

(RESEARCH ARTICLE)



WOODY FLORISTIC DIVERSITY AND COMMERCIAL TIMBER SPECIES POTENTIAL IN FOREST PATCHES OF THE BESSO CLASSIFIED FOREST, SOUTHEASTERN CÔTE D'IVOIRE

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ABSTRACT

The Besso Classified Forest, located in the south-east of Côte d'Ivoire, has faced the problem of illegal infiltration for several decades. Agriculture practiced within this forest has significantly reduced its area and its role as a production forest. However, some areas of this forest have been identified as having low levels of human intrusion. The overall objective of this study is to assess the potential of timber resources in areas untouched by agriculture. To achieve this, a systematic inventory was conducted along a forest path in three forest patches located in the center of the forest. The different paths were subdivided into 200 m² plots, arranged contiguously within each patch. Across the three patches, 52 plots, covering an area of 1.04 hectares, were inventoried. Dendrometric parameters specifically trees density, total height, and diameter were measured. A total of 526 trees with a diameter at breast height (dbh) ≥ 10 cm were recorded. They belong to 95 species, 75 genera, and 33 families. Furthermore, 305 trees were identified as commercial species. Almost all of these species fall into the export and sawmill grades. Also, the majority of the trees are short in height. The Sorensen coefficient calculated between the forest patches indicates a similar plant community. Comparative analysis of the different dendrometric parameters measured reveals no significant differences between the commercial species. However, *Celtis mildbraedii*, *Nesogordonia papaverifera*, and *Ricinodendron heudelotii* are the most commercially traded species, with values that are higher and statistically different from the other species. These results demonstrate the significant potential of these forest patches for commercial species. Measures must be taken for the sustainable management of these forest patches to ensure long-term exploitation.

Keywords: Floristic diversity, Commercial species, Classified Forest of the Besso, Forest patches, Côte d'Ivoire

1 INTRODUCTION

In Côte d'Ivoire, the forest cover, estimated at approximately 15 million hectares in the early 1900s [1], has declined to around 3 million hectares today [2]. This situation is the result of unsustainable logging combined with population growth that has led to the destruction of several thousand hectares of forest [3].

The rapid and uncontrolled exploitation of forests is primarily associated with land clearing for shifting cultivation, which has led to the fragmentation and degradation of natural habitats [4]. These pressures have been further exacerbated by extensive and itinerant industrial logging, artisanal gold mining activities, and major road construction

projects. Collectively, these activities have resulted in increased forest fragmentation and degradation, as well as the establishment of unauthorized settlements within forested areas [5].

The Besso Classified Forest (BCF) is not exempt from these pressures. For several years, the forest has experienced extensive illegal encroachment, leading to severe fragmentation and degradation, particularly as a result of agricultural expansion and poaching [6]. Several threatened plant species have reached critically low population levels, including *Afzelia africana*, *Lovoa trichilioides*, *Anopyxis klaineana* and *Pterygota bequaertii*, among others [7]. The resulting disturbance of forest biological resources represents a major challenge for the assessment of natural resources at the national level and for effective biodiversity management within the forest. However, it is clear that in the center and south of this forest there are a few islands spared from the harmful effects of agriculture. Unfortunately, the increase in illegal clearing and the removal of certain species threaten the existence of these islands. These non-anthropogenic areas, which are likely to be home to a large number of commercial species, are difficult to observe. Furthermore, the management plans developed by INPROBOIS (Wood Industry and Promotion) do not take these forest patches into account. This is mainly due to the lack of knowledge regarding the woody plant resources contained within these different forest patches. Indeed, sustainable management of the natural resources of a given area depends not only on a comprehensive understanding of the diversity of its constituent elements but also on their abundance [8].

The overall objective of this study is to assess the woody plant potential of islands spared that have remained relatively unaffected by agricultural activities, with the aim of contributing to the conservation of the Besso Classified Forest. Specifically, the study aims to describe the structure and floristic composition of woody plant communities within these forest patches and to quantify and characterize the commercial potential of the recorded species.

