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Full Length Research Paper

Long-term ecological impacts of harvesting non-timber forest products on tree species diversity at the periphery of Mbam and Djerem National Park, Cameroon

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Non-timber forest products (NTFPs) strongly contribute to livelihood security of forest-adjacent communities. This study examined the impacts of their harvesting on tree species diversity at the periphery of Mbam and Djerem National Park (Cameroon). Tree species diversity, with diameter at breast height (dbh) ≥ 10 cm, was analyzed in small plots (10 × 100 m) along seven 1-ha transects. Species diversity and floristic composition of undisturbed and disturbed sites were compared in order to obtain an indication of the impact of harvesting NTFPs. A total of 1294 stems was recorded, representing 99 species, 96 genera and 36 families. Shannon diversity index values were highest in undisturbed sites (H' > 3.5 bits), and lower in disturbed sites (H' < 3.5 bits). Analysis of variance showed significant differences in mean diversity measures between the two sites (p = 0.047). Mean number of stems cut within the disturbed sites was 15.5 ± 5.5 stems ha^{-1}. The park's region was found to be rich in Euphorbiaceae, Caesalpiniaceae and Annonaceae. The survey highlighted the effectiveness of harvesting NTFPs in the region and its impacts on tree species diversity. Efforts should be made more in order to improve the protection of the park, and the development of a suitable regional conservation of biodiversity.

Key words: Mbam and Djerem National Park, non-timber forest products, seven 1-ha transects, biodiversity, conservation.

INTRODUCTION

Forest-dwellers across the globe have a long history of dependence on a wide array of forest products for household sustenance and sale, with some 1.4 to 1.6 billion people worldwide estimated to make use of at least some non-timber forest products (NTFPs). These products are collected from natural forests, woodlands surrounding dweller's villages and homesteads, and may include food, forage, medicinal plants, construction materials, fuelwood, raw materials for handicrafts, and other products such as resins and honey (Akerele et al., 1991; Panayotou and Ashton, 1992; Belcher, 2003; Vedeld et al., 2004). Their commercialization can ideally provide an economic incentive for the preservation of forests, but the viability of this depends on the production systems employed and the extraction intensity (Belcher et al., 2005). Therefore, from an ecological perspective, NTFP harvest sustainability requires not only that the species are able to persist over the long-term, but also

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that harvest does not negatively affect community and ecosystem functions.

In Africa, non-timber forest products represent direct inputs to satisfy different household needs. While some of them are important export commodities, such as bamboo, essential oils, honey, mushrooms, or plant parts for pharmaceutical products, others provide raw materials for further processing and create employment opportunities at a local level. Often they are only means for forest-dwellers to enter the cash economy (Avocèvou-Ayisso et al., 2009; Camou-Guerrero et al., 2008; Delvaux et al., 2009; Hermans et al., 2004). Experiences with non-timber forest products have been mixed, largely due to difficulties of sustainable harvesting, the economically unviable commercialization of little-known products, and the lack of biological and ecological information on many potential useful species (Belcher and Schreckenberg, 2007). The use of *Gnetum africanum*, *Gnetum buchholzianum, Garcinia lucida* and *Prunus africana* from Central Africa to Europe is mentioned (Van Dijk, 1999; Laird et al., 2010). The case of gum Arabic in Nigeria, West Africa, in relation to supporting rural livelihoods as well as affecting the national and international markets has been cited (Tchatat, personal communication). There are tens of thousands of NTFP species, and there are only a few for which there have been detailed studies on their autoecology and the ecological effects and sustainability of harvesting (Ticktin and Shackleton, 2011; Vantomme, 2003). Protected areas remain the most commonly implemented means of formally conserving biodiversity and have been established in almost every country in the world (Chape et al., 2005; Coad et al., 2009). In theory, the majority of protected areas regulates and restricts access, denying millions of rural dwellers usufruct rights from forest lands they often previously relied upon for their livelihoods (Cernea, 2005). In spite of their extensive coverage, protected areas have been relatively poor at conserving the full representative range of biodiversity (Rodrigues et al., 2004), and most of the world's biodiversity remains at the periphery, even in complex multi-functional landscapes occupied by people (Alcorn, 1993; Putz et al., 2001; Sayer and Maginnis, 2005).

Most local farmers living adjacent to the Mbam and Djerem National Park in Cameroon depend directly and immediately on non-timber forest products. Commercial use of NTFPs in that region is thus seen as one way to lift people out of poverty. Two species are harvested and traded for their fruits on a regional scale. These are *Beilschmiedia anacardioides* and *Beilschmiedia jacques-felixii*. Another species is traded and exported on a large scale, used also for its fruits that provide substantial income to rural inhabitants, *Xylopia aethiopica* (Souare, 2006). However, the harvest is not done properly since the individuals are systematically felled with axes (Figure1). Little is known about the biology of the organisms and ecological responses of plant communities to the commercial harvest. It is known that NTFP harvest systems can have impacts at multiple ecological scales, from individuals to ecosystems; that may alter the structure and composition of plant community.

Following insights from previous research, we hypothesized that all harvesting NTFPs at the periphery of Mbam and Djerem National Park does have an ecological impact, and that overuse can significantly change the composition and structure of the forest. The survey was conducted specifically to:

1. Study the tree species diversity and floristic composition within and outside the park.
2. Assess the ecological effects of harvesting non-timber forest products on tree species diversity at the periphery of the park.

MATERIALS AND METHODS

Study site

The study was carried out within and outside the Mbam and Djerem National Park in Cameroon. The park covers an area of 416 512 ha and lies between 5°30' to 6°13' N and 12°23' to 13°10' E (Figure 2), at the northern part of the Congo basin rainforest. The geological substratum consists of a series of gneiss and undifferentiated granites. The study area is characterized by two seasons: the wet season that extends from April to November and the dry season occurs from December to March (Souare, 2006). The mean annual precipitation is 1 765.52 ± 214.17 mm, with a mean monthly temperature ranging from 22.2 to 27.7°C. The hydrography of the area is dense, with many rivers, rivers flowing on rocky beds, small waterfalls and the great river Djerem.

The main vegetation type consists of semi-deciduous forest, gallery forest and savannas (Letouzey, 1985). Most of the people live at the periphery of the park (Figure 2), and rely solely on agriculture, livestock and forest resources to meet their basic needs. Non-timber forest products exploitation has been extensive in some areas, mainly in the northern and eastern part of the park.

