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Structure, dynamics and impact of the exploitation of the woody plants of woodlands in the Sudano - sahelian zones, North Cameroon

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Abstract

This study was carried out in the Sudano- Sahelian zone of Cameroon to evaluate the floristic composition and the impact of the anthropogenic activities in woodlands areas. It aims to contribute to the sustainable management of vegetation resources. The inventory of the individuals of ligneous species was done on fields using transects methods. Results showed that, the specific richness of woodlands was 99 species belonging to 62 genera in 32 families. The most abundant families were: Fabaceae-Mimosoideae and Combretaceae. The total density was 46.65 individuals/ha^{-1}. In the unprotected zone, the total density was 28.65 individuals ha^{-1} while in the protected zone; it was 57.75 individuals ha^{-1}. The most represented species were: *Balanites aegyptiaca*, *Combretum glutinosum*, *Anogeissus leiocarpus*, *Hexalobus monopetalus*, *Loncocarpus laxiflora*, *Annona senegalensis.* Species with strong ecological value an Index of Importance Value (IVI) were: *Combretum glutinosum* (22.99), *Hexalobus monopetalus* (19.13), *Ficus sycomorus* (19.60), *Sterculia setigera* (17.52), *Annona senegalensis* (17.12), *Balanites aegyptiaca* (14.50), *Sclerocarya birrea* (13.41), *Tamarindus indica* (13.84). The whole basal area in the two zones was 47.87m^2 ha^{-1}. In unprotected zone and 16.7887m^2 ha^{-1} in the protected zone. The basal area average was 0.812 m^2 ha^{-1} . Distinctly between the zones, it was 0.518 m^2 ha^{-1} in the unprotected zone and 0.294 m^2 ha^{-1} protected zone. The greatest number of individuals was recorded in diameter classes of [10-20[and [20-30[, individuals with large diameter were scared. The majority of the individuals was concentrated around 6 m height and explained either a predominance of the shrubby species, or the influence of the anthropogenic activities dominated by trees contributing to the reduction individual's height. The (28.49 %) regeneration was weak, human activities which resulted in the strong intensity of cutting trees (38.72 %). The climatic threat, had an impact on the survival of the renewal individuals. The woody exploitation was anarchic and constituted a real threat of woody resources.

Keywords: Floristic composition, regeneration, anthropizations, woodlands, Sudano - Sahelian, Cameroon.

Introduction

The ground summit held in Rio in 1992 made it possible to humanity to become aware on the state of degradation of the natural resources and to promote the sustainable management of the biodiversity. Many scientific debates were held including/understanding since, then the direct and indirect effects of the human activities on the biodiversity (Larrere and Larrere, 1997). These debates will allow the policies authorities and researchers to take into account the notion of sustainable management of biodiversity. In spite of this collective awakening, the degradation of the biodiversity continues and constitutes a threat for humanity (Sinsin and Kampmamnn, 2010). The degradation of biodiversity is one of the most serious contemporary environmental problems which results to the biological loss of productivity upon agricultural fields (Reynolds and Stafford smith, 2002; FAO, 2008). The forests in Africa know fast processes of transformation of the rural landscapes and degradation of natural resources (Ariori and Ozer, 2005; Larwamou *et al.*, 2005; Mama *et al.*, 2013). In Cameroon, the pressure on biodiversity in general and the vegetal resources as private individuals appear increasingly strong. These resources are exploited to ensure the satisfaction of the populations needs for the subsistence, for wood-energy and wood for services, pasture (Youssaou, 2011). The exploitation of resources contributes to the acceleration of the degradation process of the fields and turns to spread and stroke all the ecosystems of dry area, together with the wettest parts. The Northern part of Cameroon, characterized by an insubstantial, weak and vulnerable ecology, is subjected to a strong degradation which generates significant changes in the composition of the local flora and the management of the resources. In spite of the efforts of protection approved by the authorities, the conservation and vegetation stock management in the Sudano-Sahelian zone are not always made to guarantee the sustainability of these resources. The agricultural extension activities and the exploitation of the resources which are increasingly intense are carried out with the damage of the woody resources. The agricultural practices are accompanied by cutting trees which strongly contribute to the reduction of woody resources (Fotsing *et al.*, 2003; Gautier and Seignobos, 2003). In the Far-North of Cameroon, the populations is increasingly, in need are of these resources. To provide for their needs, the population exploits resources in an anarchic way in harvesting non timber forest products, wood-energy, pasture, and bush fires. These anthropogenic actions combined with the climatic risks constitute the main factors of the degradation of the wooded zones. To safeguard what remains and to allow populations and upcoming generations to benefit the resources, it is significant to know the resources available, to determine the various elements which contribute to their dynamism and their exploitation. Many studies were carried out in the Sudano-sahelian area on several aspects of the vegetation: in particular the case of the vegetation in the protected area and on floristic diversity in some wooded area (Ntoupka, 1999; Fotsing *et al.*, 2003; Todou *et al.*, 2016). In the current state of knowledge, no study was carried out on the floristic composition, dynamic and the exploitation of the woody resources in woodlands. However, this aspect is significant and permitted to follow the evolution of the vegetation and to develop strategies for a sustainable management. The aims of the study is to contribute to the sustainable management of vegetal resources in the Sudano - sahelian areas.

Specifically to:

- determine the structure and the woody floristic composition of woodlands;
- determine the dynamics of woody vegetable cover;
- evaluate the impact of the activities of exploitations on the vegetation.

Materials and Methods

Study area

The study was conducted in the woodlands located in Mayo-Kani division, in Far - North region. It was situated between 10°11' 56" Northern latitude, 14°10' 40" longitude east and with altitude 623 m. The climate of the study zone was Sudano- sahelian types, characterized by two seasons: a long drying season which lasts approximately to eight (08) months, from October to May and a short raining season which lasts four (04) months covering June to September (Foundon, 2001). The Annual average rainfall was 800 mm, the annual average temperature was 28°C (Suchel, 1987). The vegetation which was Sudano-sahelian types characterized by the steppes with thorn-bush species particularly, but the general aspect was that of a savanna (Letouzey, 1985). The relief was characterized by two geomorphological forms with the vast plains relatively flat, together with an average altitude from approximately 450 m. The landscape was strewn with some solid masses terrazzo-gneissic and a significant altitude (Fotsing *et al.*, 2003).

The population was distinct by an ethnic identity mainly known to be the Guiziga, Tupuri, Moundang, Peuhls, Mofou, Guidar (Fotsing *et al.*, 2003). The economic activities were found on extensive agriculture, extensive breeding, exploitation of resources, craft industry, and small trade. The exploitation of firewood, non – timber forest products and charcoal in the other hand constituted a significant generating activity of substantial income for poor rural households.

Data collections

Investigations were conducted in two distinct woodlands area such as: The protected zone and the unprotected zone in the Sudano-sahelian area. The device of data collections was a transect methods laid out in a random way according to various orientations. The enumeration, measurement and observations on all individuals of woody species were realized inside transects of rectangular form of 2 000 m length and 20 m width, 10 transects were carried out as five (5) in each zone. Plots of 20 X 20 m were established inside transects to determine the dynamics of species renewal. Along the transects, the circumference of all tree individuals (circumference ≥ 5 cm) was measured at the base of trunk, either 60 cm above ground-level or the size of knee and not like classically in forestry, to 1,30 m (Ntoupka, 1999, and Froumsia, 2013). Moreover, for the species multicaules, all stems were taken into account. The height of individuals was estimated for tree with significant size. All individuals with the height were lower or equal to 1 m and a circumference ≤ 5cm were regarded as individuals of regenerations. To determine the potential of regeneration of species, seedlings were counted; the rejections on stumps of cut individuals were recorded. Data collected took into account: trees individuals, stumps of the systematically cut individuals; partially cut individuals; dead individuals, and various impacts on individuals of woody species.

