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Full Length Research Paper

Impact of wood cuts on the structure and floristic diversity of vegetation in the peri-urban zone of Ngaoundere, Cameroon

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The main objective of this paper was to study the impact of various wood cuts on the structure and the floristic diversity of the savannas, and to seek for durable solutions against deforestation during a four year investigation. An inventory of the woody layer on 120 sites areas of 50 × 50 m showed that savannas have structures in "L". This structure translate the state of the degradation of the vegetation. The floristic diversity showed that the characteristic species of the degradation of the shrubby savannas area are *Hymenocardia acida, Piliostigma thonningii* and *Annona senegalensis*, and those of the wooded savannas are *Daniellia oliveri* and *Cesalpinia* sp. It was also shown that highest wood cuts are depressive for the stability of the savannas and for the disappearance of the vegetable biodiversity. Consequently, they are responsible for the acceleration of the degradation and the alarming installation of the desert in wet savannas of Ngaoundéré. A measure of co-administration between the government and the bordering population must be therefore encouraged to protect and safeguard the anthropized vegetation.

Key words: Wood cuts, structure, floristic diversity, degradation, reconstitution, Cameroon.

INTRODUCTION

The impact of wood cuts on African savannas became increasingly extensive since a quarter century, accelerating therefore the degradation of the natural resources (Ndjidda, 2001). The satellite pictures of occupied grounds in the the wet savannas of the Adamaoua's region in Cameroon showed that the surface passed from 120 ha in 1951 to 1256 ha in 2001, that is, a mean rate of increase of 22 ha per year. This surface would be 1454 ha in 2010 by extrapolation. The surface of shrubby savannas decreased approximately 10.8% compared to the year 1951 due to the creation of vast fields of corn production in the North of Ngaoundéré; a major city located in that region, the appearance of a significant agriculture in the South of the city, the plantations of the corn mill company occupying 1548 ha. The galleries along the roads and near villages are the most cut by the population (Tchotsoua, 2006).

Their surfaces passed from 1844 to 784 ha between 1951 and 2001; that is, a reduction of more than 50%. Rippstein (1985), Yonkeu (1993) and Tchotsoua (2005) worked on the degradation of the wet savannas of Adamaoua by overgrazing, overpopulation, agriculture, and exploitation of woods for cooking by the local population. In North Cameroon, Ntoupka (1994, 1998) investigated the regression of the forest by the combined effects of wood cuts, bush fire and overgrazing. Mbolo (2005), Zapfack (2005), Guedje (2002) and Sonké (1998) worked on the impact of wood cuts on the structure and floristic diversity in South Cameroon's vegetation. These studies showed that wood cuts significantly affect the structure and floristic diversity of vegetation. But in the wet savannas of Ngaoundéré, no work is yet carried out on the impact of wood cuts on the structure and floristic diversity of the vegetation, except that of Chouaibou (2006) who worked on the structure of *Parkia biglobosa*

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in the district of Ngaoundéré. However that area is among those seriously threatened by anthropic activities (wood cuts, bush fire, overgrazing, etc.).

This study will be devoted to the impact of different wood cuts on the structure and floristic diversity of vegatation in general, and specifically to the modification of the structure of the vegetation, floristic diversity, and methods of conservation of the vegetables.

Description of the study area

The study was conducted in the subdivision of Ngaoundéré including ten villages namely: Béka Hooseré, Wakwa, Tizon, Beskewal, Ngaohora, Borongo, Dang, Onaref, Darang and Mbang- Mboum (Figure 1). The choice of these villages was related to their proximity to the capital of the Adamaoua region (Ngaoundéré), and to the regional weather station. They are located in an aureole of approximately 900 m² around Ngaoundéré (7°14'N, 13°34'E) except Mbang-Mboum, located some 60 km far away. In 2001, the population of Ngaoundéré was approximately 230 000 inhabitants, with a rate of increase of 2.81% (Tchotsoua, 2006). The main activities are breeding and agriculture. More than 53% of the rural population practises traditional agriculture of subsistence (millet, cassava, sorghum, potato, corn, yam, groundnut, tomato, etc). The area, however knew an industrial crop in the years 1970 with the creation of some agro-alimentary firms. The grounds are characterized by sedimentary, volcanic, granitic, and metamorphic rocks, including: Tropical ferruginous ferralitic grounds (Humbel, 1971); modal slightly ferralitic grounds (Martin and Segalens, 1966); luvisol and ferrisol, telvic or acrisols and nitosols grounds which develop on old basalts and occupy the major part of the plate; typical strongly unsaturated grounds with pseudo particles; altered ferralitic grounds; mineral rough grounds (lithosols and rankers) (Humbel, 1971); etc.

The vegetation of the region of Adamaoua corresponds to a typical soudano-guinean sector with an active aspect from shrubby to raised savannas. These savannas are dominated by *Daniellia oliveri* and *Lophira lanceolata* (Létouzey, 1968, 1986), species that are prolific with the favour of the zooanthropic factors like farming fires, pastures and clearings. In the fallow and around the villages, this formation has the same aspect with an herbaceous layer dominated by many andropogoneas (*Hyparrhenia spp., Andropogon spp.* …) and paniceas (*Panicum spp*....) which can reach at the end of the vegetative cycle up to 2 to 3 m in these zones. Abundant precipitations occur between June and August, and are null from November to February. The atmospheric relative humidity is maximum in August with a monthly average of 81.38%. The maximum monthly average for the rainy season varies from 68.32% (April) to 81.8% (August) while the minimal for season is between 3.12% (February) and 6.3% (November). The population mainly uses *Hymenocardia acida, Piliostigma thonningii, Terminalia glaucescens, Guineense Syzygium spp, L. lanceolata, Harungana madagascariensis* and *Annona senegalensis* etc, as cooking energy, *Terminalia macroptera, Terminalia glaucscens, Lophira lanceolata* and *Sysygium guineenses VAr macrocarpum* etc for coal, *Vitellaria paradoxa, Tamarindus indica, Syzygium guineense, Ximenia americana* as comestible wild fruits (Tchosoua et al*.,* 2000 and Mapongmetsem, 2005), *Piliostigma thonningii* as forage for the ruminants during dry seasons (Tchobsala, 2003), *D. oliveri, T. glaucescens, T. will macroptera, Terminalia laxiflora* and *Uapaca togoesis* for wood service, and *D. oliveri* and *X. americana* for bee-keeping.

MATERIALS AND METHODS

Choice of the different wood cuts in the savannas

To determine the degree of wood cuts, the method of “Quadrants Centered on a Point" was used. 200 plants were therefore chosen on areas of 2500 m² and the sites grouped according to their degrees of wood cuts. Sequences from 0 to 10%; 11 to 25%; 26 to 50%, and 51 to 100% were retained for the study. The choice of sites took into account the access to the wooden resource and the distance from the village (0 to 0.5 km; 0.5 to 1 km; 1 to 2 km; 2 to 4 km; 4 to 6 km and > 6 km).

Percentages of wood cuts permitted to determine four types of wood cuts (treatments) in the peri-urban zone of Ngaoundéré are:

1. Pilot or witness cuts (T0): Made up with natural formation where the percentage of wood cuts is less or equal to 10%. These are generally protected areas.
2. Weak cuts (T1): Vegetation where the percentage of wood cuts is between 11 and 25%.
3. Average cuts (T2): Where the percentage of wood cuts is between 26 and 50%.
4. Complete or total cuts (T3): Vegetation where more than 50% of woods are cut.

Experimental device

The experimental device installed in 2004 was a split-study with 3 factors (shrubby savannas, raised savannas and wooded savannas) (Table 1). The pieces were numbered from 1 to 12, delimitated by numbered cement terminals or wood stakes. 30 sites were selected for each treatment; that is 120 sites in total (3 types of savannas × 4 types of cuts × 10 villages). A compass was used for a good orientation on the study area

Methods of data collection and analysis of vegetation

The heights and diameters of the vegetation were measured by a team of five persons: The pointer, three assistants and a guide who plays the role of coordinator and monitor. The team sweeps each tailboard of 50 × 50 m one after the other. The species are identified in local language by the guides and thereafter compared to those of the herbaria of Wakwa (Adamaoua) and the schools of fauna of Garoua and Yaounde. The species that were not identified in these herbaria are sent in the National Museum of Natural History of the Institution Smithsonian and Missouri Botanical Garden in the United States of America.

The readings of the vertical stratification were taken in the

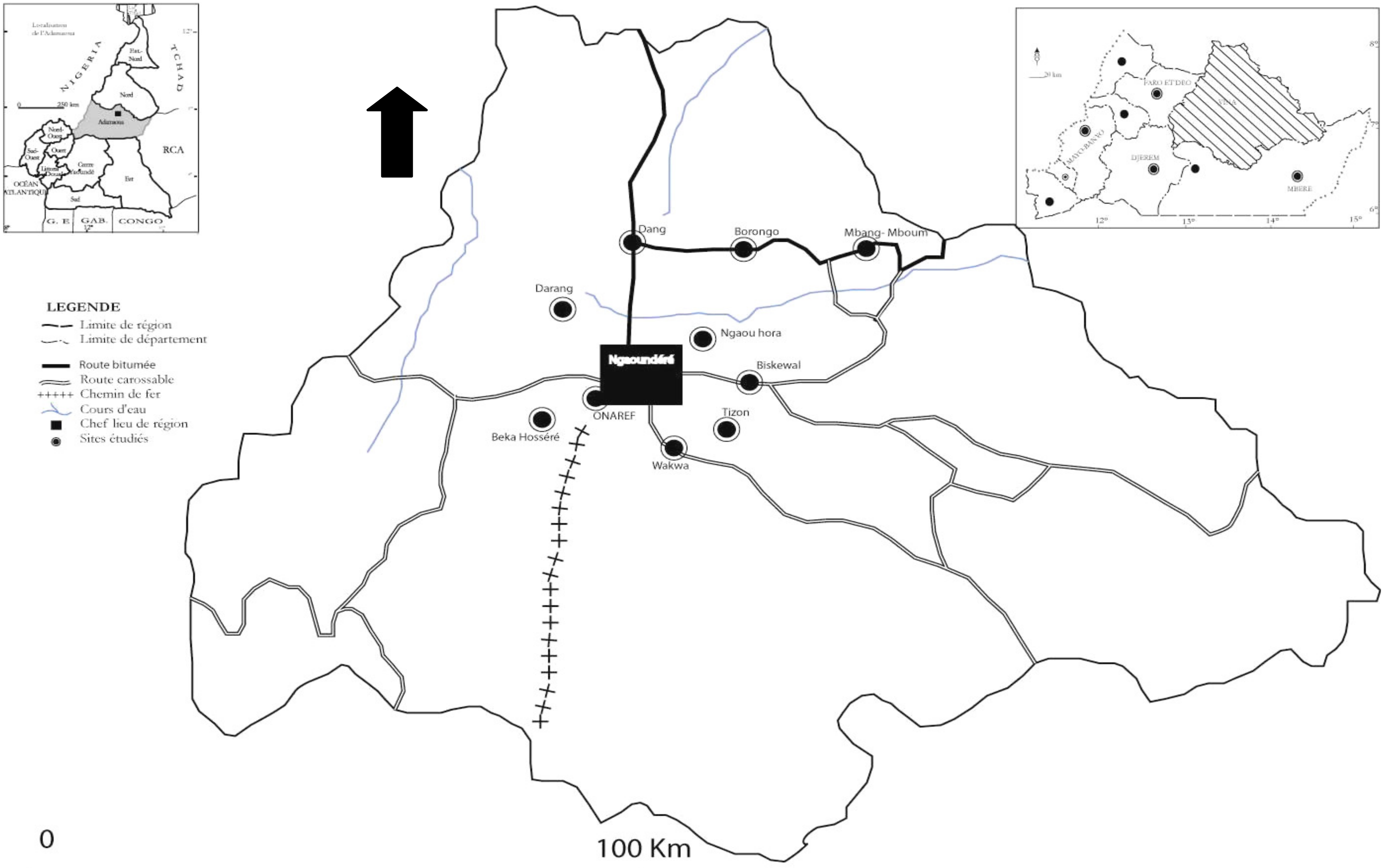

Figure 1. Study area.