Data collection

Representative and homogeneous vegetation types were selected on the basis of physical and anthropogenic disturbance of the forest. Sampling was done from June to August 2011 using the transect method to determine the vegetation cover, developed by Lejoly (1993), Condit (1995), and Guedje (2002). Seven 1-ha (10 m × 1000 m) linear transects were established within and outside the park (Figure 2), with a total of 70 plots established along the seven transects, for data collection. The plots were rectangular, measuring 100 m × 10 m. Three transects (T1, T2 and T3) were located within the park; four other transects (T4, T5, T6 and T7) were located at the catchment of the park. T6 and T7 were established in the northern and eastern sectors, respectively, where the three main species, namely *Xylopia aethiopica*, *Beilschmiedia anacardioides* and *Beilschmiedia jacques-felixii*, are exploited for their non-timber products (Figure 1). The transects were established in the sites situated near the park where no other human land use was noticed. T4 and T5 were established in the other sectors of the park where no human activity was noticed, even the collection of NTFPs. All

Figure 1. A typical view of harvesting NTFP in the area of Mbam and Djerem National Park.

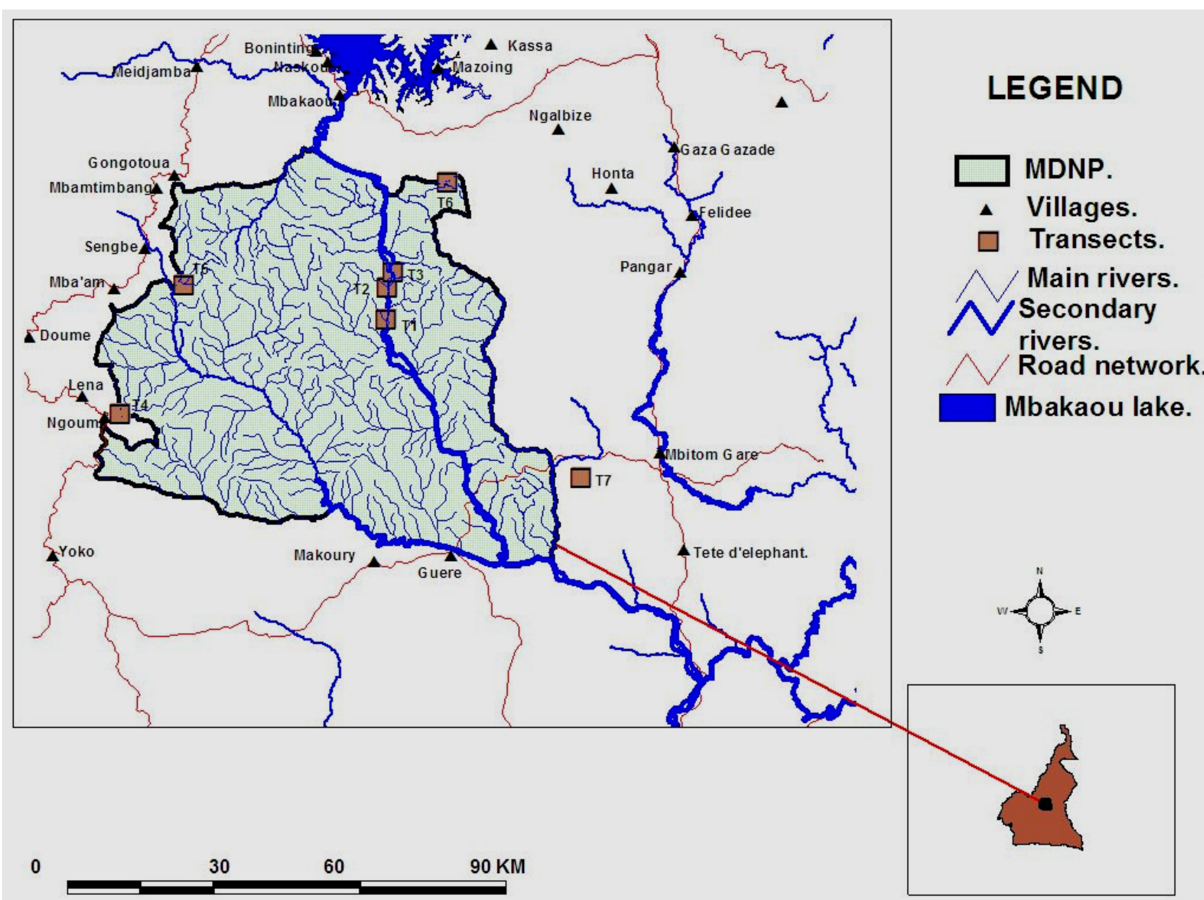

Figure 2. Map of location of the study site. MNDP: Mbam and Djerem National Park.

transects were recorded with a global positioning system (GPS) (Garmin Map 62S).

Within each transect, all trees with a diameter at breast height (dbh) ≥ 10 cm were recorded and characterized by the following attributes: species name and dbh. The dbh was measured with a diameter tape (Jackson MS) at 1.3 m above ground level. For buttressed trees, the dbh was taken 30 cm above the buttresses. Identification of the most common species was done directly in the field whenever possible. Voucher specimens were prepared for unidentified species and deposited at Yaoundé national herbarium (YA) for identification. Identifications were also done with the help of "Flora of West tropical Africa" (Hutchinson et al., 1972; Tailfer, 1990; Keay, 1989), and the different volumes of "Flora of Cameroon".

To assess the ecological effects of harvesting non-timber forest products on tree species, both the number of destroyed and standing trees was recorded. Tree diversity species and floristic composition within disturbed and undisturbed sites were compared.

Data processing and analysis

Plant species were sorted out into different life forms. We assessed diversity with Shannon-Weaver diversity index (H') (Magurran, 2004), Shannon's Evenness index (EQ), and Simpson diversity index (D). Diversity index takes into account not only the number of species but also whether species are more or less equally abundant, or whether in contrast one or a few species dominate.

$$H' = - \Sigma \, Ni/N \log_2 Ni/N$$

where H' = index of species diversity (bits), Ni = number of individuals of a given species i, N = total number of individuals, $\log_2$ = logarithm in basis 2.

$$EQ = H'/\log_2 N$$

This index varies from 0 to 1.

$$D = \Sigma \, (Ni/N)^2$$

where Ni is the specific contribution of species i for the vegetation cover.

Mean comparisons of the diversity indices between disturbed and undisturbed areas were done using ANOVA test.

