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Full Length Research Paper

Woody species composition, structure and diversity of vegetation of Kalfou Forest Reserve, Cameroon

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Studies were carried out in the Kalfou Forest Reserve to make an assessment of the flora diversity and to develop preservation guidelines facing the increase in its degradation. The composition of woody species, structure, diversity, density, dominance, frequency of species and family importance value were described and evaluated in all the forest reserve area. A total of 86 species representing 58 genera and 28 families of woody species were identified. The families of Combretaceae, Fabaceae-caesalpinioideae and Fabaceae-mimosoideae were the most abundant families in the Kalfou Forest Reserve. The density of stems ≥ 10 cm circumference and the basal area were higher in the Doulouk and Gonoray parts of the reserve. The distribution of stems of the main species in classes of circumference had shown a reverse "J" shaped curve. The number of stems of shrubs species was important and strongly influenced globally the diameter and the height of the stems which were lower. Species diversity was a slight difference among the various parts of the forest reserve area. The species abundance showed that, 20% of the species were infrequent. The dynamic of renewal of species were ensured by the weakly regeneration: seedling (2.03%), rejection issues (41.97%) and the death rate of individual species was 8.02%. Disturbances and the vulnerability of the seedlings did not ensure species sustainability. Preservation systems and adequate management were therefore recommended in order to ensure sustainable management of the Kalfou Forest Reserve resources.

Key words: Biodiversity, preservation, forest reserve, sustainability.

INTRODUCTION

Following the Rio Earth Summit in 1992, the world summit on sustainable improvement in Johannesburg in 2002 and that of the parks of the IUCN in Durban in 2003 which reaffirm the main aspects of the preservation of biodiversity and the negative assessments of actions of preservation of biodiversity in the world, were made.

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However, the protected areas, as a means of preservation and management of biodiversity, share their riches biodiversity and the diversity of their products could contribute to the reduction of poverty in these areas (Anonymous, 2009; Galindo, 2010). Nevertheless, they face a lot of pressure from human as well as natural phenomenon to ensure sustainable improvement of the resources (Aubertin and Vivien, 1998). These factors dangerously threaten the preservation and management; subsequently, strongly cause the regression of the side of protected areas (Brunner et al., 2001; Ervin, 2003b). The

Kalfou Forest Reserve is one of the mainly protected areas in the Far-North region-Cameroon. It is characterized by relatively poor ecosystems and submitted to human disturbances such as the cutting down of flora for fuel, construction materials and poles, furniture, the harvesting of non timber forest products, medicines, the overgrazing and bush fires (Wafo, 2009; Madi et al., 2003). These factors induce a remarkable degradation of flora, leading to their scarcity and the alteration of the ecosystems as well as a significant loss of biodiversity (Khresat et al*.,* 1998; Darkoh, 2003). In this regard, it will be essential to have reliable and relevant ecological and environmental data in order to supervise in future, factors responsible of the biodiversity extinction in this protected area. The problem faced is that of preservation and the sustainable management of resources in the Kalfou Forest Reserve which is subjected to a high degradation which con-sequently is unable to meet the objectives for which it was created. in spite of the significant number of studies (Fotsing et al., 2003; Wafo and Huynh, 2009), carried out based on land sat images to provide first basic elements for the characterization of the landscapes of the Far-North Region, Cameroon, no field study was conducted specifically on the evaluation of woody species in the Kalfou Forest Reserve. The main objective of this research is to create awareness on the Kalfou Forest Reserve for it sustainable management. The specific objectives include: (1) the determination of woody species in the Kalfou Forest Reserve; (2) the evaluation of the diversity of woody species and structure, and (3) the evaluation of the dynamic regenerations of woody species.

MATERIALS AND METHODS

Study area

This study was carried out in the Kalfou Forest Reserve, located between 10°17 ' and 10°28' latitude, 15°06' and 15°21' longitude and at an altitude of 250 m (Figure 1). The Sudano-Sahelian climate is characterized by two different seasons: the dry season which lasts for 8 months (ranging from October to May) and the short rainy season which lasts for 4 months (ranging from June to September). The average (± standard deviation (SD)) annual rainfall from1970 to 2010 was evaluated 748 ± 120 mm, while the mean annual temperature was 28°C. The characteristic of flora in the region is that of steppes with thorn-bush made up of shrubby savannas with a very irregular herbaceous floor cover dominated by thorn-bushes, strongly degraded as the result of human actions (Letouzey, 1985). The economic activities of the bordering populations are mainly extensive and subsistence agriculture, extensive livestock, exploitation of resources and small trade.

