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**Biosciences**

# Biodiversity and Conservation of the Vegetation of A Private Forest in Allany (Agboville, Ivory Coast)

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| Abstract | Original Research Article |
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Today, plant biodiversity is being degraded worldwide. Among the various tools that can, if not stop, at least slow down the loss of biological diversity, protected areas and private forests, botanical gardens, occupy a major place. The objective of this study is to assess the floristic diversity and the conservation value of biodiversity in this private reserve. Surface surveys coupled with itinerant inventories in this forest at Allany in the Department of Agboville (Ivory Coast), have made it possible to inventory three plant formations. The flora comprises 328 species divided into 233 genera and 75 families. Among these species, nineteen are West African endemics. The site contains 16 species on the IUCN Red List and threatened with extinction. The forest also contains many species that have become rare in Côte d'Ivoire. This exceptional biodiversity is not subject to human pressures. In an integrated approach to biodiversity management, we encourage its transformation into a private reserve or a private botanical conservatory.
**Keywords:** Biodiversity, Conservation, Private reserve, Allany (Ivory Coast).

## INTRODUCTION

The mobilization around the Paris Climate 2015 conference (COP 21) was an opportunity to highlight the vulnerability of the environments and populations of the South to global warming. The measurement of biodiversity is decisive for ecological research and conservation [1, 2]. Today, plant biodiversity is being degraded worldwide [3]. Every decade, 0.1% of species disappear [4]. Among the various tools that can, if not stop, at least slow down the loss of biological diversity, protected areas and private forests, botanical gardens, seed banks outside of protected conservation areas, occupy a major place. Thus, according to [5, 2], conservation is the first issue that is centrally important within the field of biodiversity. Unfortunately, for decades, Côte d'Ivoire has seen its forest cover degrade [2]. This reduction of the Ivorian forest is mainly the result of the exploitation of marketable forest species and the need for land for cash crops (cocoa, coffee, pineapple, banana, rubber, etc.), the products of these activities being destined for export. With population growth, mainly due to migration, the clearing of land for food crops, mainly for the local population, and bush fires have also put pressure on the forest. Ivory Coast 's forest cover increased successively to 16 million hectares in 1960, then to 8 million ten years later, an average loss of 400,000 hectares per year [6]. In the 1970s, the Ivorian forest massifs only covered 5.4 million hectares. Today, according to [2], only about 2.5 million hectares of forest remain, 30% of which is thought to be occupied by agricultural plots for cash crops such as coffee and cocoa.

To remedy this problem, the Ivorian state encourages the creation of private forests to conserve plant and animal biodiversity. As a result, the decision to create a private reserve or voluntary nature reserve has become possible for individuals or communities with private property rights [7]. The general objective of this study is to assess the plant biodiversity of a private forest located in an agricultural area in Ivory Coast. More specifically, this study aims to determine the types of plant formation encountered in the forest, to assess the forest's floristic diversity and finally to estimate the value of the private forest due to the presence of species with a special and commercial status within it.

## MATERIAL AND METHOD
### Study Environment

The private reserve (6° 11' 45.3" - 6° 11' 44.02" N and 4° 17' 22.45" - 4° 17' 25.34" W) is located in Allany in the Department of Agboville. It is a semi-deciduous dense forest subject to a sub-humid

tropical climate, belonging to the mesophilic sector according to the subdivisions established by [8]. The climatic vegetation is the semi-deciduous humid dense forest in the sense of [9]. It covers 50 hectares on a schisto-birrimian-granitic base on which ferralitic and hydromorphic soils have developed. The average annual temperature is 26.72°C. The average annual rainfall is 1585.3 mm. The climate determines a potential vegetation of semi-deciduous dense humid forest.

## DATA COLLECTION

The sampling plan was designed in such a way as to place surveys in all types of vegetation encountered on the site, i.e. primary forest (n=10 surveys) and fallow land in the same forest (n=7 surveys). Thus, 17 surveys were implemented in the domain. The area survey method was used. It allows to obtain quantitative data on the floristic composition of a biotope. Within each of the selected biotopes, rectangular plots were randomly arranged. These plots were 50 m x 30 m (1500 m2) in size. Such a surface area will make it possible to take into account the minimum areas of plant communities in tropical forests [10]. The vegetation survey for this study consisted of a census of all vascular species present in the area and their cover according to the recommendations of [11]. The geographical coordinates of the survey points were recorded using GPS. Complementary itinerant inventories were carried out in all parts of the forest. These inventories made it possible to complete the floristic list. All species were identified. All species have been identified. The names of the taxa were updated thanks to the work of [12]. Species nomenclature follows APG [13].

