Title: Carbon of Chaillu Forests based on a phytosociological analysis in Republic of Congo, more than meets the eye?

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Short title / Running head: Carbon of Chaillu forests, Congo

Abstract:
The objectives were to quantify aboveground, belowground and dead wood carbon pools near Mayoko in the Chaillu massif of Republic of Congo and explore relationships between carbon storage and plant diversity of all growth forms. A total of 190 plots (25 m by 25 m) were sampled (5,072 stems, 211 species) and data analysed using recommended central-African forest allometric equations. Mean stem diameter at breast height was 33.6 cm, mean basal area 47.7 m^2 ha^{-1} and mean density of individuals 407 ha^{-1}. Mean aboveground carbon (AGC) ranged from 13.93–412.66 Mg C ha^{-1}, belowground carbon from 2.86–96.97 Mg C ha^{-1} and dead wood from 0.00–7.59 Mg C ha^{-1}. The maximum AGC value recorded in a plot was 916 Mg C ha^{-1}. The analysis performed using phytosociological association as basis rather than broad vegetation type is unique. AGC values for undisturbed *terra firme* forest sites featured among the highest recorded for African tropical forests. Considering only tree diversity, a weak, yet significant, relationship existed between AGC and species richness, Shannon-Wiener index of diversity and Fisher's alpha. However, if diversity of all plant growth forms is considered, no relationship between carbon and plant diversity existed.

1. Introduction

Due to increased anthropogenic greenhouse gas (GHG) emissions, a strong interest to stabilise CO_2 and other GHG concentrations to mitigate climate change has emerged. Despite covering only 10% of the world's land surface tropical forests play a crucial role in the global carbon cycle as they contain approximately one half of carbon within terrestrial vegetation (Hubau et al., 2020). However, tropical forests are threatened by land-use change and logging. Deforestation and forest degradation account for 15% (peat degradation included) of global carbon emissions (Van der Werf et al., 2009), which is the second largest anthropogenic carbon dioxide source in the atmosphere. Because of rapid tropical forest deforestation, mechanisms rewarding activities that target reducing emissions from deforestation and degradation (REDD) have been developed (Maniatis et al., 2013), and these were subsequently extended (REDD+) by additionally considering forest conservation, sustainable forest management and carbon stocks enhancement.

To understand African rainforest's potential to contribute towards REDD+, recent work focussed on quantifying carbon stocks (Lewis et al., 2013; Day et al., 2013; Fongnzossie et al., 2014; Doetterl et al., 2015; Loubota Panzou et al., 2018; Zekeng et al., 2020); comparing carbon in monodominant *versus* mixed stands (Cassart et al., 2016; Umunay et al., 2017); investigating different strata contributions (Memiaghe et al., 2016; Fayolle et al., 2016; Hubau et al., 2019); and improving allometric relationships (Djomo et al., 2010, 2016; Fayolle et al., 2013, 2018; Kearsley et al., 2013; Ngomanda et al., 2014; Djomo & Chimi 2017). Other studies considered estimating rainforest carbon content through remote sensing (Mitchard et al., 2009; Saatchi et al., 2011; Xu et al., 2017; Mitchell et al., 2017; Bouvet et al., 2018). In the Republic of Congo (RoC), studies were conducted primarily in the northern Likouala district (Ifo et al., 2017, 2019; Bocko et al., 2017; Ekoungoulou et al., 2018) or on the Bateke Plateau in Lesio-Louna (Ekoungoulou et al., 2014, 2015; Ifo et al., 2015). Hence, a dearth of carbon stocks information appears in the country's west. Most studies focused on quantifying carbon stocks in broad-scale vegetation classes, thus ignoring small-scale landscape variations. However, because rainforests play a key role as ecosystem service provider, considering complexity and accounting for fine-scale variations when analysing carbon storage, appears important.

It is often assumed that safeguarding areas with high carbon stocks will simultaneously conserve biodiversity (Strassburg et al., 2010; Day et al., 2013, Arasa-Gisbert et al., 2018; Steur et al. 2020). However, relationships between carbon stocks and biodiversity in tropical forests are not straightforward and depend on spatial scale (Poorter et al., 2015; Sullivan et al., 2017), taxonomic groups studied (Van de Perre, 2018) and measures of diversity used. Generally, a weak positive relationship exists between tree diversity and carbon stocks at fine spatial scales (<1 ha), which disappears at coarse spatial scales (≥1 ha). At small scales, niche complementarity and sampling effects dominate (Chisholm et al., 2013; Poorter et al., 2015), while at large scales, environmental gradients underlie patterns (Chisholm et al., 2013). Mensah et al. (2020) found evidence that structural complexity and large-sized trees could explain species richness–AGC relationships across vegetation types. When assessing biodiversity and carbon stocks relationships among several organismal groups, Van de Perre et al. (2018) found a positive, linear relationship for tree richness only; but no relationships between carbon stocks and richness of bark lichens, fungi, flies, ants, birds, rodents and shrews. Although the relationship between carbon stocks and tree diversity has been explored for tropical African forests the relationship between carbon stocks and diversity of all plant growth forms (i.e. trees, shrub, lianas, grasses and forbs collectively) has not yet been reported in tropical African forests.

The present quantitative study contributed to an iron-ore mining feasibility/baseline study spanning seven aspects (habitats, plants, mammals, avifauna, herpetofauna, entomofauna, freshwater). Local carbon storage benchmarking formed part of the habitats' investigation because information was needed to minimise deforestation. The objectives were firstly to quantify aboveground, belowground and dead wood carbon pools, at and around the proposed mining site (the Mayoko study area) at a fine scale thus reporting per phytosociological association instead of broad vegetation type. Secondly, structural and floristic attributes of phytosociological associations are analysed in relation to carbon stocks. Thirdly, relationships between carbon storage and plant diversity are explored for all growth forms collectively and not only tree diversity.

2. Study Area

The study area spans 156,900 ha in RoC's Mayoko District, Niari "Département" (Figure S1, supplementary material). It lies within the biodiversity rich Lope-Chaillu-Louesse landscape (LCLL) defined by the "Central Africa Regional Program for the Environment" of USAID. The LCLL, associated with high endemism and rare forest types (De Wasseige et al., 2012), centres on the Chaillu Massif, a mountainous region that sheltered a Pleistocene forest refuge for Africa. The LCLL holds the highest large mammal densities of any tropical forest and houses many endemic plant, mammal, bird, fish, reptile and amphibian species (The Congo Basin Forest Partnership, 2006).

The region is further known for its mineral resources. Mean annual precipitation and temperature for Monts Birougou, 70 km distant, in Gabon, are 1800 mm and 22°C respectively (Gautam and Pietsch, 2012) with the rainy season extending from mid-September to mid-June. The LCLL portion within RoC rests on old (3.2 billion years) undifferentiated Archean gneiss with ferralitic soils (Chatelin, 1968). Terrain ranged from flat inundatable valley bottoms to summits of hilly formations characteristic of the Chaillu Massif. Hillside slopes varied from gentle to steep, but remained <80%.

A phytosociological analysis of the Mayoko rainforest data based on 235 sample plots identified twelve plant associations (see Van Rooyen et al., 2019 for full descriptions and supplementary material for a summary), classified as ranging from highly disturbed to fairly intact. A wet to dry gradient and a permanently inundated to temporarily inundated gradient were also distinguished.

