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Vegetation Composition and Structure of the Mount Cameroon Cloud Forest

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Abstract

The study investigated the vegetation composition and structure of the Mount Cameroon cloud forest using two permanent 1-ha plots established at 2026 m and 1858 m elevation within the Etinde Community Forest. The research aimed to provide updated baseline information on this poorly studied ecosystem and establish permanent plots for future long-term ecological monitoring. A total of 4631 woody stems were recorded across all size classes, comprising 35 species, 29 genera, and 22 plant families. Of these, 1219 stems had diameters at breast height (DBH) ≥ 10 cm, while 73.7% belonged to smaller size classes, indicating active forest regeneration. The family Rubiaceae was the most species-rich and abundant, followed by Moraceae and Oleaceae. Species richness differed between plots. The lower-elevation plot (1858 m) contained 25 tree species compared with 19 species in the higher-elevation plot (2026 m), suggesting a decline in diversity with increasing altitude. Only nine species were common to both plots, indicating high species turnover and strong floristic heterogeneity. The regeneration layer (<10 cm DBH) comprised 3412 stems distributed among 15 families and 19 species, with Rubiaceae again dominating. The herbaceous layer contained 18 families, although only three families, Acanthaceae, Piperaceae, and Poaceae, occurred in both plots, demonstrating considerable understory heterogeneity. Diversity analyses revealed moderate species diversity but low evenness. Plot 2 showed higher species richness (50 species) and Shannon diversity (H' = 1.9) than plot 1 (31 species; H' = 1.6), while both plots exhibited high Simpson diversity values (0.9). Structural analyses indicated mature montane forest characteristics, with mean DBH ranging from 20.1 to 25.9 cm and basal areas of 30.5 - 52.1 $m^2 \cdot ha^{-1}$. Overall, the Mount Cameroon cloud forest exhibits low similarity between the two plots and high beta diversity (soresens index = 0.3), strong elevational zonation, active regeneration, and substantial conservation value, particularly as a refuge for the threatened species *Prunus africana*.

Keywords

Vegetation Composition, Vegetation Structure, Cloud Forest, Mount Cameroon

1. Introduction

The world currently contains approximately 4.14 billion hectares of forests, of which 45% are tropical forests. Tropical forests therefore represent the largest forest biome on Earth and are disproportionately important for biodiversity conservation, carbon sequestration, climate regulation and ecosystem functioning [1] [2]. Despite their global importance, they continue to face greater deforestation pressure than other forest types, making their conservation a major international priority [3] [4].

Tropical forests are characterized by extraordinary biological diversity and complex structural organization. Their multi-layered vegetation, high species richness, and intricate ecological interactions make them among the most productive and important ecosystems on Earth. Understanding their diversity and structure is essential for conservation, sustainable management, and climate-change mitigation [5] [6].

These forests are classified into several major types based on climate, rainfall, altitude, and vegetation characteristics. The principal categories include tropical rainforests, moist deciduous forests, dry forests, thorn forests, montane forests and swamp forests. Each type supports distinct plant and animal communities and provides essential ecological services [7].

A cloud forest is a mountain forest characterized by frequent cloud cover at canopy level, high humidity, abundant epiphytes, and exceptional biodiversity [8]. Globally, tropical montane forests cover about 402 million hectares, whereas tropical cloud forests occupy only 50 - 70 million hectares. Cloud forests therefore represent approximately 12% - 17% of tropical montane forest area. Despite their smaller extent, cloud forests are among the most important ecosystems on Earth because of their exceptional biodiversity, high levels of endemism, water-regulation functions, and climate-regulation services [9] [10].

Cloud forests are discontinuously distributed across tropical mountain regions of the Americas, Africa, and Asia [8]. In Cameroon, cloud forests are concentrated in the Cameroon Highlands, particularly on Mount Cameroon, Mount Kupe, the Bakossi Mountains, the Rumpi Hills and Mount Oku [11].

The cloud forest of Mount Cameroon is one of Africa's most remarkable montane ecosystems, occurring mainly between 800 and 2,500 m elevation, and is characterized by persistent cloud cover, rich epiphytic vegetation, high biodiversity, and numerous endemic species [12].

Mount Cameroon lies along the Gulf of Guinea coast in southwestern Cameroon. The mountain's geology is characterized by its active strato-volcanic nature, built upon an older basement and sedimentary layers. Its topography is a direct result of its volcanic activity, featuring an elongated summit, steep slopes, and numerous secondary volcanic cones scattered around its flanks. The mountain's location within the Cameroon Volcanic Line and its proximity to the Gulf of Guinea are critical to understanding its geological and topographical evolution [13].