## DATA ANALYSIS

The floristic diversity was analysed using the number of species considered as the first parameter of alpha diversity [14]. The biological types, chorological affinities and mode of dissemination of diasporas used were borrowed from [6]. The assessment of alpha diversity was made following the determination of the specific richness (R) and the calculation of the Shannon diversity index. This index measures the species composition of a stand by taking into account the specific richness and relative abundance. It can be summed up in the following mathematical expression:

$$H' = -\sum [(ni/N) \times \ln (ni/N)]$$

Pielou's equitability was also calculated. It provides information on the distribution of numbers between the different species. This index is calculated according to the following mathematical formula:

$$E = H' / \ln S$$

We used the Sørensen similarity coefficient to measure the floristic similarity between the degraded and non-degraded forest plots on the estate. It is calculated as follows:

$$Ks = [2c /a + b] \times 100$$

A Kruskal Wallis test was applied in order to compare the calculated indices of the three biotopes studied. This choice was due to the fact that the conditions of normality and homogeneity were not met for our variables. The level of significance chosen for these analyses was 5% (P = 0.05). This test was carried out using R ®3.2 software.

## RESULTS

### Description of the different plant formations encountered in the field

1.1.1. There are three main plant formations identified on the site. These are primary forest (Fig-1A), post-cultivation fallows (Fig-1B) and perennial crops (Cocoa: Theobroma cacao L., Coffee: Coffea arabica L.) and food crops. Cocoa and coffee orchards are in production (Fig-1C). The main food crops are (Fig-1D): banana (Musa sapientum), yams (Dioscorea alata, D. cayenensis, D. dumetorum), cassava (Manihot esculenta), maize (Zea mays), rice (Oryza glaberrima and O. dumetorum). sativa), taro (Xantoxoma maffa), aubergine (Solanum melongena), chilli (Capsicum frutescens), okra (Hibiscus esculentus), tomato (Solanum lycopersicum).

### Floristic Composition

The floristic inventory of the site has identified 328 species, divided into 233 genera and 75 families. The Fabaceae family with 39 species, i.e. a rate of 11.89%, is the best represented. It is followed by the Apocynaceae (23 species or 7.01%), the Malvaceae (20 species or 6.10%), the Rubiaceae (18 species or 5.49%), the Annonaceae and the Moraceae with 12 species each, or 3.66%. Some families such as the Amaranthaceae, Amaryllidaceae, Balanophoraceae, Bromeliaceae, Burseraceae..., are less represented with only 1 species (i.e. a rate of 3.66%).

### Biological Types

The spectrum of biological types at the study site indicates that microphanerophytes account for 50% of the species inventoried (Fig-2). Nanophanerophytes present 24% of species, followed by geophytes and mesophanerophytes, which present 15% and 5% of species respectively. The others are less represented. Thus, chamephytes, hemicryptophytes and therophytes each present 2% of the species.

**Fig-1: View of a portion of the studied forest**
**Legend:** 1A: View of a primary part, 1B: View of the fallow land, 1C: View of a cocoa field, 1D: View of a food crop

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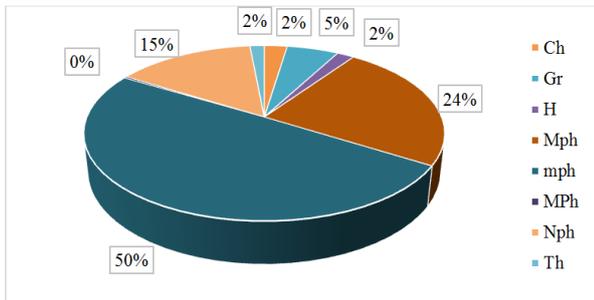


**Fig-2: Spectrum of biological types of flora in the study environment**
**Legend** : mph - microphanerophytes, Mph - mesophanerophytes, Nph - nanophanerophytes, MPh - megaphonerophytes, Gr- géophytes, H - hemicryptophytes, Ch. -chamephytes, Th - therophytes, Ept- epiphytes

## Mode of Dissemination

The spectrum of spread of the diasporas of the estate's flora highlights the dominance of endozoochory with 212 species, i.e. 66% of the total number. Anemochorous species are also well represented in the domain. We inventoried 85 species, i.e. 26%. Epizoochory species are very poorly represented in the domain (15 species, i.e. 5%). Barochory species, with only 08 species, i.e. 3% of the total number, are less represented in the domain.

