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Diversity of woodlands in the groundnut basin of Kaffrine region in Senegal

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ABSTRACT

Objective: This work has examined the current state of woodlands in the groundnut basin to determine its importance
Methodology and results: The floristic diversity of woodlands in the Groundnut Basin of was studied through ecological parameters. The woody flora contained 75 species with a predominance of three (3) families (Combretaceae, Mimosaceae and Caesalpiniaceae) represented by more than six (6) species. The statements from the four targeted rural communities indicated: 31 species for Ndiognick, 43 for Birkelane, 46 for Saly Escale and 48 for Ida mouride. The overall average density was 17 individuals/ha and varied depending on rural communities: 7 individuals/ha for Ndiognick, 9 individuals/ha for Birkelane, 18 individuals for Ida mouride and 39 individuals for Saly Escale. In Ndiognick and Birkelane rural communities, the cover was lower because they were less provided in species (*Cordyla pinnata, Combretum glutinosum, Piliostigma reticulatum* and *Adansonia digitata*) with summits higher than 5m²/ha. The flora and the woody vegetation selected parameters indicated that the level of organization of the woody species was not similar as well as the pressure on the woody species in the rural communities. The diversity of the wood species was reducing due to anthropogenic action and the deterioration due to climate conditions.
Key words: Diversity floristic, diversity index, impact index

INTRODUCTION

Giffard (1974) found that tree cover had reduced over a period of thirty years in all regions of Senegal. It had sometimes disappeared in some areas due to worsening climate change and human action. In the Groundnut Basin in Senegal, clearing for cropland expansion and grazing has contributed to forest degradation. In 1983, the Society for Development and Agricultural Extension (SODEVA), estimated that before 1993, all arable land in the Groundnut Basin would be cultivated considering the rate of clearance at that time (Niang, 1990). Samba *et al.*, 2000, found in a study in North Central Groundnut Basin in the forest of *Faidherbia albida* that 42% of inventoried species could not withstand the environmental conditions and human activities and will experience a decrease in time The number of most species (*Ficus platyphylla*, *Aphania senegalensis*, *Diospyros mespiliformis*) continues to decline despite the existence of natural regeneration that seems important (during the rainy season) to only certain species, especially those of the family of Combretaceae (*Guiera senegalensis*, *Combretum glutinosum*, *Combretum aculeatum*.) but is subsequently removed during harvest and pre-crop work. The reintroduction of tree in the agrarian landscape appears as a means to restore these degraded agricultural systems to improve rural incomes (Bonkoungou, 1985, Belsky *et al.*, 1993).This work examines after 19 years of exploitation, the current state of woody stand diversity through tree structures to determine its importance in different lands.

MATERIEL AND METHODS

Site Description: The study was conducted in the Groundnut Basin in Senegal, precisely in the regions of Koungheul and Kaffrine located between longitudes 15 ° 86 'W and 14 ° 58' E and latitude 14 ° 74 'N and 13 ° 74' S (figure 1). The climate is Sudano-Sahelian with a rainy season of short duration ranging from June to July to October and a long dry season from 8 to 9 months. The monthly average temperatures minimum and maximum are respectively 18.2 ° C (January) and 40.7 ° C (April). The average annual temperature is 29.6 °C.

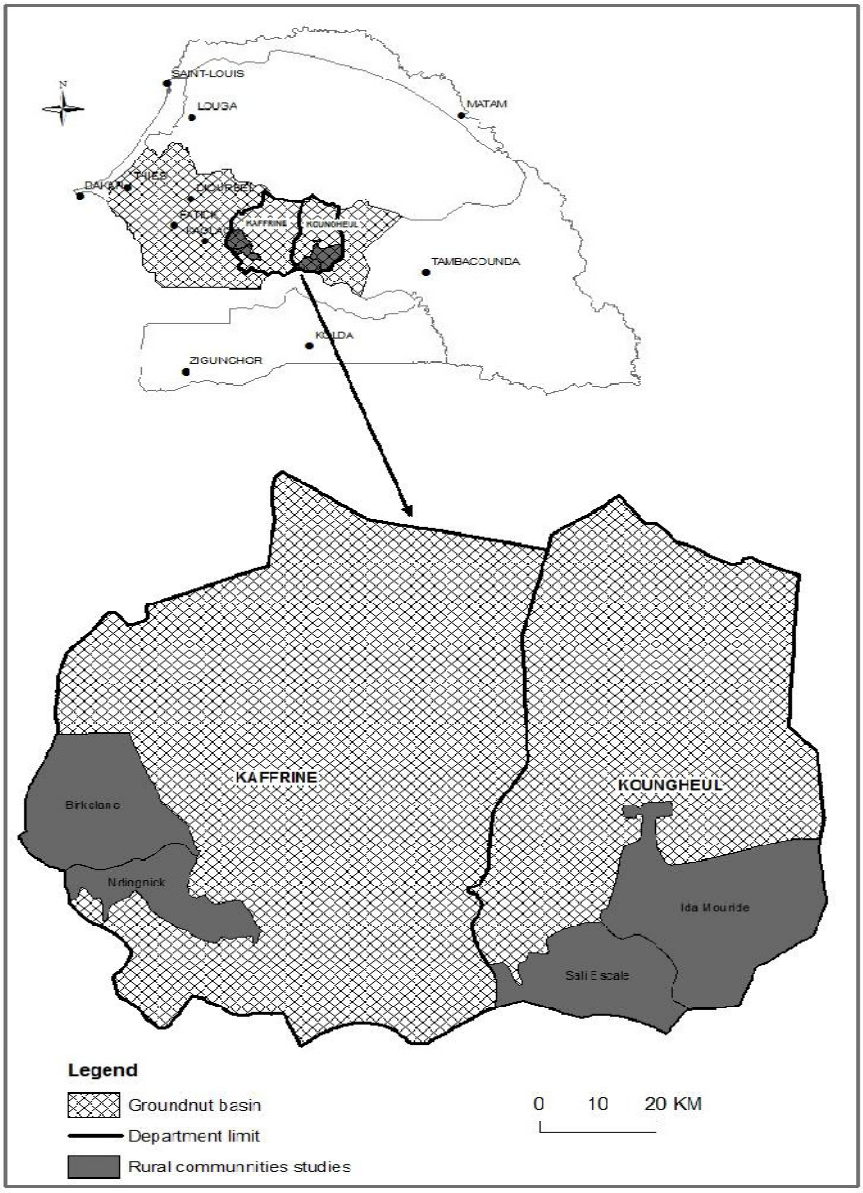


Figure 1: Site location of the studied area (DEFCCS/CSE, 1996)