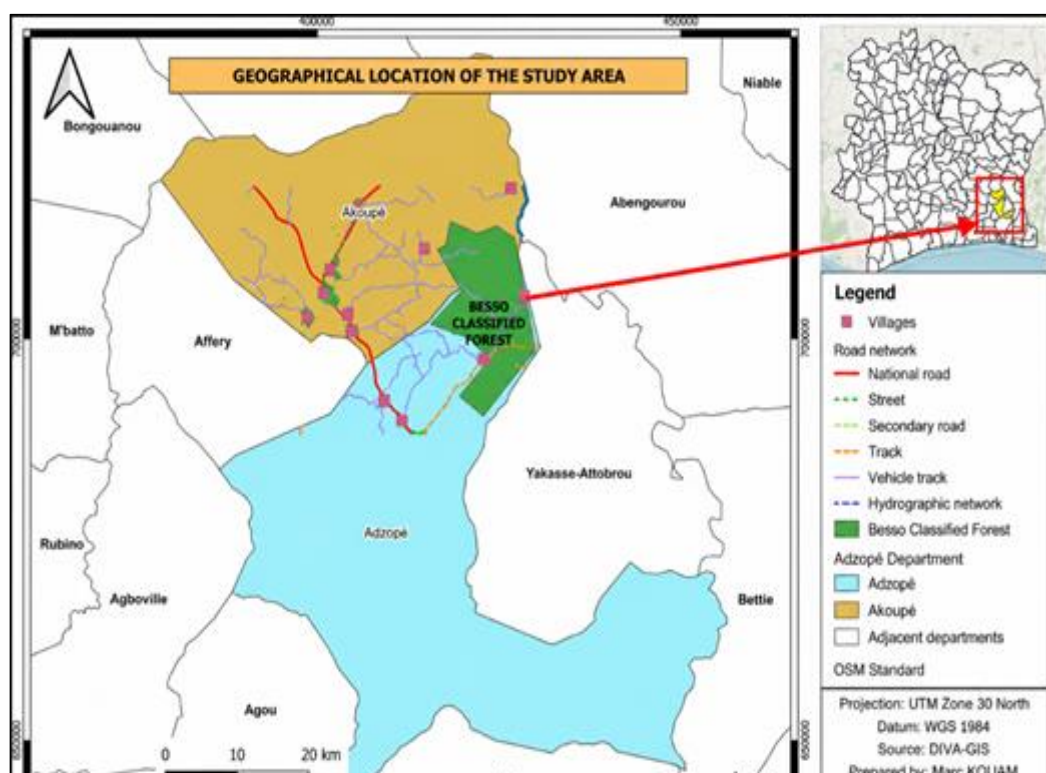


Figure 1: Location map of the Besso Classified Forest

2 MATERIALS AND METHODS

2.1 Study site

The present study was conducted in the Besso Classified Forest. This forest massif is located in the Mé region in the south-east of Côte d'Ivoire. The regional capital is the city of Adzopé. This forest is bounded by the departments of Adzopé and Yakassé-Attobrou to the south and to the north by the department of Akoupé (Figure 1). At the time of its establishment, the Besso Classified Forest (BCF) covered an area of 37,000 ha. Following several instances of partial declassification, its current area has been reduced to 21,565 ha [7].

The classified forest of the Besso has an average altitude estimated at 150 m [9]. This narrow relief between the upper basins of the Agnéby and the Mé, which is very hilly, reveals many lowlands [10]. The geological formations are

dominated by metamorphic rocks, schists and sandstones [9]. According to [11], the soils encountered in the FCB are of the feralitic type and are generally fertile.

The climate is sub-equatorial, characterized by an average monthly rainfall of between 18.6 and 262.1 mm. Rainfall is distributed across four distinct seasons: a long rainy season from March to July; a short dry season in August; a short rainy season from September to November and a large dry season from December to February.

2.2 Study design

2.2.1 Assessment of the floristic diversity in Forest Patches

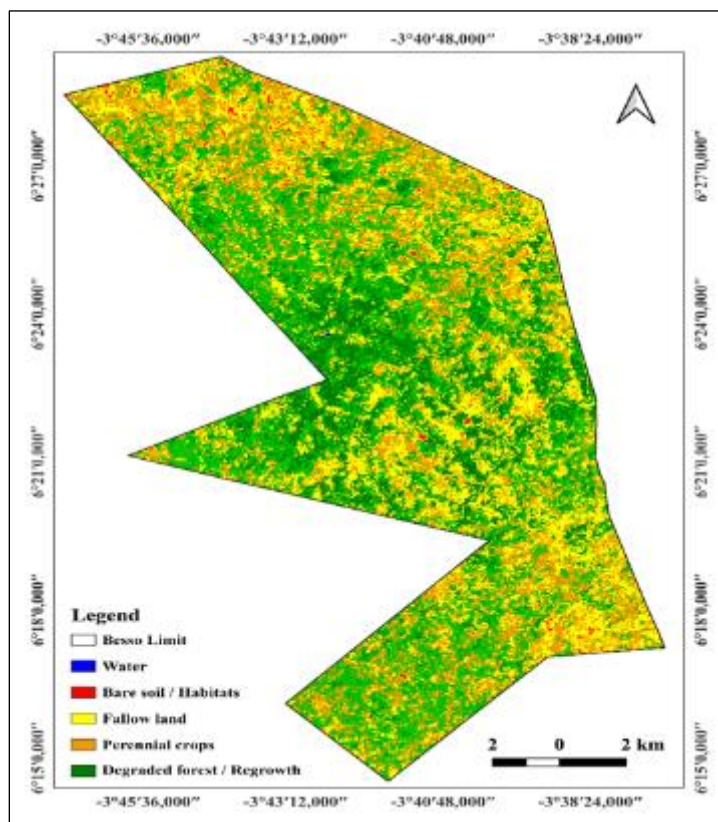


Figure 2: Land cover map of the Besso Classified Forest

Three forest patches located in the central part of the Besso Classified Forest (BCF) were selected based on the land-use and land-cover map produced as part of this study (Figure 2), as well as information provided by field surveyors working for INPROBOIS. These forest patches were selected because they showed relatively limited human encroachment compared with other forest patches in the central part of the BCF. The sampling design followed the management inventory approach proposed by [12]. According to this author, this sampling design provides a sufficiently representative inventory of the flora of a forest (Figure 3). This method was also used by [13]. In each forest patch, a linear transect was established from one end of the patch to the other. Floristic inventories along the transects were conducted using 200 m² plots arranged in straight lines. Accordingly, 19 plots were established in the first forest patch for the inventory. In the second forest patch, the inventory was conducted in 16 plots, whereas 17 plots were established in the third forest patch. Within these plots, a systematic inventory of all woody individuals with a diameter at breast height (dbh) ≥ 10 cm was conducted. dbh was measured at 1.30 m above ground level. For each tree, dbh was measured, total height was estimated, and the species was identified. The recorded individuals were subsequently grouped into different diameter and height classes to assess the structural characteristics of the woody vegetation.

