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...
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
Hooséré, Onaref, Wakwa, Tizon, Beskewal, Ngaohora, Borongo,
Dang, Darang and Mban-Mboun 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 oligera 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 prox-
imity 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 prospect, four types of wood logging were
selected:

i) Pilot or witness logging (T0): 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 (T1): vegetation where the percentage of wood
logging is between 11 and 25%;

iii) Average logging (T2): vegetation where the percentage of wood
logging is between 26 and 50%;

iv) Complete or total logging (T3): 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, delimited 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

Calculation of the relative density (Dr):

\[
Dr(\%) = \frac{C}{D} \times 100
\]

with C = number of individuals of a species; D =

Calculation of the relative dominance:

\[
Dre = \frac{SB}{Sb} \times 100
\]

with Sb = basal surfaces of a species and Sb =

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
Pichod-Viala, 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

$$R = \frac{r_{ob}}{r_{at}}$$

with $r_{ob}$ as the av individuals of the between the indivi
Table 1. Experimental design.

| S/N | Village |
|-----|---------|
| 1   | 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    | ScT2    | SaT3    | SbT2    | ScT3    |
| 5   | SaT2    | ScT1    | SaT3    | ScT1    | SaT1    | ScT3    | SbT2    | SbT0    | SbT1    | ScT3    |
| 6   | ScT3    | SbT1    | SaT0    | SaT0    | SaT1    | ScT0    | SaT0    | ScT2    | SbT0    | SbT3    |
| 7   | SaT1    | SbT3    | SaT1    | SaT3    | ScT2    | SaT2    | SbT1    | ScT1    | SbT1    | SbT3    |
| 8   | SaT1    | SbT0    | SbT1    | SbT3    | ScT1    | SbT1    | SbT3    | ScT0    | SbT3    | SaT2    |
| 9   | SaT2    | SaT3    | SaT1    | SaT2    | ScT0    | ScT0    | ScT2    | ScT3    | ScT2    | ScT0    |
| 10  | SbT2    | ScT0    | SaT1    | ScT3    | SbT1    | SaT1    | SbT0    | SaT3    | SbT0    | SaT0    |
| 11  | ScT2    | SaT0    | SbT3    | SbT0    | SbT2    | SbT0    | SaT2    | SaT1    | SbT0    | SbT2    |
| 12  | SaT2    | SbT0    | SbT1    | SbT3    | SaT0    | SbT2    | SaT1    | SaT3    | ScT0    | 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 $C = (r_{ob} - r_{at}) / \delta r$, $t = 0.26136Nd^{1/2}$, with $\delta r$ as the standard error on the average distance observed in the case of a
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 presence 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**

**Characteristics 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 value 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 *Mytragyna inermis* (0.3%) had the least important values.

**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%), Cesalpiniaaceae (54.74%) and Annonaceae (28.38%) had the most relative important value, but Myrsinaceae (0.53%), Oicaceae (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 ($p > 0.05$), 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 |
|---------------------|----------------------|------------|------------|
|                     | T₀                   | 63,300     | 35,220     |
|                     | T₁                   | 63,360     | 34,980     |
| Shrubby Savanna     | T₂                   | 53,610     | 32,070     |
|                     | T₃                   | 61,590     | 31,710     |
|                     | Total                | 241860     | 133980     |
|                     | T₀                   | 46440      | 24360      |
|                     | T₁                   | 58020      | 35820      |
| Arborescent Savanna | T₂                   | 62400      | 30660      |
|                     | T₃                   | 51990      | 35130      |
|                     | Total                | 218850     | 125970     |
|                     | T₀                   | 38010      | 19440      |
|                     | T₁                   | 43980      | 23280      |
| Woody Savanna       | T₂                   | 59070      | 23310      |
|                     | T₃                   | 45960      | 22560      |
|                     | Total                | 187020     | 88590      |

Key: T₀ = Pilot or witness logging; T₁ = weak logging; T₂ = average logging; T₃ = total or complete logging.

 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 (T₃)

The recovery of trees is maximal in arborescent savanna with T₃ (1154.21 m² 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 m² 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 T₁, T₂ and T₃; H. acida in T₂ and T₃ and Psorospermum febrifigum in T₁ in shrubby savanna. In the arborescent savannas, only H. acida represented a grouped distribution (T₁ and T₂) (Table 9).

DISCUSSION

In the three types of plant formations observed in Ngaoundéré and environs, we found 102 species classified 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 environs.

| 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            | 0.0  |
| 3   | Pilostigma thonningii         | 11.64   | 8.24    | 3.86   | 14.1   | 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   | 12.7   | 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 macropera          | 2.38    | 2.44    | 0.76   | 5.57   | 60  | Psidium guajava               | 0.2  |
| 11  | Psorospermum febrifugum       | 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 sparrnium             | 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  | Occhna 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  | Zanthoxyllum 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  | Albizia 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  | Trikila 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 heudolitii         | 0.0  |
| 35  | Protea matiensis              | 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.

