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STRUCTURAL DIVERSITY OF VEGETATION IN THE CLASSIFIED FOREST OF ORUMBO BOKA (CENTRAL OF IVORY COAST)

Abstract: *Objective : This study aims to make a structural description of the vegetation of the Orumbo Boka forest (Ivory Coast) in order to provide useful baseline data for the rational subsequent management of this classified forest. Methodology and results: A botanical inventory was carried out in 500 m2 (25 m x 20 m) plots set up in each of the habitats of the classified forest. Within the plots, arborescent individuals with a Diameter at Breast Height (DBH) greater than or equal to 2.5 cm at 1.30 m above ground level were counted. For individuals with buttresses and stilt roots higher than 1.30 m, the diameter was measured at 50 cm just above the buttresses or stilt roots. For branched individuals less than 1.30 m high, each stem was considered as a plant in its own right and measurements were made on each of them. This study identified a total of 4416 individuals of trees with a DBH greater than or equal to 2.5 cm on 2.3 ha with a higher average density at forest level (2050.4 ± 288.3 individuals / ha) than the two other habitats which are fallow and cultivated area. Conclusion: these results reveal the specific richness of this classified forest, which is sufficient to justify its protection.*

Key words: *Classified forest, DBH, Plot, Orumba boka.*

Language: *English*

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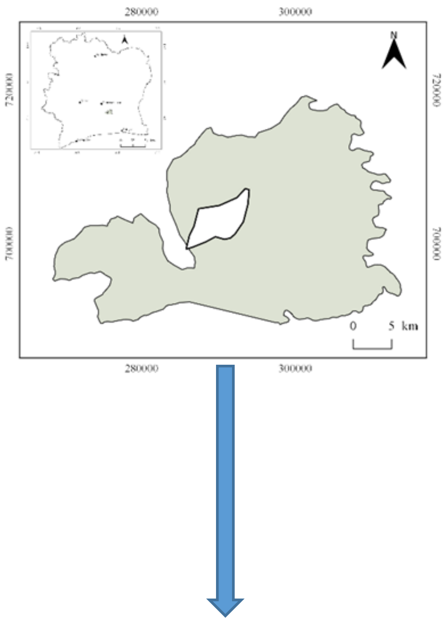
Introduction

Tropical rainforests are ecosystems of proven importance [1,2,3]. They play a key role in biodiversity conservation and carbon storage [4]. Despite the important services provided by these forest ecosystems, they remain under serious threat worldwide, due in part to the current population growth in the world's regions [5]. Like the countries of tropical West Africa, the degradation of the Ivorian plant cover is becoming increasingly alarming. The centre of the country, which is a forest-savanna contact zone where vast cocoa plantations are now located, is experiencing a sharp decline in its forests. In response, the State has proceeded to classify some of these forests, including that of Mount Orumbo Boka. This forest is under permanent threat from the surrounding populations who live there. It is subject to several actions such as hunting, agriculture, deforestation, etc. For a reasonable and sustainable management, a good knowledge of the floristic composition, the structure of its vegetation and the state of evolution of its ecosystems is necessary. However, very few studies exist on this classified forest. The structure of a plant formation provides a great deal of important information about it. Therefore, in order to provide useful basic data for a rational future management of this classified forest of the Orumbo Boka, the present study aims to give an overview of the structural diversity of the vegetation of this classified forest. The aim is to describe the vegetation structure for each of the biotopes encountered in this forest, including the montane and piedmont.