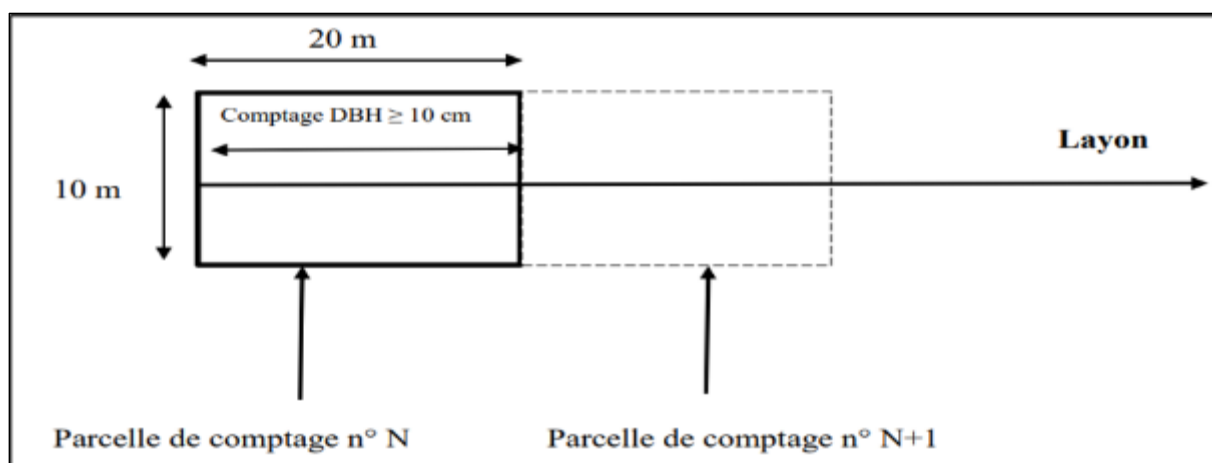


Figure 3: Woody Plant Counting Design

2.2.2 Assessment of Commercial Timber Species Potential in Forest Patches

The potential of woody trees has been evaluated according to the parameters of quality, status and health status of trees considered as commercial species based on the activity report of [7].

2.2.2.1 Estimation of Tree Quality

During the inventory, the total height of all trees belonging to species considered to be commercial timber species was estimated. The bole height up to the first major branch was also estimated. This measurement was used to classify the trees into three quality classes according to [12]:

- **Quality class 1 (export quality):** trees with a defect-free bole length greater than 6 m;
- **Quality class 2 (sawing quality):** trees with a defect-free bole length ranging from 3 to 6 m;
- **Quality class 3 (reject quality):** trees with a defect-free bole length of less than 3 m.

2.2.2.2 Assessment of the Health Status of Commercial Timber Species

An assessment of the health status of each plant of commercial species was carried out during the surveys. The trees were divided into two groups, [12]:

- **Healthy trees** are those with no apparent defects;
- **Unhealthy trees** are those showing defects, decay, or broken stems (bole breakage).

2.2.2.3 Estimating the status of commercial species

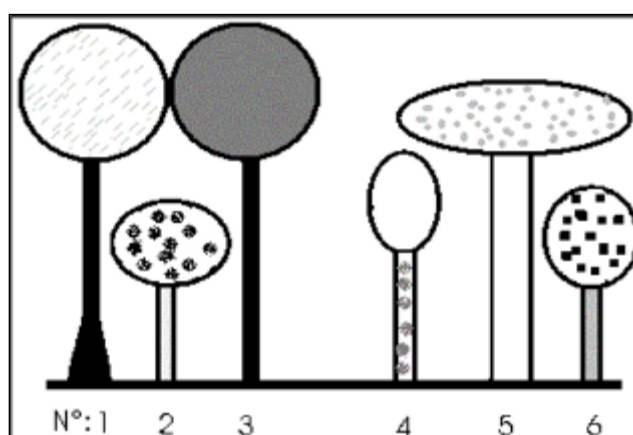


Figure 4: Assessment of tree social status. Dominant tree: No. 5; codominant trees: Nos. 1 and 3; suppressed trees: Nos. 2, 4, and 6

During the inventory, the social status of each individual belonging to a commercial timber species was determined. Individuals were classified as dominant, codominant, or suppressed (Figure 4). Dominant trees were those whose crowns overtopped those of neighboring trees. Codominant trees were those whose crowns were at approximately the

same height as those of neighboring trees. Suppressed trees were those whose crowns were below those of neighboring trees.

2.3 Data analysis

2.3.1 Vegetation structure

2.3.1.1 Basal area

The basal area (G) corresponds to the sum of the cross-sections of adult individuals at dbh ≥ 10 cm per hectare [14, 15]. It is a precise indicator of the woody productivity of a plot. It is also an index of land and space occupation by trees. The basal area is expressed in square meters per hectare (m^2/ha) and is calculated as follows:

$$G = \frac{\pi}{4} \sum_{i=1}^n D_i^2$$

With: D_i = diameter at 1.30 m from the ground of each tree inventoried

2.3.1.2 Density

The density (D) is defined as the number of individuals per unit area. It reflects the land use by species [16]. It is expressed in the number of individuals per hectare (individuals/ha). This index was calculated using the following formula:

$$D = \frac{N}{S}$$

Where; N: number of stems identified and S: total area expressed in hectares.

