.6	14.2 \pm 9.7
Coefficient of variation				
Richness	9.19	10.31	16.38	18.61
Shannon-Weaver	3.52	4.34	6.57	9.32
Simpson	0.80	1.11	3.22	3.84
Fisher-α	13.23	15.02	27.45	31.17

The total number of stems registered and identified is distributed as follows: 15,168 large trees (DBH \geq 10 cm) belonging to 271 species, 4567 medium trees ($5 \leq$ DBH < 10 cm) belonging to 242 species, and 2010 small stems ($1 \leq$ DBH < 5 cm) belonging to 167 species. Many species were recorded to occur in more than one diameter class. The rarefaction curve, showing the tree species richness in the thirty 1-ha sample plots rises only slowly towards the end, suggesting that the forest trees species.

3.2. Floristic Composition

The FIV average values of the most important families within the whole 28 1-ha plots are presented in **Table 2**. The families Fabaceae (IVI = 77.74), Malvaceae (IVI = 16.98), Apocynaceae (IVI = 16.82) and Irvingiaceae (IVI = 13.25) are the four most important families with the highest IVI, in the whole FMU considering the whole tree community of the 28 1-ha sample plots of FMU 09-025. Moreover, these four families also appear as the families with the highest FIV in the large and small trees classes (**Table 2**).

The first ten families with the highest number of species in descending order for the entire study area as shown in **Figure 4** was Fabaceae (67 species), Annonaceae (24 species) Euphorbiaceae (22 species), Rubiaceae with (19 species), Annonaceae (19 species), Malvaceae with (18 species), Meliaceae (13 species) and Olacaceae, Ebenaceae Apocynaceae (10 species) each and sapotaceae with 7 species.

These ten families accounted for 72.5% (200 species) of total species sampled and contributed 66.4% (5397 individuals) of the total plant sampled in the study area. From these 5397 individual plants, 3315 were recorded in Block A and 2082 were recorded in Block B. Three of these families, Fabaceae, Annonaceae and Euphorbiaceae were the most diverse families, which accounted for 40.9% of

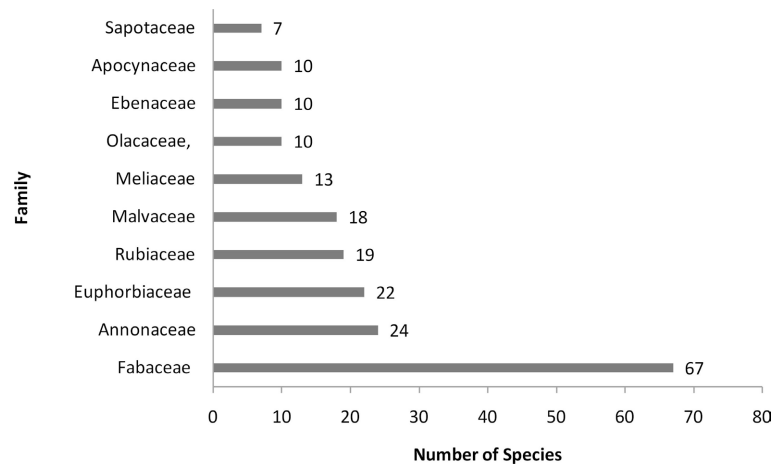


Figure 4. Ten most Abundant families in the entire study site.

overall species richness and contributed 113 species that accounted for 44.3% (3599) of the total number of plant sampled in the entire that is FMU 09025). It is however noted that these most diverse families are not the same when considering trees by the three diameter classes. Because their emergent or large canopy trees account for much of the basal area recorded in the plots, species of the, Fabaceae, Irvingiaceae, Ochnaceae and Myristicaceae were the most dominant, contributing primarily to the floristic composition of the canopy, thereby justifying their high IVI at the level of large tree. The Fabaceae, Urticaceae, Myristicaceae and Rubiaceae owed their high FIV values to their density, contributing mostly to the medium trees classes with numerous individuals but exhibiting a rather low basal area; high FIV values were produced by medium trees. Fabaceae, Euphorbiaceae, Urticaceae and Apocynaceae owed their high IVI values to their density, contributing mostly to the small trees classes with numerous individuals but exhibiting a rather low basal area. This implies that Fabaceae is the most dominant plant species in the FMU because it is shown to be dominating in all the classes.