The analysis of rainfall series 1958-2008 showed that the interannual average rainfall was 640 ± 171 mm. The coefficient of variation was 27%. The minimum rainfalls were recorded during the year 1979 (408 mm), 1980 (443 mm) and 1983 (437 mm) and the highest in 2006 (910 mm) and 1999 (895 mm). The average rainfall duration was 45 days. The comparison of the annual precipitation to the interannual average rainfall allowed to show that one year out of two was dry (47% exactly). It also identified the year of failure in the series

to 1967 (Figure 2).Thus, two periods could be considered (figure 2):

- the first period from 1958 to 1967, was characterized by years where rainfall was generally above interannual average rainfall: it was the wet period. The average rainfall was 729 ± 182 mm or a variation of 25%;
- The second period, from 1968 to 2008, was characterized by a succession of rainfall deficit years (23). The average rainfall was 619 ± 162 mm. The variation was 15% over the previous period.

The number of rainy days per year is same for all three columns and equal to 45 days. The amount of water recorded per rainy days is 14.53 mm for all the chronic, 14.04 for the second period and 16.55 mm for the first period (Table 1).

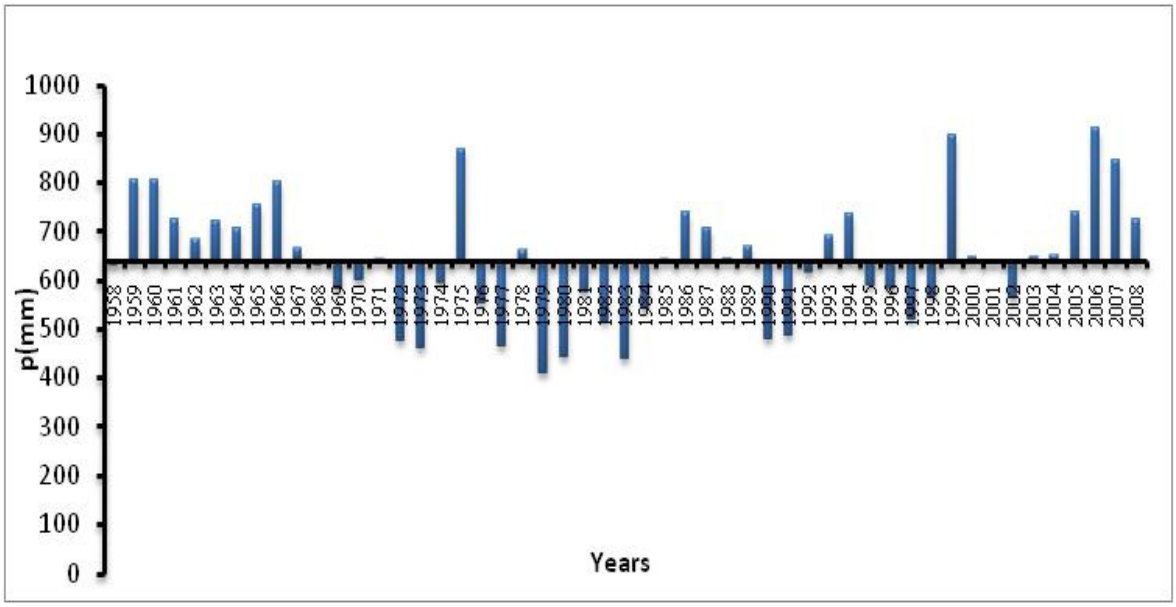


Figure 2: Progressive tendency of pluviometry (1958- 2008) (Source: ANAMS, 2009)

Table 1: Number of rainy days per year and quantity of rainfall

	Period	**Number of rainy days**				**Q mm/j**
		Moy	**CV (%)**	**Min**	**Max**	
Study area	*1958 to 1967*	45	18.1	31	61	16.55
	1968 to 2008	45	25.8	28	93	14.04
	1958 to 2008	45	24.4	28	93	14.53

The rainy season begins in May and ends in October (Figure 3). During this period, there is a trend of higher rainfall than temperature (P> 2T). High temperatures are often observed during the dry season (during which P <2T). Between October and the end of February, temperature is about 28 ° C on average and it is the cold dry season. It is around 31.17 ° C between March and early June, the hot dry season. The months of July, August and September are the biological wet period accumulating 84.7% of precipitation. The peak is reached in August (the wettest); where it receives 37.1% of the annual precipitation.

