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Floristic Diversity and Stand Structure of the Ngambe-Ndom-Nyanon Communal Forest, Littoral Region of Cameroon

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Abstract

The present study aimed to contribute to the sustainable management of the Ngambe-Ndom-Nyanon communal forest in Cameroon. Thus, an evaluation of the floristic diversity and stand structure of the forest was carried out. By using systematic sampling, a diverse inventory of the plant species was carried out, taking into account the dendrometric measurements of all the species present in the forest (trees, shrubs, herbs). Data were analyzed with Microsoft Excel software to bring out curves and histograms. This software also made it possible to produce tables and also to come up with different diversity indexes. A total of 19,007 individuals from 395 plant species grouped into 99 families were identified in the area. The family Euphorbiaceae was the most represented. Species dominated in this stand were *Uapaca guineensis* and *Pycnanthus angolensis* with 9% and 6% of individuals identified. The result of the Shannon index showed that all the strata in the forest are diversified with the highest values in the adult secondary forest (FSA) with indices of 4.74, followed by young secondary forest (FSJ) and the secondary forest (FS) with indice respectively 4.68 and 4.61. The values of the Sorensen index show that 100% of species are common in the young secondary forest (FSJ) and the adult secondary forest (FSA). In the same forest, the FSA and Swamp with FSJ and Swamp have just 15% of species in common respectively. This diversified forest stand projects an inverted J structure, thus testifying to its strong potential for stems of the future. According to the research objectives, some measures were proposed for sustainable management of this forest, such as the reforestation of areas degraded by agricultural activities and the promotion of agroforestry practices by using trees with the high fertilizing potential to improve agricultural yields while preserving the trees in place.

Keywords

Floristic Diversity, Stand Structure, Floristic Index, Dendrometric

1. Introduction

The Congo Basin is the second largest forest area in the humid tropical zone after the Amazon for its wealth of natural resources and its biodiversity. Tropical rainforests are among the most valuable and important ecosystems on the planet and are the most species-rich area of the world (Hill & Hill, 2001; Thies et al., 2011). They contain over 50% of species with the enormous wealth of animals such as insects, amphibians, reptiles, mammals and birds (Gibbs et al., 2007; Sedlacek et al., 2007). They have generally been recognized as essential for the survival of humanity thanks to their multiple biological, ecological, economic and socio-cultural functions (CIRAD-FRA, 2009). These forests constitute important critical habitats in terms of the biological diversity they contain and in terms of the ecological functions they serve (SCBD, 2001). One of the most remarkable examples is that of the forests of the Congo Basin representing one of the regions in the world which has vast interconnected expanses of tropical rainforest supporting a great diversity of plants (Tadjuidje, 2009). According to Megevand et al. (2013), the Central African forest has an important potential for floristic diversity, an estimated more than 10,000 species of which 3000 are endemic. For these reasons, more than 800 million people in this area depend on tropical forests for fuel, timber extraction, and non timber forest products (NTFPs) (Chomitz et al., 2007). Such activities may have affected tropical forests through fragmentation, deforestation and land degradation which are the greatest threat to ecological services provided by these forests (Hansen et al., 2020).

The Cameroon forest is one of the important components of this forest block with about 20 million hectares (ha) of tropical rainforests (MINFOF, 2006). Cameroon is the second country in Central Africa with several plant species (8260 species) after the DRC (MINFOF, 2006). The estimate was revised downwards more precisely with 7850 plants species including 815 threatened with extinction (Onana & Cheek, 2011). The exploitation of timber was considered an important source of income from forests. Moreover, the potential of exploitable species on the basis of the current conditions of the timber market amounts to approximately 750 million cubic meters; and timber is Cameroon's second export resource (30%) after oil (60%) (Nkomé, 2010).

Studies conducted by the FAO (1991) revealed that more than 17 million hectares of forests disappear each year in the world, representing an annual loss of 1.2% of tropical forests (FAO, 2004). For a long time, the management of natural resources was not a priority for the governments and development projects of the countries of the region. But in recent years, it appears that it is the very basis of agricultural and pastoral production that is threatened if nothing is done.

There is indeed a narrowing of the ecological margin and a decline in biological diversity, while at the same time, on the markets, the prices of products derived from natural resources are low, take little account of the ecological dimension, cities increase, and induce deforestation, etc. In order to remedy this situation, particularly in terms of technological innovations, choice of agricultural model, and involvement of populations in the management of forest resources (FAO, 2004). The rate of deforestation in Cameroon forests including council forest remains one of the highest in the Congo Basin (Tchatchou et al., 2015). According to the Food and Agricultural Organization (FAO), between 2000 and 2010, the annual rate of deforestation of Cameroon's tropical rainforest of the Congo Basin was approximately 1.04%. Furthermore, it is reported that about 75% of the forest in Cameroon (including council forest) has been degraded as a result of forest exploitation (Mayaux et al., 2013). As a result, development and conservation experts as well as indigenous rights advocates have embraced the management of council forests to address deforestation and forest degradation as well as improve the livelihoods of communities that depend on these forests. Management of these forests allows local populations to benefit from forests and their resources, as opposed to outside entrepreneurs or economic and political elites. By acquiring rights over natural resources and related increases in organizational strength, the residents of the municipality as well as the local population can also improve participation in democratic processes (Tchatchou et al., 2015). Communal control over these forests therefore decreases the opportunities for nonlocals to engage in destructive forest use, resulting in a positive conservation impact.

Council forest is a forest that constitutes part of Cameroon's permanent forest, which is governed by an agreement between the municipality and the Ministry of Forests and Fauna (Alemagi et al., 2016). Cameroon's council forests are usually endowed with a management plan executed by the council or municipality under the supervision of MINFOF. Conservation policies have often created conflicts between governments, development agencies and local people. These policies have very often ignored the dependence of these communities on their territory. In many cases, local communities have been evicted from their habitats without being provided with suitable alternatives in terms of work and sources of income (Temgoua, 2007). The 1994 forestry law divides the forestry sector into Permanent Forest Estate (DFP) and Non-Permanent Forest. Within the meaning of this law, the local populations benefit from the right of use, which is the right to exploit all forest, wildlife and fish products with the exception of protected species for personal use (MINEF, 1994). The sad fact is that the overexploitation caused by the production of firewood (Madi et al., 2003). With the advent of natural environment conservation zones, local communities living in protected areas or on their outskirts, and who depend directly on natural resources to meet their basic needs, feel cheated by forest administrations.

