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Original Research Article

Ecological characterization of the Vegetation in the Sudano-Sahelian Zone of Cameroon

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Abstract: The study was carried out in the Mayo-Danay, Mayo-Kani, Mayo-Sava and the Logone-Chari Divisions in the Far-North Region of Cameroon, to ecologically characterize the shrub savannahs, wooded savannahs, protected areas and sacred forests of the sudano-sahelian zone. In total, 48 hectares were chosen at random with 12 hectares per Division. The experimental design was a split-plot (4 x 4) x 3, where the 4 Divisions represented the main factor and the 4 types of vegetation the secondary factor. Dendrometric parameters (DBH and number plant species) where observed on $100m^2$ plots. Results indicate that vegetation has an "L" structure, obtained when the DBH was taken into consideration. *Guiera senegalensis*, *Anogeissus leiocarpus* and *Combretum collinum* showed ecological indexes with high values (35.78, 34.39 and 32.87 respectively), whereas a lower index was obtained for *Boswellia dalzielii* (0.01), *Lonchocarpus laxiflorus* (0.01) and *Steganotaenia araliacea* (0.01). The Mayo-Sava and Logone-Chari Divisions were the most affected by the deforestation based on the density of species. In the framework of sustainable and rational development of natural resources in the sahelian area, it is suggested to intensify reforestation in these two Divisions.
Keywords: Deforestation, biodiversity, excessive exploitation, soudano-sahelian, Cameroon.

INTRODUCTION

Savannahs are the brittle ecosystems between the herbaceous and ligneous stratus [1]. They are the dynamic systems which evolution depends on the intensity of environmental factors [2]. In the framework of general climate changes and the overgrown the world population, the pressure on the ecosystems of arid areas is amplified with an accelerated speed [3]. In Cameroon, the sahelian zone is essentially sylvopastoral and the economy depends on the exploitation of natural resources, particularly the vegetation. This zone is a natural pasture for livestock that allows the rural populations to satisfy their needs by exploiting ligneous and non-ligneous products [4]. Because of their important implication in agriculture, ecological and environmental aspects, the problem of their protection represents the main challenge [5] to be focused on. In order to stabilize the climate change and fight against the desertification, researches have been conducted in the study area, and include the contribution valuing trees [6], state and perspective of forest reserves [7], actions of human on climate change [8] information system for integrated analysis of space [9] and impacts of disturbing actions of human (pasture, fire, cutting of tree) on the dynamic of vegetation in the sudano-sahelian zone [10]. According to our knowledge, no work has been investigated on ecological characterization of vegetation in this area (structure, regeneration dynamism). Such a study will provide additional information for reconstruction, sustainable and rational management of plant resources in this area. It aims (i) at studying the structure of vegetation population on their DBH parameter (ii) analyzing the dynamic of natural ligneous resources by estimating the diaspores density and index of important value of species in terms of Divisions (iii) determining their adaptation mode in their environment.

Presentation of the study zone

Investigations were carried out in the Mayo-Danay, Mayo-Kani, Mayo-Sava and the Logone-Chari Divisions and were related to vegetation types (Shrub Savannah, Wooded Savannah, Protected Area and Sacred Forest). The divisions were chosen because of the importance of established desertification surfaces. The climatic is of sudano-sahelian type characterized by a long dry season (from October to June) and a short rainy season (from July to September). This region is occupied by vast lowlands which are extended from mounts Mandara to the Lake Chad basin [8] and covers a surface of about 34263 km², and extending between 10 and 13 degrees North of latitude and 13 and 15 degrees East of longitude [9, 11]. It is limited in the East with two permanent water flows (the Logone and the Chari), in the West with the Federal Republic of Nigeria, and in the South with the North Region.