1-MATERIAL AND METHODS

1-1-Study site

The study took place in the area of Mount Orumbo Boka in central Ivory Coast in the Toumodi department (Figure 1), more precisely in the Kpouébo sub-prefecture. This Sub-prefecture lies between latitudes North 6°19'60" and 4°51'0" and longitudes West. Mount Orumbo-boka is located between the villages of Akakro-N'zipro, Kpouébo, Bassakro, and Assakra. The climate of the region is transitional equatorial [6]. Annual rainfall ranges from 1106 mm to 1300 mm. Temperatures vary between 26.5°C and 28°C with an annual average of 27.14°C. The vegetation of the zone belongs to the mesophilic sector of the Guinean domain [7]. It consists of a mosaic of Guinean savannahs and semi-deciduous dense humid forests with *Celtis spp*, *Triplochiton scleroxylon* and *Aubrevillea kerstingii*. Several soil types occur in the study area. The soils are more or less reworked ferralitic types, or ferruginous types derived from sandy granitic colluvium [8], very suitable for agriculture.



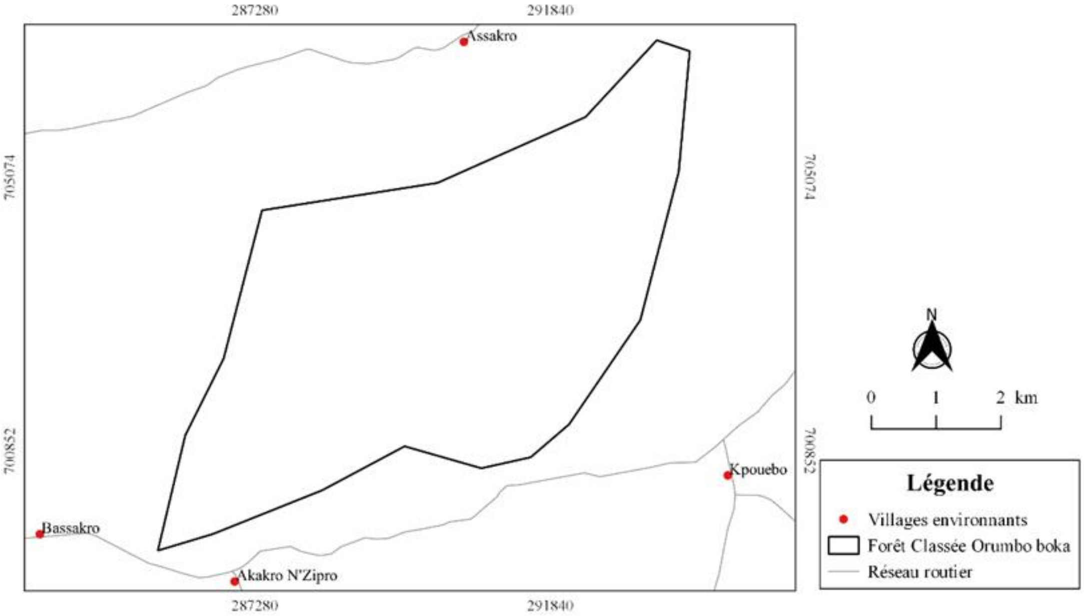


Figure 1: Location maps of the Orumbo Boka Ranked Forest

1-2-Data collection

The survey carried out in this forest identified 3 biotopes: forests, fallow land and cocoa plantations. Botanical inventories were carried out in each of these habitats. Thus, plots of 500 m² (25 m x 20 m) were set up. Within the plots, all tree individuals with a Diameter at Breast Height (DBH) greater than or equal to 2.5 cm at 1.30 m above ground level were counted (Figure 2). The choice of this minimum diameter value makes it possible to maximise the diversity of plant species by better characterising the floristic composition and density of species in a biotope [9,10] . For individuals with buttresses and stilt roots over 1.30 m high, the diameter was measured at 50 cm just above the top of the tree. buttresses or stilt roots. At the level of individuals branching less than 1.30 m, each stem was considered as a plant in its own right and measurements are carried out on each of them [11]. A total of 74 plots were established: 14 plots in forests, 25 plots in fallow (from cocoa plantations) and 35 plots in plantations, all located in cocoa plantations. Species not identified in the field were harvested, and a herbarium was set up to enable them to be identified at the National Floristic Centre (NFC).