The eruption history of Mount Cameroon is dynamic, with records beginning from the fifth century, when the Carthaginian explorer Hano, the Navigator named it the "CHARIOT OF THE GODS". Locations and ages of ancient lava flows are not known, because the clear documentation of their eruption history started with the 1909, 1922, 1954, 1959, 1982, 1999, 2000 and up to 2012 when the last eruption occurred with known vents and lava flow tracts. This stratovolcano is thus made up of overlaying and overlapping lavas of varying ages [14]-[16]. Therefore, the soils of Mount Cameroon are predominantly young, highly fertile volcanic soils (Andisols) derived from the weathering of basaltic lava, pyroclastic deposits, and volcanic mudflows (lahars). Periodic volcanic eruptions continually replenish the landscape with fresh volcanic materials, contributing to high soil fertility and making the surrounding region one of the most productive agricultural areas in Cameroon and West Africa [15] [17] [18].

The mountain is internationally recognized as one of Africa's most important biodiversity hotspots. The mountain supports more than 3000 - 3500 plant species and a remarkable diversity of mammals, birds, reptiles, and amphibians. Extending from sea level to 4,095 m, its continuous altitudinal gradient encompasses six major vegetation zones, ranging from coastal and lowland rainforest through submontane and montane cloud forests to montane grasslands and alpine vegetation near the summit [17] [19]-[21].

The cloud forest of Mount Cameroon is formed by the rapid cooling of warm, moist air as it meets cooler, high-altitude air from the Gulf of Guinea. It is maintained by frequent orographic uplift and mist condensation, but is periodically fractured by volcanic eruptions and harbours an extraordinarily rich ecosystem. The cloud forest coincides with the altitudinal range of *Prunus africana* abundance (the bark extract is used for the treatment of prostate hyperplasia), and out of current range of intense deforesting human activities, makes this forest attractive for both long and short-term biodiversity and ecological studies.

Although Mount Cameroon is one of the best-studied tropical mountains in Central Africa, significant gaps remain in our understanding of the diversity and vegetation structure of its cloud forest ecosystem. Most existing research is based on a relatively small network of plots established in the late 1980s and early 1990s, with detailed analyses largely confined to studies by Payton *et al.* [22], Proctor *et al.* [17], and Forboseh *et al.* [20]. These studies have provided valuable baseline information on altitudinal zonation, forest structure and species composition, but several important questions remain unanswered. A recent study by Seraphine *et al.* [23] on altitudinal changes in the floral diversity and carbon stocks failed to include a species checklist, and of the few species mentioned as important showed inappropriate identification. Consequently, the current status, trajectory, and resilience of Mount Cameroon's cloud forest vegetation remain poorly understood, highlighting the need for new permanent-plot studies to provide updated baseline data for conservation and climate change.

The current research was designed to document the vegetation composition and structure of the Mt Cameroon Cloud Forest using permanent plots that will in the future provide useful data on these understudied aspects of Mt Cameroon.

2. Materials and Methods

2.1. Description of the Study Site

Mount Cameroon is an active volcano, located in the South West Region of Cameroon along the Gulf of Guinea between latitude 3˚57' to 4˚28' N and longitude 8°58' to 92°4' E and is the only active volcano along Cameroon volcanic line [24]. It covers a surface area of 58.154 ha. The peak of Mount Cameroon is located at 4°13'00"N 9°10'21"E, rising to an elevation of 4100 m, and is recognized as the highest point in Sub-Saharan western and central Africa [25].

The climate of Mount Cameroon is a highly humid tropical climate, strongly influenced by its proximity to the Atlantic Ocean and its dramatic increase in altitude. It is characterized by exceptionally high rainfall, particularly along the coast, which decreases with altitude. The region is among the wettest in the world. Debundscha, at the base of Mt. Cameroon, receives an average annual rainfall exceeding 10,000 mm [26]. At lower altitudes (below 800 m), temperatures are high and stable, ranging from 18˚C to 26˚C. Temperatures decrease significantly with elevation [27]. A distinct long wet season occurs from April to November, while the dry season runs from December to March. The area is consistently very humid, between 85% and 95%.

The soils of Mount Cameroon are primarily rich, fertile volcanic soils formed from weathered basaltic lavas, pyroclastic flows, ash and lahars. They vary from Andosols on upper slopes to humid ferrallitic soils at lower elevations, characterized by high fertility, slightly acidic to neutral, and high organic matter content, particularly in forest areas. The soils are rich in minerals but often have poor moisture retention capacity due to their porous nature [13] [15] [18].