Table 2. Average family importance value index of the most important families (in bold) for the whole tree community and the tree size classes.

Family	IVI			
	Whole FMU	Large Trees	Medium Trees	Small Trees
Fabaceae	77.74	83.61	74.59	51.88
Malvaceae	16.96	21.31	18.56	35.45
Apocynaceae	16.82	18.63	16.41	22.05
Irvingiaceae	13.25	15.46	13.69	20.33
Ochnaceae	13.14	15.33	13.61	20.23
Myristicaceae	12.29	14.97	13.21	17.40
Combretaceae	12.24	10.75	13.20	13.96

Continued

Euphorbiaceae	12.03	10.60	12.36	10.07
Meliaceae	10.48	9.88	12.32	10.02
Rubiaceae	10.35	9.57	11.76	7.46
Annonaceae	9.66	9.20	9.68	7.17
Urticaceae	9.31	9.01	9.68	7.10
Humiriaceae	7.63	8.63	9.53	6.14
Olacaceae	6.47	7.62	6.90	5.98
Cannabaceae	6.04	6.60	6.29	5.66
Moraceae	5.82	6.30	5.61	5.43
Sapotaceae	5.68	5.23	5.50	5.19
Burseraceae	5.48	5.23	4.35	5.15
Rhizophoraceae	5.44	4.54	3.90	4.89
Ebenaceae	4.66	3.78	3.73	4.03

For the entire FMU, the four species with the highest IVI are, *Erythrophleum ivorense* (16.18), *Alstonia boonei* (14.98) from fabaceae family, *Lophira alata* (11.01) from Ochnaceae and *Musanga cecropioides* (10.55) from Urticaceae. This is very perfect for the tree census at the level of large trees. *Erythrophleum ivorense*, *Alstonia boonei*, *Lophira alata*, *Terminalia superba*, *Guibourtia ehie*, *Pterocarpus soyauxii*, *Desbordesia glaucescens*, *Musanga cecropioides*, *Sacoglottis gabonensis*, *Ceiba pentandra*, *Staudtia kamerunensis*, *Piptadeniastrum africanum*, *Celtis zenkeri*, *Tetraberlinia bifoliolata*, *Pycnanthus angolensis*, *Anopyxis klaineana*, *Eribroma oblonga*, *Plagiosiphon longitubus*, *Distemonanthus benthamianus*, *Nauclea diderrichii* were the most dominant species contributing to the canopy's floristic composition, where large trees result in high IVI values (Table 3).

Table 3. Average importance value index of the most important species (in bold) for the whole tree community and the tree size classes in the FMU025.

Species	IVI			
	Whole FMU	large	Medium	Small
<i>Erythrophleum ivorense</i>	12.36	16.18	18.13	13.20
<i>Alstonia boonei</i>	11.17	14.15	11.02	10.80
<i>Lophira alata</i>	10.50	12.36	10.37	9.06
<i>Terminalia superba</i>	9.49	11.98	8.82	7.72
<i>Guibourtia ehie</i>	8.72	10.48	7.30	6.81
<i>Pterocarpus soyauxii</i>	8.37	9.40	7.26	6.53
<i>Desbordesia glaucescens</i>	7.44	9.03	6.87	5.93
<i>Musanga cecropioides</i>	6.63	8.21	6.59	5.04