Correlation between the index values was determined using a multivariate analysis, principal component analyses (PCA). This is a statistical procedure where the effects of several factors under investigation are ranked based on their magnitudes of interaction. Similarities between transects based on floristic diversity were determined using Sorensen's similarity index which was computed, based on presence/absence data on the species. It was calculated from the following equation:

$$Cs = \frac{2j}{2j + a + b}$$

where j = number of species held in common, a = number of species found at only site A and b = number of species found at only site B. This index potentially varies between 0 and 1, and a value close to 1 indicates greater similarity between transects, and hence low β-diversity (Magurran, 2004).

We compared the altitude values of disturbed and undisturbed areas using Kruskal-Wallis test. Structural characteristics (stem density, basal area, and mean diameter) were computed for each transect and averaged per vegetation unit for all individuals with a dbh ≥ 10 cm.

To describe the ecological importance of species and families within each transect as well as for the total flora, the species importance value index (IVI) (Curtis and McIntosh, 1951), and family importance value index (FIV) (Mori et al., 1983), were also calculated:

Relative abundance = (number of trees of the species or family/total number of trees) × 100
Relative frequency = (frequency of a species/sum of all frequencies) × 100
Family relative diversity = (number of species in a family/total number of species) × 100
IVI = relative density + relative frequency + relative dominance
FIV = family relative diversity + relative density + relative dominance

All the statistical analyses were performed with R software version 2.14.1. The Vegan package developed by Oksanen et al. (2010) was used to calculate diversity indices. The graphs were performed with Microsoft Office Excel 2007 software.

RESULTS

Tree diversity and species richness within and outside the park

A total of 1294 stems of dbh ≥ 10 cm was recorded within the seven transects (Table 1), representing 99 species, 96 genera and 36 families. About 95.2 % of trees were identified to species level, 4.8% remain unidentified. The number of species per transect varied from 20 to 48, with a mean of 34.85 ± 10.60 species ha^{-1}. The number of species was lower in disturbed sites (23 species and 20 species for T6 and T7 respectively). The Shannon diversity index (H') values were highest in undisturbed sites; they varied from 4.15 to 6.00 bits. Values of the Shannon diversity index were lower in disturbed sites (H' ranged from 2.56 to 2.66 bits) (Table 1). The Shannon Evenness index (EQ) values varied from 0.85 to 1 in undisturbed sites, and from 0.59 to 0.6 in disturbed sites. Values of Simpson's index varied from 0.05 to 0.09 in undisturbed sites, and from 0.13 to 0.28 in disturbed sites. Values of Shannon's diversity index and Shannon's Evenness index were positively correlated (Pearson, r = 0.97; P = 0.05). Values of Shannon's diversity index and Shannon's Evenness index were negatively correlated with values of Simpson's index (Pearson, r = -0.77 and -0.82 respectively; P = 0.05) (Figure 3).

Mean diversity measures differed significantly between disturbed and undisturbed sites (ANOVA test, p = 0.047). The mean number of stems was 184.85 ± 74.31 stems ha^{-1}, ranged from 91 to 314 stems ha^{-1}. The total basal area varied from 8.11 to 25.01 m^2 ha^{-1}, with a mean value of 16.77 ± 5.78 m^2 ha^{-1}. The mean dbh of all transects ranged from 20.52 ± 13.41 cm to 35.87 ± 26.23 cm. Dbh values were highest in T6, T7 and T5 (35.87 ± 26.23 cm, 30.29 ± 14.75 and 30.02 ± 26.76 cm, respectively), and lower in T1, T2, T3 and T4 (20.52 ± 13.41 cm, 24.81 ± 17.29 cm, 25.97 ± 28.21 cm, and 27.09 ± 20.14 cm

Table 1. Number of taxa, diversity indices and structural characteristics of seven 1-ha transects within and outside the Mbam and Djerem National Park, Cameroon.

Parameter	T1	T2	T3	T4	T5	T6	T7
Density (individuals ha^{-1})	314	247	221	114	176	131	91
Basal area (m^2 ha^{-1})	14.39	17.56	25.01	10.14	22.47	19.73	8.11
Mean dbh (cm)	20.52 ± 13.41	24.81 ± 17.29	25.97 ± 28.21	27.09 ± 20.14	30.02 ± 26.76	35.87 ± 26.23	30.29 ± 14.75
Number of family	28	21	19	16	21	15	15
Number of genera	48	47	39	27	39	23	20
Number of species	48	47	39	27	40	23	20
Shannon index (bits)	5.23	6.00	4.82	4.15	4.49	2.66	2.56
Shannon's Evenness index	0.92	1.00	0.91	0.88	0.85	0.60	0.59
Simpson index	0.09	0.05	0.08	0.07	0.08	0.13	0.28

T1: transect 1, T2: transect 2, …, T7: transect 7.

respectively) (Table 1). The mean number of stems cut within the disturbed sites for harvesting NTFPs was 15.5 ± 5.5 stems ha^{-1}.

Floristic composition

The 10 most important families (those of the highest values of FIV index) represented less than 30% of all families, but accounted for 48.28% of the total FIV of all transects considered together (Table 2). They contributed 95.37% of the total number of individuals and the total basal area of all transects. The three families with the highest FIV and number of individuals were Euphorbiaceae (52.90), Caesalpiniaceae (35.92) and Annonaceae (21.20). They were followed by Mimosaceae (20.39), Moraceae (19.73), Olacaceae (19.11), and Bombacaceae (13.56) (Table 2). The most species-rich families were Euphorbiaceae (13 species), Caesalpiniaceae (9 species), Mimosaceae (6 species), Moraceae (5 species), Annonaceae (4 species) and Sapotaceae (4 species). Species of these most important families differed in their distribution between transects (Table 2). Euphorbiaceae, Caesalpiniaceae, Mimosaceae, Moraceae, Annonaceae, Olacaceae and Burseraceae were most dominant, contributing primarily to the floristic composition of the canopy, and accounted for much of the basal area recorded in the transects. Euphorbiaceae and Olacaceae owed their high FIV values to their abundance, contributing mostly to the understory with numerous individuals, but exhibiting a rather low basal area.

The output of IVI analysis showed that *Uapaca guineensis* (16.75), *Xylopia aethiopica* (16.40), *Maprounea membranacea* (13.45), *Berlinia grandiflora* (13.30) and *Trilepisium madagascariense* (12.76) were the five most dominant species (Table 3). These species constituted 25.41% of the total importance value index, while the majority of the species (91.91%) had IVI of less than 10 (Figure 4). The families containing the ten species with the highest IVI values included Euphorbiaceae (2 species), Caesalpiniaceae (2 species), Annonaceae, Moraceae, Mimosaceae, Olacaceae, Bombacaceae and Meliaceae. A large group of species was represented by only one individual in the overall sample of the seven transects together (45 species, representing 45.45% of the total). Some species were found exclusively in one or two transects (63 species, representing 63.63% of the total). Only three species (3.03%) occurred in all seven transects: *Trilepisium madagascariense*, *Strombosiopsis tetrandra* and *Olax subscorpioides*; *T. madagascariense* and *S. tetrandra* ranked among the 10 most important species. Six species were sampled in six transects, eight in four transects (representing 6.06 and 8.08 % respectively of the total number of species).