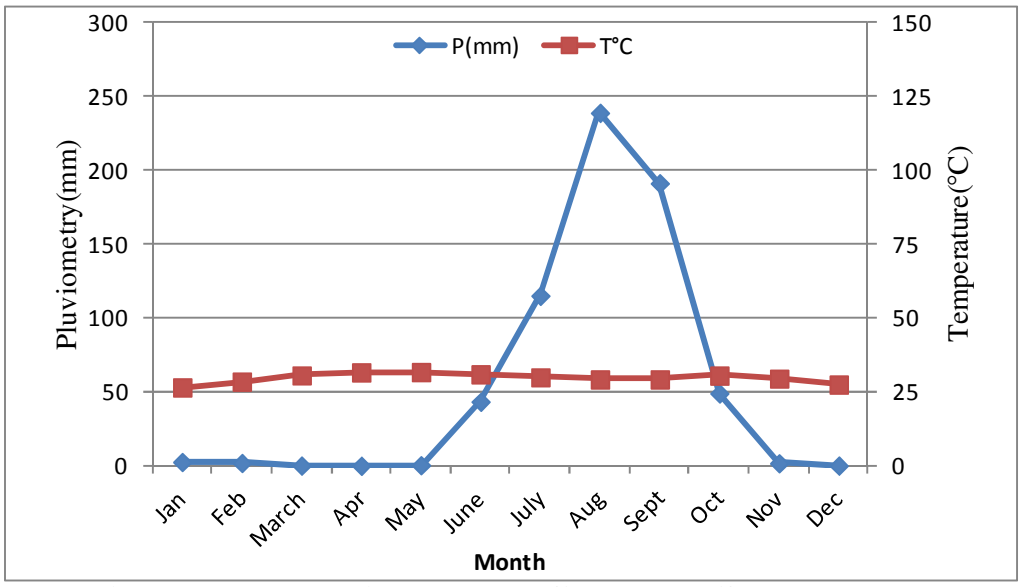


Figure 3: Ombrothermic diagram of the studied area (Source: ANAMS)

The terrain is relatively flat and low altitude, between 20 and 50 m with three major geomorphic units (Cairo 1999). It distinguishes the plateau which is the highest part of the toposequence; the glaze that leaves the edge of the plateau to the valley is the rainfed area and the valley formed by the flood zone. Studies have shown that the west-central pedoclimatic area is essentially characterized by ferruginous tropical soils which are divided into leached under the influence of water or not leached, hydromorphic soils and halomorphic according to French classification (Sarr, 2008; Atlas national du Sénégal, 2006). The vegetation is characterized by a climatic gradient and topo-edaphic conditions (MEPN, 2005 CSE, 2005). Four types of savannas exist in the study area: grass, shrubs, trees and woodland (Ndao, 2001). The herbaceous savannah is characterized by the absence or near absence of trees and shrubs. It is mainly found in the northern region of Kaffrine, in areas with very shallow soil or very dry. The floristic composition is marked by the predominance of species belonging to the family Poaceae, Cyperaceae and Acanthaceae. Among the few wood present, species of genera *Combretum* and *Guiera* are well represented. The shrub savanna comprises a nearly continuous carpet of tall grasses with shrubs. There exists closed shrub savanna (recovery rate between 15 and 25%), and opened shrubland (recovery rate between 5 and 15%). The forests of the northern region and armored areas of south-east (towards Koungheul) host this type of vegetation. The species of genera *Combretum* (*Combretum glutinosum*, *Combretum nigricans*) and *Guiera* are predominant.The savanna is marked by a nearly continuous mat with scattered trees and shrubs that cover does not exceed 25% of the area. The classified forest of Paté is one of the last relics with areas between Boulel and Gnibi. In this area of savanna few *Pterocarpus erinaceus* trees were accounted. Woodland has an almost continuous carpet with a high density of trees (8-20 m high) and shrubs forming a generally sparse cover 25 to 50% of the area. There is only one area of woodland in the extreme south of the region in depressions and along the fossil valleys, on the border with Gambia. It is the forest of Dankou that continues in Gambia lands. The species that dominate are: *Pterocarpus erinaceus*, *Terminalia macroptera*, *Bombax costatum*, *Combretum glutinosum.*

Methods: The sampling method used to identify the village lands held in each rural community to inventory woody vegetation divided the woody vegetation in units. Each unit was more homogeneous than the whole mass of in the rural community. This division was made based on the land use map (CSE, 2004). In the studied area, a total of 25 groups of villages were determined according to some cultural practices criterion (intensity of agricultural activity, diversification, mechanization level, presence or absence of fallow, trees density in the fields). In each group, equidistant transects of 500 m oriented East-West were laid down. Following each transects, every 500 m, plots of 50 m x 50 m were delineated in the fields, in the fallows and in the forests

plots of 30 m x 30 m were installed. Fifty (50) plots were ultimately laid out in each land.

The complete enumeration of the woody stand was then performed in a total of 1143 plots of 262 ha (Bakhoum *et al.*, 2012). The following parameters were measured on each tree: 1) the total height (m) to establish the stand structure, 2) the basal diameter (cm) of the trunk at 30 cm above the ground (because for many individuals, first branches are located below 1.30 m, height typically recommended in forestry) to estimate basal area, and 3) the distance (m) between trees to assess the distribution of individuals and to calculate the theoretical density; 4) the diameter of the crown to evaluate the recovery.

Data analysis: Woody flora was studied on the basis of five parameters: the floristic diversity, the diversity index of Shannon Weaver (1949), the index of regularity of Frontier and Viale (1992) and Pielou evenness index (1966) and frequency. Varying depending on the number of species recorded and abundance of each species, the Shannon index measures the variability of species composition in each rural community. We calculated evenness convenient to compare environments. The Shannon diversity and regularity indices were calculated respectively using the following formulas:

$$\overline{H'} = \sum_{i=1}^{S} \left(\left(ni/N \right) * \log_2 \left(ni/N \right) \right)$$

and

$$\overline{e} = \frac{\overline{H}}{\overline{H_{\max}}} = \frac{\overline{H}}{\log_2 S}$$

Where ni: number of individuals of a given species, i from 1 to S (number of species)N: total number of individuals. The current status of ligneous was studied through structure parameters: density, species richness, dominance index or coefficient of "concentration of dominance», index of Simpson, recovery and basal area. The analyses were performed using SPSS software (Statistical Package for Social Science) after the data entered in CSPRO (Census and Survey Processing System).