The problem encountered by the communal forest management service of the Ngambe council is: the lack of financial means to develop and monitor the forest, pay the employers of the municipal councils, donate community huts, health ceneters, potables waters, etc. to neighboring communities; no data base on the potential of the Ngambe forest and outside the management plan which is obsolete; no data on fauna monitoring and carbon; no data on sites of cultural importance (in short information that can guide forest management); no data on the are encroached by the local communities to develop agricultural land in the communal forest. Given the errors of the past, it, therefore, seems essential to rethink not only the choice of areas to be conserved but also the management approaches, which must reconcile conservation and the satisfaction of local populations (Temgoua, 2007). These operations, therefore, remain a major ecological concern, as they threaten ecosystem services and could contribute to the disappearance of species that have not yet been identified or are in danger (Laurance et al., 2009). Knowledge of the floristic potential is important to assess wood resources in order to measure the immediate effect of deforestation on the density and floristic richness of trees.

2. Methodology

2.1. Description of the Study Area

The Ngambe-Ndom-Nyanon communal forest is between latitudes 4˚14'53" and 4˚29' North and the longitudes 10˚35'05" and 10˚49' Est. It covers an area of 46,875 ha. Located in the Littoral region of Cameroon, in the Sanaga Maritime Division (**Figure 1**).

2.2. Climate and Vegetation

The rainfall regime as a whole is characterized by four distinct seasons. The distribution of the annual precipitation cycle can be summarized as follows: a long wet season from September to November; a long dry season from December to February; a small wet season from March to May; and a small dry season from June to August. The monthly average is 27˚C and the area is characterized by a relatively uniform temperature throughout the year; the thermal amplitude is low (Letouzey, 1985). The average annual rainfall is 2600 mm, spread over 205 days.

The vegetation of Ngambe-Ndom-Nyanon communal forest is a transition zone between the semi-deciduous forest and the Atlantic forest (Letouzey, 1985). The characteristic species of the Atlantic Forest are: *Lophira alata, Pycnanthys angolensis*. For the semi-deciduous zone, we have; *Afzelia africana, Altonia congensis*. The fauna ranges from large endangered mammals to tiny insects. The zone is home to so many species including rare and fully protected species.

2.3. Data Collection

2.3.1. Sampling Design

The method applied here was that of a development inventory as prescribed in Order No. 0222/A/MINEF of 25 May 2001. The sampling was a systematic sampling

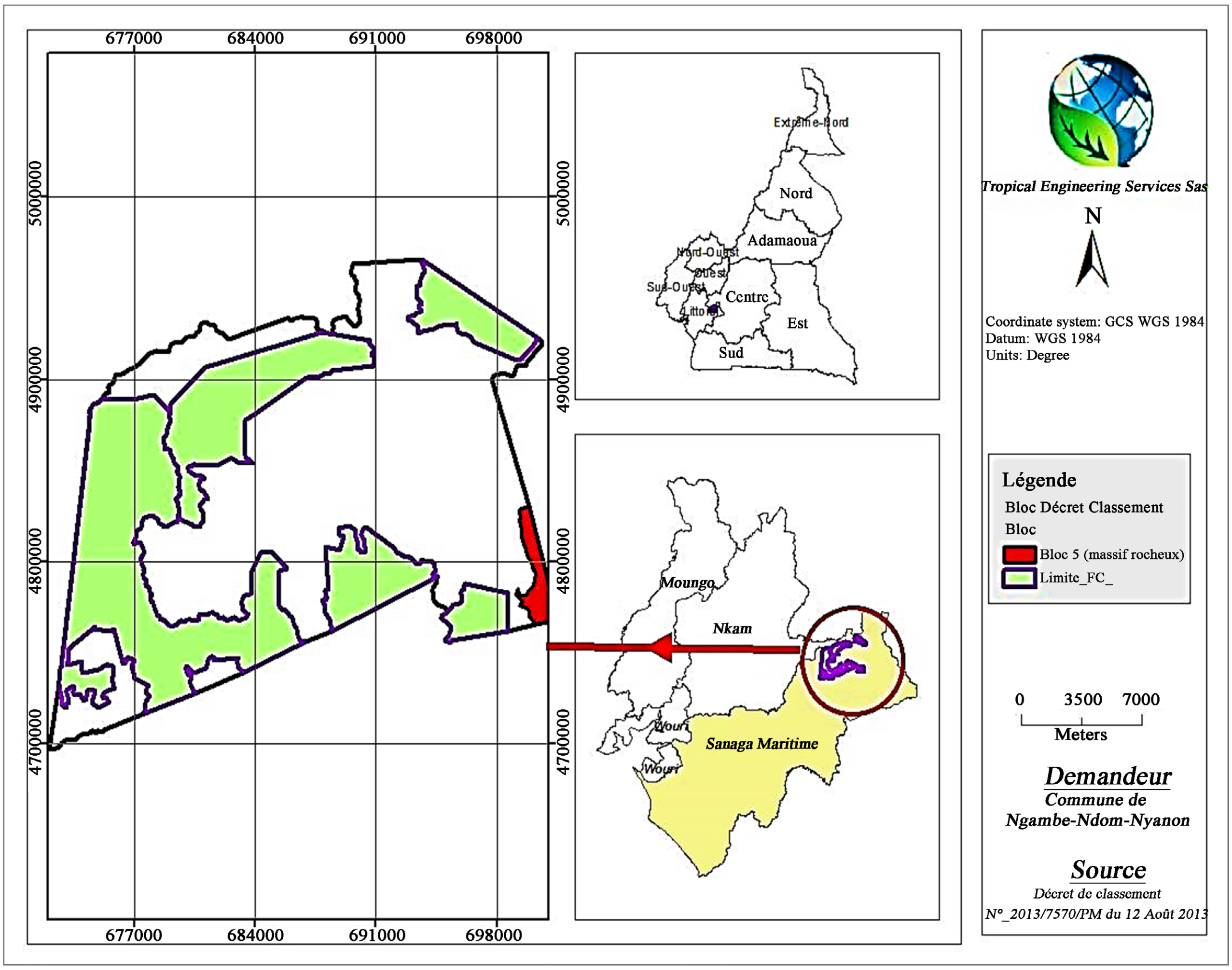

Figure 1. Location of the Ngambe-Ndom-Nyanon communal forest.

at 1 degree with sampling plots positioned continuously on transects that are equidistant and parallel. The sampling lines were as much as possible perpendicular to the general orientation of the river network so that the variability of vegetation types is best represented in the sampling. The plot as the basic unit of sampling was situated longitudinally on the counting transect; its surface was 0.5 ha with the dimensions of 250 m length (in the direction of the transect) x 20 m width (perpendicular to the transect direction) (**Figure 2**).