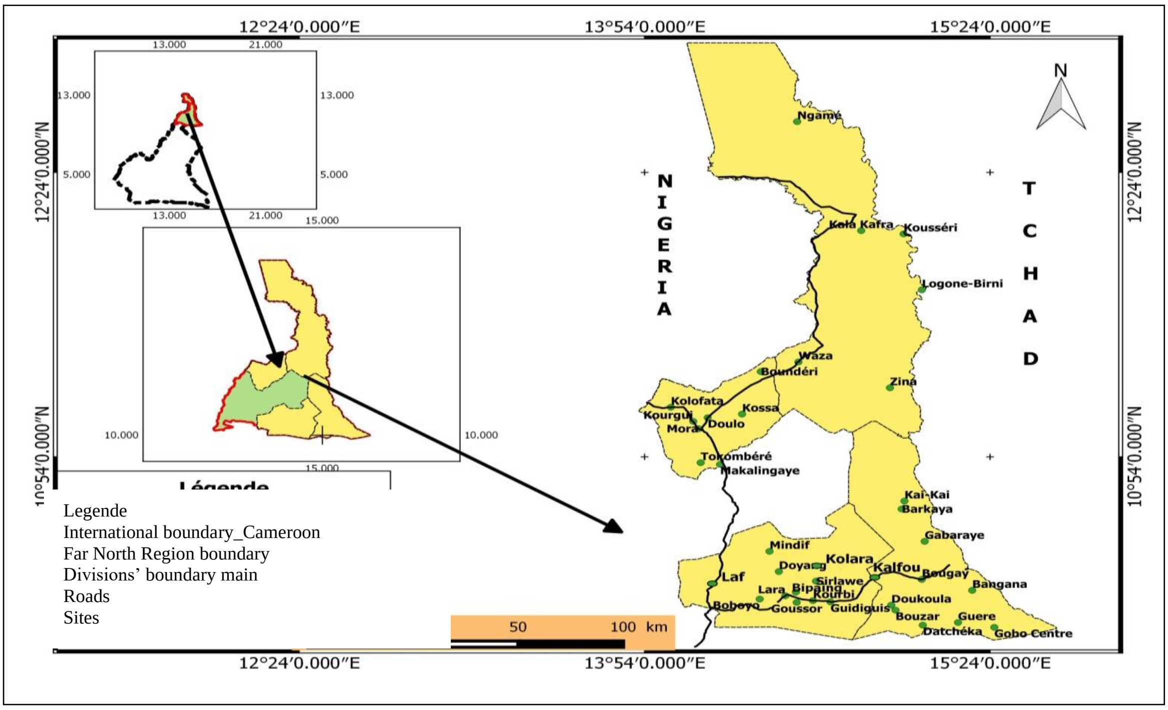

Fig 1: Localization of the area study

Sampling methods of vegetation

The Experimental system installed was a split-plot of 2 factors (4 x 4) x 3. The departments (Mayo-Danay, Mayo-Kani, Mayo-Sava and Logone-Chari) considered as main treatments, whereas the vegetal types were the secondary treatments, repeated in villages [12]. In total, 48 ha were chosen with 12 ha per Division. Each site was prospected and sampled according to the floristic sampling method done on 10 tracks of (10 x 100) m^2 one after the other. Measurement of dendrometric parameters was focused on the height of the trees, the number of individual and the DBH. The identification of species was systematically done in the field or in the laboratory (herbarium of the fauna school of Garoua and of Wakwa).

Determination of the dissemination of diaspores

Dissemination of diaspores was given using the classification [13] and [14]. The various types were:

- Sclerochores (Sclero): Not fleshy and relatively light diaspores;
- Sarcochores (Sarco): Diaspores completely or partially fleshy;
- Desmochores (Desmo): Diaspores hanging or adhesive;
- Ballochores (Ballo): Diaspores expelled by the same plants;
- Barrochores (Barro): Not fleshy diaspores;
- Anemochores (Anemo): Diaspores expelled by the wind;
- Zoochores (zoo): Diaspores expelled by animals.

Ecological characterization

The ecological profile was performed using the quantification parameters of species, such as the frequency, the abundance and the dominance, according to Braun-Blanquet [15].

Method of the relative frequency (Fr) of species was calculed using the formula:

FR (%) = A/B*100

where, FR (%) = relative frequency; A= number of processing containing the specie and B= total number of processing.

Calculation of the relative density: this was described as::

According to Rondeux [16]; Mahamat *et al.;* [17].

Dre = SB/SBT*100;

Where, Sb = basal surfaces of a species and SB = $\pi D^2/4$, D = the diameter of the stalk; SBT = total sum of all the basal surfaces of all plant species considered in an upper diameter above the ground level per hectare (m^2/ha).

Calculation of the relative density

Dr(%) =N/S/100,

Where,

N = number of the species in the research area, and S = surface area occupied by the species. From this, the earth's surface was worked out [18].

Index value of ecological of importance (IVEI)

$$IVEI = 100 * \left[\left(\frac{Ni}{\sum N_i}\right) + \left(\frac{G_i}{\sum G_i}\right) + \left(\frac{F_i}{\sum F_i}\right) \right]$$

Where, Ni: number of individuals of the species I; Gi: surface hole of the species I; Fi: frequency of the species I; the species at IVEI >=10 are those that are ecologically important [19].

Statistics Analysis

Data collected in the field were processed and classified in Excel. The Statgraphic plus 5.0 software was used for the Analysis of Variance (ANOVA), while XLSTAT helped for Principal Components Analysis (PCA).

RESULTS

Structure of the population in DBH classes

The savannah trees diameters in the Far-north region east, presented a «L» type structure (fig.2). The DBH of trees organized in classes in the savannahs varied significantly (p = 0.003) between seasons, but was almost similar between years. The numbers of species (3632 stems/ha) within the [0.01-0.05 class in 2014 and 2015 was exponentially higher (p = 0.0001) than that of other classes. Within the [0.05-0.1[class there was a very high number of stems (3250 stems/ha) in 2014 during the rainy season, while in the dry season it was rather low (3035 stems/ha). Concerning the [0.1-0.5[, [0.5-1[, [1-1.5[, >2 classes, the number of stems was always very high in the rainy season and reduced in the dry season.

