INNSPUB

Journal of Biodiversity and Environmental Sciences (JBES)
ISSN: 2220-6663 (Print) 2222-3045 (Online)
Vol. 14, No. 1, p. 61-71, 2019
http://www.innspub.net

RESEARCH PAPER OPEN ACCESS

Floristic and structural studies of the forest blocks of Nangui Abrogoua University, Cote d'Ivoire

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Article published January 26, 2019

Key words: Anthropogenic, Fragments, Botanical, Floristic.

Abstract

The rainforest, which contains more than half of the overall species diversity, is under increasing anthropogenic pressure. One of the consequences of this disappearance is the transformation of the forest landscape into a fragments of forest. This is the case of the forest relic located within the Nangui Abrogoua University. However, this forest is subject to strong anthropogenic pressures which through poaching, uncontrolled takeoffs of natural resources and some agricultural clearing. To assess the plant species diversity in this relic forest, plots, linear and itinerant surveys were conducted in this forest. To cover for the plots method, the Nangui Abrogoua Forest has been divided into 110 squares of 10 m by side. Linear method consists in counting all the points of contact of the vegetation along an imaginary vertical line, placed in an equidistant way along a graduated ribbon. The standard length of transect is 200 meters. To get a more accurate estimation of species richness and composition, additional species were added thanks to itinerant prospection. At the end of the study; we will have respectively 75 71 and 77 species divided between 65 62 and 73 genres and 36 34 38 families for Block I, Block II and Block III. At the level of the families of the whole forest, the results on the floristic wealth indicate to us that the richest families in the Blocks are Rubiaceae (Block I), Apocynaceae (Block II) and Euphorbiaceae (Block III). The study showed that many human activities are threatening the integrity of the three blocks.

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Introduction

The rainforest, which contains more than half of the overall species diversity, is under increasing anthropogenic pressure that leads to fragmentation (Tchatat *et al.*, 1999). These pressures cause its progressive destruction with more than 10% loss of forest per year (Puig, 2001). In Côte d'Ivoire, the main causes of degradation are agriculture and forest development (Alexandre 1992; Reed *et al.*, 1996). This phenomenon particularly increased after the independence in 1960 with the disappearance of more than 80% of the forest area between 1969 and 1993 (Chatelain *et al.*, 2004). One of the consequences of this disappearance is the transformation of the forest landscape into a mosaic of plantations and fragments of forests. Chatelain *et al.* (2003), showed that about a third of the Ivorian residual forest remains only in fragments lower than 10 ha. In the south, the situation in most of the park and reserve is far from being brilliant. It is even more dramatic in the urban area where most of the forests are doomed to a total disappearance under the effect of an uncontrolled exploitation by a population in strong growth (Missa *et al.*, 2018a; Missa *et al.*, 2018b). For this reason, few intact forest formations still exist in the urban area.

We can mention among the forests located in the urban area the forest of banco. The destruction of much of this forest was caused by the urbanization of the city of Abidjan. The rest of this forest formation is made up of forest fragments. This is the case of the forest relic located within the Nangui Abrogoua University. The knowledge of this forest could contribute to its conservation. The overall objective of this study is to contribute to the safeguarding of the remaining forest heritage of Côte d'Ivoire. Specifically, it is a question of characterizing the flora and the structure of the vegetation blocks of this forest relic.

Materials and methods

Sampling site

The University Nangui Abrogoua Forest (superficies of 2 ha), located in the south of Côte d'Ivoire. This forest is located in the "Région des lagunes", in the ivorian littoral sector (Fig. 1)