Continued

<i>Sacoglottis gabonensis</i>	6.57	7.03	6.13	4.90
<i>Ceiba pentandra</i>	6.30	6.21	6.11	4.86
<i>Staudtia kamerunensis</i>	5.85	5.85	5.81	4.71
<i>Piptadeniastrum africanum</i>	5.66	5.71	5.72	4.64
<i>Nauclea diderrichii</i>	5.11	5.67	5.10	4.53
<i>Tetraberlinia bifoliolata</i>	4.84	5.43	5.00	4.23
<i>Pycnanthus angolensis</i>	4.56	5.11	4.91	4.21
<i>Anopyxis klaineana</i>	3.86	5.10	4.04	3.65
<i>Eribrroma oblonga</i>	3.68	4.81	3.96	3.61
<i>Plagiosiphon longitubus</i>	3.65	4.39	3.91	3.48
<i>Distemonanthus benthamianus</i>	3.53	4.19	3.77	3.48
<i>Celtis zenkeri</i>	3.35	3.93	3.55	3.48

3.3. Conservation Value and Endemism

A total of 276 species were identified in the study site. Of the 276 species identified in the FMU, 41 species are of conservation concern according to the IUCN global Red List 2023 and IUCN local status (Onana, 2011). These species are considered species with high-priority for conservation, including rare species, threatened species. We have 6 endangered species, 11 near Threatened species, and 25 vulnerable species (Table 4).

Table 4. List of high-priority species for conservation found in the FMU09.025.

Family	species	IUCN global status (2022-2023)	IUCN local status (Onana, 2011)
Fabaceae	<i>Detarium microcarpum</i>	VU	VU
Fabaceae	<i>Gossweilerodendron balsamiferum</i>	EN	VU
Fabaceae	<i>Microberlinia bisulcata</i>	EN	VU
Fabaceae	<i>Pericopsis elata</i>	EN	LC
Fabaceae	<i>Tessmannia korupensis</i>	EN	VU
Anacardiaceae	<i>Lannea welwitschii</i>	LC var EN	LC
Papilionaceae	<i>Pterocarpus mildbraedii</i>	LC var VU	VU
Euphorbiaceae	<i>Ricinodendron heudelotii</i>	LC var VU	VU
Malvaceae	<i>Mansonia altissima</i>	LC var. EN	VU
Urticaceae	<i>Musanga cecropioides</i>	LC Var. VU	VU
Euphorbiaceae	<i>Ricinodendron heudelotii</i>	LC Var. VU	LC
Fabaceae	<i>Albizia ferruginea</i>	NT	NT

Continued

Ulmaceae	<i>Celtis tessmannii</i>	NT	NT
Sapindaceae	<i>Chytranthus mannii</i>	NT	LC
Caesalpiniaceae	<i>Didelotia letouzeyi</i>	NT	NT
Meliaceae	<i>Entandrophragma angolense</i>	VU	VU
Fabaceae	<i>Guibourtia demeusei</i>	NT	NT
Irvingiaceae	<i>Irvingia gabonensis</i>	NT	LC
Irvingiaceae	<i>Irvingia grandifolia</i>	NT	LC
Irvingiaceae	<i>Klainedoxa gabonensis</i>	NT	VU
Rubiaceae	<i>Nauclea diderrichii</i>	NT	VU
Combretaceae	<i>Terminalia superba</i>	NT	NT
Ebenaceae	<i>Diospyros crassiflora</i>	VU	VU
Ochnaceae	<i>Lophira alata</i>	VU	VU
Anacardiaceae	<i>Pseudospondias microcarpa</i>	var VU	VU
Caesalpiniaceae	<i>Azelia africana</i>	VU	VU
Caesalpiniaceae	<i>Azelia pachyloba</i>	VU	VU
Rhizophoraceae	<i>Anopyxis klaineana</i>	VU	NT
Fabaceae	<i>Berlinia korupensis</i>	VU	CR
Fabaceae	<i>Brachystegia leonensis</i>	VU	VU
Ebenaceae	<i>Diospyros korupensis</i>	VU	VU
Meliaceae	<i>Entandrophragma candollei</i>	VU	LC
Meliaceae	<i>Entandrophragma cylindricum</i>	VU	VU
Meliaceae	<i>Entandrophragma utile</i>	VU	VU
Clusiaceae or Guttiferae	<i>Garcinia kola</i>	VU	VU
Meliaceae	<i>Guarea cedrata</i>	VU	VU
Meliaceae	<i>Guarea thompsonii</i>	VU	LC
Meliaceae	<i>Khaya ivorensis</i>	VU	VU
Fabaceae	<i>Monopetalanthus microphyllus</i>	VU	VU
Fabaceae	<i>Tetraberlinia korupensis</i>	VU	VU
Ancistrocladaceae	<i>Uapaca korupensis</i>	VU	VU
Annonaceae	<i>Xylopia africana</i>	VU	VU