## Chorological Affinity

The estate's flora consists mainly of Guinean-Congolese species (GC), i.e. 183 species (57%), followed by forest-savanna transition or Guinean-Congolese-Sudano-Zambézian liaison species (GC-SZ) with 41 species, i.e. 13% of the total number. Introduced species (i) number 14 species (i.e. 4%) and West African endemic species (GCW) number 22 species (i.e. 7%). The distribution of other species inventoried according to White's classification is as follows: Afro-tropical (AT, 30 species, or 9%); Pantropical (Pan, 17 species, or 5%); African multi-regional species (PA 13 species, or 4%) and African-American (Aam, 02 species, or 1%).

## Quantitative diversity of the site

1.1.2. Two indices were calculated from the plots laid out in the different biotopes visited: the Shannon index and the Piélou equitability index. The calculated Shannon indices vary from 2.78 to 3.91 between the plots on the estate. Statistically, all the biotopes visited do not have the same diversity. The calculated equitability index tends towards 1 for all the plant formations. The calculated values vary between 0.95 and 0.98 between the three biotopes. These different values reveal that there is no dominance of one species over another within the biotopes. The Kruskal Wallis Test shows that there is no difference ($X^2$= 27.875; P = 0.84) in the Pielou equitability indices. The calculated Sørensen coefficient shows that there is little similarity between primary forest and fallow plots (35.87%). The calculated Sørensen coefficient shows that there is little similarity between primary forest and fallow plots (35.87%).

## Biodiversity conservation value of the estate

Of the species recorded in the field, 19 (or 7.04% of the total number) are West African endemic (GCW). Of these, there are no Ivorian endemics.

Nevertheless, many species that have become rare in Ivory Coast exist in this private forest. These include species such as Annickia polycarpa (DC.) Engl. and Diels, Balanites wilsoniana Dawe & Sprague, Cola lateritia K. Schum. var. maclaudii Brenan, Dacryodes klaineana (Pierre) H. J. Lam, Guarea cedrata (A. Chev.) Pellegr, Ochthocosmus africanus Hook. f., Zanthoxyllum leprieurii Guill. & Perr. Comparison of the general list of species on the estate with the IUCN Red List and the list of endangered species of Ivorian flora enabled us to identify 16 species (5.92%) on the IUCN Red List (Table 1) and 3 species (1.11%) on the list of endangered species of Ivorian flora, including Zanthoxyllum leprieurii Guill. & Perr. (Rutaaceae), a species that has become rare or endangered and is only exceptionally found in Ivory Coast. Of the 16 species on the IUCN Red List, 8 (50%) are vulnerable (VU), 2 species (1.3%) are at low risk but close to threat (LR/nt) and 3 other species (1.9%) are of minor concern (LC). The floristic inventory of the estate also made it possible to identify a total of 32 commercial species used as raw materials in the wood industry, i.e. 11.85% of the species inventoried. These species are divided into 25 genera grouped into 13 families. The most representative families in terms of the number of species are Malvaceae sensus lacto (7 species recorded, 2.59%) and Meliaceae (5 species, 1.85%).