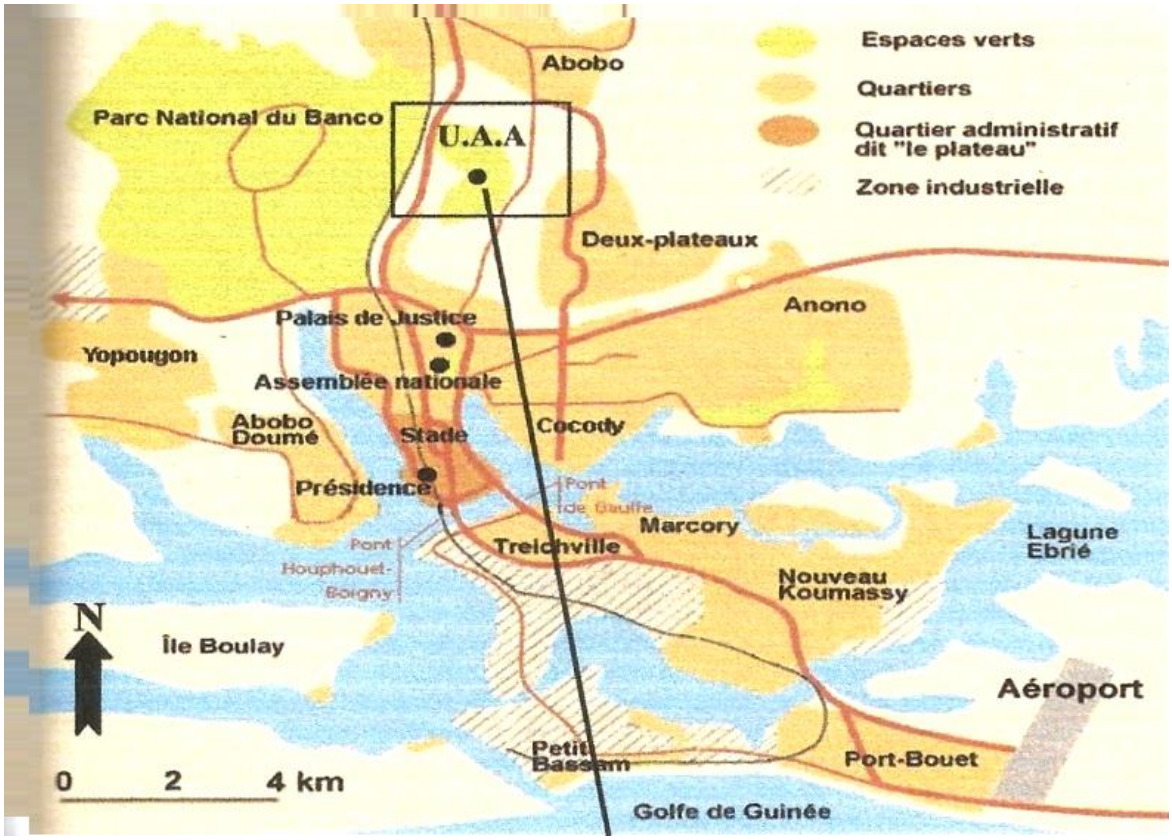


Fig. 1. Map of Université Nangui Abrogoua area, the geographical framework of this study.

The land is owned by all the urbain surrounding the forest and each of these communities hold native rights to exploit the forest. The climate of the region, which is a sub-equatorial type comprise 4 seasons (Avenard *et al.*,1971; Lauginie, 2007) a great rainy season (end of April to half July) and one dry season (from December to April) alternating with one short rainy season (from half September to the end of November) and one small dry season (half, July-half, September). The study area is characterized by the one of the Guinean domain (littoral sector). The habitat decreases with increasing area.

Field method

For the collect of data, we chose the linear method of Gautier *et al.* (1994). This method has been already used, for several studies in tropical forests (Bakayoko *et al.* (2001); Chatelain, 1996; Kouamé *et al.*, 1998).

The method consists in counting all the points of contact of the vegetation along an imaginary vertical line, placed in an equidistant way along a graduated ribbon. The standard length of transect is 200 meters. Because of the nature and humidity of soils observed in swamp areas where it is difficult to move without sinking and the small size of the dry land forests we have used a length of 100 meters.