Data analyzes

The floristic composition was determined by the classification of species inventoried by genera of which family and the species richness and floristic diversity were given.

The specific richness (RS) resulted to the total number of species of the studied community; the abundance of taxa (families, species): the absolute abundance of species in a vegetation community corresponded to the total number of individuals of this species, while its relative abundance was the report/ratio of its absolute abundance to the total number of trees as a whole, it was Ni/N where Ni was the number of individuals of species and N the total number of individuals. For a better understanding upon diversity certain index were calculated to show the similarities between ecosystems.

the Shannon-Weaver diversity index with $H = - \Sigma pi \log_2 pi$. Avec $pi = ni/N$,

relative abundance of species i, N = total number of individuals, ni = number of individuals of the species i, $\log_2$the logarithm at base 2; the Simpson index, which corresponds to the probability that two trees chosen randomly belong to the same class of diameter (Magurran, 1988). When diversity is high, its value is 0, and when diversity is low a value of 1 is interpreted as the probability that two randomly drawn individuals are of different species. Its formula is $D = 1/\sum(Ni/N)^2$and the scale factor of Sorensen. To measure biological diversity, these indices were largely used (Magurran, 2004); Pielou Equitability (E) $E = H/\log_2 R$ or $E=H/\log_2 S$ E varies from 0 to 1. The equitability of high Piélou is the sign of a balanced settlement (Dajoz, 1985). On the other hand, the low values correspond to the presence of a high number of rare species or of a small number of dominant species E ∈ [0-0,6], the equitability of Piélou becomes weak a presence of predominance species; E ∈ [0,7-0,8 [, the equitability of average Piélou [0,8-1], the equitability of raised Piélou, an absence of predominance;

Scale factor of Sorensen: $Cs = 100 [2c/ (a + b)]$ (Sorensen, 1969)

Where a: number of species of A; b: number of species of B; C: the number of common species for both zones.

The structural and dendrometric characteristics, density of stem, distribution of the individuals in diameter classes and height, the dynamics of renewal, the impact of exploitation of woody species were determined and analyzed for each zone as samples. The density was calculated for the unit of individuals (adult and regenerations) and corresponded to the number of individuals per unit of area (individuals/ ha^{-1}). It was calculated in a number of individuals for trees as for seedlings and rejections.

The relative density (Dr) = [a number of individuals of a species (total Ni)/number of individuals of all species (N)] × 100.

Basal area(S) = π ($Di^2/4$) in (m^2/ha^{-1}), where Di is the diameter of the individuals;

Relative predominance = (basal area for a species/whole basal area of all species) × 100.

To describe the ecological importance of the woody species in the various prospected zones, the Importance Value Index, (IVI) (Cottam and Curtis, 1956) was calculated thus:

Importance Value Index, (IVI) = relative predominance + relative frequency + relative density;

To determine the renewal of the resources, a more detailed analysis of natural regeneration was carried out in the two zones of inventory. Regenerations were separated in two classes taking into consideration the seedlings and the rejections resulted from stumps. The regeneration rate translated the potential of renewal resources. It was appreciated by the ratio between the number of seedlings and rejections of the stumps and the total number counted of individuals. The death rate (M): corresponds to the relationship between the number of death trees in the population and the total number of individuals counted. The degradation states wood lands were highlighted through the human activities indices and their impact on the vegetation. The rate of cutting trees was the relationship between the number of cutting individuals and the total number of individuals.

The inventory data were seized checked in an exhaustive way and was treated under Microsoft Excel and XLSTAT 8 which allowed the realization of the histograms, the comparison of averages, calculation of indices and correlations test of arise variability between the samples. Software QGIS was used for the realization of the chart of zone of study.

Results

Potential floristic of the forest solid masses

In the study area, 99 species belonged to 62 genera in 32 families were recorded (Table 1). The number of species was distributed in the two zones explored as follows: in the unprotected zone 82 species belonged to 56 genera in 29 families were identified and in the protected zone, 84 species gathered in 54 genera in 29 families were inventoried. In addition, 66 species distributed in 46 genera in 26 families were common to both zones. The unprotected zone contains 15 species not identified in the protected zone however 17 species identified in the protected zone were not known in the unprotected zone. In this, the protected zone was slightly diversified in terms of species than the unprotected zone. In fact, the protected zone at the beginning was a weakly wooded field, which benefited from this statute of protected zone for the afforestation and enrichment of woody species. In the two woodlands, the most represented families in terms of species were: Fabaceae-mimosoideae (13 species), Combretaceae (12 species), Fabaceae-papillionideae (7 species), Anacardiaceae (7 species), Moraceae (6 species), Fabaceae - caesalpinioideae and Rubiaceae which had 5 species each. The study area could be described as shrubby zone dominated by the thorny species with Fabaceae - mimosoideae and Combretaceae.

Diversity Indices

The diversity indices estimated by Shannon Weaver (H'), varied between the both zones. It was higher in the protected zone (3.53 bits) than in the unprotected zone (3.30 bits).They enlightened a moderate floristic diversity of both study zones. The Piélou equitability (E) was 0,863 for the unprotected zone and 0,827 for the protected zone. It confirmed the values of Shannon Weaver indices of high diversity knowing that the values approaching the unit had a large specific diversity. The index of Sorensen was 0.7952 with a scale factor of 79.52% which was higher than 50%, the two zones were floristically similar.

Structure and density of woodylands cover

In all, 2088 stems were counted including 933 and 1155 individuals respectively in the unprotected and the protected zones (Table 2). The total density was of 46.65 individuals ha^{-1}. The species most densely species represented were: *Balanites aegyptiaca*, *Combretum glutinosum*, *Anogeissus leiocarpus*, *Hexalobus monopetalus*, *Loncocarpus will laxiflora*, *Annona senegalensis*. Some species had very low density. The distributions of species densities in the two zones wasnot significantly (p= 0.085) spread, but it was overall weakly more significant in the protected zone. In the unprotected zone, the total density was 28.65 individuals ha^{-1}. The dominant species were: *Combretum glutinosum* (2.95 individuals ha^{-1}), *Hexalobus monopetalus* (2.6 individuals ha^{-1}), *Annona senegalensis* (2.3 individuals ha^{-1}), *Balanites aegyptiaca* (1.65 individuals ha^{-1}). In the protected zone, the density 35.05 individuals/$ha^{-1}$was found. Most represented species were *Balanites aegyptiaca* (4.6 individuals ha^{-1}), *Anogeissus leiocarpus* (3.1 individuals ha^{-1}), *Loncocarpus laxiflorus* (2.95 individuals ha^{-1}), *Combretum glutinosum* (2.6 individuals ha^{-1}), and *Prosopis africana* (1.95 individuals ha^{-1}). In fact, the density was higher in the protected zone (57.75 individuals ha^{-1}) than in the unprotected zone and this was obvious because the protected zone constituted actually biodiversity conservation milieu and proceeded to enrichment because of its status as protected surface. Though zones and species appear to be more densely, ANOVAs test showed that woodland status did not influenced species density (p = 0.123).