Mount Cameroon exhibits an uninterrupted altitudinal zonation of six distinct vegetation types spanning from sea level to its volcanic peak. This makes the active volcano a vital biodiversity hotspot rich in Afromontane endemics and successional pioneer species. The Lowland species-rich Rainforest (0 - 800 m) ecosystem, featuring evergreen canopy trees over 40 m high with buttress roots and a high density of lianas and has also been extensively converted into commercial plantations of oil palm, bananas, and rubber. This zone is followed by the submontane Forest (800 - 1600 m), the Montane Forest (1600 - 2000 m), the Montane Scrub (2000 - 2400 m), the Montane Grassland (2000 - 3000 m) and the Sub-Alpine Grassland (3000 - 4100 m) at the top [17] [28]. This lush vegetation supports an exceptionally diverse fauna, characterized by a high degree of altitudinal specialization, regional endemism, and threatened large mammal populations protected by the Mount Cameroon National Park [29]-[31]. They include the endangered primates (chimpanzees, drills), threatened forest elephants at lower altitudes, 86 recorded reptile species, with over 320 butterfly species recorded and is a recognized Endemic Bird Area (EBA), supporting 20 of 28 restricted-range species of Cameroon [32] [33].

This current study was carried out in the Etinde Community Forest, a buffer zone of the Mt Cameroon National Park, on the Eastern slopes of the mountain above Buea, at an altitude of 1800 - 2100 m within the cloud forest. They occur when warm, moisture-laden air from the Atlantic Ocean encounters high mountain slopes and is forced upward, cooling to create persistent fog and clouds at tree level. This constant moisture condensates on vegetation, resulting in high humidity and a unique, constant "horizontal precipitation" that feeds the dense ecosystem [17]. The constant presence of clouds maintains a humidity level near 100%, allowing plants like epiphytes, mosses, orchids and ferns to flourish, even without consistent vertical rainfall, completely covering the stem bark of most species, giving the signature look of a cloud forest [21]. However, the clouds often drift down slope into the city of Buea, seriously affecting visibility at elevations less than 1000 m.

2.2. Data Collection

The study was carried out on two 1-ha plots (100 m × 100 m) laid at two elevations. The first permanent plot was setup at an altitude of 2026 m located 50 m to the grassland and the second at an altitude of 1858m above sea level.

Each 1-ha plot was divided into 16 subplots, each measuring 25 × 25 m for ease of tree sensors for species composition and diameter at breast height measurements, alongside height estimation for forest structure determination. Heights were estimated using a 10 m extendable aluminum pipe placed vertically along the stem of the tree. For easy reference, the subplots were numbered 1 - 4 across the slope and A - D along the slope. Within each subplot, all stems with a diameter at breast height (DBH) ≥ 10 cm were tagged, diameter measured at 1.3 m from the ground using a diameter tape, heights estimated, and recorded. Lianas were shifted and mosses removed around the point of measurement before measuring the diameter. For DBH measurement on slope, the point of measurement was on the uphill side of the tree and for leaning trees, it was measured along the lower side of the tree parallel to the stem axis. For trees with malformation or bombs at 1.3 m from the ground, diameter was measured above 1.3 m and the deviation was noted as comment for that tree. Trees that developed multiple stems before breast height were tagged and measured separately for stems above 10 cm DBH and in the record book, all stems were indicated to belong to the same tree.

Two sampling units (SU) of 10 m × 10 m (100 m^2) were randomly set up within each of the 16 subplots in both plots, resulting to 32 SUs with a total area of 3200 m^2 sampled for saplings and juveniles with DBH < 10 cm but ≥2 cm measured using a diameter tape. The herbaceous layer was assessed using 1 × 1 m quadrates, randomly setup within the 16 subplots in both plots, such that each subplot had 5, for a total of 80 (5 quadrates × 16 subplots) sampling units with a total area of 80 m^2. The herbaceous layer was made up of tree seedlings and herbaceous plants.

All species encountered were identified by a field Botanist from the Limbe Botanic Garden using morphological characteristics and bark slashes alongside appropriate documentation and keys. Voucher specimens were collected for species that could not be identified in the field for later identification at the Limbe Botanic Garden Herbarium.

2.3. Data Analysis

The collected data were first organized in Microsoft Excel, and summarized in tables and charts to determine species composition, then analyzed for diversity indices.

Species richness (S), the total number of species of a population in a given ecosystem, is expressed by the total number of species observed per unit area.

In a community of S species, the Shannon-Weiner index (H') is calculated according to the following formula:

$$H' = -\sum \left(p_i \times \ln \left(p_i \right) \right) \tag{1}$$

where H' is the Shannon diversity index, p_i is the proportion of individuals belonging to the *i*th species, and the summation is taken over all S species in the community.

$H' = 0$ if all the individuals in the stand are represented by one and the same species, or if each species in a stand is represented by a single individual; H' will be at its maximum when all the individuals are equally distributed over all the species. The higher the value of this index, the greater the diversity. A value greater than 3.5 bits indicates high floristic diversity [34].