| No. | Species                     | Fre | DRe | Dr  | IV  |
|-----|-----------------------------|-----|-----|-----|-----|
| 37  | Ekebergia senegalensis      | 0.25| 0.98| 0.27| 1.5 |
| 38  | Uapaca paludosa             | 0.69| 0.22| 0.55| 1.46|
| 39  | Alchornea cordifolia        | 0.14| 0.96| 0.15| 1.25|
| 40  | Vitellaria paradoxa         | 0.39| 0.52| 0.33| 1.24|
| 41  | Oncoba spinosa              | 0.07| 0.79| 0.34| 1.2 |
| 42  | Securidaca longipedunculata | 0.49| 0.25| 0.44| 1.18|
| 43  | Sporospermum senegalensis   | 0.63| 0.22| 0.33| 1.18|
| 44  | Allophyllus sp.             | 0.21| 0.18| 1.14| 1.14|
| 45  | Trema orientalis            | 0.28| 0.24| 0.47| 1   |
| 46  | Ficus glumosa               | 0.23| 0.56| 0.2  | 0.99|
| 47  | Acacia siberiana            | 0.32| 0.27| 0.3  | 0.89|
| 48  | Phyllanthus muellerianus    | 0.35| 0.12| 0.4  | 0.88|
| 49  | Gardenia triacantha        | 0.39| 0.26| 0.11 | 0.76|
| 50  | Ochna afzelii              | 0.35| 0.14| 0.25 | 0.74|

| No. | Species                     | Fre | DRe | Dr  | IV  |
|-----|-----------------------------|-----|-----|-----|-----|
| 87  | Grewia sp.                  |     |     |     |     |
| 88  | Terminalia micrantha        |     |     |     |     |
| 89  | Jasmimum dichotomum         |     |     |     |     |
| 90  | Ficus trichopoda            |     |     |     |     |
| 91  | Grewia bicolor              |     |     |     |     |
| 92  | Terminalia togoensis        |     |     |     |     |
| 93  | Antidesma venosum           |     |     |     |     |
| 94  | Lanea acida                 |     |     |     |     |
| 95  | Ficus thonningii            |     |     |     |     |
| 96  | Gardenia ternifolia         |     |     |     |     |
| 97  | Carissa edulis              |     |     |     |     |
| 98  | Indeterminate 3             |     |     |     |     |
| 99  | Mytragina inermis           |     |     |     |     |

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  | Indetermine 1   | 0.46    |
| 2   | Annona          | 13.47   | 8.17    | 6.74    | 28.38  | 33  | Uapaka          | 0.69    |
| 3   | Piliostigma     | 11.64   | 8.24    | 7       | 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  | Indetermine 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  | Sena            | 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  | Chiera          | 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  | Jasminum        | 0.02    |
| 27  | Maytenus        | 0.18    | 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   | Hymenocardiae  | 18.54    | 8.56    | 30.96  | 58.06  | 18  | Rutaceae       | 0.14     |
| 2   | Cesarinaceae   | 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   | Acardiaceae    | 1.27     | 1.93    | 6.23   | 10.03  | 24  | Aricaceae      | 0.79     |
| 8   | Moraceae       | 0.63     | 1.74    | 7.59   | 9.97   | 25  | Meliaceae      | 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  | Flacouriaceae  | 0.39     |
| 14  | Sapindaceae    | 1.7      | 0.99    | 1.55   | 4.25   | 31  | Loganaceae     | 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  | Oacaceae       | 0.12     |
| 17  | Araliaceae     | 1.62     | 2.07    | 0.43   | 4.12   | 34  | Tiliaceae      | 0.12     |
|     | Total          |          |         |        |        |     | Total          | 100      |

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

| Wood logging | Shrubby savannas | Arborescent savannas |
|--------------|------------------|----------------------|
|              | T0    | T1    | T2    | T3    | T0    | T1    | T2    | T3    | T0    |
| 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 (m².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 | 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, arborescent savannas; C, woody savannas.

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

| Scientific names             | Shrubby savanna | Arborescent savanna | Woody |
|------------------------------|-----------------|---------------------|-------|
| **T₀**                       | **T₁**          | **T₂**              | **T₃**| **T₀**          | **T₁**          | **T₂**              | **T₃**| **T₀**          | **T₁**          | **T₂**              |
| *Allophyllus africanus*      | ***             |                     |       | ***             | ***             |                     |       | ***             | ***             |                     |
| *Annona senegalensis*        | ** * * **       | ** * * **           | ** ***| ** ***           | ** ***           | ** ***             | ** ***| ** ***           | ** ***           | ** ***             |
| *Cussonia barteri*           | ***             | ***                 |       | ***             | ***             | ***                 |       | ***             | ***             | ***                 |
| *Daniellia oliveri*          | *** * ***       | ***                 | ***   | ***             | ***             | ***                 | ***   | ***             | ***             | ***                 |
| *Entada africana*            | *** * ***       | ***                 | ***   | ***             | ***             | ***                 | ***   | ***             | ***             | ***                 |
| *Harungana madagascariensis* | ** * ***        | ***                 | ***   | ***             | ***             | ***                 | ***   | ***             | ***             | ***                 |
| *Hymenocardia acida*         | ** * *** *      | ** * ***            | ** ***| ** ***           | ** ***           | ** ***             | ** ***| ** ***           | ** ***           | ** ***             |
| *Piliostigma thonningii*     | ** * * * ***    | ** * * * ***        | ** * *| ** * * * ***     | ** * * * ***     | ** * * * ***        | ** * *| ** * * * ***     | ** * * * ***     | ** * * * ***        |
| *Psorospermum febrifugum*    | *               | ***                 | ***   | ***             | ***             | ***                 | ***   | ***             | ***             | ***                 |
| *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 significant. These species are over-scat-tered in the outer-urban zone of Ngaoundéré because of the fragility of the ecosystems. How-
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 tasks. 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 therapists. Mapongmetsem and Akagou (1997) showed that the situation of the firewood is already alarming in Adamawa and even worsened these recent years with the multiforn 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, Pilostigma thomningii and Securidaca longepedunculata are requested.

The local population appreciates S. longepedunculata for the treatment of rheumatism; 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 (Ntoupa, 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, T3 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 T3. 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 disappearance 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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