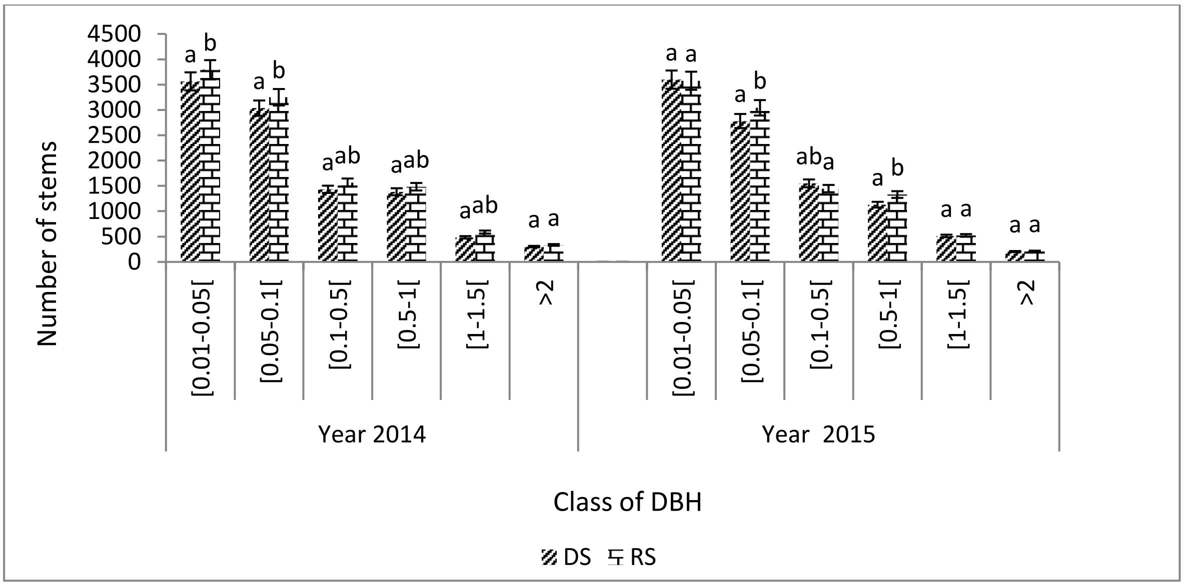

Fig 2: Differences in diameter breast heigh (DBH) classes of tree species as influenced by cropping seasons in study years

Figure having the same letters are not significantly different at the shord indicated.

DS=Dry season and RS=Rainy season

Dispersion diaspores of plant species in the study area

The mechanism of dispersion of diaspores varied with diaspore types, vegetation types and Divisions (Table 1). In the Mayo-Danay Division, the mean number of anemochores varied from (27.6) in the shrub savannah to (18.15) in the sacred forests. There was a significant difference (p= 0.01) among the anemochores encountered in the different vegetation types in Mayo-Kani Division. In the Mayo-Sava, the mean number of anemochores was 24.55 in the shrub savannahs, and 17.75 in the protected areas. In the Mayo-Danay, the mean number of ballochores varied from 28.32 in the sacred forests to 17.24 in the shrub savannahs. There was a significant difference (p = 0.005) between means of ballochores recorded in different vegetation types in the Mayo-Kani Division. Values ranged from 16.26 in the shrub savannahs to 25.42 in the sacred forests, while in the Logone-Chari, it was 26.9 in protected areas and only 14.6 in the shrub savannahs. The analysis of variance indicated a highly significant difference (p = 0.04) between the means barrochores encountered in different vegetation types in Mayo-Kani. In the Mayo-Sava, the mean barrochores varied from 15.06 in savannah trees to 11.48 in shrub savannahs. In the Mayo-Danay Division, the mean sarcochores was 16.85 in the sacred forests and 10.14 in shrub savannahs. In the Mayo-Sava Division, the mean sarcochores changed from 16.61 in the sacred forests to 8.38 in the shrub savannahs, while in the Logone-Chari, it was rather 12.9 in the protected areas and 7.5 in shrub savannah. As far as sclerochores are concerned, a significantly difference was observed within Division between vegetation types (p = 0.0001) with the highest number (14.65) protected areas of Mayo-Danay, and the lowest (5.09) in sacred forests of Logone-Chari. There was a significant difference (0.0001<0.001) among the means of Zoochores mostly noticed in the Mayo-Sava, varying from 33.41 in protected areas to (26.43) in the shrub savannahs.