2. Methods

2.1 Sampling procedure

Site selection followed a multistage, stratified, semi-random sampling approach (Bourgeron et al., 2001; Van Rooyen et al., 2016, 2019). Broad habitat classes, slope, altitude, aspect, river/stream size, roads and distance to nearest villages were the strata used to identify landscape variability and assign sampling locations. This was applied to a landscape spanning 6,278 sampling-grid cells of 500 m by 500 m (0.25 km^2). Final site placement within each predefined habitat type is provided in Table S1, Figure S2. As the pre-selection of sites for sampling was based on model-based analysis, some limited expert decision was allowed for final site placement. Experts were permitted to move a location within a 100 m of a pre-selected location if the habitat type did not match the planned selection (which may have been a result of digital elevation model limits or human action).

We identified and enumerated trees with DBH ≥15 cm in the plots. The use of this diameter cut-off permitted the inclusion of many plants to capture the basis of woody species populations (Gaugris and Van Rooyen, 2007). To quantify the contribution of the ≥10–15 cm cohort, individuals falling in this size class were also enumerated in a selection of plots in three different plant associations. For coarse woody debris only items ≥15 cm in diameter were considered. The litter and soil carbon pools were not sampled. The biomass contained in the woody species was surveyed at 190 sites selected from the vegetation study's total of 235 sites (Van Rooyen et al., 2019).

At each survey site, a representative square (25 m x 25 m) plot was sampled (Van Rooyen et al., 2019). For each qualifying woody individual in the plot, records spanned:

- (i) species name;
- (ii) alive or dead status;
- (iii) DBH (cm) or 30 cm above the highest point of the buttress (using a Vernier calliper or a graduated stick if tree diameter exceeded Vernier dimensions);
- (iv) tree height (m) (using a $Nikon_{TM}$ "Forestry Pro" hypsometer), canopy diameter (m) (considered as the widest canopy diameter section that could be observed from the ground, measured with the hypsometer) for live trees;
- (v) DBH and height were recorded for standing dead trees;
- (vi) for all large logs lying on the ground, stem diameter (if ≥15 cm at log midpoint) and length were measured. Lying dead trees were recorded if rooted in the plot or when stems were entirely within the plot. Dead stems lying across a plot, from one boundary to an opposite boundary were also recorded.

A graduated 4-m long stick was used to calibrate height and canopy diameter while a SuuntoTM clinometer was used occasionally to verify hypsometer records.

2.2 Data analysis

Because carbon survey sites were at the same locations as the phytosociological sites, each carbon site could be allocated to one of the plant associations identified by Van Rooyen et al. (2019) in their phytosociological classification. Carbon related information was therefore analysed per phytosociological association to develop a fine-grained representation in the landscape rather than a higher order representation at broad vegetation type as is usually done when insufficient detailed information is available on the vegetation.

2.2.1 Carbon stocks

Aboveground biomass: Chave et al. (2014) proposed using a single allometric equation to estimate tree aboveground biomass (AGB) across pantropical vegetation types when wood specific gravity, trunk diameter and total tree height are available:

$$AGB_{est} = 0.0673 \times (\rho D^2 H)^{0.976} \quad (\sigma = 0{:}357;\ AIC = 3130;\ df = 4002) \quad (1)$$

Where AGB_{est} equals aboveground biomass (kg) and D = DBH (cm), ρ = oven-dry wood density (g cm^{-3}) and H = tree height (m).

Fayolle et al. (2018) recommended using two regional allometric equations for Congo Basin forests, one if tree height is available and one without tree height:

$$AGB_{est} = 0.125 \times \rho^{1.079} \times D^{2.210} \times H^{0.506} \quad (2)$$

$$AGB_{est} = \exp\left[0.046 + 1.156 \times \ln(\rho) + 1.123 \times \ln(D) + 0.436 \times (\log(D))^2 + 0.045 \times (\ln(D))^3\right] \quad (3)$$

All three equations were applied to the dataset. Equation 2 generally provided a conservative estimate, equation 3 a generous estimate, while the Chave et al. (2014) equation lay between the other two estimates. Since Fayolle et al. (2018) acknowledged that the Chave et al. (2014) equation provided reasonable estimates of AGB at moist sites, it was selected for reporting in the current study. Furthermore, it allows comparisons with other studies using this commonly used equation.

Biomass was calculated for each woody individual in a plot and the sum obtained for the plot. Biomass values per association were derived from the mean value of all plots in an association. Values for wood density were derived from the African wood density database (Carsan et al., 2012), global wood density database (Zanne et al., 2009); PROTA database (Prota4U; http://www.prota4u.org/) and Brown (1997).

Belowground biomass: The belowground biomass (BGB) was derived by using root-to-shoot ratios (Eggleston et al., 2006). For tropical moist forest with AGB <125 Mg ha^{-1} a root-to-shoot ratio of 0.205 is recommended and a ratio of 0.235 if AGB is ≥125 Mg ha^{-1} (Mokany et al., 2006; Nasi et al., 2009; Ekoungoulou et al., 2014).

Standing dead trees: Standing dead trees typically consisted of the trunk only. For standing dead trees equation 4 below was applied to derive a tree biomass estimate (Brown et al., 1989).

$$Y = EXP(-3.3012 + 0.9439 * \ln(D^2 * H)) \quad (4)$$

where Y equals AGB (kg), D = DBH (cm) and H equals stem height (m). This value was converted to a 'trunk only' biomass by dividing by a biomass expansion factor (BEF). A BEF value of 2.039 was used, being the mean value quoted by Brown et al. (1989) for dry to moist transition in the tropics. In cases where only stumps from previously harvested trees remained, the stump's volume was calculated as a cylinder. The volume value was converted to biomass using a mean wood density for species from tropical Africa (Fayolle et al., 2018). BGB was not calculated for standing dead trees.

Coarse woody debris (including lying dead wood): To obtain lying dead wood dry mass, the log volume was calculated as a cylinder. This volume value was converted to dry mass using a mean wood density for species from tropical Africa (Fayolle et al., 2018).

Conversion of dry mass to carbon: An overall value of 50% carbon was used in this study for the aboveground, belowground, litter and debris carbon pools (Gifford, 2000).

Carbon map: The vegetation map (Van Rooyen et al., 2019), indicating the spatial distribution of the associations described, was used as base map and converted to a carbon map using a carbon class approach. Six carbon classes were distinguished to span the range of mean AGC per plant association. Each association was allocated to the class in which its mean AGC fell. The vegetation map was then visualised depicting carbon classes instead of plant associations.

