International Journal Of Engineering Research And Development
e-ISSN: 2278-067X, p-ISSN: 2278-800X, www.ijerd.com
Volume 13, Issue 9 (September 2017), PP.21-30

Forest Regeneration of The Bateke Plateau Savannahs From Acacia Auriculformis Plantations in The Democratic Republic of The Congo.

Tolérant K. LUBALEGA[1, 2, 3] *.Valère Gbawe[2], Damase P.KHASA[1] ; Jean-Claude RUEL[1] ; Jean LEJOLY[4].

[1]*Département de sciences du bois et de la forêt (Centre d'étude de la forêt), Faculté de foresterie, de géographie et de géomatique, Université Laval, Québec, G1V 0A6, Canada.*
[2]*Département de Gestion des ressources naturelles, Faculté des sciences agronomiques, Université de Kinshasa, Kinshasa XI, RDC*
[3]*Département de Phytotechnie, Faculté des sciences agronomiques, Université de Kikwit, Kikwit, RDC*
[4]*Université Libre de Bruxelles, Herbarium BRLU, 50 Av. F.D. Roosevelt, C.P. 169, B-1050 Bruxelles, Belgique.*

RÉSUMÉ : L'agrosylviculture appliquée sur le plateau des Bateke, en RDC a fait l'objet d'une analyse scientifique basée sur les inventaires de régénération forestière naturelle dans le sous-bois d'A. auriculiformis et A.mangium, d'une chronoséquence de six âges différents (3, 4, 7, 9, 10 et 29ans) et d'une savane arbustive qui a servi comme contrôle. Elle a pour objectif d'évaluer, analyser et de mesurer l'effet des systèmes agroforestiers (safts) sur les régénérations forestières naturelles issues de reboisement par les plantations d'A. auriculiformis, d'A. mangium et à la conservation de la biodiversité sur le plateau des Bateke. L'analyse de variance multivariée (MANOVA) conduite avec la procédure du modèle linéaire généralisé (GLM) effectuée sur la base de données collectée, a révélé un effet significatif des espèces sur le site, l'âge de plantations, le Dhp (cm), la hauteur totale de l'arbre (m) et la surface terrière (m2/ha). Il ressort des résultats obtenus que la mise en place des plantations présente une évolution en stades de successions forestières secondaires qui apparaissent sous les plantations d'A. auriculiformis et A.mangium. Un écosystème forestier se reconstitue assez rapidement sur le périmètre des plantations d'A. auriculiformis et A. mangium en lieu et place de l'ancien écosystème de savane caractéristique du plateau des Bateke.

Motclé: agrosylviculture, régénération forestière, Plateau des Bateke, chronoséquence, Zavi, Provaco, Mampu1 et mampu 2.

ABSTRACT: Agroforestry applied on the set of Bateke, DRC was the subject of a scientific analysis based on natural forest regeneration inventories in the undergrowth A. auriculiformis and A.mangium, a time sequence of six different ages (3, 4, 7, 9, 10 and 29years). It aims to evaluate, analyze and measure the impact of agroforestry systems (SAFTS) on natural forest regeneration after reforestation plantations A. auriculiformis, to A. mangium and conservation of biodiversity on the plateau of Bateke. Multivariate analysis of the generalized linear model procedure (GLM) performed on the collected database, revealed a significant effect of the species on the site, the age of plantations, the DBH (cm), the total height of shaft (m) and basal area (m2 / ha). The results obtained as the establishment of plantations present evolving stages of secondary forest succession which also appear on the plantations in abandoned plantations A. auriculiformis and A.mangium. A forest ecosystem is recovering quite quickly on the perimeter plantings A. auriculiformis and A. mangium in place of the former savannah ecosystem characteristic' plateau Bateke.

Keyword: agroforestry, forest regeneration, Plateau Bateke, chronosequence, Zavi, Provaco, Mampu1 and Mampu 2.

I. INTRODUCTION

Acacia plantations play a major socio-economic role on the Bateke plateau (Paul, 2011, Schure et al., 2011, Schure et al., 2012). Despite this important role, they contribute to the regularization of the climate and participate through photosynthesis in the processes of mitigation or adaptation to climate change. They also produce firewood and charcoal that would solve the energetic problem of the city of Kinshasa (Trefon et al., 2010). But their potential to contribute as a catalyst to natural forest regeneration is still limited and fragmented. The overall objective of this study is to evaluate, analyze and measure the impact of A plantations. Auriculiformis, A. Mangium in agroforestry systems (safts) on natural regeneration from reforestation. The technical itineraries of these plantations require fire protection measures. This is what justifies the paving strips of 25m wide around the plantations in the form of firewalls, an alternative to the putting in defense in the implementation of this biotechnology. As such, Acacia plantations of an agroforestry system can also be used as a strategy for increasing forest areas with the prospect of a natural reintroduction of species in the region.

Significant contributions from plantations of A. Auriculiformis and A. mangium to improve the fertility of the sandy soils that characterize the Bateke plateau, with a richness in kaolinite as a type of clay are those of Koy (2005); Koy et al. (2009); Kasongo (2009); FAO (2011); Sente (2011) Atangana et al. (2014) and Nsombo (2016). The Plantations of A. Auriculiformis and A. mangium applied to the savannahs of the Bateke Plateau are of the sequential type, and are based on a detailed operational schedule which organizes and plans all the activities of the preparation of the land, planting, Maintenance and harvesting by agroforestry campaign spread over the whole year. They are part of the safts (Torquebiau, 2000). The particularity of this approach lies in the combination of agricultural plantations (food crops and fruit trees) and forest plantations of long-term precious species, exotic fast-growing species (Peltier et al., 1993 , 1994 and 1995, Harmand et al., 1997 and 2004) or local (edible caterpillar species (Latham, 2003)). The former are aimed at human food security, and the last two are for the production of timber and wood energy. In addition to the above-mentioned approach, the forested fallows (Nkuku in Kikongo, vernacular) associated with large and small farms are also applied. Three main research questions are addressed: (a) What are the spontaneous species that regenerate in Acacia undergrowth in plantations? B) What ecological factors have contributed to the development of these spontaneous species? C) What is the significance of the dynamics of the species inventoried in the undergrowth? In order to achieve this, the following hypotheses have been verified: (i) The establishment of A plantations. Auriculiformis and A.mangium may show evolution in secondary plant succession stages observed by Peltier (2010) and Lubalega et al., 2016,(ii) a forest ecosystem is reconstructed fairly rapidly on the perimeter of A plantations. Auriculiformis and A. mangium in place of the old savannah ecosystem characteristic of the Bateke Plateau, a perception of agroforestry on the Bateke plateau, iii) age of A.auriculiformis and A. mangium plantations influences regeneration Natural forest.