In these forests, measurement is made each 1 meter. The minimal and maximum height of each contact with the vegetation is measured using a stake of 8 meters. This stake is drawn up vertically. The values beyond 8 meters heights are estimated. For each contact, the species and the distance to which each individual is met on transect are noted.

The plot method was usually use for forest inventories in tropical zone (Spichiger *et al.*, 1996; Hawthorne, 1996; Adou Yao *et al.*, 2007).

In order to record a maximum representative species of the inventory zone, for the study, the University Nangui Abrogoua Forest has been divided into 110 squares of 10 m by side. The position (altitude/longitude) of each plot was recorded by a GPS. In each plot all vascular plant species (trees, shrubs, grass, and lianas) were recorded. Some details data were recorded (DBH individuals numbers) for individuals with diameter equal or more than 5 cm at 1m 30 high. To get a more accurate estimation of species richness and composition, additional species were added thanks to itinerant prospection.

Data analysis

After establishing, species were examined to identify and count endemics, referring to previously checklist established by Poorter *et al*. (2004). In order to appraise the floristic diversity in the three block of University Nangui Abrogoua Forest relic. To compare the floristic of the three block, the sorensen similarity coefficient is use. To appreciate vegetation condition, gap width, and biotope recovery has been used.

The recovery of each biotope was built from averages of the strata of different survey. These comparisons have been performed using either species richness of a category, or density. Density as understood in this contribution is the percentage of sampling points at which a species has been recorded.

Results

Floristic composition

Table 1 shows the number of species, genera and families encountered in each block. At the end of the three linear readings made in the three blocks, we have respectively 75; 71; 77 species divided between 65; 62; 73 genres and 36; 34; 38 families for Block I, Block II and Block III. Linear surveys revealed 130 species, surface surveys carried out in Block I revealed 125 species. Of these species, 28 have D.B.H. greater than or equal to 5 centimeters. The roving survey revealed 54 species. For the whole forest, we have inventoried 310 species divided between 230 genera and 98 families.

The number of these endemic Ivorian species varies according to the blocks. In block I, 5 species are present. These are *Leptoderris miegei*, *Albertsia cordifolia*, *Macaranga beillei*, *Psychotria brachyanthoides*, *Baphia bacoensis*. At the level of the block II we have 3 species, of which *Macaranga beillei*, *Leptoderris miegei* and by *Psychotria brachyanthoides*. Finally, in block III, 2 species are found: *Leptoderris miegei*, *Macaranga beillei*. At the level of endemic West African species, 22 species are present in block III. In block I and II, we met respectively 17 and 19 species. The total number of endemic Ivorian and West African species is respectively 5 and 27 in the forest of Nangui Abrogoua University.

Table 1. Floristic wealth of species.

Parameters	Block 1	Block 2	Block 3
number of species	75	71	77
number of kind	65	62	73
number of family	36	34	38

The number of these is variable from one block to another. In Block III, 6 species were encountered, while in Block II we have 8 species. All of these species are represented in Block I. Introduced and cultivated species are in total 14 throughout the University forest.

The linear survey allowed us to show that *Dioscorea smilacifolia* and *Neuropeltis acuminata* occupy abundantly all the intervals of height of the forest of the University. However, creepers with wide distribution are *Icacina mannii*, *Pyrenancantha vogeliana* and *Flagellaria guineensis*.

Table 2. Sorensen similarity coefficient.

	Block I	Block II	Block III
Block I	100	-	-
Block II	59	100	-
Block III	48	53	100

The undergrowth is frequently dominated by *Palissota hirsuta*, *Angylocalyx oligophylux* and *Microdesmis keayana*. However, from the point of view of abundance, *Microdesmis keayana* dominates. The height interval 2 to 4 meters is dominated by *Baphia nitida*, *Microdesmis keayana* and *Chrysophyllum subnudum*.

The height range 4 to 8 meters is dominated by *Baphia nitida*, *Macaranga beillei*, *Funtumia africana*, *Dacryodes klaineana*, *Blighia welwitschii* and *Chrysophyllum subnudum*. The height range 8 to 16 meters is dominated by *Dacryodes klaineana, Lophira alata*, *Elaeis guineensis* and *Blighia welwitschii*. *Piptadeniastrum africanus* and *Lophira alata* are the species that emerge above the canopy. They dominate by their frequency.