2.2.2 Importance Value Index (IVI)

The importance Value Index (IVI) of a species was calculated as:

$$IVI = \frac{\text{Relative \% frequency} + \text{Relative \% density} + \text{Relative \% dominance}}{3}$$

where:

$$\text{Relative \% frequency} = \frac{\text{Number of units where species occurred}}{\text{Total number of units}} \times 100$$

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

$$\text{Relative \% dominance} = \frac{\text{Relative \% canopy diameter} + \text{Relative \% tree height} + \text{relative\% DBH}}{3}$$

and where:

Relative % canopy diameter = Total canopy diameter of a species X 100

Total canopy diameter of all species

Relative % tree height	=	$\frac{\text{Total tree height of a species}}{\text{Total tree height of all species}}$ X 100
Relative % DBH	=	$\frac{\text{Total DBH of a species}}{\text{Total DBH of all species}}$ X 100

2.2.3 Plant diversity

Species richness (S), Shannon-Wiener (H') (H´= $-\sum_i \frac{n_i}{n}\ ln\frac{n_i}{n}$) where n is number of individuals, exponent of Shannon-Wiener, evenness (E) (calculated as H' divided by the logarithm of the number of taxa (S)), and Fisher's alpha (a) (S = a *ln*(1+n/a) were computed (consult Hayek & Buzas, 2010 for details and parameter description and Van Rooyen et al. (2016) for comparable use of these indices) for the *tree inventory* per plot and a mean per association calculated. Species richness, evenness and H' were computed with PC-ORD (McCune & Mefford, 2011) and Fischer's alpha by means of PAST (version 3.02; Hammer 2014 https://is.muni.cz/el/1431/podzim2015/Bi5980/um/PAST_3_manual.pdf). For plots where the *full floristic inventory*, i.e. including shrubs, lianas, epiphytes and herbs, was available, the same diversity indices were calculated for the full inventory list.

2.2.4 Statistical analysis

To determine statistically significant differences between mean AGC values of associations, a nonparametric Kruskal-Wallis one-way analysis of variance, at a 5% level of significance, was performed in Graphpad Prism (San Diego, CA, USA; http://www.graphpad.com).

2.2.5 Taxonomy

Taxonomy follows that used by Centre d'Etude sur les Ressources Végétales, Herbier National du Congo, Brazzaville, Republic of Congo.

3. Results

3.1 Carbon storage

In total 4886 living trees, 186 standing dead trees and 219 lying dead logs were measured in 190 plots, whereby 41 plant families and 211 species were recorded with 96.7% of individuals identified to species level, another 2.0% to genus level and 1.3% unidentified. Three families (Fabaceae, Burseraceae and Phyllanthaceae) contributed to >50% of overall AGC and five families collectively constituted 55% of individuals measured (Fabaceae, Burseraceae, Myristicaceae, Euphorbiaceae and Phyllanthaceae) (Table S2). The three species containing most carbon were *Aucoumea klaineana, Uapaca guineensis* and *Coelocaryon preussii* (naming authorities given in Table S3), whereas the most numerous species were *Coelocaryon preussii, Uapaca guineensis* and *Plagiostyles africana*. The 20 most numerous species accounted for almost 60% of individuals measured (Table S4), while almost 25% of species were recorded only once. Although a good agreement existed between the 20 species with highest carbon and highest density values, some species, such as *Klainedoxa gabonensis* and *Engomegoma gordonii,* with few but large individuals, yielded a high carbon value. In the case of IVI, size (relative dominance value), density and frequency are incorporated into a single value to provide a good estimate of a species' contribution (Table 3).

AGC ranged from 13.93 Mg C ha^{-1} (A2) to 412.66 Mg C ha^{-1} (A10) and belowground carbon (BGC) from 2.86 Mg C ha^{-1} (A2) to 96.97 Mg C ha^{-1} (A10) across the nine associations evaluated (Table 1). AGC differed significantly among associations ($p < 0.0001$), with two groups being distinguished (Table 1). Dead wood ranged from 0.00 Mg C ha^{-1} (A4) to 7.59 Mg C ha^{-1} (A2). Mean DBH of the 4886 trees measured (≥15 cm) was 33.6 cm, ranging from 18.5 cm (A2) to 37.4 cm (A11) across associations (Table 2). Across all plots surveyed, mean basal area was 48.7 m^2 (range: 7.3 m^2 (A2) to 64.4 m^2 (A10)) and mean density of individuals was 407 ha^{-1} (range: 264 ind ha^{-1} (A2) to 492 ind ha^{-1} (A8)). The carbon map indicates that *ca*. 50% of the area was covered by the two highest carbon classes (Figure 1).

Mean association AGC was significantly correlated to density of individuals with ≥15 cm DBH ($p = 0.0190$, $r^2 = 0.5684$); density of individuals with ≥70 cm DBH ($p = 0.0001$, $r^2 = 0.8919$); basal area ($p < 0.0001$, $r^2 = 0.9437$); DBH ($p = 0.0013$, $r^2 = 0.7940$); tree height ($p = 0.0077$, $r^2 = 0.6614$); wood density ($p = 0.0072$, $r^2 = 0.6667$), but not to tree canopy diameter ($p = 0.1473$, $r^2 = 0.2749$).

3.2 Structure, floristics and carbon relationships per phytosociological association

The twelve associations identified in the phytosociological study ranged from highly disturbed and degraded to fairly intact forest. A wet to dry gradient was distinguished, with three associations ranging from permanently inundated to periodically inundated and five *terra firme* associations. Nine of the twelve associations were sampled for carbon content (Table 1). Association 1 (A1) represented anthropogenic vegetation of garden complexes. Most species found there were utilisable, with few small individuals of indigenous, pioneer species, but none with DBH ≥15 cm. A3, a highly degraded young secondary forest occurring primarily along roadsides could not be sampled for carbon because individuals were too small for inclusion. The wetland/*terra firme* transitional forest, A7, was unfortunately not surveyed for carbon stocks.

A2's degraded forests and fern glades represented early successional stages following forest clearing, characterised by pioneer species (*Musanga cecropioides, Anthocleista schweinfurthii* and *Harungana madagascariensis*). It had the lowest AGC (mean 13.93 Mg C ha^{-1}; minimum 9.99 Mg C ha^{-1}; maximum 17.88 Mg C ha^{-1}) of enumerated associations, but the highest dead wood carbon (Table 1). It also had the lowest mean tree density, stem diameter, tree height, wood density and basal area of all associations (Table 2). The size class distributions of stem diameter, tree height and wood density (Figures S3–S5) show a preponderance of smaller classes. On a mass basis the Urticaceae (34%) and Gentianaceae (25%) accounted for >50% of the association's carbon (Figure 2). The Urticaceae, primarily *Musanga cecropioides*, contributed to 42% of all individuals (Figure S6), followed by the Euphorbiaceae (14% of all individuals). The IVI ranked *Musanga cecropioides* (34%), *Anthocleista schweinfurthii* (13%) and *Harungana madagascariensis* (9%) as the three most important species (Table 3).

Associations 4 to 6 represented the wetland vegetation along a gradient from permanently inundated to periodically inundated. AGC progressively increased from A4 to A6, with a concomitant increase in the percentage of individuals with a DBH ≥70 cm and percentage contribution of these individuals to total AGC (Tables 1, 2). A4's permanently inundated swamp forests had the second lowest AGC (mean 64.08 Mg C ha^{-1}; minimum 12.57 Mg C ha^{-1}; maximum 120.03 Mg C ha^{-1}, Table 1) in the study area and most structural parameters were also second lowest (Table 2; Figures S3–S5). On a mass basis, the Apocynaceae (36%), Rubiaceae (20%) and Annonaceae (12%) made the largest contribution to the AGC pool (Figure 2). Species with the highest IVI were *Mitragyna stipulosa* (19%), *Voacanga thouarsii* (14%) and *Xylopia rubescens* (12%) (Table 3). A5 represented a mixture of swamp forests and riverine forests. Compared to A4, mean AGC (209.27 Mg C ha^{-1}; minimum 72.42 Mg C ha^{-1}; maximum 443.35 Mg C ha^{-1}, Table 1) was >3 times higher. Mean values for the structural parameters measured were also higher in A5 than A4 (Table 2; Figures S3–S5). On a mass basis, the Fabaceae made the largest contribution (28%) to the AGC pool, followed by the Anacardiaceae (14%) and Rubiaceae (11%) (Figure 2). Species wise, *Pseudospondias microcarpa* (14%), *Mitragyna stipulosa* (10%) and *Coelocaryon preusii* (9%) contained the most AGC (Figure S6). These three species also had the highest IVI scores (Table 3). A6's riverine and periodically inundated forest was associated with small river courses. Among the wetland associations, it had the highest AGC (mean 327.69 Mg C ha^{-1}; minimum 53.19 Mg C ha^{-1}; maximum 660.35 Mg C ha^{-1}) (Table 1) and also the highest mean values for structural parameters measured (Table 2; Figures S3–S5). The Phyllanthaceae contributed most to AGC (23%) and number of individuals (17%). Other families with high biomass values were Fabaceae (19%) and Myristicaceae (13%) (Figure 2). Species contributing most to AGC were *Uapaca guineensis* (23%), *Berlinia grandiflora* (10%) and *Coelocaryon preussii* (9%).