Basal area in the two zones was 47.87 m^2 ha^{-1} in unprotected zone was 31.09 m^2 ha^{-1} and 16.78 m^2 ha^{-1} in the protected zone; the basal area average was 0.812 m^2 ha^{-1}. Distinctly between the two zones, it was respectively of 0.294 m^2 ha^{-1} in the unprotected zone and protected zones. In the un protected zone, species with most significant basal area were: *Ficus ingens* (6.03 m^2 ha^{-1}), *Sterculia setigera* (2.73 m^2 ha^{-1}), *Anogeissus leiocarpus* (2.40 m^2 ha^{-1}), *Tamarindus indica* (2.26 m^2 ha^{-1}), *Sclerocarya birrea* (1.99 m^2 ha^{-1}), *Balanites aegyptiaca* (1.69 m^2 ha^{-1}), *Boswellia dalzielii* (1.32 m^2 ha^{-1}), *Hexalobus monopetalus* (1.31 m^2 ha^{-1}), *Entada Africana* (0.91 m^2 ha^{-1}), *Azadirachta indica* (0.90 m^2 ha^{-1}), *Terminalia glaucescens* (0.89 m^2 ha^{-1}), *Bombax costatum* (0.89 m^2 ha^{-1}), *Lannea schimperi* (0,84 m^2/ ha^{-1}), while in the protected zone it was rather high at the species: *Balanites aegyptiaca* (2.63 m^2 ha^{-1}), *Sterculia setigera* (1.73 m^2 ha^{-1}), *Anogeissus leiocarpus* (1.64 m^2 ha^{-1}), *Lonchocarpus laxiflorus* (1.21 m^2 ha^{-1}), *Boswellia dalzielii* (1.18m^2 ha^{-1}), *Acacia seyal* (0.68 m^2 ha^{-1}), *Tamarindus indica* (0.66 m^2 ha^{-1}), *Ficus ingens* (0.62 m^2 ha^{-1}), *Sclerocarya birrea* (0.58 m^2 ha^{-1}), *Acacia hockii* (0.44 m^2 ha^{-1}), *Combretum glutinosum* (0.43 m^2 ha^{-1}) (Table 2).

The ecological importance of species was determined by the Importance Value Index (IVI) (Tables 2). It was variable on each zone according to species but the variability was not significantly (p=0.0634). In the unprotected zone, species with strong ecological importance (IVI) were:*Combretum glutinosum* (22.99), *Hexalobus monopetalus* (19.13), *Ficus sycomorus* (19.60), *Sterculia setigera* (17.52), *Annona senegalensis* (17.12), *Balanites aegyptiaca* (14.50), *Sclerocarya birrea* (13.41), *Tamarindus indica* (13.84), *Azadirachta indica* (10.82), and *Terminalia glaucescens* (10.24). These species mark the unprotected zone vegetation aspect. In the protected zone, species with strong ecological importance with an Importance Value Index (IVI) were: *Balanites aegyptiaca* (41.94), *Loncocarpus laxiflora* (24.06), *Anogeissus leiocarpus* (17.71), *Combretum glutinosum* (17.40), *Prosopis africana*(13.39), *Sterculia setigera* (13.18), *Acacia seyal* (11.21), *Acacia senegal* (10.71), *Annona senegalensis* (10,11). These species characterized the protected zone vegetation aspect.

Diametric structure

The distribution of individuals in diameter classes of both woodlands (unprotected zone and protected zone) shown a structure in" L " shape (Figure 2). In the two zones, the greatest number of individuals were in the diameter classes of [10-20 [and [20-30[. These classes respectively contain 40.33 % and 24.67 % of individuals recorded in the unprotected zone and 61.34 % and 28.87 % from the individuals calculated in the protected zone. There was not a significant variability between classes (p=0.111). Individuals with diameter ≥ 50 cm or m represented 5.98% for the unprotected zone and 1.28% for the protected zone. In the two zones, individuals with large diameter ≥ 90 cm were scared. However, some individuals with diameter higher than 90 cm were inventoried in the following species: *Ficus ingens, Sclerocerya birrea, Acacia albida* in the unprotected zone. These species were not exploited too much by farmers, mainly because of the bad quality of their wood little use as wood-energy or wood for service.

Vertical distribution

The distribution of individuals in height in the two zones followed the same tendency as the distribution in diameter (Figure 3). In the two zones the greatest number of individuals was met in the highest class of [3-6[m, that represented 45.32 % of individuals counted in the unprotected zone and 55.77 % from the individuals recorded in the protected zone. The individuals with highest length of 12 m were rare in the two zones. Concentration of individuals around 6 m height showed either the predominance of shrubby species, or the influence of anthropogenic activities dominated by cutting of individuals which mostly contributed to the individuals height reduction. It was noted that, the individual's height did not exceed 14 m in the two woodlands; the vegetation was dominated by shrub species and could be qualified as a shrubby land. In the various explored zones, a linear correlation between diameters and the height was strongly significant (R^2 = 0.97; P = 0. 0001). The two variables (diameter and height) of the ligneous species observed in the unprotected zone and protected zone were strongly dependent.

Regeneration and dynamics of the population

In the study areas a total number of 595 individuals of woody species regeneration compared to seedlings were counted in the two woodlands. The total rate of regeneration of woody species was 28.49 %. The regeneration rate varies at each species (Table 3). This variability was shown by the calculation variance (p=0.00021). Species with the strongest regeneration capacity and greatest density of regeneration individuals were: *Combretum glutinosum* (10.2 seedling ha^{-1}) either a regeneration rate of (32.15%), *Combretum aculeatum* (6.45 seedling ha^{-1}), *Annona senegalensis* (6.05 seedling ha^{-1}) (19.07%), *Piliostigma reticulatum* (4.65 seedling ha^{-1}) or a regeneration rate of (20.33%), *Cassia sieberiana* (4.35 seedling ha^{-1}) or a regeneration rate of (13.71%), *Feretia .apodanthera* (3.95 seedling ha^{-1}) or a regeneration rate of (12,45%), *Hexalobus monopetalus* (3.52 seedling ha^{-1}) or a regeneration rate of (11.11%), *Commiphora africana* (2.95 seedling ha^{-1}), *Dichrostachis cinera* (2.85 seedling ha^{-1}), *Balanites aegyptiaca* (2.62 seedling ha), *Acacia polyacantha* (2.4 seedling ha. Individuals of regeneration were not recorded for some species such as: *Acacia albida*, *Capparis fascicularis*, *Celtis integrifolia*, *Combretum micranthum*, *Haematostaphis barteri*, *Terminalia glaucescens*. However, it should be noted that stems with aspect as individuals regeneration were not all resulting from the germination of seeds during the two last years. Some were from the frequency of bush fires which desiccated annually these individuals. They were always presented in the form of seedling. The low capacity of regeneration could be attributed to the harmful effects of human activities and the climatic risks which impacted on many seedlings survival. Potential regeneration potentiality was very weak and did not permit to ensure the renewal of the woody resources. It became an imperative to develop strategies to ensure for the future generation upon the availability of resources.

Regeneration by emission of rejections

After cutting down trees, some species were able to emit rejections. The whole of the 39 species having emitted rejections were counted in the woodland. The rate of rejections was 5.53%; which varied according to species' (Table 4). Species which regenerated well after cut were: *Combretum glutinosum* (22.80 %), *Anogeissus leiocarpus* (17.20 %), *Combretum collinum* (13.66 %), *Annona senegalensis* (6.59 %), *Hexalobus monopetalus* (4.53 %), *Piliostigma reticulatum* (3.41%), *Combretum fragrans* (3.54 %), *Balanites aegyptiaca* (4.76 %), *Piliostigma thonningii* (2.07 %), *Feretia apodanthera* (1.83 %), *Guiera senegalensis* (4.51 %) and the very weak rejections rates were observed in the following species: *Dalbergia melanoxylon*, *Ficus ingens*, *Gardenia ternifolia*, *Tamarindus indica*,*Dichrostachis cinera*, *Acacia polyacantha*, *Steriospermum kunthianum*. Globally, species emit rejections after the cutting; however, there were ecological and environmental parameters to take into account at the time of cut. In spite of a relatively high regeneration rate, the vegetable population does not evolve; its evolution was influenced by intense human activities and the climatic risks.