The results on the floristic wealth, at the level of the families, indicate to us that the most important families are in descending order:

At the level of Block I, for the 75 species; Rubiaceae (6 species, 8 pc), Fabaceae (5 species or 7 pc), Euphorbiaceae (4 species or 5 pc), Apocynaceae (4 species, 5 pc), Annonaceae (4 species or 5 pc), Fabaceae (4 species, 5 pc); - For the 71 species of Block II, Apocynaceae (7 species, 10 pc), Fabaceae (6 species, 8 pc), Euphorbiaceae (4 species, 6 pc), Annonaceae (2 species, or 3 pc); - Euphorbiaceae (6 species, 8 pc), Fabaceae, (5 species, 6 pc), Rubiaceae (5 species, 6 pc), Apocynaceae (4 species, 5 pc), Annonaceae (3 species, 4 pc), Connaraceae (3 species, 4 pc), for the 77 species of Block II (Fig. 2).

The results on the floristic wealth, at the level of the families of the whole forest, indicate to us that the richest families in species are Rubiaceae, Euphorbiaceae and Apocynaceae; they are placed in first position, with respectively 29, 19, and 19 species 9; 6 and 6 p.

Distribution of Biomorphological Types

The Fig. 3 analysis gives us the distribution of the biomorphological types in the three blocks. Creepers (Lmp, LmP and LMP) and arborescent microphanerophytes (mp) have the highest proportions in all three blocks, which are represented by *Baphia nitida* in all blocks.

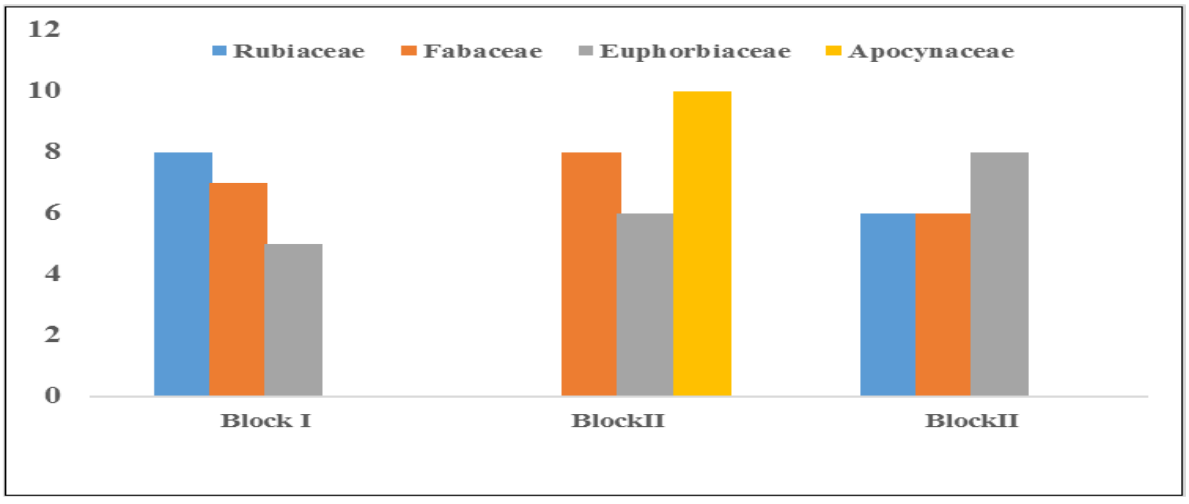


Fig. 2. Dominant families of the three blocks.

Then follow the mesophanerophytes (mP) represented abundantly by *Funtumia africana* at blocks I and II.

At the level of the biomorphological types, we note the highest percentage of shrubs in the block III (23 p.c.), they are represented abundantly by *Baphia nitida*, while in the block I, the percentage is low (16 p.c.). In this block, the shrubs are represented by *Macaranga beillei* and *Baphia nitida*.