RESULTATS

Floristic diversity

Floristic composition: The flora of the study area consisted of 75 woody species distributed in 59 genera and 33 families. Five (05) families were the most represented: they were Combretaceae (9 species), Mimosaceae (8 species), Cesalpiniaceaes (7 species), Euphorbiaceae and Moraceae (4 species). Many families were represented by only one species. Only seven genera were represented by more than one species: *Acacia* and *Combretum* (5 species), *Ficus* (4), *Grewia* (3), *Piliostigma*, *Zizyphus* and *Terminalia* (2) (Table 2). The number of families varied depending on rural communities. Ida mouride rural community was the fitted with 25 families. Birkelane and Saly Escale contained respectively 23 and 21 families and 17 for Ndiognick.

The genus distribution varied according to rural communities. Ida mouride had the highest number (41), followed by Saly Escale (37), Birkelane (36) and Ndiognick (26). Based on the floristic composition of Ndiognick rural community it had 31 species, 43 species for Birkelane, Saly Escale and Ida Mouride indicated respectively 46 and 48 species. These results showed that the flora of the rural communities in Koungheul department (Saly Escale and Ida Mouride) was richer in species, genera and families. The analysis of the 1958-2008 series which showed a largest average interannual rainfall in the department of Koungheul with 670 mm compared to the Department of Kaffrine with 611 mm (Anams, 2009) may partly explained this trend.

Table 2: Woody flora inventoried according to rural communities

Family	Species	Rural Community			
		Birkelane	Ndiognick	Saly Escale	Ida mouride
Anacardiaceae	*Sclerocarya birrea*		+	+	+
	Lannea acida	+		+	+
	Heeria insignis		+	+	
Annonaceae	*Hexalobus monopetalus*	+		+	+
	Annona sp			+	+
Apocynaceae	*Baissea multiflora*				+
	Adenium obesum	+			
Arecaceae	*Borassus aethiopium*	+	+		
Asclepiadaceae	*Calotropis procera*	+	+		
	Leptadenia hastata	+			+
Balanitaceae	*Balanites aegyptiaca*	+	+		
Bignoniaceae	*Stereospermum kunthianum*	+		+	+
Bombacaceae	*Adansonia digitata*	+	+	+	+
	Bombax costatum			+	+
Burseraceae	*Commiphora africana*	+			
Capparaceae	*Maerua angolensis*	+		+	+
	Cadaba farinosa	+			
	Crataeva religiosa			+	
Celastraceae	*Maytenus senegalensis*				+
Cesalpiniaceae	*Piliostigma reticulatum*	+	+	+	+
	Cordyla pinnata	+	+	+	+
	Tamarindus indica	+	+		
	Bauhinia rufescens	+	+		+
	Cassia siberiana		+	+	+
	Piliostigma tonninguii			+	
	Parkinsonia aculeata				+
Combretaceae	*Combretum glutinosum*	+	+	+	+
	Guiera senegalensis	+	+	+	+
	Combretum micranthum			+	+
	Anogeissus leiocarpus	+	+	+	+
	Terminalia macroptera	+		+	+
	Combretum nigricans	+	+	+	
	Combretum aculeatum	+			
	Terminalia avicinoides	+		+	+
	Combretum leucardii			+	
Ebenaceae	*Diospyros mespiliformis*	+	+		+
Euphorbiaceae	*Jatropha curcas*				+
	Euphorbia balsamifera	+		+	+
	Hymenocardia acida				+
	Securinega virosa	+			
Fabaceae	*Pterocarpus erinaceus*	+		+	+
	Erythrina senegalensis				+
Icaciniaceae	*Icacina senegalensis*		+	+	
Liliaceae	*Asparagus Pauli-Gulielmi*	+			
Loganiaceae	*Strychnos spinosa*	+		+	+

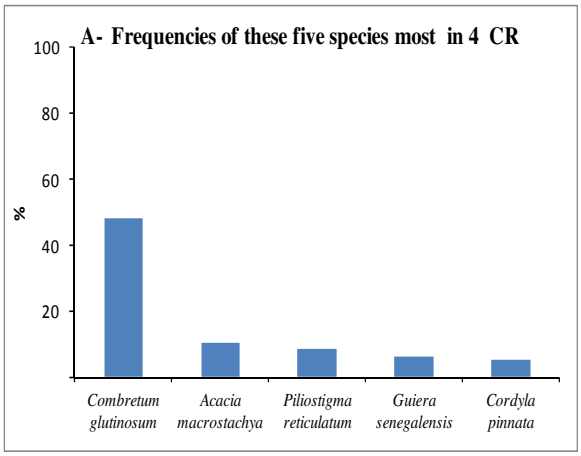
Family	Species	Rural Community			
		Birkelane	Ndiognick	Saly Escale	Ida mouride
Meliaceae	*Azadirachta indica*	+	+	+	+
	Ekebergia senegalensis			+	
Mimosaceae	*Acacia macrostachya*	+	+	+	+
	Acacia seyal	+	+	+	+
	Prosopis africana	+	+	+	
	Dichrostachys glomerata	+		+	+
	Acacia .nilotica var adansonii	+	+		+
	Acacia siberiana	+	+		
	Acacia senegal			+	
	Albizzia chevalieri	+			
Moraceae	*Ficus sp*		+	+	+
	Ficus iteophylla	+			+
	Ficus capensis			+	
	Ficus gnaphalocarpa		+		
Myrtaceae	*Eucalyptus camaldulensis*				+
Opiliaceae	*Opilia celtidifolia*			+	
Poaceae	*Oxytenanthera abyssinica*				+
Polygalaceae	*Securidaca longipedunculata*	+	+	+	+
Rhamnaceae	*Zizyphus mauritiana*	+	+	+	+
	Zizyphus gola				+
Rubiaceae	*Feretia apodanthera*	+	+	+	+
	Gardenia triacantha			+	+
	Mitragyna inermis		+	+	
Sapindaceae	*Aphania senegalensis*				+
Sterculiaceae	*Sterculia setigera*	+		+	+
Tiliaceae	*Grewia bicolor*	+	+		+
	Grewia tenax			+	
	Grewia villosa			+	+
Ulmaceae	*Celtis intigrifolia*		+	+	+
Verbenaceae	*Vitex doniana*			+	
Total		**43**	**31**	**46**	**48**