Table 1. Experimental device**.**

N°	Bes	Beka	ONA	Bor	Wak	Tiz	Nga	Dar	Dan	Mba
1	SaT3	SaT3	SaT2	SaT3	ScT0	SaT0	SaT3	SbT0	ScT1	ScT0
2	SaT2	SaT2	SaT3	ScT3	ScT3	SaT1	SaT2	SaT0	ScT2	SaT0
3	ScT3	SaT0	ScT0	SbT1	ScT2	SaT2	SaT1	SaT1	ScT3	SbT0
4	ScT2	ScT0	ScT3	ScT2	SbT1	SaT0	SaT0	ScT0	ScT0	SbT2
5	SbT1	SbT3	SaT0	SaT1	SbT0	SbT1	SbT0	SaT2	SaT0	SbT3
6	SbT3	SbT2	SbT0	SbT0	SbT2	SbT0	SbT2	SaT3	SaT2	SbT1
7	SbT0	SbT0	SbT3	SbT3	SaT1	SbT3	SbT1	ScT3	SaT1	SaT3
8	SaT0	ScT1	SbT1	ScT0	SaT2	SbT3	SbT3	SbT3	SaT3	SaT2
9	ScT0	ScT3	ScT1	SaT0	SaT0	ScT3	ScT3	SbT2	SbT3	SaT1
10	SaT1	ScT2	ScT2	ScT1	SbT3	ScT2	ScT2	SbT1	SbT0	ScT3
11	SbT2	SaT1	SbT2	SaT2	SaT3	ScT1	SbT1	ScT2	SbT2	ScT2
12	ScT1	SbT1	SaT1	SbT2	ScT1	ScT0	ScT0	ScT1	SbT1	ScT1

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.

heights' sequences of: 0-50 cm; 50-130 cm; 130-200 cm; 200-400 cm; 400-600 cm; 600-800 cm; 800-1000 cm; 1000-1200 cm; 1200-1400 cm; 1400-1600 cm; 1600-1800 cm, 1800-2000 cm, 2000-2500 cm and >2500 cm. The measurements of the horizontal stratification related to the diameters of the trees were taken according to the following sequences: 0-5 cm; 5-10 cm; 10-15 cm; 15-20 cm; 20-25 cm; 25-30 cm; 30-35 cm; 35-40 cm; 40-50 cm; 50-60 cm; 60-80 cm; 80-100c m; 100-120 cm, 120-150 cm, 150-200 cm, 200-250 cm and > 250 cm.

The heights were measured on all alive and cut species on areas of 50 x 50 m^2 according to a cross or linear transect in each village. For highest trees with more than two meters, a clinometer was used. The numbers of cut and alive trees were taken to evaluate the death rate of the flora per unit of area. Measurements of the circumferences at heights of 1.30 cm were taken to evaluate the cut susceptibility of the species. The woody cover of each species was measured starting from the surface of projection of the foliages on the ground using a decametre. The measurements of natural regeneration were taken on the seedlings heights less or equal to 50 cm from the ground in the rainy season (Tchobsala, 2003).

The analysis of the results was done by several methods:

1. The profile of stratification suggested by Amougou (1986) for tropical areas was adopted:

a. Layer A or higher arborescent layer, made up with very high trees (35 m and more);
b. Layer B or average arborescent layer, whose heigths are between 25-35 m, forming a more or less continuous and dense canopea;
c. Layer C or lower arborescent layer, constituted with 15-25 m heights trees;
d. The layer D or shrubby layer, made up with small trees and shrubs less than 15 m height.

For these arborescent layers, it was necessary to add the herbaceous layer or layer E which can reach 3 m height, constituted of epiphytes and lianas.

The combination of these 4 layers offers 15 types of stratification with a single possibility of complete stratification, 4 possibilities with 3 layers, 6 to 2 layers and 4 mono-stratified possibilities. Moreover, each one of these layers can be subdivided into sub-layers which are indicated from the top to the bottom by numbers 1, 2 and 3 affected by letters indicating the layers. For example, a sub-layer D can be presented as follows:

D1: 10-15 m, small trees;
D2: 5-10 m, shrubs;
D3: 5 m and less, shrubs or suffruteux.

2. Richness of the settlement: It corresponds to the relationship between the number of individuals and species;
3. The index of diversity of Shannon (1949) in Legendre and Legendre (1984) is given by:

$$ISH = - \sum(Ni/N) \log_2 (Ni/N)$$

where N_i is the number of species i and N the total number of the species.
3. Equitability (EQ) of Piélou in Frontier and Pichod-Viale (1993) is given by:

$$EQ = ISH/\log_2 N.$$

It corresponds to the relationship between the observed diversity and the maximum possible diversity of the number of species N.
4. The index of diversity of Simpon is given by:

$D = 1/\sum (Ni/N)^2$ (Begon et al., 1987)

or simply

$D = \sum (Ni/N)^2$ (Colinvaux cit.Sonké, 1998).

5. The absolute density (Ni) of a taxon corresponds to the total number of the stems of this taxon per unit of area.
6. The relative density (Dr.) is the relationship between the number of individuals of a species and the total number of individuals of all the species met on an area multiplied by 100.
7. Terrian surface (St) of species i is the sum of the terrian surfaces of all representant of the species.
8. The relative predominance (Pr.) of species i is the ratio of its terrian surface to the total terrian surface of the settlement
10. The absolute frequency (F) of species i is the number of statement containing this species.
11. The relative frequency is the number of the statements containing this species to the total number of the statements multiplied by 100. According to Braun- Blanquet (1932), the indices

Table 2. Indices of relative frequency.

Symbols	Indices	Type of death
I	0- 20	Accidental species
II	21-40	Additional species
III	41-60	Rather frequent species
IV	61-80	Frequent species
V	81-100	Very frequent species

Table 3. Delimitation of the layers according to the maximum diameter reached.

Categories of species	Diameter	Category
Arborescent species		
Large (wooded savannas)	100 cm exceed	A
Averages (raised savannas)	Ranging between 50 and 100 cm	B
Small (raised savannas)	Ranging between 20 and 50 cm	C
Shrubby species		
Large (shrubby savanna)	Ranging between 10 and 20 cm	D
Averages (shrubby savanna)	Ranging between 3 and 10 cm	E
Small (shrubby savanna)	Ranging between 0 and 3 cm	F

of this frequency is summarized in Table 2. The delimitation of the layers was made on the basis of maximum diameter reached (Table 3), using the scale of Letouzey (1986) and Volter (1993), and making some modifications to the various categories of species. The species were classified in two groups (arborescent and shrubby) and, various categories were retained within these groups.
12. The principal phytogeographical types are those admitted for Africa (Lebrun, 1947). The recognized types are the species with broad geographical distribution including:

a. Cosmopolitans (Cos): Species found throughout the whole world;
b. Pantropicales (Pan): Species known in Africa;
c. Tropical-American and Asian;
d. Afro American (AA): Species extended in tropical Africa and America;
e. Paleotropical (Pal): Species present in Africa and tropical Asia, Madagascar and Australia;
f. Afromalgaches (AM): Species common to the islands of Madagascan and central African areas;
g. Multi-regional African (PRA): Species whose surface of distribution covers several floristic African areas or two floristic areas which are not in contact.
We also have guineean and soudano zambezian species (G-sz) species including:

a. Sub-Omni guineo-congolese (GC): Species presented in all the floristic guinean area;
b. Central (CG): Species whose surface of distribution goes from Cameroon to the Democratic Republic of Congo;
c. Western guineans (WG): Species which are widespread of Western Africa in Western Cameroon;
d. Cameroon-Congo (CaCo): Species only found in the Cameroonian solid mass and the Congolese basin;
e. Cameroon-Gabon (Ca-Gab): known species only of the forest solid mass Cameroon-Gabon-Mayumbe.
f. Cameroon (Camwood): Species only found in Cameroon.

13. According to Lebrun (1947), the biological type of a species is the whole of the anatomical and morphological devices which characterize its vegetative apparatus and make conspicuous its habitat and its aspect independently to its systematic position and adaptation to the environmental conditions. Biological types according to the classification of Raunkiaer (1934), adapted to the tropical areas by Schnell (1971) are:

a. Phanerophytes including:

i. Megaphanerophytes (MgPh), whose heights are around 30 m;
ii. Mesophanerophytes (MsPh), whose heights range between 10 to 30 m;
iii. Microphanerophytes (McPh) , whose heights range between 2 to 10 m;
iv. Nanophanerophytes (NnPh), shrubs with heigths under 0.4 to 2 m.
v. Phaneorophytes lianescents (Phgrv. Phgr); voluble plants with gimlets, cramps roots, crawling or supported;
vi. Phaneorophytes epiphytes (Phep).

b. Chameophyts (CH):

i. Chameophytes drawn up (Chd);
ii. Chameophytes prostrate (Chpr);
iii. Chameophytes crawling (Chrp);
iv. Chameophytes climbing (Chgr);

c. Geophytes (G): Plants whose persistent growths or buds are sheltered in the ground during the bad season:

i. Rhizomateux geophytes (Grh);
ii. Tuberaux geophytes (GB);
iii. Geophytes climbing (Ggr);
iv. Geophytes epiphytes (Gep).

d. Hemicryptophytes (H): plants which the growths are located at the short-nap cloth of the ground:
* Cespiteux Hemicryhytes (Hce).

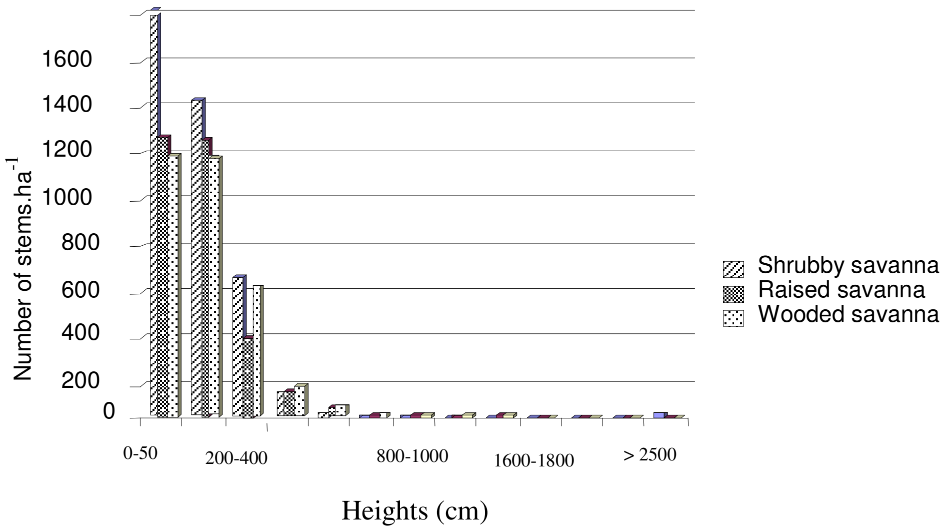

Figure 2. Structure of the population according to the size of the trees.

e. Theophytes (Th): Annual plants or at very short growing period, deprived of persistent buds themselves and whose survival is ensured by seeds, they include:

i. Theophytes drawn up (Thd);
ii. Theophytes prostrate (Thpr);
iii. Théophytes scapeux (Thsc).

f. Hydrophytes (Hy); watery plants.
In this work, we interested only to the megaphanerophytes, mesophanerophytes and microphanerophytes. Trees which have less than 10 cm diameter to height of the chest were exclusively inventoried.