Data collection

According to the information gotten from the investigations among neighbouring populations which determined the characteristic of the surface area of the Kalfou Forest Reserve, five parts: Barodewol, Hadande, Doulouk, Gonoray and Saroudja were marked out, following trails created by firewood cutters and grazing, to sample for the inventory of woody species (Figure 1). These different parts had the same ecological characteristics, except the intensity of human activities (cutting, grazing and bush fire) which differs among others. The inventory was carried out at the end of the rainy season and at the middle of the dry season when species could easily be identified, transected easily and assessed with regard to the regeneration capacity of species by rejections and seeds germination. A total of 48 transects of 2000 × 20 m were marked out over an area of 192 ha in the forest reserve area: ten in the Barodewol, Doulouk, Gonoray and Saroudja parts and eight in the Hadande part. In order to evaluate the renewal capacity of woody species, plots of 50 × 50 m were realized at an opened field as well as covered field for the determination of young plants inside transects randomly. Transects and plots were then systematically surveyed, and all woody species with circumference ≥ 10 cm were enumerated and identified. Number of stems, cutting trees, individual dead trees, rejections from and all young plants of the woody species were also enumerated. The circumference were also measured at 0.3 m from the soil using a measuring tape and the height of the largest stem using a graduated pole or clinometers for the tallest trees. According to the investigations, a list of main species were drawn up, the number of stems, death rate and regeneration capacity were recorded. All trees or shrubs encountered in the field were grouped according to species; while those which are not well-known were identified in the national herbarium in Yaoundé-Cameroon. The species composition of the different parts was described using the following parameters.

1. Relative dominance = (total basal area for a species/total basal area of all species) × 100.
2. Relative density = (number of individuals of a species/total number of individuals) × 100.
3. Relative frequency = (frequency of a species/sum of all frequencies) × 100.
4. Relative diversity = (number of a species in a family/total number of species) × 100.
5. The importance value index (IVI) = relative dominance + relative density + relative frequency.
6. The family importance value (FIV) = relative dominance + relative density + relative diversity.

The frequency of a species is defined as the number of transects (2000 × 20 m) in which the species occur.

The theoretical range for relative dominance, relative frequency, relative density and relative diversity is 0 – 100%, so that IVI of species and FIV may vary between 0 and 300%. Structural characteristics (stem density, basal area, and circumference class distributions) were calculated for each part for all individuals with a circumference ≥ 10 cm belonging to the most important species. To compare diversity within each part, the Margalef's index, Simpson's index, Shannon's measure of evenness, Shannon-Wiener's information index and Diversity index (D) were calculated. These indices are widely employed to measure biological diversity (Magurran, 2004). The dynamic of renewal species was evaluated from trees death rate, regeneration rate such as seeds germination and rejections. XLStat 8.4 was used for data analysis.

RESULTS

Species composition

A total of 86 woody species representing 58 genera and 28 families were found in the Kalfou Forest Reserve, of

