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ALLOCATION OF PLANT GROUPS BY ANTHROPOGENIC ACTIVITIES IN THE OUEME-BOUKOU CLASSIFIED FOREST (FCOB) AT THE BENIN CENTRE

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ABSTRACT

The wood resources of classified forests are nowadays subject to accelerated degradation. This research aims to characterize plant groups and their use by anthropogenic activities in the Ouémé-Boukou classified forest (FCOB). The field surveys were carried out among 81 people through a reasoned sampling according to the economic activities having an impact on the study forest. Following the sigmatist method of Braun Blanquet (1932), the floristic inventory was carried out in 31 circular squares of 18 meters radius installed according to the criterion of homogeneity of the vegetation and the topography of the environment. The collected data was submitted to the CAP (Community Analysis Package) software for the realization of the dendrogram. Thus, 27 woody species divided into 14 families and 23 genera have been inventoried and are classified in 3 plant groups. The most dominant families are Combretaceae (35%), Cesalpiniaceae (29.54%), Sapotaceae (20.17%), Papilionaceae (11.11%) and Mimosaceae (6.33%). The most represented life forms are Mesophanophytes (46.27%) and Microphanerophytes (38.53%). In terms of chorological realities, Guineo-Congolese species (43.57%) and Sudanese species are more represented (49.73%). In addition, agriculture, aerial grazing, wildfires, coal production and population growth are among the determining factors in the degradation of the study area. The flora of the study area gives a slight hope by its multiple regenerations despite anthropogenic pressure.

Keywords: FCOB, diversity, plant groupings, anthropogenic activities.

1. INTRODUCTION

The purely natural environment is becoming increasingly rare. Population growth, the aspiration for social well-being and technical progress have led to the destruction and degradation of the natural habitat of forests. According to FAO (2007), natural resources are part of each country's national heritage and their use and conservation must be the subject of an explicit national policy. Thus, man has revealed himself through his activities, the first destroyer of nature. The ecosystem services enjoyed free of charge by man have now become very scarce commodities. On this point, Malthus (1798), established the relationship between population growth and available resources to show that population growth is infinite and evolves exponentially, on the other hand the available resources increase only arithmetically and remain limited.

In developing countries in general, particularly in Benin, the question of degradation of the natural environment is acute. Research by Sinsin and Kampmann (2010) on the state of natural resources in Benin revealed that with nearly 25% of its territory erected as a classified reserve, i.e. an area of 1,303,000 ha, Benin is above 10% recommended internationally. Unfortunately

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nowadays, it is clear that these forests are threatened by wildfires, agriculture, extensive cattle grazing, illegal and irrational logging, pollution in all its forms, etc. According to Orékan (2007), the plant formations of the Upper Ouémé Basin in Benin are experiencing a regressive evolution of their areas in favor of agricultural land. At present, especially in southern Benin, most of the classified forests have almost disappeared.

The ecosystem services offered by nature in general and woody plant species in particular are multiple, but in continuous decline, due to the spectacular evolution of technical progress, reinforced by demographic growth and supported by environmental migrations. From 1990 to 1995, Benin lost 298,000 ha of forest cover, corresponding to an average loss of about 60,000 hectares of forest per year. In addition to this loss of inhabitants, there are proportional losses of species (Sinsin and Kampmann, 2010).

To reinforce the strategy to combat environmental degradation, some areas are declared classified forests. Benin has 44 classified forests covering an area of 1,292,543 ha or 11.5% of the national territory (Sinsin and Kampmann, 2010). Indeed, the classified forest of Ouémé-Boukou was erected as a classified state forest with an area of 20,500 hectares according to Order No. 5898 SE of 13 August 1954 (Guédou, 2001). Despite the efforts made to safeguard ecosystems in general and those of classified forests in particular, the classified forest of Ouémé-Boukou is under strong anthropogenic pressure.

1.1 Study Environment

Located in central Benin, the classified forest of Ouémé-Boukou is located between the parallels 7°45' and 7°58' latitude nord on the one hand and 2°22' and 2°32' longitude est on the other hand. It covers an area of about 20,500 ha and is limited to the north by the Arrondissement de Sakin, to the east by the Arrondissement de Bessé, to the south by the Arrondissement de Okpara and then to the east by the Commune of Dassa-Zoumè (PAPFCOB, 2013) (sigure 1).

