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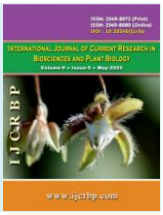

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Impacts of the anthropic activities on the fragmentation of the habitats of the fauna of the Bénoué National Park

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Abstract

The biodiversity of the Bénoué National Park is subject to high anthropic pressures, responsible of the fragmentation of the wild fauna. The present study aims to i) study the different anthropic activities contributing to the parceling out of habitats of fauna, ii) show the evolution of the fragmentation of the vegetation in the study area, iii) study the influence of the anthropological activities on the floristic composition, the ecologic structuration and characterization of the vegetation of BNP and at last iv) propose some precautionary measures of the biodiversity of the park. A sample of 150 people was surveyed on the level of the villages (Banda, Bouck, Dogba, Gamba and Sackdjé) and 30 people on the level of the forest agents of PNB and from the administration. The satellite images were used to evaluate the evolution of the fragmentation of the habitat fauna. 48 squares of 20 m × 20 m were installed in four non-fragmented vegetable formations (pilot zones) and four fragmented vegetable formations for the record of the vegetation. Analysis of the data by Statgraphics plus 5.0, XLstat, and Excel showed that gold washing and transhumance (100%), poaching (77%), the exploitation of the wood of heating (57%) are the principal activities which split up more the habitat of fauna. The satellite images showed that the annual loss of surface of the dense vegetable formations and the opening of the landscape of the Park is estimated at 0.98% per hectare a year from 2000 to 2015. The impacts of the fragmentation of the habitat of fauna result in the threat of disappearance of the vegetable biodiversity The installation of the services of sensitization anti-poaching (98.33%), the sanction of the coalmen (97.08%), the installation of the local structures for management of the Park (95.00%), the creation of drillings in all the bordering villages (93.33%), the availability of the ecological guard, the means of conveyance. The functioning of the local committees of vigilance in all the villages (92.50%), the very strong implication of ministries MINFOF (96.67%), MINEP (79.66%), MINESUP (74.25%) and MINEPAT (71.33%) constitute the principal proposals for conservation and protection of the BNP.

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Introduction

The demographic explosion induced to the modification and the fragmentation of the habitats of the natural ecosystems with significant pressures leading to insulation and an extinction of the biodiversity (Smith and Hellmann, 2002; Feeley and Terborgh, 2008). The fragmentation of the habitat means that there is division of great natural ecosystems in smaller and more isolated each other, which is a barrier to the dispersion of the communities and the animal and vegetable species. This fragmentation of the ecosystems are due to the exploitation of the natural resources by gold washing, the breeding, the poaching, the bush fires, coal mining, the urbanization, industries etc. Indeed the fragmentation of the habitats of fauna is recognized as being the principal cause of the reduction in the biodiversity and the disappearance of the species (Naveh and Lieberman, 1984; Fahrig, 2003). The Bénoué National park is strongly affected by this phenomenon of the fragmentation of habitat of fauna because of the alarming human practices caused by the populations surrounding the park. In Cameroun, in spite of the efforts of protection authorized by the authorities through the Ministries of the Forests and fauna (MINFOF), the Environment and the nature conservancy (MINEP), for the management and the perpetuation of the natural resources of our protected surfaces, the phenomenon of the fragmentation of the habitat of wild fauna is not mastered yet by the public authority and the civil society. This work aims at evaluating the anthropic influence on division of habitats of fauna in the BNP in North-Cameroun; specifically it enables: i) to study the various anthropic activities contributing to the parceling out of the habitats of fauna, ii) to show the evolution of the fragmentation of the vegetation of the study area, iii) to study the influence of the anthropological activities on the floristic composition, the structuring and the ecological characterization of the vegetation of the BNP, and finally iv) to put forward precautionary measures of the biodiversity of the Bénoué National Park.

Location of the study area

The study was undertaken in the Bénoué National park, located between 7°55 and 8°40 of Northern latitude and between 13°33 and 14°02 of longitude East. It belongs to the network of protected surfaces of the North Cameroun region which counts 3 national parks, 28 zones of interest hunting, 2 zones of interest hunting to co-administration and 2 zones of interest hunting to Community management. This park covers a surface of 180 000 ha and is bordered: in the North by the Mayo Ladé and Laindelaol rivers; in the South by the Mayo Dzoro river; in the East by the Bénoué river; and in the West by trunk road N°1 NGaoundéré - Garoua, from the bridge on Mayo Dzoro to the village Banda; the old road NGaoundéré - Garoua, from Banda to ex-Djaba; by main road N 1, from ex-Djaba to the bridge on Mayo Salah; from Mayo Salah river up to the point of junction with Mayo Ladé river (Fig. 1).

Choice of the study area

The interest of this study was related to the fragmentation of the habitats of the BNP in the north Cameroun region, because of its statute of national park. This protected surface of the region is threatened much by the anthropisation. Moreover, the BNP offered many possibilities of sampling in landscapes better representative of the vegetation of north-Cameroun, formations of the savanna which one finds in most of central Africa and west. Moreover, the park is large enough and the central core still relatively badly protected from the anthropic pressures like uncontrolled fires of the stockbreeders.

Investigations into the various activities carried out within the Park near to bordering populations and data on the human activities

This phase of investigation is based on the analysis of the relation between the bordering populations and the reserve on the one hand, between the forest agents and the administration on the other hand. The latter was carried out in the form of semi-structured interview (Mary and Besse, 1996). These talks focused on a questionnaire previously tested (Martin, 1995). Two types of questionnaire were elaborated and were destined respectively to the local populations and the managers of the BNP. The questionnaires comprised variables of identification of surveyed and questions relating to the activities practiced inside and at the periphery of the Park, with the perception which the populations have of the reserve, on the various activities that these populations carry out in the park, of their participation in the management of this protected surface as well as difficulties encountered by the forest agents in the achievement from their mission, in order to ensure itself of the good formulation of the

questionnaires. During this study, five bordering villages (Bandaged, Bouck, Dogba, Gamba and Sackdjé) were prospected.150 people were surveyed with 30 people per village.30 people were also questioned on the level of the forest agents of the BNP and the administrators.

The investigations were supplemented by direct observations during our fieldwork with the assistance of the forest agents or the local guides. This prospection made it possible to identify on the field the principal illicit activities undertaken in the reserve and the exploited species. The observations are consigned in observation files of the various anthropic impacts of the park. Photographs were taken on the site as well as the geographical coordinates of record using a receiver GPS for space analysis.

In addition to investigations, the various activities are supplemented by direct observations in the various vegetable formations (Twamasi, 2001) with the assistance of the local guides. This prospection of the natural formations enabled to identify on the ground the principal illicit activities undertaken in the site and the exploited species. The observations are also consigned in a card of observation of the anthropic activities. Photographs are taken on the site. The human signs to note are as follows: camping (gold washer, great hunting), track, cut of machete, broken branch, trap, extraction of honey, skinning of tree, latex extraction and collection of the fruits.

Method of data acquisition from the field

The surface of phytosociological statement in tropical milieu (Sinsin, 1993) was adopted in this study. Those ones used alternatives surfaces between 100 and 1000 m^2 according to vegetable formations and layers. In this study, the surface of statement is 400 m^2 for all the sampled layers. These statements were done according to the sigma method of Braun-Blanquet (1932) used by many authors (Sinsin, 1993). This method is based on the principle of floristic homogeneity of studied surface. For each species, inventoried, one affects a coefficient of abundance-predominance which is the expression of the related space occupied by the whole of individual from every species. Generally, the admitted coefficients are:

5: species covering 75 to 100% of the surface of statement (AC: average collection=87.5%);

4: species covering 50 to 75% of the surface of statement (AC: average collection=62.5%);

3: species covering 25 to 50% of the surface of statement (AC: average collection=37.5%);

2: species covering 5 to 25% of the surface of statement (AC: average collection=15%);

1: species covering 5% of the surface of statement (AC: average collection=3%) + species covering 0 to 1% of the surface of statement (AC: average collection=0.5%).

Experimental device of the statements of the vegetation

The card of inventory was prepared as a preliminary. It is characterized by the elements describing squares, the covering of the vegetable layers, the geographical coordinates, the human activities and the dendro-ecological activities. The floristic readings were taken on 48 sites inside the Park in eight types of different vegetable formations (natural raised savanna, fragmented raised savannas, shrubby natural savannas, fragmented shrubby savannas, wooded natural savannas, fragmented wooded savannas, natural forest galleries and fragmented forest galleries) with 6 repetitions. They were carried out each time that one identifies a factor of anthropisation on the surfaces of 20 m X 20 m following 8 rectilinear transects. The experimental device is a completely randomized block with two factors, the first factor consists of eight vegetable formations (F1, F2.....F8) and the second factor is made of six statements in each vegetable formation (R1, R2... R6) (repetitions). These statements were carried out in a random way in eight rectilinear transects (Table 1).