Similarity among plant communities

Sorensen's similarity coefficient among undisturbed communities was presented in Table 4. It varied from 0.35 to 0.56. The community T1 shared a great number of species with T2 (t test, p = 0.38) and T5 (t test, p = 0.07); (Cs = 0.56 and 0.50 respectively). The communities T3 and T2 shared lower number of species with T5 and T4(Cs = 0.35 and 0.36, respectively). Altitude values varied slightly between disturbed and undisturbed sites (Kruskal-Wallis test, p = 0.31).

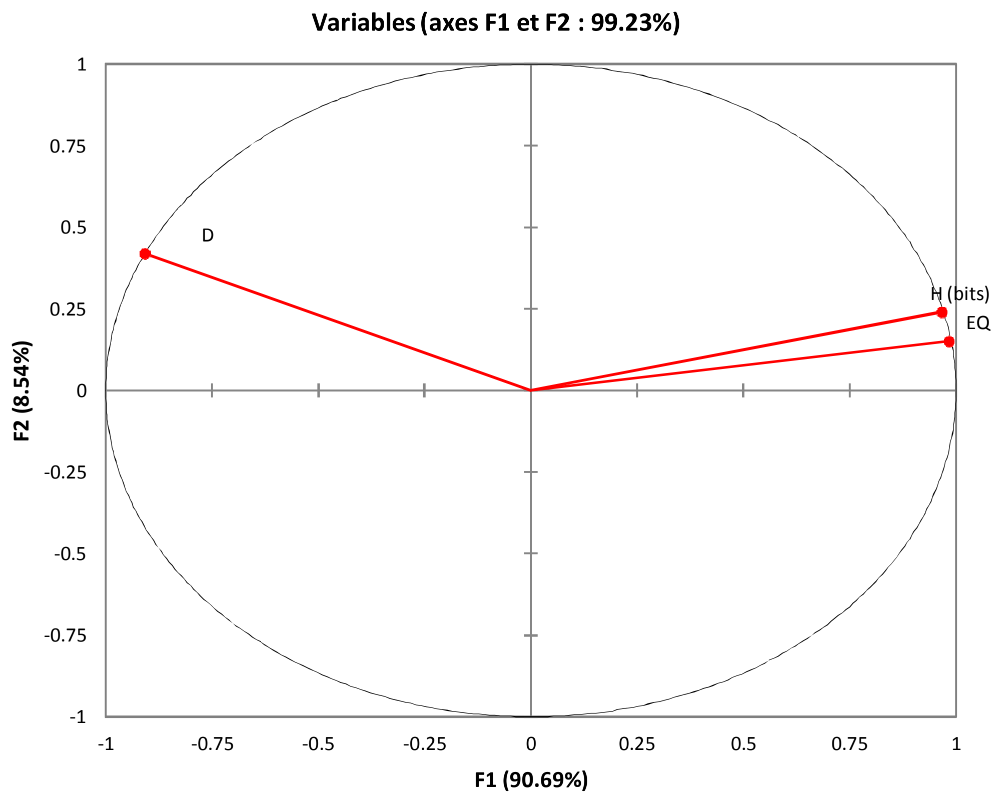

Figure 3. Correlation between Shannon's diversity index, Shannon's Evenness index and Simpson's index values showed by PCA. PCA: Principal component analysis.

DISCUSSION

Tree diversity of Mbam and Djerem National Park area and impacts of harvesting NTFPs on communities

Forest communities considered rich are characterized by a Shannon diversity value of about 3.5 bits or higher (Kent and Coker, 1992). The seven 1-ha transects established within and outside the Mbam and Djerem National Park showed different values of Shannon's index. The undisturbed sites (T1, T2, T3, T4 and T5) had high values of Shannon's diversity (H' > 3.5 bits; Table 1). They can accordingly be considered very diverse. As shown by similar results in previous studies (Pitman et al., 2002), such high diversity seems to be derived from a great abundance of rare species. All tropical forests have rare species, which generally present high risk of at least local extinction (Kenfack et al., 2006). The high evenness observed in undisturbed sites indicates the floristic stability of the sites. Sonké (1998) observed that ecosystems that have reached a level of maturity, and that are not subject to disruptive constraints have high evenness index value (0.6 < EQ ≤ 0.8). In this study, 16 to 28 families were inventoried in each 1-ha transect of the undisturbed sites, which falls in the medium of the range of 16 to 58 families found for tropical forests as a whole (Gentry, 1988; Campbell et al., 1992).

The disturbed sites (T6 and T7) due to NTFP-harvesting showed low values of Shannon's diversity index (H' = 2.66 and 2.56 bits respectively). They had low evenness index values (EQ ≤ 0.6). Dajoz (1982) reported that ecosystems that are in a transitional state or that are subject to permanent disturbances have low evenness index value. The low evenness of the sites can be attributed to the anthropogenic disturbances. The results had shown significant difference in mean diversity measures between disturbed and undisturbed sites (ANOVA test, $p = 0.047$). Mean altitude values differed slightly between the sites (Kruskal-Wallis test, $p = 0.31$). Furthermore, 15 families were inventoried in each 1-ha transect of the disturbed sites, this result falls out of the medium of the range of 16 to 58 families found for tropical forests (Gentry, op. cit.). The mean number of stems cut within the disturbed sites for harvesting NTFPs was 15.5 ± 5.5 stems ha^{-1}. Parren (1991) pointed out that when harvesting is high and 8 to 12 stems destroyed per ha, damages caused to the plant communities are very significant, notably to intermediate strata and the regeneration.

Floristic composition and its significance

In terms of family index value (FIV), Euphorbiaceae was

Table 2. Family importance value (FIV) of the 10 most important families (in bold) of each transect, and global FIV for all seven 1- ha transects censused within and outside the Mbam and Djerem National Park.