2.3.2. Sampling Intensity

The sampling intensity depends on the variability of a required parameter in the whole population and the decision which is taken concerning the precision of the estimation of this parameter. The required parameter in this case, is the volume of the group of the principal exploited species. The Cameroonian norms state that a number of 500 plots shall be sufficient to obtain a precision of 10% for the volume of the main exploited species on the probability threshold of 95%. Accordingly, the sampling intensity in this case was: 250 ha/12.083ha = 2.07%. The corresponding equidistance (E) of the transects was then:

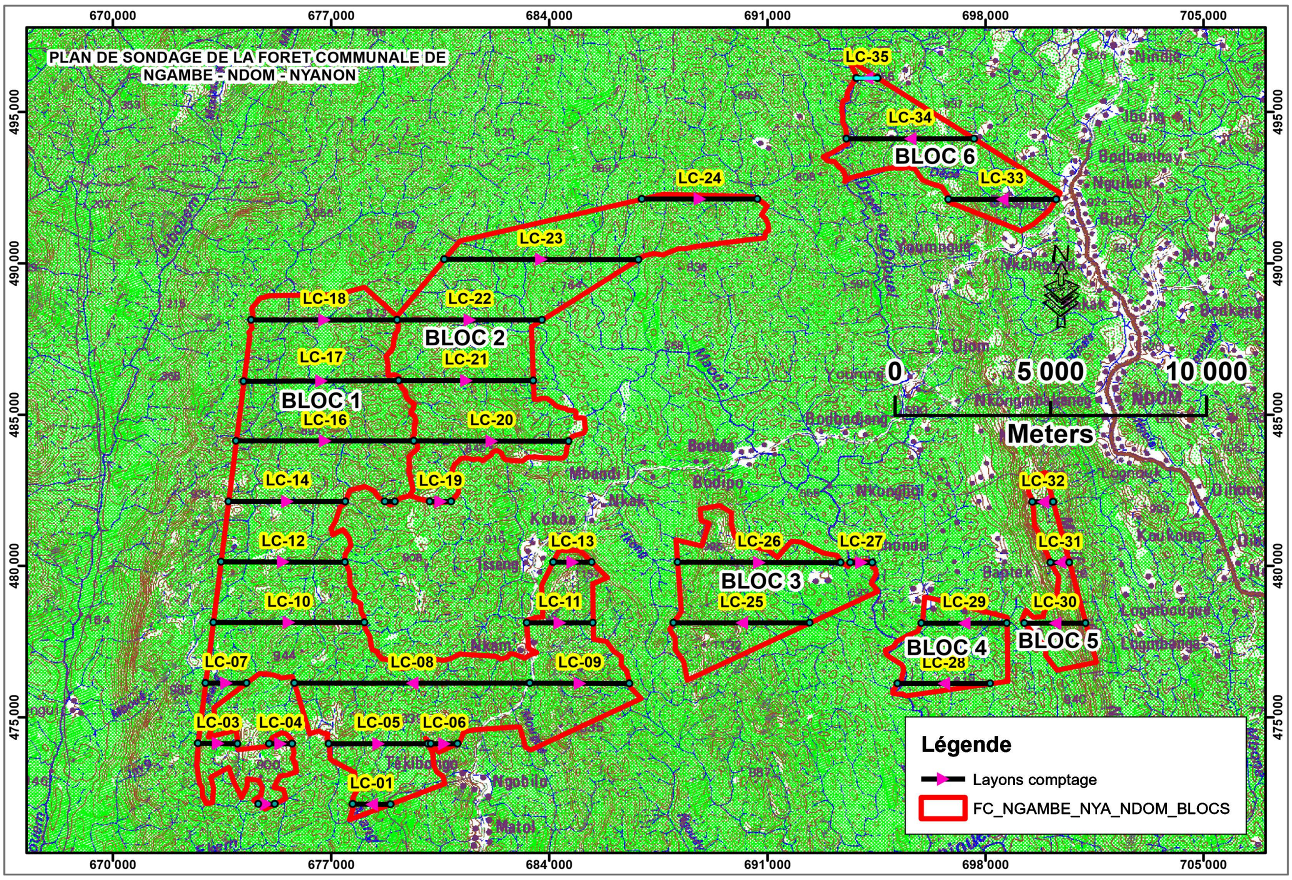

Figure 2. Survey plan of the Ngambe-Ndom-Nyanon communal forest.

Table 1. Provisional technical basis.

Total surface area	20,401 ha
Survey rate	1%
Surveyed are	204.01 ha
Plot area	0.5 ha
Number of plot	408
Length counting lanes	102,005 m
Equidistance	2000 m

- E = Area to be covered by the inventory (ha) × 20 m/250ha;
- E = 2000 m;
- Where E was the equidistance.

A total of 102.05 Km of counting transects were temporally established to be opened in the field, corresponding to a total of 408 sampling plots (Table 1).

2.3.3. Diversity Inventory Technic

It was carried out by an inventory team made up of 10 persons (a team leader; a pointer to record the data collected; two prospectors for circumference measurement; two chainmen to materialize the limits of the plot; one botanist for recognition of species; one compass manipulator for orienting; one head macheter to open the plots; and one local worker).

During this phase, random sampling was carried out with a survey rate of 1% of the total study area. Count plots were placed on a map. On the ground and using a GPS, the 250 m long and 20 m wide paths on each side of the path were delimited using a measuring tape. Within each plot, all trees with a diameter at breast height (DBH) ≥ 5 cm and all shrubs were systematically recorded and their diameter was measured at the height of 20 cm. Trees with a diameter smaller than 5 cm were considered as regeneration (Mahamane & Saadou, 2008).

2.4. Analysis

The data collected in the field were inserted into Microsoft software excel version 2013 to bring out curves and histograms. This software also made it possible to produce tables and also to come up with different diversity indexes.

2.4.1. Floristic Characteristics

- **Compositional diversity**

The species and families were classified according to the type of land cover, and the specific richness was established, that was the number of species per hectare. The specific contribution was also calculated by the following formula.

$$X = \frac{n_i}{N} \quad (1)$$

where X= specific contribution; n_i = Total number by species; N = Total workforce.

The Shannon diversity index was used to measure or assess the level of organization of the ecosystems (Cancela Da Fonseca, 1980 quoted by Ntoupka, 1999). Diversity was seen in systems as a measure of the organization of the system and the degree of sensitivity to disturbances. An optimal organization is one for which disturbances cannot have a reduced impact on diversity (Thorgnang, 2000). Diversity indicates how individuals are distributed among the different species represented within a community. It is a dispersion parameter whose measurements are obtained, among other things, by the Shannon index and the Piélou Equitability calculated using the Past 3 software.