II. MATERIAL AND METHODS

The Bateke plateau is located between 4 ° and 5 ° south latitude and between 15 ° 30 'and 16 ° 30' east longitude; It covers an area of 21,823 km^2 (Nsombo, 2016). It is a sort of border between the city of Kinshasa and the province of Kwango. The administrative part of the town of Kinshasa is located in the eastern part of Maluku commune in Kinshasa, 80 km from Kinshasa and covers an area of 7000 km^2 (Biloso, 2008). This study area is limited to the north by the Congo River and the territory of Kwamouth (Kwilu Province); On the east by the territory of Bagata and Kenge (Province of Kwango); To the south by the territory of Kasangulu and Kimvula (Province of Central Kongo) and to the west by the commune of N'sele (Biloso, op cit).

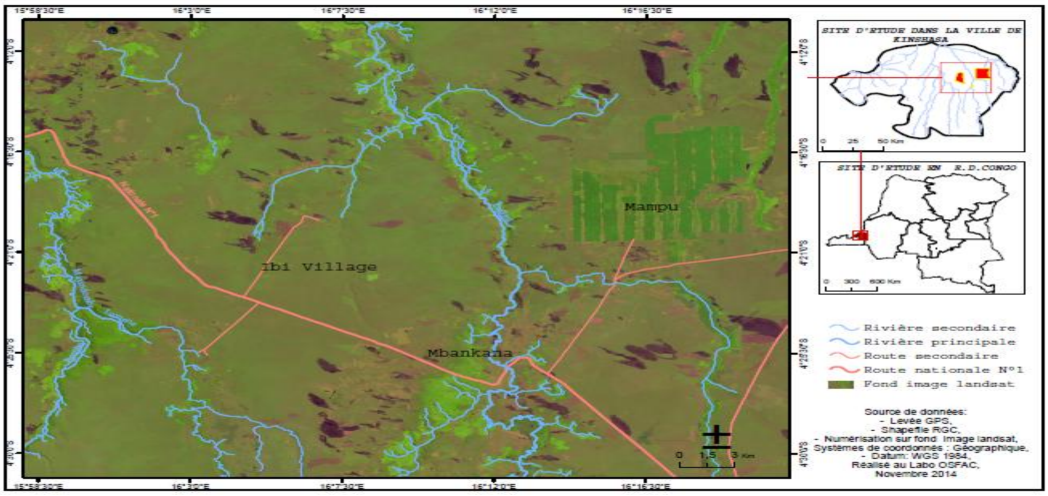

Figure 1. Rental of the Bateke Plateau (RD C)

The Bateke Plateau is a vast expanse of the Kalahari ocher sand series. It is deeply cut from the deep valleys flowing from the South to the North. The soils have an essentially sandy particle size (Lubalega et al., 2016). They are mineral soils developed on Kalahari sand. There is a mixture of sandy soils and other soils with kaolinitic or ferralitic tendencies (Kasongo, 2009). In the plain zone, alluvial soils with variable texture and podzols are found. Organic soils are located at Malebo Pool (Ndembo, 2009). They are characterized by a low clay content (less than 20%) over a depth of at least 100 cm, a low reserve of alterable minerals, pH <7 (acidic soil) and low in exchangeable bases (Ca, Mg, K, Na) (Khasa et al., 1995). There is a poor evolution of the organic matter with a C / N ratio decreasing in depth, yet it is the only element able to retain water, thus keeping the moisture in the soil. The profiles are of the AC type, with an accumulation of organic matter in the upper layers (Makoko et al., 1994; Khasa et al., 1995) which makes them poor for agriculture. The plateau of the

Bateke enjoys the general influence of the characteristic climate of the city province of Kinshasa. The latter is characterized by a climate of type Aw_4, according to the Koppen classification (1931). It is a humid tropical climate with two major seasons: a dry season that lasts 4 months (from the second half of May to the first half of September) and a rainy season of 8 months (from the second half of September to the first half of May). The average annual temperature oscillates around 25 ° C. The annual mean rainfall is about 1500 mm (Lubalega et al., 2016).

Hydrographically, the Bateke plateau is crossed by the Mai-ndombe, Lufimi and Duale rivers, bordered by forest galleries, whose development varies according to the place (Peltier et al., 2010). The vegetation is mainly grassy but there are some forest galleries. It is characterized by a shrub savanna with Hymenocardiaacida, Crossopteryx febrifuga, Annonasenegalensis and Vitexmadiensis alternating with a grassy savanna at Loudetiademeusii, Cteniumnewtonii, Landolphialanceolata and Hyparrheniadiplandra. The plantations of A. Auriculiformis and A. Mangium, implanted on the Bateke plateau precisely in Mampu and Ibi-village, served as experimental treatments. A chronosequence of Acacias was chosen taking into account six different ages scattered across the plateau. The study sites are about 20 km apart.

