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Full Length Research Paper

Characterization and impact of wood logging on plant formations in Ngaoundéré District, Adamawa Region, Cameroon

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This study was conducted to characterize the different plant formations (shrubby, arborescent and woody savanna) and to ascertain the impact of wood logging on the floral diversity in the guinea savanna zone of Ngaoundéré District, Adamawa Region, Cameroon. The "Point-Centered Quarter (PCQ) Method" was used on 120 sites measuring 50 × 50 m. Results showed that according to the types of wood logging in the different plant formations, the species generally had an over-scattered distribution, and only the protected savannas had a gregarious distribution. The increased wood logging affects savannas' stability and the disappearance of the floral biodiversity which are consequently responsible for the accelerated degradation. This is an alarming situation which enhances the progress of desert and the loss of biodiversity in the guinea savanna of the Adamawa Region, Cameroon. It is advocated that a concerted effort between the government and the local population should be established to protect and save the biodiversity in the guinea savanna of the Adamawa Region, Cameroon.

Key words: Cameroon, impact, wood logging, distribution, biodiversity.

INTRODUCTION

The biodiversity is often used as a contracted shape of the biological diversity (Ndam, 1998; China et al., 2003). It groups together the generic and specific diversity, the populations and ecosystems and bases itself on the specific wealth and the relative abundance of the species. This biodiversity is actually endangered by the wood logging phenomenon which took an unequalled scale a quarter of century ago in the African savannas leading to the accelerated degradation of the natural resources which constitute the productive basic capital. In the Adamawa Region of Cameroon, several authors thought that the causes of the transformation and the degradation of the guinea savanna could be due to overgrazing, over-population led by human migration from the Far North region of Cameroon, agriculture and exploitation of wood by the local population (Rippstein, 1985; Yonkeu, 1993; Ndjidda, 2001; Tchotsoua, 2006). In the North-Cameroon, it has been asserted that the regression of the forest is due to the combined effects of wood logging, bush fire and overgrazing (Ntoupka, 1994, 1998). In Cameroon, the impact of wood logging on the distribution of the floral diversity is well known in the Southern part (Sonké, 1998; Guedje, 2002; Zacfack, 2005), but in the guinea savanna of Adamawa which is intermediate to the forested south and the Sahelian North, there is a paucity of information on the wood logging activities. Chouaibou (2006) reported the distribution of *Parkia biglobosa* in the district of Ngaoundéré which is the capital of the Adamawa Region, Cameroon; however, this region is among those that are threatened by the anthropological wood logging, bush fire

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and overgrazing.

Since the signing of the conventions on the presser-vation of the biological diversity and the use of biological resources in a long-lasting way in 1992 in Rio de Janeiro, Brazil, these conventions are yet to be implemented in our sub-Saharan guinea savannas, where many of the plant species are either cut or harvested by men for several uses. Thus, the present study was carried out to characterize the different plant formations and to estimate the impact of wood logging on the floral diversity in the guinea savanna zone of Ngaoundéré District, Adamawa Region, Cameroon.

MATERIALS AND METHODS

Study area

The study was undertaken in ten (10) villages namely: Béka Hooseré, Onaref, Wakwa, Tizon, Beskewal, Ngaohora, Borongo, Dang, Darang and Mban-Mboum all located in the Ngaoundéré district of the Adamawa Region, Cameroon (Figure 1). These villages are located at about 10 km for the shortest and 60 km for the farthest distance from Ngaoundéré the capital city of Adamawa Region, Cameroon. Ngaoundéré is located at latitude 7° 19' N and longitude 13° 34' E. Its population was estimated at about 230,000 inhabitants in 2001 (Tchotsoua, 2006) with an increase rate of 2.81% per annum. The main ethnic groups are the Fulbés, Mbororos, Gbayas, Mboums, Dourous, Yemyems, Hausas and the Koutinés. The economic activities of the local inhabitants are mainly animal husbandry and land farming. The soil of the area belongs to the geo-morphological domain of the plateau of Adamawa. They are characterized by sedimentary, volcanic, granitic and metamorphic rocks.

The vegetation of the Adamawa corresponds to a typical Sudano-guinea savanna constituted with shrubby, arborescent and woody savannas. These savannas are dominated by *Daniellia oliveri* and *Lophira lanceolata* (Letouzey, 1986). The precipitations are maximal in August and practically null from November to February. The hygrometric is maximal in August with a monthly average humidity of 81.38%.

Choice of the different wood logging zones in the guinea savannas of Adamawa Region, Cameroon

To choose the different wood logging, interviews were conducted with group of persons. The prospections with the population in the site were made. The types of wood logging in the savannas de-pended on the degree of accessibility to the site (absence or proxi-mity to easy access road), the distance to the village (0 to 0.5, 0.5 to 1, 1 to 2, 2 to 4, 4 to 6, > 6 km) and the percentage of the wood cut. At the end of prospection, four types of wood logging were selected:

i) Pilot or witness logging (T_0): made up with natural formation where the estimated percentage of wood logging is less or equal to 10%. They are generally protected areas by the inhabitants;

ii) Weak logging (T_1): vegetation where the percentage of wood logging is between 11 and 25%;

iii) Average logging (T_2): vegetation where the percentage or wood logging is between 26 and 50%;

iv) Complete or total logging (T_3): vegetation where more than 50% of woods are cuts.

Experimental technique

The point-centered quarter (PCQ) technique described by Farid et al. (2006), Kevin (2007) and Tchobsala (2010, 2011) was used in this study. This technique consisted in choosing a direction at random in the savannas under study (Figure 2).

Experimental design

The study was a split-plot design with 3 factors (shrubby savanna, arborescent savanna and woody savannas) (Table 1). The pieces were numbered from 1 to 12, delimitated by numbered cement terminals or wood stakes. One hundred and twenty sites (3 types of savannas × 4 types of cuts × 10 villages) were selected with 30 sites for each treatment.