Family	Global FIV	T1	T2	T3	T4	T5	T6	T7
Anacardiaceae	9.62	9.57	9.97	9.04	15.94	10.69	-	-
Annonaceae	21.20	27.35	21.25	12.5	15.88	17.43	29.64	35.78
Apocynaceae	5.19	4.55	8.56	-	-	9.33	-	9.39
Araliaceae	0.54	-	-	-	-	3.31	-	-
Bignoniaceae	4.15	3.64	6.24	5.44	-	-	-	11.57
Bombacaceae	13.56	17.01	-	16.66	-	-	-	-
Boraginaceae	1.08	-	-	-	-	-	7.6	-
Burseraceae	12.54	8.72	9	12.86	15.88	14.49	28.83	14.05
Caesalpiniaceae	35.92	27.21	33.75	35.36	52.07	64.99	33.23	25.53
Chrysobalanaceae	0.49	-	-	-	-	-	-	6.07
Combretaceae	2.21	3.29	-	-	7.94	-	-	6.48
Ebenaceae	3.01	3.07	3.7	3.14	-	3.4	5.67	-
Euphorbiaceae	52.90	58.94	54.07	59.21	42.85	40.84	36.32	87.05
Guttiferae	3.41	-	3.89	8.69	-	-	6.86	-
Huaceae	0.49	2.31	-	-	-	-	-	-
Hypericaceae	1.86	2.44	-	-	7.67	-	-	6.23
Irvingiaceae	2.14	2.69	5.2	-	-	3.33	-	-
Meliaceae	10.14	6.61	15.54	6.23	18.44	10.57	14.74	-
Mimosaceae	20.39	18.78	23.07	15.38	30.08	22.17	24.31	26.9
Moraceae	19.73	16.35	26.43	25.85	25.19	13.2	18.52	18.32
Myristicaceae	7.30	5.86	11.68	4.44	11.33	8.17	-	7.2
Myrtaceae	1.01	2.32	-	-	4.89	-	-	-
Ochnaceae	3.53	6.72	5.88	-	-	4.7	-	-
Olacaceae	19.11	13.47	13.04	14.98	28.58	17.35	46.80	19.07
Palmae	4.76	-	-	24.11	-	-	-	-
Papilionaceae	3.44	-	-	10.09	-	4.24	7.32	-
Putranjivaceae	0.5	2.32	-	-	-	-	-	-
Rhamnaceae	0.49	-	-	3.02	-	-	-	-
Rubiaceae	5.98	6.08	-	-	-	12.61	17.23	-
Sapindaceae	1.19	2.99	-	-	4.93	-	-	-
Sapotaceae	9.32	10.33	7.39	10.72	-	19.56	-	13.38
Sterculiaceae	6.54	7.92	5.56	9.93	5.41	8.13	6.03	-
Tiliaceae	1.69	2.51	2.97	-	-	-	-	-
Ulmaceae	0.5	-	-	-	4.89	-	-	-
Verbenaceae	7.35	10.02	9.44	-	-	7.77	9.11	12.9
Violaceae	1.78	3.08	2.5	-	-	3.41	-	-

T1: transect 1, T2: transect 2, …, T7: transect 7.

the most important family throughout the study site (Table 2). It was followed by Caesalpiniaceae and Annonaceae. Euphorbiaceae and Caesalpiniaceae had two species each with the highest IVI values (Table 3). This result corroborates the findings of Letouzey (1985) who characterized forests of the southern Adamawa plateau in Cameroon as transitional forest rich in Euphorbiaceae and Caesalpiniaceae. The importance of the Caesalpiniaceae family in the site is also one of the characteristics of the Guineo-Congolian forests (White, 1983). Other important families such as Olacaceae and Burseraceae are also known to be good indicators of old evergreen atlantic forests (Senterre et Lejoly, 2001; Gonmadje et al., 2011). Doucet (2003) also showed, in the case of Gabon's rainforests, that high levels of endemism were associated with high dominance of Caesalpiniaceae and Olacaceae. As such, Mbam and Djerem National Park area might be rich in endemic

Table 3. Importance value index (IVI) of the 10 most important species (in bold) of each transect, and global IVI for all seven 1-ha transects censused within and outside the Mbam and Djerem National Park.

Species	Global IVI	T1	T2	T3	T4	T5	T6	T7
Uapaca guineensis	16.75	6.13	16.75	27.14	-	31.73	17.01	81.37
Xylopia aethiopica	16.40	36.05	25.84	-	-	3.81	40.92	59.67
Maprounea membranacea	13.45	38.36	21.12	2.05	-	1.77	9.77	29.15
Berlinia grandiflora	13.30	2.53	29.43	5.53	48.25	41.74	-	-
Trilepisium madagascariense	12.76	4.41	14.24	18.98	4.24	3.72	8.82	14.21
Piptadeniastrum africanum	12.08	31.17	12.52	-	-	10.34	26.96	-
Ceiba pentandra	12.07	1.51	-	50.74	-		-	-
Strombosiopsis tetrandra	11.02	6.94	7.87	5.48	23.73	11.08	56.73	3.65
Trichilia gilletii	8.19	3.61	13.51	19.63	18.66	3.56	2.11	-
Erythrophleum suaveolens	7.22	-	1.3	2.34	2.47	20.84	16.14	7.28
Vitex doniana	7.06	18.12	13.52	-	-	8.72	2.34	4.77
Gambeya boukokoensis	6.76	17.74	4.91	-	-	19.8	6.27	7.92
Lannea zenkeri	6.46	9.4	7.19	8.54	20.91	6.1	-	-
Canarium schweinfurthii	6.36	2.05	-	2.6	17.75	18.71	21.48	4.07
Hylodendron gabunense	6.00	1.93	-	-	-	37.55	2.16	-
Olax subscorpioides	5.31	1.96	1.28	2.2	7.98	8.92	7.34	9.57
Oncoba glauca	4.84	-	1.95	19.78	-	9.72	-	-
Dacryodes buettneri	4.80	-	1.36	2.05	-	2.86	28.45	-
Pterygota macrocarpa	4.60	4.29	-	4.16	21.52	6.16	2.15	-
Hallea stipulosa	4.60	-	-	-	-	9.39	20.25	-
Antidesma venosum	4.47	8.61	3.67	1.76	14.65	-	8.86	-
Phoenix reclinata	4.10	-	-	28.01	-	-	-	-
Funtumia elastica	4.02	5.95	9.04		-	6.6	-	10.11
Markhamia lutea	4.00	6.47	10.09	7.15	-		-	13.93
Ochna calodendron	3.95	9.4	7.96	-	-	4.36	-	-
Pycnanthus angolensis	3.54	1.17	-	2.26	19.62	3.66	3.74	3.98
Albizia glaberrima	3.49	-	2.13	-	27.5	-	-	20.34
Afzelia bipindensis	3.23	1.16	-	9.28	2.45	2.09	-	-
Diospyros abyssinica	2.82	2.87	4.32	1.81	-	1.77	2.44	-
Symphonia globulifera	2.72	-	1.87	14.16	-	-	-	-
Ekebergia senegalensis	2.71	-	9.36	-	-	-	3.76	-
Milicia excelsa	2.65	-	12.19	3.89	-	-	-	-
Strombosia pustulata	2.60	4.65	4.7	3.63	-	-	-	-
Sterculia tragacantha	2.15	7.54	1.82	1.75	3.09	-	-	-
Terminalia macroptera	2.15	3.65	-	-	11.46	-	-	6.06

Table 3. Contd.