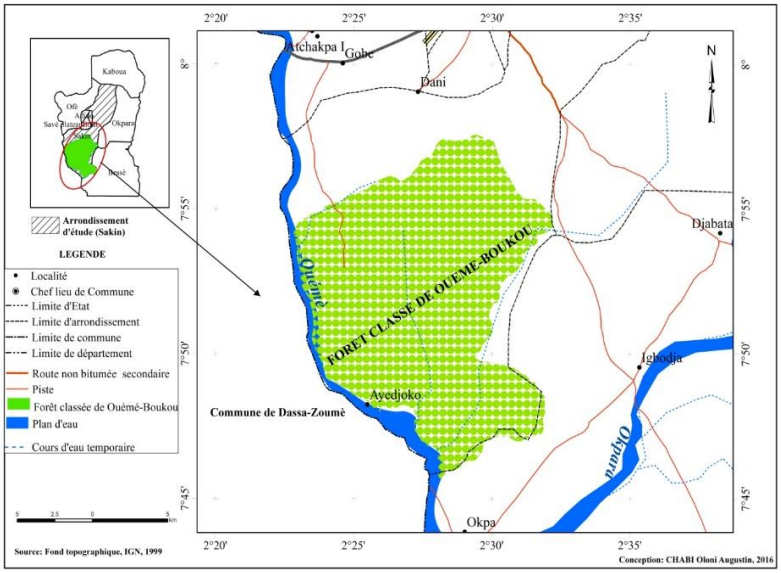

Figure 1 : Situation of the classified forest of Ouémé-Boukou

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The classified forest of Ouémé-Boukou is located in the Commune of Savè which enjoys a Sudano-Guinean climate characterized by a dry season and a rainy season. During wet periods, plant species find water substances for their growth and regeneration while during dry periods, most trees lose their old leaves for further regeneration. In addition, the soils found there are tropical ferruginous soils and hydromorphic soils. Overall, these soil types are relatively fertile and facilitate the growth and development of various plant species. Thus, because of these characteristics, these types of soil attract farmers, which leads to strong anthropogenic pressure due to the rapid growth of populations bordering the study area (PAPFCOB, 2013).

11.7 km long, the hydrographic network consists of several rivers that collect the waters towards the Ouémé River whose main tributary is Okpara. The meeting of the Ouémé River and the Boukou River has led to the name Ouémé-Boukou (Guédou, 2001). The availability of water promotes the development of gallery forests that are unfortunately exploited by populations for various purposes.

In addition, according to the Recencement Général de la Population et de l'Habitation (RGPH4, 2013), the Commune of Savè has 87,177 inhabitants. The most represented socio-cultural groups are the Nagot (65.35%), the Fon (13.73%), the Natimba (6.53%), the Adja (5.13%) and the Mahi (2.03%). The main economic activities of the populations bordering this forest are: agriculture, hunting, breeding, fishing, trade, crafts, transport, logging.

2. METHODOLOGICAL APPROACH

2.1. Collection of floristic data

Thirty-one (31) circular squares with a radius of 18 m were installed according to the criterion of homogeneity of the vegetation and topography of the environment. The coordinates of the center of the squares were recorded in the GPS. Two categories of woody species were collected from the squares according to their condition. These are living woody species and those affected by human activity.

Living species with a diameter greater than or equal to 10 cm were measured at 1.30 m above the ground. Each species has been assigned an abundance-dominance coefficient which is the expression of the relative space occupied by all the individuals of each species. The dominance abundance coefficients used are those of Braun-Blanquet (1932), This method has already been used by researchers such as Sinsin (1996), Guédou (2001) and Issiako (2015). Generally, these coefficients vary from 0 to 5.

5: cash covering 75 to 100% of the survey area (RM = 87.5%);

4: cash covering 50 to 75% of the survey area (RM = 62.5%);

3: cash covering 25 to 50% of the survey area (RM = 37.5%);

2: cash covering 5 to 25% of the survey area (RM = 15%);

1: cash covering 1 to 5% of the survey area (RM = 3%);

+: cash covering 1% of the survey area (RM = 0.5%).

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For species affected by human activity, they were systematically counted by place. Elements of anthropogenic disturbance were collected by direct observation. Only species whose diameter is greater than or equal to 10 cm are concerned by this count. Figure 2 shows the distribution of places.