Data analysis

Calculations of relative frequency, relative density, relative dominance and relative important value of the species

Calculation of the relative frequency (Fr):

Fr (%) = $\frac{A}{B} \times 100$, with A = number of the statements containing species; B = total number of the statements.

Calculation of the relative density (Dr):

Dr (%) = $\frac{C}{D} \times 100$, with C = number of individuals of a species; D = total number of the individuals encountered on a considered surface.

Calculation of the relative dominance:

Dre = $\frac{Sb}{Sbt} \times 100$, with 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 (≥ 5 cm) above the ground level by hectare (m^2/ha).

Calculation of plant recovery rate:

The ligneous place setting (DC = canopy cover) of individual ligneous plants or of the population by hectare can be calculated as follows: DC = r^2, representing the area of projection of the foliage expressed, where m^2 (r = the averages horizontal distance of the trunk at the extremities of branches. DC (ha^{-1}) = the sum of sur-faces (r^2) covered by the foliage of all the ligneous plants by ha, expressed in percentage (%) of total ligneous place setting on an hectare.

Calculation of the important value of curtis (IV):

IV (%) = Fr + Dr + Dre, with Fr = relative frequency, Dr = relative density and Dre = relative dominance. The (IV) varies between 0 and 300%.

Analysis of species distribution, species abundance and species dispersal

To analyze the distribution of species abundance, the models of

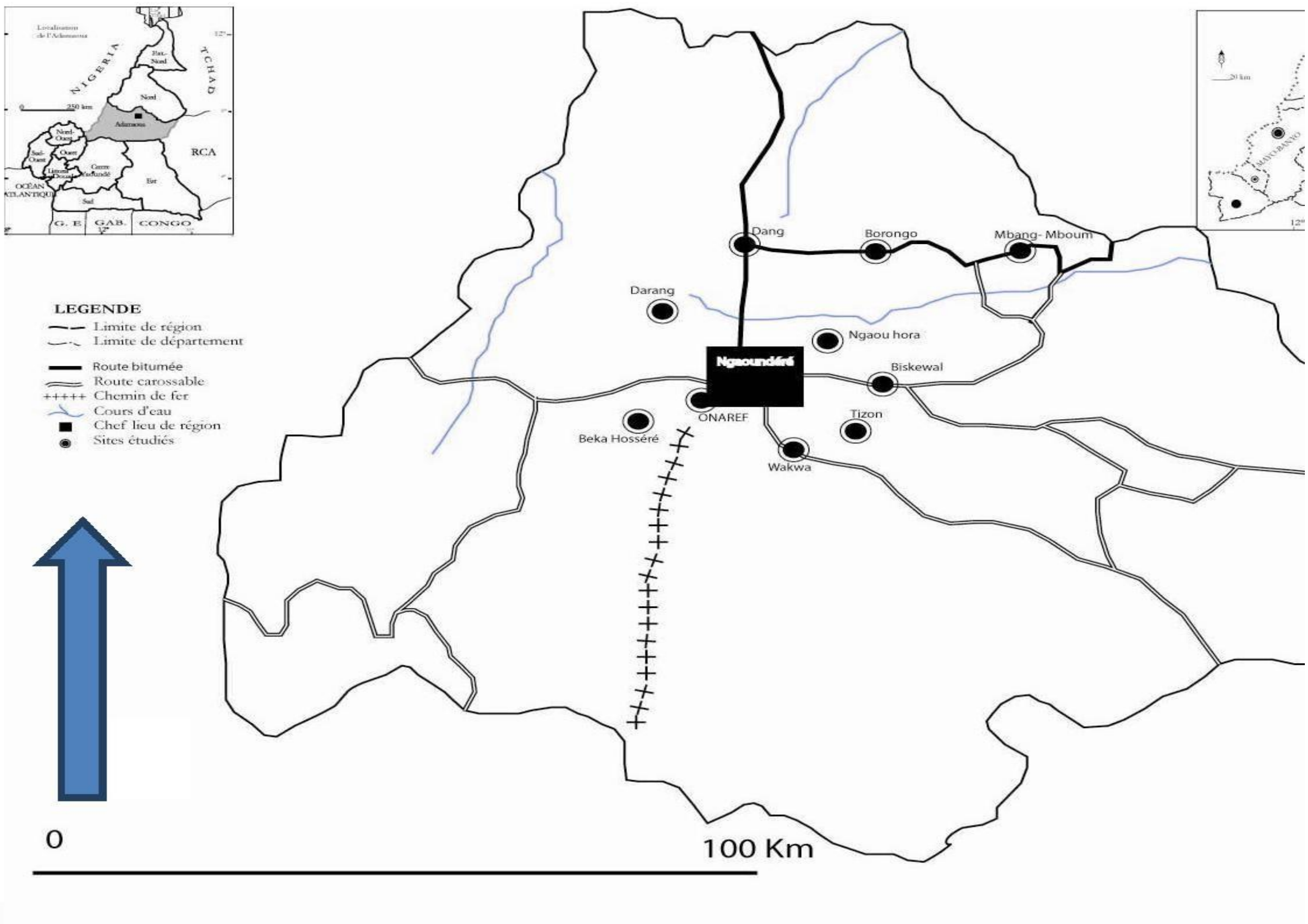

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Figure 1. Map of study area.

Pichod-Viale, 1993), while the model of Pareto (Frontier and Pichod-Vilae, 1993) used to analyze the structure of wet tropical dense forest was adopted to analyze the structure of the guinea savanna observed in the study which is a zone of transition between the wet tropical forest and the sahelian savanna. The species distribution is the distribution of the number of trees species by class

diameter. To study the horizontal organization of the plant communities, we used the dispersal parameter of all the individuals of the community. The closest neighbors method described by Clark and Evan (1954) was used to analyze the dispersal of all the population. This method allows specifying the way and the degree of remoteness of the random distribution of individuals of a given population.