Hymenocardia acida	2.04	6.66	-	-	5.7	-	-	3.72
Mallotus oppositifolius	1.83	-	2.56	4.51	2.54	-	-	-
Harungana madagascariensis	1.81	1.18	-	-	11.99	-	-	3.65
Ficus exasperata	1.68	2.6	-	2.04	2.55	-	-	-
Syncephalum subscordatum	1.67	-	-	5.94	-	-	-	-
Margaritaria discoidea	1.61	4.75	-	-	-	-	-	9.11
Alchornea laxiflora	1.60	1.29	1.34	2.69	-	-	-	-
Pseudospondias microcarpa	1.60	-	-	-	6.03	9.62	-	-
Myrianthus arboreus	1.60	-	6.6	-	2.54	-	-	-
Macaranga spinosa	1.50	1.28	1.27	-	-	1.76	-	3.6
Parkia bicolor	1.46	-	-	-	6.09	3.93	-	-
Daniellia oliveri	1.38	-	-	-	12.54	-	-	-
Scyphocephalium mannii	1.38	2.47	6.86	-	-	2.91	-	-
Bombax buonopozense	1.32	8.00	-	-	-	-	-	-
Duboscia macrocarpa	1.23	2.7	1.99	-	-	-	-	-
Rinorea bipindensis	1.22	3.5	-	-	-	2.14	-	-
Angylocalyx pynaertii	1.21	-	-	8.1	-	-	-	-
Brachystegia mildbraedii	1.15	1.37	-	2.51	-	-	-	-
Monopetalanthus heitzii	1.12	1.14	2.92	-	-	-	-	-
Irvingia grandifolia	1.11	2.27	2.58	-	-	-	-	-
Amphimas pterocarpoides	1.09	-	-	-	-	1.78	3.1	-
Cordia aurantiaca	1.03	-	-	-	-	-	8.57	-
Allophyllus africanus	1.00	3.55	-	-	2.43	-	-	-
Tetrapleura tetraptera	0.99	-	1.37	1.74	-	-	-	-
Klainedoxa gabonensis	0.98	-	1.29	-	-	1.8	-	-
Syzygium guineense var. *macrocarpum*	0.97	1.16	-	-	2.49	-	-	-
Cylicodiscus gabunensis	0.97	1.27	4.57	-	-	-	-	-
Pterocarpus soyauxii	0.93	-	-	6.6	-	-	-	-
Staudtia kamerunensis	0.91	-	1.29	-	-	-	-	-
Ricinodendron heudelotii	0.87	-	-	3.69	-	-	-	-
Manilkara fouilloyana	0.87	-	-	-	-	10.19	-	-
Autranella congolensis	0.87	-	1.95	5.54	-	-	-	-
Xylopia staudtii	0.85	-	-	3.82	-	-	-	-
Coelocaryon preussii	0.66	-	2.3	-	-	-	-	-
Fernandoa adolfi-fridericii	0.58	3.2	-	-	-	-	-	-
Morus mesozygia	0.58	1.68	-	-	-	-	-	-
Afrostyrax lepidophyllus	0.56	1.17	-	-	-	-	-	-

Table 3. Contd.

Chlamydocola chlamydantha	0.56	-	-	-	-	3.55	-	-
Cleistopholis patens	0.56	-	-	-	-	4.95	-	-
Beilschmiedia anacardioides	0.55	-	2.51	-	-	-	-	-
Detarium macrocarpum	0.55	-	1.85	-	-	-	-	-
Pentaclethra macrophylla	0.55	1.73	-	-	-	-	-	-
Elaeis guineensis	0.54	-	-	2.01	-	-	-	-
Eribroma oblongum	0.53	-	-	1.97	-	-	-	-
Cola acuminata	0.52	-	4.08	-	-	-	-	-
Desplatsia dewevrei	0.52	-	1.6	-	-	-	-	-
Polyscias letestui	0.51	-	-	-	-	2.96	-	-
Canthium arnorldianum	0.49	-	-	-	-	3.6	-	-
Pavetta camerounensis	0.49	1.31	-	-	-	-	-	-
Scorodophloeus zenkeri	0.49	-	-	1.82	-	-	-	-
Tabernaemontana crassa	0.49	-	-	-	-	1.87	-	-
Rauvolfia mannii	0.48	-	1.35	-	-	-	-	-
Rinorea angustifolia	0.47	-	1.27	-	-	-	-	-
Rinorea gilletii	0.47	-	-	-	-	1.87	-	-
Bridelia ferruginea	0.47	-	1.3	-	-	-	-	-
Annona senegalensis	0.47	-	-	-	2.44	-	-	-
Pseudocedrela kotschyi	0.47	-	-	-	-	1.73	-	-
Discoglypremna caloneura	0.47	-	1.27	-	-	-	-	-
Trema orientalis	0.47	-	-	-	2.61	-	-	-
Mammea africana	0.47	-	-	-	-	-	2.48	-
Parinari excelsa	0.47	-	-	-	-	-	-	3.49
Croton sylvaticus	0.47	-	-	-	-	1.78	-	-
Maesopsis eminii	0.47	-	-	1.75	-	-	-	-
Drypetes grossweileri	0.08	1.21	-	-	-	-	-	-

T1: transect 1, T2: transect 2, …, T7: transect 7.

species.