14. The types of dissemination of diaspores were given according to the classification of Dansereau and Lems (1957). The various types are:

a. Pterochores (Ptéro): Small diaspores with aliform appendices;
b. Pogonochores (Pogo): Diaspores with feathery or silky appendices;
c. Slerochores (Scléro): Not fleshy and relatively light diaspores;
d. Sarcochores (Sarco): Diaspores completely or partially fleshy;
e. Desmochores (Desmo): Diaspores hanging or adhesive;
f. Ballochores (Ballo): Diaspores expelled by the same plants;
g. Barrochores (Baro): Not fleshy diaspores;
h. Pleochores (Pleo): Small diapores with a floating appendix.

15. StatBox version 6.40 was used for the factorial analysis of the principal components (ACP) of the structure of the vegetation.

RESULTS

Structure of the vegetation according to the various types of vegetable formations

The structure of the vegetation as a function of the types of savannas is presented in Figure 2. It is seen that in general, cut savannas have structures in "L", materialized by a great number of minor stems and little adult stems. Such a structure generally presents a good arborescent regeneration after wood cuts. The curve of tendency presents an equation of the form $y = -2601.2\ x + 25300$ with a coefficient of correlation of 0.5249. The number of the stems is more significant in shrubby savannas with vegetables' heights between 0 and 200 cm. In the three types of formations, there is a reduction in the number of stems when the size of trees increases. From 200 cm the number of stems is almost null.

Structure of savannas according to the various types of wood cuts

The structure of the vegetation in the treatments T0, T1, T2 and T3 is presented in Figure 3. It can be seen that in some type of savannas, the number of stems is significant between 0 and 200 cm (T0). Shrubby and wooded savannas are more representative in the number of stems. Raised savannas are richer in stems of vegetables with heights between 0 and 130 cm for the treatment T1. The number of the stems decreases when the heights of the trees increase. From 200 cm, the number of the stems becomes null. In fairly cut savannas (T2), the trees have more significant stems in wooded savannas where trees' heights are between 0 and 130 cm while highly cut savannas (T3) present less stems. From 200 cm, few trees are found. In general, the vegetation consists in young plants resulting from the regeneration of the cut trees. It is at the level of shrubby savannas that the number of rejections is significant

Impact of wood cuts on the evolution of the structure of savannas from 2004 to 2006

The structure of the vegetation from 2004 and 2006 presented a light regressive evolution (Figure 4). The

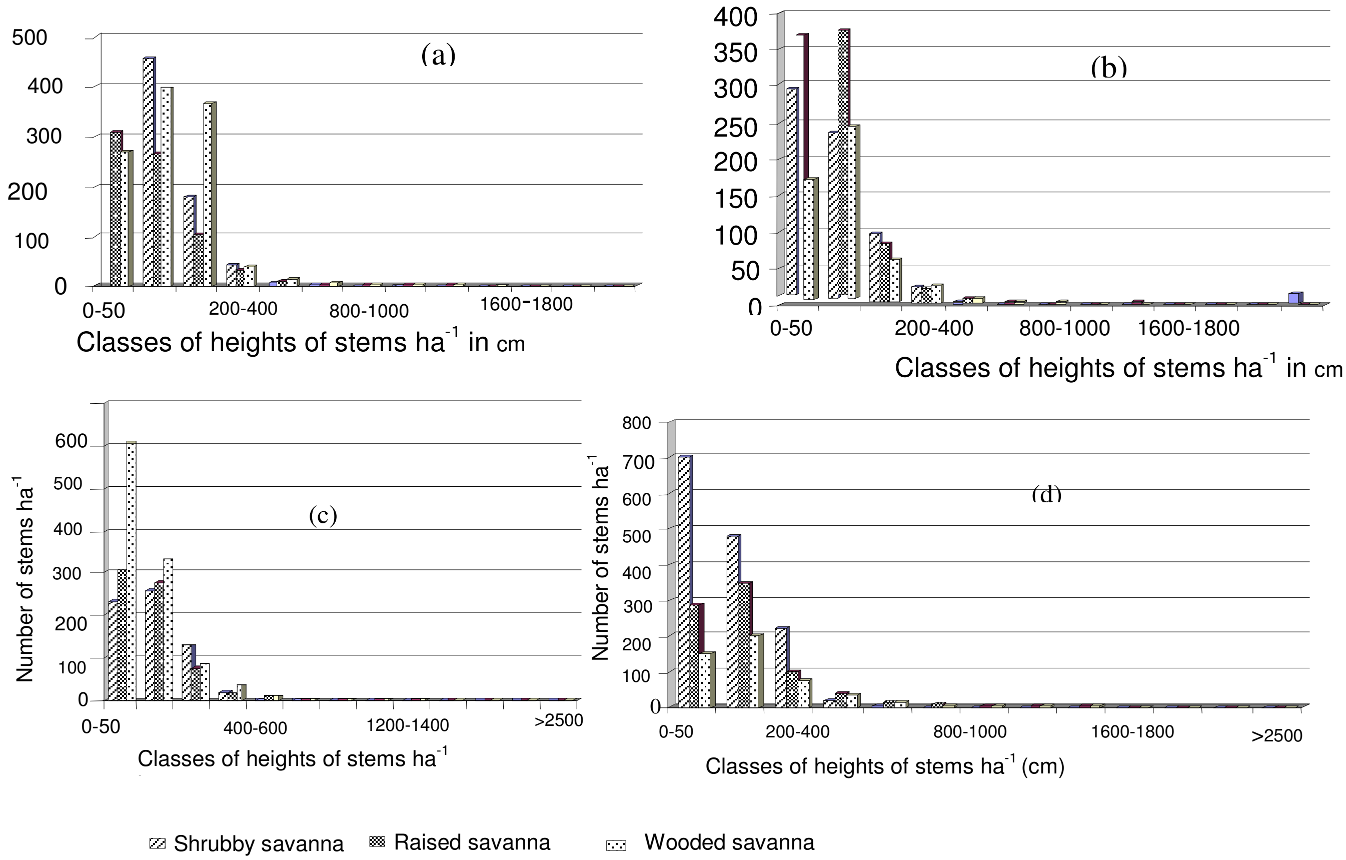

Figure 3. Structure of savannas according to the cuts: (a), weak (b), average (c) and strong (d).

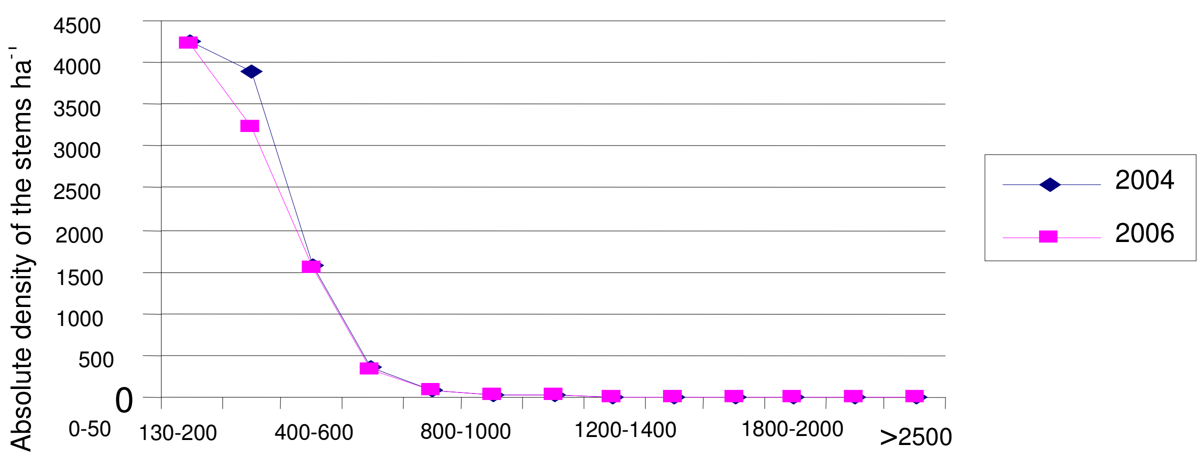

Figure 4. Evolution of the vertical structure of the vegetation of 2004 to 2006.

number of the stems decreased gradually from 2004 to 2006. This translates the regression of the wet savannas of Ngaoundéré. The curve of evolution of the stems by hectare decreased brutally from the heights 0 - 50 cm to 400 - 600 cm. From 600 up to 2500 cm, the curve is superimposed on the x-coordinate. It can be seen from the graph that the structure of the heights is represented by the curve in "L ".

Diametric structure of the ligneous family

The classes of trees with diameters from 0 to 10 and 10 to 20 cm present highest number of stems (Figure 5). In

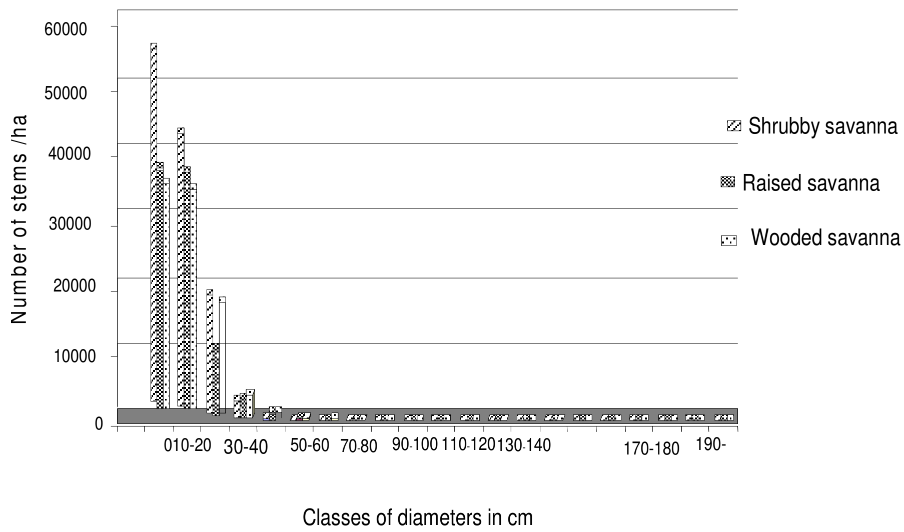

Figure 5. Diametric structure of the ligneous family in savannas of the cuts.

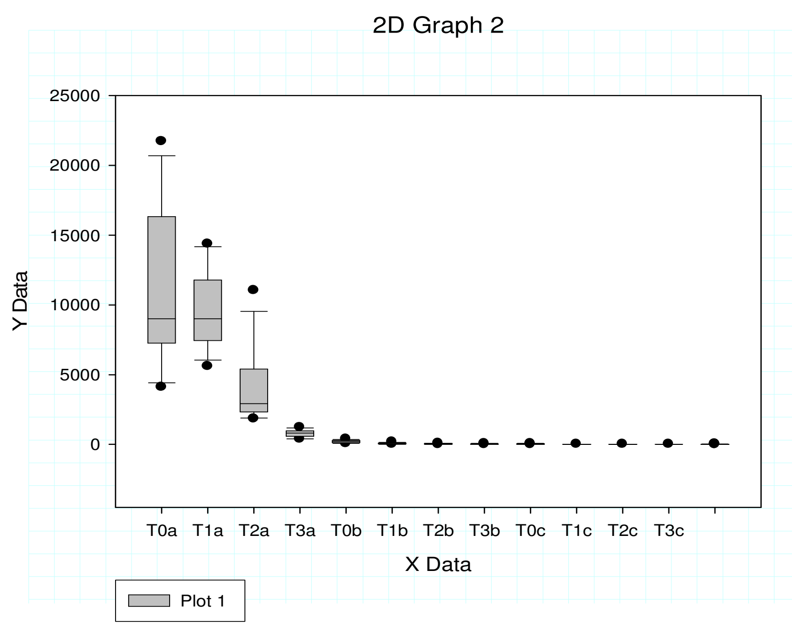

Figure 6. Diametric structure of the ligneous family as a function of various wood cuts. T0a: treatment T0 shrubby savanna;T1a treatment T1 shrubby savanna; T2a treatment T2 shrubby savanna; T3a treatment T3 shrubby savanna; T0b treatment T0 raised savanna; T1b treatment T1 raised savanna; T2b treatment T2 raised savanna; T3b treatment T3 raised savanna; T0c treatment T0 wooded savanna; T1c treatment T1 wooded savanna; T2c treatment T2 wooded savanna; T3c treatment T3 wooded savanna

these classes, highest number of rejects are found.

