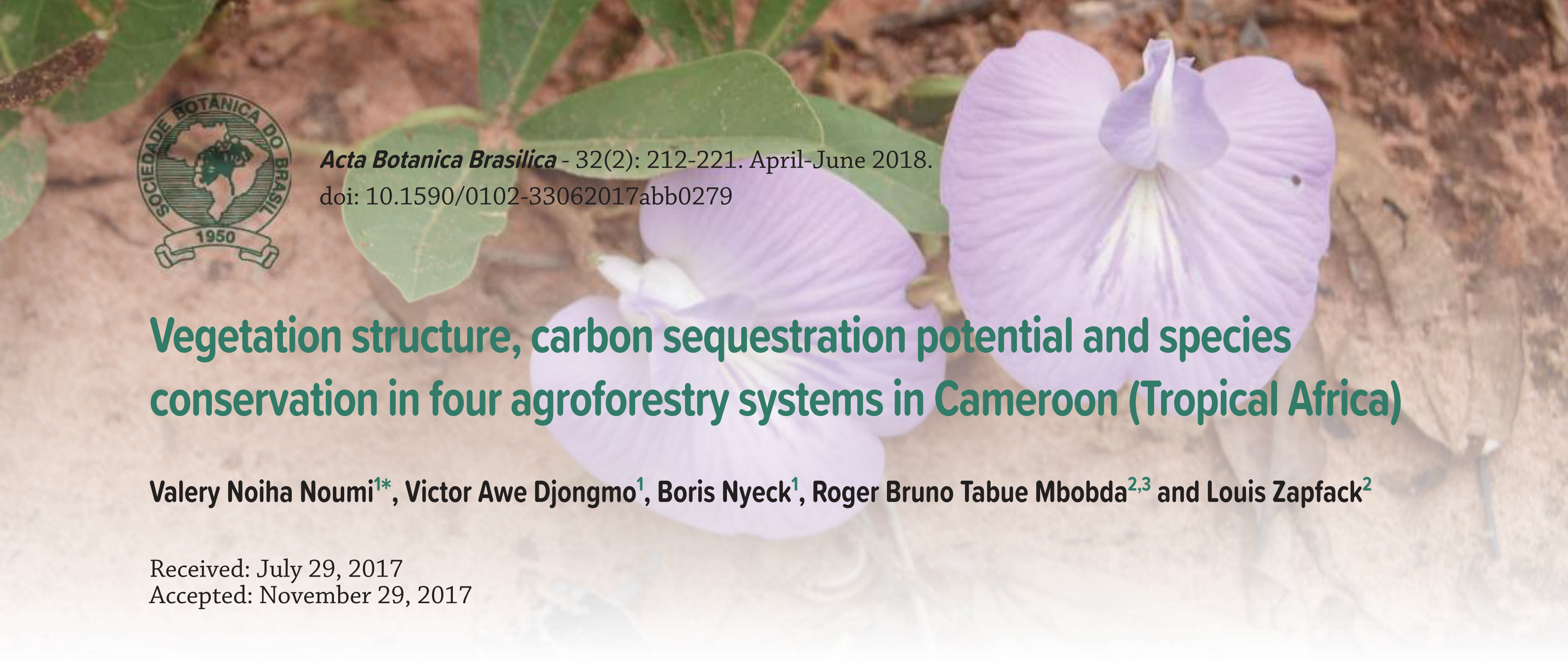

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Vegetation structure, carbon sequestration potential and species conservation in four agroforestry systems in Cameroon (Tropical Africa)

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ABSTRACT

As the rate of forest degradation continues to rise, agroforestry may serve as a way of conserving species and carbon sinks. The aim of this study was to assess agrobiodiversity and carbon sequestration potential in agrosystems in Cameroon. Three age groups of agrosystems were studied. Data were collected in 100x50 m^2 quadrates. Density ranged from 53.17±0.08 to 1463±50.11; basal area from 2.07±0.00 to 988.39±16.13 m^2/ha; Shannon diversity from 3.3±0.71 to 3.68±0.72; Carbon storage from 12.1±0.27 to 54.65±1.38 t C/ha for 1-10-year-old agrosystems with lowest values in neem; 34.78±0.87 to 71.34±1.6 t C/ha for 10-20-year-old stands with lowest values in cashew; 28.24±0.04 to 108.51±2.46 t C/ha for +20-year-old stands with highest values in eucalyptus; Carbon sequestration potential from 296.7±1.98 to 859.33±10.01 t CO$_{2eq}$/ha. The highest carbon stocks were found in eucalyptus stands ($p<0.05$). Several endogenous species, especially *Afzelia bipindensis* (EN), *Leptoderris ledermannii* (EN), *Mansonia altissima* (EN), *Entandrophragma cylindricum* (VU), *Nesogordonia papaverifera* (VU), *Quassia sanguinea* (VU), *Vitellaria paradoxa* (VU), *Afzelia africana* (VU), *Erythrina senegalensis* (LC), *Detarium microcarpum* (LC), *senna spectabilis* (LC), were assessed. Other overexploited species, especially *Carissa edulis*, *Zanthoxylum zanthoxyloides*, *Adansonia digitata*, *Securidaca longepedonculata*, were assessed as well. The studied systems are significant CO$_{2eq}$ sinks and refuge centre for agrobiodiversity.