The Simpson index gives the probability that two individuals selected at random from a population belong to the same species. The formula used to calculate it is:

$$D = 1 - \frac{\sum n(n-1)}{N(N-1)} \tag{2}$$

where D is the Simpson's diversity index "n" is the number of individuals of a particular species, and "N" is the total number of individuals of all species. It is a diversity index that varies between 0 and 1. Where 0 indicates infinite diversity and 1 signifies no diversity [35].

The Pielou's Equitability Index (EQ): This is the ratio between the observed diversity and the maximum possible diversity, given the total number of species N. It is used to compare the diversity of two quadrats with different diversity indices [36].

$$\mathrm{EQ} = \frac{H'}{\log N} \tag{3}$$

with H': Shannon's diversity index, $\log N$ is the logarithm to base 10 of number of species.

Similarity between plots was determined by Soresens's coefficient given by:

$$Cs = 2J/(a+b) \quad (4)$$

where: Cs = Sorensen's coefficient;

J = Number of species shared between plots;

a = Number of species in plot 1.

$$\text{Relative frequency} = \frac{\text{Frequency of a Species}}{\text{Total Frequency of All Species}} \times 100 \quad (5)$$

Stand structure was determined by the distribution of individuals by diameter classes. All results were summarized in tables and charts.

For the estimation of tree Basal Area (m^2), diameter at breast height (D) in meter recorded for each tree was used. The following formula was used to estimate Basal Area

$$BA = \pi D^2/4 \quad (6)$$

where BA is Basal Area (m^2), D is diameter at breast height in meter and π is pi = 3.143 (Constant).

Stem volume was estimated using a form factor of **0.50**, a commonly adopted approximation for mixed tropical forests [37] [38]. Although form factors vary among species and sites, values close to 0.50 are widely used for preliminary volume estimation in tropical forest inventories.

$$V = 0.50 \times BA \times H \quad (7)$$

where V is tree Volume (m^3), BA is Basal Area, and H represents height.

3. Results

This study recorded a total of 4631 tree stands in all size classes for which DBH was measured, made up of 35 species distributed within 29 genera and 22 plant families for both plots 1 and 2. A total of 1219 (26.3%) individuals comprised of tree stems with DBH ≥ 10 cm that all received tags while the remaining 3412 (73.7%) comprised stems with DBH < 10 cm. Rubiaceae was the dominant family represented by 6 species in 6 genera, followed by Moraceae with 4 species in 2 genera and Oleaceae with 3 species in two genera. There were 15 families represented by only one species.

For trees with DBH ≥ 10 cm, plot 1 (2026 m asl) recorded 19 tree species across 19 genera and 16 families for a total of 653 stands, while plot 2 (1858 m asl) was more species-rich with 25 tree species across 23 genera and 17 families, with 566 stands. There were 7 families, 9 genera and 9 species common to both plots 1 and 2. Nine (9) families, 10 genera and 10 species were unique to plot 1 while for plot 2, 12 families, 15 genera and 17 species were unique (**Table 1**).

The most abundant family of plot 1 was Rubiaceae [181 individuals in three genera; *Ixora* (132), *Psydrax* (38) and *Pavetta* (11)]. The families Aquifoliaceae (75 individuals) and Oleaceae (71 individuals) came in second and third places respectively. Although the family Rutaceae was represented by two genera, the stem count was small (5) just ahead of Primulaceae with only two individuals and Cornaceae represented by one individual (**Table 1**). In plot 2, Pittosporaceae recorded a stand density of 112 with one species, Oleaceae had 102 stems in three species, followed by Stilbaceae with 81 individuals in one genus and *Prunus africana* of Rosaceae with 75 individuals.

Among the common Families in the two plots, *Nuxia* recorded (60 + 81), *Prunus* (13 + 75) and *Olea* (71 + 13) as the most abundant genera, while *Zanthoxylum* (1 + 1) was the least represented (**Table 1**).

Data from the trees (<10 cm DBH) censored in the two plots revealed a total stem count of 3412, belonging to 15 families, 19 genera and 19 species. There were 8 families common to both plots, with 7 and 6 unique to each of plots 1 and 2 respectively. The family Rubiaceae was the most represented with five genera (*Psychotria* with 804 stands, *Ixora* 200, *Psydrax* 137, *Pavetta* 124), in both plots. However, *Coffea* (25) was recorded only in plot 2. The family Oleaceae followed with one species, (*Olea capensis*), having 144 individuals from both plots and *Nuxia congesta* with 112 individuals in plot two only. The least represented family was Bignoniaceae, with single stand of *Kigelia Africana* in plot 1 only, followed by *Rapanea melanophloeos* of the family Primulaceae with 6 individuals in plot one only (**Table 2**).