Floristic inventory

An inventory of species was directly made on field. The non identified species were collected with the assistance of the guides and put in herbarium for identification or confirmation at the herbarium of the school of fauna of Garoua. The team of research consisted of a botanist specialist to identify the various species, the conservative of the park also, the Eco guards for safety, the trackers to direct us towards the practicable roads in addition to the four trainees to collect the different data. The collection is made according to the method of transect recommended by Senterre (2005). A standard

card of ecological descriptors is filled out at the same time with the realization of the floristic statements. In each square, all the species of trees are raised and for all the individuals having a size of 1.30 m, the dendrometric parameters (the height to establish the structure of the settlement, the diameter of the bunch, the circumference at the base of the trunk with 1.30 cm of the ground to estimate burrow surface and to study the distribution of the woody individuals according to the classes of circumference)., the circumferences of the largest stem, of the average stem and the smallest stem were measured in order to determine the average circumference. The geographical coordinates of the squares of floristic inventory are recorded using the GPS.

Treatment and data analysis

Horizontal structure of the ligneous family

The ecological profile was made by using parameters of quantification of species. The concepts used relate to the evaluation of the frequency, abundance and predominance.

The frequency is the number of individuals of a species on the total number of the individuals of all the species of a given site. The absolute frequency of a species represents the total number of statements where the species is present. According to Braun-Blanquet (1932), the relative frequency is the ratio expressed as a percentage between the number of the statements containing this species and the total number of the statements multiplied by 100.

$$RF\ (\%) = \frac{A}{B} \times 100$$

Where, RF (%) = Relative frequency, A = number of treatments containing the species and B = total number of the treatments. This proportion or frequency permits to determine the individuals accidental in cash, additional, rather frequent, frequent and very frequent

Abundance indicates the total number of individuals of the species. The abundance of the species can be absolute or relative. Absolute abundance is the total number of individuals of the species on the total number of the individuals of the studied site. Relative abundance is the ratio of absolute abundance on the total number of individuals of the community.

Predominance relates to the covering of the individuals of each species and it is expressed as a percentage. Absolute predominance (DA) is the ratio of the total burrow surface of the species (TBSe) on the total burrow surface of the sample (TBSS).

$$DA = \frac{TBSe}{TBSS}$$

Relative predominance (RP) or relative covering is the ratio of the total burrow surface of the species (STTe) on the total burrow surface of community (TBSC) multiplied by 100.

$$RP = \frac{STTe}{TBSC} \times 100$$

The density is given by the formula: D = N/S with N = number of the species of the study area and S = surface occupied by the species. In addition to that, surface burrow was calculated.

Surface burrow was given by the formula: $Gi = \pi D_H 2 / 4$ where Gi is burrow surface of species I, D_B is the diameter of the bunch of the species. Specific diversity was analyzed using the indices of diversity (Magurran, 1988; Kent and Coker, 1992). Indeed, several types of mathematical formulas enable to calculate these indices. Among them, those which were selected and of a common usage are as follows:

The Relative Importance Value of Curtis is the sum of the relative density, the relative frequency and of relative covering. RIVC (%) = RF+RP+RDe with RIVC: Relative Importance Value of Curtis; RF: Relative frequency; RP: Relative predominance; RDe: Relative density.

The index of diversity of Shannon is given by the following formula: $H = - \Sigma pi \log 2pi$, pi = proportion of species i within the grouping. The calculation of the Shannon's index is founded on the assumption that diversity is a function of the probability pi = Ni / N of presence of each species i in a set of individuals. This index lies between 0,5 bit (index of very low diversity) and 4,5 bits approximately or exceptionally more in the case of sample of big size of complex communities (Frontier, 1983).

Equitability of Pielou (E) which is the reverse of the index of Shannon.

The index of Simpson is a formula enabling to calculate the probability that two individuals selected by chance in a given environment are same species.

$$D = \sum Ni\ (Ni-1)/N\ (N-1)$$

D: Index of Simpson, Ni: number of individuals of the species given.N: numbers total individuals. The index varies between 0 and 1.The more it approaches 0, the more the chances to obtain individuals of different species are high.

The scale factor of Jaccard (Le Floch, 2007) enables to compare the different squares. It is given by the formula:

$$PJ = \frac{c}{a+b-c} \times 100$$

Where a = number of species of the list a (zone 1); b = number of species of the list b (zone 2), c = number of species common to both zones. The similarity between habitats is expressed by the high value of this index. The Hamming's distance by Floch (2007) is added to this index to compare the floristic statements according to the formula: H = 100 – PJ, where PJ is the index of Jaccard (Table 2).

Vertical structure of the ligneous family

For the distribution in class of diameter, the method of Letouzey (1968) was adopted. In this classification, individuals are divided into four classes: the lower layer made of shrubs having a diameter ranging between 0 and 10 cm; the layer including the small trees of diameter from 10 to 20 cm; the average layer made up of trees of diameter ranging between 20 and 30 cm; the higher layer as for it includes the trees having a diameter higher or equal to 30 cm. From the results of the measurements of height, the individuals were gathered in class of amplitude 5 cm, all these classes were simplified thereafter in great classes:regeneration, future stems, average stems and large trees.

Method of remote detection

The remote detection consisted in downloading satellite images (landsats) on the site of http://earthexplorer. usgs.gov/ and http://glovis.usgs.gov. For the cartography and the follow-up of the dynamics of vegetable cover, one chose because of time necessary for the follow-up of the dynamics of savannas and the availability of the images of two dates. It is about the image of 2000 known as initial, and an image of 2015 known as finale. For each one of these periods, we downloaded two scenes landsat 7 ETM+ and two scenes landsat 8 OLI of coordinates (183/55 and 184/55) owing to the fact that totality of our study area is obtained only by the fusion of both of two scenes. For the digital processing of these various scenes using software ENVI 4.5 several phases were retained:

The operations of pretreatment of images and collection of the bands of the various scenes. In order to better carry out the operations of treatment, it is necessary to gather the bands retained in the same file multispectral image. All the bands of the file resulting from the mosaic of scenes 183/55 and 184/55 are combined in only one file under ENVI thanks to the tool « layer stacking » for these images; The mosaic is an operation which consists in connecting several scenes landsat constitutive of our zone given in only one block. ENVI 4.5 enabled us to carry out this operation for the zone of the GNP and its periphery by connecting scenes 183/55 and 184/55 for each corresponding year (1987, 1999 and 2014).

A coloured composition is an operation which consists in combining the bands in order to emphasize the various types of surfaces on a multispectral image. One used compositions 4-3-2 (Landsat TM and ETM+) and 5-4-3 (Landsat OLI) known as "wrong colors which is a very popular composition for the studies of vegetation in which the vegetation appears in dark colour of red to light according to the type. Water as-with it appearing in colour of dark blue to green blue, frames in colour of very clear blue and naked grounds in pinkish red. Zone division of the study area consisted in extracting the part of the image corresponding to the study area from the polygon representing the limits of the park and the district of Djohong.

Supervised classification consists in extracting the classes of information on the images in coloured composition. For our study, the classes of occupation of the soil retained for classification are: forests galleries, clear forests, wooded savannas, raised savannas, shrubby savannas, grassy savannas, soils, water and burner. Vectorization enables to pass from a raster layer inside which informations are represented by pixels with a vectorial layer where information is represented by objects (points, lines, polygons) Tabopda GW (2010). The various classes of occupation of the ground

obtained by classification were transformed into polygons for the continuation of work.

Production of the charts: For the production of the map of vegetable cover, several handling under QGis 2.10 was necessary. It is in particular requests, the space analyses, addition of other layers of information and page-setting.

Statistical analysis of data

After counting and regrouping, the data were entered EXEL, a matrix "statements x species" was elaborate on the basis of presence/absence of species, with in line the species and in columns the statements. The elaborate matrix was subjected to the specialists of multivariate analysis with an aim of highlighting the dispersion of the species as well as the principal vegetable formations which emerge from. Variance analyses using software XLSTAT and STATGRAPHICS Plus 5.0 were used to check the differences between the treatments at the level of the number and the surface. In the presence of significant variance analyses, the comparisons of averages were carried out using the test of Fisher. In addition, the difference in the composition of the mediums (standard of vegetable formation) was tested by analysis of multivariate variance. Parameters such as the height, the density, burrow surface and the diameter were the subject of an analysis in principal component (ACP). As for the satellite image it was possible thanks to different scenes namely: the scenes Landsat ETM+ of 2000 and scenes of Landsat 8 OLI of 2015.The digital processing of these various scenes is made using software ENVI 4.5. For the production of the maps of vegetable cover, several handling under the software QGis 2.10 was used.