Keywords: agrosystems, conservation, CDM, IUCN, sinks

Introduction

From the clauses agreed at CoP21 and CoP22, agrosystems can offer palliative solutions to the detrimental effects resulting from the deterioration of the climate system. As part of the fight against climate change through mitigation of greenhouse gas (GHG) emissions, many African countries, and particularly Cameroon, have signed and ratified treaties and conventions. These countries have also validated their REDD+ preparation document through the Forest Carbon Partners Facility (FCPF) Participants Committee.

REDD is not always limited to emissions that occur from the increase and decrease of carbon stocks in forests. Some proposals indicate that REDD should be integrated into a broader approach that includes the use of other lands. Also, in order to optimize the fight against climate change, the northern industrial countries should invest in the Clean Development Mechanism (CDM) projects put up by southern countries. These projects aim at reducing emission of CO$_2$, which in turn implies reception of "carbon credits" by southern countries. A link between REED and CDM could exist given that forest plantations reduce pressure on the forest resource. We have associated CDM sequestration component of CO$_{2eq}$ and REDD+.

Over the past two decades, despite the fact that much works have been undertaken in assessing and estimating

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carbon stocks in agrosystems in Africa (Sonwa *et al*. 2001; 2007; Zapfack *et al*. 2002; 2013; 2016; Saint-André *et al*. 2005; Ngueguim *et al*. 2009; Adamou 2010; Mapongmetsem *et al*. 2011; Mohamed *et al*. 2011; Kemeuze *et al*. 2015; Manfo *et al*. 2015; Noiha *et al*. 2015a; b; 2017; Djongmo 2016; Jiagho *et al*. 2016; Hamadou 2016; Ngossomo 2016; Witanou 2016); the latter, carried out in the various agroforests existing in Africa, describe these systems very little, and very few of these studies present a comparative study of the sequestration potential of these artificial ecological systems among themselves. At this time when natural ecosystems are disappearing at an alarming rate, it is clearly necessary today to outline the carbon sequestration potential of agrosystems; so that, their compensatory role in the mitigation process of Climate change be made known.

The atmospheric CO$_2$ concentration has increased to 31 % since 1750. This increase which is due to fossil fuel combustion and land use change which necessitates an identification of strategies to mitigate the threat of global warming. Deforestation, biomass burning, conversion of natural to agricultural ecosystems, drainage of wetlands and soil cultivation are the principal causes of greenhouse gas emissions (Lal 2004). Several works have showed the role of agroforestry systems as an opportunity to reduce CO$_2$ concentrations in the atmosphere by increasing carbon (C) stocks in agricultural lands (Zapfack *et al*. 2002; 2013; 2016; Albrecht & Kandji 2003; Oelbermann *et al*. 2005; Saint-André *et al*. 2005; Lufafa *et al*. 2008; Takimoto *et al*. 2008; Singh & Lodhiyal 2009; Torres *et al*. 2010; Kumar *et al*. 2011; Hergoualc'h *et al*. 2012; Kuyah *et al*. 2012; Thangata & Hildebrand 2012; Somarriba *et al*. 2013; Kemeuze *et al*. 2015; Manfo *et al*. 2015; Jiagho *et al*. 2016; Noiha *et al*. 2017).

Afforestation might be a measure to balance emissions from naturel ecosystem degradation. Re-planted areas could probably be true carbon sinks and refuge centres for endogenic species which are threatened by the anarchical exploitation of natural ecosystems. With these hypotheses in mind, the present study was carried out with the main goal to assess and compare both agrobiodiversity and C sequestration potential in four agroforestry systems in Cameroon.