2.3.1.3 Distribution of individuals by classes

It makes it possible to account for the demographic structure of woody individuals [17]. The measurement of the diameter at breast height of woody species has made it possible to divide them into nine (09) diameter classes. In addition, the estimation of the height of individuals during inventories has made it possible to establish the vertical structure of species considered commercial. Thus, three (03) height classes have been defined to evaluate the potential of the islands in the center of the Besso Classified Forest in commercial species.

2.3.2 Botanical characterization index

2.3.2.1 Index of Family Importance Values

The Family Importance Value Index (IVIF) allows us to assess the diversity of a family and its importance in relation to other families [18, 19]. It is expressed as a percentage and is obtained according to the following formula:

$$\text{IVIF} = \text{Relative Dominance} + \text{Relative Density} + \text{Relative Diversity}$$

Where:

- Relative density = $100 \times (\text{Number of individuals in a family} / \text{Total number of individuals in the sample})$
- Relative diversity = $100 \times (\text{Number of species in a family} / \text{Total number of species})$
- Relative dominance = $100 \times (\text{Basal area of a family} / \text{Total basal area of the sample})$

2.3.2.2 Index of species significance

This index gives information on the number of individuals, their distributions and importance according to basal area for each species [20, 21]. It makes it possible to highlight the most represented species [19]. The Species Importance Values Index (SIEI) is calculated according to the formula below:

$$\text{IVIE} = \text{Relative Dominance} + \text{Relative Density} + \text{Relative Frequency}$$

Where:

- Relative density = $100 \times (\text{Number of individuals of a species} / \text{Total number of individuals})$
- Relative frequency = $100 \times (\text{Frequency of one species} / \text{Total frequencies of all species})$

- Relative dominance = $100 \times (\text{Basal area of a species} / \text{Basal area of the sample})$

2.3.3 Sørensen similarity coefficient

The Sørensen coefficient of similarity makes it possible to characterize, objectively and quantitatively, the degree of floristic resemblance of two environments [22, 17]. This coefficient has been used because of its widespread use in the literature. It is calculated as follows:

$$I_{\text{Sørensen}} = 2a / (2a + b + c) * 100$$

The Sørensen coefficient of similarity is expressed as a percentage. The values of this coefficient vary between 0%, for totally different compositions, and 100%, for compositions that are completely identical to each other. If the Sørensen coefficient is greater than or equal to 50%, it is concluded that there is homogeneity [23, 19].

2.4 Statistical analysis of the data

Statistical analyses made it possible to compare the abundant and most commercialized species with each other on the basis of the dendrometric parameters measured. To do this, an Anova from a mixed model was performed. The significance of the test was set at the α threshold of 0.05 ($P < 0.05$).

3 RESULTS

3.1 Woody Species Diversity Across the Three Forest Patches

3.1.1 Family Distribution Across the Three Forest Patches

Across the three forest patches, a total of 33 plant families were recorded. The Malvaceae, Cannabaceae, Fabaceae, Meliaceae and Euphorbiaceae were the five most important families, with the highest Relative Importance Value (RIV) indices. Among these five families, only the Malvaceae, Cannabaceae, and Euphorbiaceae had the highest basal areas (Table 1).

Table 1: Relative Importance of the 20 Most Frequently Recorded Plant Families Across the Three Forest Patches of the Besso Classified Forest

Family	Basal area (m ²)	Dominance relative (%)	Relative density (%)	Relative diversity (%)	Relative Importance Value (%)
Malvaceae	8.598	23.832	26.426	13.542	63.799
Cannabaceae	6.981	19.350	15.019	3.125	37.494
Fabaceae	3.286	9.108	12.167	14.583	35.859
Meliaceae	2.118	5.871	10.837	7.292	23.999
Euphorbiaceae	4.486	12.434	6.274	4.167	22.875
Moraceae	1.362	3.775	3.612	6.250	13.637
Ebenaceae	0.649	1.799	6.654	4.167	12.620
Urticaceae	0.937	2.597	2.852	3.125	8.574
Sapotaceae	0.558	1.547	1.901	4.167	7.614
Rubiaceae	0.470	1.303	1.901	4.167	7.371
Boraginaceae	1.305	3.617	1.141	2.083	6.841
Apocynaceae	0.452	1.253	1.711	3.125	6.089
Annonaceae	0.363	1.006	0.760	3.125	4.892
Myristicaceae	0.902	2.500	0.951	1.042	4.492
Phyllanthaceae	0.403	1.117	0.951	2.083	4.151
Chrysobalanaceae	0.543	1.505	0.380	2.083	3.969

Anacardiaceae	0.286	0.793	0.951	2.083	3.827
Simaroubaceae	0.475	1.317	0.760	1.042	3.119
Rutaceae	0.124	0.344	0.570	2.083	2.997
Irvingiaceae	0.636	1.763	0.190	1.042	2.995
Other	1.144	3.171	3.992	15.625	22.788
Total	36.078	100	100	100	300

3.1.2 Species Composition Across the Three Forest Patches

Table 2: Relative Importance Value of the 20 Most Frequently Recorded Species Across the Three Forest Patches

