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Research article

Early succession in the tropical forest in southern Cameroon, Central Africa

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Abstract: Every year in tropical regions, large areas of forest are converted into agricultural field crops by the means of slash and burn. After two or three year's cultivation when the yields decline, the field is abandoned and the farmer clears another portion of forest to plant crops. Following a synchronic approach, early forest succession was studied in southern Cameroon in 70 square plots of 400m² each from former field crops aged between one and five years. In these plots, floristic inventory was done by recording all plant species while a Braun-Blanquet cover abundance index was assigned to each. Quantitative data involved the counting of all tree and shrub individuals of at least 5 cm diameter at breast height (DBH). For each plot the age, the type of vegetation cleared before the last cropping season, the vegetation around the fallow and the number of farming cycles in the same plot were considered as environmental data. The type of crops planted in his former field was also taken into consideration. Data were analyzed using PC-Ord 5.19. Five clusters were discriminated in relation with crops planted and land management. Thickets of *Chromolaena odorata* developed on fallows frequently reconverted into field crops whereas forest fallows were subjected to light disturbance. In *Chromolaena* thickets, forest recovery is slower than in forest fallows.

Keywords: Succession - Pioneer species - Fallow - Age - Southern Cameroon - Rain forest.

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INTRODUCTION

Tropical forests are important to mankind since they host a rich biodiversity. They provide not only food and medicinal plants to people but they also play an important role in regulating the global climate. With the growth of the world population, tropical forests are destroyed in order to cover human needs that are getting increased. Deforestation in the tropics is still taking place at an alarming rate since large areas of forest are cleared to establish factories, ranches, buildings and others. FAO (2016) reports that within the period 1990 to 2015, the extent of world forest decreased from 4128 to 3999 million ha. Among causes of deforestation in the tropics, logging and shifting cultivation are reported to be the most important (Brown & Lugo 1990, Laurance 1999, Gemerden 2004) and the two systems are often linked. Logging companies have enough means and they use heavy machinery to open roads in the forest in order to search trees species they want. The tracks opened in the forest are afterwards used by farmers to encroach. Shifting cultivation tin the tropics is done with archaic or rudimentary tools, and concerns not less than 300 million persons (Klemick 2011). This agricultural practice leads to the dominance of secondary vegetations are widespread in tropical areas until Gómez-Pompa & Vasquez-Yanes (1972) consider that they characterize our present epoch.

In southern Cameroon during the dry season especially around December and January, large parts of the forest are cleared to establish field crops. The understory of the forest is slashed followed by the felling of trees. Farmers clear invariantly mature or secondary forests or thickets of *Chromolaena odorata* (L). King & Robinson (hereafter *Chromolaena*). Very often they prefer clearing *Chromolaena* because they have realized that the yield of their crops in such conditions is good (Ngobo *et al*. 2004). When *Chromolaena* is not available, the young secondary forest where the softwood of the trees can be easily cut is preferred to mature forest. Useful

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trees or those with hardwood are spared by the farmer since they cannot afford chainsaw to fell them. All plant debris is gathered and left on the site for some weeks for drying and is burnt later. In some cases and according to the type of crops to be planted like peanuts, more than one burning is required. Foresta (1984) recognizes some important effects of fire. Fist fire clears the site by reducing clutter due to falling trees. Second, the ash released during burning is rich in mineral elements and nutrients that enrich the soil. Third, it destroys some predators and pests that could eventually attack the crops. After burning and with the arrival of rains by mid-February or early March, planting takes place. Before planting peanuts the farmer stirs the soil while no other field processing is required prior to the planting of maize, cassava, banana and water seed melon. These crops are inter planted in the plot. In search of good yield, weeding is done when the crops reach a certain height. As soon as the crops are mature, the harvest is done and the field is abandoned after two cropping seasons. Crops like peanuts, maize and cassava which need a few months to get mature are harvested during the first year. Bananas at the opposite are harvested the year after. The abandonment of the field aims to restore soil fertility (Nye & Greenland 1961, Aweto 1981, Christanty 1986, Ickowitz 2006), and is considered as the starting point of forest succession (Egler 1954, Richards 1955, Schnell 1971). During this period, many changes both in structure and specific composition of the fallow take place. Despite the availability of a large literature (Richards 1955, Kahn 1982, Uhl *et al.* 1982, Swaine & Hall 1983, Saldarriaga *et al.* 1988, Swaine & Whitmore 1988, Turner *et al*. 1997, Tucker *et al*. 1998, Guariguata & Ostertag 2001) the understanding of the different patterns of forest succession in various areas in the tropics remains a matter of concern. The present study covers the first five years of succession and aims to understand the different patterns of, 1) species assemblage; 2) species composition and dominant species; 3) structural characteristics.