Materials and methods

Study site

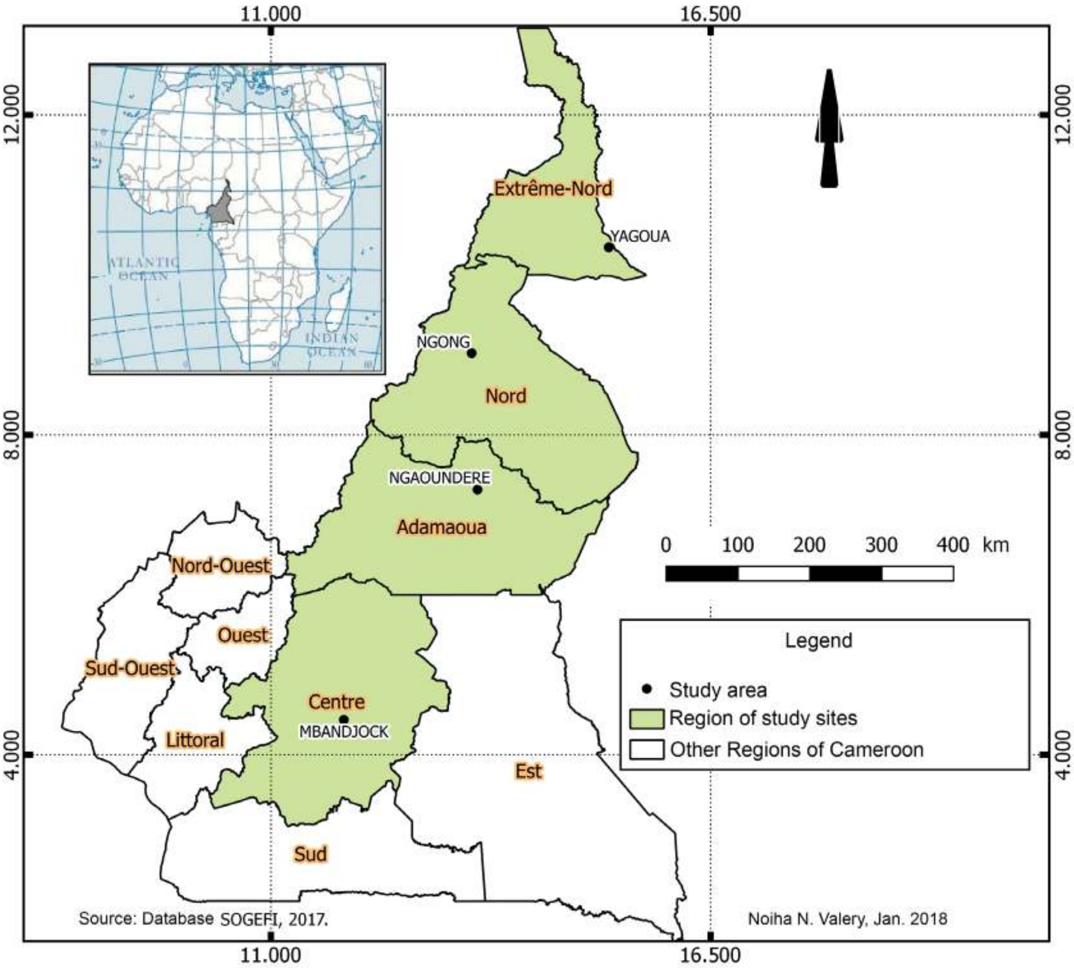
This study was carried out in Central Africa principally in Cameroon. The choice of the site was based on the availability of agroforestry systems in Cameroon. The main criterion of agrosystems selection was based on predominance; in the Far North region, agroforests based on *Azadirachta indica* (neem) were predominant, in the north region, those with *Anacardium occidentale* (cashew) were abundant, and the stands of *Eucalyptus* spp. were predominant in the Adamawa region. In the southern part of the country we selected cocoa stands (Fig. 1). The ages of the stands were taken into account in the choice to predict the evolution of the amount of carbon stored. So, the stands were then subdivided into three age groups each:]0-10[; [10-20[and ≥ 20 years.

Data collection

For each stand of the chosen agroecosystems, three types of land covers were selected according to the age of the stands. Each agroforest stand was 0-10 years old; 10-20 years and over 20 years. Community sampling units were established to enumerate and identify floristic composition. For each agroforestry system areas, three sites were selected (three times replicated for each site) to establish four 100 × 50 m sampling plots of three stages (0-10, 10-20 and 20+ year old) respectively (Fig. 2). This methodology was similar to that of Du *et al*. (2015) even though they established nine 20 x 50 m sampling plots of five stages. The survey area was 2 ha per site. Several blocks or squares (quadrates) with definite size (5 x 5 m^2) were established in the stands and savannah to identify total number of timbers (Some trees were identified directly in the field using monograph; for other trees, specimens were collected and compared to those available in the National herbarium of Cameroon). The Spatial data layers contours (altitude, slope and aspect) and vegetation types were extracted from topo sheet. Suunto Hypsometer was used for measuring the height of the trees. Likewise, for measuring diameter and circumferences, instruments like Caliper, Finnish Caliper and measuring tape were employed for all woody species (dbh≥2 cm). GPS and compass were used to install and locate stands. The diameter was measured at 1.30 m aboveground for trees and at 0.30 m and 0.50 m for shrublets and shrubs respectively.

Data analysis

All statistical analyses were performed with STATGRAPHICS plus version 5.0 (2016) software for Windows. One-way analysis of variance (ANOVA) was used to find out whether the age of stands had an effect on the floristic parameters, the average of carbon storage and the sequestration potential of the stands. We also compared density, basal area, diversity and carbon pools between stands and savannah using Duncan test. Correlations between species richness-biomass, density-biomass and basal area-biomass variables were determined by using the *Pearson's* rank correlation coefficient (*r*) and model performance was assessed on the basis of the coefficient of determination (R2) and on *p-value*. A *p-value* = 0.05 was used to reveal the statistical significance.



Source: Database SOGEFI, 2017.

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Figure 1. Sites localization.