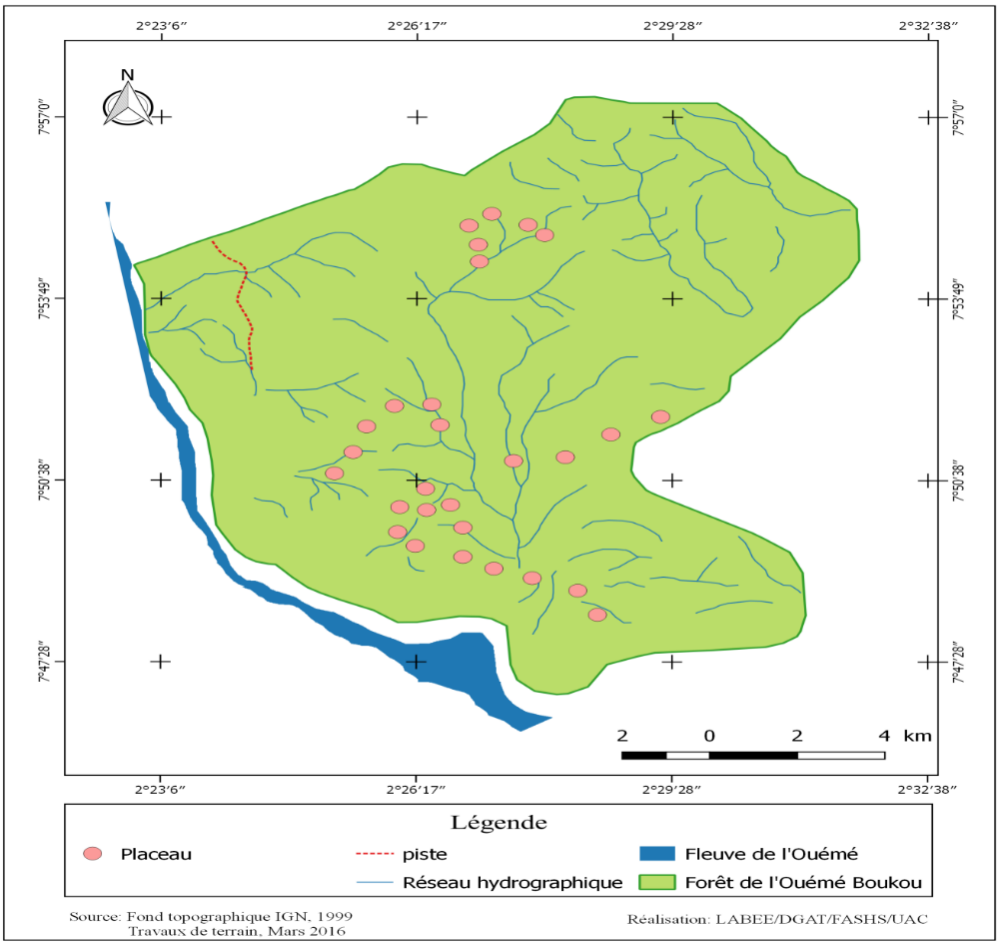

Figure 2: Distribution of places

2.2. Data processing method

Following the manual analysis of the floristic survey sheets, a microcomputer equipped with Microsoft Word was used to write the document; the Excel spreadsheet for the calculations of the various indices and parameters; Arc View for the realization of the maps and CAP (Community Analysis Package), for the realization of the dendrogram. A matrix of data codified in presence-absence (0-1) of all phytosociological surveys was carried out using the Excel spreadsheet. This matrix is then subjected to a hierarchical classification in the CAP (Community Analysis Package) software at 33% dissimilarity. The dendrogram thus obtained made it possible to individualize the different plant groups.

The specific diversity indices, the raw and weighted spectra of the biological and phytogeographical types were determined by grouping. The same applies to dendrometric

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parameters. The specific diversity indices mainly concern the specific wealth, the Shannon diversity index and the Pielou fairness,

- **Specific richness (R):** indicates the total number of plant species present in a given environment.
- **The Shannon diversity index (H):** expresses the variety of species and their relative abundance; its formula is: **H = -∑ni/Nlog2ni/N** with **no** number of each species category **i**; **N** total number of all species in the group concerned. **H** ranges from 0 to 5 bits.

- If **H** is between [0; 2] bits, then the medium is out of balance so instability of the study medium.

- If **H** is between [2; 2.5] bits, then the study medium is moderately stable.

- If **H** ≥ 2.5 bits, the environmental conditions are favorable for the installation of many species.

- **Pielou equitability (E**): **E = H/$_{log2R}$,** where **H** denotes the Shannon diversity index; **R,** Specific wealth and $_{log2R}$ maximum wealth **E** is between [0-1]. According to Dadjoz (1975), the high values of Pielou's equitability is a sign of the balance between the species involved while, the low values of Pielou's equitability. is evidence of an unequal distribution of species as a result of human actions.

✓ **Determination of raw and weighted spectra**

For each group, a raw spectrum expresses the percentage of the number of species corresponding to each biological or phytogeographical type in relation to the total number of species. Its formula is as follows: **Sb** = $\frac{n}{N} \times 100$ where neither is the total number of a given biological or phytogeographical type i and N is the total number of species belonging to the group in question.

The weighted spectrum expresses the percentage of the average overlap of each biological or phytogeographical type in relation to the total overlap.

Its formula is: **Sp** = $\frac{ri}{R} \times 100$ where ri is the total overlap of a given biological type or phytogeographical type i and R, the average overlap of the group. The calculated raw and weighted spectra are realized and presented in figure form using Excel 2016 software.

✓ **Dendrogram parameters**

It takes into account the calculations of density and the terre area.

Density (D) is the average number of standing trees reduced to per hectare. Its formula is:

D= $\frac{ni}{S} \times 1000$ where n is the total number of trees in the square of area S. As for the terrière area(G), it is the sum of the sections of the trunks of the trees at 1.30 m above the ground, expressed in m²/ha. Its formula is as follows**: G= (π d²)/4×S; G** is in **m²/ha** with **d** the diameter of the trees (cm). **S** is the surface of each place.

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In addition, after manual analysis of the inventory sheet, the Excel 2016 software made it possible to sort the species according to the human activity that affected it. This made it possible to identify the species affected by the users of the classified forest of Ouémé-Boukou.