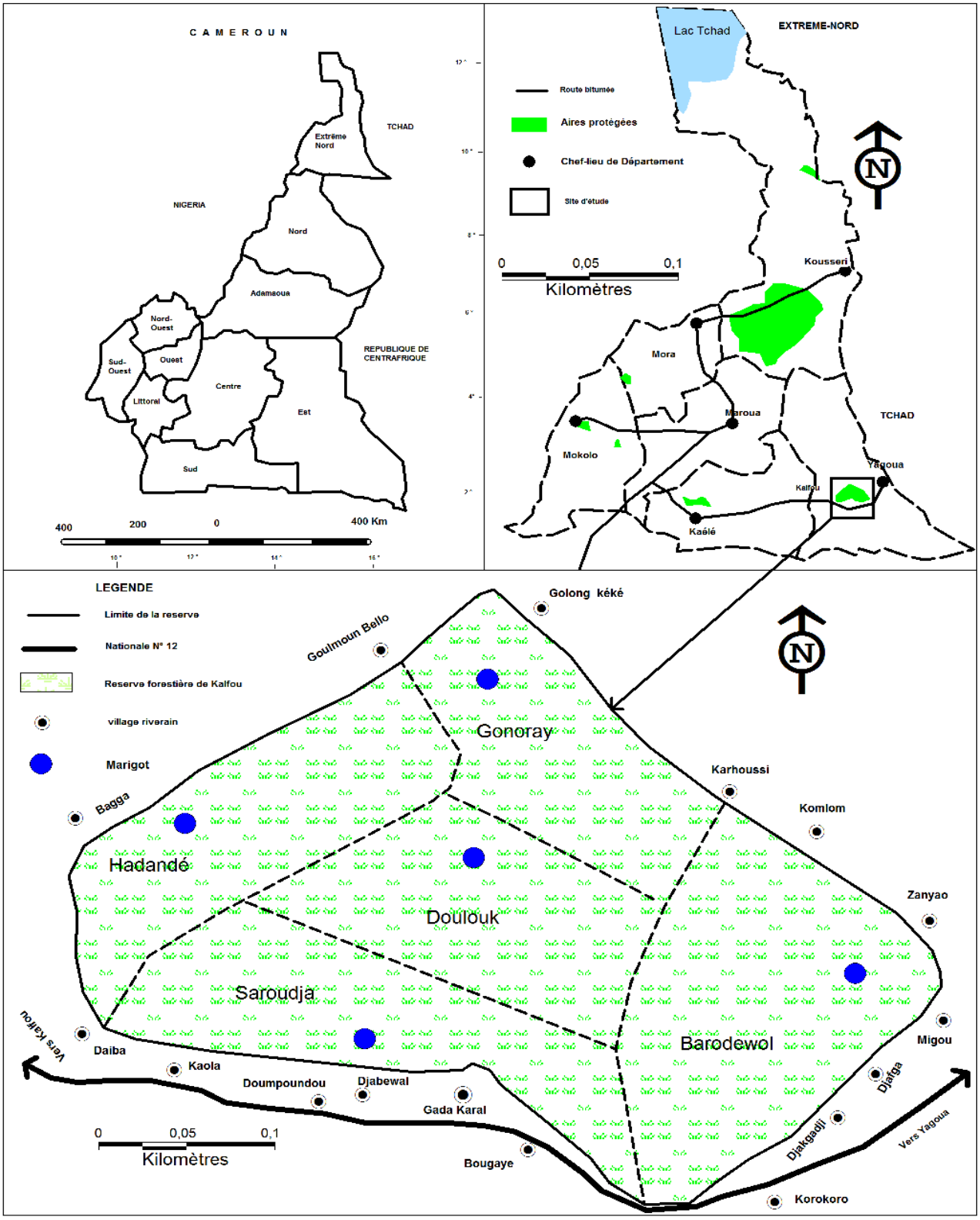

Figure 1. Study area. limite de la reserve = boundary of the reserve; limite des zones d'échantillonnage = border of sampling area and trail; National N° 12 = National road N°12; Réserve forestière de Kalfou = Kalfou Forest Reserve; Marigot = Periodic river; Village riverain = neighboring village; Kilométre = Kilometer; Aire protégée = protected area; Study area; Chef lieu de department = Division head quarter. Source: Base SIG of the cities of Cameroon LB/UN, April 2012, Baska Toussia.

which 68, 76, 76, 79, and 83 species were identified in the Barodewol, Hadande, Saroudja, Doulouk, and Gonoray parts, respectively (Table 5). The number of genera was different from each part, while the Barodewol part was the least. The stem density per hectare (mean ± standard deviation (SD)) was in the decreasing order: 609.33 ± 68.43 stems ha^{-1} in the Doulouk part, 580.98 ± 62.95 stems ha^{-1} in the Gonoray, 535.56 ± 61.40 stems ha^{-1}, 418.78 ± 48.45 stems ha^{-1} in the Saroudja and 408 ± 42.05 stems ha^{-1} in the Barodewol parts, showing that the lowest stem density was recorded in the Barodewol and Saroudja parts. No significant difference was noted between the density of stems and the number of species in the various parts of the forest reserve, ($p \geq 0.025$). The basal area varied in each part and the highest was recorded in the Doulouk part, followed by the Gonoray part, while the Barodewol part accounted for 438.63 ± 21.05 m^2 ha^{-1}. The average diameter of all individuals trees ≥ 10 cm circumference and the corresponding total basal area were higher in the Doulouk and Gonoray parts as compared to other parts of the forest reserve area. The Barodewol part had the lowest diameter, consequently the lowest basal area. Trees in the Kalfou Forest Reserve were characterized by their low diameter, though the large number of shrubs species deeply influenced globally the size of stems.