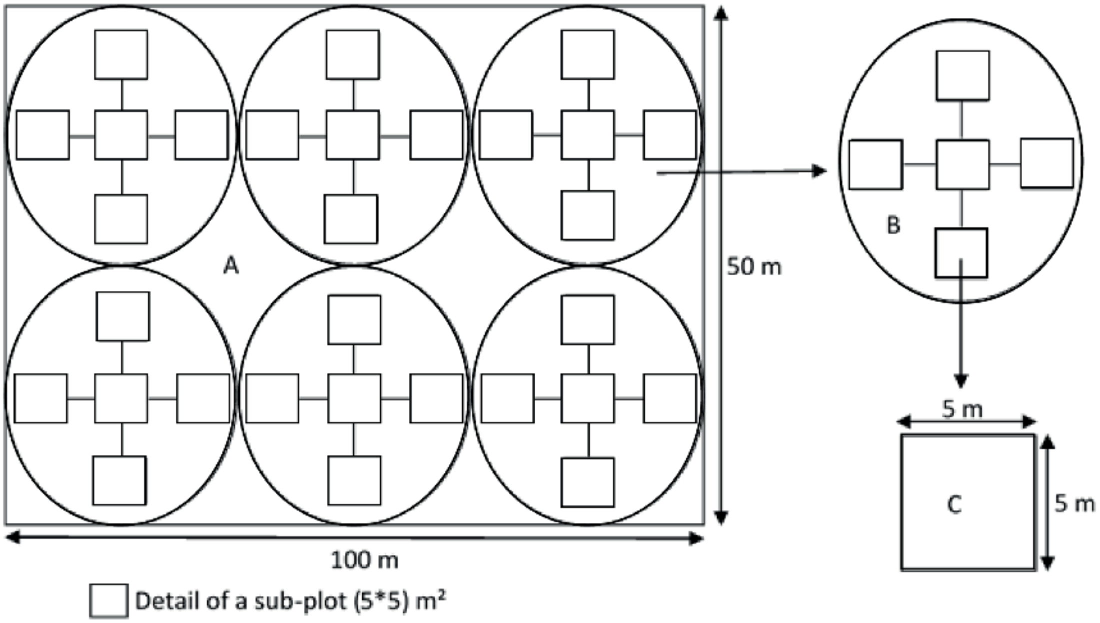

Figure 2. Detail of the method sampling. **A.** Plot of 5000 m^2; **B.** Five blocks of four sub-plots; **C.** detail of sub-plots.

Stand diversity and structure

The analysis of the stand diversity has focused on: 1. The diversity of Shannon (ISH) index (Frontier & Pichod-Viale 1992):

$$\text{ISH}= -\sum \frac{ni}{N}\text{Log}_2\left(\frac{ni}{N}\right)$$

with ni= number of the species i, N = number of all species; ISH is expressed in bit. 2. The equitability of Piélou (1966) $\text{EQ} = \frac{ISH}{Log2N}$. 3. Coefficient of similarity of Sorensen (K) (1948) *apud* Ngueguim *et al*. 2009: $\text{K} = \frac{2c}{a+b}x100$, with a = number of species of the statement 1, b = number of species of the statement 2, c = number of species common to the two statements. 4. Index of Ecological Importance (IVI) (Curtis & Macintosh (1950) *apud* Adjonou *et al*. 2010). IVI= relative Dominance $_{\text{(species)}}$ + relative Density $_{\text{(species)}}$ + relative Frequency $_{\text{(species)}}$. 5. Density (D): This is the number of individuals per ha. In the plots, the density (D) is calculated based on the formula: $\text{D} = \frac{n}{S}$; D: density (trees/ha), n: number of trees present on the considered surface and S: reporting surface (ha). 6. Basal Area (BA): This allows presenting in m²/ha the surface of each species at 1.30 m (dbh); the formula:

$$\text{BA} = \frac{\pi}{4}\sum_{i=1}^{n}\text{d}_{\text{i}}^{2} = \frac{1}{4\pi}\sum_{i=1}^{n}\text{C}_{\text{i}}^{2}$$

with BA: basal area (m²/ha), d: diameter (m), C: (m) circumference. 7. Size-class distribution: to catch the diametric structure in the understories of the eucalyptus stands, timbers were grouped in class of diameters with amplitude of 10 cm. Thereby, the aspect of the evolution of species in the understories was forecasted through a histogram of distribution.

Carbon stocks assessment

Aboveground biomass (AGB) of woody species was evaluated according to the allometric equation developed by Brown *et al*. (1997) for dry tropical climates: $\text{AGB}=\text{e}^{[-1.996+2.32*\ln(\text{DBH})]}$; with AGB: aboveground biomass (kg), DBH: diameters at breast height (cm) for Far north and north stands. In Adamawa and Center sites, we used the allometric model of Chave *et al*. (2005): Aboveground biomass (AGB): $\text{AGB}= \alpha\text{e}^{[-1.499 + 2.148*\ln(\text{DBH}) + 0.207*(\ln(\text{DBH})2 - 0.0281*(\ln(\text{DBH}))3]}$; where α is the specific density of woody species. From these biomasses, the amount of carbon (Kg/ha) is obtained by multiplying biomasses by a conversion factor of 0.47.

Belowground biomass (BGB) was extrapolated from AGB according to the allometric equation developed by Cairns *et al*. (1997): $\text{BGB} =\text{e}^{[-1.0587+0.8836*\ln\text{ (AGB)}]}$.

Total carbon: TB = AGB + BGB (FAO 2011); with TB: total biomass (kg); AGB: aboveground biomass and BGB: belowground biomass.

Sequestration potential assessment

The total stock of carbon estimated in t/ha was converted into equivalent amount of CO2_{eq} absorbed using the ratio 44/12 corresponding to the CO2_{eq}/C report. This value was subsequently evaluated in monetary value using the ecological service value estimated at 10 USD/t CO2_{eq} (Ecosystems Marketplace 2016).

Conservation state: an overview of species conservation in the studied stands

To be able to assess the conservation status of all recorded species, we did a literature review and checked the red data list of the species catalogued by the IUCN through the link: www.iucnredlist.org/search.

Results

Floristic structure

There were significant differences in density and basal area amongst the selected sites ($p<0.05$). Density ranged from 53.17±0.08 to 1463±50.11 timbers/ha. Basal area ranged from 2.07±0.00 to 988.39±16.13 m²/ha. For each of these parameters, the most important values were found in neem stands (Tab. 1).