The ratio R is used

$R = r_{ob}/r_{at}$-r_{ob},

with r_{ob}, as the av
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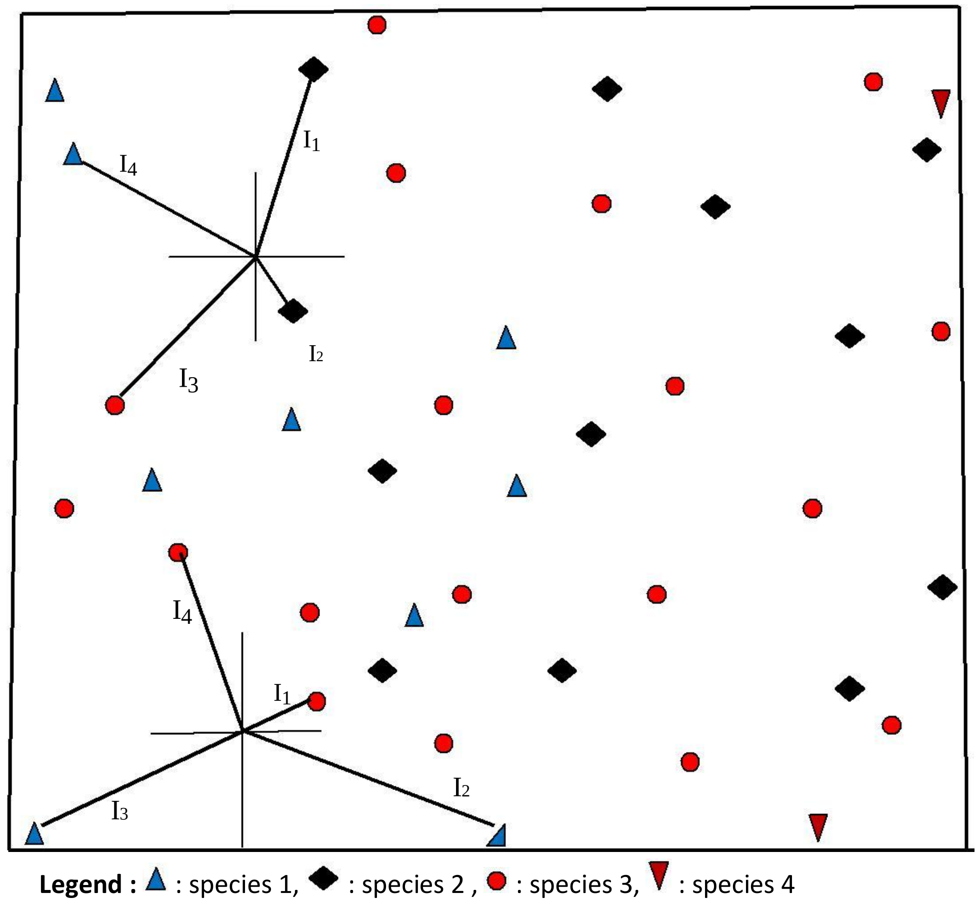

Figure 2. Point-centered quarter (PCQ) technique.

Table 1. Experimental design.

	Village									
S/N	**DAN**	**BEK**	**ONA**	**BOR**	**WAK**	**TIZ**	**NGA**	**BES**	**DAR**	**MBA**
1	SbT2	SaT3	SbT0	SaT3	ScT1	SaT0	SaT0	SaT2	ScT1	SbT2
2	SbT3	SaT0	SbT1	SaT2	SbT0	ScT2	ScT0	ScT2	SbT0	SbT1
3	ScT3	SbT3	SaT2	ScT0	SaT0	ScT0	ScT3	ScT3	SbT2	SaT1
4	ScT1	ScT2	ScT1	ScT0	ScT3	SbT2	ScT3	SaT3	SbT2	ScT3
5	SaT2	ScT1	SaT3	ScT1	SaT1	SaT3	ScT2	SbT0	SbT1	SbT3
6	ScT3	SbT1	SaT0	SaT0	SaT1	ScT0	SaT0	ScT2	SbT0	SbT3
7	SaT1	SbT3	SaT1	SaT3	ScT2	SaT2	SbT1	ScT1	SbT1	SbT3
8	SbT1	SbT0	SbT1	SbT3	ScT1	SbT1	SbT3	ScT0	ScT3	SaT2
9	SaT2	SaT3	SaT1	SaT2	ScT0	ScT0	ScT2	ScT3	ScT2	ScT0
10	SbT2	ScT0	SaT1	ScT3	SbT1	SaT1	SbT0	SbT3	SaT0	ScT2
11	ScT2	SaT0	SbT3	SbT0	SbT2	SaT0	SaT2	SaT1	SbT0	SbT2
12	SaT2	SbT0	SbT1	SbT3	SaT0	SbT2	SaT1	SaT3	SaT3	ScT1

Key: BES, Beskewal; BEK, Beka; ONA, ONAREF; BOR, Borongo; WAK, Wakwa; TIZ, Tizon; NGA, Ngaouhoura; DAR, Darang; DAN, Dang; MBA, Mbang-Mboum; Sa, shrubby savannas; Sb, raised savannas; Sc: wooded savannas.

If R = 1, the distribution is random, If
R < 1, the distribution is grouped,
If R > 1, the distribution is over-scattered.