Similarity among undisturbed communities and the significance

Similarity in species composition varied among communities along altitudinal gradient. The relative discontinuity in species composition between communities T3/T5 and T2/T4 could be attributed to the marked transition in altitude among these communities. The similarity in species composition among communities appeared to arise mainly between T1/T2 (t test, p = 0.38), and T1/T5 (t test, p = 0.07). This could be attributed to the location of these communities at lower altitudes. Such an altitudinal transition governs microclimatic conditions such as temperature, radiation, moisture and the nature of substrate which in turn influence plant growth and recruitment (Teshome et al., 2004; Tadesse et al.,

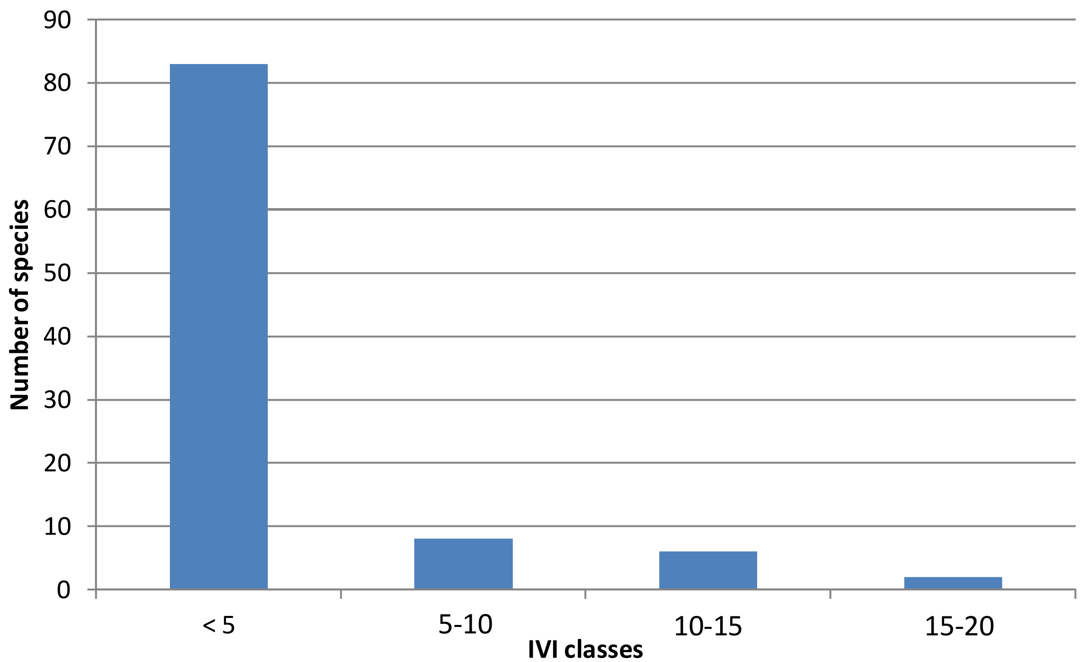

Figure 4. Distribution of the IVI among species. IVI: Importance value index.

Table 4. Sorensen's coefficient similarity among undisturbed communities.

Communities	Altitudinal ranges	Number of species included in comparison	Number of species in common	Sorensen's coefficient of similarity
T1/T2	710-745/710-740	68	27	**0.56**
T1/T4	710-745/830-880	57	17	0.45
T2/T3	710-740/730-750	67	20	0.45
T3/T4	730-750/830-880	51	14	0.42
T4/T5	830-880/695-733	54	13	0.38
T3/T5	730-750/695-733	65	14	0.35
T2/T4	710-740/830-880	63	12	0.36
T2/T5	710-740/695-733	66	21	0.48
T1/T3	710-745/730-750	76	20	0.41
T1/T5	710-745/695-733	65	22	**0.50**

2008). According to Sonke (1998), Cs ≥ 0.5 means that the communities i and j compared belong to the same plant community or have near floristic composition.

Conclusion

Non-timber forest products harvesting can have significant impacts at multiple ecological scales, from individuals to ecosystems. It may alter the structure and composition of plant communities. People living adjacent to the Mbam and Djerem National Park in Cameroon depend directly and immediately on NTFPs, and their commercial use in that region is thus seen as one way to lift people out of poverty. While the livelihood benefits of NTFPs have been widely acknowledged, the contribution of NTFP sector in that region to biodiversity conservation is less certain. Our study has shown that harvesting NTFPs has negative ecological impact on tree species diversity in the region. Plant communities in disturbed sites were characterized by lower Shannon diversity and evenness index values, comparing with undisturbed sites where these index values are highest. Mean diversity measures differed significantly between the two sites (ANOVA test, p = 0.047). Mean altitude values differed slightly between the two sites (Kruskal-Wallis test, p = 0.31). One obvious outcome from our analysis is that by the criteria of high diversity and the presence of a large number of rare species (Myers et al., 2000; Kyer et Barthlott, 2001), the Mbam and Djerem National Park region is of great conservation value, and the excessive utilization of the species may put the species at risk. More effort is required to improve the protection of the park and its periphery, and the development of a suitable regional conservation of biodiversity.

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REFERENCES

Akerele O, Heywood V, Synge H (1991). Conservation of medicinal plants. Cambridge University Press, Cambridge p. 362.

Alcorn J (1993). Indigenous people and conservation. Conserv. Biol. 7:424-426.

Avocèvou-Ayisso C, Sinsin B, Adégbidi A, Dossou G, Van Damme P (2009). Sustainable use of non-timber forest products: impact of fruit harvesting on Pentadesma butyracea regeneration and Financial analysis for its products trade in Benin. For. Ecol. Manag. 257:1930-1938.

Belcher B (2003). What isn't an NTFP? Int. For. Rev. 5(2):161-168.

Belcher B, Ruiz Perez M, Achidiawan R (2005). Global patterns and trends in the use and management of commercial NTFPs: implications for livelihoods and conservation. World Dev. 33:1435-1452.

Belcher B, Schreckenberg K (2007). Commercialisation of non-timber forest products: a reality check. Dev. Policy Rev. 25:355-377.

Campbell DG, Stone JL, Rosas AJR (1992). A comparison of the phytosociology and dynamics of three floodplain (Varzea) forests of known ages, Rio Jurua, western Brazilian Amazon. Bot. J. Linn. Soc. 108:213-237.

Cernea MM (2005). Restriction of access is displacement: a broader concept and policy. For. Migr. Rev. 23:48-49.

Chape S, Harrison J, Spalding M, Lysenko I (2005). Measuring the extent and effectiveness of protected areas as an indicator of meeting global biodiversity targets. Philos. Trans. R. Soc. B. 360:443-455.

Coad L, Burgess N, Fish L, Ravillious C, Coorigan C, Pavese H, Granziera A, Besançon C (2009). Progress towards the Convention of Biological Diversity terrestrial 2010 and marine 2012 targets for protected area coverage. Parks 17:35-42.

Condit R (1995). A review of La Selva: Ecology and Natural History of a Neotropical Rainforest. Ecoscience 2:209-210.

Curtis JT, McIntosh RP (1951). An upland forest continuum in the prairie-forest border region in Wisconsin. Ecology 32:476-496.