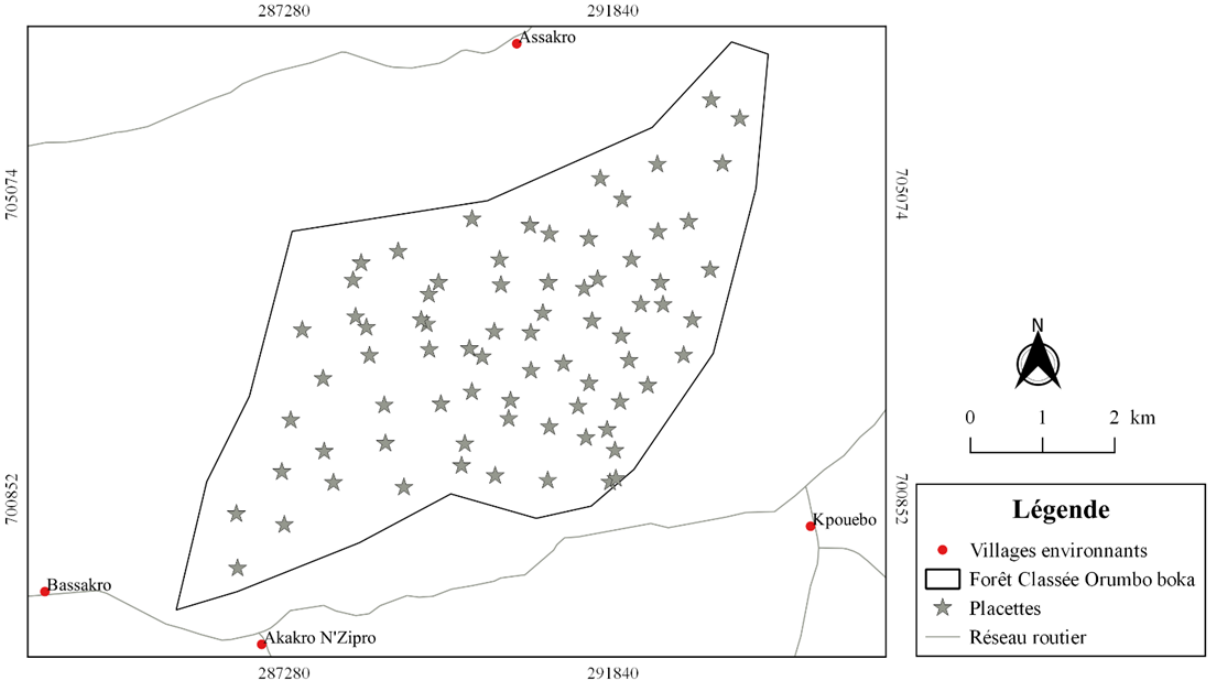


Figure 2: Location map of inventory plots in the FCOB

1-3-Data Analysis

Within each biotope, the density of individuals was evaluated by counting the number of individuals per hectare; the basal area was calculated using the following mathematical formula :

$$G = \pi D^2/4$$

G is the basal area expressed in m² / ha, π = 3.1416 and D is the diameter determined from the circumference measured during the inventories. This parameter is characteristic of the stability of a biotope [12]. The distribution of individuals per diameter class, also called "total structure" by foresters [13], makes it possible to account for the demographic structure of woody stands through histograms of the distribution of individuals per diameter class. In this study, the choice of a minimum DBH of 2.5 cm allowed to compare the floristic diversity obtained by considering three ranges of minimum DBH values: 2.5 cm ≤ DBH < 5 cm (regeneration individuals); 5 cm ≤ DBH < 10 cm (juvenile individuals) and mature individuals with DBH greater than 10 cm. Finally, the total biomass is obtained by summing the above-ground biomass and the root biomass.

$$BT = AGB + BGB$$

With BT, the total biomass, BGB for the underground biomass in Kg and AGB, the aboveground biomass.