The statistical difference between r_{at} and r_{ob} can be appreciated by using the formula $C = (r_{ob}-r_{at}) / \partial r$, $t = 0.26136Nd^{1/2}$, with ∂r as the standard error on the average distance observed in the case of a

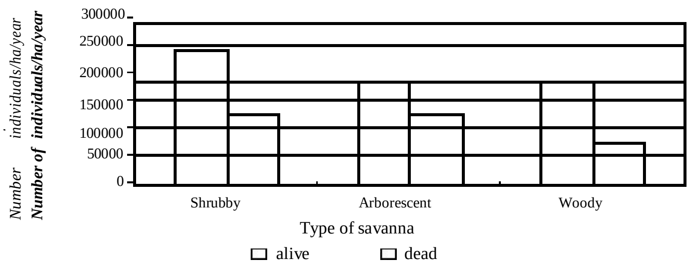

Figure 3. Biological state of the different plant formations in Ngaoundéré environs, Adamawa Region, Cameroon.

random distribution, d = the density, N = the number of individuals. The species dispersal concerns the individuals of the same species. The analysis of the distribution of the individuals of the same species within the inventories was made by the "run test" method (Siegel, 1956). We considered the value (1) for the pre-sence and the value (0) for the absence. "Run test" examines the distribution of the species along the transect, allows to determine if we observe more or less sequences "run" than in the case of a random distribution. Significance levels were considered at $P \leq 0.05$, $P \leq 0.01$ and $P \leq 0.001$.

RESULTS

Characterisitics of the different plant formations in Ngaoundéré and environs

In whole, three types of plant formations were observed in the area: the shrubby, arborescent and woody savannas. The number of trees alive decreased from 241,860 trees/ha/year in the shrubby to 133,980 trees/ha/year in the woody savanna; however, the number of dead trees also decreased from 141,210 trees/ha/year in the shrubby savanna to 131,242 trees/ha/year in the arborescent savanna, but with a drastic decrease in the woody savanna. The mortality rate of these individuals is more important in shrubby and arborescent savannas. It is observed that in the three plant formations, the number of trees alive is almost twice the number of dead trees (Figure 3). This rate decreases in woody savannas. Indeed, shrubby and arborescent savannas undergo a strong pressure of wood cuttings and pastures.

Relative frequency, relative dominance, relative density and relative important values of the tree species in the different plant formations

Of all the 4,320 points of reading, *Hymenocardia acida* (58.01%) recorded the most important relative value. This species was the most important tree species in the savanna with a relative frequency of 18.54%, relative dominance of 8.56% and relative density of 30.96% (Table 3). *Lannea acida* (0.06%), *Carissa edulis* (0.05%) and *Mytragina inermis* (0.3%) had the least important values.

Relative frequency, relative dominance, relative density and relative important value of trees' genera in the different plant formations

Sixty two (62) genera were inventoried in the plant formations. The genera *Hymenocardia* (58.06%) had the most important relative value of all the genera encountered in the plant formations, while the genera *Antidesma* (0.07%) and *Mytragina* (0.03%) having the least values (Table 4).

Relative frequency, relative dominance, relative density and relative important value of the trees' families in the plant formations

Of the 34 families listed, Hymenocardiaceae (58.06%), Cesalpiniaceae (54.74%) and Annonaceae (28.38%) had the most relative important value, but Myrsinaceae (0.53%), Olacaceae (0.49%) and Tiliaceae (0.23%) families were sparsely found (Table 5).

Distribution of species abundance in the plant formations of Ngaoundéré environs

Figure 4 illustrates the rank- frequency of the distribution of the ligneous species in the plant formations of Ngaoundéré and environs. The most important species is *H*. *acida* (3134.4 plant individuals/ha/year) located on the vertical axis of the graph, while *C*. *edulis* and *M*. *inermis* were the least to be found in the plant formations of Ngaoundéré and environs located on the horizontal axis of the graph. The adjustment of this distribution in the model of Motumura gave a linear function of equation $\log_2 (y) = 8.6764 - 0.0895x$, with high significance ($P < 0.001$, $R^2 = 0.9515$). Where y is the frequency of the species (log N) and x its rank (log r).

Species distribution in relation to wood logging in the different plant formations

Table 2 describes the plant species distribution in relation to wood logging in the three types of plant formations studied. In shrubby and arborescent savannas, no significant difference was observed in both the number of live and dead trees between the different types of wood logging ($p \geq 0.05$), while in the woody savanna a significant difference was observed in the number of live trees between the different type of wood logging with an elevated number of trees (59070/ha/year) in T_2.

Distribution, density and recovery of the species according to the types of savannas and wood logging

Table 6 represents the results of distribution, density and recovery of the species in relation to the plant formations and wood logging. The distance between the individuals

Table 2. Distribution of trees species of the different plant formations in relation to wood logging/ha/year.

Plant formation	Type of Wood logging	Live trees	Dead trees
Shrubby Savanna	T_0	63,300	35,220
	T_1	63,360	34,980
	T_2	53,610	32,070
	T_3	61,590	31,710
	Total	241860	133980
Arborescent Savanna	T_0	46440	24360
	T_1	58020	35820
	T_2	62400	30660
	T_3	51990	35130
	Total	218850	125970
Woody Savanna	T_0	38010	19440
	T_1	43980	23280
	T_2	59070	23310
	T_3	45960	22560
	Total	187020	88590

Key: T_0 = Pilot or witness logging; T_1 = weak logging; T_2 = average logging; T_3 = total or complete logging.

varies from 3.77 to 5.54 m. There was no significant difference between the three types of plant formations and the various treatments ($p \leq 0.05$). The ratio R varies between 1.06 to 2.13 for shrubby savanna; 1.44 to 1.97 for the arborescent savanna and 1.15 to 2.18 for the woody savanna.

Distribution, recovery and density of the different types of plant formations in relation to distances from the villages surveyed

On the sites, the species were randomly distributed within 0.5 to 1 km (R = 0.99) (Table 7). They are grouped for the distances > 6 km (R = 0.91); 4 to 6 km (R = 0.93) and of 2 to 4 km (R = 0.71) and over-scattered for the distances of 0 to 0.5 km (R = 1.34) and of 1 to 2 km (R = 2.39) with regards to the villages.