4. Discussion

4.1. Diversity of the FMU09-025 Forest

The interpretation of diversity indices reflects a better floristic characterization of forest communities (Sonké, 2004; Abada Mbolo et al., 2016; Zekeng et al., 2021). These indices show how rich or poor a forest is in terms of species abun-

dance. A forest is therefore considered rich if it is characterized by a Shannon diversity index greater than or equal to 3.5 (Kent & Coker, 1992). Therefore, our study site, FMU 09-025, at the levels of the whole tree community and the large and medium tree groups had high values of Shannon diversity ($H' > 3.5$) and Fisher- α can, accordingly, be considered very diverse. The forest management Unit harbours rich and diverse trees and maintains a high level of floristic diversity. However, the Shannon-Weaver index of small stems groups is **2.94**, showing that it is not rich and diverse. This is confirmed by the rarefaction species accumulation curve. this curve shows that the rate of species increased with sampling effort and had reached an asymptote, indicating that the diversity of the FMU small stem group had been satisfactorily captured and that even if the sample area increases, the diversity will not increase. However, the Simpson index justifies the representativeness of the flora by some species in terms of their abundance (Sonké, 2004). McElhinny et al. (2005) showed that diversity indices such as Shannon's, Simpson's and Pielou's are only elements of measurement and biodiversity characterization.

It is realized that results from this study showed that the FMU 09-025, species richness varied from 100 to 133 species per ha and that this species richness decreased with tree size groups. The species richness of large trees found in this study (52 ± 23.8 species-ha⁻¹) was different to the values of 119 ± 9 and 96 ± 10 species-ha⁻¹ found in Cameroon Atlantic forest of Okoroba and Yingui, respectively (Fobane, 2017; Zekeng, 2020). However, the number of 276 species found in the FMU09-025 was similar to the 271 species of the semi-deciduous forest of east Cameroon (Zekeng, 2020) and lower than the values of 384 species found in the Akak forest area (Ayamba et al., 2019) but greater than the value of 207 species found in terra firme evergreen forest in the Dja Biosphere Reserve in Cameroon (Djuikouo et al., 2010) and the value of 205 species found in the same sites (Tabue et al., 2016). Moreover his result is also higher than the value of 127 species obtained in a semi-deciduous forest of east Cameroon (Chimi et al., 2018) and the value of 222 species found in the Kimbi-Fungom National Park (Amos et al., 2019).

4.2. Floristic Composition

The different tree diameter classes each had a different assemblage of ecologically dominant species. The most important species found in the three strata included *Erythrophleum ivorense*, *Alstonia boonei*, *Lophira alata*, *Terminalia superba*, *Guibourtia ehie*, *Celtis zenkeri*, *Desbordesia glaucescens*, *Musanga cecropioides*, *Sacoglottis gabonensis*, *Ceiba pentandra*, *Staudtia kamerunensis*, *Piptadeniastrum africanum*, *Nauclea diderrichii*, *Tetraberlinia bifoliolata*, *Pycnanthus angolensis*, *Anopyxis klaineana*, *Eriobroma oblonga*, *Plagiosiphon longitubus*, *Distemonanthus benthamianus*, *Pterocarpus soyauxii* etc. Based on this importance value index, this means that, there was a high abundance of pioneer species that could indicate a more advanced level of forest degradation in the

inventory plot. This means that FMU09-025 is subjected to timber exploitation. Based on field work and field report there has been the illegal exploitation in the form of wild. Some of our sampled plots experienced logging of varying intensity, mirroring the status of a large fraction of forests in the Congo basin (Megevand et al., 2013). This gives rise to different species especially some level of new shoots. It is noted that differences of species along the different strata may be explained by the environment's quality which was consequent to the soil composition and the topography of each habitat (Zekeng, 2020).