Individuals Mortality

The total individual's death rate was 3.83% in the study zone. The most affected species by death in the two zones were: *Anogeissus leiocarpus*, *Balanites aegyptiaca*, *Piliostigma reticulatum*, *Entada africana*, *Eucalyptus camadulensis*, *Acacia hockii*, *Acacia nilotica*, *Acacia polyacantha*, *Ziziphus mauritiana* (Table 5). These species were seriously exploited by the populations especially for wood-energy and craft service. Generally, the death rate seems weak, but it had serious consequences on ligneous cover in the zone.

Intensity of wood cutting

The activities of cutting wood were remarkable through the stumps of various species in study zone (Table 6). The total number cutting trees individuals was 809 stumps representing a systematic cut and 427 individuals partially cut in the two zones. The cut down trees was evaluated to 38.72 %. In the two zones, the rates of cut were: unprotected zone (50.39 %) and that of the protected zone (24.33 %). This practice was permanent; it can equally contribute to the overpressure of significant number of individuals on woody species in a given period. The actions of cut constituted a serious threat and remain a significant factor of woody cover degradation in the Sudano-sahelian area. In addition, this was related to its unusefulness and importance in the satisfaction of the populations needs. In this rural zone, wood constitutes the principal source of energy, craft production, construction and several other uses for households. The most cut species were: *Combretum glutinosum* (14.73%), *Anogeissus leiocarpus* (11.11%), *Combretum collinum* (8.03%), *Annona senegalensis* (4.25%), *Balanites aegyptiaca* (3.06%), *Piliostigma reticulatum* (2.99%), *Feretia apodanthera* (2.91%), *Combretum fragrans* (2.28%), *Hexalobus monopetalus* (2.28%), *Guiera senegalensis* (2.04%). The practice of cut down individuals for the satisfaction of households need was often selective on the populations and had a negative impact on the evolution of the vegetation wiring the degradation of woodlands. The harvest of the non timber forest products (fruits, sheets, flowers, barks, and roots) also constituted another factors degradation of resources. In the study zones, 4.49% of inventoried individuals were traumatized, barked and uprooted; these individuals were identified at the following species: *Khaya senegalensis*, *Boswellia dalziellii*, *Sterculia setigera*, *Balanites aegyptiaca*, *Acacia nilotica*, *Terminalia glaucescens*, *Annona senegalensis*, *Celtis integrifolia*, *Bombax costatum*, *Adansonia digitata*.

Discussion

Floristic composition and structure of woody species

The richness of the two woodlands was 99 species belonging to 62 genera in 32 families. The number of species was distributed in the two zones explored as follows: in the unprotected zone, 82 species belonging to 56 genera in 29 families were identified and in the protected zone, 84 species gathered in 54 genera in 29 families were inventoried. These results were related to those of Thorgnang (2001), and those of Savadogo *et al*. (2007) recorded respectively in the Gawar forest reserve, Far-North Cameroon, in the Tiogo forest, Burkina Faso and the Kalfou forest reserve, Cameroon, 117 species belonging to 80 genera and 37 families, 89 species represented by 66 genera and 29 families and 101 species belonging to 71 genera and 36 families in the milieu characterized by vegetations of Sudano-sahelian savannas. On the other hand the studies of Mahamat (1991) in the Kalamaloué national park and Teicheugang (2000) in the Zamay forest reserve, and Bognounou *et al.*, (2009) in the sectors north-sahelian, south-sahelian, north-sudanian and south-sudanian of Burkina Faso and Todou *et al*, 2016) in the Moutourwa zone Cameroon found the same type of vegetation with few, less species. The difference between these results was due to the present study was carried out in two importance zones, in particular in the protected zone and in the unprotected zone. The most represented families in the terms of species were: Fabaceae-mimosoideae (13 species), Combretaceae (12 species), Fabaceae-papillionideae (7 species), Anacardiaceae (7 species), Moraceae (6 species), Fabaceae-caesalpinioideae and Rubiaceae had each 5 species. The zone can be described as shrubby zone dominated by the thorny species with Fabaceae-mimosoideae and Combretacées. Diatta *et al.*(2009) in the Ngazobil (Joal-Fadiouth) reserve in the same type of vegetation in Senegal, found similar results with Fabaceae-mimosoideae, Combretaceae which were the most dominant families. Studies of Poilecot *et al.* (2006) showed that families best represented in the Zakouma national park in the Sudano-sahelian zone of Chad were: Combretaceae, Capparidaceae, Bignoniaceae and Boussim *et al.* (2009) in Center-North and the Mid-west in zone sahelian of Burkina Faso also showed that Combretaceae, Caesalpiniaceae were dominant. In the whole, 1279 stems were recorded including 573 and 706 individuals respectively in the unprotected and the protected zones. The total density was 33.17 individuals ha^{-1}. Species densely represented were: *Balanites aegyptiaca*, *Combretum glutinosum*, *Anogeissus leiocarpus*, *Hexalobus monopetalus*, *Loncocarpus laxiflora*, *Annona senegalensis*, *Commiphora africana*, *Sclerocarya birrea*. The result was very weak compared to those of Savadogo *et al.* (2007) in savannas of Burkina Faso, Adjonou *et al*. (2009) in the national park Oti-Kéran in Northern Togo and Diatta *et al*. (2009) which found the more significant densities of individuals of woody species. Species densely represented were: *Guiera senegalensis*, *Anogeissus leiocarpus*, *Balanites aegyptiaca*, *Combretum collinum*, *Hexalobus monopetalus*, *Ziziphus mauritiana*, *Acacia seyal*, *Combretum glutinosum*, and *Piliostigma reticulatum*.

The structure of distribution of individuals in diameter classes of ligneous species in the unprotected and the protected zones shows a " L " shape. The greatest number of individuals was in the diameter classes of [10-20[and [20-30[. Individuals with large diameter were rare. However some individuals with greatest diameter than 90 cm were noted belonging to the following species: *Ficus ingens*, *Sclerocerya birrea*, *Acacia albida*; they were inventoried in the unprotected zone. These species were not too much exploited by famers, mainly because of the bad quality of their wood little used like wood-energy or wood of service. This same structure was also observed in the zone sudanian in Ngaoundéré (Cameroon) and was regarded as a degradation index (Tchobsala *et al*, 2010). According to (Whitmore, 1990), the high densities of low diameter classes ensured the future of natural formation while the low densities of larger classes trees resulted from the natural selection and were in fact the seed-bearer ones which ensure the sustainability of woody cover. Such a distribution, was a typical stable populations, suitable for the renewed by natural regeneration (Mbayngone *et al.*, 2008b). On the other hand, Smith (1984), Konaté (1999), Maltamo *et al*.(2000), Poilecot *et al.* (2006), Savadogo *et al*. (2007) and Boussim *et al.* (2009) in Sudano-sahelian savannas of Africa presented woody populations structures to a pace out of a bell shape. This distribution of the populations of trees and shrubs is irregular and the distribution which does not show any form of symmetry concerns an abnormal distribution of individuals (Doucet *et al.*, 2007 and Boussim *et al.*, 2009). This structure makes it possible to predict the vulnerability of the species due to the strong human activity at the origin of the regression of the individuals of large diameter and the weak regeneration (Smith, 1984; Maltamo *et al.*, 2000; Doucet *et al.*, 2007). A settlement is really in good regeneration when the young individuals are well represented in population (Boussim *et al*., 2009).