From the aforementioned, it can be seen that species with the highest importance value index in the forest reserve were *Anogeissus leiocarpus* (34.41%), *Guiera senegalensis* (26.91%), *Balanites aegyptiaca* (18.57%), *Combretum collinum* (12.28%), *Sclerocarya birrea* (14.86%) and *Ziziphus mauritiana* (12.13%). In each part of the reserve, species with the highest IVI in the Barodewol part were *G. senegalensis*, *C. collinum*, *Lannea schimperi*, *A. leiocarpus* and *B. aegyptiaca*, which have a range of 29.09% of the total IVI (Table 1). Moreover, *G. senegalensis*, *A. leiocarpus*, *B. aegyptiaca, Z. mauritiana* and *S. birrea* were among the most abundant species in the Hadande part and they represented about 29.52% of the species. *A. leiocarpus, Daniellia oliveri, G. senegalensis, B. aegyptiaca* and *Hexalobus monopetalus* in the Doulouk part, represented 27.63% of the total IVI. In addition to this, *A. leiocarpus*, *G. senegalensis*, *B. aegyptiaca*, *C. collinum* and *Combretum molle* were identified as the most abundant species among others in the Gonoray part with 29.60% of IVI value. At the end, *A. leiocarpus*, *G. senegalensis*, *B. aegyptiaca*, *S. birrea* and *C. collinum* were recorded as species with the highest IVI in the Saroudja part which in total gives 35.68%. Some species are weakly represented in the total area of the Kalfou Forest Reserve with the important value of less than 1%. When they were characterized by their irregular distribution in the forest reserve area; they stood out as the rarest species (Table 2). A total of 20 species representing 23.26% of the total number of species were classified as rarest species in the Kalfou Forest Reserve.

Fabaceae-mimosoideae (11 species), Combretaceae (10 species), Fabaceae-caesalpinioideae (9 species), Capparaceae (8 species), Moraceae (7 species) and Rubiaceae (6 species) were found to be the most species-rich families bearing the family importance value (FIV) for: 27.77, 83.21, 28.18, 14.83, 11.51 and 12.17%, respectively (Table 3). Out of the total number of families, 50% were characterized by their lowest FIV < 5%. The last five families were Celastraceae (1.52%), Sapotaceae (1.41%), Asclepiadaceae (1.39%), Ebenaceae (1.25%) and Ulmaceae (1.18%). Combretaceae, Fabaceae-caesalpinioideae, Fabaceae-mimosoideae and Capparaceae which were taxonomically diverse and made up the largest groups of taxa in the Kalfou Forest Reserve. Although Combretaceae had the highest FIV owing the high stem density of its constituent species: *G. senegalensis* (67.61 stems ha^{-1}), *A. leiocarpus* (58.77 stems ha^{-1}) and *C. collinum* (29.87 stems ha^{-1}).

Structure

From the total number of species identified in the forest reserve, about 24% were defined as main species according to their food supply, firewood, grazing, ecology and environmental value. A total number of 38785 stems with the circumference ≥ 10 cm from these species were recorded in the Kalfou Forest Reserve area. The distribution of stems by the circumference classes in every part of the reserve show a reverse “J” shaped curve (Figure 2). Most individuals of species, with 57% in the Barodewol part, 51% in the Hadande, 50% in the Doulouk, 49% in the Gonoray and 48% in the Saroudja part, were concentrated in the 10 to 30 and 30 to 50 cm circumference classes. Comparing the first two circumference classes from every part, the number of stems was lower in class 10 to 30 cm than in class 30 to 50 cm, with each having a particular variation. The distribution of the number of stems differs among circumference classes. The variation was determined by the result of the variance which shows a significant difference ($p < 0.001$). Generally, the number of stems with big circumference from classes 150 to 170 to > 190 cm was very low in all parts of the forest reserve. These stems belong to the tree species which developed greater diameter. Among the range of species, five had a remarkable large average circumference: *S. birrea* (127.68 cm), *Prosopis africana* (117.90 cm), *Terminalia macroptera* (107.71 cm), *Bombax costatum* (97.48 cm) and *Vitellaria paradoxa* (92.93 cm).