Diametric structure of the vegetation according to the various wood cuts

The treatment T0a presents the greatest number of the individuals, followed by T1a and T2a. The others are almost equal in density of individuals (Figure 6). The analysis of principal component (ACP) shows that the values of Pearson are significant (except diagonal) for the threshold alpha = 0.05 (bilateral test). This shows that the structure of the vegetation varies according to the classes of the diameters of the stems. The highest average is for

Table 4. Average and standard deviations of the diametric structure of the woody state.

Classes of diameters in cm		Average	Standard deviations
0-10	A	10735.50	5348.62
10-20	B	9592.75	2637.72
20-30	C	3902.75	2527.11
30-40	D	796.67	245.51
40-50	E	218.25	90.32
50-60	F	76.67	44.18
60-70	G	43.67	30.81
70-80	I	28.17	21.95
80-90	J	28.50	22.40
90-100	K	6.58	5.87
100-110	L	2.83	2.85
110-120	M	1.50	1.98
120-130	N	1.58	2.33
130-140	Q	2.75	6.03
140-150	U	3.08	6.49
150-160	S	3.75	9.57
160-170	V	1.83	3.34
170-180	W	0.58	0.86
180-190	X	0.42	0.76
190 -200	Y	0.42	1.11
>200	Z	0.33	0.62

the class of diameters between 0-10 cm (10735.50 stemsha^{-1}year^{-1}) with a standard deviation equals to 5348.62. The lowest average is obtained for the class of diameters greater than 200 cm (Table 4).

The analysis of the principal variables component, according to the axes F1 and F2 shows a variation of 57% in the classes of diameters (Figure 7). The classes A, B and C are under the axis, the others are gathered around similar values (variable (axes F1 and F3) 53%, variables (axes F1 and F4) 46%, variables (axes F2 and F3) 38%, variables (axes F2 and F4) 31%, variables (axes F and F4) 27%).

Classification of the species according to the maximum diameter

The species were classified depending on the diameters reached. In the wet savannas of Ngaoundéré, a great number of stems has diameters between 0-10 cm (Table 5). *H. acida, H. madagascariensis, P. thonningii, Annona senegalinsis* etc are mainly found. The density of these stems decreases as the diameter increases. When the diameter is beyond 100 cm, there is no stem in the shrubby savannas. In addition, the density remains significant for wooded savannas and form forest galleries of high trees. In this class, *D. oliveri, Cesalpinia* sp., *Z. guiennese VAr. guinense, T. glaucescens, L. lanceolata,* etc. are found.

Influence of wood cuts on the survival and the biological state of the species as a function of each type of vegetable formation

Figure 8 presents the effects of wood cuts on the density of alive and dead stems in the three types of vegetable formations. In the shrubby savannas, treatment T1 presents the greatest number of alive stems, while much of cut stems are found in T3. In raised savannas, the number of the cut stems is more significant. However, the numbers of cut stems are approximately the same in the four treatments. In wooded savannas, the numbers of alive stems are approximately the same for T0 and T2. They are relatively less in T1 and T3. The number of the cut stems is very weak for the whole treatments.

Influence of various types of wood cuts on the biological state of the vegetation

Figure 9 summarizes the impact of the wood cuts on the density of the stems as a function of the treatments. For the treatment T0, the density of alive stems is significant in the shrubby and wooded savannas, but it is less in raised savannas. The numbers of cut stems decrease in

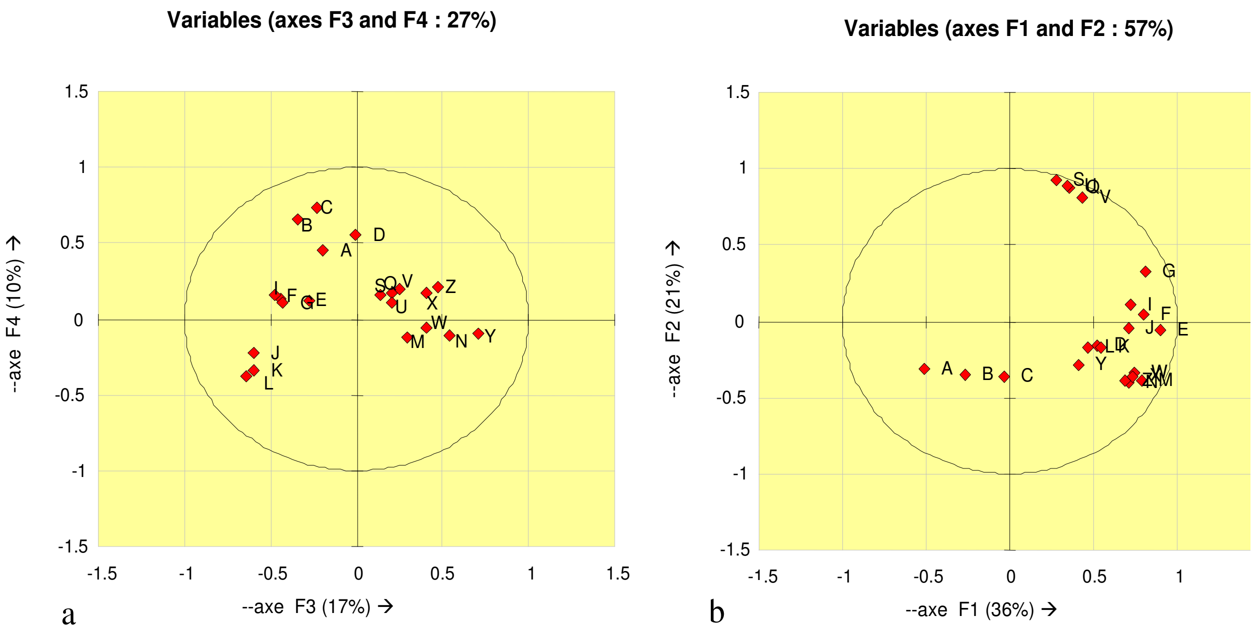

Figure 7. Variation between the classes of diameters of the vegetation of Ngaoundéré.

Table 5. Classification of the species according to the diameters reached.

Diameter (cm)	Categories	Shrubby Savanna	Raised savanna	Wooded savanna
0-10	E et F	1852	1256	1186
10-20	D	1430	1247	1160
20-50	C	736	490	741
50-100	B	6	30	138
>100	A	0	10	76

the shrubby and wooded savannas. They are very weak in protected savannas, showing that in the protected savannas, the activity from the exploitation of wood resources is controlled. For slightly cut savannas (T1), the number of alive stems is relatively significant in raised savannas. For the treatment T2, the number of alive stems is very high in wooded savannas. Treatment T3 presents a great number of alive and cut stems. This number falls when one passes from shrubby to wooded savannas.

Impact of wood cuts on the evolution of the density of species from 2004 to 2006

The vegetation is mainly made up of shrubs e.g *H. acida, P. thonningii* and *H. madagascariensis* which respectively had absolute densities of 3077, 1025 and 1542 stems.ha^{-1} in 2004; and 2907, 949 and 1511 stems.ha^{-1} in 2006. The relative densities of these species were respectively 27.63, 9.21 and 6.021% in 2004. In 2006, there was a light reduction in the relative density: 27.53, 8.99 and 6.023% respectively, for these species. The difference between the relative densities of these species is not too perceptible because of their speed of regeneration. These three species clearly colonize shrubby savannas. Species like *H. Madagascariensis, T. glaucescens* and *D. oliveri* having relative densities of 13.851, 5.516 and 5.421% in 2004 are forest species with affinity to Ngaoundéré's region. Their relative densities also slightly increased in 2006, respectively 14.340, 5.746 and 6.670%. They are more present in the forest galleries or wooded and raised savannas. Indeed, the species with forest affinity have a high capacity of regeneration towards threats.

Impact of the wood cuts on the floristic composition and the density of the species

140 species, 60 kinds, 34 families, and 371 alive stems.ha^{-1}year^{-1} were averagely identified in 2004 and

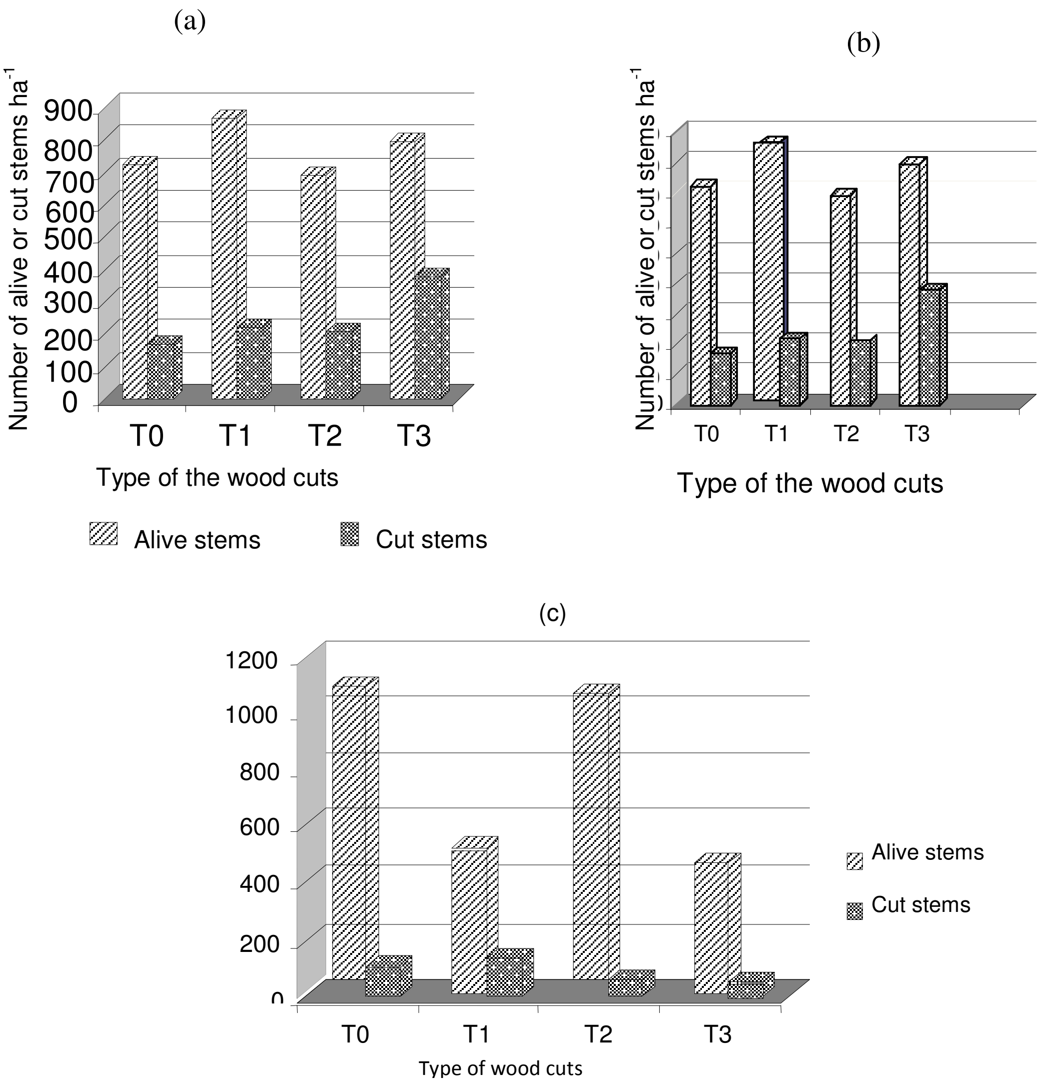

Figure 8. Density of the stems alive and cut in shrubby savannas (a), raised (b) and wooded (c).