Associations 8 to 12 represented *terra firme* vegetation where in all cases, the Fabaceae and Burseraceae were among the top three families contributing most to AGC, with the Olacaceae, Phyllanthaceae and Euphorbiaceae prominent in some associations. Although differences occurred at species level as illustrated by IVI scores (Table 3), *Uapaca guineensis* and *Aucoumea klaineana* represented a large proportion of AGC in all *terra firme* associations.

A8 occurred on mid- and upper slopes in two distinct patches in the study area. It had the third highest value for AGC (mean 340.10 Mg C ha^{-1}; minimum 68.99 Mg C ha^{-1}; maximum 700.94 Mg C ha^{-1}) (Table 1), but the highest mean density of woody individuals of all associations (492 individuals ha^{-1}) (Table 2). A9's degraded *terra firme* forests occurred primarily on steep mid-slopes, on the iron-ore bearing formation in the study area's centre.

Compared to other *terra firme* forests it had the lowest AGC (mean 186.56 Mg C ha^{-1}; minimum 77.36 Mg C ha^{-1}; maximum 874.07 Mg C ha^{-1}), but the second highest value for dead wood carbon (Table 1) and the lowest mean values for most structural parameters measured, except for mean wood density (Table 2; Figures S3–S5). A10’s *terra firme* forests occupied mostly foot- to upper slopes in the study area’s southeast. It had the highest AGC of all associations (mean 412.66 Mg C ha^{-1}; minimum 63.43 Mg C ha^{-1}; maximum 916.05 Mg C ha^{-1}) (Table 1). A11 occurred predominantly on foot to upper slopes of iron-bearing hills and had the second highest value for AGC of all associations (mean 380.78 Mg C ha^{-1}; minimum 140.12 Mg C ha^{-1}; maximum 760.24 Mg C ha^{-1}) (Table 1). Mean values for stem diameter, tree height, canopy diameter and wood density were the highest of all associations (Table 2; Figures S3–S5). A12 occurred predominantly in the study area’s north. Because it was close to settlements a substantial tree logging disturbance was recorded at almost all sites surveyed. It had the second lowest value for AGC among *terra firme* associations (mean 232.57 Mg C ha^{-1}; minimum 59.17 Mg C ha^{-1}; maximum 627.46 Mg C ha^{-1}) (Table 1).

3.2 Plant diversity

Overall, diversity parameters for the tree component of the *terra firme* associations appeared higher than for wetland associations (Table 4a). If diversity of all growth forms (data from Van Rooyen et al. 2019) is considered, A9 stood out as most diverse. Considering only tree diversity, there was a weak, yet significant, relationship between AGC and species richness, Shannon-Wiener index of diversity and Fisher’s alpha (Table 4b). However, if the diversity of all growth forms is considered, none of the relationships between AGC and diversity parameters were significant (Table 4b).

4. Discussion

It should be kept in mind that plant associations identified through the phytosociological analysis (Van Rooyen et al., 2019) were distinguished on the basis of their total floristic composition and not only that of the tree component. In the case of the early successional vegetation (A2), permanently to periodically inundated and riverine vegetation (A4–A6) the floristic composition of the woody component of each association was quite distinct. However, the woody component among the *terra firme* associations (A8–A12) showed more similarities, with differences often due to human disturbance level. Katembo et al. (2020) found evidence of the existence of stable dominance states, induced by endogenous processes, such as biological positive feedbacks fostering monodominance in the Congo Basin. Apart from the successional vegetation, the intact wetland and *terra firme* associations in Mayoko are believed to represent such stable dominance states.

A large proportion of carbon stocks data in African forests is derived from studies estimating AGB in these forests. If a 50% carbon content is assumed, the mean AGC in 260 Congo Basin and contiguous forests is 215 Mg C ha^{-1} (Lewis et al., 2013) with a maximum value of 375 Mg C ha^{-1} reported for the Dja Biosphere Reserve in Cameroon. Swamp forest had a lower AGC at 161 Mg C ha^{-1} (Lewis et al., 2013). Additionally, AGC stock for intact old-growth forest in the central Congo Basin is significantly lower than stocks recorded for outer regions of the Basin, due to the lower forest stature in the central Congo Basin (Kearsley et al., 2013).

An initial look at carbon stocks in Congo basin forests (Nasi *et al.,* 2009) reported 216 Mg C ha^{-1} for closed evergreen forests, 85 Mg C ha^{-1} for swamp forest and 54 Mg C ha^{-1} for a mosaic forest-cropland dominated by *Musanga* and *Macaranga* spp. This value for closed evergreen forests agrees closely to the mean value provided by Lewis et al. (2013). A detailed analysis of carbon stocks for nine forest types in the Kom-Mengamé forest conservation complex, South Cameroon, reported the highest AGC for old secondary forest (246 Mg C ha^{-1}), followed by riparian forest (239 Mg C ha^{-1}) and then periodically flooded forest (182 Mg C ha^{-1}) (Fongnzossie et al., 2014). More recent studies in Cameroon reported higher AGC values for secondary forests (339 Mg C ha^{-1}) and old secondary forests (292 Mg C ha^{-1}) (Banoho et al., 2020). In an intact forest in Monts Birougou National Park, Gabon, 70 km distant from the current site, mean AGC was 146 Mg C ha^{-1} (Gautam and Pietsch, 2012). In RoC's Likouala Department, Bocko et al. (2017) reported a mean of 148 Mg C ha^{-1} for permanently inundated forest (range 117–248 Mg C ha^{-1}), 292 Mg C ha^{-1} for periodically inundated forest (range 270–315 Mg C ha^{-1}) and 295 Mg C ha^{-1} (range 198–352 Mg C ha^{-1}) for *terra firme* forests. In the same region, Ifo et al. (2018) compared AGB in two monodominant seasonally flooded forests with a *terra firme* forest and found no significant difference between the forest types (equivalent AGC *Guibourtia* dominated seasonally flooded forest = 194 Mg C ha^{-1}; *Lophira* dominated seasonally flooded forest = 203 Mg C ha^{-1}; *terra firme* forest = 207 Mg C ha^{-1}). Also in the same region, old growth forest AGB was significantly higher than that of a selectively logged forest (dry mass: 560 Mg DM ha^{-1} as opposed to 291 Mg DM ha^{-1}) (Ekoungoulou et al., 2018). In the Pool Department, mean values of 136 Mg C ha^{-1} and 174 Mg C ha^{-1} were reported for secondary forest and gallery forest respectively (Ekoungoulou et al., 2015).