METHODS

Study area

The study area is located in the southern region of Cameroon and stretches between 2° 22′ to 2° 23′ N and 9° 49′ to 11° 17′ E (Fig. 1). It is bordered in the West by the Atlantic Ocean and in the south by Gabon and Equatorial Guinea while in the north many agro-industrial plantations of rubber, palm oil and many logging concessions are found.

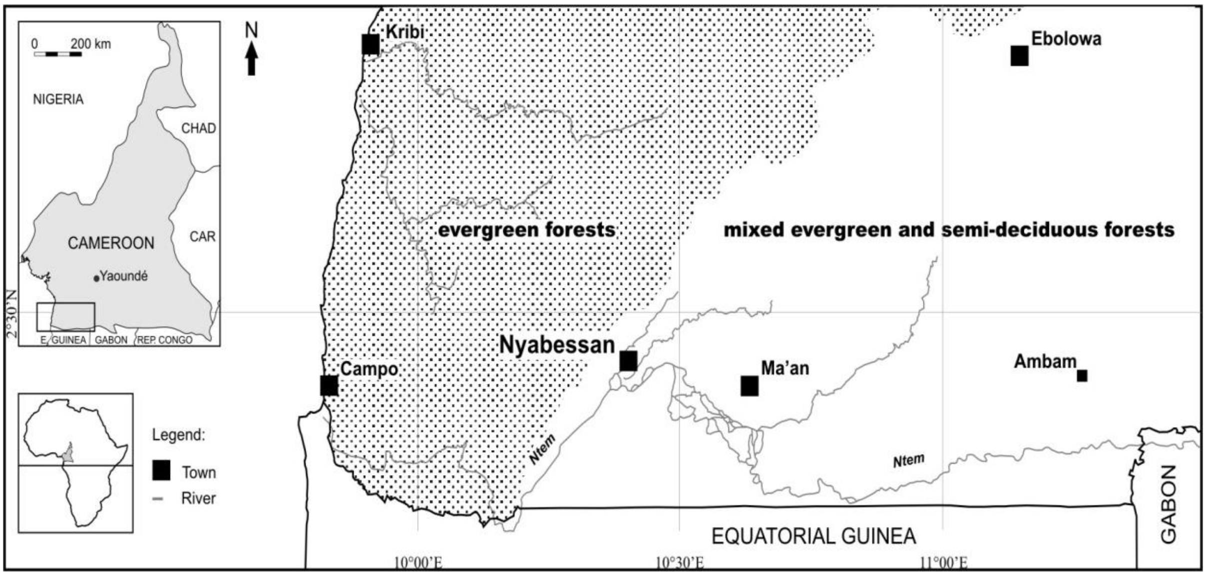

Figure 1. Map of the study area.

Within the research area the Campo-Ma'an National Park is classified as a Technical Operation Unit (TOU), a protected area where no agricultural, logging or hunting activity is allowed. From the coast in the West to the Campo-Ma'an National Park, the entrance village is Mvini while the exit is Ebianemeyong in the East.

The area is under the influence of equatorial climate with four seasons: one short and one long rainy seasons (March to May and August to November respectively) and one short and one long dry seasons (June to July and December to February respectively). Temperatures are moderate with an average of 25°C.