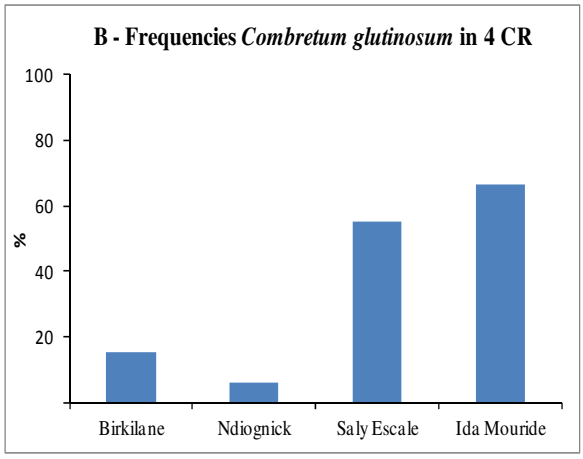
The + sign indicates presence of species in the rural community

The rural communities of Ida contained 4 characteristic families (Myrtaceae, Celastraceae, Poaceae and Sapindaceae). Saly Escale contained 2 (Verbenaceae and Opiliaceae) as well as Birkelane (Burseraceae and Liliaceae). The rural community of Ndiognick did not record any characteristic family. Each of these families was represented by one species (Table 2 and 4). Like families, rural community Ndiognick did not contain any characteristics genus. Saly Escale accounted 4 (*Vitex, Ekebergia*, *Crataeva* and *Opilia*). *Commiphora, Securinega, Cadaba, Albizzia*, *Adenium and Asparagus* were the 6 characteristic genera in Birkelane rural communities. Ida mouride indicated 8 genera (*Jatropha*, *Maytenus*, *Hymenocardia*, *Parkinsonia*, *Erythrina*, *Baissea*, *Oxytenanthera and Aphania*) (Table 2 and 4).The characteristic species varied according to rural communities. Birkelane accounted 7 (*Commiphora africana*, *Combretum aculeatum*, *Securinega virosa*, *Cadaba farinosa*, *Albizzia chevalieri*, *Adenium obesum* and *Asparagus pauli-gulielmi*. Only *Ficus gnaphalocarpa* characterized Ndiognick rural communities. *Opilia celtidifolia*, *Acacia senegal*, *Ekebergia senegalensis*, *Crataeva religiosa*, *Ficus capensis*, *Vitex doniana*, *Combretum leucardii, Piliostigma thonninguii*, *Grewia tenax* were the 9 species linked to Saly Escale rural communities. In Ida

Mouride rural communities, 10 characteristic species were identified: *Eucalyptus camaldulensis*, *Maytenus senegalensis*, *Hymenocardia acida*, *Parkinsonia aculeata*, *Erythrina senegalensis*, *Ziziphus gola*, *Baissea multiflora*, *Oxytenanthera abyssinica*, *Aphania senegalensis*, *Jatropha curcas* (Table 2 and 4).The rural communities of Ndiognick were distinguished by absence of characteristic family and genus. Ida and Saly Escale were richer in characteristic species. These were generally uncommon or rare; revealed their presence by a specific ecological biotope (Akpo, 1998; Ramade, 2003).Twelve species (16%) belonging to all four rural communities were identified. It was *Combretum glutinosum*, *Acacia macrostachya*, *Piliostigma reticulatum, Guiera senegalensis*, *Cordyla pinnata Securidaca longipedunculata*, *Zizyphus mauritiana*, *Azadirachta indica*, *Acacia seyal*, *Feretia apodanthera*, *Adansonia digitata* and *Anogeisus leocarpus*.

Frequency of species: The frequency indicated the contribution to the floristic composition. Figure 4 showed the representativeness of the five most common species of woody flora and the specific frequency of each of them in the four rural communities. The population was mainly dominated by *Combretum glutinosum* which represented almost half of the number (48.3%) followed by *Acacia macrostachya* (10.3%), *Piliostigma reticulatum* (8.5%), *Guiera senegalensis* (6.3%) and *Cordyla pinnata* (5.2%) (Figure 4A). *Combretum glutinosum* was present respectively in Ida mouride (67%) and Saly Escale (55%). At Birkelane and Ndiognick the specific frequency of *Combretum glutinosum* was less than 20% (Figure 4B). *Acacia macrostachya* was practically identified in Saly Escale with a frequency exceeding 20% (Figure 4C). The specific frequency of *Piliostigma reticulatum* was below 10% in Ndiognick and Saly. The maximum frequency was observed in Birkelane (14%) (Figure 4D). *Guiera senegalensis* was strongly represented in Birkelane (36%), while in other rural communities; its specific frequency was less than 6% (Fig. 4E). *Cordyla pinnata* was more present in Ndiognick, followed by Saly Escale and Ida mouride. The specific frequency was very low (2.3%) in Birkelane (Figure 4F). The specific frequency of *Combretum glutinosum* was linked to its remarkable presence in the forest of Koungheul (89.8%) of Ida mouride and in the protected area of Mousdalifa (65.1%) of Saly Escale. *Acacia macrostachya* ranked second because of its remarkable presence in the protected area (28.4%). The frequency *Guiera senegalensis* was linked to its strong representation in the forest (60.7%) and in fallows of Birkelane and Ndiognick. The low specific frequency variation of *Piliostigma reticulatum* between rural communities was associated with a fairly even distribution in fields and fallows with a slight dominance in fallows of Birkelane. *Cordyla pinnata* justified its presence by preserving in particular fields of Ndiognick due to its multiple uses.