Results and discussion

Anthropic activities contributing to the parceling out of the habitats of the flora according to the perception of the bordering populations

The figure 2 gathers the principal activities undertaken in the study area. Transhumance (100%) and gold washing (100%) are the first two activities practiced in all the villages. The stockbreeders are with the research of the fodder resources in the course to nourish their animals. The population being poor gives itself to the research of gold in the park to provide for the financial need for their family. The population exploits 65.33% the park for the traditional pharmacopeia. This activity is used at 80% in the Sackdjé village, of 73.33% in Gamba, of 60% in Banda and 56.67% in the village Bouck and Dogba. The park is the subject to 64.67% of the wood cuts for the wood of energy in the villages, whose 100% in Banda, 80% with Sackdjé. The other anthropic activities practiced in the parks are the craft industry (61.33%), the poaching (51.33%), the carbonization (35.33%). All these human pressures take an active part in the fragmentation of the GNP. The actors of these various anthropic activities use several techniques (pruning, uprooting, cut of the large trees, holes mining) for the fragmentation of the habitat of wild fauna. There is a very significant difference ($0.0000 < 0.05$) between the various activities.

Degrees of the human pressures in the various vegetable formations

Table 3 indicates the rate of anthropic pressure on the vegetable formations. These results show that the fragmented zones (88.12%) present the strongest pressure degree [raised savannas (26.25%); shrubby savannas (21.25 %) and wooded savannas (17.50 %)] while the forest galleries undergo only low pressures (13.13 %).

But in a specific way, raised savannas are threatened by the bush fires, the wood cuts and the poaching, transhumance and gold washing. For shrubby savanna, they are threatened by transhumance, then the poaching; wood the cuts, the bush fires. For timbered savannas, the bush fires represent the most disturbed pressures. As for the forest galleries, they are particularly threatened by the bush fires.

However the natural zones have respectively a total pressure of 11.88 % in raised savannas (4.38%), wooded savannas (3.13%), shrubby savannas (2.50 %) and the forest galleries (1.88%). There is a strong anthropic pressure in the exploited zones and that can be justified by the easy access of the population and the domestic animals in the BNP.

Evolution of the fragmentation of the vegetation within the study area

Fig. 3 [a and b] shows that the clear forest consisted of a homogeneous fragment in 2000; but 15 years later, one observes several fragmented tasks. The number of the tasks increases and the size of these tasks decreases by

the rupture of continuity and the increase in the insulation of these tasks. Specifically in space considered, one does not find only the clear forest, but a mosaic made up of timbered savannas, raised savannas, shrubby savannas and grassy savannas. There is a great reduction of the various colors (range of the green to the clear green) generating in its turn the increase in the naked grounds.

Changes of the occupation of the ground within the GNP between 2000 and 2015

The increase in the occupation of the ground in 2000 and the occupation of the ground in 2015 was observed at the level of classes of occupation of ground. It is noted that there is a true regression of the clear forests. In fact, the clear forests were in 2000 one of the vegetable formations most abundant with a percentage of 21.86% and in 2015 they were evaluated to 8.58% that means they lost 13.28% of its surface (Table 4). However the percentage of occupation of the shrubby savanna ground, grassy savannas and fields knew a very considerable increase.

State of development of fragmentation within the BNP between 2000 and 2015

The analysis of the crossing of the occupation of the soil in 2000 and the occupation of the soil in 2015 shows some modifications which have taken place on the level of the classes of occupation of the soil. It comes out from this analysis that apart from the classes of shrubby savannas and grassy savannas which knew great extensions of their surface and to a lesser extent raised savannas and naked soils, all other classes of occupation of the soil knew a contracting of their surface (Fig. 4). It is the case of the clear forests which preserved only 13.28% of their surface.

The wooded savannas preserved 11.95% of their surfaces. The forests galleries have kept 7.09% of their surface and for raised savannas there are only 5.72% of their surface which was preserved a strong rate of fragmentation. The major part of the surfaces lost by the classes of occupations of the soil concerning the regressive dynamics was colonized by the formations of shrubby savannas and grassy savannas. One notes that the vegetable formations of this area degrade oneself at worrying intervals. Thus, to maintain, decrease or reversing the tendency, one needs a solution in a lapse of time because the change of the surface is very significant. The clear annual loss of the surface of this Park is estimated at 0,98% in hectare per annum. If we project this degradation by 2035, there will be an estimate of the rate of degradation of the Bénoué national park of about 19.60%.

Impact of fragmentation on specific diversity and the ecological characterization of the BNP

Distribution of the ecological preference of vegetable species in the BNP

The calculated frequencies enable us to include the horizontal distribution of the listed species. Figure 5 illustrates the histogram of frequency of the woody species inventoried in the BNP. The 103 species, 80 about (77.66%) of the flora have an index of frequency equal to I. Some of them were recorded in only one statement and are qualified rare species.

It is the case of: *Adenolobus rufescens, Albizia ferruginea, Boswellia papyrifera, Boswellia dalzielii, cussonia arborea, Erytrina senegalensis, Ficus glumosa, Ficus platyphylla, Haematostaphis barteri, Lannea humilis Parinari curatellifolia* and *Phyllanthus muellerianus.*

A total of 19 species (18.44%) has an index of frequency equal to II. It is those which have a relative frequency ranging between (20 and 40 %). They are additional species The species with index of frequency is equal to III only represent 4 species that is to say 3.88% of the inventoried flora. They are rather frequent species.

Diversity on the level of families

It is deduced from this Table 5 that the species are divided into 35 families comprising 34 families in the pilot zones and 29 in the exploited zones. These families do not have the same importance or same diversity.

If some like Sapindaceae, Apiaceae, Araliaceae are represented by only one genus and only one species, others on the other hand are represented by several species in the pilot zones as well as in the fragmented zones. Indeed, in the pilot zones, Caesalpiniaceae alone present 11 genus, Mimosaceae have 7 genus, Euphorbiaceae have 5 genus, Fabaceae and Rubiaceae has each one 4 genus, Anacardiaceae, Combrétaceae,

and Meliaceae have each one 3 genera.

For the fragmented zones there are in first position Caesalpiniaceae and Mimosaceae which present each one 7 genera, Euphorbiaceae and Fabaceae are reduced to 3 genera each one in the fragmented zones. In addition, in comparison with the various values one notices that: the fact that a family counts several kinds does not really imply that it is much diversified.

It is the example of Caesalpiniaceae which includes up to 11 genera, count only 239 individuals with a relative density of (12.33%) having the relative Importance Value of Curtis of 25.39% while Combretaceae which, having only 3 genus count up to 468 individuals with a relative density of 24.14% and, of 35.49% of relative Importance Value of Curtis. Indeed, the family of Combretaceae (35.49%) is most abundant as individuals in the study area because it has the highest relative Importance Value of Curtis.

However, it is worth to note that some families are only found in the pilot zones and have low relative Importance Value of Curtis. They are: Apiaceae (1.78%), Araliaceae (4.29%), Burseraceae (7.96%), Chrysobalanaceae (3.76%), Polygalaceae (1.69%), Sterculiaceae (5.22%). Some families are much used in the traditional pharmacopeia.

Comparison of the various formations of vegetations

Table 6 presents the homogeneity or the heterogeneity of the site according to the test of Jaccard. The floristic difference is very strong between wooded savannas fragmented and raised savannas fragmented (80.00%).

It is strong between fragmented raised savannas and natural wooded savannas (68.57%), fragmented raised savannas and natural shrubby savannas (68.33%), fragmented forest galleries and fragmented raised savannas (65.45%), natural shrubby savannas and fragmented shrubby savannas (68.05%).

On the other hand it is strong between natural raised savannas and fragmented shrubby savannas (62.67%). The floristic difference is average between thirteen zones. That shows a relative heterogeneity between these zones. However, it is weak in fragmented gallery forest and natural raised savannas (39.34%), the natural forest galleries and fragmented wooded savannas (38.03%), the natural forest galleries and natural raised savannas (36.23%), and the low value is between the natural forest galleries and natural wooded savannas (30.43%). This difference would be due to the degree of anthropization on the study area in particular the one of the natural forest galleries and wooded savannas natural.

The anthropogenic influence on the density of vegetable formations

The highest density is observed in the natural zones (Fig. 6). The average density of our eight sites is about 700 stems/hectares. There is an irregular distribution of the ligneous family in the various inventoried vegetable formations. The total density of the ligneous family varies respectively in the exploited and natural zones from 231 to 419 individuals/hectare in the forest galleries with a difference in 188 individuals/hectare, then in wooded savannas we have 276 to 542 individuals/hectare with a difference of 266 individuals/hectare.