Table 1: Diversity of diaspore species in study areas

Treatment	Vegetal formations	Anemo	Ballo	Barro	Sarco	Sclero	Zoo	Desmo	p-value	LSD
Mayo-Danay	Shrubs savannahs	27.6_{c}^{e}	17.24_{a}^{d}	13.24_{a}^{bc}	10.14_{a}^{b}	8.11_{a}^{a}	28.19_{a}^{e}	7.81_{a}^{a}	0.0025	4.43
	Wooded savannahs	23.14_{b}^{c}	22.66_{b}^{c}	15.03_{ab}^{b}	11.9_{a}^{a}	12.16_{b}^{a}	33.2_{b}^{d}	10.9_{b}^{a}	0.0018	2.05
	Protected areas	19.21_{a}^{c}	27.05_{c}^{d}	16.21_{b}^{b}	13.05_{b}^{a}	14.65_{bc}^{a}	37.87_{c}^{e}	15.3_{d}^{ab}	0.0003	0.68
	Sacred forests	18.15_{a}^{c}	28.32_{c}^{d}	14.65_{a}^{ab}	16.85_{c}^{b}	13.48_{b}^{a}	29.55_{a}^{d}	12.8_{bc}^{a}	0.0003	1.36
	LSD	1.79	1.79	2.68	3.08	0.88	1.28	0.39		
	p-value	<0.001	0.026	0.31	0.202	0.027	0.054	0.009	<0.001	
Mayo-Kani	Shrubs savannahs	25.33_{c}^{e}	16.26_{a}^{d}	12.26_{a}^{c}	9.16_{a}^{ab}	7.13_{a}^{a}	27.21_{a}^{ef}	6.83_{a}^{a}	<0.0001	4.2
	Wooded savannahs	23.8_{b}^{c}	23.32_{b}^{c}	15.69_{b}^{b}	12.56_{b}^{a}	12.82_{b}^{a}	33.86_{c}^{d}	11.56_{b}^{a}	0.0004	3.96
	Protected areas	17.58_{a}^{c}	25.42_{bc}^{d}	14.58_{ab}^{b}	11.42_{b}^{a}	13.02_{b}^{ab}	36.24_{d}^{e}	13.67_{c}^{ab}	<0.0001	5.22
	Sacred forests	19.14_{ab}^{d}	29.31_{d}^{e}	15.64_{b}^{ab}	17.84_{c}^{bc}	14.47_{bc}^{a}	30.54_{b}^{e}	13.79_{c}^{a}	0.0003	1.01
	LSD	2.11	10.5	8.38	17.42	19.21	19.21	20.1		
	p-value	0.0186	0.005	0.09	0.01	0.01	<0.0001	0.017	<0.0001	
Mayo-Sava	Shrubs savannahs	24.55_{b}^{d}	15.48_{a}^{c}	11.48_{a}^{b}	8.38_{a}^{a}	6.35_{a}^{a}	26.43_{a}^{de}	6.05_{a}^{a}	0.0026	4.77
	Wooded savannahs	23.17_{b}^{d}	22.69_{b}^{d}	15.06_{b}^{c}	11.93_{b}^{a}	12.19_{b}^{ab}	33.23_{c}^{e}	10.93_{b}^{a}	0.0003	0.13
	Protected areas	17.75_{a}^{c}	25.59_{c}^{d}	14.75_{b}^{b}	11.59_{b}^{a}	13.19_{b}^{ab}	33.41_{c}^{e}	13.84_{c}^{ab}	0.0002	0.41
	Sacred forests	17.91_{a}^{c}	28.08_{d}^{d}	14.41_{b}^{ab}	16.61_{c}^{bc}	13.24_{b}^{a}	29.31_{b}^{d}	12.56_{bc}^{a}	0.01	0.28
	LSD	2.11	9.75	7.63	16.67	18.46	19.35	0.39		
	p-value	0.0146	0.0007	0.25	0.054	0.055	0.014	0.017	<0.0001	
Logone-Chari	Shrubs savannahs	23.67_{cd}^{e}	14.6_{a}^{d}	10.6_{b}^{c}	7.5_{a}^{b}	5.47_{a}^{a}	25.55_{b}^{ef}	4.41_{a}^{a}	<0.0001	4.75
	Wooded savannahs	22.58_{c}^{c}	22.1_{c}^{c}	14.47_{c}^{b}	11.34_{b}^{a}	11.6_{b}^{a}	32.64_{c}^{d}	10.34_{b}^{a}	<0.0001	6.64
	Protected areas	19.06_{b}^{d}	26.9_{d}^{e}	16.06_{cd}^{bc}	12.9_{b}^{a}	14.5_{c}^{ab}	33.72_{c}^{f}	15.15_{c}^{b}	<0.0001	2.28
	Sacred forests	9.76_{a}^{b}	19.93_{b}^{c}	6.26_{a}^{a}	8.46_{a}^{b}	5.09_{a}^{a}	21.16_{a}^{d}	5.17_{a}^{a}	0.001	1.88
	p-value	<0.0001	0.007	0.0005	0.027	0.0037	<0.0001	<0.0001	<0.0001	
	LSD	2.11	9.5	7.38	16.42	18.11	19.1	0.39		

The numbers which have the same letters at the same column are not significantly different at the top indicated.
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Anemo: Anemochore, Ballo: Ballochore, Barro: Barrochore, Sarco: Sarcochore, Sclero: Sclerochore Zoo: Zoochore and Desmo: desmochor

Principal component Analysis (PCA) of tree species in different Divisions

Analysis of main component (ACP) illustrated by figure 3 involving the distribution of plant species in vegetation types was focused on the factorial plane of the two axes f1 and f2, and enables gathering the ligneous species that have similar correlations. The analysis of variables shows that species like *Guiera senegalensis, Anogeissus leiocarpus, Feretia apodanthera, Balanites aegyptiaca, Azadirachta indica, Combretum collinum, Combretum adenogonium* and *Combretum glutinosum* are the most represented. The density of these species was very high in the study area. Others species were poorly represented form clouds around the two axes (axis f1 and f2: 95.69). Instead the Mayo-Sava and Logone-Chari were also positively correlated as far as the similarity in species within these two Divisions is concerned. However, the Mayo-Danay and Mayo-Kani Divisions on one side, as well as the Logone-Chari and Mayo-Sava Divisions on the other, were not correlated, since they were opposed to the abscise axis.