Comparing AGC values from different sources should be done with circumspection, because the methods to collect and analyse the data are not uniform. Thus differences in plot size, number of plots, lower DBH limit for inclusion and allometric equations applied all come into play when making such comparisons. In the current study the DBH limit for inclusion was >15 cm, whereas most studies use ≥10 cm. A comparison of plots with and without the ≥10–15 cm cohort, indicated that this size class constituted 1–2.5% of the mean AGC in the three associations compared. Thus, values reported in this study represent a slight underestimate. Plot size in the current study was small (0.06 ha) which is known to result in a high coefficient of variation (Grusso et al. 2016), however a large number of plots were surveyed. Furthermore, Pinto et al. (2021) advocate sample sizes of 0.06 to 0.14 ha (lower limit agrees with current study) to sample carbon-diversity relationships in tropical vegetation.

Overall, estimated AGC values for fairly undisturbed (Van Rooyen et al., 2019) *terra firme* forest sites in Mayoko study area were higher than values reported for tropical forests in central Africa. The maximum AGC value recorded in a single plot in the current study was 916 Mg C ha^{-1}, which is approximately 3-fold higher than previous published values for Congo forests and close to the world's highest known AGC stock, 1,053 Mg C ha^{-1}, found in Australian temperate moist *Eucalyptus regnans* forests (Keith et al., 2009). Overall, carbon stocks for *terra firme* associations at Mayoko, except for A9 and A12, exceeded the mean AGC value reported for RoC's Likouala and Pool Department (Bocko et al., 2017, Ekoungoulou 2015, 2018) as well as at Monts Birougou National Park, Gabon (Gautam and Pietsch, 2012). Such high carbon values were associated with a high mean basal area (47.73 m^2) which was also higher than published values for tropical forests (Chave et al., 2003, Djuikouo et al., 2010, Feldpausch et al., 2011, Lewis et al., 2013).

In contrast, AGC in the early successional Association 2 was lower than reported for a mosaic forest-cropland dominated by *Musanga* and *Macaranga* spp. (Nasi et al., 2009). In the wetland cluster the size class distributions of stem diameter, tree height and wood density (Figures S2–S5) clearly show a progression from predominantly small, short trees with a low wood density to a larger proportion of individuals in the larger size, height or wood density classes. Mean AGC of A4, the true swamp forest, was lower than values reported by Bocko et al. (2017) for permanently inundated forest, however, mean AGC for A5 was comparable to values reported for similar forests (Djuikouo et al., 2010; Lewis et al., 2013 ; Fongnzossie et al., 2014; Ekoungoulou et al. 2015; Ifo et al., 2018) and mean AGC for A6 was comparable to periodically flooded forests by Bocko et al. (2017), although it exceeded those reported by Djuikouo et al. (2010), Lewis et al. (2013), Fongnzossie et al. (2014) and Ekoungoulou et al. (2015). In one of A5's subassociations, *Gilbertiodendron* spp. were dominant. AGC in this subassociation was 259.26 Mg C ha^{-1}, which is comparable to the value provided by Lewis et al. (2013, 257.5 Mg C ha^{-1}) for *Gilbertiodendron dewevrei* dominated forests, but slightly lower than 298 Mg C ha^{-1} quoted by Djuikouo et al. (2010) in Cameroon. Overall, the AGV in the wetland associations thus fell within the range of previously reported values.

Overall, *terra firme* forests had a higher aboveground carbon than swamp and periodically flooded forests, supporting findings of Djuikouo et al. (2010), Lewis et al. (2013), Fongnzossie et al. (2014) and Bocko et al. (2017). Among *terra firme* forests, A9 and A12, which showed signs of degradation from human activities had the lowest AGC. The highest carbon storage was found in Associations 10 and 11 where human disturbance was lowest.

Mean association AGC reported in the Mayoko study area was significantly correlated to basal area, density of individuals ≥70 cm DBH, tree height, wood density, DBH, density of individuals ≥15 cm DBH, but not to tree canopy diameter ($p = 0.1473$, $r^2 = 0.2749$). These significant relationships support the findings of (Poulsen et al. 2020).

The current study confirms the weak relationship between tree diversity and AGC at small spatial scales found in other studies (Chisholm et al., 2013; Poorter et al., 2015; Sullivan et al., 2017; Amara et al., 2019). However, if all plant growth forms are considered, not merely the trees, no relationship between carbon and plant diversity existed even at small spatial scales. This lack of relationship supports Tchouto et al. (2005) who contended that tree diversity was a poor indicator of overall biodiversity levels for central African rainforests as it did not provide details on the herbaceous, shrub and epiphytic layers, which, combined, harbour the majority of species diversity in such habitats (Lovett & Wasser, 2008; Corlett & Primack, 2011).

The fine-grained results derived through analysing woody species carbon content in the various plant associations defined for a study area could allow developers to prepare sensitive plans for infrastructure placement in areas of forest landscapes, thereby avoiding areas of high carbon content in order to reduce the impact on carbon release whenever possible. Such an approach would provide useful guidance tools to promote compliance with evolving standards of good practice (IFC, 2019; UNDP, 2021).

5. Conclusions

AGC stock values in the Mayoko study appear to be amongst the highest yet recorded for African rainforest. Furthermore, the current study is the first for central Africa to report carbon storage per plant association defined through phytosociological analysis. This approach highlights substantial differences between associations and the importance of being able to map such differences to limit deforestation in high carbon content sectors.

Considering only tree diversity, there was a weak, yet significant, relationship between AGC and several diversity parameters. However, if the diversity of all growth forms is considered, none of the relationships between AGC and diversity parameters were significant.

6. Data availability statement

The data supporting this study's findings are available on request from the corresponding author. Data are not publicly available due to privacy restrictions.

7. Acknowledgements

Gratitude is expressed to Professor Jean Marie Moutsamboté who provided assistance with identifications of specimens and to the "Institut de Recherche en Sciences Exactes et Naturelles" (IRSEN, also called GERDIB in 2012 and 2013) for providing experts and access to the reference plant collection of "Herbier National du Congo".

8. Conflict of interest statement

The authors agree with the manuscript. No conflict of interest is declared.

9. References

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Resources: Noel van Rooyen; Supervision, Alain Thomas and Jerome Y. Gaugris;
Validation: Ben Orban and Alain Thomas;
Visualisation: Karsten Drescher, Caroline Vasicek Gaugris and Jerome Y. Gaugris;
Writing – original draft: Margaretha W. van Rooyen, Noel van Rooyen and Jerome Y. Gaugris;
Writing – review & editing: Margaretha W. van Rooyen, Caroline Vasicek Gaugris and Jerome Y. Gaugris.

Funding:
This research is part of a multidisciplinary group of investigations requested and funded by the mining client operating in country in Republic of Congo between 2012 and 2014 in the context of an environmental and social impact assessment for a proposed Iron Ore mine. The project was abandoned by the client in 2015 and sold in 2016. Due to privacy clauses, the name of the client is kept as confidential. Name will be provided upon request made per email to the corresponding author.