Distribution, density and recovery of the species in the sites with easy access (T_3)

The recovery of trees is maximal in arborescent savanna with T_3 (1154.21 $m^2 ha^{-1} year^{-1}$) from 2 to 4 km of the villages. In the arborescent savanna, the farthest distance from the villages was characterized by encountering the big trees such as *D. oliveri* and *Cesalpinia* sp (25 to 60 cm of diameter) that are not cut by lumberjacks. These species have a very important recovery in order of 40 to 60 m^2 by individual. In the whole of the sites and according to the distances with regard to the villages, trees have average distances varying between 1.55 and 6.29 m, with R oscillating between 0.31 and 2.92 (Table 8).

Specific dispersal of the species in the various plant formations in Ngaoundéré and environs

The distribution of the species was observed inside every type of savanna with treatments. The species which were present at least 10 times in 360 points of reading were held for the analysis of the specific dispersal. Among these species, only 15 on 102 species were inventoried by the method of distance between the species and were held for the analysis of the gregariousness. A total of 82 species represented scattered or over-scattered distributions. The species which have a significantly grouped distribution ($p < 0.05$) were *Annona senegalensis* in T_1, T_2 and T_3; *H. acida* in T_2 and T_3 and *Psorospermum febrifigum* in T_1 in shrubby savanna. In the arborescent savannas, only *H. acida* represented a grouped distribution (T_1 and T_2) (Table 9).

DISCUSSION

In the three types of plant formations observed in Ngaoundéré and environs, we found 102 species classi-fied into 60 genera and 33 families. Three hundred and sixty one (371) stems.ha^{-1} were found alive in 2004 and 351 stems ha^{-1} in 2006. These results are similar to those reported by Thorgnang (2001) who listed 117 species into 80 genera and 37 families in the forest of Gawar. Our results are greater than those reported by Mahamat (1991) and Teicheugang (2000) who found 21 species and 11 botanical families in the National Park of Kalamaloué (4500 ha) and 75 species, 46 genera and 24 families in the forest reserve of Zamay, respectively. The majority of the species had a grouped distribution with high or very

Table 3. Relative frequency, relative dominance, relative density and relative important value of tree species in Ngaoundéré and envir ons.

S/N	Specie	FRe (%)	DRe (%)	Dr (%)	IV (%)	S/N	Specie	FRe
1	*Hymenocardia acida*	18.54	8.56	30.96	58.1	51	*Ficus sycomorus*	0.0
2	*Annona senegalensis*	13.47	8.17	6.74	28.4	52	*Flacourtia vogelii*	0.
3	*Piliostigma thonningii*	11.64	8.24	7.8	27.7	53	*Nuxia congesta*	0.1
4	*Daniellia oliveri*	4.4	17.4	3.09	24.9	54	*Combretum* sp,	0.1
5	*Terminalia glaucescens*	5.65	4.58	3.86	14.1	55	*Erythrina senegalensis*	0.1
6	*Entada africana*	4.14	6.61	1.9	12.7	56	*Neoboutonia velutina*	0.0
7	*Harungana madagascariensis*	4.47	2.32	4.18	11	57	*Maesa lanceolata*	0.0
8	*Ficus* sp.	0.07	0.03	7.06	7.16	58	*Albizia coriaria*	0.1
9	*Lannea* sp.	0.05	0.04	6.31	6.4	59	*Malacantha alnifilia*	0.2
10	*Terminalia macroptera*	2.38	2.44	0.76	5.57	60	*Psidium guajava*	0.2
11	*Psorospermum febrifigum*	2.22	1.38	1.51	5.11	61	*Ximenia americana*	0.1
12	*Syzygium guineense var guineense*	2.15	1.22	1.2	4.57	62	*Combretum glutinosum*	0.2
13	*Croton macrostachyus*	1.23	2.12	1.2	4.55	63	Indeterminate 1	0.0
14	*Syzygium guineense var macrocarpum*	2.01	1.05	1.12	4.18	64	*Carissa spanrium*	0.1
15	*Cussonia barteri*	1.62	2.07	0.43	4.12	65	*Terminalia sp,*	0.2
16	*Erythrina sigmoidea*	0.93	2.6	0.47	4	66	*Ficus platyphylla*	0.0
17	*Lannea chimperi*	1.2	1.89	0.48	3.57	67	*Strichnos spinosa*	0.1
18	*Cinera macrostachys*	0.37	0.14	2.57	3.09	68	*Senna alata*	0.2
19	*Lophira lanceolata*	1.09	0.7	1.29	3.08	69	*Ochna schweinfurthiana*	0.2
20	*Bridelia ferruginea*	1.13	1.1	0.82	3.04	70	*Nauclea latifolia*	0.1
21	*Parkia biglobosa*	0.44	2.43	0.16	3.03	71	*Pavetta crassipes*	0.0
22	*Allophyllus africanus*	1.44	0.65	0.79	2.88	72	*Ficus capreaefolia*	0.0
23	*Zanthoxylum zanthoxyloides*	0.14	2.34	0.07	2.55	73	Indeterminate 2	0.0
24	*Terminalia laxiflora*	1.02	0.67	0.8	2.49	74	*Strichnos innocula*	0.0
25	*Gmelina arborea*	0.21	2.1	0.04	2.35	75	*Psychotria psychotrioides*	0.0
26	Indeterminate 4	1.06	0.4	0.8	2.26	76	*Albizia lebbeck*	0.1
27	*Vitex madiensis*	0.28	1.72	0.22	2.22	77	*Paulinia pinnata*	0.0
28	*Albizzia zygia*	0.67	1.05	0.36	2.08	78	*Lonchocarpus laxiflorus*	0.0
29	*Vitex doniana*	0.76	0.94	0.38	2.07	79	*Eugenia poliensis*	0.1
30	*Steganotaenia araliacea*	1	0.5	0.52	2.02	80	*Flacourtia indica*	0.0
31	*Lanha golungensis*	0.32	1.42	0.27	2	81	*Ficus sur*	0.0
32	*Maytenus senegalensis*	0.81	0.79	0.35	1.95	82	*Senna spectabilis*	0.0
33	*Trikilia rocka*	0.86	0.63	0.41	1.9	83	*Margaritaria discoidea*	0.0
34	*Bridelia ndellensis*	1.06	0.28	0.52	1.86	84	*Landolphia heudelotii*	0.0
35	*Protea madiensis*	0.76	0.26	0.62	1.64	85	*Vitex simplicifolia*	0.0
36	*Hyphaene thebarca*	0.79	0.09	0.66	1.55	86	*Vitex* sp,	0.0

Table 3. Contd.