This percentage is high in blocks II and III with respectively 22 and 26 pc. In blocks I and II, we note the presence of large trees (megaphanerophytes), these large trees are represented by *Lophira alata*, *Piptadeniastrum africanum* and *Chrysophyllum subnudum* of which the proportions are respectively for block I and II 6 p.c. and 1 p.c.

These blocks have the highest percentages at the level of mesophanerophytes (14 pc). In the forest as a whole, creepers (Lmp, LmP, LMP) represent 44 pc of species, shrubs (mp, np), 33 pc, trees (mP, MP), 14 pc and so-called "Others" are represented by only 9 pc.

Coefficient of similarity

The calculation of the Sorensen similarity coefficient (Table 2) between the three blocks is C1et 2 = 59 p.c.; C2 and 3 = 53 p.c. and C1 and 3 = 48 p.c.). With a similarity coefficient of 50%, we notice homogeneity between Blocks I and II and Blocks II and III. However, we note that the most similar ones are Block I and II because they proceed the most important coefficient (59 p.c.). This homogeneity is absent between Blocks I and III because this rate is less than 50 p.c. (53 p.c.).

Vegetation structure

The percentages of contacts are variable according to the blocks (Fig. 4**)**. Overall, the base of the histogram, broad, 70 p.c., is synonymous with a high percentage in the low stratum (2 to 4 m). After this stratum, the situation is different according to the blocks. Thus, at the level of the block I (Figure 4) we note a decrease of the percentages of the low stratum (<2 meter) to the stratum 4 to 8 meter, to reach 44 pc Then, this percentage increases, to reach 55 pc, at a stratum of 16 to 32 meters. Then again a drop in the upper stratum. In this one, the recovery percentage is only 32 pc. The most overlapping stratum is 16-32 meters, while the least overlapping stratum is 4-8 meters. At block II the initial percentage, which is about 70 p. c. at stratum <2 m, increases slightly to 72 p. c. in the next stratum. Then, it remains constant at the level of strata 2 to 4 meters and 4 to 8 meters, these two strata represent the most overlapping strata. The pace of the histogram from this last layer resembles a staircase.