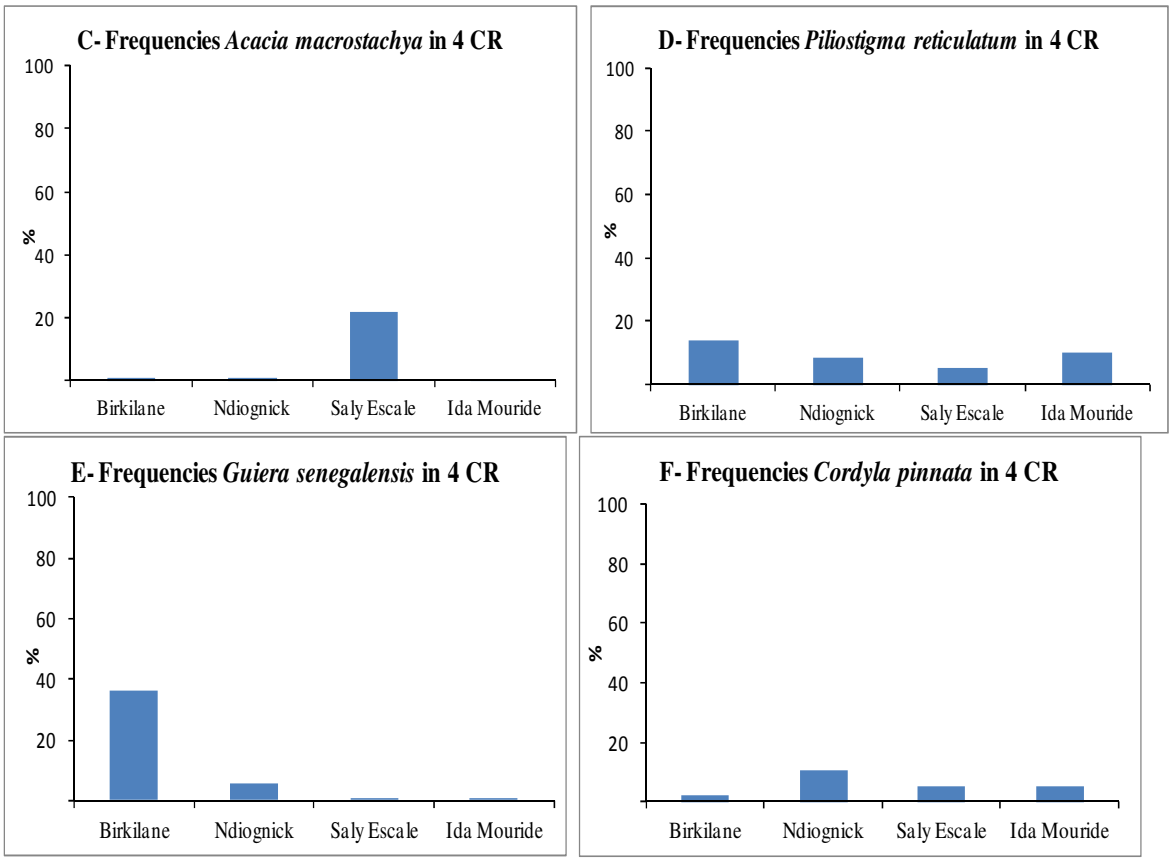


Figure 1: Frequency of the most represented species

Besides these common species included species that could be described rare because of their very low frequencies (below 0.5%). They were 55 species in which the rarest were: *Combretum leucardii, Heeria insignis, Leptadenia hastata, Grewia villosa, Ficus iteophylla, Vitex doniana, Erythrina senegalensis Zizyphus gola, Securinega virosa, Baissea multiflora, Cadaba farinosa, Ekebergia senegalensis, Crataeva religiosa, Ficus capensis, Acacia senegal, Albizzia chevalieri, Adenium obesum, Ficus gnaphalocarpa, Oxytenanthera abyssinica, Asparagus Pauli-Gulielmi, Opilia celtidifolia, Aphania senegalensis*.

Current Status of the woody stand

Indices of diversity: The diversity index of family was 3.1 in Ndiognick rural communities, in Birkelane 2.4, in Saly Escale 1.9 and 1.5 in Ida mouride. Saly and Idamouride had a similar weak index. Ndiognick indicated the highest index followed by Birkelane. The regularity index of family varied in proportion to the diversity index in the four rural communities. The diversity index of genus varied in decreasing 3.9 for Ndiognick, 3.1 for Birkelane, 2.2 and 1.9 respectively for Saly Escale and Ida mouride. As the diversity of family, that genus was comparable to Saly and Ida whereas for Birkelane and Ndiognick a difference was observed. The regularity index followed the same trend as the index of genus diversity (Table3). These results demonstrated a similar low level of organization of ligneous in Saly Escale and Ida mouride and compared to those of Birkelane and Ndiognick indicating higher values. Comparing the values, the indices showed that although Ndiognick floristic richness was the lowest its level of organization was more stable. Floristic richness does not necessarily have a positive effect on the stand stability. In Birkelane and Ida Mouride, the Shannon index was 3.40 and 2.23 respectively. In Saly Escale, this index was 2.36 and 3.52 for Ndiognick. Birkelane and Ida mouride although having different Shannon indices, have an equivalent specific richness. Saly Escale and Ndiognick also responded to this trend.The regularity index was 0.63 in Birkelane, in Ndiognick 0.71, 0.43 and 0.40 respectively in Saly Escale and Ida mouride. Birkelane and Ndiognick have a comparable regularity index whereas species richness was different (Table 3 and 4).