- **The Shannon Diversity Index (ISH)**

$$\text{ISH} = -\sum N_i/N \log_2 N_i/N \quad (2)$$

With N_i = number of species i; N = number of all species. ISH is expressed in bits. It is the most widely used and recommended index in the comparative study of stands because it is independent of the size of the population studied. The value of the diversity index is less than 3, this would mean that the population is not diversified and if this value is greater than 3, then the population is said to be diversified (Thorgnang, 2000).

- **The Equitability of Piélou (EQ)**

$$\text{EQ} = \text{ISH} \log_2 N \quad (3)$$

where N is the ratio of the diversity of a stand or a sample and the number N of species present in the plot, it expresses the equitable distribution of individuals within species. This index varies between 0 and 1. When a species constitutes the majority of the population EQ tends towards 0. EQ tends towards 1 when all the species have the same abundance. Low equitability represents high importance of a few dominant species (Dajoz, 1982).

- **Sørensen's β index**

This other index measures the similarity in species between two or more habitats.

$$\beta = (2c)/(S1 + S2) \tag{4}$$

c represents the number of common species between two habitats. $S1$: represents the number of species for habitat 1. $S2$ represents the number of species for habitat 2. The index varies from 0 when there are no common species between the two habitats to 1 when all the species found in habitat 1 also exist in habitat 2.

2.4.2. Horizontal Structure

For the characterization of the structure of the stands encountered, it was by making a distribution of the species inventoried by class of diameter. They were grouped for each species by diameter class in order to be able to produce a population table for each type of land occupation and for all the species inventoried using the diametrical structure developed by Smith et al. (1997). With regard to the horizontal structure, the spatial structuring of the stems over the entire terror has been illustrated. The density by species and by habitat has been illustrated. The stand density was estimated based on three elements: the number of stems per unit area, the size of the stems and the spatial distribution. The density was calculated using the following formula:

$$D = N/S \tag{5}$$

with N = numbers of individuals; S = Total area inventoried; and D = Species density.

3. Results and Discussions

3.1. Results

3.1.1. Floristic Characteristics

1) Sampling effort and ecological profile

Among the 408 plots planned, the surveys were carried out on 406 plots at a distance of 93,232 m, i.e., a realization rate of 91.39% covering the blocs 1, 2, 4, 5, 6 of the Ngambe-Ndom-Nyanon communal forest. A total of 19,007 individuals have been identified corresponding to 395 species grouped into 99 families. The flora of the natural formation is dominated by the trees layer (61%), followed by the shrubs (32%), and lastly the herbaceous (7%) (**Table 2**).

2) Specific contributions

The data processed show that the most species represented were *Uapaca*

Table 2. Proportion of different biological forms present in the Ngambe-Ndom-Nyannon communal forest.

Biological type	Number of species	Percentage
Trees	11647	61%
Shrubs	6062	32%
Herbaceous	1404	7%
Total		100%

Table 3. Diversity index.

Diversity index	Total	FS	FSA	FSAD	FSD	FSJ	FSJD	SWAMP
Taxa_S	395	266	376	110	84	272	84	33
Individuals	19006	2880	12525	372	284	2512	392	41
Shannon_H	4.765	4.61	4.749	4.231	3.872	4.685	3.872	3.43
Equitability_J	0,797	0.8256	0.801	0.9001	0.8739	0.8358	0.8738	0.9811

guineensis with 9% (1138 individuals) of the 19,007 individuals inventoried, followed by *Pycnanthus angolensis* with 6% (1117 individuals). Moreover, the family Euphorbiaceae was the most represented (2473 individuals identified; 14% of all the population listed), followed by Fabaceae and Myristicaceae with respectively 1730 (10%) and 1218 (7%). The least represented families were the Buddlejaceae and the Araliaceae with one individual each.

3.1.2. Specific Diversity

1) Shannon index and Piélou Equitability

Based on inventory, we observed 4.765 for Shannon's index and 0.797 for Piélou's equitability (Table 3). This proves a high specific diversity and the effectiveness of trees inventoried is fair in this forest concession. The adult secondary forest (FSA) has the highest Shannon index (4.74) followed by the young secondary forest (FSJ) and the secondary forest (FS) with respectively 4.68 and 4.61. The Piélou equitability index is greater than 50% for all the strata. It implies the diversity of all the strata such as the Shannon index.

2) Sorensen index

The young secondary forest (FSJ) and adult secondary forest (FSA) have 100% of common species followed by adult secondary forest (FSA) and secondary forest (FS), and secondary forest with (FS) yong secondary forest (FSJ) which has in common 80% of species respectively. In the same forest, the adult secondary forest (FSA) and Swamp with young secondary forest (FSJ) and Swamp express a low similarity index of 15% each. The numbers on a blue background indicate the highest similarity index of 1.00 when crossing the young secondary forest and the adult secondary forest (Table 4). Otherwise, the orange background expresses a low similarity index of 0.15 when crossing adult secondary forests and swamps: 0.15 for crossing swamp and young secondary forests.

Table 4. Sorensen index.

Sorensen (β)	FS	FSA	FSAD	FSD	FSJ	FSJD	Swarmp
FS	x	0.80	0.52	0.41	0.80	0.42	0.21
FSA		x	0.44	0.35	1.00	0.35	0.15
FSAD			x	0.68	0.44	0.65	0.22
FSD				x	0.35	0.67	0.17
FSJ					x	0.35	0.15
FSJD						x	0.21
Swamp							x

Stratum meaning (FS: Secondary Forest; FSA: Adult Secondary Foret; FSAD: Degraded Adult Secondary Forest; FSD: Degraded Secondary Forest; FSJ: Young Secondary Forest).

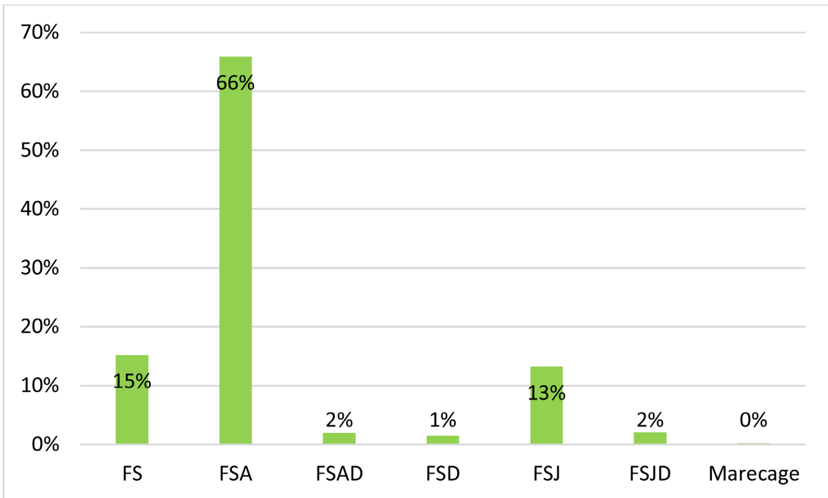

Figure 3. Distribution of stems by land use type.