Species	Basal area (m ²)	Dominance relative (%)	Relative density (%)	Relative Frequency (%)	Relative Importance Value (%)
<i>Celtis mildbraedii</i>	5.336	14.637	10.646	7.143	32.426
<i>Nesogordonia papaverifera</i>	2.028	5.563	5.703	5.476	16.742
<i>Ricinodendron heudelotii</i>	2.851	7.820	3.802	3.810	15.432
<i>Berlinia confusa</i>	1.541	4.227	4.943	4.762	13.932
<i>Mansonia altissima</i>	0.98	2.688	4.943	3.810	11.441
<i>Triplochiton scleroxylon</i>	2.448	6.715	2.091	2.143	10.949
<i>Trichilia monadelpha</i>	0.796	2.183	4.183	3.810	10.175
<i>Entandrophragma angolense</i>	0.751	2.060	3.802	4.048	9.910
<i>Diospyros canaliculata</i>	0.373	1.023	4.373	4.048	9.443
<i>Discoglypsemna caloneura</i>	1.598	4.383	2.091	2.619	9.094
<i>Pterygota macrocarpa</i>	0.682	1.871	3.422	2.857	8.150
<i>Celtis zenkeri</i>	1.218	3.341	2.662	1.905	7.907
<i>Ceiba pentandra</i>	1.031	2.828	2.091	2.381	7.300
<i>Sterculia rhinopetala</i>	0.695	1.906	2.662	2.619	7.187
<i>Antiaris toxicaria</i>	1.042	2.858	1.711	1.905	6.474
<i>Cordia platythyrsa</i>	1.246	3.418	0.951	0.952	5.321
<i>Celtis adolfi-friderici</i>	0.426	1.169	1.711	2.143	5.022
<i>Pycnanthus angolensis</i>	0.901	2.471	0.951	1.190	4.613
<i>Pouteria pierrei</i>	0.447	1.226	1.331	1.667	4.224
<i>Albizia zygia</i>	0.491	1.347	1.331	1.429	4.106
Other	9.575	26.265	34.601	39.286	100.151
Total	36.456	100	100	100	300

Across the three forest patches, a total of 527 woody individuals were recorded, representing 95 species and 75 genera. The most important species were *Celtis mildbraedii*, *Nesogordonia papaverifera*, and *Ricinodendron heudelotii*. These

three species were followed by *Berlinia confusa*, *Mansonia altissima*, *Triplochiton scleroxylon*, and *Trichilia monadelpha* (Table 2).

3.1.3 Sørensen Similarity Coefficient

The Sørensen similarity coefficient calculated among the three forest patches based on species composition yielded values above 50% (Table 3). These values indicate that the three forest patches have a generally homogeneous floristic composition, with a relatively high degree of similarity. However, Forest Patches 2 and 3 exhibited the highest floristic similarity, with a similarity coefficient of 57%.

Table 3: Comparison of the Floristic Composition of the Three Forest Patches

Forest Patches	Patches 1	Patches 2
Patches 2	55%	
Patches 3	56%	57%

3.1.4 Woody Stand Structure

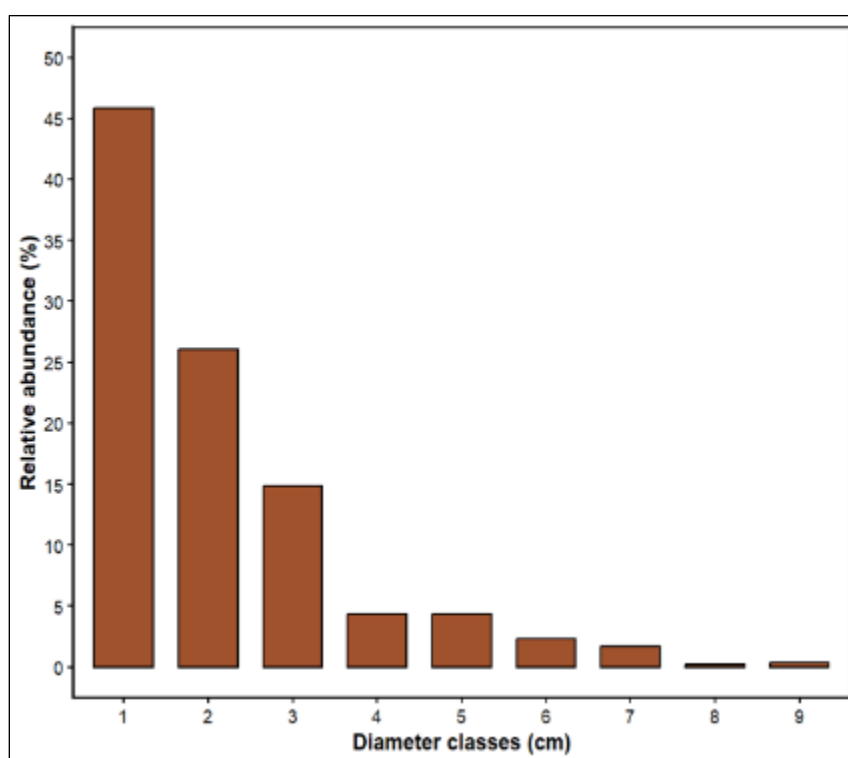


Figure 5: Diameter structure of woody vegetation across the three forest patches.