Table 3: Variation of flora parameters according to rural communities

Parameters	Values			
	Birkelane	**Ndiognick**	**Saly Escale**	**Ida Mouride**
Floristic richness	43	31	46	48
Index of family diversity	2.4	3.0	1.9	1.5
Index of family regularity	0.5	0.7	0.4	0.4
Index of genus diversity	3.1	3.9	2.2	1.9
Index of genus regularity	0.6	0.8	0.4	0.4
Index of Shannon	3.403	3.516	2.357	2.230
Index of regularity	0.627	0.710	0.427	0.399

Structure of the woody stand

The structure of the stand was carried out by the following parameters: density, recovery, basal area, specific richness, index of dominance, families, genera and species characteristics

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Table 4: Variation of the woody stand parameters according to rural communities

Parameters	Values			
	Birkelane	**Ndiognick**	**Saly Escale**	**Ida Mouride**
Density (individuals/ha)	9.26	7.16	39.30	18.26
Basal area (m^2/ha)	4.19	2.77	8.05	3.24
Recovery (m^2/ha)	183.29	151.92	475.76	329.94
Average Specific Richness	3.8	4.7	4.8	4.4
Families characteristics	2	0	2	4
Genera characteristics	6	0	4	8
Species characteristics	7.0	1.0	9.0	10.0
Index of dominance	2.4	0.8	20	9.6
Indifferent Species	12			

The dominance is defined by the importance of a species depending on the area or volume it occupies. It varied according rural communities: 0.8 in Ndiognick, 2.4 Birkelane, 9.6 in Ida mouride and 20 in Saly Escale. It was significantly higher in Saly Escale and lowest in Ndiognick (Table 4).

- **Density:** The density is the ratio between number of species and total area of inventoried plots. The overall average density was 17 plants / ha. It was 7 individuals / ha Ndiognick, 9 individuals / ha for Birkelane, 18 individuals / ha for Ida mouride and 39 individuals / ha Saly Escale (Table 4). This showed that lands in the rural communities of Saly Escale were densely populous. Those Ndiognick were less endowed in number of individuals per hectare. Only two species (*Combretum glutinosum* and *Acacia macrostachya*) had a density per rural community superior or equal to 9 individuals / ha. *Acacia macrostachya* reached this density in Saly Escale rural communities and *Combretum glutinosum* and had a density of 22 individuals / ha in the same rural communities and 12 trees / ha in Ida mouride. The highest densities in Birkelane and Ndiognick rural communities were 3 individuals / ha respectively for *Guiera senegalensis* and *Securidaca longipedunculata*. Overall, species density per rural community was relatively low.
- **Recovery**: The woody recovery is the vertical projection of the surface of the crown of the tree to the ground. It indicates the portion of the ground covered by the foliage of the tree. The total recovery of new plants was 278.05 m^2/ha or 2.78% of the surface of the study sites. Note that of the 75 species encountered, only 4 had recovery values greater than 5 m^2/ha. They represented 65% of total recovery. It was *Cordyla pinnata* (29.69 m^2/ha), *Combretum glutinosum* (20.58 m^2/ha), *Piliostigma reticulatum* (7.37 m^2/ha) and *Adansonia digitata* (7.09 m^2/ha). The nature of *Cordyla pinnata*, large species (important recovery) and among the five most represented species justified the value of its recovery rate. The recovery analysis according to rural communities showed a high variability. The value varied of 151.91 m^2/ha for Ndiognick, 183.29 m^2/ha for

Birkelane, 329.94 m^2/ha for Ida mouride to 475.76 m^2/ha for Saly Escale (Table 4). The surface of the shade produced by trees in Saly Escale was 3.1 times higher than that produced in Ndiognick.

- **Basal area:** The basal area still called basal cover is the sum of the surfaces of tree trunks at 0.30 m. For a species, it is the sum of the surfaces of different individuals of the species. The average value was 4.371 m^2/ha varying according to rural communities. It was 2.77 m^2/ha in Ndiognick, 3.24 m^2/ha in Ida mouride, 4.19 in Birkelane m^2/ha and 8.05 m^2/ha in Saly Escale (Table 4). The value of the basal area in Saly Escale was almost 3 times that of Ndiognick, 2.5 times the value in Ida mouride and 2 times that in Birkelane. Only two species (*Cordyla pinnata* and *Adansonia digitata*) had a basal area greater than 1 m^2/ha per rural community as well as for the entire population. The species *Combretum glutinosum*, *Acacia macrostachya*, *Piliostigma reticulatum, Guiera senegalensis* which were characterized by their significant frequencies had very low values basal area (less than 1m^2/ha). It seemed that for these four species their frequency was inversely proportional to the size of their trunks.

Measurement of impact: To determine the impact of woody stand use, we calculated an index of impact based on the average rank obtained per rural community. The principle was to assign scores ranging from 1 to 4 to the parameter values chosen for the flora and vegetation (Table 5 and 6). Note 1 corresponded to the minimum value of the parameter and 4 for the maximum value. We then proceeded to adding the points obtained by the different settings for the same rural community. The total score for each category was then divided by the sum of points distributed (9 x 4) + (9 x 3) + (9 x 2) + (9 x 1), let be 90. For different modes of parameters used, the maximum value of the impact factor cannot exceed 0.4 (40%). Lower is the value of this index, the higher is the pressure. We can then compare the different environments (rural communities) or follow the temporal evolution of the same type of environment. The rural communities of Ndiognick and Birkelane obtained respectively 18.9% and 22.2%. Values had evolved in Ida muouride (25.6%) and Saly Escale (33.3%). The value of the impact index was significantly higher in Saly Escale. The lower index value obtained for Ndiognick indicated a strong pressure on the woody.