Southern Cameroon is part of the Congo craton (Vicat 1998) which comprises the Ayina, the Nyong and the Ntem geological units. The study is carried out in the Ntem unit which is about 2.9 to 2.5 billion years old (Ngako 2007) and its basement complex is made of metamorphic rocks such as migmatites, gneiss and quartzites dating from Precambrian era (Nougier 1979).

In majority, the soils are ferralitic, either red or yellow and rich in iron oxides and hydroxides with acidic pH standing between 4.8 and 6. Hydromorphic soils are found around the Ntem River, the streams and the periodically inundated forests and they are not suitable for agriculture because their high water content.

Data collecting

Floristic and environmental data were collected in 70 square plots of 400 m² demarcated individually in fallows aged from one to five years. Plots were georeferenced since their coordinates were taken using a GPS Garmin 12. Floristic inventory involved the census of all plant species present in the plot. Each species in a plot was assigned a Braun-Blanquet cover-abundance index whereas quantitative data were based on the counting of all individuals of trees and shrubs with a minimum diameter at breast height (DBH) of 5 cm. The floristic data was used to design the floristic matrix. Precipitations of the area were got from Suchel (1972).

Many environmental data were considered. The age of each fallow was determined by interviewing farmers. In some cases the age was estimated by coupling the year the field was created with an event that occurred in the village, at regional or national level. The vegetation surrounding the fallow was taken into consideration and could be a mature forest (1), secondary forest (2), a dense thicket of *Chromolaena odorata* (3) or a forest on one side and a thicket of *Chromolaena odorata* on the other (4). The vegetation type cleared before the last agricultural season was taken into account and could be a mature (1) or secondary (2) forest or a thicket of *Chromolaena odorata* (3). The number of farming cycles in the same plot could be one (1), two (2) multiple (3) or unknown (4). Soils samples were collected to determined the texture following the Munsell scale. The texture was categorized as sandy (1), silty (2) or clayey (3).

Data analysis

The cover abundance index of each species was converted into its relative value and a constant 1 was added to the value. Then the total was log transformed in order to avoid large disparities among relative values. The vegetation classification was done by carrying out a cluster analysis using the software PC-Ord 5.19 (McCune & Mefford 2006). Character species of each vegetation group was determined by calculating its indicator value (IndVal) following Dufrêne & Legendre (1997). An indicator species analysis followed by a Monte Carlo test was performed to find the diagnostic species of each vegetation group at $p<0.05$. The Shannon diversity index, the species richness and the Pielou's evenness of each plot were generated automatically by the software.

Structure of the plots was analyzed by calculating the following parameters: Basal area (BA) is the sum of the cross-section of individuals with DBH not less than 5 cm following the formula:

$$\mathrm{BA} = \frac{1}{2}\pi d^2$$

Where, d is the DBH of the tree or shrub individuals.

The stem density is calculated as the number of individuals of at least 5 cm DBH per hectare.

The floristic composition of the different vegetation units was analyzed by calculating the following phytosociological parameters and diversity indices:

$$\text{Relative density} = \frac{\text{Total number of individuals of the species}}{\text{Total number of individuals of all species}} \times 100$$

$$\text{Relative frequency} = \frac{\text{Number of plots in which the species is present}}{\text{Total number of all plots}} \times 100$$

$$\text{Relative dominance} = \frac{\text{Basal area of the species}}{\text{Total basal area of all species}} \times 100$$

$$\text{Relative diversity} = \frac{\text{Number of species of the family}}{\text{Total number of species of all families}} \times 100$$

The Family Importance Value (FIV) was also calculated according to Mori *et al.* (1983) as follows:

FIV = Relative Diversity + Relative frequency + Relative Dominance.

Descriptive statistics were carried out with Statistica 6.0 package.

RESULTS

Environmental factors and species assemblages

On the physiognomic point of view two types of fallows were distinguished which are peculiar by the dominant species they harbor. Two main sets of fallows being thickets of *Chromolaena odorata* (or

Chromolaena hereafter) and forest fallows for a total of five clusters were distinguished. The majority of the fallows (60%) in this study are *Chromolaena* thickets and they comprise two clusters whereas the forest fallows have three.