In raised savannas we have a difference of 308 individuals/hectare and at last shrubby savannas which have a difference of 311 individuals/hectare what proves that the forest galleries are less threatened compared to the other formations and that shrubby savannas are the most touched; decreasing thus considerably the density of individuals. The anthropic activities (cut of wood, bush fires, uprooting of the trees for the traditional pharmacopeia) considerably decrease the density of the individuals.

Vertical structure of the ligneous family of the various vegetable formations

Fig. 7 presents the distribution of the ligneous family in height class. The vegetation presents a structure in "L". The individuals having heights lower than 2 m are more abundant in all the formations natural and exploited vegetation. This marks a strong regeneration of the ligneous family in the sites. This regeneration is very marked in shrubby savannas where the stems of regeneration are 623 individuals /hectare.

However, the ligneous family of size ranging between 5 and 10 cm are represented in the raised savannas with only 32 individuals/hectare, galleries (43 individuals/ hectare), the wooded savannas (51 individuals/hectare) and shrubby savannas where individuals least represented are of 61individuals/hectare.

Dispersion of the ligneous family in the various squares

The representation of statements and species on the factorial design of axes 1 and 2 enables to gather the ligneous species having similar characters. The analysis in principal component focus on the three axes, F1, F2, F1 and F2 of percentages of real value respectively 31.25%, 18.24% and 49.50%. It is noted that the axis F2 allows a better dispersion of the sites of species. The natural forest galleries and natural wooded savannas present a strong correlation (p=0.619). Moreover, these two factors present very similar species (Fig. 8A). There is also a highly significant correlation between natural raised savannas and natural wooded savannas (p=0.379).

These two vegetable formations have close species. The formation of natural wooded savannas is very distant compared to the 6 other vegetable formations but is closer to the natural forest galleries. It presents some species similar to these last ones. Natural wooded savannas are less affected by the anthropisation. As for the various species, the figure 8 B shows that they are grouped in the beginning and form a cloud of points, it is what proves that the species are less diversified in the various vegetable formations. They are thus for the majority the accidental species. However some species such as *Isoberlinia doka*, *Bridelia ferruginea*, *Anogeissus leiocarpus* and *Combretum collinum* present a dispersion very far away from the other species, this would be justified by its abundance and its high diversity in the various statements.

Impacts of anthropisation on the disappearance of the ligneous species

The most threatened species by the phenomenon of anthropisation are *Afzelia africana* (84,00%), *Khaya senegalensis* (82,00%), *Nauclea latifolia* (81.33%). However, the species *Borrasus aethiopum* (54.00%) is the less threatened of the park (Table 7). As for the various villages, the village Sackdjé (90.00%) presents a more significant percentage of disappearance of species, that could be explained by the scarcity of these vegetable species which, formerly were of easy access.

Analysis of the variance indicates a non-significant difference between the villages ($p \geq 0.05$) as well as for species ($0.36 \geq 0.05$). Some vegetable communities of the GNP count among the most threatened species in the world. Some of them are already indexed in the "Red dated books" from the UICN. Others, without being in immediate risk of extinction, present as from now, a degree of rarefaction worrying.

Participative measures of bordering populations for the conservation of the biodiversity

Cameroon appears particularly well equipped by the nature, concerning ecosystems, fauna or flora. This biodiversity constitutes the main part of the uses of the population mainly rural which, because of the economic situation, added to the practices, turn mechanically round towards these resources to survive.

Consequently, the pressure is reinforced on the biological capital which is threatened by erosion, to the detriment of the future generations. Thus, to rectify this situation, several objectives and strategies of conservation are considered for the bordering population. Table 8 presents the methods of fitting out of the vegetation of the Park by the bordering population. It is deduced from this table that the populations contribute to the conservation of the vegetation.

Indeed, the proportion of alternative energy (94.00%) constitutes the most significant means of the conservation by the local population follow-up by the creation of drillings to the periphery of the Park (92.00%), to privilege the access in the Park for the bordering populations (77.33%), to set up and to make function the local comities in all villages (74.67%), to create other monitoring stations (74.00%) are as many the means being able to remedy to these different exploitations. The proportion of alternative energy is considered by almost all the population in all the villages (Bandaged and Dogba: 100.00%, Bouck: 90.00%, Sackdjé: 96.67% and Gamba: 83.33%).The villages Sackdjé (79.00%) and Bandaged (73.33%) attach the importance to the various measures of follow-up, because according to them these different means seem to be effective for the conservation of this park in order to limit and to control the exploitation of the natural resources and to ensure their perennially. Contrary to the other populations, the population of Bouck (55.00%) does not actively contribute to the maintaining of the biodiversity. The analysis of the variance shows that there is no significant difference between the methods undertaken by the local population neither between the villages ($0.05 < p$).

Table 1. Experimental device.

R/S	S1	S5	S2	S6	S3	S7	S4	S8
R1	F1	F7	F3	F6	F4	F6	F4	F8
R2	F2	F5	F2	F8	F1	F6	F2	F6
R3	F1	F7	F3	F5	F3	F8	F3	F7
R4	F4	F8	F1	F7	F4	F5	F2	F5
R5	F3	F8	F4	F6	F1	F6	F3	F7
R6	F3	F8	F4	F5	F2	F7	F1	F5

R = raised, S = transect, F = vegetable formation; 1, 2, 3, 4,5, 6, 7 and 8 represent respectively, natural forest gallery, natural raised savanna, natural shrubby savanna, natural wooded savanna, fragmented forest gallery, fragmented raised savanna, fragmented shrubby savanna and fragmented wooded savanna.

Table 2. Threshold of comparison of the floristic statements according to the Hamming's distance.

Threshold	Comparison
<20	Very weak floristic difference
20<H<40	Weak floristic difference
40<H<60	Average floristic difference
60<H<80	Strong floristic difference
80<H	Very strong floristic difference

Table 3. Numbers human pressures in the various vegetable formations.

Human pressures	ZTG	ZFG	ZTR	ZFR	ZTV	ZFV	ZTS	ZFS	TT	TF
Gold washing	0	1	0	7	0	2	0	1	0	11
Transhumance	1	4	0	7	3	8	2	7	6	31
Poaching	1	3	0	8	1	7	0	3	2	22
Cross of wood	0	4	2	8	0	7	1	6	3	28
Pharmacopeia	1	3	1	2	0	3	2	3	4	14
Bush fires	0	6	4	10	0	7	0	8	4	35
Total pressure	3	21	7	42	4	34	5	28	19	141
Total pressure (%)	1.88	13.13	4.38	26.25	2.50	21.25	3.13	17.50	11.88	88.12

Table4. Types of occupation of the ground between 2000 and 2015 (%).

Period	2000		2015		Evolution	
Types of occupation of the ground	Surface (hectares)	Percentage	Surface (hectares)	Percentage	Progression	Regression
Forests galleries	490270.5	10.91	160718.4	3.82		-7.09
Clear forests	982575	21.86	360686.7	8.58		-13.28
Wooded savannas	1747377	38.88	1131721.2	26.93		-11.95
Raised savannas	312720.3	6.96	52075.8	1.24		-5.72
Shrubby savannas	233523	5.20	539572.5	12.84	7.64	
Grassy savannas and fields	521111.7	11.59	994238.1	23.66	12.07	
Naked grounds	143408.7	3.19	870937.2	20.73	17.54	
Water and burning	63790.2	1.42	92200.5	2.19	0.77	
Total	4494776.4	100.00	4202150.4	100.00		

Table 5. Density, Predominance, Importance Value of Curtis and Number of individuals of species and of type of families [NG = Number of genus = Number of species, NI = Number of individuals, RF = relative Frequency, RDe = relative Density, RP. = relative Predominance, RIVC = relative Importance Value of Curtis].