There was no significant difference in plant diversity amongst the sites and therefore amongst the selected

Table I. Floristic parameters amongst the studied agrosystems.

Sites	Agrosystems	Floristic Parameters		
		D (ind./ha)	BA (m²/ha)	IIE (%)
Ngaoundéré	Eucalyptus	53.17 ± 0.08b	2.07 ± 0.00b	22.09 ± 4.01a
Ngong	Cashew	60.09 ± 1.25a	5.99 ± 0.00a	20.08 ±1.79a
Yagoua	Neem	109.89 ± 2.03c	11.34 ± 0.01c	20.08 ±1.79a
Mbandjock	Cocoa	1463±50.11d	988.39±16.13d	163.99±20.23d

Notes: In the same column, values affected with the same letter are not statistically different. D: density; BA: basal area; IIE: index of ecological importance.

Table II. Floristic diversity amongst the studied agrosystems.

Sites	Agrosystems	Species richness	ISH	EQ
Ngaoundéré	Eucalyptus	42 ± 1.58b	3.57 ± 0.29a	0.99 ± 0.3a
Ngong	Cashew	44 ± 1.25a	3.60 ± 0.70a	1 ± 0.1a
Yagoua	Neem	39 ± 0.95c	3.3 ± 0.71a	1 ± 0.1a
Mbandjock	Cocoa	46±0.91d	3.68±0.72a	0.98±0.1a

Notes: In the same column, values affected with the same letter are not statistically different. ISH: Shannon index; EQ: Piélou evenness

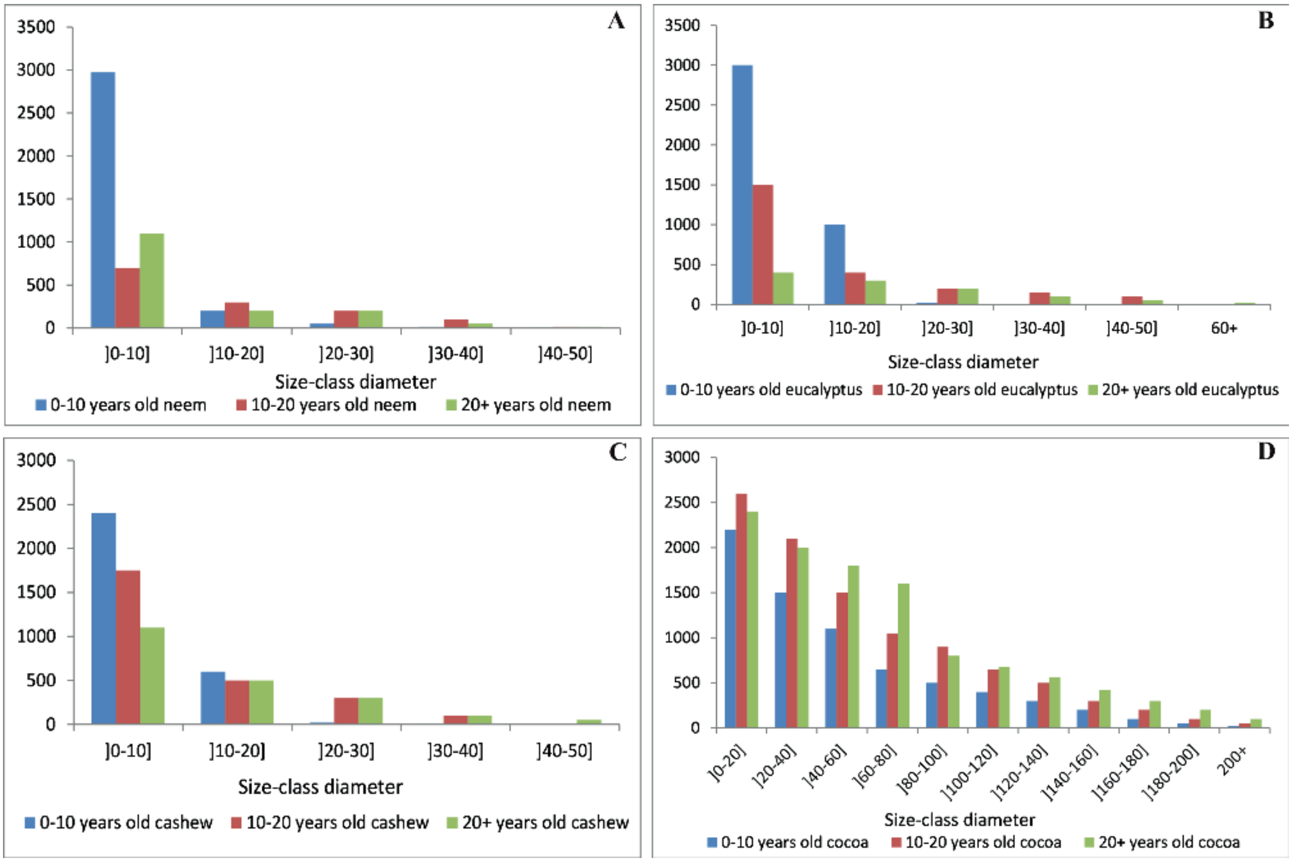

Figure 3. Size-classed diameter distribution. **A.** Neem stand; **B.** Eucalyptus stand; **C.** cashew stand; **D.** Cocoa stand. Please see PDF version for color reference

agrosystems (p>0.05) (EQ of the order of 1 in Tab. 2); Shannon index ranged from 3.3±0.71 to 3.68±0.72.