Potential of regeneration of woody cover

The renewal of species by seedlings permitted to count 595 individuals woody species and those similar to the seedlings. In the Sudano-sahelian explored woodlands a density of 14.87 seedlings ha^{-1} were counted. The total rate of seedling regeneration was 28.49 %. Teitcheugang (2000) in the Zamay forest reserve, (Poilecot *et al., 2006)* in the national park of Zakouma, Diatta et al. (2009) in the reserve of Ngazobil (Joal-Fadiouth) in Senegal, showed a more significant regeneration. Species with strong regeneration and the greatest density of seedlingwere: *Combretum glutinosum*, *Combre tumaculeatum*, *Annona senegalensis*, *Piliostigma reticulatum*, *Cassia sieberiana*, *Feretia apodanthera*, *Hexalobus monopetalus*, *Commiphora Africana*, *Dichrosta chyscinera*, *Balanites aegyptiaca*, *Acacia polyacantha*, *Combretum collinum*. Some species such as: *Acacia albida*, *Capparis fascicularis*, *Celtis integrifolia*, *Combretum micranthum*, *Haematostaphis barteri*, *Lannea schimperi*, *Terminalia glaucescens* had regeneration problems. The processes of trees regeneration could be influenced by certain factors such as the dissemination mode, viability, the dormancy and the predation of seeds (Condit *et al.*, 2000; Khurana and Singh, 2001). The tardy bush fires can cause a significant mortality of natural regeneration individuals (Luoga *et al.*, 2004). The regeneration of many woody species was made difficult by the harmful action of fires and pasture (Gould *et al*., 2002; Thiombiano *et al.*, 2003). In the Sudano-sahelian zone, among many seedlings in year, more than three quarters lived only 3 months a maximum during the rainy season and survival of those live which remain and cross the hard dry season was very difficult what justifies in addition weak regeneration. The regeneration by rejections of stumps represented a rate of 5.53 %. This regeneration rate was also weak and unfortunately, these individuals of regeneration were brittle and vulnerable. The rejections were grazed by animals in a cyclic way (Poilecot *et al.*, 2006).

Impact of woody cut

The cut of individuals was evaluated to 38.72 % in the study zone. This practice was permanent, it contributed to overpressure of a significant number of individuals in the population during a given period. Actions of cut take place on the exploitable of individuals and in a selective way, they constituted a serious threat thus and remain a significant factor of the degradation of woody cover of woodlands. These elements were raised by (Ntoupka, 1999; Bruijinzeel, 2004) who showed that the exploitation of wood-energy and service was one of the more harmful practices to blooming of woody settlements. It was selective and appeared by the systematic cut of species individuals (Madi *et al*., 2003). It was an illegal and badly organized practice, associated the bad techniques of pruning which contributed to the degradation of woody resources.

Conclusion

Transects established in the two woodlands: protected zone and unprotected zones one allowed highlighting the floristic composition and human activities impact. The specific richness of the woody species was 99 species belonging to 62 genera in 32 families. The woodland was described as a shrubby vegetation dominated by thorny species with Fabaceae-mimosoideae and Combretacées families. The unprotected zone contains 15 species not identified in the protected zone and 17 species identified in the protected zone were not in the unprotected zone. Indeed, the protected zone was slightly diversified in terms of species than the unprotected zone. Definitely, the protected zone which, in the beginning was a little timbered milieu, benefited from the statute of protected zone. Actually, it is a surface of afforestation and woody enrichment. The total density was of 46.65 individuals ha^{-1}. The dominant species were: *Combretum glutinosum*, *Hexalobus monopetalus*, *Annona senegalensis*, *Balanites aegyptiaca*. The distribution of the individuals showed that the greatest number of individuals was in the diameter of class [10-20 [and [20-30]. This distribution is strongly influenced by the human activities. The significant number of stocks, observed in its solid masses translates the strong anthropogenic pressure which this vegetation undergoes. Consecutively, regeneration by seed germination and that by emission of rejections of the stocks after the cut are weak to ensure the renewal of the species. The anthropogenic activities correlated with the pejoration of the climate are intensive and have a significant ecological impact on the exploited species and the biological diversity of the zone. If in the zone, the concern of the peasants is to diversify the sources of income and to face the insufficiency of the agricultural production and with poverty, the intensive and selective practices of exploitation of the woody species, will constitute a significant threat for the requested species. It is to be feared that, in the upcoming years, these resources will disappear.

Table 1: Floristic composition of woodland.

Family	**Species in unprotected zone**	**Species in protected zone**
Anacardiaceae	*Haematostaphis barteri*	*Haematostaphis barteri*
	Lannea acida	*Lannea acida*
	Lannea barteri	*Lannea barteri*
	Lannea fruticosa	*Lannea fruticosa*
	Lannea humilis	
	Lannea schimperi	*Lannea schimperi*
		Ozoroa isingnis
	Sclerocarya birrea	*Sclerocarya birrea*
Annonaceae	*Annona senegalensis*	*Annona senegalensis*
	Hexalobus monopetalus	*Hexalobus monopetalus*
Apocynaceae	*Adenium obesum*	
Asclepiadaceae		*Calotropis Procera*
	Gymnema sylvestre	*Gymnema sylvestre*
		Sarcostema viminale
Apiaceae	*Steganotaenia araliacea*	
Balanitaceae	*Balanites aegyptiaca*	*Balanites aegyptiaca*
Bignoniacées	*Stereospermum kuntianum*	*Stereospermum kuntianum*
Bombacaceae	*Bombax costatum*	*Bombax costatum*
		Adansonia digitata
Burseraceae	*Commiphora africana*	*Commiphora africana*
	Commiphora pedunculata	
	Boswellia dalzielii	
Capparaceae	*Maerua angolensis*	*Maerua angolensis*
	Capparis sepiaria	*Capparis sepiaria*
	Capparis fascicularis	*Capparis fascicularis*
	Crateva adansonii	*Crateva adansonii*
Fabaceae-Ceasalpinioideae	*Afzelia africana*	*Afzelia africana*
	Piliostigma reticulatum	*Piliostigma reticulatum*

		Piliostigma thonningii
	Tamarindus indica	*Tamarindus indica*
	Bauhinia rufescens	*Bauhinia rufescens*
Celastraceae	*Maytenus senegalensis*	*Maytenus senegalensis*
Combretaceae	*Anogeissus leiocarpus*	*Anogeissus leiocarpus*
	Combretum aculeatum	*Combretum aculeatum*
	Combretum fragrans	*Combretum fragrans*
	Combretum glutinosum	*Combretum glutinosum*
	Combretum collinum	*Combretum collinum*
	Combretum molle	*Combretum molle*
	Combretum nigricans	*Combretum nigricans*
	Guiera senegalensis	*Guiera senegalensis*
	Terminalia avicinoides	
	Terminalia glaucescens	*Terminalia glaucescens*
	Terminalia laxiflora	
	Terminalia macroptera	*Terminalia macroptera*
Ebenaceae	*Diospyros mespiliformis*	*Diospyros mespiliformis*
Euphorbiaceae	*Euphorbia poisoni*	*Euphorbia poisoni*
	Euphorbia soudanica	*Euphorbia soudanica*
	Flueggea virosa	*Flueggea virosa*
		Bridelia scleroneura
Fabaceae-papillionoideae	*Senna singueana*	*Senna singueana*
		Cassia errereh
	Cassia sieberiana	*Cassia sieberiana*
	Dalbergia melanoxylon	*Dalbergia melanoxylon*
	Entada africana	*Entada africana*
	Lonchocarpus laxiflorus	*Lonchocarpus laxiflorus*
	Pterocarpus erinaceus	*Pterocarpus erinaceus*
		Pterocarpus lucens
Hymenocardiaceae	*Hymenocardia acida*	*Hymenocardia acida*
Loganiaceae	*Strychnos spinosa*	*Strychnos spinosa*
		Strichnos innocua
Meliaceae	*Azadirachta indica*	*Azadirachta indica*
		Khaya senegalensis
Fabaceae-mimosoideae	*Acacia albida*	
	Acacia ataxacantha	*Acacia ataxacantha*
		Acacia gerrardii
	Acacia hockii	*Acacia hockii*
		Acacia nilotica
	Acacia polyacantha	*Acacia polyacantha*
		Acacia senegal
	Acacia seyal	*Acacia seyal*
	Acacia sieberiana	*Acacia sieberiana*
	Albizia chevalieri	*Albizia chevalieri*
	Dichrostachis cinera	*Dichrostachis cinera*
	Prosopis africana	
		Prosopis juliflora
Moraceae	*Ficus ingens*	*Ficus ingens*
	Ficus sycomorus	*Ficus sycomorus*