37	*Ekebergia senegalensis*	0.25	0.98	0.27	1.5	87	*Grewia* sp,	0.0
38	*Uapaca paludosa*	0.69	0.22	0.55	1.46	88	*Terminalia micrantha*	0.0
39	*Alchornea cordifolia*	0.14	0.96	0.15	1.25	89	*Jasmimum dichotomum*	0.0
40	*Vitellaria paradoxa*	0.39	0.52	0.33	1.24	90	*Ficus trichopoda*	0.0
41	*Oncoba spinosa*	0.07	0.79	0.34	1.2	91	*Grewia bicolor*	0.0
42	*Securidaca longepedunculata*	0.49	0.25	0.44	1.18	92	*Terminalia togoensis*	0.0
43	*Sporospermum senegalensis*	0.63	0.22	0.33	1.18	93	*Antidesma venosum*	0.0
44	*Allophyllus* sp,	0.21	0.18	1.14	1.14	94	*Lanea acida*	0.0
45	*Trema orientalis*	0.28	0.24	0.47	1	95	*Ficus thonningii*	0.0
46	*Ficus glumosa*	0.23	0.56	0.2	0.99	96	*Gardenia ternifolia*	0.0
47	*Acacia siberiana*	0.32	0.27	0.3	0.89	97	*Carissa edulis*	0.0
48	*Phyllanthus muellerianus*	0.35	0.12	0.4	0.88	98	Indeterminate 3	0.0
49	*Gardenia triacantha*	0.39	0.26	0.11	0.76	99	*Mytragina inermis*	0.0
50	*Ochna afzeli*	0.35	0.14	0.25	0.74		Total	10

Key words: Fre, Relative frequency; DRe, relative dominance; Dr, relative density; IV, Importance value of the species.

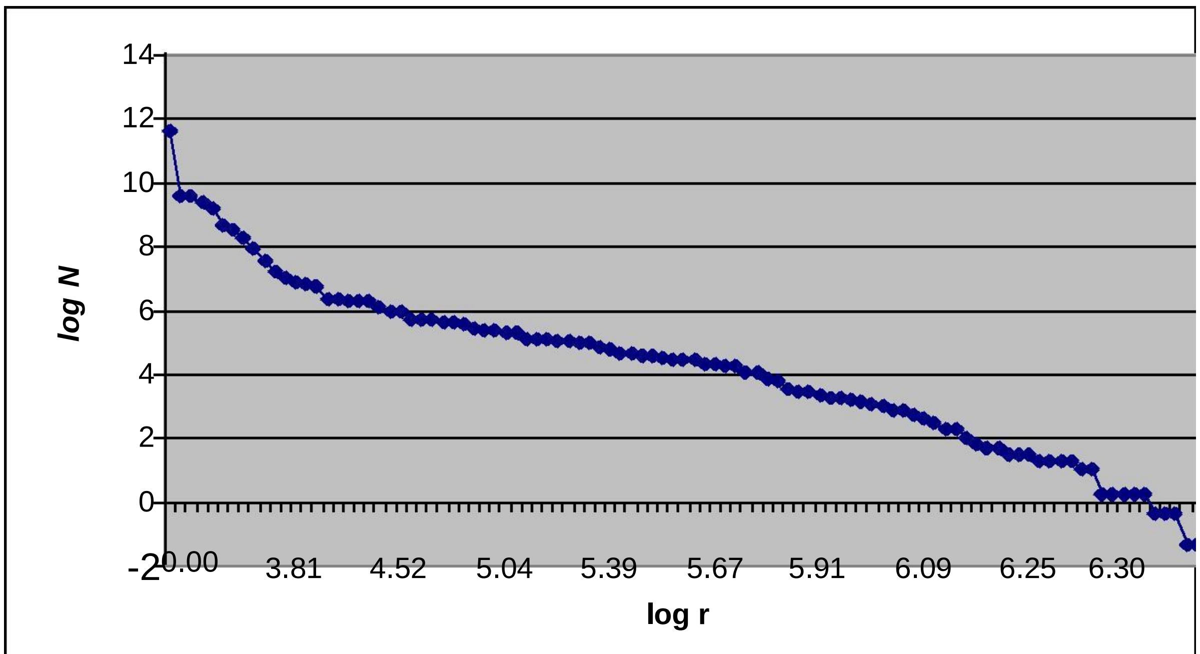

Figure 4. Diagram rank-frequency of the distribution of the woody species in the savannas.

Table 4. Relative frequency, relative dominance, relative density and relative important value of the genera in the different plant formations.