The *Chromolaena* thickets (42 plots) are former fields of cassava, maize or groundnuts which were created by clearing *Chromolaena* thicket and they are low in stature since tall trees are rare or absent. The most dominant plant species is *Chromolaena odorata* and its stem can reach a height of three to four meters. Most of the species are herbaceous and vines while woody lianas are rare.

Plots in which they were established had undergone multiple farming cycles. In most of these fallows, the canopy closure was equal to zero since no tree or shrub individual was recorded. However, when considering the surrounding vegetation, the precipitations and the nature of the soil, these thickets split into clusters 1 and 2 (Table 1).

Table 1. Descriptive attributes of the clusters.

Clusters	Surrounding vegetation				Previous vegetation type			Number of farming cycles			
	1	2	3	4	1	2	3	1	2	3	4
1	9.1	27.3	54.5	9.1	0.0	0.0	100.0	9.1	9.1	63.6	18.2
2	6.4	51.6	32.2	9.8	3.2	16.2	80.6	3.2	13.0	80.6	3.2
3	69.2	0.0	23.1	7.7	69.2	15.4	15.4	53.8	30.8	0.0	15.4
4	10.0	20.0	70.0	0.0	30.0	50.0	20.0	30.0	0.0	20.0	50.0
5	40.0	60.0	0.0	0.0	0.0	100.0	0.0	0.0	60.0	0.0	40.0

Few fallows were surrounded by mature forest with only 9.1% in cluster 1 and 6.4% in cluster 2. Secondary forest was bordering 27.3% in cluster 1 while it concerned more than half of the fallows in cluster 2. Most of the fallows in cluster 1 (54.5%) had dense thickets of *Chromolaena* at their neighborhood versus 32.2% in cluster 2. Forest on one side and *Chromolaena* thicket on the other was found in almost the same range in the two clusters (9.1% and 9.8%).

In the hinterland were the precipitations are low, most of the fallows in cluster 1 (54.5%) are established on clayey soil versus 27.3% on sandy soil and 18.2% on silty one (Table 2). In cluster 2, most of the fallows (74.2%) were found on sandy soil on the coast where the precipitations are the highest whereas the other ones (25.8%) are on silty soil. No fallow was found on clayey soil.

Table 2. Soil types in the different clusters.

Clusters	Types of soil		
	Sandy	Silty	Clayey
1	27.3	18.2	54.5
2	74.2	25.8	0.0
3	53.8	38.5	7.7
4	40.0	10.0	50.0
5	40.0	60.0	0.0

At the opposite of *Chromolaena* thickets, the 28 forest fallows are former fields of banana, cassava and water-seed melon and they have a good number of woody plants which are trees, treelets, shrubs or lianas. In some cases, trees can reach 20 m high especially in stands of *Musanga cecropioides* R. Br. ex Tedlie. They split into three clusters and are found on all types of soil but with preference on sandy soil (53.8% cluster 3), silty soil (60% in cluster 5) and clayey soil (50% in cluster 4).

The vegetation bordering these fallows is in majority either mature forest (69.2% in cluster 3), secondary forest (60% in cluster 5) or *Chromolaena* thicket. Forest on one side and *Chromolaena* thickets on the other were surrounding only 7.7% of fallows in cluster 3.

Forest fallows are former fields that were created by clearing only mature forest in clusters 3 and 4 (respectively 69.2% and 30% of fallows), secondary forest (50 and 100% of fallows in clusters 4 and 5 respectively (Table 1). No field was created at the detriment of *Chromolaena* thickets.

The number of times the same plots had been converted into fields is either one in cluster 3 (53.8%) and cluster 4 (30%), or two in cluster 3 (30.8%) and cluster 5 (60%), but was not known with certainty in cluster 4 (50%) and cluster 5 (40%).

Fallows belonging to cluster 3 are former banana fields dominated by stands of *Musanga cecropioides* where the height of the trees could reach 15 m causing a high closure of the canopy. Their mean age is 3.7±1.1 years and 53.8% of them developed on sandy soil, 38.5% on silty soil and 7.7% on clayey soil. The mature forest was bordering 69.2% of the fallows and was the vegetation type cleared before the last cropping season in the same proportion.