	Ficus glumosa	*Ficus glumosa*
	Ficus thoningii	
	Ficus sur	
		Ficus platiphylla
Myrtaceae		*Eucalyptus camaldulensis*
Polygalaceae	*Securidaca longepedonculata*	*Securidaca longepedonculata*
Olacaceae	*Ximenia americana*	*Ximenia americana*
Rhamnaceae		*Ziziphus mauritiana*
	Ziziphus mucronata	*Ziziphus mucronata*
	Ziziphus spina-christi	*Ziziphus spina-christi*
Rubiaceae	*Feretia apodanthera*	*Feretia apodanthera*
	Gardenia ternifolia	*Gardenia ternifolia*
	Mitragyna inermis	
	Sarcocephalus latifolius	*Sarcocephalus latifolius*
		Gardenia erubescens
Rutaceae	*Vepris heterophylla*	
Sapotaceae	*Vitellaria paradoxa*	*Vitellaria paradoxa*
Sterculiaceae	*Sterculia setigera*	*Sterculia setigera*
Tiliaceae	*Grewia bicolor*	
	Grewia flavescens	
Ulmaceae	*Celtis integriflora*	*Celtis integriflora*
Verbenaceae	*Vitex doniana*	*Vitex doniana*
	Vitex madiensis	

Table 2: Density of populations and ecological importance of species

	Unprotected zone			**Protected zone**		
Espèces	Density/ha	Basal area (m^2 ha^{-1})	IVI	Density/ha	Basal area (m^2 ha^{-1})	IVI
Acacia albida	0.15	0.19	1.69	-	-	-
Acacia gerrardii	0.15	0.05	1.21	0.15	0.02	0.99
Acacia polyacantha	-	-	-	0.5	0.21	4.15
Acacia nilotica	-	-	-	0.7	0.40	6.41
Acacia hockii	0.05	0.009	0.39	1.25	0.44	9.75
Acacia senegal	0.1	0.015	0.73	1.5	0.36	10.71
Acacia seyal	0.1	0.08	0.75	1.25	0.68	11.21
Acacia sieberiana	0.2	0.14	1.67	0.1	0.03	0.77
Adenium obesum	0.1	0.01	1.17	-	-	-
Albizia chevalierii	-	-	-	0.05	0.007	0.32
Afzelia africana	0.05	0.17	0.39	0.05	0.09	0.85
Annona senegalensis	2.35	0.03	17.12	0.05	0.004	10.11
Anogeissus leiocarpus	0.85	2.40	6.1	3.1	1.64	17.71
Azadirachta indica	0.45	0.90	10.82	0.6	0.33	5.39
Balanites aegyptiaca	1.65	1.69	14.5	4.6	2.63	41.94
Bombax costatum	0.5	0.89	8.92	-	-	-
Boswellia dalzielii	0.55	1.32	6.71	0.45	1.18	9.61
Bridelia scleroneura	0.15	0.01	5.27	0.05	0.007	0.32

Cassia sieberiana	0.2	0.02	1.46	0.15	0.02	1
Celtis integriflora	0.1	0.30	0.76	-	-	-
Combretum collinum	0.95	0.11	7.65	0.7	0.11	4.67
Combretum aculeatum	-	-	-	0.1	0.004	0.59
Combretum fragrans	0.5	0.19	3.88	1.05	0.28	7.69
Combretum glutinosum	2.95	0.69	22.99	2.6	0.43	17.4
Combretum micranthum	0.1	0.002	2.16	0.15	0.01	0.95
Combretum molle	0.25	0.13	1.76	0.3	0.08	2.22
Combretum nigricans	0.05	0.002	0.78	-	-	-
Commihora africana	1.2	0.57	8.45	1.2	0.33	8.82
Commiphora pedunculata	0.05	0.01	2.18	-	-	-
Dalbergia melanoxylon	0.4	0.48	2.85	0.6	0.20	4.62
Dichrostachis cinera	0.05	0.01	1.89	0.55	0.08	3.67
Diospyros mespiliformis	0.35	0.16	2.49	-	-	-
Eucalyptus camadulensis	-	-	-	0.15	0.05	1.2
Entada africana	1.05	0.91	7.91	0.2	0.13	1.93
Feretia apodanthera	0.2	0.008	4.32	0.4	0.03	2.47
Ficus ingens	0.75	6.03	5.3	0.05	0.62	4
Ficus sycomorus	0.05	0.09	19.6	-	-	-
Gardenia ternifolia	0.2	0.03	1.7	0.05	0.005	0.31
Grewia flavescens	0.05	0.006	0.45	0.05	0.007	0.32
Guiera senegalensis	0.15	0.007	1.07	-	-	-
Haematostaphis barteri	0.2	0.25	1.43	0.05	0.03	0.51
Hexalobus monopetalus	2.6	1.31	19.13	0.55	0.15	4.04
Hymenocardia acida	0.05	0.009	4.55	-	-	-
Khaya senegalensis	0.05	0.14	0.38	-	-	-
Lannea acida	0.25	0.24	2.2	0.05	0.02	0.46
Lannea barteri	0.3	0.29	2.9	-	-	-
Lannea humilis	-	-	-	0.1	0.08	1.06
Lannea fruticosa	0.4	0.24	3.74	0.6	0.15	4.34
Lannea schimperi	0.8	0.84	6.41	0.4	0.18	3.37
Lonchocarpus laxiflorus	0.05		3.04	2.95	1.21	24.06
Piliostigma reticulatum	0.55	0.13	4.28	0.35	0.04	2.29
Piliostigma thonningii	0.35	0.11	2.84	0.45	0.06	2.94
Pterocarpus erinaceus	0.05	0.08	0.62	0.05	0.03	0.46
Prozopis juliflora	-	-	-	1.95	0.38	13.39
Pterocarpus lucens	0.1	0.24	1.49	0.1	0.07	1.03
Senna singueana	-	-	-	0.1	0.07	1.01
Securidaca longepedonculata	-	-	-	0.05	0.08	0.77
Sclerocarya birrea	1	1.99	13.41	1.1	0.58	9.77
Sterculia setigera	1.25	2.73	17.52	0.5	1.73	13.18
Stereospermum kunthianum	0.3	0.75	4.52	0.05	0.08	0.77
Strychnos spinosa	0.05	0.006	0.37	-	-	-

Tamarindus indica	0.8	2.26	12.84	0.4	0.66	6.22
Terminalia avicinoides	0.15	0.07	1.29	-	-	-
Terminalia glaucescens	1.05	0.89	10.24	0.85	0.27	6.49
Terminalia laxiflora	0.05	0.05	0.53	0.1	0.05	0.59
Terminalia macroptera	0.5	0.38	4.74	0.05	0.004	0.61
Vepris heterophylla	0.05	0.002	0.35	-	-	-
Vitex doniana	-	-	-	0.05	0.04	0.57
Vitellaria paradoxa	0.2	0.18	1.98	-	-	-
Ximenia americana	-	-	-	0.45	0.05	2.91
Ziziphus spinacristi	-	-	-	0.1	0.004	0.6
Ziziphus mauritiana	0.25	0.01	1.81	0.65	0.07	4.18
Ziziphus mucronata	0.05	0.004	0.36	0.3	0.04	1.95