Dajoz R (1982). Précis d'écologie. 4è édition, Paris, Bordas p. 503.

Delvaux C, Sinsin B, Darchambeau F, Van Damme (2009). Recovery from bark harvesting of 12 medicinal tree species in Benin, West Africa. J. Appl. Ecol. 46:703-712.

Doucet JL (2003). L'alliance délicate de gestion forestière et de la biodiversité dans les forêts du centre du Gabon. Thèse de doctorat, Faculté Universitaire des Sci. Agronomiques, B-5030 Gembloux p. 323.

Gentry AH (1988). Tree species richness of upper Amazonian forests. Proc. Natl. Acad. Sci. 85:156-159.

Gonmadje CF, Doumenge C, McKey D, Tchouto GMP, Sunderland TCH, Balinga MPB, Sonke B (2011). Tree diversity and conservation value of Ngovayang's lowland forests, Cameroon. Biodivers. Conserv. 20(12):2627-2648.

Guedje M (2002). La gestion des populations d'arbres comme outils pour une exploitation durable: l'exemple de *Garcinia lucida*. Thèse PhD, Univ. Bruxelles p. 266

Hermans M, Akoègninou A, Van LJG (2004). Medicinal plants used to treat malaria in Southern Benin. Econ. Bot. 58:239-253.

Hutchinson J, Dalziel J, Hepper (1972). Flora of West Africa. Vol. III-2, Crown Agent for Overseas Governments pp. 278-574.

Keay RWJ (1989). Trees of Nigeria. Cambridge University Press, p. 476.

Kenfack D, Thomas DW, Chuyong G, Condit R (2006). Rarity and abundance in a diverse African forest. Biodivers. Conserv. 16:2045-2074.

Kent M, Coker P (1992). Vegetation description and analysis. A practical approach, New York: John Wiley and Sons p. 363.

Kier G, Barthlott W (2001). Measuring and mapping endemism and species richness: a new Methodological approach and its application on the flora of Africa. Biodivers. Conserv. 10:1513-1529.

Laird SA, McLain RJ, Wynberg R (2010). Wild product governance: finding policies that work for non-timber forest products. Earthscan, London pp. 83-198.

Lejoly J (1993). Ethnobotanique et méthodologie pour les inventaires biologiques. Projet Ecofac (Conservation et utilisation rationnelle des écosystèmes forestiers en Afrique Centrale) Agreco-CTFT, Bruxelles p. 137.

Letouzey R (1985). Notice de la carte phytogéographique du Cameroun au 1: 500 000. Institut de la carte internationale de la végétation. Toulouse, France pp. 63-142.

Magurran AE (2004). Measuring biological diversity. Blackwell Publishing: Oxford, UK p. 256.

Mori SA, Boom BM, Carvalino AM, Dos Santos TS (1983). The ecological importance of Myrtaceae in an eastern Brazilian wet forest. Biotropica 15:68-70.

Myers N, Mittermeier RA, Mittermeier CG, da Fonseca GAB, Kent J (2000). Biodiversity hotspots for conservation priorities. Nature 403:853-858.

Oksanen J, Blanchet G, Kindt R, Legendre P, O'Hara RB, Simpson GL, Solymos P, Stevens MHH, Wagner H (2010). Vegan: community ecology package, version 1.17-3.

Panayotou T, Ashton P (1992). Not by timber alone: economics and ecology for sustaining tropical forests. Island, Washington, DC, 39 p.

Parren MPE (1991). Silviculture with natural regeneration: A comparison between Ghana, Côte-d'Ivoire and Liberia. Netherlands, Wageningen p. 199.

Pitman NCA, Terborgh JW, Nunez PV, Neill DA, Ceron CE, Palacios WA, Aulestia M (2002). A comparison of tree species diversity in two upper Amazonian forests. Ecology 83(11):3210-3224.

Putz FE, Blate GM, Redford KH, Fimbel R, Robinson J (2001). Tropical forest management and conservation of biodiversity: an overview. Conserv. Biol. 15:7-20.

Rodrigues ASL, Andelman SJ, Bakarr MI, Boitani L, Brooks TM, Cowling RM, Fishpool LDC, Fonesca GAB, Gaston KJ, Hoffmann M, Long JS, Marquet PA, Pilgrim JD, Pressey RL, Schipper J, Sechrest W, Stuart S, Underhill LG, Waller RW, Watts MEJ, Yan X (2004). Effectiveness of the global protected area network in representing species diversity. Nature 428:640-643.

Sayer JA, Maginnis S (2005). Forests in landscapes: ecosystem approaches to sustainability. Earthscan, London p.257.

Senterre B, Lejoly J (2001). Tree diversity in the Nsork rain forest (Rio Muni, Equatorial Guinea). Acta Bot. Gal. 148:227-235.

Sonké B (1998). Etudes floristiques et structurales des forêts de la réserve de faune du Dja.Thèse Doctorat, Univ. Libr. Bruxelles p. 267.

Souare K (2006). Produits forestiers non-ligneux dans la périphérie nord du parc national du Mbam et Djerem : ethnobotanique, écologie et stratégies de gestion durable. Mémoire DEA, Univ. Yaoundé I, p. 79.

Tadesse WG, Denich M, Demel T, Vlek PLG (2008). Human impacts on the *Coffea arabica* gene pool in Ethiopia and the need for its *in situ* conservation. In: Engels JMM, Rao VR, Brown AHD, Jackson MT eds. Managing Plant genetic Diversity. CABI Publishing, UK, pp. 237-247.

Tailfer Y (1990). La forêt dense d'Afrique Centrale : Approche botanique et systématique. Wageningen, CTA p. 1271.

Teshome S, Demel T, Sebsebe D (2004). Ecological study of the

vegetation in Gamo Gofa zone, southern Ethiopia. J. Trop. Ecol. 45:209-221.
Ticktin T, Shackleton C (2011). Harvesting non-timber forest products sustainably: Opportunities and challenges. In: Shackleton S, Shackleton C, Shanley P Eds. Non-timber forest products in the global context. Spring pp. 149-169.
Van Dijk JFW (1999). An assessment of NWFPs resources for the development of sustainable commercial extraction. In: Sunderland TCH, Clark LE and Vantomme P Eds. Current issues and prospects for conservation and development of NWFPs of Central Africa. FAO, Rome p. 84.
Vedeld P, Angelsen A, Sjaastad E (2004). Counting on the environment: forest incomes and the rural poor. Environ. Department paper No. 98, World Bank, Washington, DC p.114.
White F (1983). The vegetation of Africa. UNESCO, Paris p. 356.