4.3. Implications for Biodiversity Conservation

This study found that there are some species with high priority for conservation in the FMU-09-025 which accounted for about 14.9% of all the species identified and measured. This result shows that this FMU requires rigorous attention to the application of standards and rules for sustainable management as well as for biodiversity conservation. Unfortunately, there is limited attention given to this forest unit given the fact that there is rampant cutting down of trees which may result to degradation of this forest unit. If this study is compared with other studies carried out in protected areas in Cameroon, it emerges from this study that production forest areas should also receive at least minimum attention from the point of view of both biodiversity conservation and sustainable management (Gonmadje et al., 2011; Fobane, 2017). From a high standard point on conservation, this study provided the conservation status of the species at a national scale (Onana & Cheek, 2011) as well as the global scale (IUCN, 2020). It reveals that some species were threatened at the global level, while at the local level they were not threatened.

Taking into account that this FMU is being logged, it is urgent to ensure that it is managed sustainably. This study found out that some high-priority species for conservation were recorded across the entire vertical strata of the forest unit. It is noted in Cameroon that the loss of biodiversity in production forests is most often linked to non-compliance with the operator's management plan. Sometimes it is related to non-compliance with low-impact logging standards, which is occasionally unintentional because of lack of knowledge (Ferenc et al., 2018). Therefore, the capacity of the FMU peripheral members to master reduced-impact logging standards should be strengthened to ensure its correct implementation in the field by each logger. This can be very serious with the spirit of no personal gain initiatives which are most of the time frustrate effort that could help the society.

In order to manage and protect this forest from the rampant degradation from human actions, the use of agroforestry should be primordial. There are some researches that have also suggested this observation. For instance Zekeng et al. (2019) point out that agroforestry systems, including agricultural plantations, are the forest's main drivers to non-forest land conversion. They also note the urgency to stop this FMU to avoid the loss or disappearance of the high-priority

species for conservation identified. The intrusion and encroachment of local people into the hunting can be justified because most local people are of the opinion that they do not feel the impact of forest exploitation on their well-being. This means that to protect non timber species in the forest, the council and conservation office at Campo should work hand in glove to make sure that the local hunters are either converted or given alternative sources of income.

5. Conclusion

The Forest Management Unit (FMU09-025) is one of the biodiversity forests around the Campo Maan National Park. The importance of the forest for the conservation of tree diversity within Cameroon is very important given the fact that timber exploitation in the country is frustrating the fate of biodiversity survival. The present study has determined the floristic diversity of understorey and overstorey strata of this FMU. The research has remarked that that the FMU is a rich and diverse ecoregion which must be taken seriously if biodiversity conservation is going to maintain its state in Cameroon It documents that most species inventoried in this forest have Guineo-Congolian-wide distributions and that it is also home to rare and threatened species. This study begins to fill in a significant gap in the floristic knowledge about Cameroon's communal forests. Its results give a first idea of the Communal Forest's diversity. Further studies characterizing plant diversity and biogeography of endemic and rare species in the entire FMU09-025 and other communal forests are required to confirm these first conclusions and gain the data needed to support informed decisions on conservation and more sustainable management of the communal forests of Cameroon. Besides the hosting of plant species of conservation value, this Forest Management Unit house a high number of African elephants and other wildlife species. Thus, its destruction could be very much detrimental to the biodiversity conservation cry in the country.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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