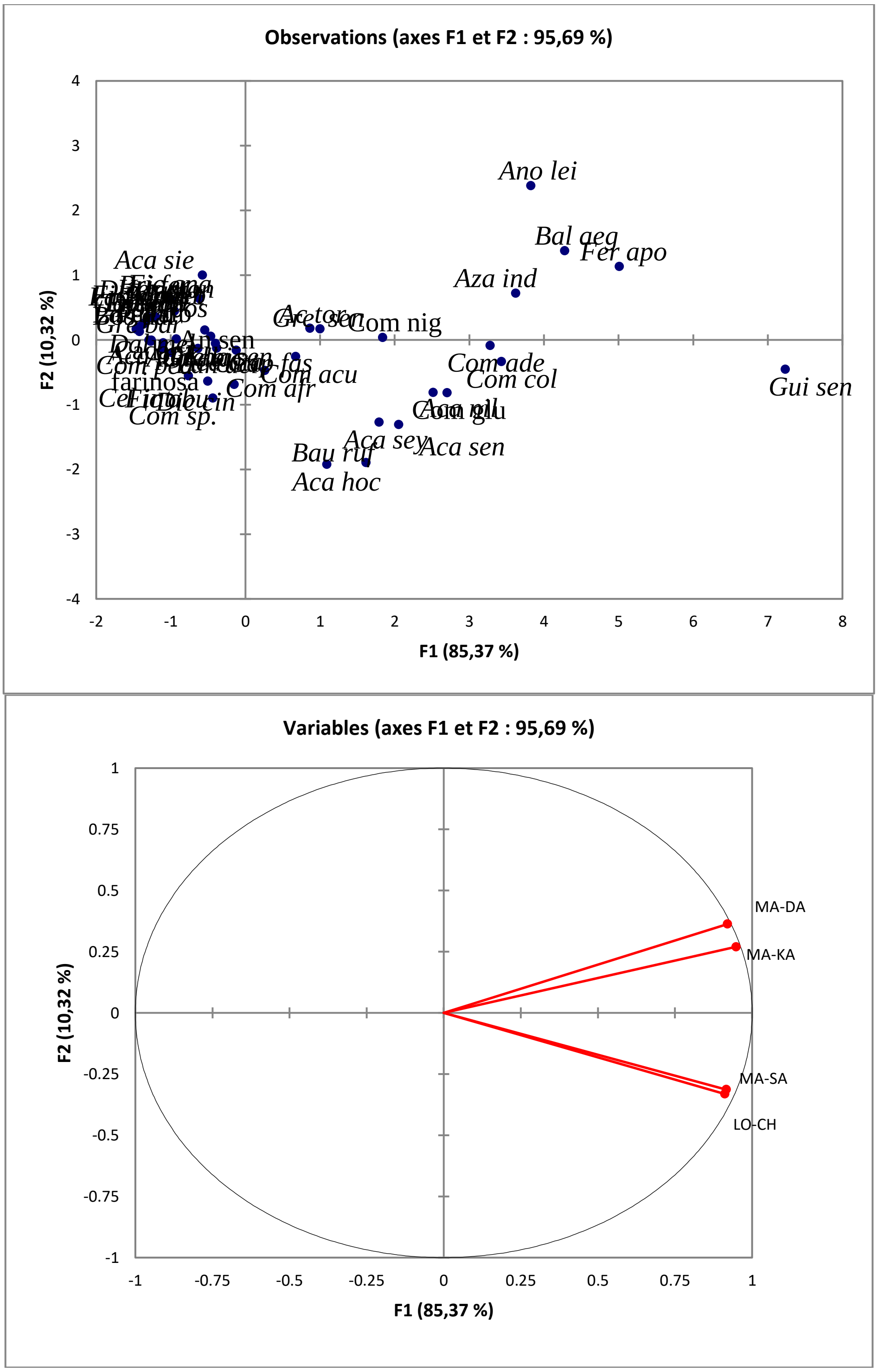

Fig 3: Principal component Analysis (PCA) of tree species in different Divisions

Index value of ecological of importance of species within Divisions (IVEI)

The analysis of the floristic richness allowed identification of 73 species within the 48 ha of studied area. Tables indicates 2a and 2b the index values of ecological importance (IVEI) of species that varied from one Division to on other, from one year to another and from one species to another. The condition is that the species should have an IVEI >10. Hence, the following species eligible: *Guiera senegalensis* (35.78), *Combretum collinum* (34.39) and *Anogeissus leiocarpus* (32.87). Species with lower IVEI such as *Boswellia dalzielii* (0.01), *Lonchocarpus laxiflorus* (0.01), *Steganotaenia araliacea* (0.01), *Mitragyna inermis* (0.02), *Maerua angolensis* (0.04) and *Prosopis africana* (0.05) were not eligible.

Table 2a: Variation of index of values of ecological importance between Division and vegetations types in 2014