Above Ground Biomass (AGB) was calculated from the equation of [14]. This is the equation specific to semi-deciduous dense humid forests. The basic mathematical model is as follows:

$$AGB = \rho \times \exp\left(-1{,}499 + \ln(D) + 0{,}207 \times (\ln(D))^2\right) - 0{,}0281 \times (\ln(D))^3)$$

In this formula, AGB refers to the Biomass of the tree above ground in kg; D, the trunk diameter 130 cm; and ρ: the species specific gravity (g.cm3). Tree densities were obtained from the following databases: Global wood density data base [15]. For species for which we did not know the density, we used the default value (ρ = 0.58 g/cm3) for tropical forests in Africa [16]. Specific equations were also used to estimate the biomass of the different species not taken into account by the [14] equation. Thus, for palm biomass (coconut, rowan and oil palm), the [17] equation was used. For banana and coffee trees, the equations of [18] were used as a basis for calculations. The biomass of cocoa trees was estimated using two equations; that of [19] for diameters between 1.3 cm and 26.8; that of [20] for the largest (Table I).

Table I : Allometric equations used to calculate the biomass of surveyed species

Plant species	Equations used	Sources
Theobroma cacao	$AGB = 10^{(-1{,}625) + 2{,}626 * LogD}$	[19]
Coffea sp.	$AGB = 0{,}281 * D^{2,06}$	[21]
Musa spp.	$AGB = 0{,}030 * D^{2,13}$	[21]
Other palms	AGB = exp (2,134 + 2,530 * ln (D))	[17]

Below Ground Biomass (BGB) is predicted from the above-ground biomass estimate. Root biomass was estimated in accordance with the guidelines established by the [22]. According to these guidelines, the root biomass equivalence of standing woody trees is found by multiplying the value of the above-ground biomass (AGB) by a coefficient R, whose value is estimated at 0.24. The above-ground biomass (AGB) is estimated by multiplying the above-ground biomass (AGB) by a coefficient R, whose value is estimated at 0.24.

$$BGB = AGB \times R$$

With BGB designating the underground biomass determined in Kg, ABG, the aboveground biomass in Kg and R, Root to shoot ratio.

For the statistical analysis of the results, the Kruskal-Wallis non-parametric test was carried out in order to compare the averages two by two and to assess whether or not there were significant differences between them.

2-RESULTS

2-1-Density in different habitat types

The survey conducted in this area identified a total of 4416 individuals of trees with a DBH greater than or equal to 2.5 cm on 2.3 ha. The average density varies from one habitat to another (Table II). Taking into account the habitats present in the study area, the mean density was greater in the forests with 2050.4 ± 288.3 individuals / ha. This is followed by fallow land with a mean density value of 1581.25 ± 741.3 individuals / ha). The areas of crops have the fewest individuals per hectare with an average of 175.2 ± 128.5. The Kruskas walis test showed that there was a significant difference in mean habitat density ($\chi2$ = 76.1; $p < 0.0001$).

2-2-Basal areas in different habitat types

All individuals with DBH greater than or equal to 2.5 cm from the Orumbo-Boka area reported the highest mean basal area, 62.7 ± 12.3 m² / ha (Table II). This is followed by fallow land with an average value of 46.8 ± 28.9 m² / ha. While the lowest mean basal area of 8.25 ± 3.06 m² / ha was obtained in crops. The differences observed between the mean values of the basal areas were significant ($\chi^2 = 43.6$; $p < 0.0001$).

2-3-Distribution of stems by diameter classes

The horizontal structure of the different habitat types in the Orumbo-Boka area shows differences in the shape of the curve Taking into account all habitats (forest, fallow and crop), mature individuals with a diameter greater than 10 were most numerous in fallow and cocoa fields (Figure 3). On both sides of this class, densities of individuals were poorly represented. The histogram of stem distribution in cultivated areas showed a sawtooth pattern. However, in forests, the regressive evolution of stems from the smallest to the largest diameters gave the curve an inverted "J" shape beyond the 10 cm DBH.