III. DATA COLLECTION AND ANALYSIS

Analysis of the effect of agroforestry on natural forest regeneration at the Bateke plateau in the DRC focused on regeneration and dendrometry inventories in related plantations, an observation of 29 more abundant woody forest species Was made out of the total of 43 species present in the study sites. Dhp, total tree height and basal area in an Acacia chronosequence of six different ages constituted the dendrometric characteristics of the study. The sampling plots were established within the A plantations. Auriculiformis and that of A. Mangium of different ages (3, 4, 7, 9, 10 and 29 years old) in Mampu1, Mampu 2, those of Ibi-villages were placed in the ZAVI, PROVACO and in the forest carbon sink of Danone. The plots set up in the shrub savanna for the natural regeneration of the forest carbon sink of the Ibi-World Bank project served as a control. This choice is justified by their long experience on agroforestry practices carried out in time and space on the Bateke plateau. The six plantations and the shrub savanna are located in different locations but under similar conditions. They constitute our experimental units or study treatments. Ten sampling plots were installed at each site, representing a total of seventy plots throughout the system. They measured 25 m by 25 m each, ie 625 m2 for each experimental unit considered separately or 1/16 (one sixteenth) per hectare. These various plots were the subject of regeneration inventories: floristic and dendrometric, then an analysis of biological forms made it possible to identify the different typological groups existing. The main component species of regeneration in the Acacia plantations were grouped into series (savannah and forest) according to Duvigneaud (1949), White (1983), Lubini (2003) and Belesi (2009). The grouping of these species in forest and savannah series made it possible to distinguish the process of reforestation in progress within the chronosequence chosen. The types of diaspores used are those defined according to the Dansereau and Lems (1957) classification used by Evrard (1968) and Lubini (2003).

The mathematical model underlying the analysis of variance is: Y = A B A * B. This corresponds to a partition of the square sum of the model in components attributable to the effect of each variable, when the variables are added sequentially (one by one in order) to the model according to the order Prescribed in the "Model" statement. The generalized linear model (GLM) procedure, using the SPSS software, was carried out on our dendrometric inventory data. This procedure considers different theoretical approaches to the analysis of variance by providing four sums of squares as well as the statistics associated with these sums of squares. That is, the sum of square for an A-effect is adjusted for all other factors appearing in the model, with the exception of interactions involving factor A and factors nested within factor A. L The homogeneity of residual variances with a normal tendency allowed their use directly without any transformation.

Specific diversity was assessed by counting species present in the sampling plots, in addition to their relative frequency, which represents the greatest regularity with which individuals of the various species occur in the plots. To achieve this the Braun-Blanquet scale of abundance-dominance, based on the number of individuals of the species and the recovery of the species; With the following mean values of overlap: + = 0.5; 1 = 3; 2 = 15; 3 = 37.5; 4 = 62.5; = 5 = 87.5. The dominance frequency index results from the sum of the relative frequency (Fr) and the relative overlap (Dr) is DF = FR + DR.

IV. RESULTS

Table 1 below shows the composition of the inventories of natural forest regeneration in the A.auriculiformis and A.mangium plantations studied.

Table 1: Floral composition of natural forest regeneration in the Bateke Plateau.

N°	ESPÈCES	Famille	Série	TB	TD	DP
1	*Adeniacassampeloïdes*Planch Hook	Passifloraceae	forestière	Th	Sar	Pan
2	*Afromomum sanguineum* (K Schum)	Zingiberaceae	savanicole	Grh	Sar	At
3	*Afromomumalboviolaceum* (R) K. Schum) *	Zingiberaceae	forestière	Grh	Sar	PR
4	*Albiziaadianthifolia*(Schum) W. F Weiht	Fabaceae	savanicole	mph	Bar	PR
5	*Alchorneacordifolia* (Schum et Thonn)	Euphorbiaceae	forestière	mph	Sar	At
6	*Allophylusafricanus*P. Beauw	Sapindaceae	forestière	mph	Sar	At
7	*Annonasenegalensis*PersSubsq	Annonaceae	savanicole	Nph	Sar	GCZ
8	*Anthocleistaschweinfurhtii*Gilg	Gentianaceae	forestière	mph	Bal	BCG
9	*Barteria nigratana*Hook f	Passifloraceae	forestière	mph	Sar	GC
10	*Chromolaenaodorata* (L) R. King Robin Son	Asteraceae	lisière	Td	Pog	Pan
11	*Dichostemmaglaucescens*Pierre	Euphorbiaceae	forestière	mph	Sar	GC
12	*Dioscoreaalata* L	Dioscoreaceae	forestière	Gt	Sar	At
13	*Dioscoreasmilacifolia*dewild et ThDur	Dioscoreaceae	forestière	Gt	Pté	Gc
14	*Ficusexasperatat*Vahl *	Moraceae	lisière	mph	Sar	Pal
15	*Funtumia elastica* (Peuss) stpf	Apocynaceae	forestière	mph	Pog	GC
16	*Gaertnenapanicaluata*Benth	Rubiaceae	forestière	mph	Sar	CG
17	*Harunganamadagascariensis*Lam Ex Poir	Clusiaceae	forestière	mph	Sar	PR
18	*Hugoniaplatycepala*Welw ex Oliv *	Hugoniaceae	lisière	mph	Sar	CG
19	*Hymenocardiaacida*Tull	Phyllanthaceae	savanicole	mph	Pté	PR
20	*Hymenocardiaulmoïdes*Oliv	Phyllanthaceae	forestière	mph	Pté	PR
21	*Hypparrheniadiplandra*(Itac) *Stpf*	Poaceae	savanicole	H	Sclé	Pla
22	*Kolobopetalumchevalieri*(Hutch &dalzaTroupin) *	Minispermaceae	forestière	Phgr	Sar	CG
23	*Leptactinapymaertii*Dewild	Rubiaceae	forestière	Lph	Sar	Cg
24	*Macaranga spinosa* MuelArg	Euphorbiaceae	forestière	mph	Sarc	GC
25	*Maragaritariadescordea*(Baill) Webster	Euphorbiaceae	forestière	mph	Sar	PR
26	*Millettia drastica* Welw ex baker	Fabaceae	forestière	mph	Bal	GC
27	*Millettialaurentii*Dewild	Fabaceae	forestière	mph	Bal	BCG
28	*Millettiaversicolor*Welw ex Baker	Fabaceae	forestière	mph	Ball	GC
29	*MusangacecropioIdes*R Br *	Moraceae	forestière	Th	Sar	Pan
30	*Oncoba welwitschii* (Oliv) Gilg	Salicaceae	forestière	mph	Sar	CG
31	*Palisotaambigua* (P. Beauw) CB Cl *	Commelinaceae	forestière	Chd	Sarc	GC
32	*Palisota hirsute* (Thums) K SchumexDewild *	Commelinaceae	forestière	Chd	Sarc	CG
33	*Parquetinanigrescens* (Afzel) Bullock *	Asclepiadaceae	forestière	Lph	Sar	BCG
34	*Pauridiantra dewevrei* Dewild	Rubiaceae	forestière	mph	Sar	BC
35	*Pteridiumaquilinum*(L) Kuhn	Hypolepidaceae	forestière	Grl	sar	Cos
36	*Smilax kraussiana*Meisn	Smillaceae	savanicole	Lph	sar	At
37	*Strychnospungens*Solered	Loganiaceae	savanicole	mph	Bal	BCG
38	*Tabernaemontana crassa* benth *	Apocynaceae	forestière	mph	Sar	GC
39	*Tachypogonthollonii*De Wild	Poaceae	savanicole	H	Sclé	Pal
40	*Tarenalaurentii*(Dewild) Garcia	Rubiaceae	forestière	mph	Sar	BCG
41	*Vernonia brazzavillensis* Aubr ex Comp	Asteraceae	forestière	Mph	Pog	Pan
42	*Vitex ferruginea* Schum&Thonn	Verbenaceae	savanicole	mph	Sar	GC
43	*Vitexmadrensis*Oliver	Verbenaceae	savanicole	mph	Sclé	GSZ