Families	FT	NG	NE	NI	D.r	F.r	D.R	IVC	FF	NG	NE	NI	D.r	F.r	D.R	IVC
Anacardiaceae	1	3	4	56	2.89	6.6	1.5	10.98	1	2	5	27	3.13	4.42	5.12	12.67
Annonaceae	1	2	2	100	5.16	5.56	0.69	11.4	1	2	2	19	2.2	3.54	0.66	6.4
Apiaceae	1	1	1	9	0.46	0.69	0.62	1.78								-
Araliaceae	1	1	1	8	0.41	0.35	3.53	4.29								-
Bignoniaceae	1	2	2	15	0.77	1.39	6.64	8.8	1	2	2	15	1.74	2.21	4.52	8.47
Bombacaceae	1	2	2	11	0.57	2.43	16.49	19.49	1	2	2	6	0.69	0.88	18.09	19.67
Burseraceae	1	2	3	14	0.72	1.04	6.2	7.96					-	-	-	-
Celastraceae	1	1	1	18	0.93	1.74	1.29	3.95	1	1	1	3	0.35	0.88	5.53	6.77
Cesalpiniaceae	1	11	12	239	12.33	7.29	5.77	25.39	1	7	9	186	21.53	10.6	5.97	38.12
Chrysobalanaceae	1	1	1	1	0.05	0.35	3.36	3.76								-
Clusiaceae	1	2	2	67	3.46	1.74	1.39	6.58	1	2	3	19	2.2	9.73	0.99	12.92
Combretaceae	1	3	10	468	24.14	7.99	3.36	35.49	1	3	10	135	15.63	9.73	4.52	29.88
Dipterocarpaceae	1	1	1	25	1.29	2.08	2.08	5.45	1	1	1	16	1.85	0.88	1.38	4.12
Ebenaceae	1	1	1	8	0.41	1.39	0.84	2.64	1	1	1	20	2.31	-	2.65	4.97
Euphorbiaceae	1	5	6	141	7.27	7.29	2.08	16.64	1	3	4	61	7.06	7.52	2.23	16.81
Fabaceae	1	4	5	30	1.55	4.51	3.69	9.75	1	3	3	34	3.94	3.54	5.97	13.44
Flacourtiaceae	1	1	1	2	0.1	0.69	0.27	1.07	1	1	1	3	0.35	0.44	0.74	1.53
Hymenocardiaceae	1	1	1	38	1.96	1.04	1.19	4.19	1	1	1	20	2.31	1.33	0.4	4.04
Loganiaceae	1	1	2	17	0.88	4.17	1.72	6.76	1	1	2	4	0.46	1.77	1.6	3.84
Meliaceae	1	3	3	113	5.83	4.17	8.31	18.3	1	3	3	23	2.66	4.87	4.72	12.25
Mimosaceae	1	7	10	142	7.32	7.29	3.69	18.31	1	7	11	59	6.83	9.29	3.11	19.23
Moraceae	1	1	3	14	0.72	2.08	1.95	4.76	1	1	4	20	2.31	3.54	3.96	9.82
Myrtaceae	1	2	2	20	1.03	1.74	1.95	4.72	1	2	3	48	5.56	4.87	2.96	13.38
Ochnaceae	1	2	3	8	0.41	1.39	4.04	5.84	1	2	3	14	1.62	2.21	1.49	5.32
Olacaceae	1	1	1	12	0.62	2.08	1.19	3.89	1	1	1	5	0.58	1.33	1.08	2.99
Opiliaceae	1	1	1	32	1.65	1.39	1.39	4.43	1	1	1	12	1.39	1.77	0.59	3.75
Polygalaceae	1	1	1	3	0.15	0.69	0.84	1.69								-
Proteaceae	1	2	2	23	1.19	2.08	0.84	4.11	1	1	1	2	0.23	0.88	0.82	1.94
Rhamnaceae	0				-	-	-	-	1	1	1	2	0.23	0.88	9.75	10.86
Rubiaceae	1	4	4	86	4.44	5.9	0.92	11.26	1	2	2	33	3.82	5.75	1.72	11.29
Sapindaceae	1	1	1	69	3.56	3.82	2.2	9.58	1	1	1	37	4.28	2.21	1.84	8.34
Sapotaceae	1	1	1	16	0.83	1.74	4.04	6.6	1	1	1	1	0.12	0.44	3.78	4.34
Sterculiaceae	1	1	1	9	0.46	1.39	3.36	5.22								-
Tiliaceae	1	1	1	62	3.2	2.08	0.62	5.9	1	1	1	10	1.16	1.33	0.35	2.83
Verbenaceae	1	3	4	63	3.25	3.82	1.95	9.02	1	3	4	30	3.47	3.1	3.44	10.01
Total (35)	34	76	96	1939	100	100	100	300	29	59	84	864	100	100	100	300

Table 6. Floristic coefficient of similitude of Jaccard and Hamming distances between the various formations [PJ = Jaccard index; H = Hamming Distance].

	GFN		GFF		SRN		SRF		SVN		SVF		SBN		SBF	
	PJ	**H**	**PJ**	**H**	**PJ**	**H**	**PJ**	**H**	**PJ**	**H**	**PJ**	**H**	**PJ**	**H**	**PJ**	**H**
GFN	0.00	100.00	57.14	42.86	63.77	36.23	48.33	51.67	59.09	40.91	65.08	34.92	69.57	30.43	61.97	38.03
GFF	57.14	42.86	0.00	100.00	60.66	39.34	34.55	65.45	47.54	52.46	53.45	46.55	56.92	43.08	53.85	46.15
SRN	63.77	36.23	60.66	39.34	0.00	100.00	44.26	55.74	65.08	34.92	37.33	62.67	50.65	49.35	58.33	41.67
SRF	48.33	51.67	34.55	65.45	44.26	55.74	0.00	100.00	26.98	73.02	31.67	68.33	31.43	68.57	20.00	80.00
SVN	59.09	40.91	47.54	52.46	65.08	34.92	26.98	73.02	0.00	100.00	31.94	68.06	50.00	50.00	43.24	56.76
SVF	65.08	34.92	53.45	46.55	37.33	62.67	31.67	68.33	31.94	68.06	0.00	100.00	57.35	42.65	64.06	35.94
SBN	69.57	30.43	56.92	43.08	50.65	49.35	31.43	68.57	50.00	50.00	57.35	42.65	0.00	100.00	57.33	42.67
SBF	61.97	38.03	53.85	46.15	58.33	41.67	20.00	80.00	43.24	56.76	64.06	35.94	57.33	42.67	0.00	100.00

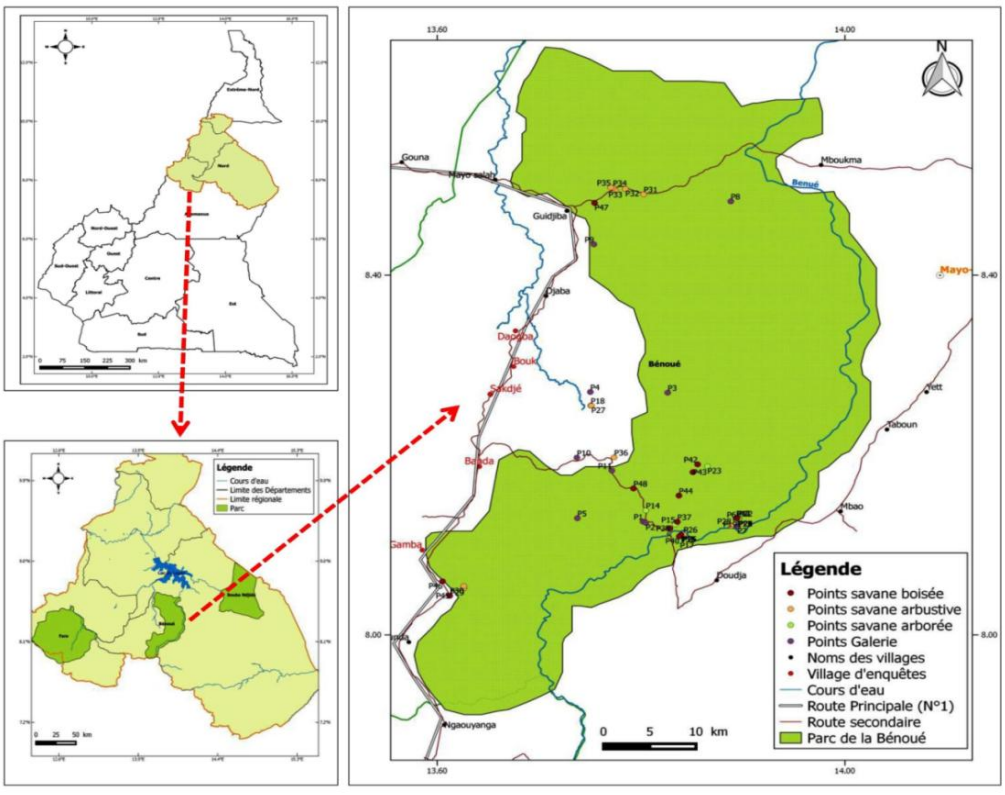
Table 7. Vegetable species in process of disappearance according to the perception of surveyed (%).