351 stems.ha^{-1} in 2006. The evolution of the specific density of the vegetation (Table 6) shows that the species which do not tolerate the wood cuts such as *T. indica, Securidaca longepedunculata* and *Strychnos spinosa* are disappearing in the savannas. In 2006, 13 new species appeared in the sites of study. This is the case of *Erythrophleum guinneensis, Heeria pulcherima* and *Nuxia congesta.* On the other hand, 25 species disappeared in 2006.

Among them *T. indica, Combretum* sp. and *Croton* sp. It could be noted that much of the species lost their density from 2004 to 2006 e.g. *H. acida* (170 stems.ha^{-1}year^{-1}), *P. thonningii* (76 stems.ha^{-1}year^{-1}), *A. senegalensis* (35 stems.ha^{-1}year^{-1}) and *H. madagascariensis* (30 stems.ha^{-1}year^{-1}). Other species gained in density during these three years. Among them *D. oliveri, Allophyllus africanus* and *Pachira aquatica.*

These results show that the degree of drageonment or the rejections of these species is very significant.

Dynamics of the natural regeneration of the species according to savannas

In the whole thirty hectares inventoried, shrubby savannas presented the highest capacity of regeneration (Figure 10). Raised and wooded savannas appreciably have the same densities of rejections per hectare.

The average density of the rejections is 3712.45 stems.ha^{-1} for individuals with circumference lower than 3 cm, and 1423.41 stems.ha^{-1} for the individuals with circumference greater than 3 cm.

Influences of wood cuts on natural regeneration

Regeneration is more significant for the treatment T0

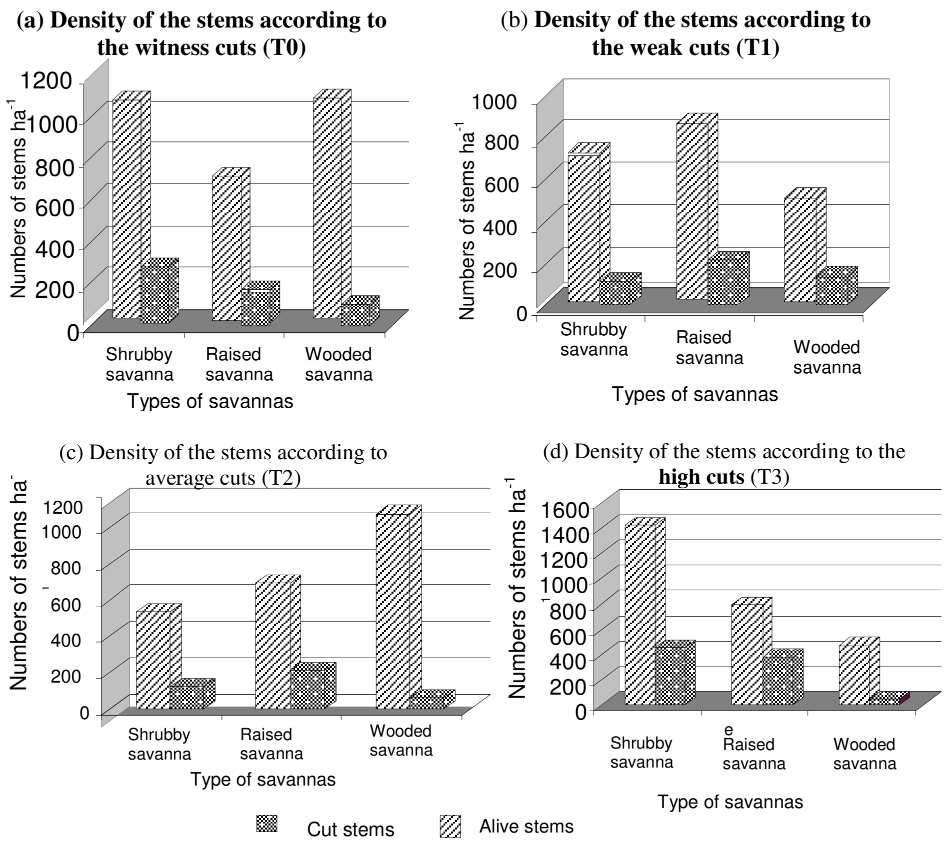

Figure 9. Density of the stems according to the cuts: witness (a), weak (b), average (c) and high.

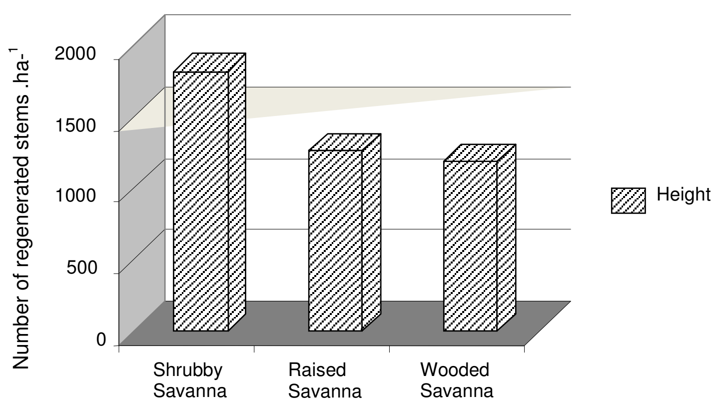

Figure 10. Density of the seedlings according to savannas.

(391.933 stems.ha^{-1}) with a standard deviation of 181.2306 stems.ha^{-1} (Table 7).

Evolution of the rejections after wood cuts

The heights and the diameters of the seedlings were measured each year on pieces of 10 × 10 m cut at the level of the ground in order to study the dynamics of these species. It was observed that, some species integrated the parcel and others disappeared due to the pressure of the wood cuts. The height of each stem was measured each year during three years. During the first year, each rejection was marked, this made possible to evaluate the mortality of the stems. The mortality of the seedlings is in majority due to the activities of the

Table 6. Absolute density (stems ha^{-1}) and relative and profit or loss of the ligneous family of the species (en %).

Scientifics names	Absolute density	Relative density 2004	Absolute density 2006	Relative density 2006	Scientifics names	Absolute Density	Relative density 2004	Absolute Density 2006	Relative density 2006
Acacia polyacantha	14.47	0.13	12.47	0.12	*V. paradoxa*	16.42	0	9.17	0
Acacia siberiana	0.47	0	0.07	0	*Commiphora kerstengii*	1.23	0.01	1.01	0
Afzelia africana	7.3	0	6.17	0	*Cordia africana*	0.12	0	0.1	0.01
Albizia chevalieri	0.83	0.01	0.8	0.01	*Cordia myxa*	0.01	0.01	0	0.02
Albizia coriaria	12.65	0.11	9.63	0.09	*Cordia sinensis*	0.63	13.85	0.61	14.34
Albizia lebbeck	4.63	0.04	4.63	0.04	*Corianga sp*	0.93	0.01	1.23	0.01
Albizia zygia	17.85	0.16	15.9	0.15	*Crossopteryx febrifuga*	0.14	0.83	0	0.83
Albizia adianthifolia	4.53	0.12	3.53	0.1	*Croton macrostachys*	92.18	0.01	88	0.01
Alchornea laxiflora	1.29	0	1.2	0	*C. zambesicus*	0.03	0.03	0.03	0.03
Allophyllus sp	46.55	0.42	66.47	0.63	*Cussonia africanus*	0	0	0	0
A. africanus	106.38	0.96	126.37	1.2	*Cussonia barteri*	40.65	0	39.83	0
Ancylobotrys amoena	0.07	0.14	0	0.13	*D. oliveri*	603.53	0.37	703.21	0.38
Andira inermis	0.07	0	0.03	0	*Ekebergia senegalensis*	8.5	5.42	9.5	6.67
A. senegalensis	670.48	6.02	635	6.02	*Entada africana*	312.67	0.08	300.5	0.09
Berlinia grandiflora	0.34	0	0	0	*Erythrina senegalensis*	3.11	0.29	3.07	0.23
Boswelia sp	0.11	0	0	0	*Erythrina sigmoidea*	235.4	0.02	213.14	0.02
Bridelia ferruginea	155.12	1.39	150.23	1.42	*Erythrophlium guinense*	238.48	2.81	2.5	2.85
Bridelia ndelensis	0.33	0	0.13	0	*Espèces undeterminées*	1.97	0.02	1.01	0.01
Burkea africanus	13.13	0.01	10.13	0.02	*Eugenia nigerina*	0.77	2.11	0.13	2.02
Carissa edulis	8.17	0.06	1.2	0	*Ficus capreafolia*	0.02	0.02	0	0.01
Carissa spanarum	13.5	0.07	10.5	0.01	*Ficus vogelii*	1.32	0.04	0.5	0.03
Cinera machrostachys	68.31	0	60.1	0	*Ficus glumosa*	28.85	0	18.53	0
Citrus sp	0.04	0.61	0.03	0.57	*Ficus vallis-choudae*	0.87	0.19	0.57	0.19
Clausena anisata	1.17	0	1.11	0	*Ficus platiphylla*	1.03	0	0	0
Combretum glutinosum	1.1	0.01	0.12	0.01	*Ficus sp.*	0.55	0.01	0.43	0
Combretum micrantha	26.05	0.02	25.9	0.01	*Ficus sur*	1.34	0.26	0.1	0.18
Combretum nigricans	0.02	0.07	0	0.06	*Ficus sycomorus*	8.43	0.01	8.3	0
Combretum molle	243.04	0.36	239.89	0.36	*Ficus thonningii*	2.25	0.01	1.13	0.01
Combretum lecardii	1.2	0.01	0	0	*Ficus trichopoda*	0.01	0	0.17	0
Flacourtia sp	0.13	0	0.13	0	*Flacourtia indica*	12.53	0.08	9.41	0.08
Flacourtia vogelii	0.07	0.01	0.02	0	*Ochna Scheinfurthii*	9.21	0.04	8.23	0.04
Flueggea virosa	0	0.75	0.02	0.78	*Oncoba spinosa*	2.07	0.47	1.07	0.48
Garcinia livingstonei	0.27	0.01	0.13	0.01	*Ormocarpum bibracteatum…*	0.04	0.47	0.09	0.47

Table 6. Cont'd.