## DISCUSSION

Our work has shown that the estate still contains 30 hectares of primary forest. According to [7], the semi-deciduous forests extend under climates with a more marked dry season (2 to 3 months) and annual rainfall of between 1,350 and 1,650 mm. There are two other types of plant formations on the study site, namely post-cultivation fallows, degraded parts of the same forest and perennial crops and food crops. Investigations in the field make it possible to draw up a first draft of a floristic catalogue since the field has no reference flora. The floristic inventories carried out on the estate have enabled 328 species to be counted, divided into 233 genera and 75 families. These species constitute a fairly significant wealth and represent 9.02% of the totality of Ivorian flora as listed by [6]. This private forest owes its high floristic richness to the protection it enjoys. However, the specific richness of our study site is less than that of the classified forest of Bamo also located in the department of Agboville [15] inventoried 417 species distributed between 83 families and 305 genera, with a dominance of Guinean-Congolese (GC) species, 62.32%. The floristic richness of the studied area is also less than that of the classified forest of Yapo-Abbé according to the inventories of [16]. Corthay R [16] counted 794 species in the Yapo-Abbé classified forest, which is the most important plant formation in the Agboville department. The most dominant botanical families (with at least 7 species) on the site are the Fabaceae, Apocynaceae, Malvaceae, Rubiaceae, Annocaceae, Meliaceae, Moraceae, Sapindaceae and Euphorbiaceae as is the case in the majority of Ivorian forests. Indeed, several Ivorian forests are dominated by the same procession of families [7]. Nevertheless, it is worth noting that the choice of nomenclature adopted influences the rank of families. In this work, we have opted for [13] with the consequence that the family Euphorbiaceae is fragmented. In the sense of [9], the semi-deciduous dense humid forest corresponds to the centre of Guinean-Congolese floristic endemism with a dominance of Guinean-Congolese (GC) species. Our results show that Guinean species (GC: 57%) and West African endemics (GCW: 7%) are largely dominant, with proportions reaching 64%. For [18], the dominance of Guinean species in the floristic background of the studied forest is proof that this forest belongs to the Guinean-Congolese endemic centre. For [18], phytogeography is therefore a main tool for species management and conservation. They allow hypotheses to be made on the age, geographical origin, rate of evolution and migration routes of taxa in the domain.

According to [19], protected areas are the key element in any biodiversity conservation strategy for a country or region. This is particularly true for Ivory Coast, where the other elements of an integrated conservation strategy are little or not developed (botanical or zoological gardens, seed banks, sustainable management of ecosystems outside protected areas, etc.). To do this, one of the key actions is to establish a network of protected areas, which is at the heart of any well thought-out conservation or sustainable development strategy [19]. We believe that in an integrated approach to biodiversity management, other actions should be implemented: in situ (sustainable use of natural resources outside protected areas...) or ex situ (creation of arboretums, botanical conservatories, zoos, species breeding...) as suggested by Adingra [15]. These aspects, which are secondary in relation to national protected area systems, will undoubtedly help preserve biodiversity in Côte d'Ivoire. Thus, in our opinion, the concern for biodiversity protection in Ivory Coast involves the creation of private reserves. We can say, in view of our inventory, that the area is biologically rich and natural resources are not subject to pressure. Pluricontinental species are poorly represented in the forest. According to [6], the degree of disturbance of a forest is indeed marked by the relative importance of the group of cosmopolitan, pantropical and palaeotropical species. The Guineo-Congolese species are for the most part true forest species. Thus, the domain, through the protection or the prohibition of clearing that it benefits from, allows the conservation of some species that have become rare in Côte d'Ivoire. Indeed, the owner's will not to cultivate in the forest protects it from the tools of vegetation destruction. On an ecological level, this forest, with forest species such as (Balanites wilsoniana Dawe & Sprague, Cola caricaefolia (G. Don) K. Schum, Cola nitida (Wind.) Schott & Endl, Dalbergia oblongifolia G. Don, Dialium aubrevillei Pellegr.,

Cuerva macrophylla (Vahl) Wilczek ex N. Hallé, Zanthoxylum leprieurii Guill. & Perr.), may constitute, as suggested by [7], for the relict forests in the savannah zone in Ivory Coast, a starting point for the reconquest of the Ivorian forest and the ever-decreasing plant biodiversity. Despite its small size, the estate has significant concentrations of biodiversity at the local and regional level. In view of the above, we agree with [20] that the estate meets the recognised criteria for the creation of a Voluntary Nature Reserve. Indeed, the site abounds in species on the IUCN Red List and West African endemic species (GCW).

## CONCLUSION

The vegetation present throughout the site is in a very good state of conservation. The quantitative and qualitative diversity of the site is quite high. The list of species inventoried in these plant formations totals 328 species, divided into 233 genera and 75 families. The site is characterised by a dominance of African species, Guineo-Congolese, phanerophytes and Fabaceae sensu lacto. It is a fairly diverse forest, given the number of biological types. The diversity of the estate's flora is also reflected by the presence of several species with special status such as West African endemic species (19 species) and especially those on the IUCN Red List. The results obtained, although preliminary, will provide basic arguments for the creation of a private forest. A policy of encouraging the creation of private forests must be made, by supporting the action of individuals or villagers, for the safeguard of the forest and the floristic diversity in Ivory Coast.