3. RESULTS

3.1. Plant groupings

The floristic inventory carried out in the thirty-one (31) squares made it possible to inventory 27 woody plant species. Figure 3 shows the dendrogram of the hierachic classification of the pupils.

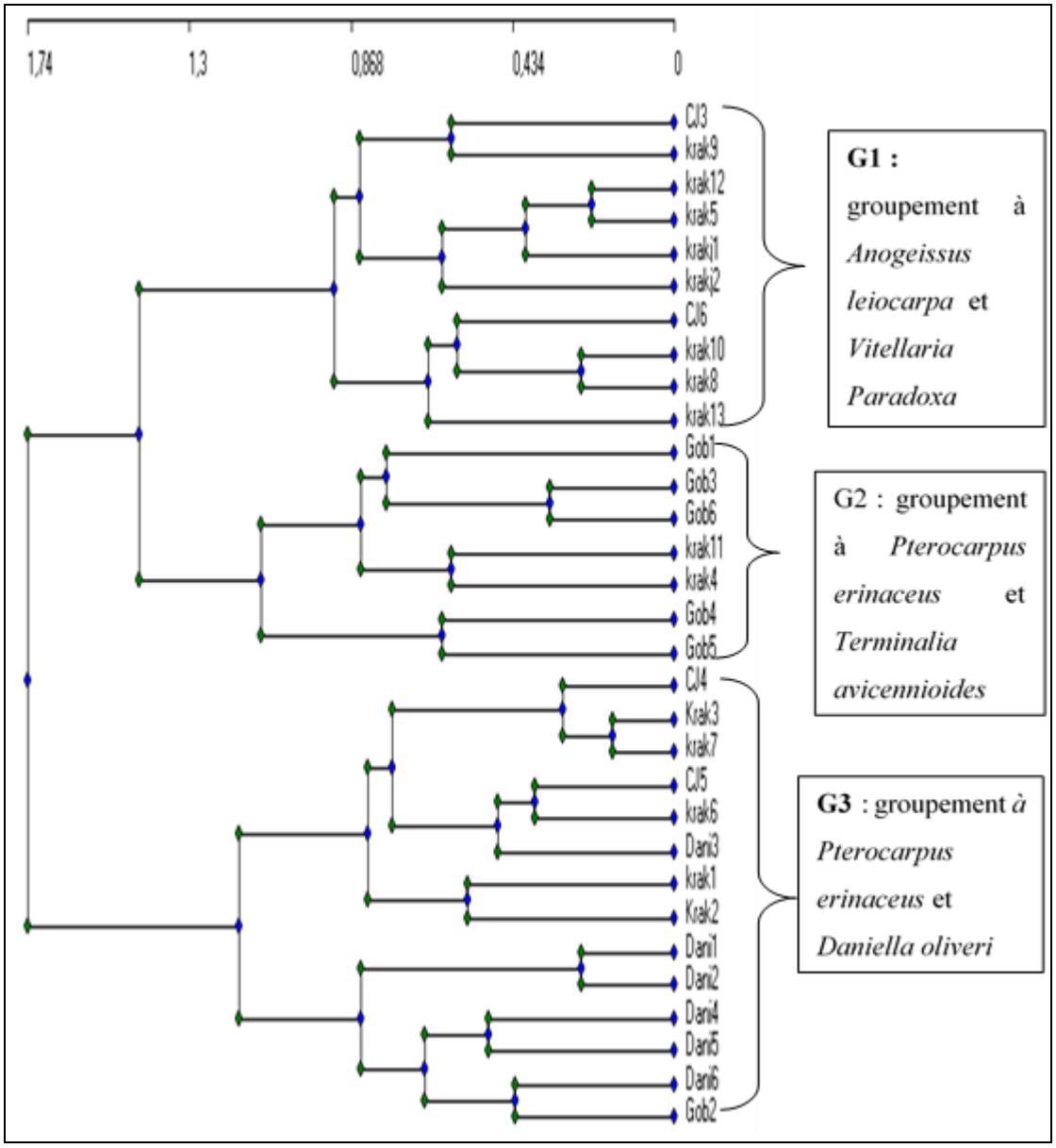

Figure 3 : Plant groups of the classified forest of Ouémé-Boukou
Source: Data processing, March 2016

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From the analysis of Figure 3, three plant groups emerge, namely:

- the G1 group with *Anogeissus leiocarpa* and *Vittelaria paradoxa*;

- the G2 group with *Pterocarpus santalinoides* and *Terminalia avicennioides*;

- the G3 group in *Vitellaria paradoxa* and *Daniella oliveri.*

The G1 Group with *Anogeissus leiocarpa* and *Vittellaria paradoxa* consists of the clear forest which has 16 plant species divided into 12 families and 17 genera. The most represented genera are *Anogeissus* (40.85%), *Vitellaria* (19.2073%); *Pterocarpus* (13.7195%) and *Isoberlinia* (3.0487%). In terms of families, the most dominant are *Cesalpiniaceae* (37.03%), *Sapotaceae* (22.75%), *papilionaceae* (12.16%) and *Araliaceae* (4.23%).