Sorensen's coefficients of floristic similarities amongst the northern sites were generally high (>50).

From the analysis, each stand exhibits a classic exponential decay distribution (of Sharp "L" or "J" if inverted). This exponential decay reflects the predominance of individuals with small diameters (Fig. 3). This structure shows that, there is a strong regeneration of the undergrowth of the stands by the presence of several individuals with a small diameter (<10 cm). This is the main characteristic of forest stands assumed to be in equilibrium, with many small-diameter individuals and few large-diameter individuals.

Factor analysis of correspondence (CFA) of carbon stock amongst species in different types of the studied plots showed a 99.88 % correlation along the F1 and F2 axis shared equally (49.94 % for the F1 axis and 49.94 % for the F2 axis, Fig. 4). The dispersion of the different species is positively correlated. Species such as *Terminalia albida*, *Terminalia schimperiana*, *Burkea africana*, *Azadirachta indica*, *Lannea schimperi*, *Gardenia aqualla*, *Acacia sieberiana* and *Combretum adenogonium* were the most represented. The species scattered in the figure were very dense. This implies that they stand a chance of being encountered in all the studied geographical areas. The other species that were less represented formed clouds around the two axes (axes F1 and F2: 99.48 %); which consequently implies that they are less dense and cannot be found everywhere in the studied geographical areas. On the ecological level, these species were accidentally present in the different geographical zones studied.

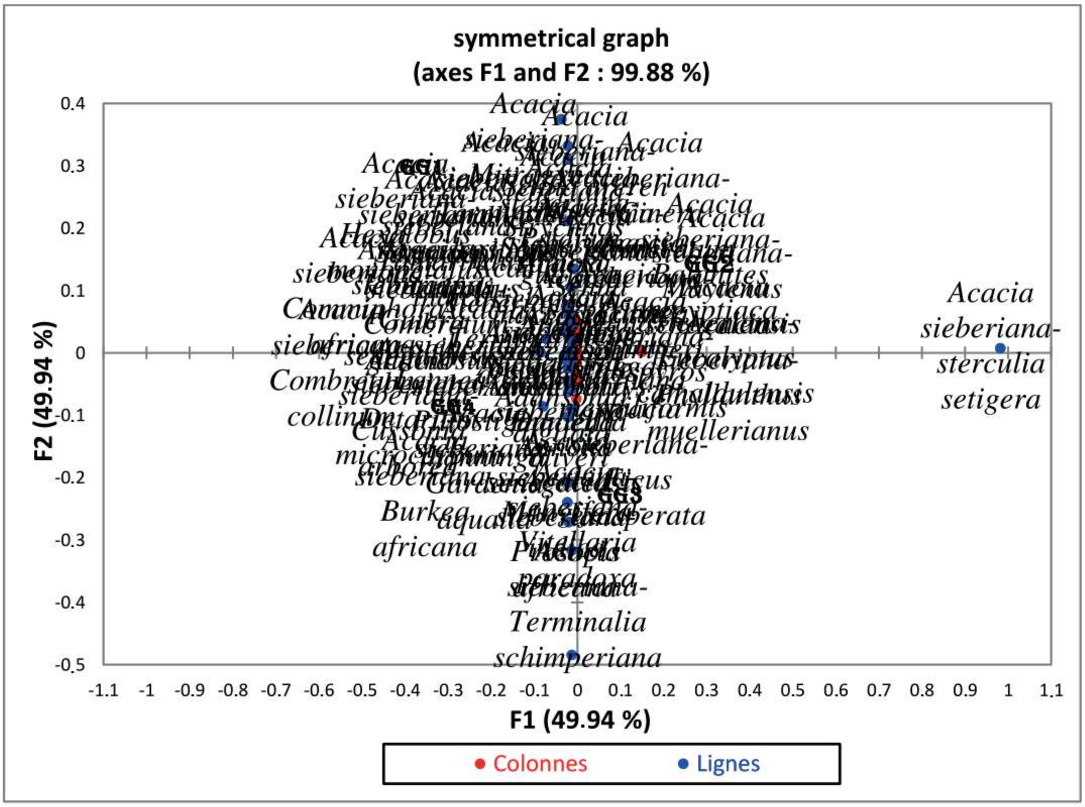

Figure 4. Correlation between carbon storage and species. Please see PDF version for color reference.

Carbon storage and sequestration potential

For the same age groups, there was a significant difference amongst the agrosystems studied both in the above and belowground stocks (p=0.0000). Eucalyptus stands of all age groups stored more carbon compared to other systems (Tab. 3).

The sequestration potential varied significantly among the stands ($p<0.05$). CO^2 sequestration was more important in eucalyptus stands (Tab. 3).

Density and basal area affected carbon stocks. For each considered parameter, the Pearson's coefficient was very strong ($r>0.5$); indicating an influence of the number of species and density on the carbon sequestration potential (Tab. 4). This correlation, as can be seen, was more significant with the basal area (r=0.987; $p<0.0001$) being proportional to the breast height diameter (dbh) which is an important factor in the biomass stock.

The number of individuals per hectare can influence biomass by a summation effect; this explains the significant correlation observed in the number of species and density ($p<0.0001$).