Gardena triacantha	11.71	0.01	11.63	0	*P. aquatica*	0	0.02	10.36	0.02
Gardenia aqualla	1.79	0	1.73	0	*P. biglobosa*	13.44	0.04	11.27	0.04
Gardenia ternifolia	4.57	0	2.53	0	*Paullinia pinnata*	0.13	0	0.11	0
Gmelina arborea	3.5	0.03	2.5	0.02	*Persea americana*	0	0	0.02	0
Grewia barteri	0.23	0	0.33	0	*Phyllanthus muellerianus*	50.51	0.06	48.9	0.07
Grewia bicolor	4.3	0.11	1.43	0.09	*Phyllanthrus sp*	0.03	0.08	0.03	0.08
Grewia flavescens	0.2	0.11	1.2	0.11	*Phyllantus reticulatus*	0.8	0.01	1.8	0.01
Grewia venusta	0.03	0.02	0.02	0.02	*P. thonningii*	1024.91	0.02	948.63	0.01
Grewia villosus	2.53	0.04	0	0.02	*Platycerium stemaria*	0	0.09	0.19	0.06
Gynocarpus americanus	0	0.02	0	0.01	*Psidium guajava*	5.8	0	6.17	0.05
H. madagascariensis	1542.2	0.04	1511.9	0.01	*Psorospermum febrifigum*	84.75	0	79.87	0.1
H. pulcherima	0	0	1.1	0.01	*Psorospermum senegalensis*	66.88	0.12	63.23	0.11
Hexalobus monopetalus	2.48	0	2.03	0.01	*Saba senegalensis*	0.17	0.02	0	0.02
H. acida	3077.37	0	2907.2	0	*Sapium ellipticum*	0.14	27.64	0	27.57
Hyphaena tebaica	15.19	0.02	13.7	0	*Securida longepedunculata*	38.49	0	36.1	0
Jasmimum dichotomum	0.56	0.01	0.63	0	*Senna alata*	77.1	0.45	74.77	0.46
Keetia cornelia	0.02	0	0.17	0	*Senna javanica*	0.03	0	0.01	0
Keetia multiflora	0.95	2.14	0.07	0.02	*Senna sp.*	0.07	9.21	0.01	9
Keetia venusta	2.5	0.01	1.5	0.01	*Senna spectabilis*	0.17	0	0.14	0
Kigelia africana	0.43	0	0.17	0	*Sizygium guiénne Var macrocarpum*	257.07	0	257.07	0
Landolphia heudelotii	1.27	0	0.3	0	*Sizygium guiennensis var guiennensis*	14.24	0	23.5	0
Lannea acida	4.1	0	1.53	0	*Steganotaenia araliacea*	71.22	0.74	68.83	0.75
Lannea chimperi	68	0	70.93	0	*Sterculia tragacantha*	82.32	0	79.31	0.01
Lonchocarpus laxiflorus	0.17	0	0.07	0	*Strichnos inocula*	0.77	2.31	1.04	2.44
L. lanceolata	126.98	0	124.83	0	*S. spinosa*	18.68	0.76	17.7	0.76
Mangefera indica	3.98	0	3.87	0	*T. indica*	0	0.6	0	0.6
Maranthes polyandra	0	0	0.14	0	*Tectona grandis*	0.4	0.12	0.4	0.1
Margaritaria discoidea	0.03	0	0	0	*Tectonia grandulosa*	1.68	0	0.23	0
Maysa lanceolata	52.59	0.23	50.97	0.25	*Terminalia brownii*	0	0	0.21	0
Maytenus senegalensis	51.98	0.01	49.97	0	*Terminalia dewevrei*	0.17	0.05	0.77	0.06
Maytenus undatus	0.03	0	2.14	0	*T.a glauscescens*	614.19	0.35	605.87	0.34
Morelia senegalensis	0	0.15	0.02	0.09	*Terminalia laxiflora*	163.58	0.69	160.97	0.71
Musa balbisiana	0	0	0	0	*Terminalia macroptera*	112.1	0.05	133.4	0
Mytragina sp	1	0.04	1	0.01	*Terminalia micrantha*	143.7	0	120.1	0
Neoboutonia velutina	4.85	0.61	4.4	0.67	*Terminalia* sp	3.28	0	0	0
Neocaria macrophylla	31.73	0	24.21	0	*Trema orientalis*	2.47	0.13	1.46	0.22

Table 6. Cont'd.

N. congesta	0	0.15	0.14	0.06	*Trickilia rocka*	40.08	0.64	37.83	0.65
Ochna Afzeli	6.17	1.14	7.17	1.18	*Uapaca acuminata*	0.38	0.01	0.07	0.01
Uapaca heudeloti	0.99	0	2.37	0.02	*Uapaca chevalieri*	0.06	0.03	1.36	0
Uapaca paludosa	2.37	0	2.1	0	*Vitex madiensis*	16.77	1.47	6.25	1.53
Uapaca sp	0.05	0	5.77	0	*Vitex simplicifolia*	1.74	1.01	1.6	1.27
Uapaca vanhouttei	0.07	0.01	0	0.01	*Vitex* sp1	0.26	0	0	0
Uvaria angolensis	2.11	0.15	2.12	0.1	*Voacanga africana*	10.13	1.29	6.63	1.14
Uvaria chamea	0	2.18	0.25	2.27	*Voacanga thoursis*	21.5	0.03	20.11	0.03
Vepris herophylla	6.63	0	0	0	*X. americana*	17.25	0.02	10.77	0.01
Vernonia amygdalina	0.13	0	0.13	0	*Xylopia parviflora*	0.52	0	0.5	0
Vernonia sp	0.02	0.02	1.01	0	*Zantozilum giletii*	3.5	0.02	3.2	0.02
					Total	11134.2	100	10544	100

Table 7. Comparison of the regeneration rates according to the treatments and the types of savannas.

	T0	T1	T2	T3	Mean	Standard deviation
Shrubby savanna	599.967	292.4	231.833	700.2	456.1	229.038
Raised savanna	307.567	368.9	306.867	288.567	317.98	35.071
Wooded savanna	268.267	171	605.6	147.767	298.16	211.503
Average	391.933	277.433	381.433	378.844	357.41	53.618
Standard deviation	181.231	99.795	197.7259	287.0683	191.46	76.784

fragments of the stems or by the climatic and zooanthropic factors. The density per hectares of the marked rejections passed from 1319 stems.ha^{-1}year^{-1} in 2004 to 623 stems.ha^{-1} in 2006 in shrubby savannas, 1317 stems.ha^{-1} in 2004 to 911 stems ha^{-1}year^{-1} in 2006 in raised savannas. In wooded savannas, the density of the rejections passed from 385 stems.ha^{-1} in 2004 to 158 stems.ha^{-1}year^{-1} in 2006 (Figure 11).

Annual mortality of the species

H. acida presents a very high number of dead individuals (66 stems ha^{-1}year^{-1}) in the three types of savannas, followed by *P. thonningii* (30 stems ha^{-1}year^{-1}) and *A. senegalensis* (23 stems ha^{-1}year^{-1}) (Table 8). In general, shrubby savannas are more threatened with regards to the mortality of the stems (12 stems ha^{-1}year^{-1} on average) per year. Indeed, during the first stages of the development, some species have a high rate of mortality at the level of the seedlings. According to Puig et al. (1989), this rate is often higher when the seedlings are gathered particularly near the foot of the tree; in fact, the roots of the tree emit toxic substances to the plants. The seedlings being heliophilous in the first stages of development, this mortality can also be due to the weak luminosity under the tree. The action of predator, caterpillars or the phytophagous parasites is not negligible on the mortality of the seedlings.

Floristic diversity in the savannas disturbed by the wood cuts

Abundance and specific richness of the vegetation

There are abundant and rich species in the savannas of the peri-urban zone of Ngaoundéré (Table 9). It comes out that species are abundant in

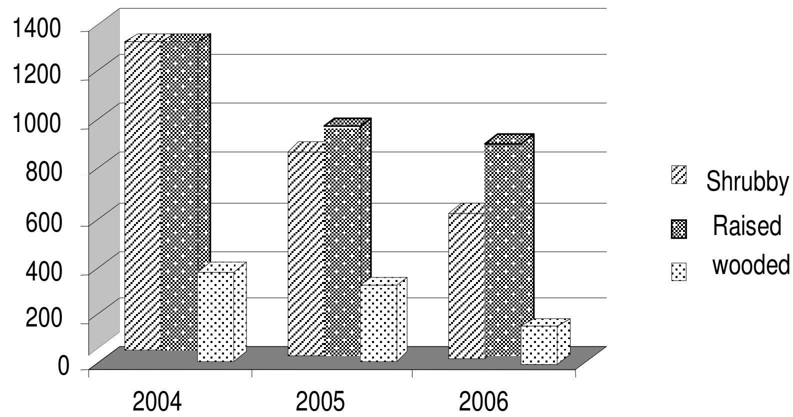

Figure 11. Evolution of rejects of 2004 to 2006.

Table 8. Annual mortality of the species (stems.ha^{-1}year^{-1}).

Scientific names	A	B	C	Means
A. zygia	3	3	1	2.0±1.0
A. africanus	4	6	39	16.0±14.9
A. senegalensis	42	18	10	23.0±12.3
B. ferruginea	1	0	5	2.0±2.0
Combretum collinum	1	3	1	2.0±0.9
Cussonia bartherii	1	2	5	2.0±1.4
C. macrostachys	2	4	2	2.0±0.8
E. africana	2	2	2	2.0±0.2
D. oliveri	20	23	1	15.0±9.1
Ekenebergia senegalensis	1	3	13	5.0±4.9
E. sigmoidea	3	2	7	4.0±2.1
H. acida	143	50	4	66.0±51.6
L. lanceolata	3	2	3	2.0±0.6
Protea madiensis	5	36	1	14.0±14.8
P. thonningii	56	20	14	30.0±17.1
P. febrifigum	9	2	1	4.0±3.4
F. glumosa	2	4	1	2.0±1.0
Securidaca longepedonculata	7	5	3	5.0±1.4
Sizygium guiennense var. macrocarpum	28	8	1	12.0±10.3
T. laxiflora	13	3	2	6.0±4.8
T. glaucescens	1	1	1	1.0±0.2
T. macroptera	2	4	1	2.0±1.0
Steganotegea araliacia	1	0	1	1.0±0.3
Trikilia emmental	3	4	3	3.0±0.6
H. madagascariensis	0	0	2	1.0±0.7
Voacanga sp.	0	1	2	1.0±0.8
Sysygium guiennense var guienense	0	1	2	1.0±0.7
Flacourtia indica	1	0	1	0.3±0.2
Vitex doniana	1	2	2	1.0±0.4
V. madiensis	0	1	0	0.2±0.2
Mean	12±15	7±8	4±4	8.0±2.7

a: Shrubby savanna; B: raised savanna; C: wooded savanna.

Table 9. Specific abundance and richness of species a: specific abundance A; specific richness R.

	T0		T1		T2		T3		Total	
Types of savannas	**A**	**R**	**A**	**R**	**A**	**R**	**A**	**R**	**A**	**R**
Shrubby	240	77	197	67	211	65	205	64	853	273
Raised	220	66	208	59	221	67	230	67	879	259
Woode	242	81	239	83	247	90	246	76	974	330
Tot	702	224	644	209	679	222	681	207	2706	862

Table 10. Values of the indices of Shannon (ISH), the equitability of Piélou (EQ), Simpon (D) and its reverse (D') of the species in savannas according to the treatments.

	Treatments	ISH	EQ	ISH/EQ	D	D’
Shrubby savannas	T0	2.51	0.36	6.97	3.87	0.26
	T1	2.29	0.33	6.94	2.78	0.36
	T2	2.15	0.31	6.94	3.14	0.32
	T3	2.09	0.3	6.97	2.94	0.34
Raised savannas	T0	2.11	0.3	7.03	3.38	0.3
	T1	1.92	0.28	6.86	3.08	0.32
	T2	2.2	0.32	6.88	3.38	0.3
	T3	2.33	0.34	6.85	3.81	0.26
Wooded savannas	T0	2.71	0.39	6.95	4.16	0.24
	T1	3.02	0.44	6.86	3.9	0.26
	T2	3.27	0.47	6.96	4.2	0.24
	T3	2.56	0.37	6.92	4.23	0.24

wooded savannas with a total of 914. Indeed, the distribution of the diaspores in the wooded savannas by the zoochores is favourable to the abundance of the species. In these savannas, due to the seasonal cultures in the forest galleries by some farmers, there is less disturbance compared to shrubby savannas. The difference between shrubby and raised savannas is the weakness of species. They are respectively 853 and 879 for shrubby and raised savannas. Ficher test at the doorstep of 5% shows that there is no significant difference between these types of savannas.Specific richness in shrubby savannas (273) is largely higher than those of raised savannas (259) and wooded one (330).The intense activities of wood cuts and grazing are generally the factors of the recruitment of new exotic species, and are at the origin of this great richness in the shrubby savannas. The protected sites (702) are much richer. But with regard to the specific richness, there is no considerable difference between the various types of wood cuts. However, the richness is weak for T3 (207) compared to T0 (224).

Indices of Shannon, the equitability of Piélou, Simpon and its reverse

The indices of Shannon (ISH), the equitability of Piélou (EQ), Simpon (D) and its reverse (D'), and the ratio ISH/EQ (Table 10) are very high in the three types of savannas for the whole types of treatments.