3.1.3. Structural Diversity

1) Horizontal structure

Stem distribution and dominant species in the whole massif

It emerges from Figure 3 that the distribution of inventoried timber by type of land occupation is highly represented in the adult secondary forest (FSA) with 66% (12,522 individuals), followed by the secondary forest (FS) with 15% representing 2880 individuals of the total species and 13% for the young secondary forest (FSJ) representing 2512 individuals. The dominated species here were *Uapaca guineensis* and *Pycnanthus angolensis*. It also shows that the degraded secondary forest (FSD) and swamp occupations are least represented in the forest with 284 individuals (*Pycnanthus angolensis* as dominante species) and 41 individuals, or 0.20% (with *Pentaclethra macrophylla* as dominate species) respectively. This could be due to many anthropogenic activities characterized by illegal exploitation of wood and the practice of burn agriculture which lead to the loss of plant cover.

3.1.4. Spatial Structure of Stems

The vegetation of the different plots sampled is mainly trees; plants of small diameter are generally found there. Thus the diameter class mainly represented is the class [0 - 10] and [10 - 20] with respectively a density of 14.75% of stems/ha and 13.42% of stems/ha (**Table 5**). The repartition of individuals inventoried in the different diameter classes and per habitat shows variation class according to habitat (**Figure 4**). These results also illustrate the reduction of woody species according to diameter classes. This reduction is explained by the fact that there is strong anthropic activity in the massif, due to the cutting carried out by the loggers who especially prefer the stems of small diameters, thus preventing these stems from having diameters more or less important. One could proceed by a rotational prohibition and the elaboration of a zoning plan.

3.1.5. Stand Structure

As shown in **Figure 5**, the diametric structure of stands by land cover and for the entire forest inverted J structures, which reflects the presence of more future stems grouped in the diameter class [0 - 10] and [11 - 20] representing 3009 and 2737 individuals inventoried respectively than ligneous trees having reached the minimum diameter of operability (DME). The presence of more stems of the future was explained by the fact that there was good anthropic activity in the forest massif, by the cuts carried out by the populations specially to have arable land and for the illegal exploitation of the timber.

3.1.6. Densities per Habitat

As indicated in **Figure 6**, the density varies widely depending on their different

Table 5. Distribution of stem diameter classes.

Diameter class (cm)	Total effective (TE)	Density (E/ha)
0 - 10	3009	14.75%
11 - 20	2737	13.42%
21 - 30	1921	9.42%
31 - 40	1518	7.44%
41 - 50	739	3.62%
51 - 60	493	2.42%
61 - 70	330	1.62%
71 - 80	383	1.88%
81 - 90	32	0.16%
91 - 100	44	0.22%
101 - 110	6	0.03%
111 - 120	0	0.00%
121 - 130	3	0.01%
131 - 140	1	0.00%
141 - 150	1	0.00%

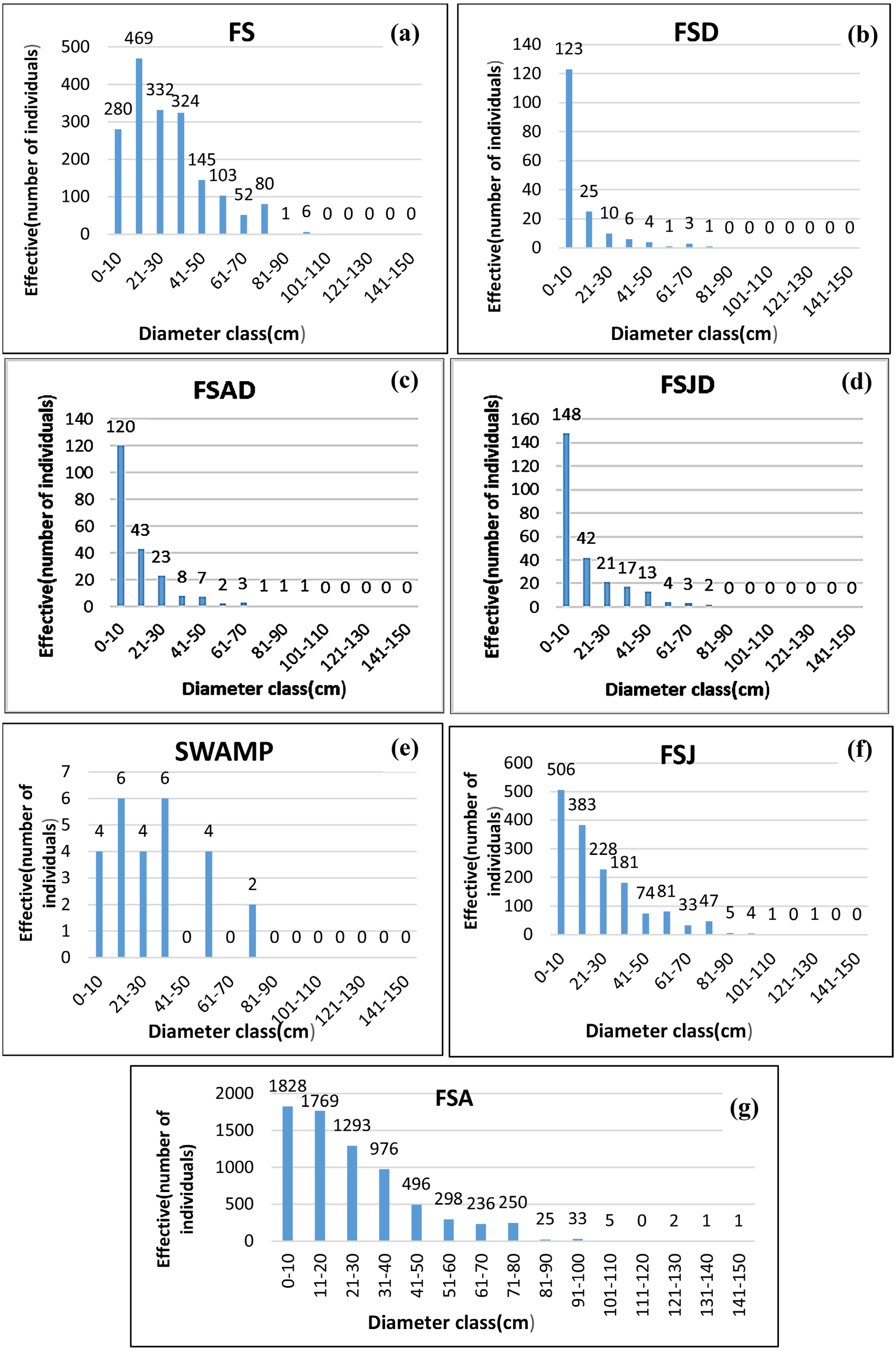

Figure 4. Different diameter classes and per habitat.