Several families, genera and species represented in ≥10 cm DBH size class were absent in the lower size class and vice versa. In plot 1, 11 plant families were represented in both size classes ≥ 10 cm and <10 cm DBH, while in plot 2, only 8 families were common to both size classes.

Four and nine families were present at the ≥10 cm DBH class respectively, while Bignoniaceae and Urticaceae were only present in the <10 cm DBH size class for plots 1 and 2 respectively.

At species level and in plot 1, while the families Primulaceae and Rutaceae were represented at both size classes, their respective species, *Maesa lanceolata* and *Zanthoxylum* sp., only occurred at the ≥10 cm DBH class. *Psychotria peduncularis* of Rubiaceae was only recorded at the ≥10 cm DBH class.

In plot 2, *Zanthoxylum* was also not represented in the <10 cm DBH size class, while *Psychotria, Coffea* and *Ixora* were only present in the small stem size class.

Table 1. Species composition and frequency of occurrence of stands DBH ≥ 10 cm in two plots within the Mount Cameroon cloud forest.

Family	Species	Abundance	
		Plot 1	Plot 2
Araliaceae	*Schefflera mannii* (Hook.f.) Harms	43	1
Ericaceae	*Agauria salicifolia* Hook. f ex Oliver	36	1
Oleaceae	*Olea capensis* L.	71	13
Rosaceae	*Prunus africana* (Hook. f.) Kalkman.	13	75

Continued

Rubiaceae	*Pavetta hookeriana* Hiern.	11	13
	Psydrax dunlapii Gaertn.	38	11
Rutaceae	*Cluasena anisata* Hook. f. ex Benth.	4	10
	Zanthoxylum sp.	1	1
Stilbaceae	*Nuxia congesta* R. Brown ex Fresenius	60	81
Aquifoliaceae	*Ilex matis* (L.) Radlk	75	-
Cornaceae	*Alangium Chinense* (Lour.) Harms	1	-
Monimiaceae	*Xymalos monospora* (Harv.) Baill.	5	-
Moraceae	*Ficus sur* Forssk	14	-
Myrtaceae	*Syzygium staudii* (V. Engl.) Mildbr.	36	-
Primulaceae	*Rapanea melanophloeos* (L.) Mez.	10	-
	Maesa lanceolata Forssk.	2	-
Pittosporaceae	*Pittosporum senacia* Putt.	96	-
Rubiaceae	*Ixora foliosa* Hiern.	132	-
Sapindaceae	*Allophylus bullatus* Radlk.	5	-
Moraceae	*Ficus mucuso* Walw. ex Ficalho	-	1
	Trelepisium madatascrienses DC.	-	1
	Ficus lutea Vah.	-	13
Myrtaceae	*Syzygium paniculatum* Gaertn.	-	7
Oleaceae	*Strombosia ceylanica* Gardner.	-	86
	Strombosia blume Benth. Et Hook. f.	-	3
Pittosporaceae	*Pittosporum undulatum* Vent.	-	112
Annonaceae	*Xylopia staudtii* Engl. & Diels.	-	25
Araliaceae	*Polyscia fulva* (Hiern) Harms.	-	11
Bignoniaceae	*Tebubuia rosea* (Bertol.) DC.	-	5
Elaeocarpaceae	*Sloanea manifelia*	-	2
	Plagiostyle sp.	-	28
	Macaranga campensis Benth.	-	17
Lamiaceae	*Vitex rivularis* Gurke.	-	40
Meliaceae	*Entandropragma utile* (Dawe & Sprague) Sprague	-	3
Lauraceae	*Laurus nobillis*	-	6
	Total	**653**	**566**

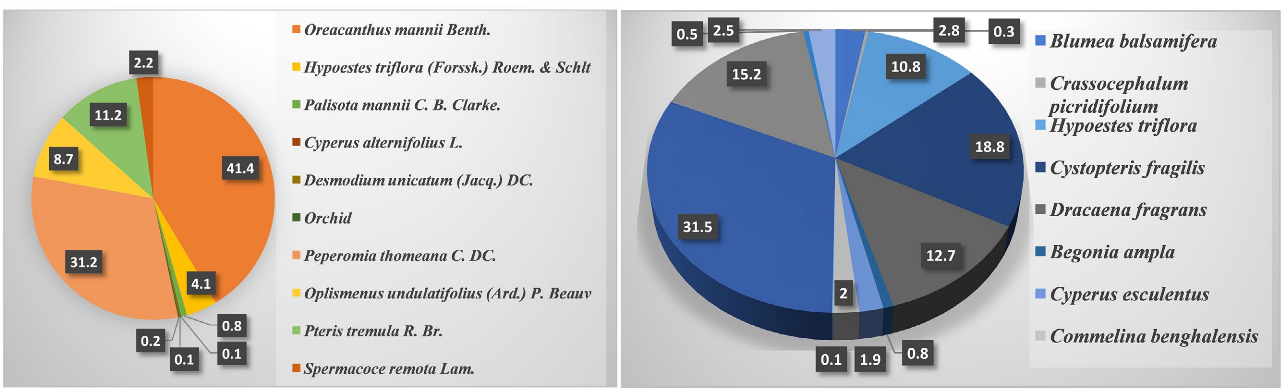
Table 2. Species composition of stems with diameter < 10 cm in two plots within the Mount Cameroon cloud forest, indicating presence (+) or absence (−).