The fallows in cluster 4 are located in the hinterland in an area under low precipitations between Nyabessan and Ma'an. They are former fields of water-seed melon and cassava in which stems of *Chromolaena* were regularly found either dying or already dead. The mean age is 4.0±1.2 years and these fallows are found on all types of soil with 50% of them growing on clayey soil, 40% on sand and 10% on silt. Most fields (80%) were established by clearing mature and secondary forests (Table 1).

Cluster 5 is a set of five fallows under high precipitations on the coast and with a mean age of 2.8±0.8 years. These fallows were forest regrowth dominated by *Harungana madagascariensis* Lam. ex Poit. and *Selaginella myosorus* (Sw) Alston. They are former cassava fields that were established by clearing secondary forest (Table 1). Mature forest bordered 40% of them and secondary forest 60% (Table 1). These fallows developed only over sandy (40%) and silty (60%) soils and most of the plots (60%) in which they are found had been farmed twice (Table 1).

Floristic composition

A total of 467 species belonging to 336 genera and 95 families were recorded. Ten of these families are the most diverse and each comprises not less than ten species (Table 3).

Table 3. Ten ten diverse plant families in general and in the five clusters.

Families	Clusters					
	General	**1**	**2**	**3**	**4**	**5**
Rubiaceae	56[31]	25[19]	32[19]	29[20]	32[22]	8[8]
Leguminosae	43[32]	21[18]	30[21]	26[22]	20[18]	11[11]
Euphorbiaceae	34[23]	22[14]	17[18]	20[18]	25[19]	8[8]
Poaceae	15[12]	10[8]	11[9]	7[7]	8[8]	4[4]
Apocynaceae	14[11]	9[8]	10[9]	10[8]	12[10]	3[3]
Sterculiaceae	13[5]	5[4]	5[4]	7[4]	8[5]	1[1]
Moraceae	12[5]	5[3]	8[3]	8[4]	7[3]	2[2]
Annonaceae	11[9]	6[4]	5[5]	5[5]	9[8]	3[3]
Compositae	11[10]	9[9]	10[9]	7[7]	6[5]	3[3]
Commelinaceae	10[6]	6[4]	8[5]	9[5]	8[5]	3[2]

Note: The figures in brackets represent the number of genera.

The Rubiaceae come first with 56 species followed by the Leguminosae 43 species and Euphorbiaceae 34 species. Almost all of these families comprise woody plant species apart from the Compositae, the Poaceae and the Commelinaceae which are rich in herbaceous plants most of which are ruderal. Either a cluster is a *Chromolaena* thicket or a forest fallow, the variation of both species and generic diversities is moderate. However, their values are low in cluster 5 where all genera except eight of them including *Costus*, *Dioscorea*, *Rhektophyllum* are each represented by a single species.

Indicator species

A total of 80 species were found as indicator or character species of the five clusters distributed as follow: four in cluster 1, seven in cluster 2, nine in cluster 3, forty in cluster 4 and twenty in cluster 5. For each cluster only the top species with high indicator value at $p<0.05$ are presented below (Table 4).

Table 4. Top indicator species in the different clusters.

	Clusters				
	***Chromolaena* thickets**		**Forest fallows**		
	1	**2**	**3**	**4**	**5**
Mean age →	1.9	3.03	3.76	4	2.8
Species					
Paullinia pinnata L.	30	0	0	6	0
Lygodium smithianum C. Presl ex Kuhn	31	0	1	9	0
Otomeria guineensis Benth.	27	0	0	0	0
Asystasia gangetica (L.) T. Anderson	3	41	2	1	0
Chromolaena odorata (L.) King & Robins	37	39	11	8	1
Stachytarpheta cayennensis (Rich.) Vahl	6	38	0	1	0
Phyllanthus amarus Schum. & Thonn.	15	38	0	1	0
Jateorhiza macrantha (Hook.f.) Exell & Mendonça		4	2	47	3
Palisota barteri Hook.f.	0	1	39	9	9
Rauvolfia macrophylla Ruiz & Pav.	3	0	37	4	0
Musanga cecropioides R. Br. ex Tedlie	1	1	35	13	22
Bridelia micrantha (Hochst.) Baill.	11	2	33	9	0
Macaranga monandra Müll.-Arg.	0	0	0	57	0