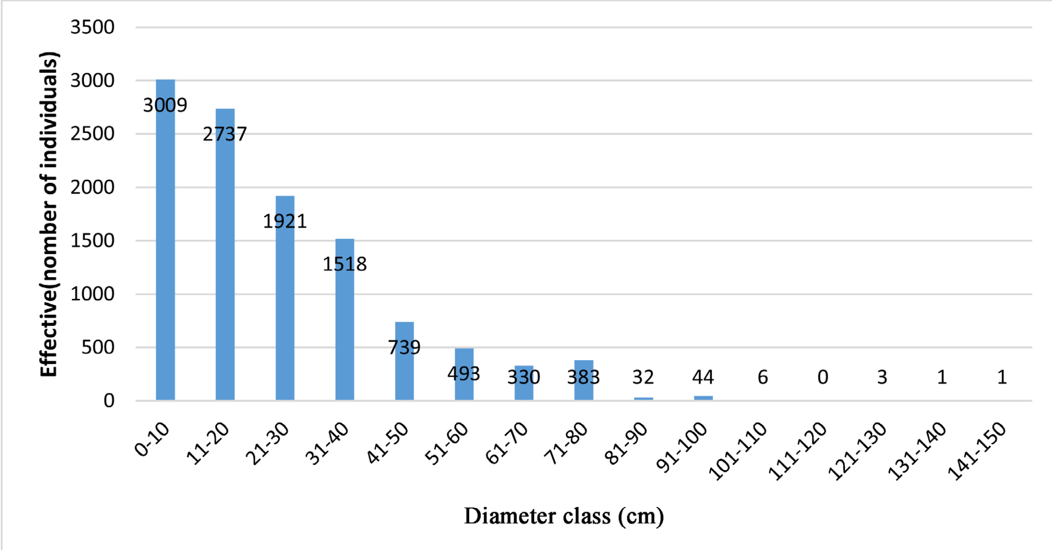

Figure 5. Diametric structure of stands by land cover and for the entire forest.

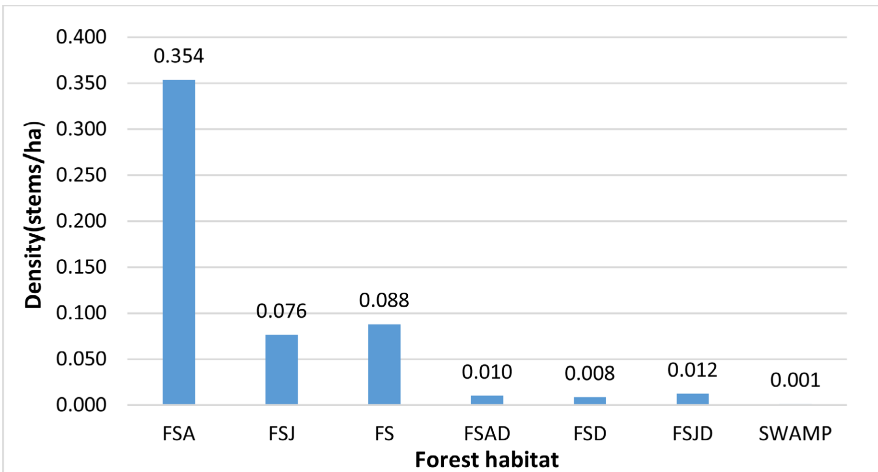

Figure 6. Density of species for each forest habitat.

habitat. It can be seen from **Figure 6** that the adult secondary forest (FSA) has the highest number of timber with 7213 individuals' representation a density of 0.354 stems per hectare followed by the secondary forest (FS) with 1792 individuals representing 0.088 stems per hectare. This result also illustrates a very low representation of stems per stratum hence having less that an individual per hectare in the forest concession due to the poor richness of the massif. This reduction is explained by the fact that there is strong anthropic activity in the massif due to the cutting carried out by the loggers, seasonal bush fires and over exploitation of the resources.

3.2. Discussion

3.2.1. Floristic Diversity

The proportion of different biological forms present in this area shows that the flora of the natural formation is dominated by the trees layer (61%), followed by the shrubs, and the herbaceous which is least represented. This result differs from that of Atoupka (2016) in West Cameroon in the community forest of Koupa-Matipit whereby the flora of the natural formation is dominated by the shrub layer (71.42%), and the trees have a proportion of 28.57%. No herbaceous plant was found in the massif. In relation to floristic diversity, Devineau (1984) conclude that the presence of a species in a given environment depends on three factors: its affinity with the conditions of the environment, its capacity to resist competition from other species, and finally, the possibility that its diaspores have of reaching the environment. Calculations on the specific diversity based on inventory data give values of 4.765 for Shannon's index and 0.797 for Piélou's equitability. This is synonymous with a high specific diversity and the effectiveness of the trees inventoried is fair in this forest concession. These results are similar to that obtained by Ntonmen et al. (2020) who showed a rich diversity (Shannon index; 4.44) of the understory in the semi-deciduous forest in Cameroun. However, these results are different from those obtained by Atoupka (2016) in the land of koupa Matapi in Noun who had found values of 1.113 for the Shannon-Weaver diversity index and 0.29249043 or 29.24% for the Shannon-Weaver equitability, which is synonymous with the lack of diversity. Zapfack et al. (2002) find that the primary forest of the southern part of Cameroon is the second habitat rich in floristic species behind the secondary forest while the agricultural lands are poor in large trees and the cocoa trees are rich in edible and medicinal plants. The conversion and fragmentation of primary forests into other types of habitats during timber extraction and other forms of forest exploitation, are generally considered to be major factors in the decline of species populations (Bobo, 2007). According to the forest richness, with 19007 individuals inventoried, 395 species grouped into 99 families and the family Euphorbiacea was the most represented. The dominant species were *Uapaca guineensis* and *Pycnanthus angolensis.* These results are different from that of Kandeu (2021) who found in the IRAD concession of the Mbalmayo forest reserve (Cameroon) that the population of the Mbalmayo forest inventoried is 1157 individuals from 107 plant species grouped into 33 families and of which the Fabaceae family was dominated. The two species dominate in this stand were *Gilbertiodendron dewevrei* and *Musanga cecropioides* with respectively 13.32% and 9.17%, and also different from Atoupka (2016) who in West Cameroon in the community forest of Koupa-Matipit who reveals a richness of 14 species grouped into 10 families with the Hymenocardiaceae family as dominate plant. On reading the Sorensen index values, we notice through these results that 100% of species are found in the young secondary forest (FSJ) and adult secondary forest (FSA). Followed by adult secondary forest (FSA) and secondary forest (FS), and secondary forest with (FS) young secondary forest (FSJ), which have in common 80% of species respectively. In the same forest, just 15% of species are common in respectively the adult secondary forest (FSA) and Swamp, with the young secondary forest (FSJ) and Swamp expressing a low similarity index. These results differ from Kandeu (2021) who found in the IRAD concession of the Mbalmayo forest reserve (Cameroon) that 48% forest species inventoried in the fields are also encountered in the fallow land because these habitats have in common the mode of land use which is the practice of agriculture by local communities who have empirical knowledge of the fertilizer trees in a forest environment that improve the fertility of their soil and increase lie their agricultural yields. 51% of the species inventoried in secondary forests are also found in swamps which are conservation forests for research activities. On reading the Sorensen index values, we notice through these results that the strongest indices of similarity appear when we cross ecosystems that have not been severely affected by human activities. On the other hand, human activities through the cutting of wood for energy wood and the destruction of woody forest cover for the conversion of land for agricultural purposes greatly increase the disappearance of certain species in this forest concession.