	Year 2014																
SPECIES	IVEIMD		IVEIMK		IVEIMS		IVEILC			IVEIMD		IVEIMK		IVEIMS		IVEILC	
	DS	RS	DS	RS	DS	RS	DS	RS	SPECIES	DS	RS	DS	RS	DS	RS	DS	RS
Acacia ataxacantha	1.57	2.58	1.23	2.32	1.7	4.36	1.98	2.66	*Ficus abutifolia*					6.77	5.17		
Acacia hockii			2.11	2.48	7.88	7.62	6.17	7.23	*Ficus gnaphalocarpa*	0.28	0.37			5.72	4.17	0.73	1.05
Acacia nilotica	2.79	2.21	1.37	1.64	13	12.9	7.28	7.51	*Ficus platyphylla*	0.6	1.16						
Acacia polyacantha					5.83	6.69	5.83	3.65	*Gardenia aqualla*	0.58	1.51						
Acacia senegal	3.44	3.73	2.48	1.61	14.8	15.4	21.9	20.7	*Grewia barteri*	0.24	0.54	1.24	0.74	0.37	0.89	1.64	2.28
Acacia seyal	2.5	2.33	2.73	2.23	13.1	14.1	18.6	17.2	*Grewia bicolor*							0.58	1.45
Acacia sieberiana	1.77	1.56	1.37	1.52					*Grewia senegalensis*	0.24	0.34						
Acacia tortilis	3.73	3.31	5.69	4.62	7.06	7.3	8.02	8.01	*Guiera senegalensis*	34.7	35.8	17.9	16.8	31	30.6	21.1	19.1
Adansonia digitata					3.51	5.74			*Hexalobus monopetalus*	12.2	11.7	24.2	25.9	2.77	2.94	14.3	12.9
Albizia lebbeck	0.66	0.84							*Khaya senegalensis*	0.94	1.48	0.87	0.62				
Anogeissus leiocarpus	26.5	23.6	30.2	31.3	4.58	3.24	4.54	5.51	*Lannea acida*					0.65	0.84		
Annona senegalensis	1.61	1.89			1.04	1.28	2.39	2.65	*Lannea fruticosa*	3.02	2.26			4.39	3.38	8.49	10.6
Azadirachta indica	15.3	16.9	16.7	17.5	14.5	16	15.6	20.2	*Lannea schimperi*	0.32	0.23	0.97	0.78				
Balanites aegyptiaca	29.4	29.3	25.2	22.5	13.7	9.61	29.3	27.5	*Lannea* sp.	0.05	0.17			3.01	3.38	3.11	3.1
Bauhinia rufescens	0.21	0.87	6.11	6.24	7.14	6.48	1.04	2.84	*Lonchocarpus laxiflorus*	0.01	0.02	0.02	0.03				
Bombax costatum	0.58	0.71							*Maerua angolensis*	1.35	1.02	0.02	0.16	2.13	2.54	1.6	1.99
Borassus aethiopum	1.85	1.16							*Maytenus senegalensis*	2.78	2.49	2.15	2.16	1.13	1.34	0.56	1.49
Boswellia dalzielii	0.01	0.01	0.99	0.41					*Mitragyna inermis*			0.15	0.03				
Bridelia ferruginea	3.43	3.58							*Phyllanthus muellerianus*	1.53	1.25	1.24	1.62				
Cadaba farinosa	1.58	1.03	1.87	1.41	3.06	3.57	3.73	3.14	*Piliostigma thonningii*	8.73	9.06	18.4	17.5	13.8	11.6	13.9	11.3
Capparis fascicularis	1.01	1.91	1.48	1.43	3.39	3.94	3.22	4.68	*Piliostigma reticulatum*							12.3	14.8
Celtis integrifolia					7.22	7.49			*Prosopis Africana*	0.35	0.43	0.05	0.07	0.72	0.96	0.14	0.91
Combretum aculeatum	3.23	3.17	3.23	3.13	3.75	3.17	3.61	3.91	*Sclerocarya birrea*	1.23	2.72	1.35	0.72			0.14	0.23
Combretum adenogonium	25.4	26.5	25	25.4	10.4	10.3	8.05	8.13	*Senna siamea*	2.02	2.65						
Combretum collinum	29.6	28.1	27.8	26.1	12.5	12.6	12.8	11.7	*Senna singueana*	4.15	2.06	4.48	4.41			0.33	1.1
Combretum glutinosum	26.2	26.2	21.6	22.5	10.3	11.9	12	13.4	*Steganotaenia araliacea*	0.01	0.01	0.61	1.94	0.02	0.03		
Combretum nigricans	3.06	3.97	3.36	3.84	3.39	2.64	3.63	3.85	*Sterculia setigera*	2.91	2.53	2.23	2.22	2.86	1.22	3.14	0.91
Combretum sp.					9.93	10.9			*Stereospermum kunthianum*	1.91	2.68	2.23	2.43	0.2	0.47	1.37	2
Commiphora africana			3.75	3.03	7.24	8.11	6.58	2.56	*Strychnos spinose*			0.52	2.16	2.34	2.35	2.65	1.16
Commiphora pedunculata	1.36	1.53	1.36	1.44					*Tamarindus indica*	5.15	1.47	4.31	4.74	6.48	4.72	6.38	2.8
Dalbergia melanoxylon	1.25	1.21			2.45	3.12	0.34	0.37	*Terminalia glaucescens*	2.75	2.67	2.92	2.06	0.35	0.54	0.35	0.65
Daniellia oliveri	0.98	0.7	0.25	0.34					*Vitellaria paradoxa*			0.27	0.04				
Dichrostachys cinerea	1.34	1.45			3.29	4.17	4.66	6.26	*Vitex doniana*	0.68	1.05						
Diospyros mespiliformis	2.98	2.75	3.93	5.04	0.8	0.31	0,7	0.65	*Ximenia Americana*	1.7	1.71	1.12	0.25	3.21	3.55	0.01	0.13
Entada abyssinica	0.35	0.54							*Ziziphus abyssinica*							0.13	0,24
Faidherbia albida	3.95	4.86	4.65	4.55	7.55	6.62	2.59	3.87	*Ziziphus mauritiana*	2.12	2.25	3.31	4.12	4.26	3.97	6.11	7.24
Feretia apodanthera	9.83	9.95	15.1	15.9	14.7	15.9	12.3	9,98	*Ziziphus spina-christi*							4.03	4.68
									total	300	300	300	300	300	300	300	300

IVEIMD= index of values of ecological importance in Mayo-Danay, IVEIMK= index of values of ecological importance in Mayo-Kani, IVEIMS= index of values of ecological importance in Mayo-Sava, IVEILC= index of values of ecological importance in Logone-Chari, RS= Rainy saison; DS= dry saison.