The specific richness (R) in the G1 group varies between 34 ± 7 species per place. Shannon's diversity index is 1.86 bits and Pielou's equitability is 0.67. These different values indicate that the diversity is average and a few species are dominant in the group under consideration. The land area of the group is 13.51 m2 / ha against a density of 229.53 trees / ha.

The G2 Group in *Pterocarpus erinaceus* and *Terminalia avicennioides*, consists largely of the gallery forest. In this formation, the plant species are more or less uniform and the representative families are: *Combretaceae* (38.51%), *Cesalpiniaceae* (31.08%), *Papilionaceae* (8.11%), *Meliaceae* (5.41%) and *Sapotaceae* (4.05%).

The specific richness (R) is 5 ± 25 species / place; the Shannon diversity index (H) is 3.51 bits and the Pielou equitability (E) is 0.51. The density (D) is 207.82 trees /hectare and the area (G) is 13.51 m²/hectare. The grouping of gallery forests with *Pterocarpus erinaceus* and *Terminalia avicennioides* is not very diverse with an almost regular distribution of species within different plant formations.

The G3 Group in *Vitellaria paradoxa and Daniellia oliveri* consists of mosaics of fields and fallow land spread over various topographical facets. In this group, 16 woody species coexist divided into 17 genera and 10 families. The five (*05*) most represented genders are : *Vitiallaria* (23.3%), *Daniellia* (16.93%), *Terminalia* (11.15%) *Pterocarpus* (11.21%) and *Burkea* (10.01%). The most dominant families are *Cesalpiniaceae* (37.03 %), *Sapotaceae* (22.751%), *Combretaceae* (14.2857%), *Papilionaceae* (12.1693%) and *Araliaceae* (4.232%).

The specific richesse (R) is 6 ± 18 species per place; the Shannon diversity index (H) is 0.231bits and the pielou (E) equitability is 0.38.

3.2. Biological and phytogeographical types and structure in diameter class of species of plant groups

3.2. 1. Biological and phytogeographical types of group G 1 with Anogeissus leiocarpa and Vitellaria paradoxa

The raw and weighted spectra of the biological and phytogeographical types of group G1 are shown in Figure 4.

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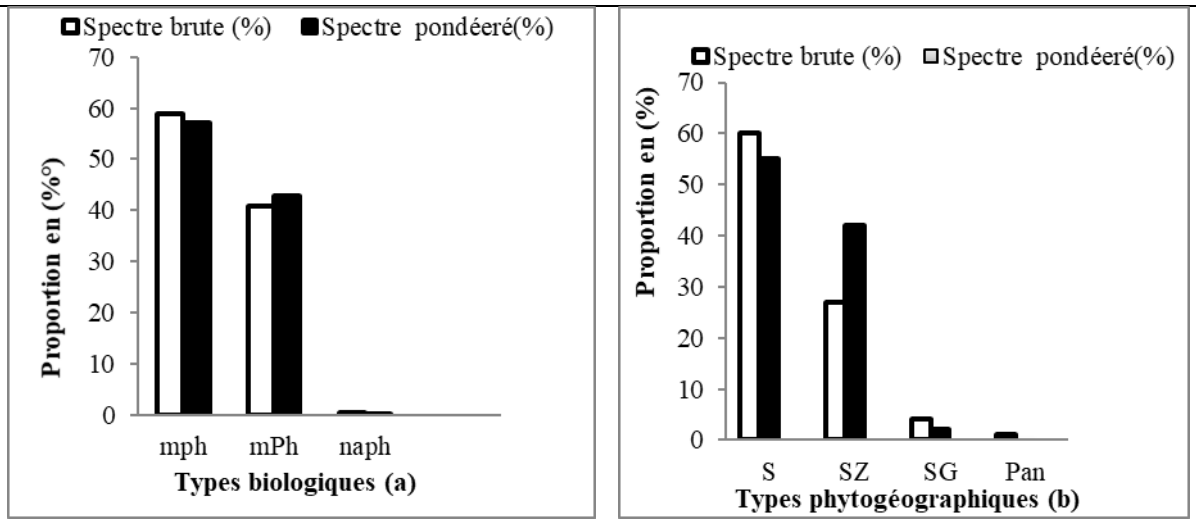

Figure 4 : Biological and phytogeographical types of Group 1
Source: Data processing, March 2016

Examination of Figure 4 (a), shows that at the level of both raw and weighted spectra, Microphanerophytes (mph) are abundant and dominant with a crude spectrum of (58.84%) and a weighted spectrum of (57.03%). Next come mesophanrphytes (40.85%) of raw spectrum and (42.83%) of weighted spectrum. Nanophanerphytes are at a very low proportion (0.3%) and 0.13% respectively for the raw and weighted spectrum. The classified forest of Ouémé-Boukou is populated by shrubs. The analysis of Figure 4 (b) shows that Sudanian species are more abundant and more dominant followed by Sudano-Zambezian species. But Sudano-Guinean species and pantropical species are at a very low proportion.