Megaphrynium macrostachyum (K. Schum.) Milne-Redh.	0	0	1	54	0
Callichilia bequaertii De Wild.		1	0	0	52
Macaranga barteri Müll.-Arg.	6	0	0	50	0
Alchornea floribunda Müll.-Arg.		12	0	0	46
Albizia adianthifolia (Schumach.) W. Wight		2	3	0	43
Palisota ambigua (P. Beauv.) C.B. Clarke	6	1	1	42	0
Aidia micrantha (K. Schum.) Bullock ex F. White	3	0	0	35	0
Eribroma oblongum (Mast.) Pierre ex A. Chev.	0	0	4	33	0
Cyperus diffusus Vahl.	15	0	0	32	0
Margaritaria discoidea (Baill.) G.L. Webster	9	0	7	31	0
Tetrapleura tetraptera (Schum. & Thonn.) Taub.	0	0	0	30	0
Harungana madagascariensis Lam. ex Poir.	2	8	1	0	80
Selaginella myosorus (Sw) Alston		0	10	4	0
Anthonotha macrophylla P. Beauv.	4	8	4	9	59
Alchornea cordifolia (Schumach. & Thonn.) Müll.-Arg.		2	23	4	3
Sabicea pilosa Hiern		0	1	5	0
Ipomoea pileata Roxb.		4	21	7	2
Anchomanes difformis (Blume) Engl.	1	8	6	10	40
Ipomoea alba L.		0	0	0	0
Dichapetalum heudelotii (Planch. ex Oliv.) Baill.	1	8	4	14	39
Scleria boivinii Steud.	11	12	2	1	39

These species were narrowly linked with the nature of the fallows. In the *Chromolaena* thickets and apart from the liana *Paullinia pinnata* L., all indicator species were herbaceous. *Chromolaena odorata* in the two clusters had the highest indicator values and they were almost similar. On ecological point of view, indicator species of cluster 1 were forest bush land species at the opposite of those of cluster 2 known as ruderal species. The *Chromolaena* thickets had few indicator species as compared to forest fallows.

At the opposite in forest fallows indicator species were related to forest environment. They comprised mostly forest pioneer tree species like *Musanga cecropioides* and *Bridelia micrantha* (Hochst.) Baill. as it was the case in cluster 3. However in cluster 4 beside forest pioneer tree species, there was a good number of non pioneer light demanding species (*e.g. Margaritaria discoidea* (Baill.) G.L. Webster) and shade bearers (*e.g. Aidia micrantha* (K.Schum.) Bullock ex F. White). The fallows of cluster 5 exhibited a situation similar to that of clusters 3 and 4. Amongst the indicator species, the pioneer forest shrub species *Harungana madagascariensis* came first with the highest indicator value. Most of the other indicator species were either herbaceous like *Selaginella myosorus*, *Ipomoea involucrate* P. Beauv. Non pioneer forest species could be found as well as shade bearers.

Structural characteristics

A total of 1226 individuals of trees and shrubs of at least 5 cm DBH were recorded in the plots. Apart from the total number of individuals per cluster, *Chromolaena* thickets exhibit low values of structural characteristics when compared to forest fallows. However stem density provides good understanding on the number of individuals. Thus in the *Chromolaena* thickets, values of these parameters were the lowest out of the five clusters. In most of these fallows, the tree stratum was absent and the only canopy found was that of *Chromolaena odorata*. The most important value of stem density was found in forest fallows especially in cluster 3 with 935 stems per ha. Cluster 5 with 430 stems per ha has the lowest value of out of the three clusters found in the forest fallows. However the stem density in that cluster was higher than those of the *Chromolaena* thickets despite its lowest number of individuals.

Table 5. Structural characteristics of the clusters.