Legend: TB = Biological types, TD = Type of diaspore, DP = phytogeographic distribution. Mph = megaphanophytes; Mph = mesophanerophytes, miph = microphanerophytes; Nph = Nanophanerophytes, lph = phanerophyteslianuex; Ch = Chamhephyte; H = Hemicriptophytes; G = geophytes; Grh = rhyzomatous geophytes; Gt = tuberous geophytes; Th = therophytes. (S): Sclerochores, (cos): Species cosmopolitan species encountered simultaneously (Bal): Ballochores (Bar): Barochores, (Dem): Desmochores (Pog): Pogonochores In the tropics and in the temperate zones (pan): Pantropical species species encountered throughout the tropical zone of the world (AA): African-American species species existing in Africa and tropical America (pal): Palaeo-tropical species encountered in Asia And tropical Africa (AT): Afro tropical species encountered in continental tropical Africa (Pr): Multiregional species Species encountered in several African phytogeopographic regions (Afm): Species Afro Malagache species present in tropical Africa and Madagascar. (GC): Congolese omni species, (BGC): Congolese guinea low species, (Congo): Congolese species (GSZ): GuineoSudanoZambezian species

Examination of Table 1 above shows a significant number of species in the regenerating forest series in the chronosequence of six different ages. A total of 24 botanical families were inventoried. Three botanical families (Euphorbiaceae, Fabaceae and Rubiaceae) were the most abundant, each with 16.3% specific diversity. Nine botanical families (Passifloraceae, Zingiberaceae, Asteraceae, Dioscoreaceae, Moraceae, Apocynaceae, Phyllanthaceae, Poaceae, Commelinaceae) each contributed 8.3%. The remaining botanical families (Annonaceae, Sapindaceae, Loganiaceae, Gentianaceae, Smilaceae, Hypoledidaceae, clusiaceae, Hygoniaceae, Salicaceae, Asclepiadaceae) each represent 4%. We note a few species of the savannah series and that of the series margin.

Biological type analysis reveals a predominance of Phanerophytes compared to other biological types. In this group of phanerophytes, it is the microphanerophytes which cover the whole territory studied.
Examination of the biological characteristic revealed that the sarcochor is the most disseminated diaspore in this reconstituted vegetation. Only 29 species are Sarcochorous, or 67.44% of the total number of species; 4 species are ballochorous, or 9.3%; 3 species pogonophores, or 6,9% 3 species are pterochores, or 6,9%; 3 species are sclerochorous, or 6.9%; 1 species is barochore, or 2.32%. Chorological analysis reveals the predominance of endemic species in the Congolese Guinean region. All species in this region account for 53.42% of the total spectrum. They are followed by African species, with wide distribution with 27.9%. Species from other phytogeographical regions are poorly represented. Dynamics of the structure and dendrometric characteristics of the studied stands.

Figure 2 shows the dynamics of the structure and dendrometric characteristics of A.auriculiformis and A.mangium stands