Species diversity

To allow a precise comparison of diversity among the five

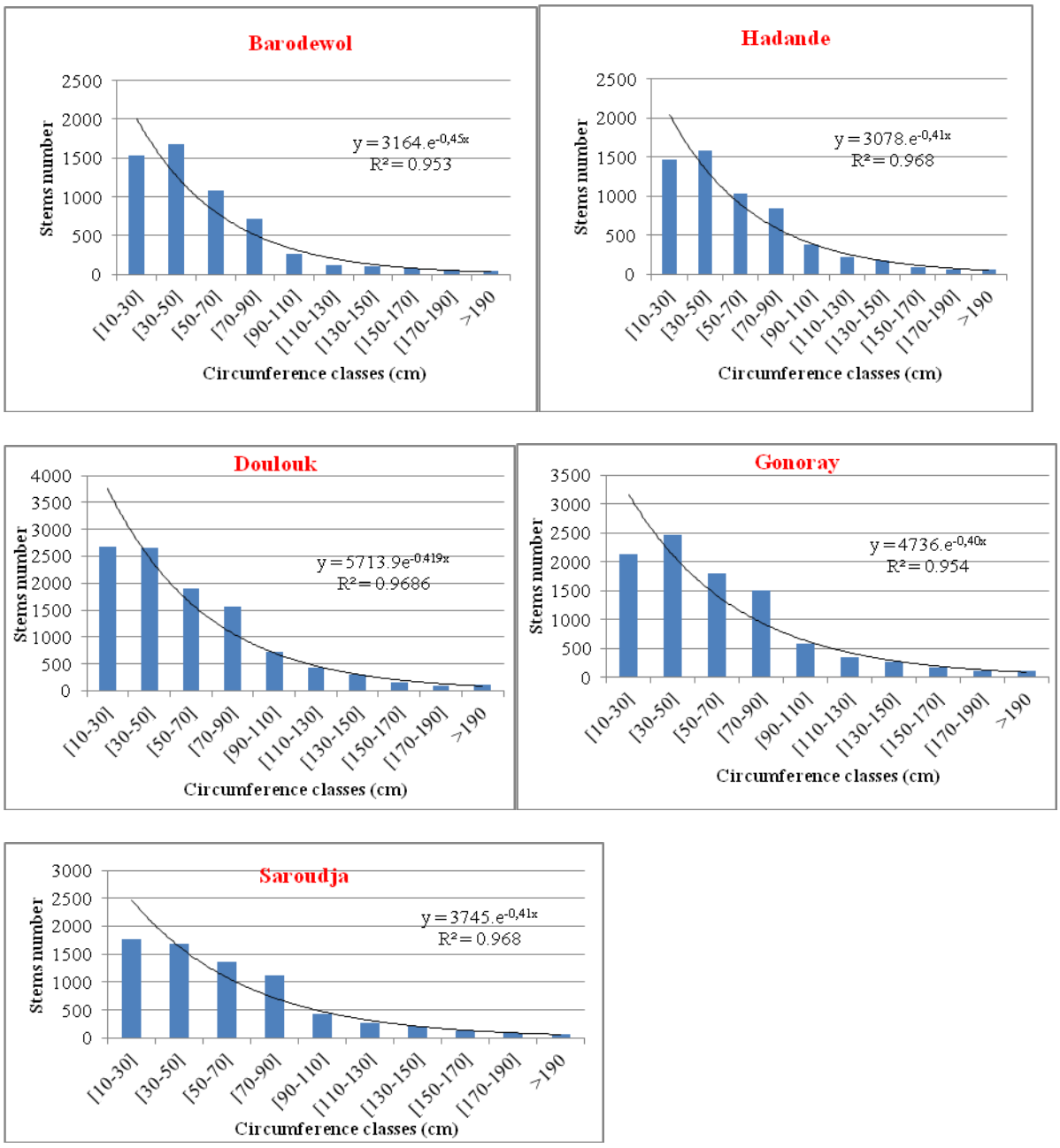

Figure 2. The distribution of stems in circumference class in the Kalfou Forest Reserve.

parts of the Kalfou Forest Reserve, a variety of diversity index were calculated (Table 4). The total number of individuals (N) as well as species richness (S) was high in the Gonoray and Doulouk parts, while the Barodewol had low species richness. The Saroudja and Hadande parts had the same number of species, although the total number of stems was relatively higher in the Doulouk than in the Gonoray part. According to the numerical species richness, defined as the number of species per specified number of individuals (S/N), the values were approximately the same in all parts of the reserve (0.0032 to 0.0045) showing that the species richness value was very low.

According to Margalef's index of species richness, representing an intermediate mathematical measure between S/N and S, the Gonoray part was the most diversify, followed by the Doulouk, Saroudja, Hadande and the Barodewol parts. Shannon's measure

Table 1. The five most abundant species in decreasing order of the importance value index (IVI).

Part	Species	Relative frequency (%)	Relative dominance (%)	Relative density (%)	IVI (%)
	Guiera senegalensis	1.99	10.30	15.213	27.509
	Combretum collinum	1.99	5.23	8.44	15.65
Barodewol	*Lannea schempiri*	1.99	10.47	2.75	15.21
	Anogeissus leiocarpus	1.99	6.09	6.37	14.45
	Balanites aegyptiaca	1.98	6.49	5.96	14.44
	Guiera senegalensis	1.83	9.89	15.11	26.84
	Anogeissus leiocarpus	1.83	10.60	7.57	20.01
Hadande	*Balanites aegyptiaca*	1.83	9.38	6.87	18.08
	Ziziphus mauritiana	1.83	4.84	5.36	12.03
	Sclerocarya birrea	1.83	8.23	1.54	11.61
	Anogeissus leiocarpus	1.70	15.20	14.68	31.58
	Daniellia oliveri	0.69	13.11	2.31	16.10
Doulouk	*Guiera senegalensis*	1.70	3.79	8.74	14.24
	Balanites aegyptiaca	1.70	5.88	4.96	12.53
	Hexalobus monopetalus	1.70	1.99	4.75	8.44
	Anogeissus leiocarpus	1.61	10.54	13.11	25.27
	Guiera senegalensis	1.61	8.14	13.18	22.93
Gonoray	*Balanites aegyptiaca*	1.61	9.56	6.50	17.67
	Combretum collinum	1.61	3.78	6.56	11.95
	Combretum molle	1.61	4.65	4.72	10.99
	Anogeissus leiocarpus	1.86	18.69	13.85	34.41
	Guiera senegalensis	1.86	8.83	16.21	26.91
Saroudja	*Balanites aegyptiaca*	1.86	8.44	8.26	18.57
	Sclerocarya birrea	1.86	10.77	2.22	14.86
	Combretum collinum	1.86	3.73	6.68	12.28