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Table 1. Carbon (mean ± standard error) contained in three pools in the various plant associations at the Mayoko study site, Republic of Congo. Values within a column with different superscripts are significantly different ($p < 0.05$)

Association number and name	Number of plots	Carbon (Mg ha^{-1}) contained in:			% carbon in ind ≥70 cm DBH	Area (ha) covered by association
		Above-ground pool	Below-ground pool	Dead wood pool		
Early Successional Association						
A2: Anthocleista schweinfurthii – Musanga cecropioides Degraded Forest and Fern Glades	2	13.93^{a} ± 3.95	2.86^{a} ± 0.81	7.59± 0.62	00.0	4437
Wetland Associations						
A4: Dichaetanthera strigosa – Selaginella myosurus Degraded Forest and Swamp Forest	5	64.08^{a} ± 20.00	14.45^{a} ± 4.87	0.00	16.5	33782
A5: Berlinia bracteosa – Raphia vinifera Swamp or Riverine Forest	17	209.27^{a} ± 28.7	49.18^{a} ± 6.74	2.49± 0.76	22.6	4817
A6: Sterculia tragacantha – Agelaea paradoxa Riverine and Periodically Inundated Forest	19	327.69^{b} ± 41.28	77.01^{b} ± 9.70	1.77± 0.56	42.2	16596
***Terra firme* Associations**						
A8: Syzygium sp. – Pseudospondias longifolia Terra firme Forest	22	340.1^{b} ± 38.22	79.92^{b} ± 8.98	4.62± 1.18	31.9	12876
A9: Scaphopetalum zenkeri – Guaduella oblonga Terra firme Forest	33	186.56^{a} ± 25.08	43.84^{a} ± 5.89	2.40± 0.51	34.2	9323
A10: Greenwayodendron suaveolens – Alchornea floribunda Terra firme Forest	50	412.66^{b} ± 26.26	96.97^{b} ± 6.17	6.32± 1.31	49.0	44697
A11:Guarea cedrata – Celtis adolfi-friderici – Santiria trimera Terra firme Forest	16	380.78^{b} ± 52.71	89.48^{b} ±12.39	1.57± 0.52	36.9	28471
A12: Piptadeniastrum africanum – Uapaca guineensis – Aucoumea klaineana Terra firme Forest	26	232.56^{a} ± 25.92	54.65^{a} ±6.09	0.72± 0.42	26.7	21575

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Table 2. Mean (± standard error) wood density, basal area, diameter at breast height, maximum tree height, canopy diameter and density of individuals in the various plant associations at the Mayoko study site, Republic of Congo

Association number and name	**Wood density (g/cm^3)**	**Basal area (m^2)**	**DBH (cm)**	**Tree height (m)**	**Canopy diameter (m)**	**Density (ind ≥15 cm ha^{-1})**	**% ind ≥70 cm DBH**
A2: Anthocleista schweinfurthii – Musanga cecropioides Degraded Forest and Fern Glades	0.3739 ± 0.0224	7.3 ± 0.4	18.5 ± 0.9	14.0 ± 1.9	10.6 ± 1.2	264 ± 8.0	0.0
A4: Anthocleista vogelii – Acroceras zizanoides Swamp Forest	0.5027 ± 0.0456	17.5 ± 4.7	23.3 ± 1.3	16.8 ± 1.0	12.0 ± 1.1	333 ± 63	1.0
A5: Berlinia bracteosa – Raphia vinifera Swamp or Riverine Forest	0.5739 ± 0.0158	40.8 ± 5.3	32.3 ± 1.0	22.0 ± 1.1	16.8 ± 1.0	355 ± 39	4.2
A6: Sterculia tragacantha – Agelaea paradoxa Riverine and Periodically Inundated Forest	0.5688 ± 0.0113	53.6 ± 5.8	33.7 ± 1.6	24.4 ± 1.0	18.5 ± 0.9	435 ± 27	8.7
A8: Syzygium sp. – Pseudospondias longifolia Terra firme Forest	0.5583 ± 0.0208	56.6 ± 4.2	34.0 ± 0.9	25.4 ± 0.9	19.6 ± 0.8	492 ± 23	4.9
A9: Scaphopetalum zenkeri – Guaduella oblonga Terra firme Forest	0.6043 ± 0.0067	34.9 ± 3.4	26.2 ± 0.8	19.2 ± 0.7	14.7 ± 0.6	389 ± 12	3.6
A10: Greenwayodendron suaveolens – Alchornea floribunda Terra firme Forest	0.6230 ± 0.0056	64.4 ± 3.3	32.4 ± 2.7	23.8 ± 0.5	197.9 ± 0.1	461 ± 15	9.2
A11:Guarea cedrata – Celtis adolfi-friderici – Santiria trimera Terra firme Forest	0.6310 ± 0.0086	48.7 ± 5.1	37.4 ± 1.4	30.1 ± 1.0	25.0 ± 1.0	350 ± 22	9.4
A12: Piptadeniastrum africanum – Uapaca guineensis – Aucoumea klaineana Terra firme Forest	0.5675 ± 0.0088	37.3 ± 4.0	33.9 ± 1.2	29.0 ± 0.9	23.8 ± 0.9	322 ± 11	4.4

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Table 3. Ten species with highest importance value scores in each association at the Mayoko study site, Republic of Congo

Species	Associations								
	Early successional	Wetland associations			*Terra firme* associations				
	2	**4**	**5**	**6**	**8**	**9**	**10**	**11**	**12**
Anthocleista schweinfurthii	12.9								
Canarium schweinfurthii	4.4								
Carapa procera var. *procera*	6.4								
Tetrorchidium didymostemon	4.1								
Macaranga monandra	4.1								
Macaranga spinosa	4.3								
Monosis conferta	4.1								
Harungana madagascariensis	9.4								
Alstonia congensis		7.7							
Anthocleista vogelii		3.8							
Dichaetanthera strigosa		5.6							
Gardenia imperialis		4.5							
Voacanga thouarsii		13.8							
Xylopia rubescens		11.5							
Anthonotha macrophylla			4.7						
Gilbertiodendron dewevrei			3.6						
Symphonia globulifera			3.6						
Pseudospondias microcarpa			8.3						
Homalium africanum		6.8	4.4						
Sarcocephalus pobeguinii				3.1					
Strombosia grandifolia				2.8		3.0			
Sterculia tragacantha			5.3	3.5					
Berlinia grandiflora			4.0	4.0					
Mitragyna stipulosa		18.8	6.3	7.6					
Syzygium sp.					3.4				
Shirakiopsis elliptica					2.4				
Dichostemma glaucescens	6.2				3.7				
Musanga cecropioides	33.9				5.5				
Pentaclethra macrophylla						2.4			3.0
Allanblackia floribunda							2.8		
Pentaclethra eetveldeana							3.2		
Greenwayodendron suaveolens							2.6	4.4	
Dacryodes pubescens								3.2	
Strombosiopsis sp.								3.2	
Piptadeniastrum africanum									3.7
Celtis adolfi-friderici								5.5	4.3
Plagiostyles africana					6.5	7.1	7.2	7.1	5.9
Heisteria parvifolia					2.9	4.1	5.0	3.8	
Petersianthus macrocarpus						5.1	2.9		3.2
Santiria trimera				2.6	6.9	3.3	4.3	6.4	3.4
Coelocaryon preussii			9.5	10.2	6.0	6.3	6.6	7.9	8.2
Aucoumea klaineana	6.3	7.9		3.4	5.7	7.7	5.8	4.4	15.6
Uapaca guineensis		5.7	5.9	14.1	5.9	4.7	4.9		12.2
Pycnanthus angolensis	4.1			3.3		2.5		3.1	4.4