Family	Species	Abundance	
		Plot 1	Plot 2
Aquifoliaceae	*Ilex mitis* (L.) Radlk.	+	+
Oleaceae	*Olea capensis* l.	+	+
Rosaceae	*Prunus africana* (Hook. f.) Kalkman	+	+
Rubiaceae	*Psydrax dunlapii* Gaertn.	+	+

Continued

	Ixora foliosa Hiern.	+	+
	Pavetta hookeriana Hiern.	+	+
	Psychotria peduncularis (Salisb.) Steyerm	+	+
Rutaceae	*Clausena anisata* Hook. f. ex Benth	+	+
Bignoniaceae	*Kigelia africana* (Lam.) Benth.	+	−
Monimiaceae	*Xymalos monospora* (Harv.) Baill.	+	−
Moraceae	*Ficus sur* Forssk.	+	−
Primulaceae	*Rapanea melanophloeos* (L.) Mez	+	−
Myrtaceae	*Syzygium staudii* (V. Engl.) Mildbr.	+	−
Pittosporaceae	*Pittosporum senacia* Putt.	+	−
Sapindaceae	*Allophylus bullatus* Radlk.	+	−
Lamiaceae	*Vitex rivularis* Gurke	−	+
Rubiaceae	*Coffea canaphora* Pierre ex Froehner	−	+
Rutaceae	*Clausena anisata* Hook. f. ex Benth	−	+
	Zanthoxylum martinicense (Lam.) DC.	−	+
Stilbaceae	*Nuxia congesta* R. Brown ex Fresenius	−	+
Urticaceae	*Boehmeria cylindrica* (L.) Sw.	−	+

The herbaceous layer of the cloud forest plots was found to contain 18 plant families, with three (Acanthaceae, Piperaceae and Poaceae) common to both plots. Plot 1 recorded 9 families unique to it, while plot 2 recorded 12 families, with 9 unique. The most abundant family was Acanthaceae with two, followed by Piperaceae with a single species for plot1, while Piperaceae, Aspleniaceae, and Poaceae in that order, recorded the highest counts for plot two. The least represented families were Cyperaceae and Fabaceae for plot 1 and Cyperaceae and Lamiaceae for plot 2 (**Figure 1**).



(A) (B)

Figure 1. Percentage coverage of herbaceous species in plot 1 and plot 2, respectively, of the Mount Cameroon cloud forest.

The calculated values for species richness, Shannon-Wiener index, Pielou's Equitability index and Simpson's index for both plots are presented (**Table 3**).

Table 3. Diversity Indices for species of plot 1 and plot 2 of the Mount Cameroon cloud forest.

Index	Value Plot 1	Value Plot 2
Species Richness	31	50
Shannon-Wiener Index (H')	1.6	1.9
Pielou's Equitability Index €	0.03	0.02
Simpson's Index	0.9	0.9
Sorences	0.3	

Size class distribution for trees with diameter at breast height ≥ 10 cm is presented (**Figure 2**) for plots 1 and 2 respectively, indicating a reverse J, with more stems at smaller size classes than the very large trees.