of evenness did not differ significantly among parts of the forest reserve. It goes the same for the Barodewol and Hadande part, where it was relatively higher than in the Doulouk and lower in the Saroudja part. Shannon-Wiener's information index, which combines species richness and evenness into a single value, indicating that the diversity of all parts were not different, while the Saroudja part was the least diversify.

Species with high preservation priority renewal dynamics of species

According to investigations carried among the populations, some species were classified as main species due to their socio economic and environmental values. Species with high value in preservation and to be considered as endangered and vulnerable in the Kalfou Forest Reserve particularly and in the Sudano-Sahelian area in general were identified. A total of 18 species, representing 20.91% of the total number of species in the forest reserve are short-listed in Table 5. The abundance of these species in the forest reserve varied and was characterized by their low IVI, less than 10%. They represented 77.78% of the total number of woody species identified in the forest reserve. Nevertheless, 72.22% of the total number of species was vulnerable, consequently by the systematic suppression of stems by cutting and death. The systematic cutting of stems rate which varied among species was globally up to 10% for all species and the total death rate represented 8.02% (Table 6). Among parts of the forest, the intensity of human activities based on cutting trees was in the decrease order as: 13.89% in the Doulouk; 15.52% in the Gonoray; 21.47% in the Saroudja; 26.89% in the Hadande parts, and 32.20% in the Barodewol part. The variability of disturbances was revealed by the calculation of variance which was significantly differing among

Table 2. The rarest species in decreasing order of the importance value index (IVI).

Species	Relative frequency (%)	Relative dominance (%)	Relative density (%)	IVI (%)
Cassia sieberianna	0.60	0.19	0.19	0.97
Grevia venusta	0.78	0.007	0.07	0.86
Boscia angustifolia	0.74	0.005	0.05	0.80
Crossopteryx febrifuga	0.566	0.06	0.03	0.64
Grevia villosa	0.60	0.004	0.04	0.64
Vitex doniana	0.56	0.03	0.02	0.61
Ficus sycomorus	0.45	0.09	0.03	0.57
Piliostigma thonningii	0.48	0.004	0.05	0.54
Vitex madiensis	0.48	0.02	0.02	0.53
Calotropis procera	0.30	0.06	0.16	0.52
Acacia nilotica	0.45	0.02	0.03	0.50
Crataeva adansonii	0.37	0.04	0.05	0.46
Adzadirachta indica	0.30	0.04	0.06	0.40
Diospyros mespilisformis	0.30	0.038	0.06	0.4
Acacia polyacantha	0.22	0.04	0.03	0.3
Bauhinia rufescens	0.26	0.01	0.01	0.29
Terminalia laxiflora	0.22	0.04	0.02	0.28
Sarcocephalus latifolius	0.19	0.01	0.01	0.21
Ficus polita	0.04	0.04	0.005	0.09
Celtis integrifolia	0.07	0.006	0.002	0.08
Ficus sur	0.04	0.003	0.003	0.04

Table 3. The ten most important families in decreasing order of family importance value (FIV).

Family	Species	N/ha	FIV (%)
Combretaceae	10	202.33	83.21
Fabaceae-caesalpinioideae	9	40.99	28.18
Fabaceae-mimosoideae	11	34.30	27.77
Anacardiaceae	3	23.89	21.52
Balanitaceae	1	32.57	15.38
Capparaceae	8	24.83	14.83
Rhamnaceae	2	32.21	13.25
Rubiaceae	6	16.89	12.17
Moraceae	7	2.38	11.51
Annonaceae	2	27.10	10.15

parts ($p < 0.001$). Through each part, the death rate among individuals was high in the Hadande (7.52%) and Gonoray part (8.02%). The regeneration rate by rejection varied among parts from 19.42% in the Gonoray to 59.02% in the Hadande part. The regeneration rate through rejections was most significant in the Barodewol and Hadande parts where the strength of the cutting trees was also high. There was significant difference among parts ($p \leq 0.001$). Moreover, the regeneration rates through seeds germination in all the different parts were less varied. From the aforementioned results, it is evident that the sustainability of these resources would not be ensured for future generation.