Species /Villages	**Banda**	**Bouck**	**Dogba**	**Gamba**	**Sackdjé**	**Average**
Afzelia africana	76.67	56.67	100.00	90.00	96.67	84.00 ± 13.87^{b}
Khaya senegalensis	83.33	63.33	96.67	83.33	83.33	82.00 ± 7.47^{ab}
Nauclea latifolia	93.33	60.00	86.67	73.33	93.33	81.33 ± 11.73^{ab}
Parkia biglobosa	56.67	80.00	90.00	76.67	90.00	78.67 ± 9.60^{ab}
Vitellria paradoxa	43.33	56.67	60.00	150.00	70.00	76.00 ± 29.60^{ab}
Balanites aegyptiaca	53.33	53.33	86.67	63.33	90.00	69.33 ± 15.20^{ab}
Tamarindus indica	73.33	93.33	76.67	56.67	30.00	66.00 ± 18.13^{ab}
Prosopis africana	46.67	40.00	60.00	80.00	90.00	63.33 ± 17.33^{ab}
Borrasus aethiopum	40.00	36.67	66.67	76.67	50.00	54.00 ± 14.13^{ab}
Average	$59.67\pm$ 17.60^{a}	$62.67\pm$ 14.53^{a}	$77.33\pm$ 14.67^{ab}	$82.67\pm$ 15.07^{b}	$75.00\pm$ 18.67^{ab}	

The affected figures of same letters are not significantly different with the threshold from 5%.

Table 8. Participative measures of bordering (%).

Methods of cogestion/villages	Banda	Bouck	Dogba	Gamba	Sackdjé	Moyenne
Proportion of alternative energy	100.00	90.00	100.00	83.33	96.67	94.00±5.87c
Creation of drillings to the periphery of the Park	100.00	100.00	93.33	76.67	90.00	92.00±6.93c
To privilege the access in the Park for the bordering ones	86.67	63.33	80.00	70.00	86.67	77.33±8.53bc
To set up and to make function the local committees in all the villages	73.33	83.33	60.00	93.33	63.33	74.67±10.93bc
Creation of other stations of monitoring	90.00	63.33	50.00	66.67	100.00	74.00±16.80bc
Severe sanction for all illegal exploiting	56.67	43.33	63.33	76.67	86.67	65.33±13.07b
Total prohibition of wood cut	76.67	46.67	70.00	40.00	76.67	62.00±14.93b
Increase in the taxes for the salesmen of the resources of the Park	50.00	40.00	70.00	56.67	90.00	61.33±14.93b
To re-examine the statute of coadministration	76.67	6.67	13.33	30.00	43.33	34.00±20.80a
Creation of an autonomous brigade for the Park	23.33	13.33	30.00	6.67	56.67	26.00±13.87a



Source : *Carte des aires protégées du Cameroun et SOGEFI 2015* Réalisation : Bouyo Ndoledje Félix 2015

Fig. 1: Location of the study area.

Table 9. Proposal of an adjustment plan for the Park.

Adjustment plan/Institutions	MINFOF	MINEP	MINEPAT	MINESUP	Average
Installation of the services of sensitization anti-poaching	100.00	93.33	100.00	100.00	98.33±2.50
Sanction of coalmen	100.00	100.00	93.33	95.00	97.08±2.92
Installation of the local structures for management of the Park	100.00	100.00	100.00	80.00	95.00±7.50
Equipment of the gamekeepers of adequate materials (boots, bags of beds…)	100.00	86.66	90.00	100.00	94.17±5.84
Creation of drillings in all the bordering villages	100.00	90.00	100.00	83.33	93.33±6.67
Availability of the means of transport for Eco guards	100.00	86.66	83.33	100.00	92.50±7.50
Installation and to make function the local committees in all the villages	100.00	80.00	100.00	90.00	92.50±7.50
Pecuniary motivation of the Eco guards	100.00	100.00	63.33	86.66	87.50±12.50
Setting-up of a true public awareness campaign on the importance of the park near to the bordering population and the various administrations	100.00	40.00	100.00	100.00	85.00±22.50
Reinforcement of the human and financial capacity for the control of this Park	100.00	100.00	86.66	53.33	85.00±15.83
Rehabilitation of the old tracks and opening of news	100.00	100.00	46.66	86.66	83.33±18.34
Creation of the structures of research and the recruitment of researchers	100.00	86.66	36.66	100.00	80.83±22.09
Not recognition of rights of the bordering populations on the park	100.00	50.00	100.00	63.33	78.33±21.67
Continuation of research on vegetable cover supposed being the habitat of wild fauna	100.00	100.00	0.00	100.00	75.00±37.50
Sanction of transhumance	100.00	83.33	53.33	60.00	74.17±17.50
Creation of an autonomous brigade for the Park	100.00	100.00	86.66	0.00	71.67±35.83
Development of the micro projects for a better knowledge of the resources of the Park	63.33	60.00	86.66	46.66	64.16±11.25
Increase in the taxes of the Park	83.33	63.33	46.66	53.33	61.66±11.67
Increase in the poor salaries of Eco guards in order to avoid any attempt at corruption	86.66	36.66	0.00	86.66	52.50±34.17
To multiply the stations of control/life level	100.00	36.66	53.33	0.00	47.50±29.17

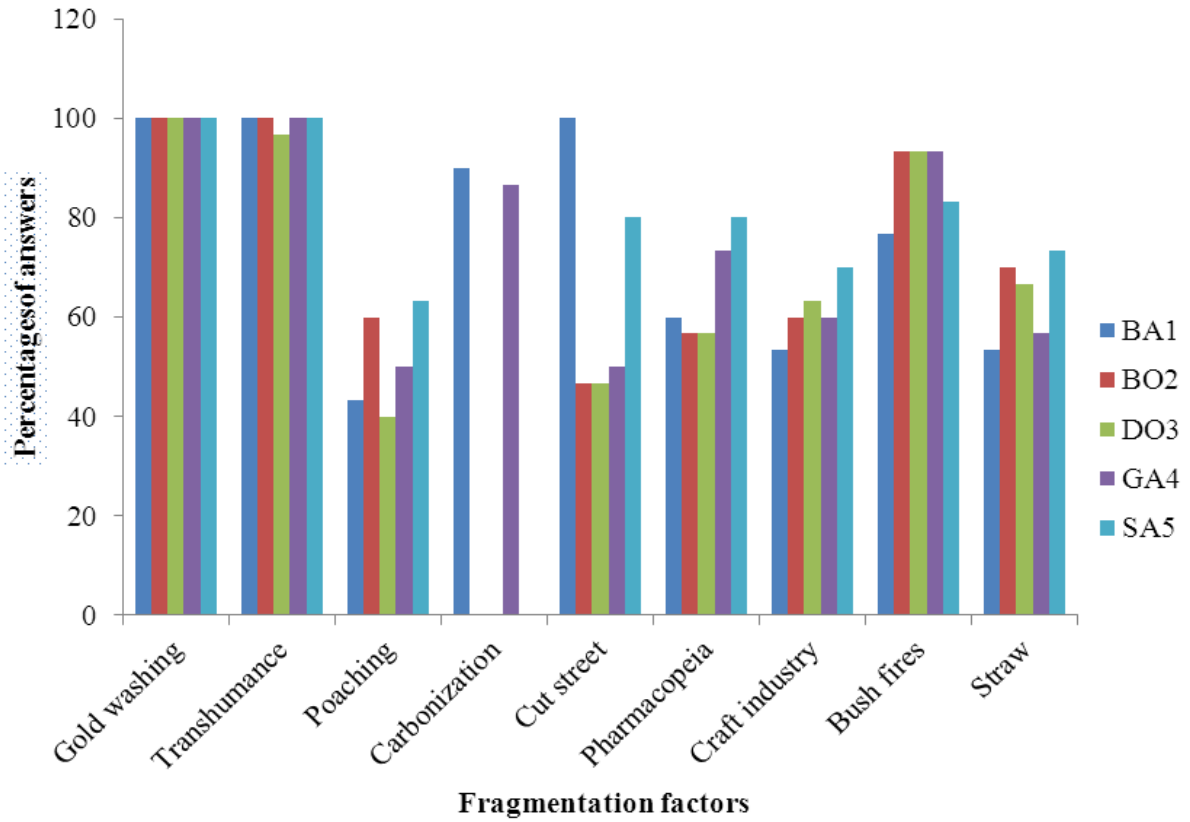


Fig. 2: Principal factors of fragmentation of the habitats of fauna in the GNP. BA1 = Bandaged; BO2 = Bouck; DO3 = Dogba; GA4 = Gamba; SA5=Sackdjé.