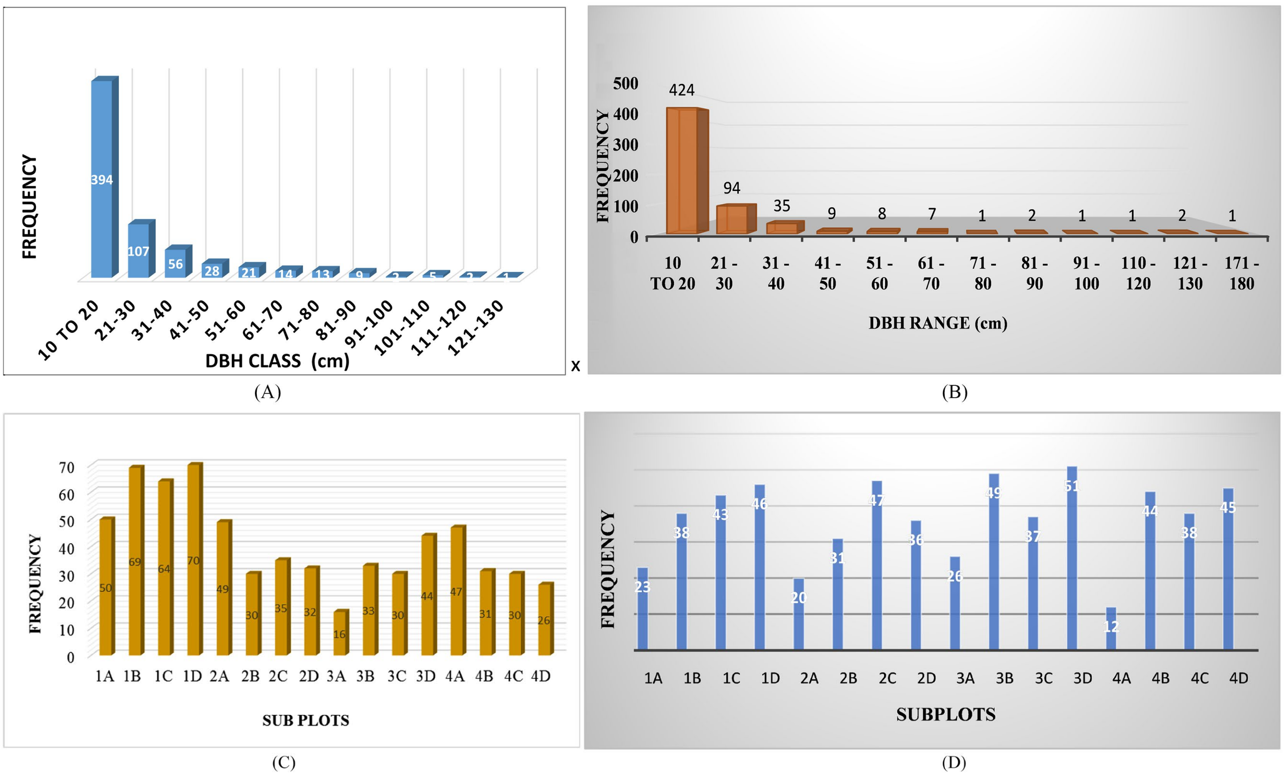


Figure 2. Size class distribution of trees plots 1 (A) and 2 (B); Distribution of trees BDH ≥ 10 cm within subplots of plot 1 (C) and plot 2 (D) of the Mount Cameroon cloud forests.

The distribution of woody species with BDH ≥ 10 cm on the forest floor of the two plots showed that subplots 1B, 1C and 1D had the highest number of stems per unit area, while 3A had the lowest for plot 1. Sub plots 3D, 3B and 2C in that order recorded the highest number of stems, while 4A and 2A recorded the least stem count in plot 2 for that DBH class.

Linear dimensions of trees with DBH ≥ 10.1 cm measured in plot 1 mean DBH of 25.9 cm (range 10 - 126.5 cm) for plot 1 and 20.1 cm (range 10.3 - 186.6 cm) for plot 2. The mean height of these same trees in plots 1 and 2 was 20.9 m (range 15 -

27.9 m) and 18.2 m (range 5 - 40 m) respectively (**Table 4**).

Table 4. Summary statistics of diameter and height of trees with DBH ≥ 10 cm sampled in two 1-ha plots in the Mount Cameroon cloud forest.

Section	Variable	N	Mean	Min	Max	St Dev
Plot 1	DBH (cm)	653	25.9	10.1	126.5	20.9
	Height(m)	653	20.9	15	27.7	8.1
Plot 2	DBH (cm)	566	20.1	10.3	186.6	16.6
	Height (m)	566	18.2	5.0	40.0	5.3

Basal area and stand volume calculations for species with DBH ≥ 10 cm indicated a total basal area of 52.057 m^2 and a stand volume of 601.53 m^3 for plot 1. Three species, *Ilex matis* (BA = 11.98 m^2, stand volume 138.131 m^3), *Nuxia congesta* (10.002 m^2, 140.273 m^3) and *Schefflera manni* (8.366 m^2, 102.442 m^3) contributed 58.3% of basal area and 63.3% of the stand volume in this plot. The total basal area and stand volume for the same category of trees in plot 2 were 30.5 m^2 and 394.7 m^3 respectively. Again, three species that contributed a total of 64% of basal area and 67.8% of stand volume in this plot were *Strombosia ceylanica* (9.922 m^2, 142.815 m^3), *Pittosporum undulatum* (4.846 m^2, 56.903 m^3) and *Prunus africana* (4.703 m^2, 66.406 m^3).