2-4-Total Biomass of the different FCOB habitats

Taking into account all individuals in the Orumbo-Boka area, the mean biomass ranged from 100.71 ± 28.7 to 47.7 ± 77.3 (Table III).

Table II: Mean values of structural parameters of vegetation in different habitats

Habitat type	Density (stems / ha)	Basal area (m² / ha)
Forest	2050,4 ± 288,3^{c}	62,7± 12,3^{b}
Fallow land	1027,9 ± 741,25^{ab}	46,8 ± 28,9^{ab}
Culture	175,2 ± 128,5^{a}	25 ± 3,06 ^{c}
Statistical test	χ^2 = 76,1 ; ***	χ^2 = 43,6 ;***

*For the same column, the mean values assigned to the same letter are not significantly different: * < 0,05, **<0,01, ***<0,001*

Table III: Average biomass values in different habitats

Habitat type	Average biomass (t / ha)
Forest	100,71 ± 28,7^{a}
Fallow land	62,1 ± 90,2^{b}
Culture	47,7 ± 77,3^{bc}
Statistical test	χ^2 = 79,54,***

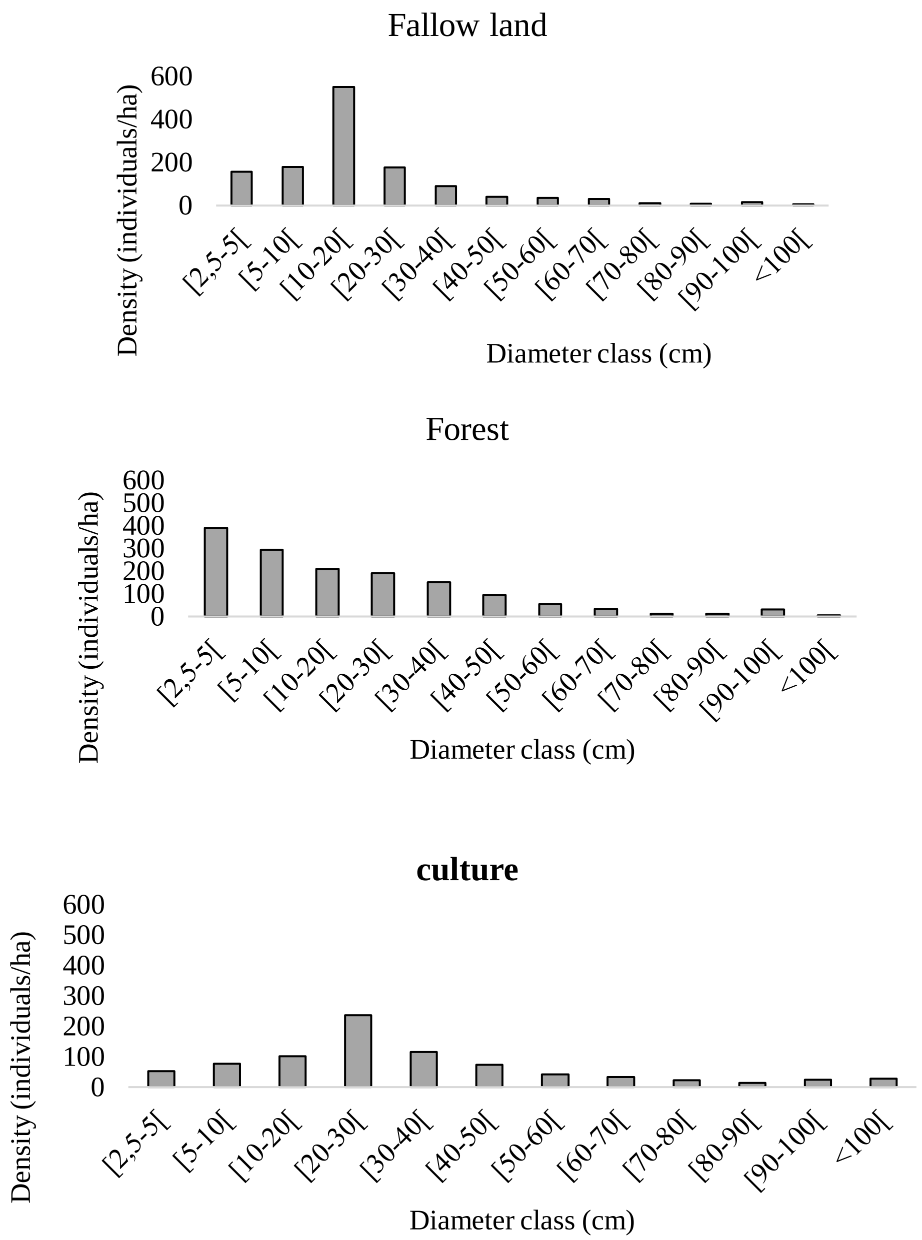


Figure 3: Histograms of the number of individuals in diameter classes in different FCOB habitats

3-DISCUSSION

Average density values vary from one habitat to another regardless of the class of DBH. When considering biotopes, the lower density of individuals in the different DBH classes of cropland areas can be explained by the agricultural clearing of this habitat. The collection of dead wood, the felling of palm trees requires trampling and leads to the extinction of species in the undergrowth. The drawbacks of anthropogenic activities on phytobiomass are reflected in the reduction of densities in areas converted into fields [23]. In cocoa (*Theobroma cacao*) crops, most cocoa trees are located in the 5 to 15 year age group. According to [24] in cocoa plantations, there is an introduction of exotic species whose densities decrease with age, either through natural death or by the action of farmers, as found by [25] in the Monogaga classified forest. Large diameter individuals are represented by the cocoa tree stalks that are becoming mature. In cocoa fields, large trees are removed either by fire or by making whole cuts in the epidermis. This can often explain the absence or reduction in the number of large trees in post-cultivation fallows. In this study, the basal areas obtained in the fallows are higher than those obtained by [26] in the Azaguié fallows. Indeed, this difference could be explained by the fact that the DBH of the trees were higher in the present study but also by the influence of the cultural