DISCUSSION

The number of families, genera and species reported in the present study was close to one third of the native woody species found in the Sudano-Sahelian zone. Lebrun (1991) reported that the woody flora (trees, small shrubs and climbers) in the dry land includes 55 families, 214 genera and 376 species (with 96 exotic species).

These results were similar to those of Savadogo et al.

Table 4. Summary of woody species characteristics and the diversity measures in the Kalfou Forest Reserve.

Diversity measure	Barodewol	Hadande	Doulouk	Gonoray	Saroudja
Family number	25	25	27	27	27
Genera number	49	52	53	55	54
Stem density per hectare	408 ± 42.05	535.56 ± 61.40	609.33 ± 68.43	580.98 ± 62.95	418.78 ± 48.45
Average circumference (cm)	43.52 ± 43.11	46.18 ± 34.54	52.49 ± 38.05	53.88 ± 35.79	46.93 ± 34.87
Average height (m)	3 ± 2.32	3.25 ± 1.99	3.65 ± 2.11	3.72 ± 1.83	3.32 ± 2.06
Basal area (m^2/ha^{-1})	438.63	486.2	854.91	686.03	513.86
Species richness (S)	68	76	79	83	76
Rate of species increase per individual enumerated, S/N	0.0042	0.0044	0.0032	0.0036	0.0045
Margalef's index of species richness, DMg = (S-1)/lnN	6.89	7.69	7.72	8.16	7.71
Shannon index (ISH=- Σ Ni/N log2 Ni/N)	1.5	1.52	1.57	1.5	1.42
Shannon's measure of evenness, J' = H'/lnS	0.35	0.35	0.36	0.34	0.33
Simpson index D = 1/∑ (Ni/N) 2	0.052	0.051	0.046	0.055	0.069
Diversity	69.54	77.55	80.6	84.54	77.46

Table 5. The list of main species with their IVI and the assessment of the renewal dynamics.

Species	**Global IVI**	**Death (%)**	**Rejections (%)**	**Seedling (%)**
Anogeissus leiocarpus	25.96	8.33	28.23	2.22
Balanites aegyptiaca	16.01	2.33	57.81	3.73
Sclerocarya birrea	10.75	1.26	3.37	2.38
Ziziphus mauritiana	10.06	5.03	19.92	4.22
Hexalobus monopetalus	9.32	9.61	20.32	5.11
Bombax costatum	7.19	6.47	5.82	6.31
Prosopis africana	6.24	6.93	33.89	0.26
Detarium microcarpum	4.68	3.33	15.07	4.17
Terminalia avicennioides	4.11	3.63	27.99	0.99
Ximenia americana	4.02	3.08	2.09	0.55
Pseudocedrela kotschyi	3.98	1.60	51.43	14.35
Tamarindus indica	3.81	1.03	12.56	4.43
Strychnos spinosa	2.75	25.00	28.85	1.15
Terminatia macroptera	2.11	5.08	14.58	4.41
Pterocarpus erinaceus	1.60	5.49	9.15	4.88
Vitellaria paradoxa	1.10	-	6.35	-
Cassia sieberianna	0.97	-	9.19	12.97
Diospyros mespilisformis	0.39	-	24.56	45.61

Table 6. The assessment of the dynamic renewal of woody species in the Kalfou Forest Reserve.

Part	Death (%)	Rejections (%)	Seedling (%)
Saroudja	5.54	27.68	1.15
Gonoray	8.02	19.42	1.90
Doulouk	4.53	21.35	2.14
Hadande	7.52	59.20	2.17
Barodewol	3.28	54.87	1.10
Global rate	5.85	34.20	1.74