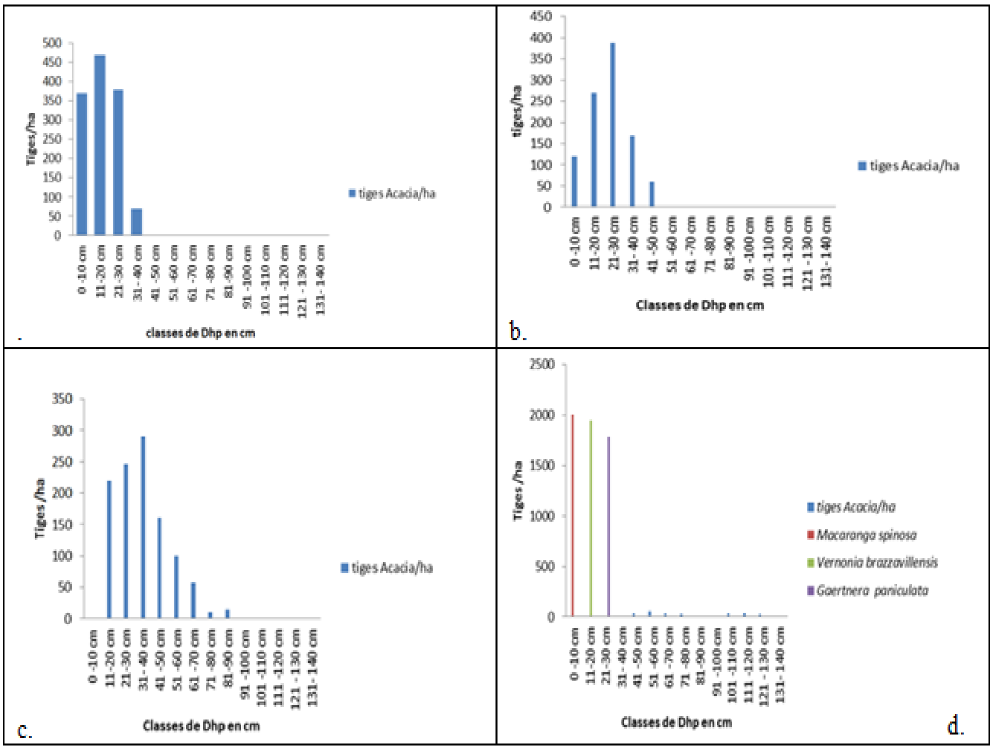

Figure 2: Inventory of forest regeneration in a chronosequence of Acacia at six different ages: a. Dendrometric control structure (3 and 4 years), b. Dendrometric structure of Acacia stand of 7 years, c. Dendrometric structure of a 9-year-old stand, d. Dendrometric structure of an Acacia stand of 10 and 29 years old. The observation of the aforementioned figure 2 reveals an absence of forest tree species in the Acacia plantations less than nine years old and the presence of a pioneer stratum in natural regeneration in the different plantations ages> 9 years of A.auriculiformis and A .mangium. Three forest tree species distributed in diameter classes (Dhp) (Macaranga spinosa, Gaertnerapaniculata and Vernonia brazzavillensis) were more remarkable in older A plantations. Auriculiformis and A. mangium.

Dynamics of natural forest regeneration of different species.
A total of twenty-nine species out of the forty-three inventoried were analyzed for the dynamics in natural regeneration within the plantations. Figure 3 below shows the dominance-frequency pattern in order of importance expressed as a percentage on colored species tags.

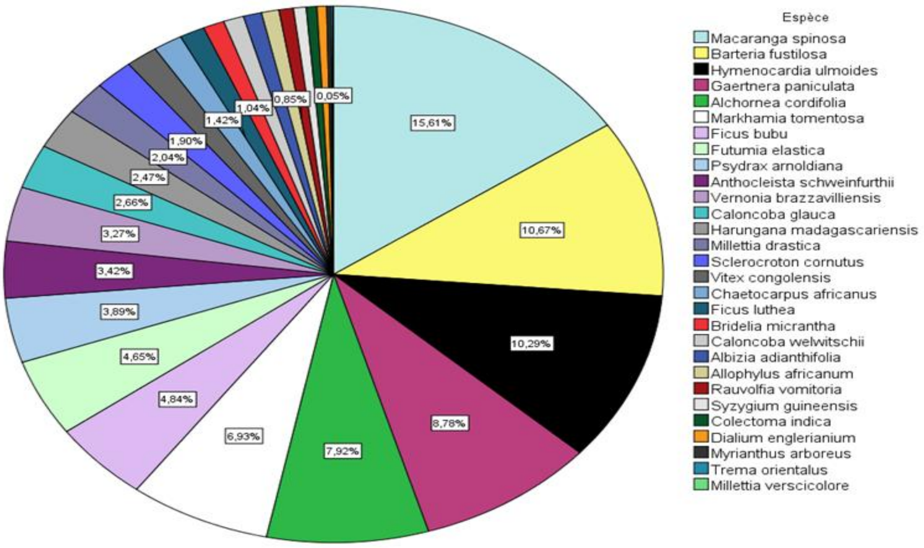

Figure 3: Dominance-frequency of twenty-nine species followed.

The observation of figure three above shows a predominance of eleven species classified in the diagram by the importance of their percentage, going in the direction of the needles of a watch. Macaranga spinosa tops 15.61%, Barteria fustilosa represents 10.67%, Hymenocardiaulmoides predominates by 10.29%, Gaertnerapaniculata follows with 8.78% and Alchorneacordifolia dominates by 7.92%.
Variation of the Dhp (cm) of the different species under study. There is a good distribution in the diametric structure with Dhp characteristics of forest regeneration and some trees are more than 20 meters high, on a Dhp varying between 0.32 to 20cm and are kept intact in the old Mampu plantation. Figure 4 below gives the variation in Dhp of species observed in the different study sites.

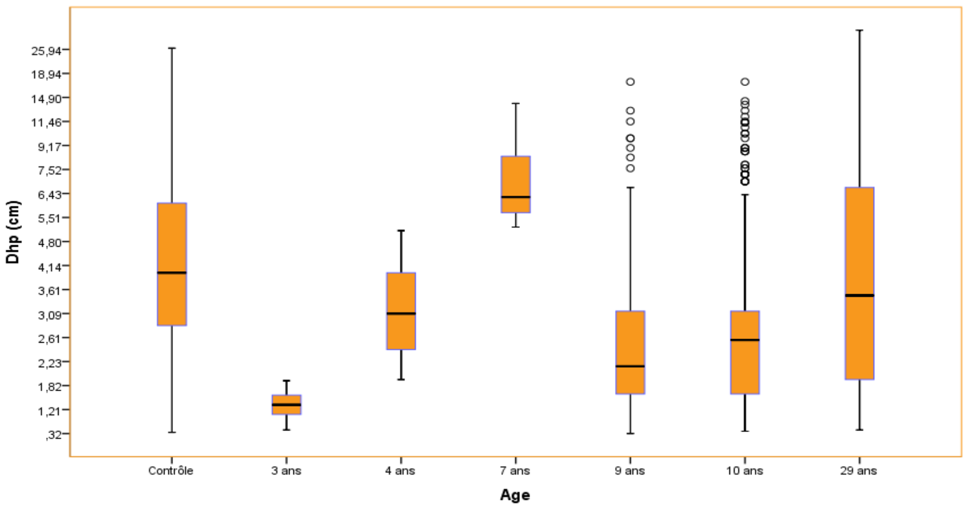

Figure 4: Variation in Dhp (cm) of the twenty-nine species followed in natural forest regeneration in the Acacia chronosequence.