4. Discussion

The Mount Cameroon cloud forest exhibits many features typical of tropical montane cloud forests. A total of 4631 woody stems were recorded across the two permanent plots, representing 35 species, 29 genera, and 22 families. Of these, 1219 stems had DBH ≥ 10 cm, while 73.7% consisted of smaller stems (<10 cm), indicating active regeneration. Rubiaceae was the dominant family, followed by Moraceae and Oleaceae. The dominance of Rubiaceae is consistent with findings from other African cloud forests, where members of this family are well adapted to cool, humid, and shaded montane environments [39] [40].

Species richness varied between plots, with the lower-elevation plot (1858 m) recording 25 species compared with 19 species in the higher-elevation plot (2026 m). This pattern supports the commonly observed decline in species richness with increasing elevation due to harsher environmental conditions such as lower temperatures, persistent cloud cover, and nutrient limitations [39] [40]. Only nine species were common to both plots, indicating high floristic turnover and strong beta diversity, characteristics typical of tropical montane cloud forests [10].

The regeneration layer (DBH < 10 cm) also displayed considerable floristic heterogeneity. Common regenerating species included *Ilex mitis*, *Olea capensis*, *Prunus africana*, and several Rubiaceae species, suggesting broad ecological tolerance and their importance in forest regeneration. Numerous species occurred exclusively in individual plots, reflecting habitat specialization and the influence of local environmental conditions on regeneration dynamics [39] [41]. The occurrence of

Prunus africana is particularly significant because this economically valuable and threatened species is heavily exploited throughout Africa for medicinal bark. Its substantial contribution to stand structure and biomass, especially in plot 2, highlights the Mount Cameroon cloud forest as an important refuge for Afromontane biodiversity and a priority area for conservation [42] [43].

The herbaceous layer exhibited similarly high spatial heterogeneity. Eighteen herbaceous families were recorded, but only three families were common to both plots. Acanthaceae, Piperaceae, and Poaceae dominated the understory, while many families were poorly represented. Such patterns indicate strong environmental filtering and microhabitat specialization, which are common features of cloud forest understories [44] [45]. The predominance of shade-tolerant and moisture-dependent taxa further confirms the cloud forest character of the study area.

Diversity indices indicated moderate species diversity but low species evenness. Plot 2 exhibited higher species richness (50 species) and Shannon diversity ($H' = 1.9$) than plot 1 (31 species; $H' = 1.6$), suggesting that lower elevations support greater species coexistence. However, very low Pielou's equitability values revealed strong dominance by a few species. Similar Simpson's index values (0.9) in both plots indicate relatively high overall diversity despite uneven species distributions, a common feature of cloud forests where environmental conditions favor a limited number of highly adapted taxa [10] [46].

Structural analyses revealed characteristics of mature montane forest. Mean DBH values were 25.9 cm and 20.1 cm in plots 1 and 2, respectively, while mean tree heights ranged from 18.2 to 20.9 m. These values fall within the range commonly reported for African montane cloud forests, which generally possess shorter canopies than lowland forests because of cooler temperatures, persistent fog, and strong winds [47]. The presence of very large trees, with diameters exceeding 120 cm, suggests the persistence of old-growth individuals and relatively low levels of disturbance.

Basal area and stand volume further demonstrated the structural importance of the Mount Cameroon cloud forest. Plot 1 recorded a basal area of 52.06 $m^2 \cdot ha^{-1}$ and stand volume of 601.53 $m^3 \cdot ha^{-1}$, while plot 2 recorded 30.5 $m^2 \cdot ha^{-1}$ and 394.7 $m^3 \cdot ha^{-1}$, respectively. In both plots, a few species contributed disproportionately to total biomass. *Ilex mitis*, *Nuxia congesta*, and *Schefflera mannii* dominated plot 1, whereas *Strombosia ceylanica*, *Pittosporum undulatum*, and *Prunus africana* dominated plot 2. Such biomass concentration in a few dominant taxa is typical of tropical montane cloud forests and reflects strong environmental filtering [45] [48].

5. Conclusions

Overall, the Mount Cameroon cloud forest shares many characteristics with other African cloud forests, including high beta diversity, strong elevational zonation, and dominance by a few ecologically important species. However, the exceptionally high species turnover, significant populations of *Prunus africana*, and the influence of volcanic history make this ecosystem particularly unique and underscore the need for conservation across the entire elevational gradient.

Its structural analysis reveals a forest with good regeneration, an indication of high potential for carbon sequestration and livelihood of local populations if well managed.

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Conflicts of Interest

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

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