precedent considered. According to a study conducted by [27], basal areas are influenced by the type of crop that existed on the plot. In forest areas within the FCOB area, the shapes of the stem distribution histograms by class show an inverted "J" curve. This pattern means that in these habitats, tree stand renewal is occurring. This shape is typical in most tropical forests [26,28,29,30]. This situation is attributed to the anthropic pressures that are notable in these environments. The work of [31] corroborates this state of affairs. Such a configuration of the distribution histogram of individuals reveals a progressive decrease in the number of individuals when the diameter class increases. Thus, the abundance of regeneration individuals over young and mature individuals, observed in riparian thickets, attests to the good reconstitution of tree stands. On the other hand, in cultivated areas (fallow land and cocoa fields) the histograms are bell-shaped. Indeed, farmers are growing cocoa trees (*Theobroma cacao*). Thus, the feet of cocoa trees are located in the 5 to 15 year age group. The work of [24] has shown that in cocoa plantations, there is an introduction of exotic species whose densities decrease with age, either through natural death or the action of farmers, as [25] found in the Monogaga classified forest. Large-diameter individuals are represented by the feet of cocoa trees as they mature. In palm groves, this is due to the method of management and maintenance of the species in these crops. Farmers promote regeneration and then reduce this regeneration to promote the growth of the palm trees. As a result of regular anthropogenic pressures in cultivated areas, the saw-tooth-shaped population structure reflects poor natural regeneration in these habitats.

CONCLUSION

The botanical inventory carried out in each habitat of the Orumbo Boka classified forest revealed the reduction of densities in areas converted into fields, the abundance of regeneration individuals on young and mature individuals. From a conservation point of view, this classified forest thus represents a fairly rich plant formation. This explains the high structural diversity observed in each habitat. It is therefore up to the State of Ivory Coast to preserve this classified forest which plays an important role in the conservation of plant biodiversity.

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