	Clusters				
	***Chromolaena* thickets**		**Forest fallows**		
Characteristics	**1**	**2**	**3**	**4**	**5**
Number of individuals	110.00	279.00	486.00	265.00	86.00
Stem densities		250.00	225.00	935.00	663.00
Basal area	4.77	2.29	21.07	15.15	6.87
I/E	3.14	6.64	10.60	4.49	4.30

The number of individuals per species (I/E) follows the same trend as stem density. Its lowest value was found in the *Chromolaena* thickets and the highest in forest fallows especially in cluster 3 which is made of stands of the forest pioneer species *Musanga cecropioides*.

Basal area follows the same trend as stem density since low values are found in *Chromolaena* thickets and the high ones in forest fallows. The extreme values are once more found in clusters 2 and 3 with 2.29 and 21.07 m² per ha respectively for the lowest and the highest. With regard to the values of both stem density and basal area, the clusters can be ranked as follows 2<1<5<4<3.

DISCUSSION

Species assemblages and floristic composition

Forest recovery in the tropics is governed by sprouts and coppices, seed bank of the soil and seeds from external sources (Uhl 1987, Saldarriaga *et al*. 1988, Alexandre 1989, Uhl *et al*. 1990, de Rouw 1993, Aide *et al*. 1995, Kammesheidt 1998). Multiple farming cycles can imply as is the case in southern Cameroon, shortening of fallow length by converting more than once the same plot into field crops. This practice depletes not only plant propagules but also the soil seed bank. Foresta (1984) reports that fire can destroy seeds stored at 5cm depth in the soil. Furthermore, establishing field crops by clearing *Chromolaena* thickets has an influence on forest succession after the abandonment of the field. Etejere (1980) in Nigeria found that seeds of *Chromolaena* are still viable after 26 months storage in the soil. Once the thickets are cleared off, the surrounding vegetation made of *Chromolaena* thickets as is the case with clusters 1 and 2 will enrich the site with seeds of this species among other since it can disperse 7 millions seeds per hectare in disturbed area (Honu & Dang 2002). This situation contributes to the persistence of *Chromolaena* thickets which can last for 20 years (de Rouw 1993).

Disturbance is light in forest fallows since the plots had undergone one or two farming cycles. Creating fields in forest environment by clearing forest implies a good contribution of regeneration mechanisms (Uhl 1987, Alexandre 1989) to forest recovery. The management of the field in relation with crops to be planted explains the forest structure of fallows in clusters 3 to 5. Once the forest is slashed and plant debris burnt, planting of banana, cassava and water seed melon does not require a special management of the field. There is no weeding concerning water seed melon since the plant creeps and climbs on dead trees that were felt or spared during clearing. The fact that the fallow period is not shortened gives more chance to the above ground biomass (James 1984, Bellingham & Sparrow 2000, Finegan & Delgado 2000) to boost forest recovery. Seeds from the neighboring mature or secondary forest also contribute to speed up forest succession.

The most important plant families found in this study are those characterizing the flora of the Guineo Congolian regional centre of endemism (White 1983) to which the research area belongs. It is fully integrated in the Lower Guinea forest refugia, which is rich in endemic species (White 1979, Linder 2001). Out of all studies carried out in the forest of central Africa regardless the country, the high diversity of these families had been recognized (Sonké 1998, Tchouto 2004, Gemerden 2004, Ngok Banak 2005, Boupoya-Mapikou 2011). Most of these families comprise a good number of non pioneer light demanding forest species which can establish onto the site at the same time with forest pioneer during opening of the forest. However, the high diversity of the Compositae, Graminae and Commelinaceae is an index of the disturbance hereby represented by shifting agriculture. They are rich in herbaceous plants that can be interpreted as the consequence of the use of fire (Hall & Swaine 1980, de Rouw 1991). The species composition of the fallows narrowly depends upon the soil seed bank, spared trees, the type of vegetation cleared before the last cropping season and inputs from the surrounding vegetation (Purata 1986). Animals visiting trees in the fallows left behind their dung rich in seeds of forest species.