It appears in Figure 4 that the Dhp of twenty-nine followed in natural forest regeneration in the chronology of six ages of Acacia shows great variability. The Dhp varied between 0 and 43 cm. The species Macaranga spinosa, Gaertnerapaniculata, Futumia elastica, Barteria fustilosa and Vernonia brazzavillensis showed greater Dhp.

Comparison of the dendrometric measurements of twenty-nine species followed

The multivariate test carried out on the different Dhp measurements, tree height and basal area of 29 species followed in natural forest regeneration in A.auriculiformis and A.mangium stands at all sites revealed an effect (P <0.05) of the variables considered. Table 2 below shows the MANOVA of each variable considered.

Table 2: MANOVA of the different variables considered.

		Site		Âge de Plantations		Dhp		Hauteur		surface terrière	
Source de variation	dl	F	Pr(>F)	F	Pr(>F)	F	Pr(>F)	F	Pr(>F)	F	Pr(>F)
Espèces	28	14,9***	0,0001	8,4***	0,0001	16,1***	0,0001	12,8***	0,0001	11,4***	0,0001

A significant effect (p <0.001) of the 29 of the forty-three species inventoried and related to both the age of the plantations and the study site in question is noted in Table 2 of MANOVA. The dendrometric parameters have revealed a vertical structure characteristic of a shrub and tree stratum for a secondary forest in formation. The upper stratum occupied by the Acacia and the lower stratum dominated by forest species. Since the climate cannot be homogeneous, each level of stratification corresponds to a set of climatic conditions that are different from the local climate.

V. DISCUSSION

The floristic composition of the Acacia plantations and the different dendrometric characteristics of natural forest regeneration inventories revealed the effect of agroforestry on forest regeneration. The chronosequence of A.auriculisformis and A. mangium of six different ages, taken into account in the study sites, is an important factor, which reveals a succession of heliophyte species in natural forest regeneration in a system preserved from fire in Ages> 9 years. Their large percentage indicates a recent colonization because it was necessary to wait until the Acacia grows to create microclimatic conditions favorable to the installation of the forest species. Certainly the flora of the immediate surroundings; Forest islets dotted across the Bateke Plateau have formed nuclei of dispersal of species of old secondary forests. These species, being of a heliophyte nature, did not suffer from the low illumination in the seedling stage as a limiting factor for their growth. Previous studies by Osborne (1980) report that soil is a seed bank, waiting only for favorable conditions for germination. The mode of dissemination of the diaspores of these species indicates that they have effective means of diaspora dispersal. It is usually done by anemo - morory and zoochory. There is a predominance of species in natural forest regeneration with diaspore totally or particularly fleshy Example: Afromomum sanguineum, Gaertnerapaniculata; Which provides information on possible interaction with the local fauna participating in the dissemination (Doucet, 2003; Lubini, 2003; Menga, 2012).

The stratification introduced by the arrival of species with a majority of forest series of different heights suggests microclimatic changes (temperature under each stratum, relative humidity and light supply) induced, approaching those that exist under a Young natural forest. The seedlings of the pioneer species can then be settled and grown in Acacia undergrowth as reported (Schnell, 1970, Anonymous, 1979, Kozlowski, 2000). There is a rapid restoration of the tree species characteristic of secondary forests, generally heliophilous and rapidly growing. This is the case of Macaranga spinosa, Gaertnerapaniculata, Barteria fustilosa, and Vernonia brazzavillensis found in most plots of different sites. These results corroborate Peltier's (2010) observations of a significant presence of non-timber forest food products such as Dioscoreaalata; And those of Lubalega et al., 2016 on the natural evolution of the savannas defended at the Bateke Plateau.

The second aspect of this chronosequence provides information on the incorporation of organic matter during the preparation of mechanized soil and those accumulated as Acacia litter in the plantation space and over time. This improvement in physicochemical conditions under the Acacia plantations was strongly supported by the studies of Kasongo (2009), Sente (2011) Lubalega et al., 2016 and Nsombo (2016). The oldest planting plots retained in our sampling system are those reforested between 1988 and 1989 in Mampu. They are distinguished from young plantations of Ibi-village (in Zavi and Provaco) by a specific richness in 13 particular species of which: 3 in valley plot on hydromorphic soil: (Afromomum sanguineum, Palisotaambigua and Hugoniaplatycepala, 4 species On sloping ground: Palisotahirsuta, Tabernaemontanacrassa, Allyphylusafricanus, Ficusexasperata, Tarenalaurentii, Kolobopetalumchevalieri and Margatariadiscoidea, 3 species in flat land: Hyparrheniadiplandra, Trachypogonthollonii and Musangacecropioides.

Apart from forest species, grassland (savannah) species have a low percentage of specific richness, ie 18%. These species are residual and testify the conquest that the forest leads on the grassy formation by being protected against the fire.

Some of these species cannot withstand the moisture and shade conditions created by this new environment and are disappearing.