Heterogeneity of the vegetation

Histogram of frequency for the whole savannas (Figure 12) shows that cut savannas present a higher index of frequency in species. The species are thus much dispersed due to the phenomenon of wood cuts, however the vegetation is heterogeneous.

Relative frequencies of the species as a function of villages and various type of wood cuts

The frequency of the species was evaluated for the villages as a function of the treatments in the various vegetable formations. It was found that the savannas of Dang (University area) present a relative frequency of 11.21% for treatment T3 in shrubby and raised savannas. The impact of students’ activities can explain this high percentage. The relative frequencies are about 11.15% for the treatments T1 and T2 in the wooded savannas of Béka Hooseré where the populations exploit the forest galleries for agriculture. The same observations were

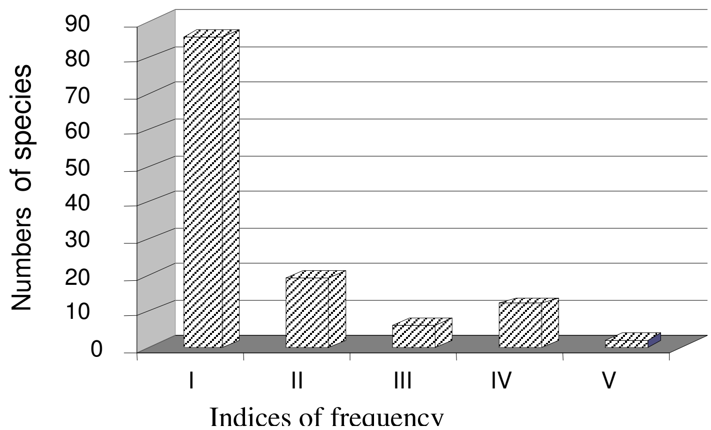

Figure 12. Histogram of frequency of the species of savannas.

Table 11. Relative frequencies of savannas according to the villages and the treatments (in %)

Savannas	Dang	Béka	Borongo	Ngaouhoura	Mbang	Ville	Beskewal	Daran	Tizon	Wakwa
SA T0	8.07	8.27	10.39	6.52	7.78	6.43	8.53	8.9	11.11	9.67
SA T1	8.07	5.4	7.89	4.78	7.39	14.06	6.48	7.72	6.54	6.04
SA.T2	7.62	8.27	4.3	8.7	6.23	10.04	10.58	7.42	7.19	8.16
SAT3	11.21	9.71	6.81	8.26	5.06	6.02	6.48	8.31	8.5	6.04
SB T0	10.76	5.76	8.6	8.26	8.95	6.83	7.51	6.83	7.52	10.57
SB T1	8.07	6.83	7.53	9.13	7.39	5.62	8.53	6.23	8.17	9.97
SB.T2	8.07	7.91	8.24	10.43	7.78	6.83	5.46	10.39	7.84	8.16
SB.T3	11.21	6.83	8.96	9.57	9.73	9.24	7.51	10.09	7.19	6.95
SC.T0	8.07	8.27	10.04	7.83	8.17	7.23	8.53	9.2	11.44	10.27
SC. T1	7.18	11.15	8.24	10	9.73	12.45	10.24	7.42	7.52	7.55
SC.T2	8.52	11.15	7.17	8.7	9.73	8.03	9.21	8.9	7.19	8.76
SC. T3	3.14	10.43	11.83	7.83	12.06	7.23	10.92	8.61	9.8	7.86
Total	100	100	100	100	100	100	100	100	100	100

SA: shrubby savannas; SB: raised savannas: SC: wooded savannas.

made in Borongo and Mbang-Mboum for T3 in the savannas' forest galleries with respective frequencies of 11.83 and 12.06%. Shrubby T1 and wooded T1 of these cities respectively present the most significant relative frequencies of the whole site of study with the percentages of 14.6 and 12.45% (Table 11). The density of the population imposed a strong pressure on these savannas.

Frequencies of the species by families

In the whole savannas, 34 families were identified. The most frequent families are Combrétaceae (10.53%), Euphorbiaceae (9.77%) and Mimosaceae (7.62%) with highest relative frequencies. But for the whole of the flora, the leguminous plants (Cesalpiniaceae, Mimosaceae and Fabaceae) are most significant in relative frequency (Table 12). On the other hand, the Sapindaceous are more raised in percentage (15 %) followed by Euphorbiacea*e* with 7.86%.

Analysis of autoecologic characters

Biological types

Table 13 presents the biological types of the savannas. It arises that the Microphanerophytes (McPh) are dominant with 62.80%, while Mesophanerophytes (MsPh) represent 19.49%. The least represented are Megaphaneorophytes (Mg pH) with 2.75%. This little percentage is explained by the low density of the trees with heights greater or equal to 30 m. The great representativeness of the microphone and mesophanerogames explain that these biological types adapt easily to guinean savannas

Table 12. Frequency of the families of the vegetation of Ngaoundéré.

N°	Families	FA	FR	NE	%
1	Anacardiaceae	87.50	3.83	3	2.14
2	Annonaceae	120.0	5.25	5	3.57
3	Apiaceae	43.33	1.90	1	0.71
4	Apindaceae	53.33	2.33	2	1.43
5	Apocynaceae	45.00	1.97	6	4.29
6	Araliaceae	76.67	3.35	1	0.71
7	Arecaceae	9.17	0.40	1	0.71
8	Asteraceae	5.00	0.22	1	0.71
9	Burseraceae	4.17	0.18	1	0.71
10	Célastracaea	38.33	1.68	1	0.71
11	Cesalpiniaceae	165.00	7.22	7	5.00
12	Combretaceae	240.83	10.53	7	5.00
13	Euphorbiaceae	223.33	9.77	11	7.86
14	Fabacaea	80.00	3.50	5	3.57
15	Flacourtiaceae	28.33	1.24	4	2.86
16	Hymenocardiaceae	84.17	3.68	1	0.71
17	Hypericaceae	155.0	6.78	3	2.14
18	Indéterminée	21.67	0.95	2	1.43
19	Meliaceae	56.67	2.85	8	5.71
20	Mimosaceae	174.17	7.62	1	0.71
21	Moracaea	78.33	3.43	10	7.14
22	Myrsinaceae	20.00	0.87	10	7.14
23	Myrtacaea	90.00	3.94	1	0.71
24	Myrtaceae	15.00	0.66	2	1.43
25	Ochnaceae	83.33	3.64	1	0.71
26	Olacacaea	20.00	0.87	5	3.57
27	Polygalaceae	23.33	1.02	1	0.71
28	Proteacea	35.00	1.53	1	0.71
29	Rubiaceae	77.50	3.39	1	0.71
30	Rutaceae	8.33	0.36	6	4.29
31	Sapindaceae	6.67	0.29	21	15.00
32	Tiliaceae	17.50	0.77	1	0.71
33	Ulmacaea	15.83	0.69	5	3.57
34	Verbenaceae	84.17	3.68	4	2.86
	Total	2286.67	100.0	140	100.00

F: Absolute frequency; FR: Relative frequency; N E: Species/family numbers; Percentages of species/family.

of Adamaoua. There is no significant difference (P<0.05) among the treatments and between the savanicole types of formation.

Physiognomical distribution

Trees dominate the savanicole formation of the peri-urban zone of Ngaoundéré. They represent 66.07% of the woody flora while 33.93% is represented by the shrubs (Table 14). This result shows that the vegetation of Ngaoundéré is a high guinean savannas formation where the species are among species of the wet dense forest and those of the sahelian savannas.

Phytogeographical distribution of the species

The pantropicale species represent 96.80% of the whole flora (Table 15) while the Afro american species (AA) are represented by 0.90% of the flora, indeed these species are not in their surface of phytogeographical distribution. The flora is always made up at the same time of groups with more or less vast distribution, and endemic groups.

Table 13. Distribution of the biological types.

Types of savannas	Treatments	Mc Ph	Mg Ph	Ms Ph	Nn Ph	Total
Shrubby savanna	T0	5.46	0.25	1.70	1.30	8.71
Shrubby savanna	T1	4.66	0.14	1.23	1.27	7.30
Shrubby savanna	T2	4.77	0.18	1.55	1.37	7.88
Shrubby savanna	T3	4.77	0.14	1.12	1.48	7.52
Raised Savanna	T0	5.13	0.29	1.45	1.27	8.13
Raised savanna	T1	4.70	0.25	1.41	1.41	7.77
Raised savanna	T2	5.06	0.25	1.63	1.23	8.17
Raised savanna	T3	5.46	0.33	1.52	1.27	8.57
Wooded savanna	T0	5.57	0.25	1.81	1.30	8.93
Wooded savanna	T1	5.68	0.18	1.99	0.94	8.79
Wooded savanna	T2	5.75	0.18	2.21	0.98	9.11
Wooded savanna	T3	5.78	0.29	1.88	1.16	9.11
Total		62.80	2.75	19.49	14.97	100.00

Table 14. Physiognomical distribution of the flora of Ngaoundéré.

Type of savannas	Type of the wood cuts	Trees	Shrubs	Total
Shrubby savanna	T0	5.94	2.77	8.71
Shrubby savanna	T1	4.35	3.02	7.38
Shrubby savanna	T2	4.97	2.88	7.84
Shrubby savanna	T3	4.93	2.66	7.59
Raised savanna	T0	5.36	2.77	8.13
Raised savanna	T1	4.97	2.81	7.77
Raised savanna	T2	5.33	2.81	8.13
Raised savanna	T3	5.47	3.17	8.64
Wooded savanna	T0	6.12	2.77	8.89
Wooded savanna	T1	6.08	2.66	8.74
Wooded savanna	T2	6.33	2.73	9.07
Wooded savanna	T3	6.23	2.88	9.10
Total		66.07	33.93	100.00

A strong proportion of species to broad distribution can be an indication of degradation. The soudano-zambezian species are null. The whole savanicole formations are dominated by annual grasses.

Impact of wood cut on the dissemination of the diasporas

Table 16 presents the types of the diaspores met in the peri-urban zone of Ngaoundéré. It releases from this table that the zoochores (18.56%) present a significant rate of dissimilation for the T0 treatment in the shrubby savannas. In protected savannas, the animals are the first freight agents of the diaspores. The second agents of dissemination in the shrubby savannas are anemochores (11.92%). The barrochores and hydrochores are found in small percentage in the wooded savannas. In the forest galleries, the barrochores are significant. According to the size of these diaspores, the speed of dissemination is low. It can be quoted that *Strichnos spinosa* are species with low speed dissemination. The agents of their dissemination are the wind, the streaming water and the domestic animals.

DISCUSSION

Impact of the wood cuts on the structure of the vegetation

The size and the diameters of the stems in the savannas of the peri-urban zone of Ngaoundéré have a structure of the type "L". This structure is the result of a strong pressure of the wood cuts on the vegetation. Indeed, the repeated wood cuts by the population of Ngaoundéré do

Table 15. Phytogeographical distribution of the species.

Type of savannas	Treatments	AA	Pan	PRA	Tot
	T0	0.07	8.38	0.25	8.71
Shrubby savanna	T1	0.04	7.16	0.18	7.38
	T2	-	7.66	0.18	7.84
	T3	0.04	7.34	0.22	7.59
	T0	0.04	7.95	0.14	8.13
Raised savanna	T1	0.07	7.63	0.07	7.77
	T2	0.04	7.95	0.14	8.13
	T3	0.11	8.38	0.14	8.64
	T0	0.07	8.56	0.25	8.89
Wooded savanna	T1	0.18	8.31	0.25	8.74
	T2	0.18	8.60	0.29	9.07
	T3	0.07	8.85	0.18	9.10
Total		0.90	96.80	2.30	100.00

Table 16. Dissemination of the species in savanna.