Dominant species

Plot management influences the establishment of species in the fallows while their survival depends upon their life history traits. Since *Chromolaena odorata* is a light demanding species and the germination of its seeds require full sunlight, it grows and develops well in fallows frequently disturbed where the canopy is highly broken and open. Shortening fallow length will give more opportunity to the seeds of *Chromolaena odorata* both stored in the soil and from external sources to invade the fallow. Its dominance drops considerably in forest fallows since individuals of forest pioneer like *Musanga cecropioides* in cluster 3 or *Harungana madagascariensis* in cluster 5 cast shade which *Chromolaena* cannot withstand. In such environment, its stems weaken and die. Our results are consistent with those of de Rouw (1991, 1993), Tchiengué *et al.* (2013) which show that regular burning lead to dominance and persistence of *Chromolaena* in fallows. The thickets form an obstacle through which seeds from an external sources cannot pass and the growth of many species is difficult. The consequence is the low number of indicator species of this vegetation type. In forest fallows where the thickets are absent the situation is different and the number of diagnostic species is high. Most of their indicator species are forest pioneer species since the seeds of these species are in large quantity and density in soil of fallows (Sergio & Gómez-Pompa 1972, Alexandre 1978, Finegan 1996). These seeds are able to withstand the hard conditions prevailing in the site at the time of abandonment of the field (Finegan 1984). The shade created by their canopy modifies considerably the understory that enables forest species of other guild categories including non pioneer light demanding and shade bearer species to establish later in the fallows following the facilitation model (Connell & Slatyer 1977).

Structure

The scarcity or absence of trees in *Chromolaena* thickets due to frequent disturbance leads to low values of stem density, basal area and I/E index. The few trees available are those that were selected by farmers during clearing. The multiple farming cycles these fallows had undergone lead to a decline of shrub and tree population. Repeated clearing and burning coupled to weeding reduce considerably the above ground biomass (James 1984, Bellingham & Sparrow 2000, Tchiengué *et al*. 2013). The low values of stem density and basal area in *Chromolaena* thickets are best regarded as a slow forest recovery in these thickets. These results are consistent with those of Aide *et al*. (1995, 1996), Finegan (1992) and Chazdon (2003) who consider that the intensity of disturbance influences forest recovery.

In the early succession in southern Cameroon, the fallows in the different clusters being almost of the same age, it is evident that the management of the plot governed the recovery of structural characteristics. The values of stem density and basal area of former banana fields are close to that of mature forest (Swaine *et al*. 1987) and can be explained by the presence of stands of *Musanga cecropioides*. This species is abundant and dominant and most of the above ground biomass is represented by its individuals. Values of the basal area depend upon the abundance and size of tree and shrub individuals present in the plot. In cluster 5, the two farming cycles with the subsequent clearing and burning had reduced part of plant residual leading to low stem density and basal area. Furthermore only *Harungana madagascariensis* and *Musanga cecropioides* are abundant species and the DBH of their individuals could not exceed 25 cm. The results in the forest fallows concord with those of Guariguata *et al*. (1997), Guariguata & Ostertag (2001) Chazdon (2003) and Uriarte *et al*. (2004) which show that forest recovers rapidly when land use is not severe. Furthermore, recovery of structural characteristics is not only controlled by time since abandonment (Purata 1986) but also by land management.

CONCLUSION

In the first five years of secondary succession, forest recovery depends upon not only time since abandonment but also on the management of the plot before planting. The low values of structural characteristics in *Chromolaena* thickets evidence the fact that this vegetation type slows up forest succession because of the regular and frequent reconversion of the same plot into field crops. It becomes necessary and advisable that when establishing field crops during clearing, farmers shall leave behind some blocks of mature forest that will serve as "succession engine". They will be seed source and will boost forest recovery in a centripetal way and reduce the extent en *Chromolaena* thicket. The fact that farmers prefer clearing *Chromolaena* thickets to establish their field crops must be encouraged since it can serve to preserve the remaining mature forest block in southern Cameroon. The light disturbance in forest fallows allows the forest pioneers to develop and modify considerably the environment, facilitating the establishment of forest shade-tolerant species.

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