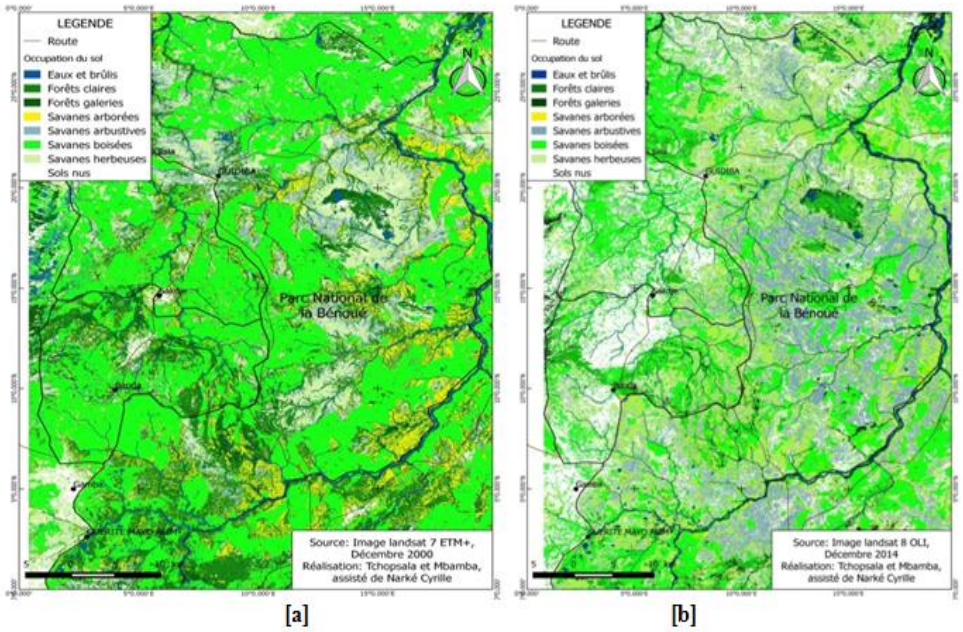


Fig. 3: [a] Landsat7ETM+image from December 30, 2000; **[b]** Landsat8 OLI image from December 2015.

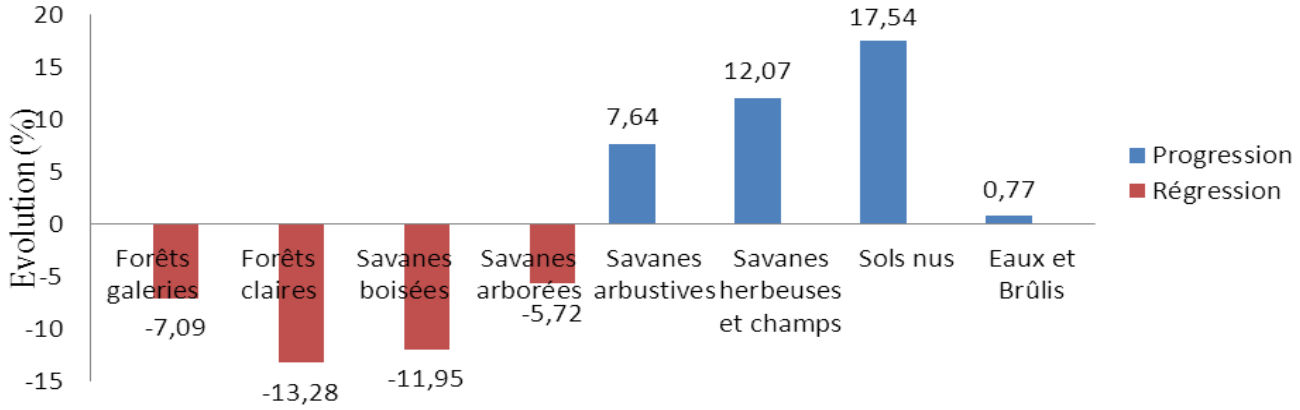


Fig. 4: Evolution rate of the fragmentation within the BNP between 2000 and 2015.

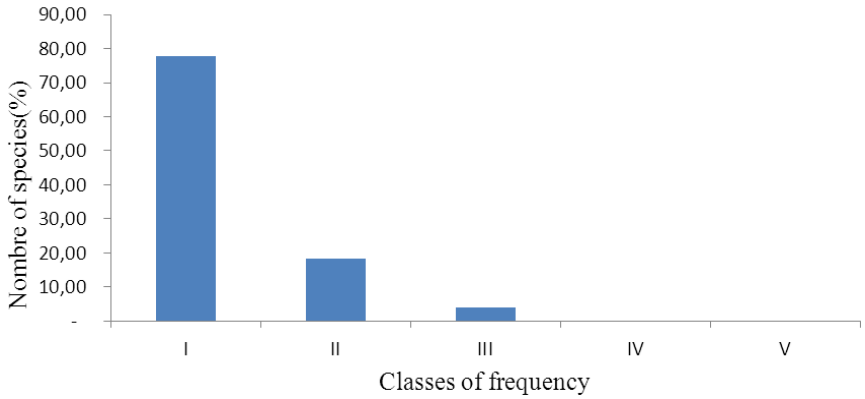


Fig. 5: Test of homogeneity/heterogeneity.

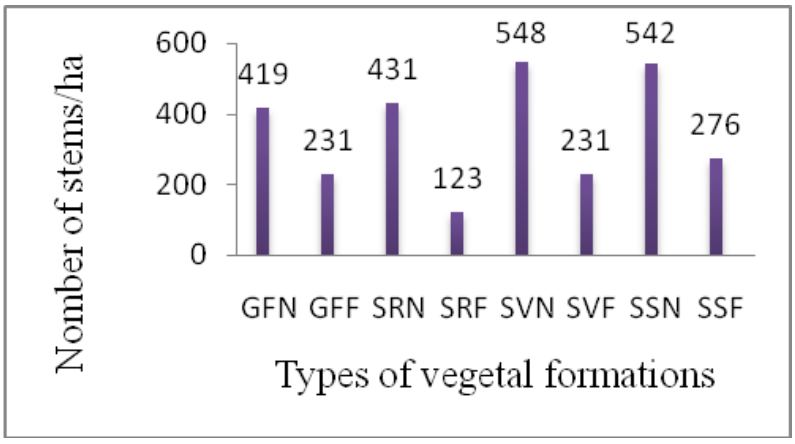


Fig. 6: Density of the various vegetable formations [NFG = natural forest gallery, FFG= Fragmented forest gallery NRS = natural raised savannas, RSF = raised savannas fragmented, NSS= natural shrubby savannas, FSS = fragmented shrubby savannas, NWS= natural wooded savannas, FWS = Fragmented wooded savannas].

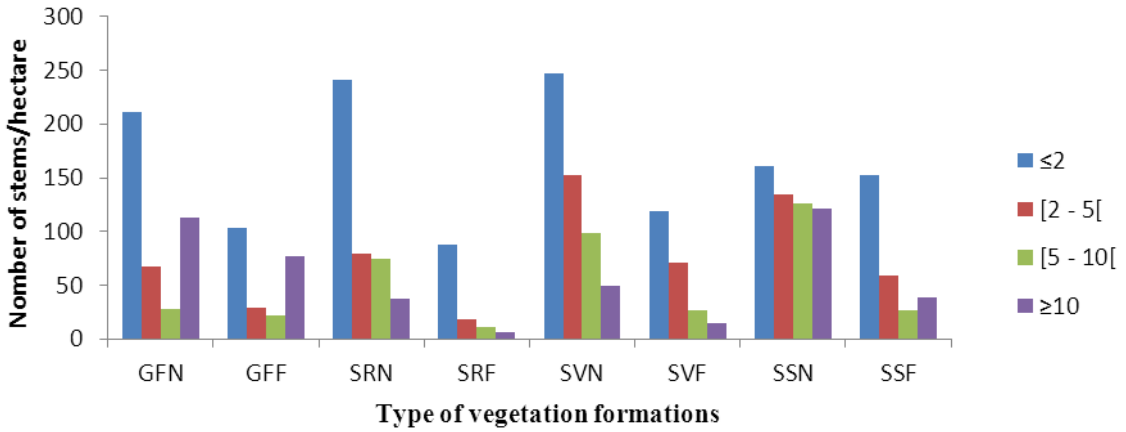


Fig. 7: Distribution of the ligneous family in height class (m). NFG = natural forest gallery, FFG= Fragmented forest gallery NRS = natural raised savannas, RSF = raised savannas fragmented, NSS= natural shrubby savannas, FSS = fragmented shrubby savannas, NWS= natural wooded savannas, FWS = Fragmented wooded savannas.

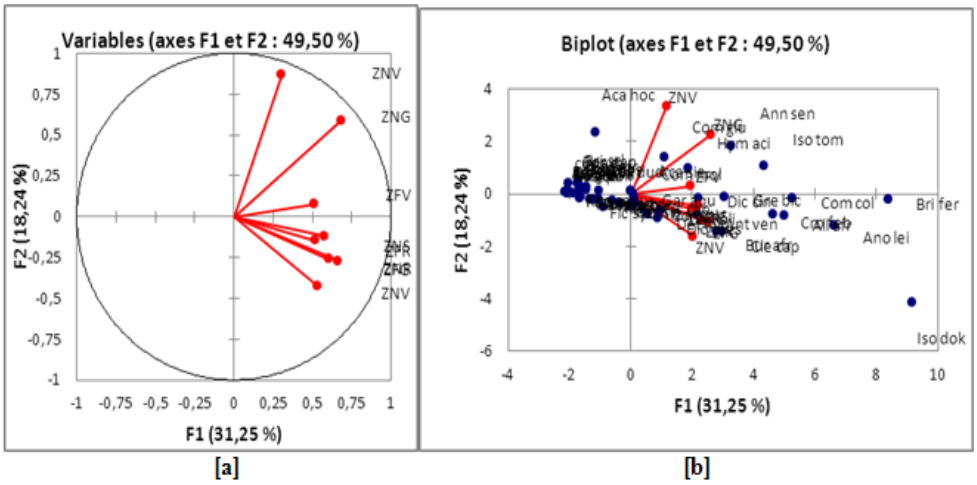


Fig. 8: ACP of the presence of species in the various statements. **[a]**-Distribution by types of vegetable formations; **[b]**-Distribution of the ligneous family in sites.