DISCUSSION

This paper examines the characteristics of the woody stand in lands in the Groundnut Basin through ecological parameters. The results showed that two stands can have a similar number of species and may have different structures (Barbault, 1992). A similar diversity index, two stands may have a different physiognomy. On the basis of Shannon index, evenness and richness, species diversity which associates appears to be adapted to classify the stands (Akpo, 1998). The dominance is an important parameter for describing the structure of a population. It is of interest, because in part determines the functional organization of the stand (Ramade, 2003). The dominance and diversity are inversely related as shown by the results of the calculation of these parameters. The characteristic species are generally uncommon or rare; reveal their presence by a specific ecological biotope (Akpo, 1998; Ramade, 2003). The results of this study show that the woodlands are declining in its diversity. In the study area, rainfall data collected show a regressive evolution with a strong interannual variability. It has been noted by many authors (Sarr, 2009; Touré 2002; Batterbury *et al.*, 2001; Hulme, 2001). Series 1958-2008 shows that two years is dry. Gareyane (2008) indicates that a succession of two or more years of moderate drought is dramatic on vegetation. A study on the characterization of soils and occupation conducted in the area showed that the most part of south-east to what belong Ida mouride and Saly Escale rural community is more densely populated and richest in species (Ndao, 2001). Senegal and West Africa, the decline of rainfall was observed indicating the onset of drought since the 1970s (Ozer *et al.,* 2010). This decrease in rainfall with dry periods has created many changes in different agro-climatic zones of West and East Africa (Diatta *et al.*, 2001). In the Groundnut Basin, such a situation has resulted in the death of standing timber in which species are most affected among other *Pterocarpus erinaceus*, *Bombax costatum*, *Prosopis africana*, *Sclerocarya birrea*. The aridity of the climate could cause this mortality by reducing the availability of water and nutrients limiting the physiological functioning of trees (Kossi *et al.*, 2009). A reduction in defense systems of trees against disease attack could be driven by activation of physiological stress caused by the extension of periods of heat and dryness of environment (Wardell *et al.*, 2003). Thus the species most sensitive to drought regress or disappear gradually. This situation confirms that the major climate constraint is not only low rainfall,

but variability in the distribution that is a determining factor in the control of the Sahelian ecosystem, changing the flora and vegetation (Ozer *et al.*, 2010; Hulme *et al.*, 2001; Darkoh, 2003). These are species like *Guiera senegalensis*, *Combretum glutinosum*, *Piliostigma reticulatum*, *Acacia macrotachya* and *Cordyla pinnata* that appear more resistant to climate shocks are more represented in area. If several studies have shown the impact of drought on plants, human activities are likely to be carriers of plant succession and environmental degradation (Dembele, 1996 Khresat *et al.*, 1998, Diallo *et al.*, 2011). Bushfires, the abuse (charcoal, timber, service and firewood, mutilation of tree fodder, non-timber products), clearing / inappropriate farming practices may partially explain this phenomenon. The excessive cutting of wood has been highlighted as an important factor in the dynamics of woody regressive (Faye *et al.*, 2008). In tropical Africa with increasing population, the fallow period is reduced or absent in places resulting in a degradation of vegetation and irreversibly (Kio, 1981). The colonization of space increases in the study area, due to population growth and the need for arable land causing invasion of new lands (Ba *et al.*, 2004; Touré, 2002). In the Groundnut Basin during clearing are preserved multipurpose species in some fields (Akpo, 2004). In clearings in tropical Africa for cultivation, many trees are felled. Despite the preservation of some useful trees in the fields, and the elimination of other action fires do not favor the recovery of the vegetation (Kio 1981, Dembele, 1996). Only shrubs are able to regenerate quickly enough resulting in a change in vegetation structure and composition (Nasi, 1994; Fournier *et al.*, 2001). The bibliographic data on work of Trochain (1940) and Adam (1965) give an idea of the richness of the forest of the study area at this time. In his contribution to the study of vegetation in Senegal Trochain (1940) indicated that the climax was a savanna colonized by the dominant species like *Khaya senegalensis*, *Anogeissus leiocarpus*, *Pterocarpus erinaceus* and *Cordyla pinnata*. Today, the south savannah deteriorates gradually yielding place to the bushland marked by the dominance of Combretaceae (*Combretum glutinosum*, *Guiera senegalensis*), Mimosaceae (*Acacia macrostachya*) and Cesalpiniaceaes (Piliostigma *reticulatum*). This degradation is accompanied often a loss of diversity in the level of genera as well in species. The current trend is characterized as well by a decline in biodiversity. The fallows, which had intensification and diversification in species, are now rarer (Touré, 2002). This changing landscape is not the exception in the study area. Identical changes are noted in tropical Africa (Kossi *et al.*, 2009).

CONCLUSION

The diversity of woody stands in the groundnut basin is identified. The parameters of the flora and vegetation indicate that the level of organization of the settlement is not the same as the pressure on the timber. In general, the woody known threats and in particular anthropogenic (abuse, inappropriate farming practices, bush fires) affect the environment. The results show that the reduction of diversity follows a gradient from west (Kaffrine department) to the east (Department Koungheul). The parameters analyzed for flora and woody vegetation indicate differences in the management of settlement of rural communities. The fact is that the ecological balance of flora and vegetation is disturbed by human actions (agricultural, pastoral, exploitation). Pressure on wood resources is increasing in the Sudanian and Sahelian regions. The increase in population, human actions aggravate the reduction of diversity initiated by natural factors (drought) for several years. It would be interesting to pursue investigations to clarify the ecological conditions of *Combretum glutinosum*, *Piliostigma reticulatum* and *Guiera senegalensis*. The study of the influence of *Combretum glutinosum*, *Piliostigma reticulatum* and *Guiera senegalensis* on yields of annual crops (millet and peanut but) is to invest, given their remarkable presence in fields. Eco-physiological studies on *Combretum glutinosum, Piliostigma reticulatum* and *Guiera senegalensis* are needed to clearly identify their interactions with annual crops. Some investigations should be pursued by a comparative study of the evolution of ligneous (Birkelane, Ndiognick, Ida mouride and Saly Escale) due to anthropogenic factors, climate and topography over time in order to propose sustainable management solutions. Actions must be taken to preserve species that are still present in the environment with the support of development patterns. *Pterocarpus erinaceus* and *Cordyla pinnata*, multipurpose species, the development of their nursery production should be encouraged and supported.

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