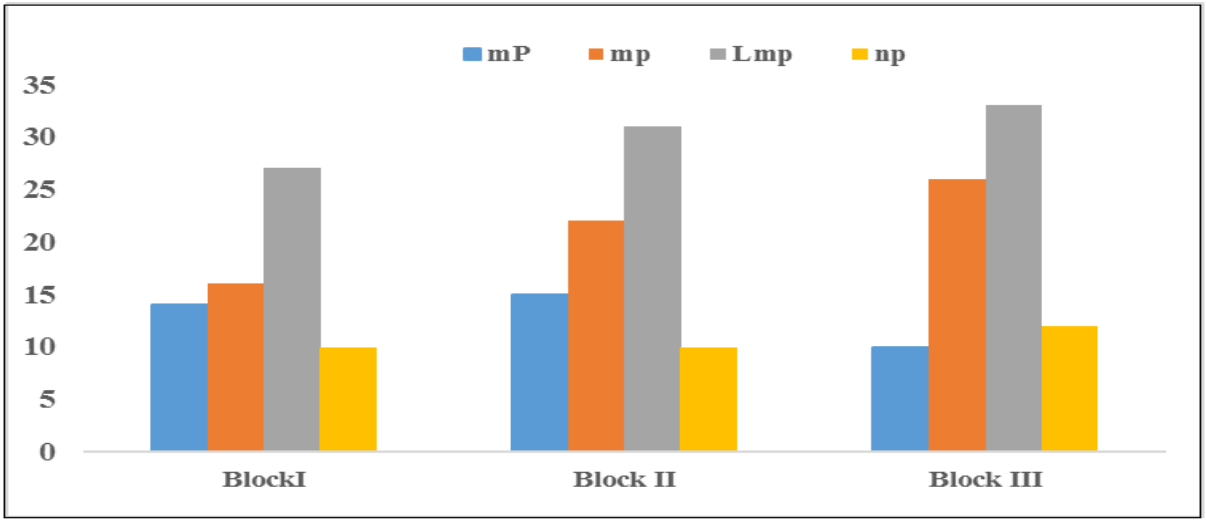
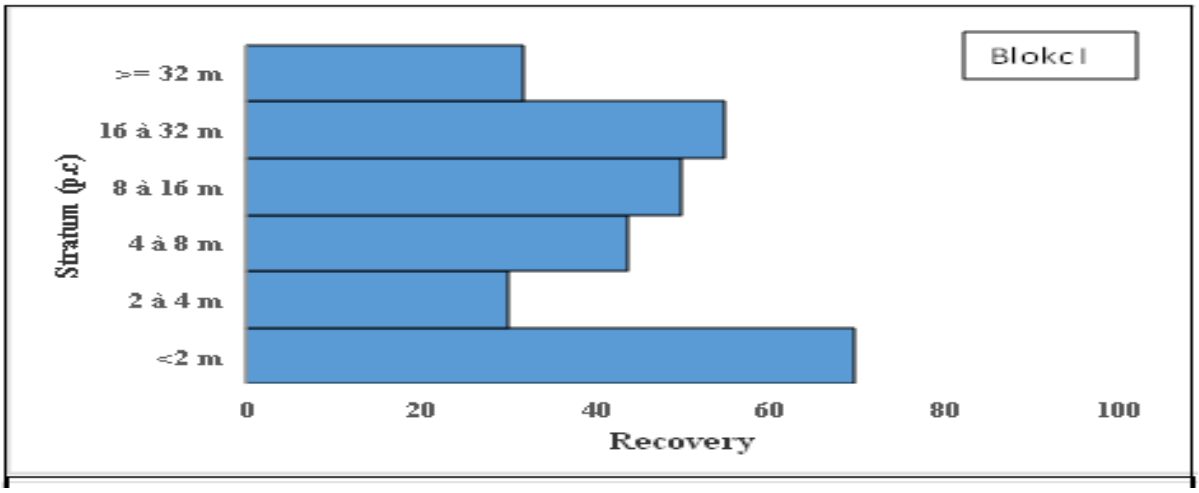


Fig. 3. Biomorphological types of the tree blocks.

We observe a decrease in the percentage from the next stratum (8 to 16 m) to the upper stratum (the least overlapping stratum). This increases from 56 to 16 pp. Block III is characterized by a decrease in the stratum percentage <2 m (71 p.c.) to stratum 4 to 8 meters (52 p.c.). At stratum 8 to 16 meters (most overlapping stratum) the percentage increases abruptly to 68 p.c. This percentage decreases again to 22 p.c. in the upper stratum; it represents the least overlapping stratum. The general look here is an overlay of two stairs. The stratum <2 meters is the base of the first staircase and the stratum 8 to 16 meters forms the base of the second staircase. The main feature is that the overlap of strata <2 meters and 8 to 16 meters are higher.