S/N	Genera	FRe (%)	DRe (%)	Dr (%)	IV (%)	S/N	Genera	FRe (%)
1	*Hymenocardia*	18.54	8.56	30.96	58.06	32	Indeternine 1	0.46
2	*Annona*	13.47	8.17	6.74	28.38	33	*Uapaka*	0.69
3	*Piliostigma*	11.64	8.24	7.8	27.68	34	*Neoboutonia*	0.02
4	*Daniellia*	4.42	17.4	3.11	25.11	35	*Vitellaria*	0.39
5	*Terminalia*	9.4	7.84	5.49	22.73	36	*Securidaca*	0.49
6	*Entada*	4.14	6.61	1.9	12.65	37	Indeternine 2	0.28
7	*Harungana*	4.47	2.32	4.18	10.97	38	*Acacia*	0.32
8	*Lannea*	1.27	1.93	6.83	10.03	39	*Phyllanthus*	0.35
9	*Ficus*	0.64	1.74	7.59	9.96	40	*Flacourtia*	0.39
10	*Syzygium*	4.16	2.27	2.32	8.75	41	*Gardenia*	0.41
11	*Psorospermum*	2.85	1.6	1.84	6.29	42	*Ochna*	0.63
12	*Croton*	1.28	2.61	1.23	5.12	43	*Strichnos*	0.16
13	*Bridelia*	2.19	1.38	1.34	4.91	44	*Lanha*	0.3
14	*Vitex*	1.16	2.81	0.62	4.59	45	*Voacanga*	0.16
15	*Erythrina*	1.01	2.79	0.69	4.57	46	*Senna*	0.35
16	*Cussonia*	1.62	2.07	0.43	4.12	47	*Maesa*	0.07
17	*Allophyllus*	1.6	0.82	1.52	3.94	48	*Carissa*	0.18
18	*Cinera*	0.37	0.14	2.57	3.08	49	*Nauclea*	0.23
19	*Lophira*	1.09	0.7	1.29	3.08	50	*Burkea*	0.25
20	*Parkia*	0.44	2.43	0.16	3.03	51	*Psidium*	0.21
21	*Albizia*	0.95	1.26	0.63	2.84	52	*Ximenia*	0.12
22	*Eugenia*	0.3	1.86	0.49	2.65	53	*Malacantha*	0.05
23	*Zanthoxylum*	0.16	2.34	0.07	2.57	54	*Psychotria*	0.02
24	*Gmelina*	0.21	2.1	0.04	2.35	55	*Grewia*	0.12
25	*Pavetta*	1.06	0.4	0.8	2.26	56	*Paulinia*	0.05
26	*Steganotaenia*	1	0.5	0.52	2.02	57	*Jasmimum*	0.02
27	*Maytenus*	0.81	0.79	0.35	1.95	58	*Lonchocarpus*	0.14
28	*Trikilia*	0.86	0.63	0.41	1.9	59	*Margaritaria*	0.07
29	*Protea*	0.76	0.26	0.62	1.64	60	*Antidesma*	0.05
30	*Hyphaene*	0.79	0.09	0.66	1.54	61	Indetermine 3	0.02
31	*Ekebergia*	0.25	0.98	0.27	1.5	62	*Mytragina*	0.02
							Total	100

Key words: Fre, Relative frequency; DRe, relative dominance; Dr, relative density; IV, relative important value of the genera.

Table 5. Relative frequency, relative dominance, relative density and relative important value of the families in the plant formations in Ngaoundéré a

S/N	Families	Fred (%)	DRe (%)	Dr (%)	IV (%)	S/N	Families	Fred (%)
1	Hymenocardiaceae	18.54	8.56	30.96	58.06	18	Rutaceae	0.14
2	Cesalpinaceae	16.43	27.08	11.23	54.74	19	Apiaceae	1
3	Annonaceae	13.47	8.17	6.74	28.38	20	Celastraceae	0.81
4	Combretaceae	10.71	8.41	6.46	25.58	21	Meliaceae	0.86
5	Euphorbiaceae	4.1	4.81	3.2	12.11	22	Sapotaceae	0.69
6	Clusiaceae	4.47	2.32	4.18	10.96	23	Proteaceae	0.76
7	Anacardiaceae	1.27	1.93	6.83	10.03	24	Aricaceae	0.79
8	Moraceae	0.63	1.74	7.59	9.97	25	Méliantaceae	0.25
9	Myrtaceae	4.37	2.34	2.54	9.25	26	Rubiaceae	0.66
10	Verbenaceae	2.06	5.13	1.21	8.39	27	Polygalaceae	0.49
11	Indeterminate 1	6.22	10.71	5.58	7.51	28	Apocynaceae	0.34
12	Hypericaceae	2.85	1.6	1.84	6.29	29	Ulmaceae	0.28
13	Fabaceae	1.09	2.79	0.69	4.57	30	Flacourtiaceae	0.39
14	Sapindaceae	1.7	0.99	1.55	4.25	31	Loganiaceae	0.16
15	Indeterminate 2	0.8	2.26	1.18	4.24	32	Myrsinaceae	0.07
16	Ochnaceae	1.72	0.89	1.61	4.22	33	Olacaceae	0.12
17	Araliaceae	1.62	2.07	0.43	4.12	34	Tiliaceae	0.12
							Total	100

Table 6. Distribution, density and recovery of the species in relation to the plant formation and types of wood logging.

Wood loggging	Shrubby savannas				Arborescent savannas				
	T_0	T_1	T_2	T_3	T_0	T_1	T_2	T_3	T_0
D	3.92	5.34	5.3	5.3	4.89	4.47	4.78	4.8	4.32
R	1.06	1.96	2.1	2	1.92	1.44	1.58	1.75	1.66
Re	458	399.6	370	314	625	561	1098	653.3	1153

Keys: D, Mean distance between the individuals (m); Re, recovery of the stems (m^2).$ha^{-1}year^{-1}$; R: ratio R of distance observed between the individuals of the co

Table 7. Distribution, recovery and density of the three types of plant formations in relation to the distances from the villages su

Parameter	Distance from the village				
	0-0.5	0.5-1	1-2	2-4	4-6
D	4.12	3.73	5.03	3	3.33
R	1.34	0.99	2.39	0.71	0.93
Re	587	560.8	956.2	659.2	723.7

Table 8. Distribution, density and recovery of the species in the sites to easy access.