Across the three forest patches, the woody stand structure exhibited a reverse J-shaped distribution (Figure 5). This pattern indicates that the stand was predominantly composed of individuals belonging to the smaller diameter classes.

3.2 Assessment of the Commercial Timber Potential of the Forest Patches

3.2.1 Relative Density of Commercial Timber Species Across the Three Forest Patches

Of the 95 species recorded, 25 have been identified as commercial species, *Celtis mildbraedii* is the most represented species, followed by *Nesogordonia papaverifera*; *Mansonia altissima*; *Ricinodendron heudelotii*; *Entandrophragma angolense* and *Pterygota macrocarpa*. Finally, 05 species including *Amphimas pterocarpoides*; *Anthonotha macrophylla*; *Bombax buonopozense*; *Guibourtia ehie* and *Pouteria altissima* had relative densities of less than 0.5%.

Table 4: Relative Density of the 25 Most Frequently Recorded Commercial Timber Species Across the Three Forest Patches

Species	Density (Number of stems/ha)	Relative density (%)
<i>Celtis mildbraedii</i>	53.8	18.4
<i>Nesogordonia papaverifera</i>	28.8	9.8
<i>Mansonia altissima</i>	25	8.5
<i>Ricinodendron heudelotii</i>	19.2	6.6
<i>Entandrophragma angolense</i>	19.2	6.6
<i>Pterygota macrocarpa</i>	17.3	5.9
<i>Sterculia rhinopetala</i>	13.5	4.6
<i>Celtis zenkeri</i>	12.5	4.3
<i>Triplochiton scleroxylon</i>	10.6	3.6
<i>Ceiba pentandra</i>	10.6	3.6
<i>Antiaris toxicaria</i>	8.7	3
<i>Celtis adolfi-friderici</i>	8.7	3
<i>Guarea cedrata</i>	7.7	2.6
<i>Sterculia oblonga</i>	6.7	2.3
<i>Aningeria robusta</i>	5.8	2
<i>Cordia platythyrsa</i>	4.8	1.6
<i>Entandrophragma cylindricum</i>	4.8	1.6
<i>Pycnanthus angolensis</i>	4.8	1.6
<i>Alstonia boonei</i>	3.8	1.3
<i>Distemonanthus benthamianus</i>	2.9	1
<i>Khaya ivorensis</i>	2.9	1
<i>Lannea welwitschii</i>	2.9	1
<i>Scottellia klaineana</i>	2.9	1
<i>Milicia excelsa</i>	19	0.7
<i>Copaifera salikounda</i>	1.9	0.7
Other	11.8	3.7
Total	293.5	100

3.2.2 Total Height Structure

The height distribution showed a dominance of small trees (≤ 10 m), No trees with a height greater than 40 m were recorded,

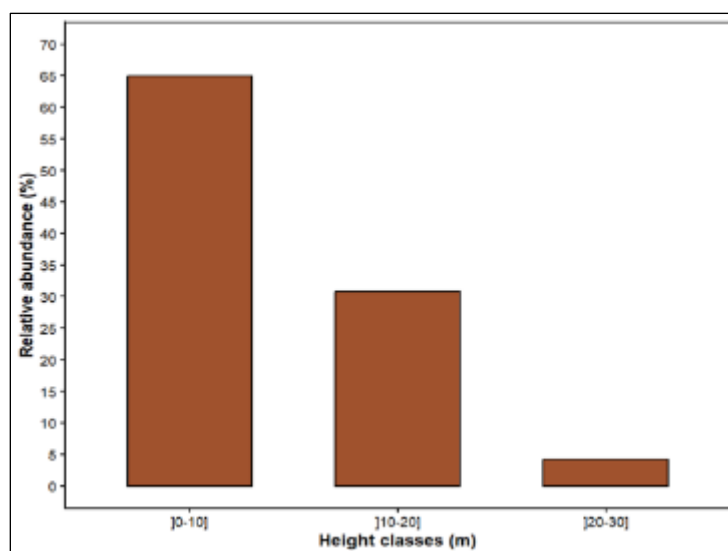


Figure 6: Height structure of commercial timber species

3.2.3 Quality of Commercial Timber Species

The distribution of commercial species into quality classes showed a high proportion of export-quality trees, followed by sawn-quality trees (Figure 7).