Table 2b: Variation of index values of ecological importance between Divisions and vegetations types in 2015 (IVEI)

	Year 2015																
	IVEIMD		IVEIMK		IVEIMS		IVEILC			IVEIMD		IVEIMK		IVEIMS		IVEILC	
SPECIES	DS	RS	DS	RS	DS	RS	DS	RS	SPECIES	DS	RS	DS	RS	DS	RS	DS	RS
Acacia ataxacantha	1.41	2.04	1.63	0.75	4.14	4.24	1.37	1.09	*Ficus abutifolia*					6.77	4.98		
Acacia hockii			2.68	1.62	7.15	7.92	6.94	6.28	*Ficus gnaphalocarpa*	0.68	0.26			5.24	5.29	0.82	1.25
Acacia nilotica	2.98	2.88	3.94	3.45	13.8	13.3	6.17	9.2	*Ficus platyphylla*	0.75	0.75						
Acacia polyacantha					5.57	6.78	4.03	4.87	*Gardenia aqualla*	0.51	0.37						
Acacia senegal	3.31	4.11	1.97	1.67	14.5	15.2	20.6	20.9	*Grewia barteri*	0.21	0.24	0.72	0.47	0.24	0.79	2.02	3.15
Acacia seyal	1.97	2.37	1.13	1.95	13.9	13.2	18.8	16.1	*Grewia bicolor*							0.4	1.55
Acacia sieberiana	1.37	1.25	2.84	1.45					*Grewia senegalensis*	0.45	0.65						
Acacia tortilis	3.11	3.49	7.2	6.52	7.4	6.69	6.71	7.01	*Guiera senegalensis*	32.6	32.2	17.6	17.7	27.7	27.5	19.2	16.6
Adansonia digitata					4.33	5.18			*Hexalobus monopetalus*	14.7	15.3	24.3	24.2	1.85	3.92	14.7	14.5
Albizia lebbeck	0.53	0.34							*Khaya senegalensis*	0.91	1.37	0.81	0.56				
Anogeissus leiocarpus	26	26.2	31.5	32.9	4.87	3.65	7.84	6.35	*Lannea acida*					0.54	0.67		
Annona senegalensis	1.65	2.19			1.87	2.36	2.85	2.98	*Lannea fruticosa*	3.25	3.45			2.61	3.22	7.44	11
Azadirachta indica	15.6	15.4	19.9	18.3	13.6	16.7	19.3	18.3	*Lannea schimperi*			0.94	1.24				
Balanites aegyptiaca	29.2	29	23.3	23.9	13.3	9.54	28.6	27.9	*Lannea* sp.					2.41	4.06	2.87	3.36
Bauhinia rufescens	0.84	0.25	6.35	6.06	7.65	6.3	1.22	2.06	*Lonchocarpus laxiflorus*	0.01	0.03	0.03	0.05				
Bombax costatum	0.64	0.85							*Maerua angolensis*	1.62	1.85	0.04	0.03	1.48	1.92	1.2	1.77
Borassus aethiopum	1.57	1.34							*Maytenus senegalensis*	2.34	2.8	0.34	0.15	0.68	0.45	0.38	1.69
Boswellia dalzielii	0.02	0.01	0.96	0.36					*Mitragyna inermis*			0.02	0.05				
Bridelia ferruginea	3.11	3.24							*Phyllanthus muellerianus*	1.66	1.24	0.68	0.69				
Cadaba farinosa	1.61	1.19	1.68	1.65	3.65	3.32	3.58	3.55	*Piliostigma thonningii*	7.94	7.76	17.9	18.3	10.5	12.5	13.1	9.1
Capparis fascicularis	1.84	1.01	1.21	2.73	2.48	3.16	3.3	2.73	*Piliostigma reticulatum*							12.7	13.2
Celtis integrifolia					7.59	6.73			*Prosopis Africana*	0.84	0.64	0.13	0.24	0.7	0.84	1.29	0.69
Combretum aculeatum	3.07	1.87	3.16	4.24	5.16	5.02	7.64	6.94	*Sclerocarya birrea*	2.98	2.64	0.81	0.41			0.29	0.23
Combretum adenogonium	23.9	25.2	25.6	26.5	11.4	11	6.11	5.75	*Senna siamea*	2.79	2.19						
Combretum collinum	34.2	34.4	28.2	29.2	14	13.5	13	13.4	*Senna singueana*	4.19	2.3	5.37	6.43	3.4	3.18	1.38	1.27
Combretum glutinosum	23.2	24.7	25.7	24.3	10.4	10	11	11	*Steganotaenia araliacea*	0.06	0.02	0.03	0.01	0.02	0.05	0.01	0.01
Combretum nigricans	4.88	4.5	3.21	3.19	8.9	7.96	4.1	4.3	*Sterculia setigera*	2.41	2.29	1.32	1.33	2.56	1.49	3.29	1.03
Combretum sp.					10	12.1			*Stereospermum kunthianum*	2.07	2.29	1.94	1.89	0.24	0.39	0.62	2.26
Commiphora africana			3.48	1.3	7.99	7.74	5.06	6.81	*Strychnos spinosa*			0.31	0.58	0.65	0.75	2.87	1.35
Commiphora pedunculata	0.23	0.41	2.03	2.63					*Tamarindus indica*	5.83	5.22	1.79	1.65	5.64	5.56	3.21	3.21
Dalbergia melanoxylon	0.61	1.03			3.41	3.48	1.02	1.32	*Terminalia glaucescens*	2.91	3.06	1.43	1.11	0.54	0.12	0.4	0.25
Daniellia oliveri	0.33	0.06	0.54	0.64					*Vitellaria paradoxa*			0.35	0.55				
Dichrostachys cinerea	1.05	1.52			2.45	2.15	4.55	5.68	*Vitex doniana*	0.13	0.13						
Diospyros mespiliformis	2.11	2.52	3.45	3.72	1.35	1.46	0.79	1.07	*Ximenia americana*	1.23	1.19	0.52	0.59	2.25	1.34	0.02	0.13
Entada abyssinica	0.23	0.75							*Ziziphus abyssinica*							0.35	0.55
Faidherbia albida	4.87	4.43	3.54	5.65	6.11	6.55	3.92	4.37	*Ziziphus mauritiana*	2.15	2.26	2.35	3.65	3.64	3.27	6.27	7.61
Feretia apodanthera	9.35	9.03	15	13.4	13.7	12.5	12.6	10.1	*Ziziphus spina-christi*							4.16	4.34
									total	300	300	300	300	300	300	300	300