Table 3: Regeneration capacity of species by the seedlings.

species	Regeneration rate in unprotected zone	Regeneration rate in protected zone	Seedling density
Combretum glutinosum	34.08	5.42	10.2
Combretum aculeatum	5.8	22.09	6.45
Annona senegalensis	29.08	2.85	6.05
Piliostigma reticulatum	28.34	3.56	4.65
Cassia sieberiana	14.08	13.4	4.35
Feretia apodanthera	18.83	7.27	3.95
Hexalobus monopetalus	20.95	3.13	3.52
Commiphora africana	12.14	6.99	2.95
Dichrostachis cinera	1.4	9.7	2.85
Balanites aegyptiaca	3.16	12.41	2.62
Acacia polyacantha	3.16	-	2.4
Combretum collinum	9.33	5.42	2.27
Acacia ataxacantha	9.68	2.85	1.87
Ziziphus mauritiana	5.98	4.56	1.65
Grewia flavescens	5.1	-	1.15
Combretum fragrans	3.34	3.42	1.07
Acacia nilotica	0.52	5.13	0.97
Guiera senegalensis	2.99	2.71	0.9
Anogeissus leiocarpus	2.28	2.71	0.8
Azadirachta indica	2.46	2.56	0.8
Acacia hockii	0.88	3.7	0.77
Senna singueana	4.4	-	0.7
Stereospermum kunthianum	3.69	0.99	0.7
Flueggea virosa	18.83	3.7	0.65
Piliostigma thoningii	3.53	-	0.62
Ximenia americana	1.2	2.28	0.57
Ziziphus mucronata	0.7	-	0.55

Entada africana	2.11	1.14	0.5
Acacia senegal	1.58	1.28	0.45
Dalbergia melanoxylon	0.7	2	0.45
Maytenus senegalensis	-	0.85	0.4
Gardenia ternifolia	2.64	-	0.37
Terminalia macroptera	2.46	-	0.35
Acacia seyal	0.7	3	0.27
Sclerocarya birrea	1.58	-	0.27
Terminalia glaucescens	-	0.14	0.25
Adenium obesum	-	0.14	0.22
Sterculia setigera	-	0.14	0.22
Diospyros mespiliformis	1.46	-	0.2
Bridelia scleroneura	0.7	0.42	0.17
Steganotaenia araliacea	0.52	-	0.17
Cochlospermum tinctorium	-	0.85	0.15
Ficus ingens	1.05	-	0.15
Lannea acida	0.52	-	0.15
Lannea schimperi	0.88	0.14	0.15
Tamarindus indica	0.88	-	0.12
Terminalia avicinoides	0.88	-	0.12
Ziziphus spina-christi	0.88	-	0.12
Bombax costatum	0.7	-	0.1
Capparis sepiaria	-	0.14	0.1
Lannea fruticosa	-	0.14	0.1
Acacia sieberiana	0.52	-	0.07
Bauhinia rufescens	-	0.14	0.07
Combretum molle	-	0.42	0.07
Grewia bicolor	0.52	-	0.07
Pterocarpus erinaceus	0.52	-	0.07
Acacia gerrardii	-	0.71	0.05
Combretum nigricans	0.35	-	0.05
Acacia albida	0.17	-	0.02
Capparis fascicularis	0.17	-	0.02
Celtis integrifolia	-	0.14	0.02
Combretum micranthum	-	0.28	0.02
Euphorbia poissoni	-	0.14	0.02
Euphorbia soudanica	-	0.14	0.02
Haematostaphis barteri	-	0.14	0.02
Lannea barteri	-	0.14	0.02
Terminalia laxiflora	-	0.14	0.02

Table 4: Capacity of stumps rejections.

Species	Number of stumps	Number of rejections	average rejection /stumps	Rejection rate
Combretum glutinosum	187	672	3.59	22.80
Anogeissus leiocarpus	141	443	3.14	17.20
Combretum collinum	112	433	3.86	13.66
Annona senegalensis	54	211	3.9	6.59
Hexalobus monopetalus	38	145	3.81	4.63
Piliostigma reticulatum	28	132	4.71	3.41
Combretum fragrans	29	79	2.72	3.54
Balanites aegyptiaca	39	69	1.76	4.76
Piliostigma thonningii	17	64	3.76	2.07
Guiera senegalensis	15	56	3.73	1.83
Feretia apodanthera	37	56	1.51	4.51
Diospyros mespiliformis	10	35	3.5	1.22
Terminalia glaucescens	10	34	3.4	1.22
Sterculia setigera	8	33	4.12	0.98
Cassia sieberiana	8	32	4	0.98
Terminalia macroptera	9	30	3.33	1.10
Entada africana	8	28	3.5	0.98
Acacia hockii	14	26	1.85	1.71
Flueggea virosa	3	18	6	0.37
Grewia flavescens	6	18	3	0.73
Ziziphus mauritiana	6	17	2.83	0.73
Lannea schimperi	3	14	4.66	0.37
Azadirachta indica	3	12	4	0.37
Eucalyptus camaldulensis	3	12	4	0.37
Commiphora africana	5	12	2.4	0.61
Combretum molle	6	10	1.66	0.73
Combretum micranthum	4	8	2	0.49
Ximenia americana	2	6	3	0.24
Combretum aculeatum	2	5	2.5	0.24
Maytenus senegalensis	2	5	2.5	0.24
Ziziphus mucronata	1	4	4	0.12
Acacia nilotica	3	4	1.33	0.37
Dalbergia melanoxylon	1	3	3	0.12
Ficus ingens	1	3	3	0.12
Gardenia ternifolia	1	3	3	0.12
Tamarindus indica	1	3	3	0.12
Dichrostachis cinera	1	2	2	0.12
Acacia polyacantha	1	1	1	0.12
Steriospermum kunthianum	1	1	1	0.12

Table 5: Mortality of the individuals in the explored zones.

Species	Unprotected zone Mortality rates (%)	Protected zone Mortality rates (%)	Whole mortality rate
Anogeissus leiocarpus	0.92	0.66	0.7
Balanites aegyptiaca	0.55	-	0.23
Piliostigma reticulatum	0.55	0.16	0.23
Bombax costatum	0.37	0.16	0.15
Combretum fragrans	0.37	0.16	0.15
Combretum glutinosum	0.37	0.16	0.15
Commiphora africana	0.37	-	0.15
Entada africana	0.37	-	0.23
Acacia hockii	0.18	-	0.15
Dichrostachis cinera	0.18	-	0.07
Entada africana	0.18	-	0.07
Sterculia setigera	0.18	-	0.07
Steriospermum kunthianum	0.18	-	0.07
Acacia nilotica	-	0.16	0.07
Acacia polyacantha	-	0.16	0.07
Ziziphus mauritiana	-	0.33	-
Eucalyptus camaldulensis	-	-	0.15

Table 6: Intensity of cut of the species in the woodlands.