Proposal of an adjustment plan for the Park

Table 9 presents the orientations of fitting up suggested by the various institutions aiming at reversing the tendency for a progressive restoration of the resources in this Park. On the whole, 20 major points were retained by the various institutions: the installation of the services of sensitization anti-poaching (98.33 %), the sanction of coalmen (97.08%), the installation of the local structures for management of the Park (95,00 %), the equipment of the gamekeepers of the adequate materials (boots, bags of beds…) (94.17 %), the creation of drillings in all the bordering villages (93.33%), the availability of means of transport for Eco guards, the installation and to make function the local committees in all the villages which have each one (92.50%) in the principal proposals chosen by the government constitute. However, the least appreciated proposal is the multiplication of the stations of control/life level and has a null proposal by the ministry for the higher education. It is necessary also to note that in the various institutions, the greatest task for a better fitting up returns to the MINFOF (96.67%) followed by MINEP (79.66%), the MINESUP abounds in (74.25%) at last the MINEPAT comes into last position (71.33%) like proportion. This variability is confirmed by the

statistical analysis which reveals the existence of a highly significant difference between the various ministries (p>0.01). But between the means of these various points of adjustment retained by the institutions, it does not exist significant difference (0.05<0.22). Through data of the investigations and those of the floristic statements, it is possible for us to make a certain number of reports and to consider thereafter a plan of arrangement for this Park. It becomes essential to specify measures which are urgently essential to improve protection of the most remarkable ecosystems.

Anthropic activities contributing to the parcelling out of the habitats of the flora according to the perception of the bordering populations in the Bénoué National park are pruning, the uprooting, the cuts of the large trees, gold washing, transhumance, farming methods etc. These activities strongly take part in the fragmentation of the habitat of wild fauna. There is a very significant difference (0.0000 <0.05) between the various activities. Among these various practices, Kiéma (2001 and 2007) showed in Burkina that transhumance occupies the first place in the anthropic activities within the protected surfaces because they are currently attended by cattle practically all the year, with periods "de pointe" related to the lack of resources (fodder, water) in the peripheries, on the avoidance of fields in culture and to the representations which have the stockbreeders with respect to these protected surfaces of the reserve of the Hippopotamus Biosphere Pond and the classified forests of Maro and Tuy (Western burkinabé). It is noted that the BNP is affected by many threats undoubtedly contributing to the fragmentation of the habitats of wild fauna. According to Vake (2006), the anthropic actions constitute today a threat of extinction of the biological diversity of some of these protected surfaces, in particular by breeding, poaching, carbonization, the uncontrolled bush fires and the anarchistic taking away of PFNL. Degree of the human pressures has an impact on the fragmentation of the various vegetable formations. The clear forest consisted of a homogeneous fragment in 2000; but 15 years later, one observes several fragmented tasks. The number of those tasks increases and the size of those tasks decreases by the rupture of continuity and the increase in the insulation of those tasks. Specifically in the considered space, one does not find only the clear forest, but a mosaic made up of wooded savannas, raised savannas, shrubby savannas and grassy savannas. There is a great reduction of the various colors (range of the green to the clear green) generating in its turn the increase in the naked grounds. This result confirms the one of (Wilcox and Murphy 1985) which shows that the phenomenon of fragmentation of sites touches the majority of the areas and its importance increased because of the development of the human activities. It has been recognized as a major ecological risk. The change in the occupation of the ground within the BNP between 2000 and 2015 because of the anthropic activities strongly modified the vertical and diametrical structure of the ligneous family of the various vegetable formations. In general one observes in the park the vegetation having a structure in ”L”. These results are similar to those of Tchobsala (2011) which showed that the vegetation in suburban savannas of Ngaoundéré is dominated by shrubs of size lower than 5 m and of individuals of diameter ranging between 10 and 20 cm. In the various squares installed in the Bénoué National park of, for the inventory of species, one realizes that species are strongly grouped by forming a cloud of points, that is what proves that the species are diversified in the various vegetable formations. This arrangement in cloud of points on the level of the origin was obtained by Tatyana *et al.,* (2003) in Guinean savannas. However some species like *Isoberlinia doka, Bridelia ferruginea, Anogeissus leiocarpus, Combretum collinum* present a much shifted dispersion from other species, this would be justified by their abundance and their high diversity in the various statements

Cuts repeated each year even each month on the same individuals in the same places make the regeneration of some species difficult. It is in the same order of idea that Doua (1999) and Tchobsala (2011) had prevented that *Hymenocardia acida* and *Syzygium guineense* var. *macrocarpum* hardly regenerate when they are overexploited. Thus, the speed of the degradation of the BNP is perceptible because the bordering villages practise all kinds of activities inside the BNP such as gold washing, transhumance, the illicit cuts and many other activities undoubtedly reducing the flora which is supposed to be protected like habitats of wild fauna. So the local population is responsible for the degradation of that Park. According to Tchobsala (2011), all the actors of wood exploitations are of the same opinion that these uncontrolled practices strongly compromise the dynamics of the vegetation in that zone. As for the various villages, it should be noted that the most conscious village of the progressive disappearance of the BNP is Sackdjé and that could be explained by the scarcity of the resources which, formerly were easy. The fragmentation of the habitat of fauna is at the origin

of the disappearance of the woody species and of the degradation of the ecosystems. It would be necessary to consider participative measures from bordering populations for the conservation of the biodiversity. These results are in agreement with those obtained by Ntoupka (1999) in the Soudano-Sahelian zone which showed that the populations are by far to be the passive actors in the degradation through the reafforestation and the planting of fruit trees.

Prospect

This study permitted to evaluate the anthropic pressures and the impact of fragmentation on the habitats of the wild flora, the classification of the various vegetable formations according to their degree of disturbance but more especially to determine the major pressures which threaten these various formations. The study on the parcelling out of the biodiversity in the BNP showed that the gold washers, the stockbreeders, the poachers, the owners of the PFNL, the coalmen, are the principal actors who effectively contribute to the destruction of the habitats of the wild flora. The consequences of this exploitation result in a modification of the floristic composition of the vegetation which is supposed to be protected as habitat of wild fauna. The index of diversity, estimated at 3.37 indicates that the anthropic activities have a strong influence on the diversity of the ligneous species undoubtedly leading to the reduction of the habitats of wild fauna. In addition, the investigations reveal that the bordering populations are for the majority aware of the state of regression of the flora making not only the life of wild fauna in a critical state but more especially their own life. This influence on the reserve resources shows the limits of the management system put in place. Indeed, the lack of means of displacement and control, the insufficiency of sensitization of the bordering populations and the insufficient number of the forest agents constitute as many problems which slow down the good management of this reserve. The durable management of the reserve can be effective only if the implication of the local populations to the actions of conservation of biological diversity is active, voluntary and that the actors of development which intervene in the milieu work in close cooperation with those in order to identify their problems and to integrate them in their action plan. As a whole, the results of this study is however necessary so that the world of the conservation takes measures so that the most habitats and the most possible species survive to these difficult centuries related to the climate changes of human origin while suggesting than the conservation of the BNP will require simultaneous interventions on the fitting up of the habitat and the management of this surface. A strategy of intervention is presented in order to direct the managers of the forest and fauna from a point of view of conservation. The abundance of a diversified flora and fauna among the men has an advantage which could appear anecdotic, but which particularly relates to education, it is the development of a naturalist culture.

To preserve to the maximum the phenomenon it is necessary to continue the sampling of the sites on the floristic and ecological characteristics by putting the accent on the dynamics of the flora supposed to be the habitat of wild fauna in time and space; to study the mechanisms of restoration of the faunal habitat and to study the evolution of the vegetation to more direct the adjustment measures; to make specific thorough studies on flora and fauna threatened of disappearance; to undertake thorough studies on the climatic and anthropic factors under the angle of fragmentation; multiplier more the sensitization in all the peripheries of the BNP on the importance and services that offer to them this biodiversity.

Conflict of interest statement

The authors declare that there is no conflict of interest regarding the publication of this article.

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