IVEIMD= index of values of ecological importance in Mayo-Danay, IVEIMK= index of values of ecological importance in Mayo-Kani, IVEIMS= index of values of ecological importance in Mayo-Sava, IVEILC= index of values of ecological importance in Logone-Chari, RS= Rainy saison; DS= dry saison.

DISCUSSION

Deforestation has an influence on the structure, the biological diversity and the share-out of species within natural savannah. Measurement of DBH of trees by classes in the savannahs varied significantly with season (p = 0.003), but not with years. The numbers of species in [0.01-0.05[class in 2014 and 2015 was exponentially higher (p = 0.0001) than that of other classes. In all the other classes, the number of species was greater in the rainy season of 2014 than the dry season of 2015. The “L” structure obtained as far as the DBH of trees is concerned may be attributed to the cutting off of trees by populations for firewood. On the other hands, it could be justified by the incapacity of trees to normally grow in diameter after cumulating hydric stresses [19, 20]. The vegetation was mostly populated with trees not more than 2m in height, and with very small diameter. This was ascribed to increase intensity of deforestation and other causes of the or extinction of vegetation. The proportion of individuals with weak diameter could be related to the influence of the grabbing on plants growth rate [21] whereas that of individuals of large diameter would result from the wind activity, which blows and breaks the most developed branches. These results are in agreement with those of Traore *et al.;* [22] in Algeria who revealed that crown diameters of between 1.75 and 13.65 m for young *Balanites aegyptiaca* compared to adults. This justifies the “L” shaped structure of the vegetation in the shrub savannah of the eastern part of the Far-North Cameroon. Our findings line with those of Chouaibou [24] who showed that in general, such a structure expresses a good regeneration of the arborescent structures of plant communities. In fact, the local population was partly responsible for the degradation of savannah. All the actors of wood exploitation were of the same opinion that the uncontrolled practices have strongly compromised the vegetation dynamism within the studied zones. The dissemination rate of species indicates that plant growth under very difficult climatic conditions, sometimes aggravated by the intense human activity [25, 26].

The distribution of diaspores varied significantly among Divisions, vegetation types. The analysis of variables by the Principal Component Analysis (PCA) test demonstrates that the species such as *Guiera senegalensis, Anogeissus leiocarpus, Feretia apodanthera, Balanites aegyptiaca, Azadirachta indica, Combretum collinum, Combretum adenogonium* and *Combretum glutinosum* were the most represented. The intensity of species dispersion revealed their presence in all the study areas. Other less represented species were found in clouds around the two axes: (axis f1 and f2: 95.69%). The Mayo-Sava and Logone-Chari were positively correlated, illustrating their similarity in species diversity. Conversely, the Mayo-Danay and Mayo-Kani were weakly correlated due to the difference in species they possess. The correlation between the Logone-Chari and the Mayo-Sava was moderately strong, whereas the ones between the Mayo-Danay and Mayo-Sava, Mayo-Kani and the Mayo-Sava were relatively weak and positive. The fluctuation found between Divisions could be justified by the fact that the species density varies from one Division to another. The weak or strong correlations observed could be attributed to variations in species density between these Divisions because certain Divisions were affected by human activities.

Similar results were reported by Teitcheugang [7] in the Zamay Reserve forest, and corroborate with those obtained by Haiwa [27] who indicated that human activities and dry season have a negative impact on ligneous species density. The drop down of leaves in the dry season has been observed from the species of the trees at the intertropical zone [28]. The diversity index values of ecological importance (IVEI) increased in the dry season and decreased from the first to the second year. This type of information is important in determining the ecologically important species in the savannah such as *Guiera senegalensis* (35.78), *Combretum collinum* (34.39) and *Anogeissus leiocarpus* (32.87) with a satisfying ecological index value. These were the most highly adapted species to climatic and edaphic conditions in the study areas. Such high species Index values were reported within natural forests in Benin [19]. On the reverse, species of weak index values were Boswellia *dalzielii* (0.01), *Lonchocarpus laxiflorus* (0.01), *Steganotaenia araliacea* (0.01), *Mitragyna inermis* (0.02), *Maerua angolensis* (0.04) and *Prosopis africana* (0.05). These low values indexes could be justified by the fact that these species are among those that are the most threated in the study area.

CONCLUSION

This study has evaluated the structural characteristics of the woody population of four Divisions in the Far-North region of Cameroon. It has revealed a regressive evolution of the ligneous species, most of which have a low DBH. The immediate consequences of deforestation were materialized by the rapid modification of species structure into the “L” shape, as related to their DBH that reflects a high regeneration rate of species. The reduction of the floristic diversity had a repercussion on the local population to whom trees occupy an important place in their everyday life. It would therefore be important to undertake ways and means of improving the regeneration of certain species identified in this research in order to ensure the well management of these degrading ecosystems. It is suggested to the civil and administrative authorities to create villager schools focused on the protection and safeguarding of forest, and to recruit qualified personnel trained in forestry to monitor activities in the field.

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