Since trees are ecologically dominant in this natural fallow of 9, 10 and 29 years = 9 +10 +29 / 3 = 16 years on average, we can calculate the land use factor of Allan (Anonyme, 1979) . Where L = Land Use Factor; C = Number of years of cultivation; F = Number of years of fallow Given that this factor is between 7 and 10, we can deduce that the agri-growers on the plateau use the improved natural fallow system. This cultural practice is ecologically appropriate and necessary for poor soil such as the Bateke plateau. Protection against bush fire therefore constitutes a defense which keeps these plantations in a state close to nature and which contributes to the reconstruction of the primitive forest. This fact confirms the anthropic origin of Congolese Guinean herb formation, as Schnell (1970) considers. Our findings are consistent with our research hypotheses, and have helped to answer the three main questions of departure.

VI. CONCLUSION

A study of the effect of agroforestry on natural forest regeneration at the Bateke plateau was undertaken in the Democratic Republic of Congo. The examination of the floristic composition carried out during the floristic and dendrometric surveys revealed a forest regeneration characterized by a relative importance of the Fabaceae, Euphorbiaceae and the dominance of the Rubiaceae which show an evolution of forest recruits and secondary forests.

ACKNOWLEDGMENT

The authors would like to thank the Hanns Seidel Foundation and the group of agroforestry initiatives in Africa (GI-Agro) for authorizing this research on the concession given to it by its partner NOVACEL in the Ibi station in Ibi-village. The authors also thank the biometrics department of the national institute for agronomic research of the DRC (INERA) for statistical consultations. This work was also partially supported by the NSERC Grants (Jean-Claude Ruel and Damase Khasa), which we thank very much.

REFERENCES

[1]. ANONYME, 1979. Écosystèmes Forestiers tropicaux, état de connaissances, P.U.F, 740p.

[2]. ATANGANA A., KHASA D., CHANG S., DEGRANGE A., 2014. Agroforesterie tropicale (1ère éd.; traduit par A.Atangana, M. Beaudoin-Nadeau et D.Khasa), Québec : Département des Sciences du bois et de la forêt, Université Laval, 412p.

[3]. BELESI H., 2009 Étude floristique, phytogéographique et phytosociologique de la végétation du Bas-Kasai en République Démocratique du Congo. Thèse de doct.Unikin. Fac.des Sciences. Groupe environnement.565p

[4]. BILOSO, M., 2008.Valorisation des produits forestiers non ligneux des plateaux de bateke en péripherie de Kinshasa (RD Congo), Thèse, Faculté des sciences, Ecoleinterfacultaire de bioingénieurs, Service d'écologie du paysage et systèmes de production végétale, Université Libre de Bruxelles, 252p.

[5]. DOUCET J-L., 2003. L'Alliance délicate de la gestion et de la biodiversité dans les forêts du Gabon. Thèse de doctorat, Faculté Universitaire des Sciences Agronomiques Gembloux, 323 p + Annexes.

[6]. DUCENNE Q., 2009. Evaluation des actions agroforestières développées à Mampu, RDC.CardnoAgrisystems Ltd. Volume I : Synthèse finale 32 p. Volume II : Rapport final 83 p.

[7]. EVRARD, 1968. Recherches écologiques sur le peuplement forestier des sols hydromorphes de la Cuvette Centrale Congolaise, Série Scientifique n°110, INEAC, 295p.

[8]. FAO, 2011, Article sur l'Agriculture sans labours (ASL), écrit et disponible sur le site officiel de la FAO : www.fao.org/ag/ca/doc/Y3782f.pdf [consulté le 3 août 2011]. Site officiel de l'Organisation des Nations Unies pour l'alimentation et l'agriculture disponible sur : http://www.fao.org/countries/55528/fr/cod/

[9]. HARMAND, J.-M., NJITI, C.F., BERNHARD-REVERSAT, F. and PUIG H., 2004.boveground and belowground biomass, productivity and nutrient accumulation in tree improved fallows in the dry tropics of Cameroon, For. Ecol. Manage. 188 (2004), pp. 249-265

[10]. HARMAND, J.-M., NJITI, C.F., PELTIER, R. 1997. Restauration de la fertilité des sols par la jachère arborée. L'agroforesterie pour un développement rural durable. Atelier international-Montpellier-France 23-29 juin 1997, pp 135-142

[11]. KASONGO R., RANST E., VERDOODT A., KANYANKOGOTE P. ET BAERT G., 2009. Impact of Acacia auriculiformis on the chemical fertility of sandy soils on the Bateke plateau, DRCongo.Soil Use and management, 25 (1) 21-27

[12]. KHASA D.P.,VALLÉ G, LI P., MAGNUSSEN S., CAMIRÉ C., et BOUSQUET J., 1995. Performance of five tropical tree species on four site in Zaïre. Commonweath Forestry Review 74:129 - 137.

[13]. KOY, K., 2005.Impact of Planted Acacia Forest on the Chemical Fertility of sandy Soil of the Bateke Plateau (D.R. Congo), Thesis of Master Degree of Science in Physical Land Ressouces.Gent University, 121p.

[14]. KOY, K., VAN RANST, E., VERDOODT, A.,. KANYANKAGOTE, P. , BAERT, G., 2009.Impact of Acacia auriculiformis on the chemical fertility of sandy soils on the Bateke plateau, D.R. Congo in Soil Use and Management 25, 21–27

[15]. KOZLOWSKI,T.T., 2000. Physiological ecology of naturel regeneration of harvested and disturbed forest stands: Implications for forest management. Forest ecology and management 158 (2002) 195-22

[16]. LATHAM P. 2003. Edibles caterpillar and their food plants in Bas-Congo; Mystole Publications, Canterbury, UK. 60p.

[17]. LUBALEGA T.K., LUBINI C., RUEL J.C., KHASA D.P., NDEMBO J., LEJOLY J., 2016. Le patron de la régénération naturelle et assistée en système préservé du feu dans les savanes arbustives d'Ibi. En préparation pour soumission la revue électronique VertigO.

[18]. LUBINI A., 2003. Ressources des forêts secondaires en Afrique centrale et occidentale francophone. Actes atelier régional FAO/IUCN sur la gestion des forêts tropicales. Douala, Cameroun, 17 – 21 novembre 2003.