3.2.2. Diameter class structure of group 1 species

Figure 5 shows the simple structure in diameter classes of the trees of the G1 group with *Anogeissus leiocarpa* and *Vitellaria Paradoxa* of the light and savannah-shrub forests.

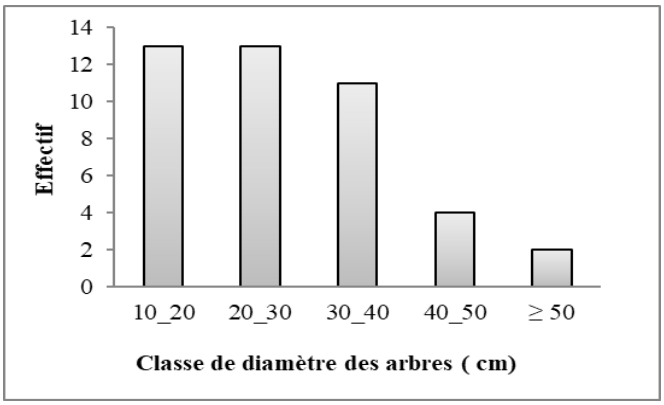

Figure 5 : Simple structure in diameter classes of the species of the G1 group
Source: Data processing, March 2016

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Examination of Figure 5 shows that individuals of class between [10-40 [cm] are the most represented. Those between [40 to 50 [and ≥50 [shall be slaughtered by operators. This grouping is therefore composed for the most part by the shrubs.

3.1.3 Raw and weighted spectra of the biological and phytogeographical types of Group 2

This group is mainly made up of gallery forests with *Pterocarpus erinaceus* and *Terminalia avicennioides* as indicator species. The biological and phytogeographical types of Group 2 are shown in Figure 6.

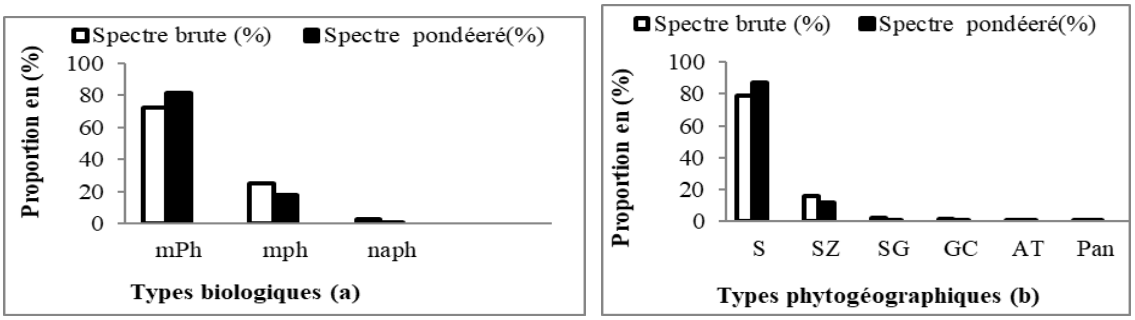

Figure 6 : Biological and phytogeographical types of Group 2
Source: Data processing, March 2016

The observation of Figure 6 (a) shows the abundance and dominance of Mesophanophytes (mPh) followed by Microphanerohytes (mph) while Nanophanerophytes (nph) are at a very low proportion; which reflects the degree of anthropization of the study area. The analysis of chorological affinity by Figure 6 (b) reveals the remarkable abundance and dominance of Sudanese species. Sudano-Zambezian species are less represented. The other species, Sudano-Guinean; Guineo-Congolese; Afro-tropical and pantropical have a small proportion. The high proportion of Sudanian and Sudano-Zambezian species reflects the invasion of the original species while the low proportion of the Afro-tropical species justifies regeneration following a strong destruction.

3.2.4. Simple structure in diameter class of group 2 shafts

The diameter class structure of group 2 is illustrated in Figure 7.

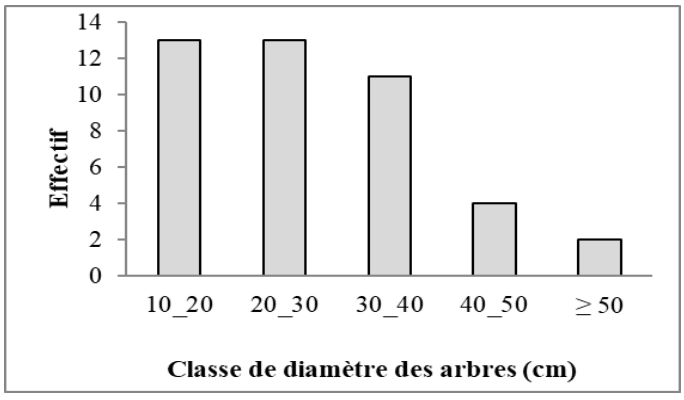

Figure 7 : Simple structure in diameter classes of group 2 species
Source: Data processing, March 2016

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The analysis in Figure 7 shows that species with a diameter between [10-20[cm; [20-30[cm and [30-40[cm are the most abundant. Beyond 40 cm in diameter, the species become rare, a sign of a strong exploitation of woody trees by the loggers of the commune. The gallery forests of the classified forest of Ouémé-Boukou are therefore in degradation.