Discussion

The dominant species in the blocks are Rubiaceae (Block I), Apocynaceae (Block II) and Euphorbiaceae (Block III). In the whole forest of the University of Abobo-Adjamé we have Rubiaceae, Euphorbiaceae and Apocynaceae. These results are consistent with those of Adou Yao *et al.* (2005) and Bakayoko (2005) it is these same families that Bakayoko *et al.* (2001) noted as predominant in the Bossematié forest. According to Aubreville (1959), the dominance of these two families is a fairly general phenomenon in most tropical forests. The dominance of the lianascent form, observed in the morphological spectrum of each block and in the forest as a whole, is not a fact specific to the Nangui Abrogoua University forest. Bakayoko (2005), Laurance and Curran (2008) have shown the predominance of this form in large forest fragments between Zagné and Taï. Châtelain (1996) made the same observations in the Yapo and Divo forests. The strong presence of lianascent species has also been reported in the flora of the Haut-Sassandra classified forest by Kouamé *et al.* (1998). Their role in the evolutionary dynamics of forests is reported by Schnitzer and Bonger (2002). In the inventoried samples, we noted 14 species introduced and cultivated; their presence is a consequence of the action of Man. The presence of these species confirms the disturbances caused by the anthropogenic action in this forest. Our work revealed the presence of 5 endemic Ivorian species and 27 West African endemic species. According to Kouamé, *et al.* (2015) and Adou Yao *et al.* (2005), the presence of it is generally a sign of great biodiversity. The forest deserves to be preserved. The comparison of the floristic composition of the three blocks shows that block III is poorer in introduced and cultivated species. This block is also the richest talking about the number of species and also the endemic species. This result is contrary to that of Missa *et al.* (2018a). According to this one, this could be explained by the geographical situation of this block which allows a better conservation more than the two other ones.



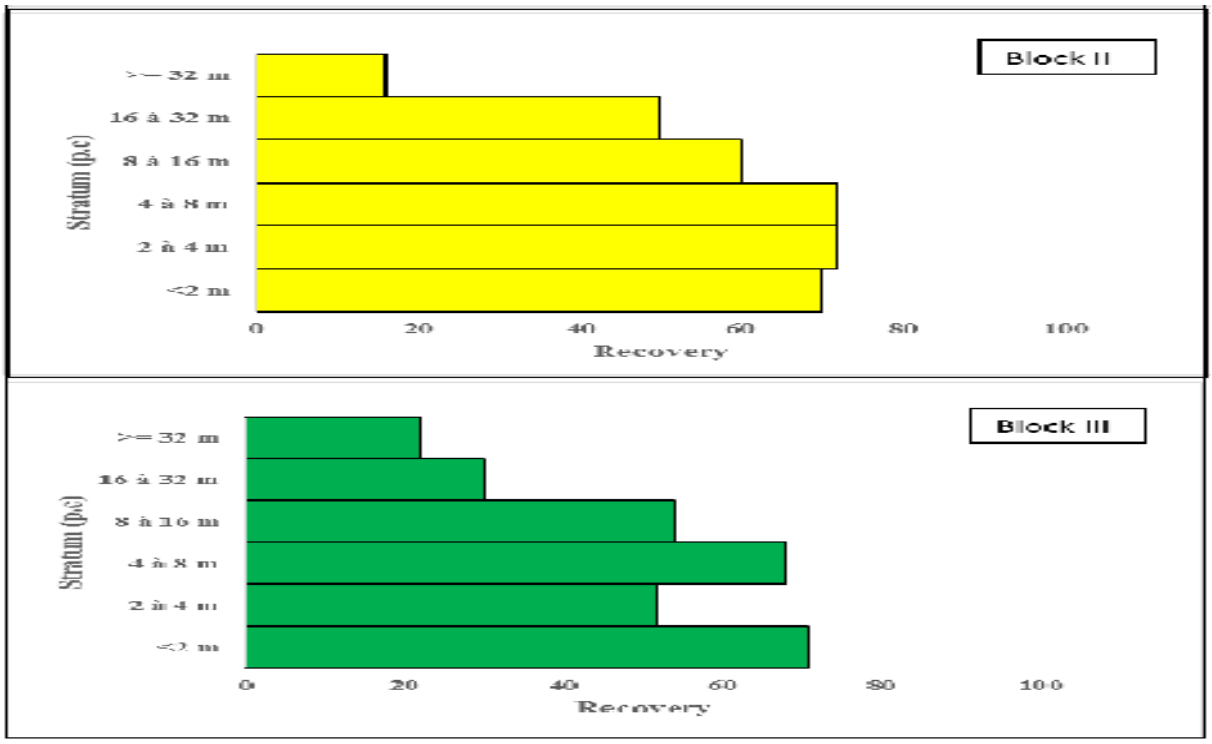


Fig. 4. Recovery of the three blocks.