3.2.2. Stand Structure

Seven forest habitats were found in this forest which are secondary forest (FS), adult secondary forest (FSA), young secondary forest (FSJ), adult secondary degraded forest (FSAD), young secondary degraded forest (FSJD), secondary degraded forest (FSD), and SWAMP which shows a rich and a diversified structure. This result is different from Kandeu (2021) in the IRAD concession of the Mbalmayo forest reserve (Cameroon) where just four (4) forest habitant was identified which are Secondary forest, Fields, Fallow and Swamp. Land use in tropical countries rapidly changes a standing structure (Veldkamp & Lambin, 2001). The fragmentation of natural habitats linked to human activities has one of the dominant processes in landscape dynamics. Fragmentation changes the floristic composition (Cabacinha & Castro, 2009). The population structure present and inverted J shape which reflect the presence of more stems of the future that is 14.75% of species found in the diameter class [0 - 10] in the Ngambe-Ndom-Nyanon communal forest and that Kandeu (2021) in the IRAD concession of the Mbalmayo forest reserve (Cameroon) present which reflects the presence of more future stems grouped in the diameter class [10 - 40] and representing 79.69% of the individuals inventoried. This was explained by the fact that there was good anthropic activity in the forest massif of the Mbalmayo reserve by the cuts carried out by the populations especially to have arable land and for illegal exploitation meanwhile the was very little activity in the Ngambe forest.

Calculations made for the density of species for each forest habitat show us that the adult secondary forest (FSA) has the highest number of species with 7213 individuals representing a density of 0.354 stems per hectare followed by the secondary forest (FS) with 1792 individuals representing 0.088 stems per hectare. This result also illustrates a very low representation of stems per stratum hence having less that an individual per hectare in the forest concession due to the poor richness of the massif. This reduction is explained by the fact that there is a strong anthropic activity in the massif due to the cutting carried out by the loggers, seasonal bush fires and over exploitation of the resources.

4. Conclusion

The vegetation of the Ngambe-Ndom-Nyanon communal forest is mainly represented by the Euphorbiaceae family, followed by the Fabaceae and Myristicaceae. *Uapaca guineensis* and *Pycnanthus angolensis* are the two woody species strongly represented in the massif. The Shannon diversity index shows a high species diversity in the whole massif, although this varies according to its strata. The FSA and the swamp with the FSJ and the swamp have only 15% of species in common respectively. This forest stand projects an inverted J-structure, thus showing a high potential for future stems and thus a sustainable use of the wood resource. However, the study revealed a low density of stems according to the strata apart from the stratum consisting of mature secondary forests. This shows the need for reforestation activities to further limit the degradation of this forest.

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Conflicts of Interest

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

References

Alemagi, D., Duguma, L., Minang, P., Kehbila, A., Yemefack, M., & Tchoundjeu, Z. (2016). Analyzing the Contribution of Cameroon's Council Forests to Climate Change Mitigation and Socioeconomic Development. In J. A. Blanco, S. Chang, & Y. Lo (Eds.), *Tropical Forests* (15 p). IntechOpen. https://doi.org/10.5772/63833

Atoupka, A.M. (2016). *Diversity and Use of Wood Resources in the Region of Koupa-Matapit, West Cameroon* (107 p). Presented with a View to Obtaining the Degree of Water, Forest and Hunting Engineer, University of Dschang.

Bobo, K. S. (2007). *From Forest to Farmland: Effects of Land Use on Understorey Birds of Afrotropical Rainforests* (169 p). Ph.D. Thesis Georg-August University of Göttingen.

Cabacinha, C. D., & Castro, S. S. (2009). Relationships between Floristic Diversity and Vegetation Indices, Forest Structure and Landscape Metrics of Fragments in Brazilian Cerrado. *Forest Ecology Management, 257,* 2157-2165. https://doi.org/10.1016/j.foreco.2009.02.030

Cancela Da Fonseca, J. P. (1980). Le concept de diversité, le chevauchement des niches écologiques et l'organisation des systèmes écologiques. *Acta Oecologica, Oecologiageneralis, 1,* 293-305.

Chomitz, K. M., Buys, P., & Luca, G. D. (2007). *At Loggerheads? Agricultural Expansion, Poverty Reduction and Environment in Tropical Forests*. World Bank Policy Research

Report, The World Bank.

CIRAD-FRA [Centre de coopération internationale en recherche agronomique pour le développement] (2009). *Le Cirad en 2008* (67 p). Centre de coopération internationale en recherche agronomique pour le développement.

Dajoz, R. (1982). *Précis d'Ecologie* (4ème éd., 503 p). Bordas.

Devineau, J. L. (1984). *Structure and Dynamics of Some Tropophilic Forests of the West African)* (188 p). MAB Savanna Program, University of Abidjan.

Food and Agriculture Organization of the United Nation (FAO) (1991). *Forestry Community a Review of 10 Years of Activity* (Flight. 7). Food and Agriculture Organization of the United Nation.

Food and Agriculture Organization of United Nations (FAO) (2004). *The State of Insecurity Food in the World—Tracking Progress towards Achieving the Goals of the World Food Summit and the Millennium Declaration* (296 p). Food and Agriculture Organization of the United Nation.