Distance /village	Types of savannas	D	R	Re	Distance/village	Types of savannas	D
0-0.5	A	4.87	1.57	176.12	2-4	A	2.66
0-0.5	B	1.55	0.31	73.74	2-4	B	4.79
0-0.5	C	2.59	0.45	351.43	2-4	C	4.48
0.5-1	A	4.60	1.50	171.1	4-6	A	5.37
0.5-1	B	1.51	0.30	71.04	4-6	B	4.01
0.5-1	C	2.59	0.45	345.41	4-6	C	3.68
1-2	A	4.59	1.21	692.4	>6	A	3.06
1-2	B	6.29	2.92	357.93	>6	B	2.18
1-2	C	4.78	2.18	561.66	>6	C	2.01

Key: A, shrubby savannas; B, arbores cent savannas; C, woody savannas.

Table 9. Specific dispersal of the species in the various plant formations.

Scientific names	Shrubby savanna				Arborescent savanna				Woody	
	T_0	T_1	T_2	T_3	T_0	T_1	T_2	T_3	T_0	T_1
Allophyllus africanus	***	***								
Annona senegalensis	**	*	*	*	**	**	**	***	***	***
Cussonia barteri	***	***								
Daniellia oliveri	***	**	***		***	***	***	***	***	
Entada africana	***	**		***	***		***	***	***	***
Harungana madagascariensis		**	***	***	***	***		***	***	***
Hymenocardia acida	**	**	*	*	**	*	**	*	**	***
Piliostigma thonningii	**	*	**	**	**	**	**	**	***	***
Psorospermum febrifigum		*	***	***					***	
Syzygium guineense var guineense		***				***			***	***
Syzygium guineense var macrocarpum		***	***		***				***	***
Terminalia glaucescens	***	***			***	***	***	***	**	***
Terminalia laxiflora		***	***							
Terminalia macroptera		***			***					***
Soft butter tree		***					***			

Key: *significant ($p < 0.05$); **highly significant ($p < 0.01$); ***very highly significant ($p < 0.001$).

highly significance. These species are over-scattered in the outer-urban zone of Ngaoundéré because of the fragility of the ecosystems. However, our results are very different from those reported by Sonké (1998) who found 90 gregarious species in the reserve of the biosphere of Dja. The strong pasture are at the gregarious specie

In the peri-urban zone of Ngaoundéré, the women are the first to be responsible for wood logging activities which they use for energy and other culinary task. The organization of rural markets of the firewood constitutes a major threat to plant species in all the different plant formations in Ngaoundéré. In the peri-urban zone of Ngaoundéré, women are more involved in wood logging activities more than the loggers, local farmers and therapeutists. Mapongmetsem and Akagou (1997) showed that the situation of the firewood is already alarming in Adamawa and even worsened these recent years with the multiform economic crisis which Cameroon is passing through. This crisis involved people to have an increased quest for charcoal and firewood, thus increasing the rate of taking away significant quantities of wood from the natural formations. In addition to the firewood, peasants cut wood like non-woody forest products selectively.

The wild fruit-lofts like *Vitellaria paradoxa*, *Tamarindus indica*, *Syzygium guineense*, *Ximenia americana*, *Vitex doniana*, *S*. *guineense* and *Parkia biglobosa* are generally cut for human consumption. Gudjé (2002) reported that, the taking away of trees as not ligneous family products contributes to the destruction of vegetation cover. For the traditional pharmacopeia, *Piliostigma thonningii* and *Securidaca longepedunculata* are requested.

The local population appreciates *S*. *longepedunculata* for the treatment of rheumatisms; likewise pastoralists in the dry tropical zones use it to increase the availability of fodder at the end of the dry season and the rainy season. These pastoralists have a practice of cutting the highest branches, to lay them down on the ground and to place them at the disposal of their cattle and the smaller livestock (Ntoupka, 1999). The disappearance of the plant species mainly is due to the wood logging for heating and charcoal, the intensification of agriculture, the traditional pharmacopeia, the construction of the houses, the bee-keeping through wood used in the hives. Species like *H*. *acida*, *S*. *guineense* spp, *D*. *oliveri*, *Terminalia* spp, *Strychnos spinosa* and *P*. *biglobosa* are over-exploited. The distribution of the species according to plant formations and the distances with regards to villages showed that the difficulty of access was one of the reasons. It can be noticed that the species are over-scattered in shrubby savannas (0 to 0.5 km), arborescent (> 6 km) and afforested (1 to 2 km).

With regards to recovery of the plant species, T_3 was observed having the highest activities of wood loggings which are very important; this consequently influenced the rate of regeneration which was also high. The sum of the recovery of the big trees and the regeneration of trees after logging is at the origin of the biggest recovery of trees in the outer-urban savanna of Ngaoundéré. However, the recovery of the species by hectare is more important in woody savanna.

CONCLUSION AND RECOMMENDATIONS

Wood logging activities represents a direct effect on the state of the individuals and consequently imposes an over-scattered distribution of the species in the different types of plant formations according to treatments. The number of the wood logging plant individuals was very important in shrubby savannas and afforested with the treatment T_3. *H*. *acida* has an important value in the Ngaoundéré savannas. It is the best regenerating plant in the vegetation and resists bushfire and wood logging in the guinea savanna of Adamawa. To manage our savannas, it is important to limit the wood logging around villages because of the over-dispersion and disappearrance of the endemic multi-purpose species in the zone. If the population does not become aware of wood logging activities and managing their forest heritage, we shall arrive at a total eradication of the gregarious endemic species of the region of Adamawa. It would be desirable that in the Sudano-Sahelian zone, victim of wood's logging begins to practise annual and seasonal wood logging rotation according to the types of plant formations. High practice of the wood logging should be sanctioned by the population itself and by the government. Other studies on wood logging activities should be carried out in the northern zone of Cameroon.

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