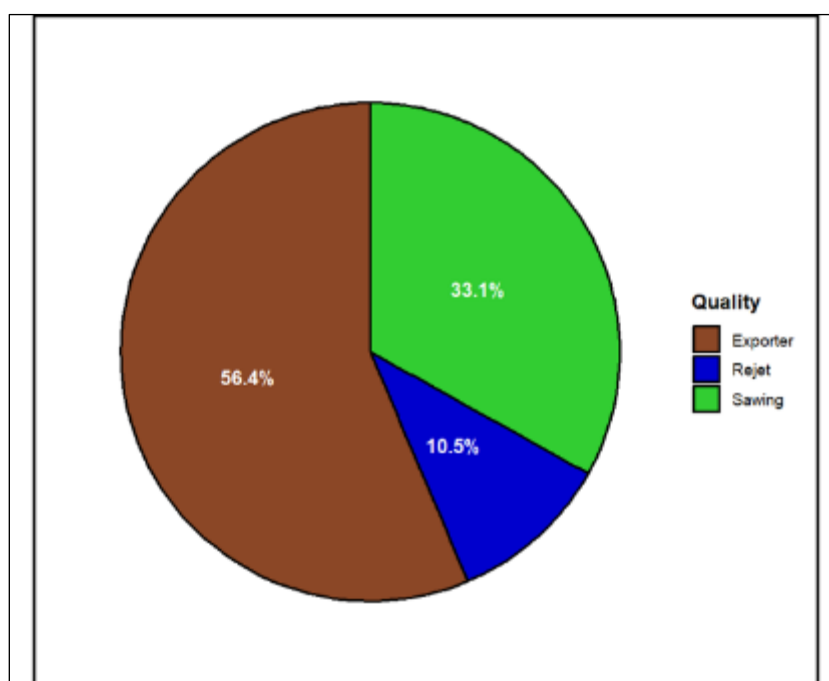


Figure 7: Distribution of Commercial Timber Species by Quality Class Across the Three Forest Patches

3.2.4 Tree Social Status and Health Status

Across the three forest patches, 78% of the individuals were classified as suppressed trees, 17% as dominant trees, and 5% as codominant trees. Regarding tree health status, the inventoried individuals were predominantly healthy (92.1%).

3.2.5 Comparative Analysis of Dendrometric Parameters of Commercial Timber Species

The comparative analysis carried out between the different dendrometric parameters measured revealed no significant difference between the most commercialized species (Table 7), *Celtis mildbraedii* recorded a value of higher and statistically different importance ($P < 0.01$) from the other species. It is followed by *Nesogordonia papaverifera* and *Ricinodendron heudelotii*. No significant difference was observed between the heights and diameters of the commercial species recorded.

Table 7: Comparative Analysis of Commercial Timber Species Based on Dendrometric Parameters

Species	Relative Importance Value (%)	Height (m)	Diameter (cm)
<i>Celtis mildbraedii</i>	36.1 ± 7.15 ^a	12.5 ± 0.788 ^a	30.0 ± 1.62 ^a
<i>Nesogordonia papaverifera</i>	17.4 ± 2.47 ^{ab}	9.69 ± 0.641 ^a	26.6 ± 0.532 ^a
<i>Ricinodendron heudelotii</i>	15.6 ± 6.14 ^{ab}	8.77 ± 1.78 ^a	33.3 ± 9.10 ^a
<i>Triplochiton scleroxylon</i>	12.2 ± 4.97 ^b	15.7 ± 3.08 ^a	44.9 ± 9.89 ^a
<i>Mansonia altissima</i>	10 ± 1.86 ^b	9.82 ± 0.581 ^a	22.9 ± 3.55 ^a
<i>Entandrophragma angolense</i>	8.6 ± 0.872 ^b	8.38 ± 0.418 ^a	21.8 ± 4.59 ^a
<i>Discoglyprema caloneura</i>	8.57 ± 8.57 ^b	3.88 ± 3.88 ^a	13.4 ± 13.4 ^a
<i>Celtis zenkeri</i>	7.73 ± 3.26 ^b	9.37 ± 0.819 ^a	28.0 ± 4.90 ^a
<i>Pterygota macrocarpa</i>	7.4 ± 3.79 ^b	6.19 ± 3.12 ^a	13.3 ± 6.65 ^a
<i>Ceiba pentandra</i>	7.3 ± 4.16 ^b	6.64 ± 3.32 ^a	21.2 ± 10.6 ^a
<i>Sterculia rhinopetala</i>	7.3 ± 3.94 ^b	6.12 ± 3.07 ^a	15.4 ± 7.73 ^a
<i>Antiaris toxicaria</i>	6.33 ± 3.03 ^b	10.8 ± 2.04 ^a	28.7 ± 9.17 ^a
<i>Pycnanthus angolensis</i>	4.17 ± 1.71 ^b	11.8 ± 3.88 ^a	36.8 ± 15.8 ^a
<i>Guarea cedrata</i>	3.97 ± 2.85 ^b	4.61 ± 2.36 ^a	10.2 ± 5.21 ^a
<i>Guibourtia ehie</i>	1.57 ± 1.57 ^b	7.67 ± 7.67 ^a	20 ± 20 ^a
<i>Khaya ivorensis</i>	1.53 ± 0.786 ^b	7.33 ± 3.84 ^a	15.4 ± 9.95 ^a
<i>Distemonanthus benthamianus</i>	1.3 ± 0.723 ^b	4.33 ± 2.19 ^a	6.97 ± 3.49 ^a
<i>Milicia excelsa</i>	1.07 ± 1.07 ^b	3.17 ± 3.17 ^a	7.92 ± 7.92 ^a
P-value	9.605e-05	0.3681	0.2651

4 DISCUSSION

Across the three forest patches, the inventory of woody vegetation recorded a total of 95 species belonging to 75 genera and 33 families. Five families were distinguished by their high Relative Importance Values (RIVs), namely Malvaceae, Cannabaceae, Fabaceae, Meliaceae, and Euphorbiaceae. A total of nine species belonging to the family Malvaceae were recorded across the three forest patches. The Fabaceae comprised six species, whereas the Cannabaceae comprised only four species belonging to the genera *Celtis* and *Trema*. These results could be explained by the fact that the Besso Classified Forest has been strongly disturbed by successive logging activities and forest clearing for agricultural purposes. These disturbances have resulted in the replacement of the original forest by secondary or anthropogenic vegetation formations [27]. Indeed, according to [25], the Malvaceae are a family characteristic of secondary forests. For [26], the Fabaceae are more abundant in dense humid forest with about a hundred species of trees or large trees at the level of the upper strata. In their work, [6] observe that the Fabaceae and the Malvaceae are the predominant families of the classified forest of the Besso.