Types of savanna	Shrubby savanna					Raised savanna					Wooded savanna				
Treatments	T0	T1	T2	T3	Tot	T0	T1	T2	T3	Tot	T0	T1	T2	T3	Tot
An	2.9	2.99	2.87	3.13	12	2.78	3.5	3.36	3.36	13	2.66	2.25	3.63	2.78	11.32
Ba	-	-	-	-	-	0.02	-	-	-	0.02	0.19	0.02	-	-	0.21
Hy	-	-	-	-	-	-	-	-	-	-	-	-	0.02	0.05	0.07
Sa	0.8	0.65	0.49	0.46	2.4	0.9	0.7	0.72	0.97	3.26	1.37	1.53	0.95	1.34	5.19
Sc	0.2	0.05	0.14	0.09	0.5	0.09	0.1	0.07	0.14	0.39	0.23	0.19	0.16	0.23	0.81
Zo	4.4	4.65	4.84	4.65	19	4.54	4	4.19	3.87	16.6	3.89	4.35	3.56	3.94	15.74
Tot	8.3	8.33	8.33	8.33	33	8.33	8.3	8.33	8.33	33.3	8.33	8.33	8.33	8.33	33.33

An : Anémochores, Ba : Barochores, Hy : Barochores; Sa: Sarcochores, Sc : Sclérochores, Zo : Zoochores

not make possible quick reconstitution of the vegetation. This situation was checked in shrubby savannas with very strong and repeated cuts on the same trees during three years. It can be noted that seedlings with heights less than two meters and trees with little diameters are threatened in the whole savannas because of the intensity of wood cuts compared to the adult subjects; this justifies the structure in L of the vegetation of Ngaoundéré. These results corroborate those of Chouaibou (2006). In general, such a structure presents a good regeneration of the arborescent layers of the vegetable communities (Anonymous, 1987). This result approaches those of Mbolo (2005) who worked in the reserve of the biosphere of Dja, Southern Cameroon, but differ from those of Amougou (1986), Sonké (1998), and Gudjé (2002).

Indeed, the wood cuts are not the only factors that give this structure to savannas of Ngaoundéré, there are also some factors not controlled like bush fires and the grazing practices which should be integrated to really understand the structural dynamics of the savannas. If Ntoupka (1999) integrated these parameters in his work in the area of the far-north region, it was to seek exactlywhich was the major factor of modification of the structure of the vegetation of Sudanese savannas

Impact of the wood cuts on the floristic composition of the species

In our study we had on average 140 species, 60 kinds and 34 families; 371 alive stems.$ha^{-1}year^{-1}$in 2004 and 351 stems.ha^{-1} in 2006. These results are similar to those of Thorgnang (2001) who listed 117 species in 80 kinds and 37 botanical families in the forest of Gawar. Our results are greater than those of Mahamat (1991) in the national park of Kalamaloué (4500 ha), with 21 species in 11 botanical families and that of Teitcheugang (2000) with 75 species in 46 kinds and 24 Families in the forest reserve of Zamay.

The richness of the savannas of Ngaoundéré would be due to the anthropic factors which would support the dissemination of the species from an area to another. Noubissié (2005) and Tchobsala (2003) showed that *D.*

oliveri is classified among the species that are more suckering in Adamaoua. As a whole, the number of the alive stems (371 stems $ha^{-1}year^{-1}$ in 2004 and 351 stems $ha^{-1}year^{-1}$ in 2006) is more significant compared to the results of several authors who worked on floristic diversity.

Dynamics of the reconstitution of the vegetation under the effects of the wood cuts

Reiterative capacity of the trees in savannas without cuts and with wood cuts

The results showed that the average density of the rejections is 3712.45 $stems.ha^{-1}year^{-1}$ for the individuals with circumference less than 3 cm in natural savannas. It is 1423.41 $stems.ha^{-1}year^{-1}$ for individuals with circumference greater than 3 cm. The number of natural rejection is more significant compared to that of Teitcheugang (2000) in the forest reserve of Zamay (1133 $ind.ha^{-1}year^{-1}$) for the individuals with diameter lower than 3 cm, 489 stems $ha^{-1}year^{-1}$ for the individuals with diameter greater than 3 cm. The density of regeneration is higher than that found in the savannas of Houbaré where *Combutum glutinosum* is the densiest species in terms of regeneration with 700.36 $stems.ha^{-1}$. This species is least used by the local population. In addition to this species *E. Africana* (272.27 stems $ha^{-1}year^{-1}$), *Combutum* sp. (198.27 stems $ha^{-1}year^{-1}$), *H. acida* (164.45 $stems.ha^{-1}year^{-1}$) have densities of more significant regeneration. Teitcheugang (2000) found 573.8 $stems.ha^{-1}year^{-1}$ in the forest reserve of Zamay. Our results are less than those of Guejé (2002) (5613 $stems.ha^{-1}year^{-1}$) for the trees which heights of the seedlings are lower than 100 cm. Indeed the work of the later one was not carried out under the same conditions. It was carried out in the reserve of Dja in the Southern Cameroon where the climate is favourable to regeneration.

The capacity of reiteration of the seedlings is very significant at the time where trees are cut. In the savannas of Ngaoundéré, *H. acida* and *D. oliveri* are the two species which have a fast capacity of regeneration. The wood cuts would support the regeneration of the seedlings. These results corroborate those of Tchobsala (1997, 2003) where *D. oliveri* for example regenerated quickly and in abundance after wood cut and especially after bush fire.

The second strategy of regeneration would be the germination of seeds. If in this work the most cut trees (T3) result in very rich seedlings from germination, the freight agents played a very significant role in the dissemination of the diaspores. Cut woods are quickly replaced and recolonized by new species. *Endada africana* and *iliostigma thonningii* are species which have a fast regeneration rate in savannas of the peri-urban zone of Ngaoundéré (Tchobsala, 1997).

In terms of regeneration, the density of the rejections is more significant in the cut pieces. It is this dynamics of regeneration that makes it possible in the savannas of the peri-urban zone of Ngaoundéré. If the local populations do not make successive cuts on the same pieces and leave savannas in fallow for two to three years, the vegetation of Ngaoundéré would not suffer from the phenomenon of degradation.

Mortality of the rejections without wood cuts

The death rate of the seedlings is very remarkable in wooded savannas. This is mainly due to the effects of moisture in the rainy season, the termites and the trampling of the animals for the watering in dry season. Sist et al. (1989) showed that the presence or the absence of the seedlings and their densities does not depend solely on the viability of seed but also of the ecological conditions (light intensity, hydromorphy of the ground).

The mortality of the seedlings is also very marked in shrubby savannas due to the fact that these areas are grazing areas for domestic animals and subjected to successive cuts. The trampling of the animals makes lose a great number of the seedlings. In the same way, the repeated cuts affect the potentialities of development of the seedlings.

Mortality of the rejections after wood cuts

The competition between the seedlings resulting from the rejections after wood cut is very marked in the first year when these seedlings are gathered near the tree's foot as in the case of *H. acida* and *S. guinense var macrocarpum.* The roots of the tree secrete toxic substances to the plants and the seedlings being heliophilous in the first stages of the development. The mortality can also follow the weak luminosity below the tree's foot. The action of predator, the caterpillars or the phytophagous parasites is not negligible on the mortality of the seedlings. This confirms the works of Puig et al. (1989) who showed that the death rate of the rejections is often higher when the seedlings are gathered in particular near the tree's foot. Tchakounté (2001) showed that bush fire is not a negligible factor on the mortality of the seedlings. The death rate also depends on the age and the stage of development of the seedlings. Gudjé (2002) showed that in the reserve of biosphere of Dja, the risk of mortality of the seedlings decreases quickly when one passes from the young plants resulting from germination to the young trees installed in under wood.

Indeed while comparing the results of the two types of regenerations (without cuts and with wood cuts), one realizes that the mortality of the seedlings is more significant in the cut pieces than in the pieces without cuts.

Dynamics of reconstitution of savannas of Ngaoundéré

Letouzey (1968) admitted that savannas perished without the presence of man. From our results under the influence of the repeated and anarchistic wood cuts in the peri-urban sector of Ngaoundéré, it would be difficult that savannas find their state of forest if the local populations are not put in co-administration with the ministries of forests and the structures specialized in the environmental protection; this fear is justified by the population's increase. An alternative solution would be to leave savannas in fallow in some few years so that they should quickly reconstitute.

The statements of the floristic composition of some sites in the forest galleries and savannas from 2004 to 2006 confirmed the declarations of Letouzey (1968): "some shrubby savannas with *T. glaucescens, P. thonningii, Bridelia ferruginea,* can settle gasoline sowings forest".

Factors like wood cuts, precipitations and fires play an important role into the forest dynamics of savannas (Séghièri, 1990). These factors are responsible for the phenomena of embushment which corresponds to the degradation of a savannas towards denser vegetable formations dominated by one or some woody species. The dominant species of embushment in the area are: *T. glaucescens, H. acida, P. thonningii* and *A. senegalensis.* These species are generally essential for rejections and germination.

CONCLUSION AND RECOMMENDATIONS

The wood cuts negatively influence the structure and the floristic diversity of the vegetation in the peri-urban zone of Ngaoundéré. The types of the wood cuts have structures in "L". Such a structure generally presents a good arborescent regeneration after cuts. The density of the stems is more significant in shrubby savannas with heights between 0 and 200 cm. In the three types of vegetable formations, there is a reduction in the number of the stems when the heights of the trees increase. From 200 cm the number of the stems is almost null.

The number of the stems decreased from 2004 to 2006. This justifies the regression of the wet savannas of Ngaoundéré. The characteristic and indicating species in the shrubby savannas under the strong pressure of the wood cuts are represented by *H. acida, P. thonningii* and *A. senegalensis*. On the other hand, for those of the wooded savannas are *D. oliveri* and *Cesalpinia* sp., the very high cuts are depressive for the stability of the savannas and the disappearance of the vegetable biodiversity. Consequently, they are responsible of the accelerated degradation and the alarming installation of the desert in wet savannas of Ngaoundéré. The intolerant species towards wood cuts are *T. indica, S. longepedunculata, Parkia biglobosa S. spinos* etc., These species can disappear easily when the pressure of the wood cuts is significant. Savannas of the peri-urban zone of Ngaoundéré have 142 species, 60 kinds and 34 families. The most represented families are Combrétaceae (10.53%), Euphorbiaceae (9.77%) and Mimosaceae (7.62%), they present the strongest relative frequencies.There are two dynamic methods for the regeneration of the species: Regeneration by germination of the diaspores and regeneration by rejection or drageonment after cut. The species that suffer after cuts are: *H. acida* (170 stems $ha^{-1}year^{-1}$), *P. thonningii* (76 stems $ha^{-1}year^{-1}$), *Annona senegalensis* (35 stems.ha^{-1}) and *H. madagascariensis* (30 stems $ha^{-1}year^{-1}$), *D. oliveri, A. africanus* and *P. aquatica.*

The biological types are dominated by trees formation. They represent 66.07% of the woody flora. 33.93% is represented by the shrubs. From the phytogeographical point of view, the panatropicales species represent 96.80% and the zoochochores 18.56%, showing a significant rate of dissimilation for the treatment T0 in the shrubby savannas.

The reconstitution of the savannas of Ngaoundéré is possible if the population reduces the rate of the wood cuts. To preserve the structure of the vegetation, some measure in co-administration between the government and the population should be considered to safeguard the anthropized vegetation of Adamaoua. A dialogue among the civil authorities, administration in charge of forest, the local population, the nongovernmental organizations and the researchers is on the way to be installed in the region of Adamaoua.

To protect this threatened biodiversity, the populations could also choose inspection committees and forests guards, annual practise rotative and selective wood cuts. They should severely sanction those who cut wood fraudulently. It is recommended to the population to be aware on the wood cuts which are a danger to the survival of the vegetation consequently to the installation of the desert within the wet savannas of Adamaoua. Co-administration will encourage the collective plantations and community forests and expresses a wish of creation of the structures of the participative follow-ups (GIC, associations, etc) for the protection and the safeguard of stressed savannas.

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