3.2.5. Biological and phytogeographical types of Group 3

Group 3 formed by champs and fallow land but also wooded savannah characterized by *Vitellaria paradoxa* (23.28%) and *Daniellia oliveri* (16.93%). The biological and phytogeographical types of group 3 are shown in Figure 8.

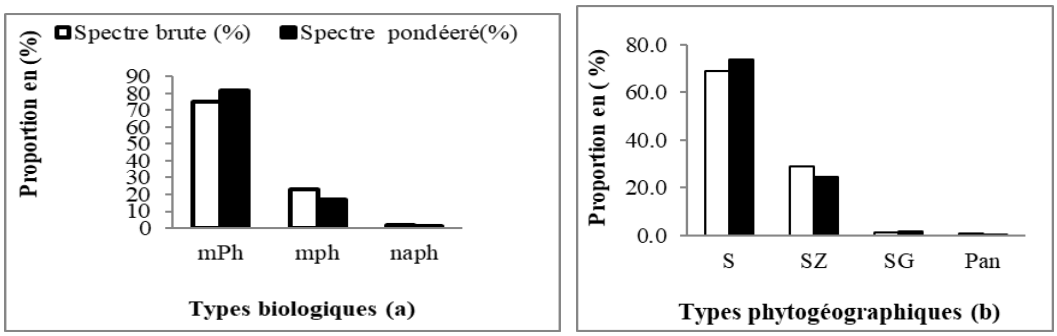

Figure 8 : Biological and phytogeographical types of Group 3
Source: Data processing, March 2016

The analysis in Figure 8(a) shows the abundance and dominance of Mesophanophytes with a crude spectrum of (75%) and a weighted spectrum of (81.60%). Then come the Microphanerophytes. Nanophanerophytes are at a very low proportion. From this analysis it emerges that there is a strong deforestation of the study area. Figure 8 (b) shows that Sudanian species are the most abundant and dominant followed by Sudano-Zambezian species. Sudano-Guinean species and pantropical species are at a negligible proportion. These results reflect the ecological imbalance due to human activities.

3.2.6. Simple structure of the diameter classes of the species in group 3

Figure 9 shows the diameter class structure of the trees consisting of *Vitellaria paradoxa* and *Daniellia oliveri* in group 3.

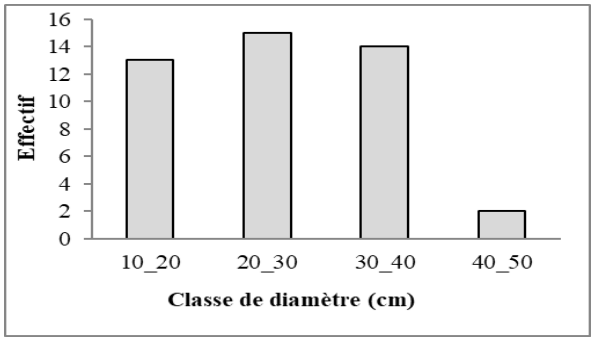

Figure 9 : Simple structure in diameter classes of group 3 species
Source: Data processing, March 2016

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The analysis in Figure 9 shows that trees of circumference class [10-20[; [20-30[and [30-40[are strongly represented. On the other hand, species of the class [40-50[are rare. Species of class with a diameter greater than or equal to 50 m are completely absent. In this grouping, plant formations are dominated by shrubs.

3.3. Factors affecting the species of plant groups in the ouémé-Boukou classified forest

Several factors lead to the degradation of the Ouémé-Boukou classified forest (Figure 10).

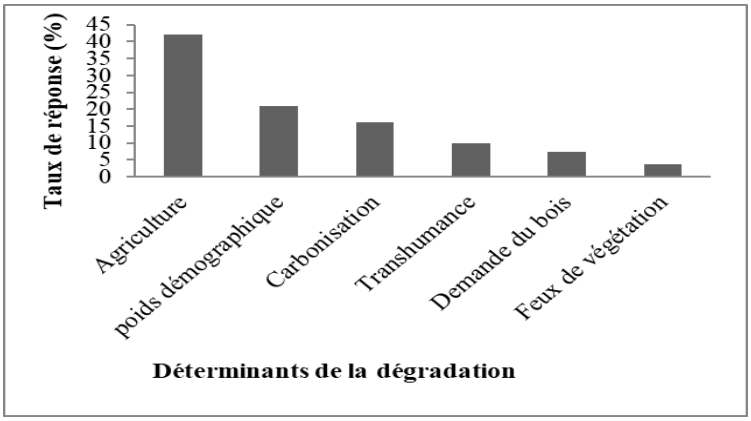

Figure 10 : Degradation factors of the Ouémé-Boukou classified forest
Source: Data processing, March 2016

Figure 10 shows by importance the factors of degradation of woody trees in the classified forest of Ouémé-Boukou. These are agriculture (42%), carbonization (16%),, timber research and seasonal transhumance (10%). Indeed, agriculture is the main activity of the population bordering the Ouémé-Boukou classified forest. Yam (*Diascorea alata)* is the most cultivated and is placed in the head of the rotation. It is grown on new wasteland, which leads to the massive destruction of trees. Every year, farmers calcine woody species in order to increase not only the arable land, but also agricultural yields (photo 1).