Species	Number of stumps	Cut rates (%)
Combretum glutinosum	187	14.73
Anogeissus leiocarpus	141	11.11
Combretum collinum	102	8.03
Annona senegalensis	54	4.25
Balanites aegyptiaca	39	3.07
Piliostigma reticulatum	38	2.99
Feretia apodanthera	37	2.91
Combretum fragrans	29	2.28
Hexalobus monopetalus	29	2.28
Guiera senegalensis	26	2.04
Acacia hockii	14	1.10
Piliostigma thonningii	13	1.02
Terminalia glaucescens	11	0.86
Diospyros mespiliformis	10	0.78

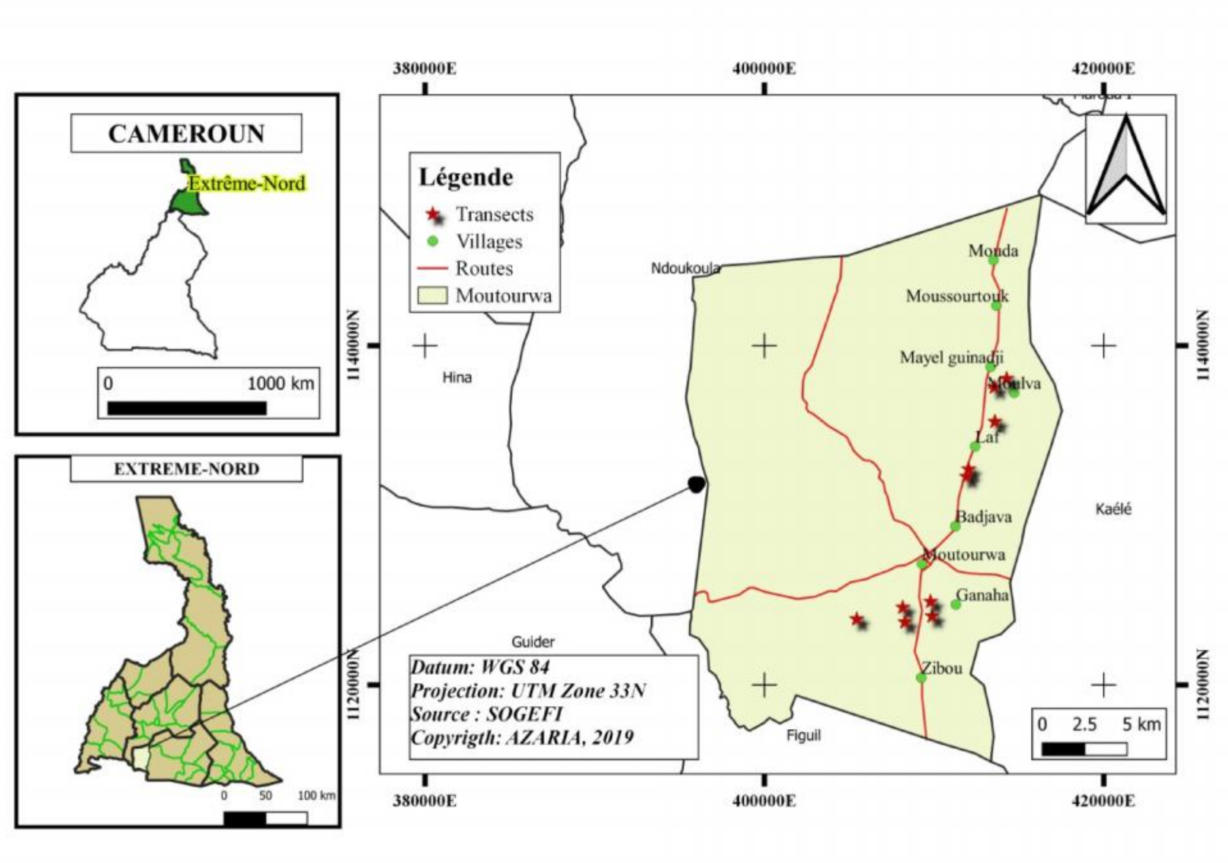


Figure 1: Localization of the study site.

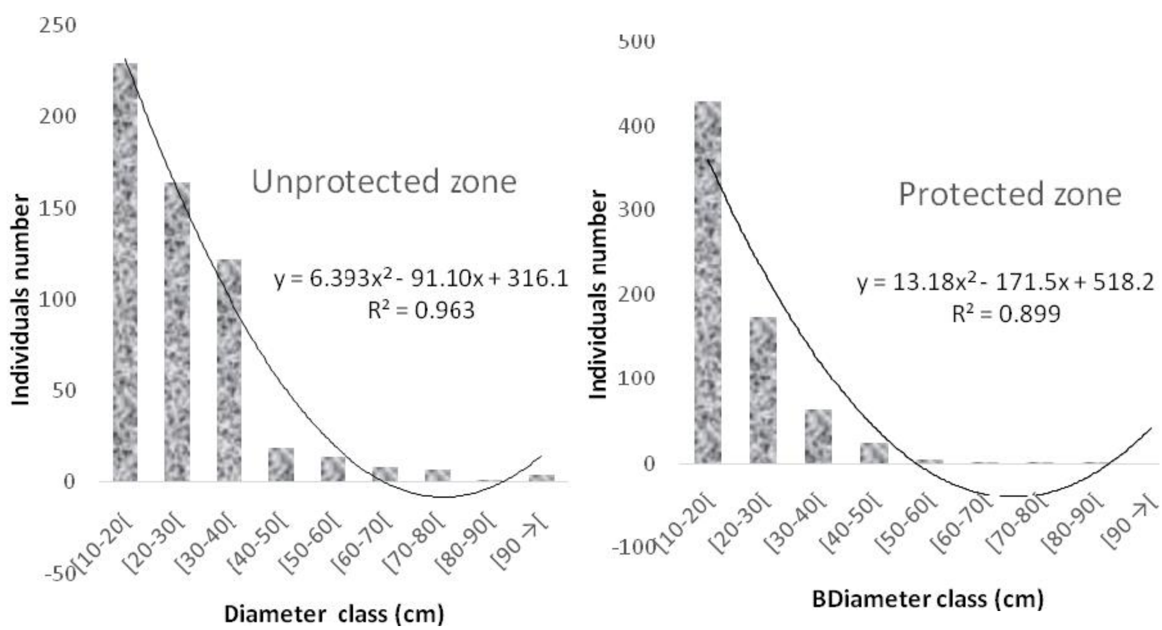
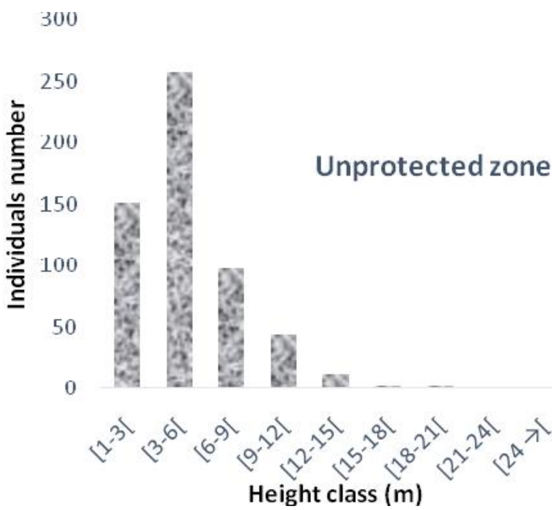


Figure 2: Distribution in diameter of individuals in woodlands.



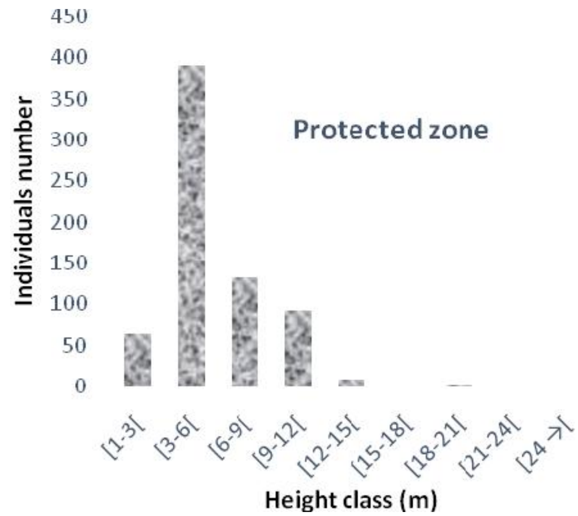


Figure 3: Distribution of individuals in height classes.

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