The Block I, although the largest, has the lowest number of species, endemic species. Missa *et al.* (2018b) to show that unlike the other two blocks, it is block II (block III in our study). This observation could be due to the strong anthropisation (Kouamé, 2016; Kokou *et al.* 2005). Indeed this block is from the most exposed geographical point of view. The poverty of the characteristic species of psammohygrophilous forests in general and of the Banco forest in particular, from which the university Nangui Abrogoua forest is derived, is remarkable. These are *Turreaenthus africanus* and *Heisteria parviflora*. At the *Turraeanthus africanus* species, we find a total absence of this one on the whole of the surface surveys and the linear surveys, only one individual was met during the traveling survey. However, as for the species *Heisteria parviflora*, we note the low frequency of this one in all the blocks. This situation is explained by the deforestation of our study area (Alexandre, 1992). Because these species are designated to characterize the forest, they should be abundant in the canopy and undergrowth, respectively. Some species, such as *Angylocalyx oligophyllus* and *Chrysophyllum subnum*, have been particularly abundant. *Angylocalyx oligophyllus* make up the bulk of the undergrowth. The forest could be described as *Chrysophyllum subnum* and *Angylocalyx oligophyllus*.

The similarity coefficient greater than 50 p.c., between blocks I and II and between blocks II and III. This percentage reflects a homogeneity between these blocks with a greater homogeneity between blocks I and II. Bakayoko (2005) made similar observations between large fragments. According to the latter with the short distance separating these blocks (road), there is a strong local variability despite the existence of homogeneity. However, between Blocks I and III the similarity is less than 50 p.c. This value indicates a lack of homogeneity. The presence of the buildings of the infirmary and L.A.C.E.N.A seems explained this absence. The value of the generic coefficient (1.35) confirms that the forest of the University is more diversified than the national Ivorian flora which according to Ake-Assi (2002), the national generic coefficient is 3.03.

This observation could be explained by the reduced area of our sampling area (0.6 ha). These different values observed for each block show that block III despite its small surface area (4 ha) is more diversified than the others. According to Missa *et al.* (2018a), it is more likely to encounter new species for few new genera, with a larger inventoried area. The percentage of low layer overlaps in all blocks is high (73, 71, 71 for blocks I, II, and III, and these observations were made by Bakayoko (2005) in large fragments. According to these authors, these high percentages observed in the low strata are signs of fragment degradation, which could be explained by the abundance of undergrowth species.

The analysis of the height class recovery of the three linear surveys carried out in the three blocks allowed us to distinguish, like Missa *et al.* (2018b), three types of overlays. However, these types of recovery at the forest level of the University are different from those of the Bossematié Forest. Châtelain (1996) distinguished seven types corresponding to a type of plant formation. The type recognized in block I resemble the type G characteristic of much degraded environments (Châtelain, 1996). Type C of Chatelain corresponds to the type of formation of secondary forests, this type is recognized in block II. It is characterized by the abundance of young trees and lianas that grow back in this type of formation. The parcel of survey 3 corresponds to Chatelain type A (1996) and Menzies type H bis (2000).

This type corresponds to the type of formation of primary forests. Unlike Bamba (2004) and Nusbaumer *et al.*(2005), we note the presence of height strata "greater than 32 m" in the three surveys. This can be explained by the emergence above the canopy of *Lophira alata* and *Pitadeniastrum africanum*.

Conclusion

This study showed that the forest relic of Nangui Abrogoua University includes species are mainly run by the populations.

The comparison of the floristic composition of the three blocks shows that block III is poorer in species. Considering conservation of the biotope we notice that the block block I has much degraded environments. However, the block III would be the best kept environment. Finally, we urge for the protection of these blocks as they represent an important refuge for the forest flora in University Nangui Abrogoua.

Acknowledgments

This work has benefited from funding from the Swiss Center for Scientific Research. Our thanks also go to Assi Yapo Jean and the field guides of the region for having agreed to accompany us on the ground.

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