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Table 4. a. Diversity parameters for the associations in the Mayoko study site, Republic of Congo; and b. equations for a linear correlation between aboveground carbon and diversity, R^2-value and significance

(a)

	Associations								
	2	**4**	**5**	**6**	**8**	**9**	**10**	**11**	**12**
Tree diversity									
Richness	7.0	5.8	9.7	13.2	15.9	14.5	16.0	14.8	11.3
Shannon-Wiener	1.62	1.29	1.97	2.22	2.39	2.50	2.53	2.50	2.20
Exponent Shannon-Wiener	5.05	3.63	7.03	9.21	10.91	12.18	12.43	12.18	9.03
Fisher's alpha	4.60	2.74	6.78	11.31	15.40	19.13	18.27	24.86	12.46
Evenness	0.76	0.79	0.79	0.74	0.75	0.86	0.83	0.87	0.82
Diversity of all growth forms									
Richness	14.0	25.4	33.8	40.5	32.7	53.2	40.0		
Shannon-Wiener	1.45	2.56	2.65	2.87	2.51	3.43	2.95		
Exponent	4.26	15.80	10.28	17.12	12.43	30.57	17.64		
Fisher's alpha	4.60	6.61	10.24	16.49	10.33	23.32	19.20		
Evenness	0.55	0.81	0.76	0.78	0.72	0.87	0.80		

(b)

	Equation	***R²***	***p***
Tree diversity			
Richness	y = 23.51x - 27.634	0.29831	<0.0001
Shannon-Wiener	y = 191.84x - 153.09	0.20966	<0.0001
Evenness	y = -24.849x + 315.59	0.00015	0.8658
Fisher's alpha	y = 2.9414x + 249.48	0.02808	0.0205
Diversity of all growth forms			
Richness	y = 0.3625x + 287.61	0.0005	0.7932
Shannon-Wiener	y = 0.098x + 302.19	5.7E-08	0.9970
Evenness	y = -142.74x + 416.53	0.0033	0.4927
Fisher's alpha	y = 2.9656x + 251.46	0.0180	0.1102

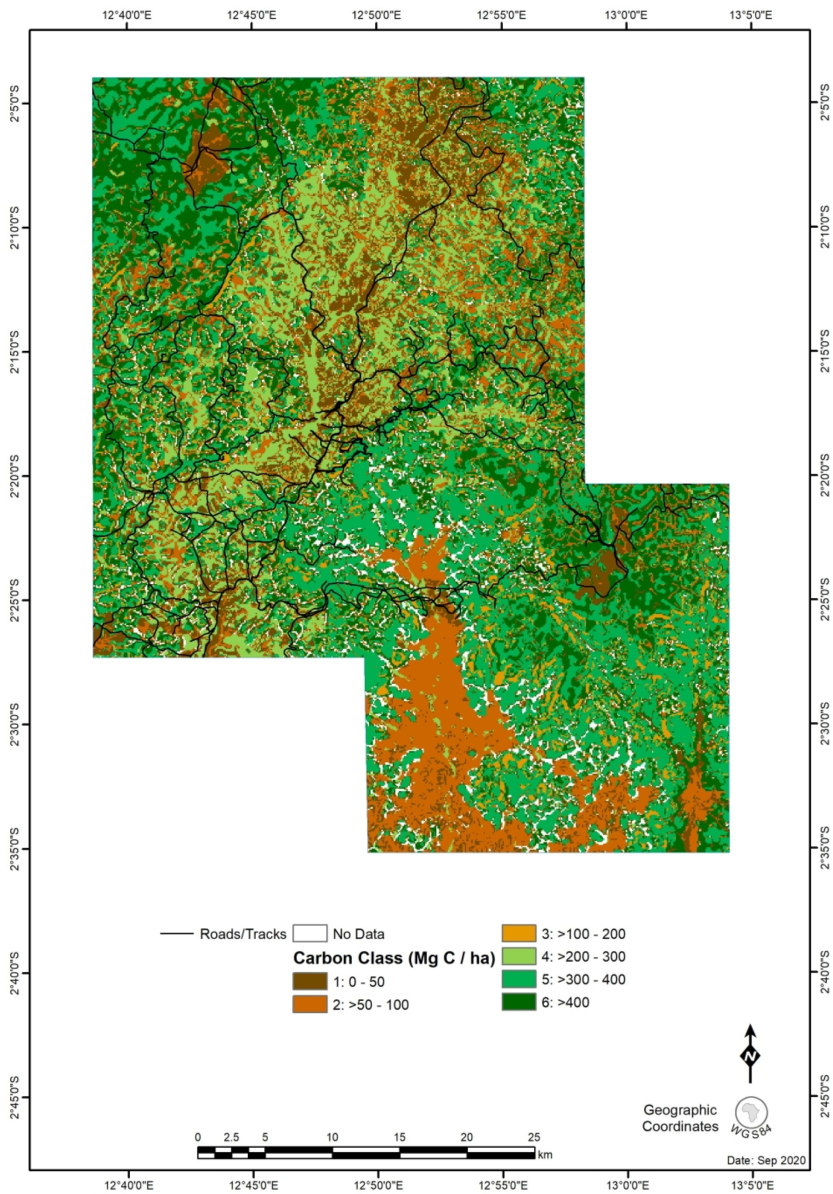

Figure 1: Carbon map for the Mayoko study area in the Republic of Congo.

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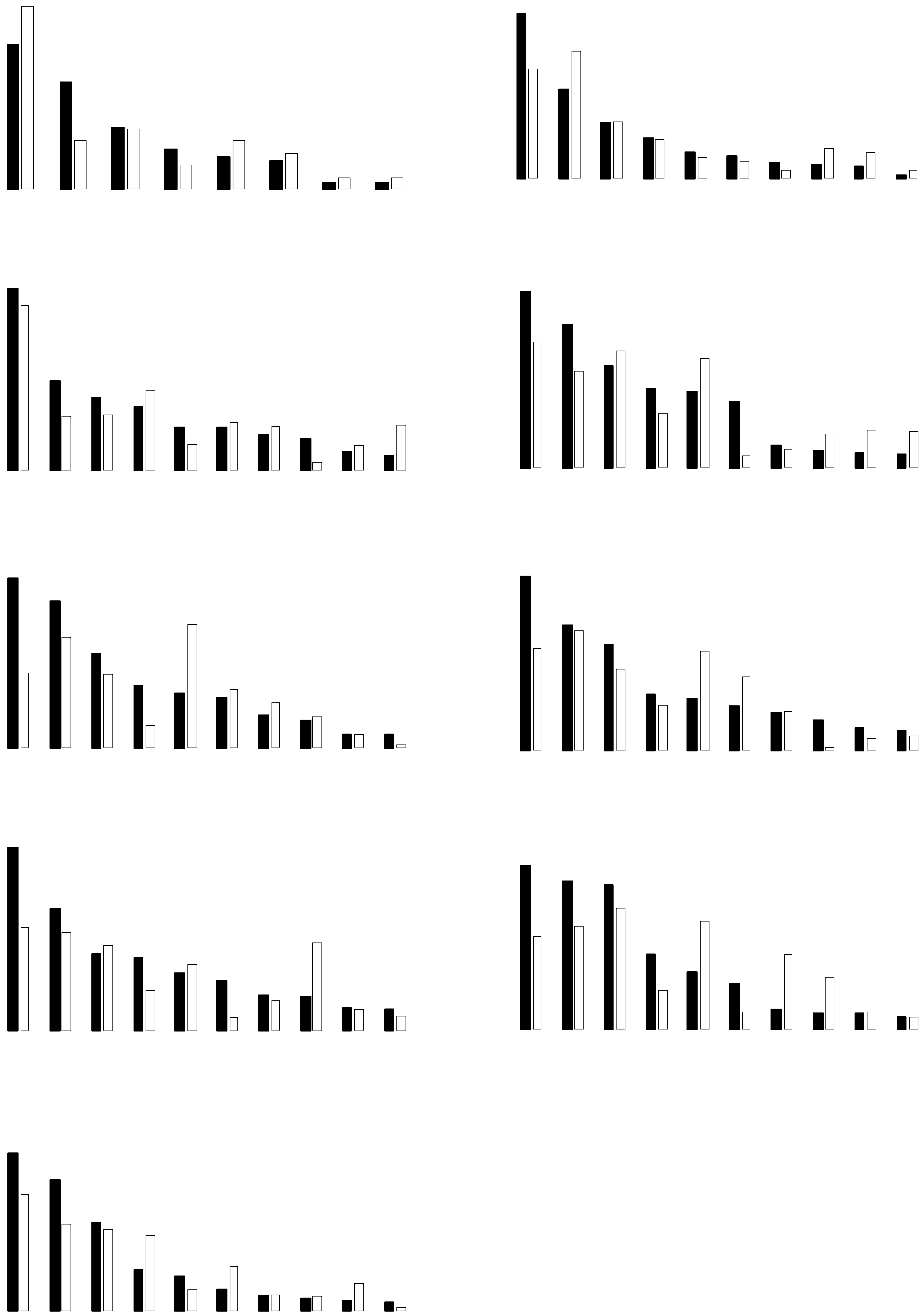