[19]. MENGA P., 2012. Écologie des peuplements naturels de Millettialaurentii De Wild. dans la région du lac Maï-Ndombe, en RD Congo - Implications pour la gestion durable d'une espèce exploitée Thèse de doctorat, Département de biologie, Faculté des Sciences de l'université de Kinshasa, République Démocratique du Congo, 1833 p + Annexes.

[20]. NDEMBO J, 2009. Apport des outils hydrogéochimiques et isotopiques à la gestion de l'aquifère du Mont Amba (Kinshasa / République Démocratique du Congo). Thèse de doctorat en cotutelle entre l'Université de Kinshasa et l'Université d'Avignon et de pays de Vaucluse. 203p.

[21]. NSOMBO B., 2016. Évolution des nutriments et du carbone organique du sol dans le système agroforestier du plateau des Bateke en République Démocratique du Congo, thèse de Doctorat. ERAIFT/ Université de Kinshasa, Aménagement et gestion intégrés des forêts et territoires tropicaux. 130p.

[22]. OSBORNE, D.J., 1980. Senescence in seeds In: Thimann, K.V, (Ed), Senescence in plants. CRC Press, Boca Raton, FL, USA, pp. 13-37

[23]. Paul C., 2011. Contribution of agroforestry activities to the financial, socioeconomic and environmental sustainability of a carbon sink project in the province of Kinshasa. Mémoire de Master, Centre for Development, Environment and Policy (CeDEP), School of Oriental and African Studies (SOAS), University of London, 136p.

[24]. PELTIER, R. ; BALLE PITY., 1993. "De la culture itinérante sur brûlis au jardin agroforestier en passant par les jachères enrichies" (From Slash and burn to sustainableagroforestry system). In : Bois et Forêts des Tropiques, n° 235 (1), pp 49-57.

[25]. PELTIER, R., 1993. "Les jachères à composante ligneuse. Caractérisation, conditions de productivité, gestion" (Bush fallow and forestfallow : characterisation, productivity and management), in La jachère en Afrique de l'Ouest. Atelier international, Montpellier, 2-5 décembre 1991, O.R.S.T.O.M., Bondy, France, pp. 67-88

[26]. PELTIER, R., 1994. "Du reboisement imposé à la prise en compte des savoirs traditionnels" (Frommandatoryreafforestation to the adoption of traditional techniques. Improvement of degraded land in North Cameroon).In : Nature Sciences Sociétés, 1 vol 2, 1994, Dunod, Paris, France, pp. 67-79.

[27]. PELTIER, R., BALLE PITY, GALIANA, A., GNAHOUA, G.M., LEDUC, B., MALLET, B., OLIVER, R., OUALOU, K., SCHROTH, G. 1995.Produire du bois énergie dans les jachères de zone guinéenne. Intérêts et limites à travers l'expérience d'Oumé en Basse Côte d'Ivoire. In : Actes du séminaire Fertilité du milieu et stratégies paysannes sous les tropiques humides. nov. 95. Montpellier, France. pp 219-227.

[28]. PELTIER R., BISIAUX F., DUBIEZ E., MARIEN J-N., MULIELE J-C., PROCES P., et VERMEULEN C., 2010. « De la culture itinérante sur brûlis aux jachères enrichies productrices de charbon de bois en Rèp. Dem. Congo » In Innovation and Sustainable Development in agriculture and Food 2010 (ISDA 2010) à Montpellier, France.

[29]. PNUD/UNOPS, 1998 : Monographie de la ville de Kinshasa, programme national de relance du secteur agricole et rural (PNSAR), Kinshasa, 247 p.

[30]. SCHNELL R., 1970. Introduction à la phytogéographie des pays tropicaux. Les problèmes généraux. Les flores, les structures. Gauthier-Villars, Paris Vol. II: 500-951.

[31]. SCHURE, J. INGRAM, V. AKALAKOU- MAYIMBA, C. (2011). — Bois énergie en RDC : Analyse de la filière des villes de Kinshasa et de Kisangani, Rapport CIFOR, http://makala.cirad.fr

[32]. SCHURE, J. MARIEN, J.-N. DE WASSEIGE, C. DRIGO, R. SALBITANO, F. DIROU, S. NKOUA, M. (2012). —Contribution du bois énergie à la satisfaction des besoins énergétiques des populations d'Afrique centrale : perspectives pour une gestion durable des ressources. Dans : DE WASSEIGE, C. DE MARCKEN, P. BAYOL, N. HIOLHIOL, F. MAYAUX ,PH. DESCLEE, B. NASI, R. BILLAND, A. DEFOURNY, P. EBA'A ATYI, R. (eds.), Les forêts du bassin du Congo : État des forets 2010. Office de publication de l'Union européenne, Luxembourg, p.109- 122.
[33]. TOLLENS E., (1994). Nourrir Kinshasa : L'approvisionnement d'une métropole africaine. Ed :L'Harmattan. 400 p.
[34]. TOLLENS, E. (2010). — Potential Impacts of AgricultureDevelopment on the Forest Cover in the Congo Basin. Banque mondiale:Washington D.C., USA.
[35]. TORQUEBIAU E.F., (2000). « Une vision renouvelée des concepts et de la classification de l'agroforesterie ». In : Life Sciences, n°323, p: 1009-1017.
[36]. TREFON, T. HENDRICKS, T. KABUYAYA, N. NGOY,B. (2010). — L'économie politique de la filière du charbon de bois à Kinshasa et à Lubumbashi : appui stratégique à la reconstruction post conflit en RDC. Institute of Development Policy and Management, Anvers, Belgique.
[37]. WHITE F., 1983.The vegetation of Africa. UNESCO, Switzerland, 356 p.

Tolérant K. LUBALEGA. "Forest Regeneration of The Bateke Plateau Savannahs From Acacia Auriculformis Plantations in The Democratic Republic of The Congo." International Journal Of Engineering Research And Development , vol. 13, no. 09, 2017, pp. 21–30.