Photo 1: Calcination of species in the CFFO

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During the fieldwork in the classified forest of Ouémé-Boukou, most of the most important species were cut in almost all the formations studied. Thus, to escape the surveillance of forest officers, loggers enter the forest from 7 p.m. to leave sometimes at 4 a.m. or even 5 a.m. The use of the chainsaw is decisive in the decline of the study area, as it allows loggers and charcoal workers to slaughter a large number of plant species in record time. This promotes fraudulent cuts and carbonization (plate 1).

Plate 1 : Foot of pterocarpus erinaceus slaughtered and carbonization furnace observed in the FCOB

Transhumance is an important factor in the degradation of woody trees in the ouémé-Boukou classified forest. Breeders prune various woody plant species including: *Pterocarpus erinanceus, Pterocarpus santalinoïdes, Isoberlinia doka, Afzelia africana, Khaya senegalensis,* etc. Currently they are having difficulty finding these species because of their scarcity. Thus, oxen sometimes graze in the fields. This leads to conflicts between herders and farmers whose crops have been destroyed.

4. DISCUSSION

The wood resources of the FCOB have been characterized into three plant groups on the 31 circular places installed with a richness of 27 woody species. This same method was used by Mazo *et al.* (2018) in Benin in the study to estimate the carbon stock in the forest block of the Kouffé and Wari-Maro mountains. On the other hand, the work of Toko *et al.* (2013), revealed the use of square squares in the study of the structure and floristic composition of dense dry forests in the Kouffé Mountains region of Benin. The result is the existence of a diversity of methods for characterizing the flora of ecosystems, the choice of which depends, among other things, on work objectives, means, etc.

The predominance of *the Cesalpiniiae* and *Combretaceae* families in the study forest is explained by the fact that they are the most represented in the plant formations of the Dahomean dry corridor (White, 1986). These results are identical to those obtained by Amahowé (2003) in the village forests of Glazoué and those obtained by Houéhanou (2011) in the sacred forests of Dassa. In addition, the predominance of *the Cesalpiniiae* and *Combretaceae* was mentioned by Schmitz (1971) as being characteristic of the Sudano-Zambezian forests and by Aubreville (1937) as those dominant savannahs in dry tropical zones.

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Diversity and equitability are relatively low in the three groups studied. In addition, the individuals observed in these groups are essentially shrubs with strong regeneration but an almost total absence of large trees. This is due to degradation factors such as agriculture, population growth, carbonization, transhumance, illegal logging and wildfires. These anthropogenic factors have been observed in abomey's reforestation perimeter as the basis for imbalances and depletion of its wood resources (Ali *et al.,* 2018). In addition, the work of Alassane (2018) reveals that agricultural areas are growing to the detriment of natural formations and that the essences with socioeconomic values are under increasingly strong anthropogenic pressures. Several other researchers have reached the same conclusion, including Houéssou *et al.,* 2013; Toko *et al.,* 2013, Ajavon *et al.,* 2018 and Boukpessi, 2018. Thus, the environment is not protected as a museum, but rather as a complex system that must be shaped according to current needs without compromising the ability of future generations to meet their own needs (Sinsin, 1996). It is therefore imperative to take into account the issue of reforestation in the study area in order to adopt significant measures.

5. CONCLUSION

This research made it possible to characterize plant groups and identify the determinants of degradation of the ouémé-Boukou classified forest (FCOB). The analysis of the results shows that the study area is full of a multitude of woody species, but very threatened. The main explanatory factor for this disturbance concerns all kinds of economic activity in the study sector; then come the natural factors that take into account the climatic hazards responsible for ecological migrations, and then the increasingly increasing population growth. Therefore, the weight of words and the shock of certain images of desolation cannot make us forget that rural populations must live, cultivate, clear and deforest not only for their own needs, but to the happiness of all.

Reforestation must therefore necessarily involve reforestation and maintenance, but also the sacralization of some of the most endangered species. Restraint in action with regard to the environment would be utopia without resorting to texts campaigning in favor of the environment among others: Law 93-009 on the regime of forests and vegetation fires in the Republic of Benin; Decree No. 96271 of 02 July 1996 on the modality of application of Law 93-009 of 02 July 1993; l 'adoption of a new forestry policy in November 1994 revised in 2011 and the strategy for the establishment of rural wood energy markets adopted in 2009.

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