Furthermore, the Economic value was correlated with aboveground carbon (r=0.697; $p<0.0001$). A significant correlation equal to the threshold of 0.5 was found between the economic value and the belowground stocks (r=0.594; $p<0.0001$). Also, a strong and significant correlation between economic value and total carbon stocks (r=0.901; $p<0.0001$) was found, which showed that these different plantations are large reservoirs of carbon (Tab. 5).

Overview for the biodiversity conservation

Floristic diversity in each agrosystem was assessed and the list was compared with that of IUCN catalogued species. Among the species listed in the understory, some have IUCN status (see www.iucnredlist.org/search; Tab. 6). Many other species from the IUCN catalogue with no status were assessed; *Carissa edulis*, *Zanthoxylum zanthoxyloides*, *Adansonia digitata*, and *Securidaca longepedoncula*.

Discussion

The Shannon diversity of understory which has the value of 3 in each agrosystem indicated the presence of pre-existing savannah species in the stands of the studied systems and these associated species were equitably and homogeneously distributed. Based on the axis of symmetry, the species were grouped into four. This cloud observed

Table III. Comparison of stocks in respect to stands and age.

Age of Stands	Parcels	Sites	Parameters		
			AGB (t/ha)	BGB (t/ha)	Total carbon (t/ha)
≤10	Cashew	Ngong	11.41 ± 0.01b	3.10 ± 0.00b	14.51 ± 0.11b
	Neem	Yagoua	10.20 ± 0.03a	1.90 ± 0.01a	12.10 ±0.27a
	Eucalyptus	Ngaoundéré	44.69 ± 0.98c	9.96 ± 0.08c	54.65 ± 1.38c
	Cocoa	Mbandjock	11.13 ± 0.11d	2.67±0.13d	13.80±0.13d
10-20	Cashew	Ngong	28.29 ± 0.28b	6.49±0.00b	34.78 ± 0.87b
	Neem	Yagoua	31.90 ± 1.59a	8.69 ±0.00a	40.58 ± 1.98a
	Eucalyptus	Ngaoundéré	58.67 ± 1.02c	12.67±0.13c	71.34 ± 1.60c
	Cocoa	Mbandjock	44.24 ± 0.07d	10.61±0.02d	54.86±0.09a
>20	Cashew	Ngong	32.56 ± 0.52b	7.46 ±0.09b	40.02 ± 0.09b
	Neem	Yagoua	23.94 ± 0.72a	4.30 ± 0.04a	28.24 ± 0.04a
	Eucalyptus	Ngaoundéré	90.02 ± 3.51c	18.49 ±0.19c	108.51 ± 2.46c
	Cocoa	Mbandjock	63.25 ± 0.06d	15.18±0.01d	78.43±0.07d

Notes: In the same column, values affected with the same letter are not statistically different. AGB: aboveground biomass; BGB: belowground biomass.

Table IV. Relationship amongst carbon reservoir, species richness, density and basal area.

Parameters	Coefficient of Pearson's correlation (*r*)		
	AGB	BGB	Total Carbon
Species richness	0.701	0.697	0.798
	($p < 0.0001$)	($p < 0.0001$)	($p < 0.0001$)
Density	0.611	0.799	0.569
	($p = 0.0000$)	($p < 0.0001$)	($p = 0.0000$)
Basal area	0.895	0.754	0.987
	($p < 0.0001$)	($p < 0.0001$)	($p < 0.0001$)

Note: AGB: aboveground biomass; BGB: belowground biomass.

Table V. Comparison of sequestration potential amongst the studied agrosystems

Sites	Agrosystems	Total Carbon (t/ha)	QCO_{2eq} (t/ha)	VE (Dollars)
Ngong	Cashew	89.31	327.47 ± 2.07b	3274.70 ± 79.80b
Ngaoundéré	Eucalyptus	234.36	859.33 ± 10.01a	8593.30 ± 189.00a
Yagoua	Neem	80.92	296.70 ± 1.98c	2967.00 ± 50.67c
Mbandjock	Cocoa	147.23	539.87 ± 8.01d	5398.70 ± 210.00d

Notes: In the same column, values affected with the same letter are not statistically different. QCO2eq: sequestration potential; VE: economic value.

Table VI. Catalogued species of the IUCN red data list in the agrosystems' understory.

Agrosystems	Species	Families	IUCN status
Neem	*Vitellaria paradoxa*	Sapotaceae	VU
Cashew	*Erythrina senegalensis*	Fabaceae	LC
	Afzelia africana	Caesalpiniaceae	VU
Eucalyptus	*Senna spectabilis*	Caesalpiniaceae	LC
	Detarium microcarpum	Caesalpiniaceae	LC
Cocoa	*Afzelia bipindensis*	Caesalpiniaceae	EN
	Entandrophragma cylindricum	Meliaceae	VU
	Leptoderris ledermannii	Fabaceae	EN
	Mansonia altissima	Malvaceae	EN
	Nesogordonia papaverifera	Malvaceae	VU
	Quassia sanguinea	Simaroubaceae	VU

Note: EN, En danger; VU, vulnerable; LC, least concern.

in figure 4 means that the correlation between carbon stocks and economic value was very high. There was equally a significant variation of the C sequestration potential among the stands ($p<0.05$). CO_2 sequestration was higher in eucalyptus stands. Density and basal area affected carbon stocks. The most important factor was dbh; neem plantations with 109 individuals and 11 m^2 of basal area and density would have had to store more carbon compared to the work of Noiha *et al*. (2015a), which showed a strong correlation of stocks with both parameters. Furthermore, the size-classed diameter distribution as shown in the figure 3 showed that the largest diameters in the neem stands do not exceed 50 cm and the same is true in cashew stands where individuals rarely reach 50 cm. However, in eucalyptus stands, individuals may exceed 110 cm. These observations are in agreement with the works of Zapfack *et al*. (2016) and Noiha *et al*. (2017) in the Lobéké National Park in southeastern Cameroon and in the cashew of Ngong in northern Cameroon respectively.