Gibbs, H., Brown, S., Niles, J. O. & Foley, J. A. (2007). Monitoring and Estimating Tropical Forest Carbon Stocks: Making REDD a Reality. *Environmental Research Letters, 2,* Article ID: 045023. https://doi.org/10.1088/1748-9326/2/4/045023

Hansen, C., Wang, L., Song, X. P., Tyukavina, A., Turubanova, S., Potapov, P. V., & Stehman, S. V. (2020). The Fate of Tropical Forest Fragments. *Science Advances, 6,* eaax8574. https://doi.org/10.1126/sciadv.aax8574

Hill, J. L., & Hill, R. A. (2001). Why Are Tropical Rain Forests So Species Rich? Classifying, Reviewing and Evaluating Theories. *Progress in Physical Geography, 25,* 326-354. http://ppg.sagepub.com/cgi/content/abstract/25/3/326

Kandeu. (2021). *Characterization of Vegetation and Uses of Woody Plants in the IRAD Concession of the Mbalmayo Forest Reserve (Cameroon).* Thesis Written to Obtain a Master of Sciences (M. Sc.) in Plant Biology, University of Dschang.

Laurance, W. F., Goosem, M., & Laurance, S. G. W. (2009). Impacts of Roads and Linear Clearings on Tropical Forests. *Trends in Ecology & Evolution, 24,* 659-669. https://doi.org/10.1016/j.tree.2009.06.009

Letouzey, R. (1985). *Notice de la carte phytogéographique du Cameroun au 1:500 000.* Institut de la carte Internationale de la Végétation.

Madi, A., Huub, P., & Sadi, B. (2003). *La demande urbaine en bois énergie et la nécessité d'une gestion rationnelle des ressources naturelles: le cas de Maroua à L'extrême-Nord du Cameroun.* HAL Open Science.

Mahamane, A., & Saadou, M. (2008). *Méthodes d'étude et d'analyse de la flore et de la végétation tropicale. Actes de l'atelier sur l'harmonisation des méthodes d'études et d'analyse de la flore et de la végétation tropicale* (67 p).

Mayaux, P., Pekel, J.-F., Descle'e, B., Donnay, F., Lupi, A., Achard, F., Clerici, M., Bodart, C., Brink, A., Nasi, R., & Belward, A. (2013). State and Evolution of the African Rainforests between 1990 and 2010. *Philosophical Transactions of the Royal Society B, 368,* Article ID: 20120300. https://doi.org/10.1098/rstb.2012.0300

Megevand, C., Mosnier, A., Hourticq, J., Sanders, K., Doetinchem, N., & Streck C. (2013). *Deforestation Trends in the Congo Basin: Reconciling Economic Growth and Forest Protection* (p. 180). World Bank, Directions in Development. https://doi.org/10.1596/978-0-8213-9742-8

Ministry of Environment and Forests (MINEF) (1994). *Terms of Application of the Forest Regime. Cameroon* (Decree n˚94/436 of August 23, 1994 fixing, 48 p). Directorate of Forests MINFOF.

Ministry of Forests and Wildlife (MINFOF) (2006). *Assessment of Achievements in Forestry Community in Cameroon and Definition of New Orientations* (Study Report, pp. 44-45, 56-57). CARDAF.

Nkomé, N. Y. (2010). *Preliminary Study for the Establishment of the Community Forest Dewaladarali in Mayo-Danay (Far North Cameroon)* (83 p). Dissertation Presented with a View to Obtaining the Engineer's Degree in Water, Forests and Hunting, University of Dschang.

Ntonmen, A. F. Y., Zapfack, L., & Chimi, D. C. (2020). Floristic Diversity and Structure of Understory in Semi-Deciduous Forests in Cameroon. *Journal of Biodiversity and Environmental Sciences, 16,* 103-110.

Ntoupka, M. (1999). *Impact of Anthropogenic Disturbance (Grazing, Fire and Logging) on the Dynamics of the Wooded Savannah in the Sudano-Sahelian Zone of Northern Cameroon* (260 p). Doctoral Thesis, University of Paul Valery-Montpellier III.

Onana, J. M., & Cheek, M. (2011). *Red Data Book of the Flowering Plants of Cameroon: IUCN Globzl Assessments*. Royal Botanic Gardens, Kew and IRAD-National Herbarium of Cameroon, Kew Publishing.

Secrétariat de la Convention sur la Diversité Biologique (SCBD) (2001). *Assessment, Conservation and Sustainable Use of Forest Biodiversity* (130 p). SCBD.

Sedlacek, O., Reif, J., & Horak, D. (2007). The Birds of a Montane Forest Mosaic in Big Babanki Area, Bamenda Highlands, Cameroon. *Malimbus, 29,* 89-100.

Smith, D. M., Larson, B. C., Kelty, M. J., & Ashton, P. M. S. (1997). *The Practice of Sylviculture: Applied Forestry Ecology* (9 e éd.). John Wiley and Sons.

Tadjuidje, K. T. E. (2009). *Contribution à la gestion durable de l'Assamela (Pericopsis elata Harms v. Meeuwen): Phénologie et régénération naturelle en plantation et en forêt naturelle* (pp. 47-48). Mémoire de fin d'études. FASA, Université de Dschang..

Tchatchou, B., Sonwa, D. J., Ifo, S., & Tiani, A. M. (2015). *Deforestation and Forest Degradation in the Congo Basin: State of Knowledge, Current Causes and Perspectives* (Occasional Paper 144). Center for International Forestry Research.

Temgoua, L. (2007). *Preliminary Study for the Development of the Forest-School of Mbalmayo, Center-South-Cameroon. Surveys of Legal and Illegal Users of the Forest to Clarify Their Practices* (120 p). DEA Thesis in Geography, University of Montpellier III.

Thies, C., Rosoman, G., Cotter, J., & Meaden S. (2011). *Intact Forest Landscapes Why It Is Crucial to Protect Them from Industrial Exploitation. Case Study: The Congo* (20 p). Greenpeace. http://www.greenpeace.org

Thorgnang, N. (2000). *Condition and Perspective of the Houbaré Wooded Area* (70 p). Graduation Thesis, Uds/FASA.

Veldkamp, A., & Lambin, E. F. (2001). Predicting Land-Use Changes. *Agricultural and Environmental Ecosystem, 85,* 1-6. https://doi.org/10.1016/S0167-8809(01)00199-2

Zapfack, L., Engwald, S., Sonke, B., Achoundong, G., & Madong, B. A. (2002). The Impact of Land Conversion on Plant Biodiversity in the Forest Zone of Cameroon. *Biodiversity and Conservation, 11,* 2047-2061. https://doi.org/10.1023/A:1020861925294