(2007) who recorded a total of 89 species representing 66 genera and 29 families in Tiogo forest, whereas, Tchobsala et al. (2010) recorded an average of 140 species, 60 genera and 34 families; in the Ngaoundere Peri-urban Savannah in Cameroon. Thorgnang (2001) also listed 117 species, 80 genera and 37 botanical families in the Gawar forest. Nevertheless, these results raised those of Mahamat (1991) in the Kalamaloue national park, who recorded 21 species and 11 botanical families and those of Teitcheugang (2000) who also recorded 75 species, 46 genera and 24 families in the Zamay forest reserve. The relatively high species richness in this area could be attributed to its statute as protected area including its value in the preservation of biodiversity and it location in the savannah woodland area. The study of Menaut et al. (1995) showed that woodlands and savannas in Africa were characterized by the increase of the species diversity. The most common families recorded in the Kalfou Forest Reserve were Com-bretaceae and Fabaceae-mimosoideae. These families are common in most savannah-woodland mosaics in Africa and more typical of the Sudano-Sahelian zone (Letouzey, 1985). The difference in species composition among different parts may be due to micro-site factors. The growth of trees in ecosystems of the semi-arid savannah is generally determined by moisture, soil characteristics, landscape position (Scholes and Walker, 1993) and species specific growth requirements (Akpo and Grouzis, 1996). For instance, some species such as *Diospyros mespilisformis*, *D. oliveri*, *Mitragyna inermis*, *T. macroptera* and *Cassia sieberiana* were found only in the periodic flooding and marshy zones, indicating that they could be well adapted to deep clay soil and better hydromorphic conditions. Hall et al. (1996) and Savadogo et al. (2007) examined for some species that *Acacia seyal* prefer heavy clay soils (vertisol), whereas *Detarium microcarpum* and *Burkea africana* were most likely to be found on gravel soils. Some species, such as *V. paradoxa*, did not thrive well in occasionally flooded areas.

With regard to stem density per hectare, the number of stems was higher than that of Tchobsala et al. (2010) enumerated in the Ngaoundere Peri-urban savannah. The difference in the results lies on the fact that the present study was carried out within the protected area, namely, that of Kalfou Forest Reserve. Besides this, the geographical location of the study area differs from other areas.

According to the structure of species in the Kalfou Forest Reserve, the distribution of trees in circumference classes produced a reverse “J” shaped curve. These results were similar for those of Savadogo et al. (2007) in Tiogo forest who demonstrated the “J” shaped curve. Moreover, Tchobsala et al. (2010) in the Ngaoundere Peri-urban savannah demonstrate also that the distribution of stems showed “L” shaped. A great number of stems were recorded from the circumference class 10 to 30 to 30 to 50 cm, indicating the high number of small trees and the higher contribution of shrub species which developed small circumference. Similar results were found by Savadogo et al. (2007) in Tiogo forest. The “J” shaped curve structure came as a result of rampant devastating of the forests basically, the suppression and the failing of big trees in addition to other factors that limited the sustainability of species (Peters, 1997). The regeneration rate through rejection and seeds germination has proven to be very low in this study; most woody species regenerate by rejection after threats such as bush fire, failing and wood cutting of trees. Analogous results were recorded by Savadogo et al. (2007) and Tchobsala et al. (2010). However, the transition from seedling to sapling or higher size classes often takes a long time due to frequent fire and drought, which induced seedling shoot die-back (Ky-Dembele et al., 2007). The average of circumference and basal area were low in the Kalfou Forest Reserve. Cutting down trees, overgrazing and other factors influenced biodiversity by reducing the number of stems desired, affected species diversity and their size (Boussim et al., 2009). These results were similar to those of Moleele and Perkins (1998). Since Kalfou Forest Reserve was not well managed because it is being exploited and often overgrazed by livestocks, the density of the desired species reduced due to the devastating effects and lack of afforestation. This partly explains the low rate of young plants renewal (Ntoupka, 1999). Most indexes showed that the diversity of species

in all parts of the forest reserve was not significantly different. Savadogo et al. (2007) studies in Tiogo forest and Tchobsala et al. (2010) in the Ngaoundere savannah, recorded the same results according to the diversity index.

The Shannon-Wiener index was usually found to fall between 1.5 and 3.5 and is rarely above 5.0 (Magurran, 2004). The values found in this inventory fall within the expected range.

Conclusion

The Kalfou Forest Reserve has a large number of woody species bound with a high diversity. The woody flora of the Kalfou Forest Reserve was dominated by shrubs species which was dominated by Combretaceae family. The renewal of species through the regeneration was weakness, the vulnerability of young plants slow down the sustainability of woody species. However, human pressures on the majority of the species are represented by woody cuts; bush fire and overgrazing which are considered as an ecological, and an environment problems were contributed to the degradation of the floras.

The management, preservation systems including local population and afforestation of rarest and desired species will therefore be highly advantageous to save this protected area from destruction, save their flora and fauna species from local extinction and to maintain a viable population size. It should be noted that the Kalfou Forest Reserve species richness and its diversity were over-degraded due to the anthropogenic pressure and the lack of government monitoring since its creation. Measures geared toward good management and monitoring of over protected areas should be taken. Measures to support the regeneration of woody species should also be taken, in order to increase the main abundance of trees and threatened species. However, successful restoration requires involvement from many disciplines and stakeholders, from government and ecologists to local communities, and from decision makers to ordinary people.

Finally, the recommendation should be made at the regional and national levels to update the current preservation status of this protected area and ensure sustainable management for flora and fauna species.

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