The largest value of aboveground carbon found in the cashew stand of over 20 years (32.56 ± 0.31 t/ha) was greater than the 21.73 t/ha from the work of Thiombiano (2010) in the cashew plantations of 22 years in Burkina Faso. This difference is likely related to the methodology of counting, but it could mainly be due to the variability of the density of the understory, which depends on the level of maturity of the cashew plantations. The stock of aboveground carbon from the control (Savannah, 10.71 ± 0.14 t/ha) did not corroborate the work of Tchobsala *et al.* (2016) in two shrubby savannah of Ngaoundéré (Cameroon) with respectively 40.89 ± 1.09 t/ha and 45.03 ± 1.22 t/ha in aboveground carbon. This difference could be as a result of the strong anthropogenic pressure in the control. These data were as important as those from the work carried out in Tanzania in some agroecosystems such as parklands, homegardens and woodlot (Singh & Lodhiyal 2009; Fonseca *et al*. 2011; Chavan & Rasal 2012).

Stocks of carbon in neem plantations of 0-10 years (12.10 t C/ha); 10-20 years (40.58 t C/ha) and more than 20 years (28.24 t C/ha) were higher than those obtained by Kanmegne (2004) in the dense rainforests of southern Cameroon (5.31 t C/ha; 6.11 t C/ha and 5.03 t C/ha respectively in primary forest, in banana plantations and old fallows). In the Savannah, carbon stocks (13.68 t C/ha) were higher than those of Mosango (1991) in the Democratic Republic of Congo (6.63 t C/ha).

Aboveground carbon in eucalyptus varied from 10.78 t C/ha to 90.02 t C/ha. In total, 204.16 t C/ha was estimated; this was higher than 57.34 t C/ha from young secondary forests of Congo, 89.31 t C/ha in cashew stands from north Cameroon and 186.92 t C/ha of degraded secondary forests of Cameroon Center region (Noiha *et al*. 2017; Mosango 1991; Zapfack 2005). This amount of carbon storage was far superior compared to those assessed in several cocoa agrosystems (Zapfack *et al*. 2016; Ngossomo 2016). The average aboveground carbon stocks in the old Eucalyptus stands (26.27 ± 0.13 t C/ha), medium Eucalyptus stands (16.47 ± 0.19 t C/ha), young Eucalyptus stands (11.3 ± 0.088 t C/ha) and Savannah (3.03 ± 0.015 t C / ha) were higher than those of Kanmegne (2004) in the moist forests of Southern Cameroon (5.31 t C/ha; 6.11 t C/ha and 5.03 t C/ha respectively in primary forest, banana plantation and old fallow).

The C sequestration potential was higher in eucalyptus stands (398.25 t CO_{2eq}/ha) than in the savannah (50.05 t CO_{2eq}/ha). In total 956.82 t CO_{2eq}/ha were sequestered for an economic value of $9,568.45/ha against 50.05 t CO_{2eq}/ha corresponding to $500.56/ha in the Savannah. Eucalyptus stands are considered as carbon sinks which could be an opportunity for financial benefits in the event of payment for environmental services in the context of the CDM.

One of the central questions of conservation is the fate of endogenous species when ecosystems are being manipulated by activities such as deforestation and permanent degradation at an alarming rate. In the Sudano-Sahelian zone of Cameroon, where the climate is severe, agroforests are installed on bare and often degraded areas. An inventory of the undergrowth of the assessed stands revealed an apparent presence of the species of the preexisting ecosystems which find refuge in these stands. Of the 7850 plant species that make up Cameroon's floristic wealth, 815 of them (10.38%) are threatened of extinction which have long term effect on the global climate. This alarm sprouted from research jointly conducted by the Agricultural Research Institute for Development (ARID) and the Royal Botanical Garden of London, England. This study named Red Data Plan Cameroon, denounces among other factors the cause of this potential disaster, the destruction of habitats due to human activities (urbanization, agriculture, etc.), natural disasters and climate change. From our results, agroforest stands typically provide shelter to endogenous species which are already threatened by anthropogenic pressures on natural ecosystems.

Conclusion

Carbon sequestration in agroforestry systems plays an important role in climate change regulation. Also, agroforestry is one of the most effective ways of reducing poverty and forest degradation. It is a systematic planting of trees together with crops with the aim of providing both long- and short-term benefits to local populations, and to enhance the carbon storage capacity for the environmental stability. In systems of more than 20 years, the potential of sequestration was comparable to that of some dense wet forests of tropical Africa. It is said that, a well-maintained system can offer both short and long-term of the important ecosystem services. The agrosystems are true carbon sinks on the one hand and a place of refuge for the endogenous species endangered by human actions on the other hand. To sum up, having seen the role agroforestry has played both biologically and socially, agroforestry can be typical centres for biodiversity conservation.

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