## REFERENCES

1. Lu HP, Wagnerc HH, Chena XY. A contribution diversity approach to evaluate species diversity. Basic and Applied Ecology, 2007; 8:1-12.
2. Ehipka N'MM, Adou LMD, Kassi N'J. Diversité floristique et valeur de conservation d'une forêt privée à Allany (Sud-Est, Côte d'Ivoire). REB-PASRES. 2018; 3(2):43-56.
3. Thomas JA, Telfer MG, Roy DB, Preston CD, Greenwood JJ, Asher J, Fox R, Clarke RT, Lawton JH. Comparative losses of British butterflies, birds, and plants and the global extinction crisis. Sciences. 2004; 303: 1879–1881.
4. Pimm SL, Ravin PH. The fater of the word's plants. Trends in Ecology & Evolution. 2017;32(5):305-390.
5. Hufty M. La gouvernance internationale de la biodiversité. Etudes internationales. 2001; 32(1):5-29.
6. Aké-Assi L. Flore de la Côte d'Ivoire: Etude descriptive et biogéographique avec quelques notes ethnobotaniques. (Doctoral dissertation, Abidjan). 1984, 1206.
7. N'Guessan AE. Diversité floristique d'une forêt privée à Dianra au Nord de la Côte d'Ivoire. (Master, Abidjan), 2016; 51.
8. Guillaumet JL, Adjanohoun E. La végétation de la Côte d'Ivoire. In : Avenard JM, Eldin E, Girard G, Sircoulon J, Touchebeuf P, Guillaumet JL, Adjanohoun E, Perraud A. Le milieu naturel de la Côte d'Ivoire. Mémoires ORSTOM. 1971; 50:157-263.
9. Aubréville A. Accord à Yangambi sur la nomenclature des types africains de végétation. Bois et Forêts des tropiques. 1957; 51: 23-27.
10. Senterre B. Recherches méthodologiques pour la typologie de la végétation et la phytogéographie des forêts denses d'Afrique tropicale. (Doctoral dissertation, Bruxelles -Belgique). 2005; 345.
11. Gillet F, de Foucault B, Julve PH. La Phytosociologie synusiale intégrée – objet et concepts. Candollea. 1991; 46: 315-340.
12. Lebrun JP, Stork AL. Enumération des plantes à Fleurs d'Afrique Tropicale. Conservatoire et Jardin Botaniques de la Ville de Genève, Genève (Suisse). 1991-1997; 1(249).
13. APG IV. An update of the Angiosperm Phylogeny Group classification for the ordersand families of flowering plants. Botanical Journal of the Linnean Society. 2016; 181: 1–20.
14. Tuomisto H. Commentary: do we have a consistent terminology for species diversty ? Yes, if we chose to use it. Oecologia. 2011; 167: 903-911.
15. Adingra OMMA. Dynamique du peuplement et stock de carbone dans la mosaïque de végétation de la forêt classée de Bamo (Côte d'Ivoire). (Doctoral dissertation, Abidjan). 2017; 158.
16. Corthay R. Analyse floristique de la forêt sempervirente de Yapo (Côte d'Ivoire) Master, Genève). 1996; 152.
17. Yongo OD. Contribution aux études floristiques, phytogéographique et phytosociologique de la forêt de N'Gotto (République de Centrafrique). Résumé de Thèse. 2003; 150:119-124.
18. Koffi KJ, Champluvier D, Neuba, FRD, Cannière C (De), Traoré D., Lejoly J, Robbrecht E, Bogaert J. Analyse de la distribution des Acanthaceae en Afrique Centrale: comparaison avec les théories phytogéographiques de Robyns, White et Ndjele. Sciences & Nature. 2008; 5(2):101-110.
19. Doumenge C, Garcia Yuste JE, Gartlan S, Langrand O, Ndinga A. Conservation de la biodiversité forestière en Afrique Centrale Atlantique : le réseau d'aires protégées est-il adéquat ? Bois et Forêts des Tropiques. 2001; 268(2):5-28.
20. Jennifer RM, Gerald S, Chng SK. Forêt à haute valeur pour la conservation: Le concept en théorie et en pratique. WWF, for a living planet. 2007; 23.