Our inventories showed that the most important woody species in the three forest patches were *Celtis mildbraedii*, *Ricinodendron heudelotii*, *Nesogordonia papaverifera*, *Triplochiton scleroxylon*, *Berlinia confusa*, *Mansonia altissima*, and *Diospyros caloneura*. According to [25], semi-deciduous moist dense forests constitute the main habitat of species of the genus *Celtis*. These species also occur in the transition zone between semi-deciduous and evergreen forests but tend to become less frequent toward coastal humid forests. According to [27], the center of the Besso Classified Forest is considered a *Celtis mildbraedii* and *Triplochiton scleroxylon* forest. These observations are confirmed by our work, which shows a dominance of these two species in the study area.

The Sørensen similarity coefficient was greater than 50% among the three forest patches, indicating a relatively high degree of floristic homogeneity between them. The highest similarity was observed between Forest Patches 2 and 3. These results could be explained by the short distance between the three forest Patches. Similar findings were reported by [28] in large forest fragments between Zagné and Tai, where the proximity of forest fragments was also associated with similarities in floristic composition.

The reverse J-shaped diameter distribution observed in the Besso Classified Forest indicates a strong predominance of young trees. According to [29], this type of diameter structure is characteristic of a young, regenerating secondary forest in a relatively stable state. The observed pattern is further reflected in the low proportion of large-diameter individuals within the study area. In contrast, [12] reported that a high abundance of large-diameter trees is generally indicative of mature forest stands. This pattern does not appear to characterize the Besso Classified Forest, which has experienced prolonged and recurrent disturbance. Repeated, and in some cases relatively recent, logging activities in this part of the forest have created canopy openings that provide favorable conditions for the establishment and development of young trees. Consequently, the predominance of small-diameter individuals may reflect the ongoing regeneration of wood vegetation following these disturbances. Our findings are consistent with observations reported by [30] in the Tai National Park and by [31] in the Djoumouna Forest in the Congo.

The majority of the commercial timber species recorded in the study area were of export quality but occurred mainly as suppressed trees. In the Banco National Park, [32] reported that 76% of the *Tarrietia utilis* individuals were of export quality, while 44.2% were emergent trees. In that study, *Tarrietia utilis* was established through artificial regeneration, which may explain the high proportion of emergent individuals, particularly under regular maintenance and silvicultural management. In natural forests, however, tree growth is generally slower because of the absence of regular maintenance and silvicultural interventions. This may explain the predominance of suppressed individuals observed among the commercial timber species in the present study.

The central part of the Besso Classified Forest was characterized by a predominance of *Celtis mildbraedii*, *Nesogordonia papaverifera*, *Mansonia altissima*, *Ricinodendron heudelotii*, *Entandrophragma angolense*, and *Pterygota macrocarpa*. These findings are consistent with those of [24], who predicted that the species most likely to dominate the future stand would include Ba (*Celtis mildbraedii*), Eho (*Ricinodendron heudelotii*), Kotibé (*Nesogordonia papaverifera*), and Fromager (*Ceiba pentandra*).

Most of the commercial timber species recorded in the study area had total heights below 20 m. Comparative analysis of the measured dendrometric parameters revealed no significant differences among the main commercially important species. This lack of significant differences may be attributed to the considerable variability in dendrometric characteristics within and among the species recorded. It may also reflect the history of forest exploitation in these forest patches, where logging activities occurred several decades ago. The current structure of the commercial timber population may therefore represent the result of post-disturbance regeneration and subsequent growth following these past logging activities.

5 CONCLUSION

The inventory conducted in three forest patches located in the central part of the Besso Classified Forest revealed a total of 33 plant families and 95 species over a sampled area of 1.04 ha. The Malvaceae were by far the most important family, with a Relative Importance Value (RIV) of 62.8%, followed by the Cannabaceae and Fabaceae. The species composition was characterized by seven particularly important species : *Celtis mildbraedii*, *Ricinodendron heudelotii*, *Nesogordonia papaverifera*, *Triplochiton scleroxylon*, *Berlinia confusa*, *Mansonia altissima*, and *Discoglyprena caloneura*.

The diameter structure of the woody vegetation exhibited a reverse J-shaped pattern, suggesting a young secondary forest undergoing regeneration. A total of 305 individuals with a diameter at breast height (dbh) ≥ 10 cm were identified as commercial timber species. The most frequently represented species were *Celtis mildbraedii*, *Nesogordonia papaverifera*, and *Mansonia altissima*. Most of these commercial timber species were classified as export quality; however, they were predominantly suppressed and generally had relatively low total heights. Further studies should extend the assessment to all forest patches within the Besso Classified Forest in order to compare their conservation status and better understand their ecological condition. Given the predominance of suppressed commercial timber species, silvicultural interventions, particularly selective thinning and vine cutting, could be considered to reduce competition and promote their growth and development.

STATEMENTS ON COMPLIANCE WITH ETHICAL STANDARDS

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Disclosure of conflict of interest

The authors declare that they have no conflict of interest regarding this article.

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