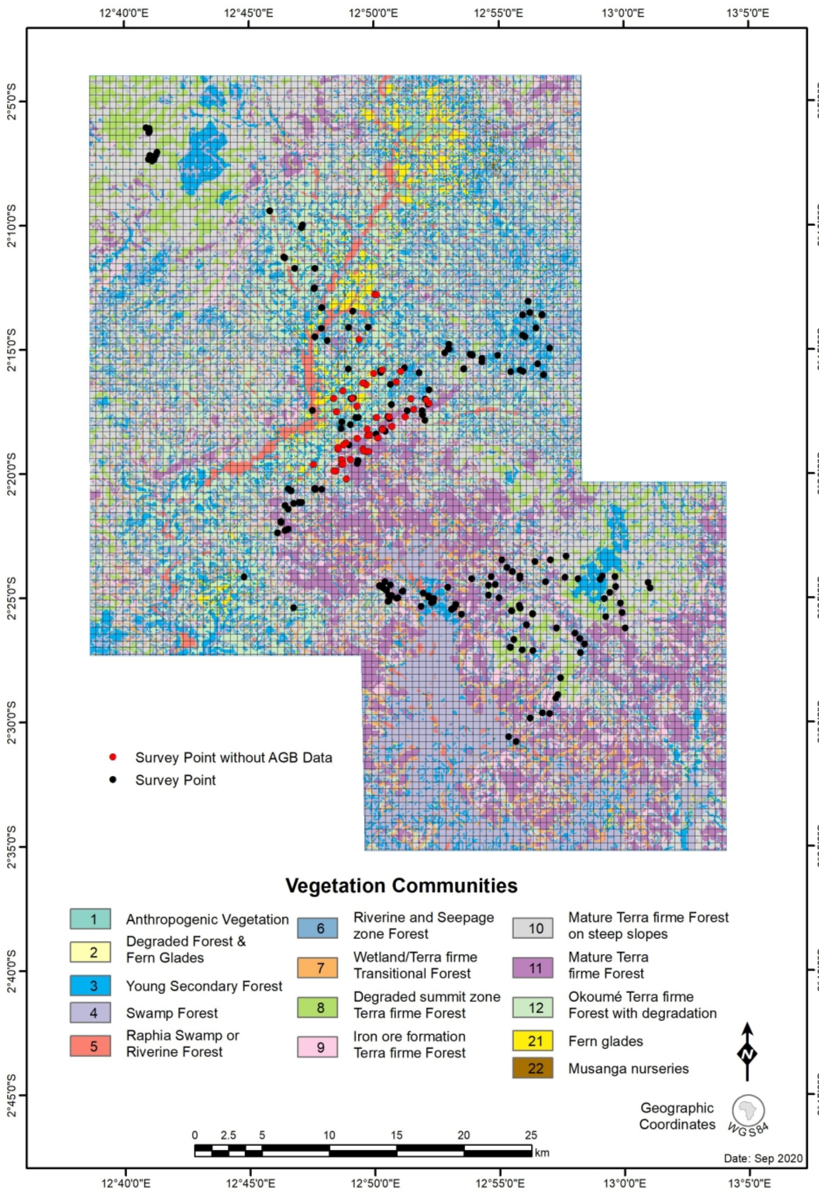
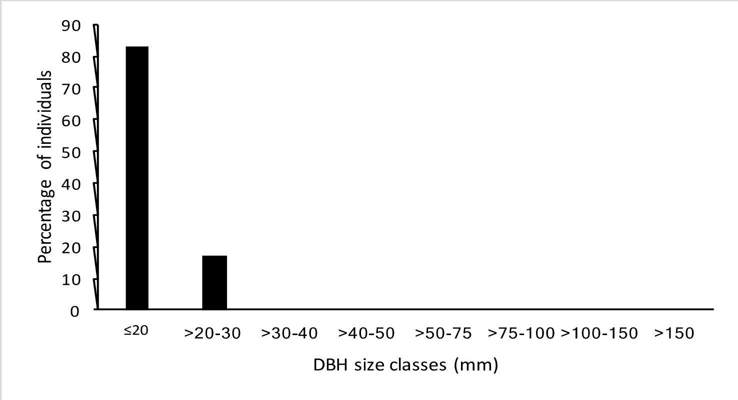


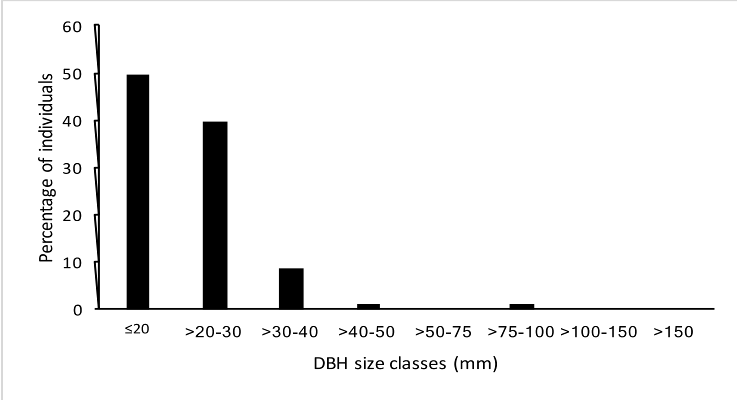
Figure S2: Location of plots and survey sites in the Mayoko study area in the Republic of Congo, showing plots with carbon measurements and plots without (survey points without AGB Data) as situated within the sampling grid used (0.25 km² grid-cells).

656x928mm (96 x 96 DPI)

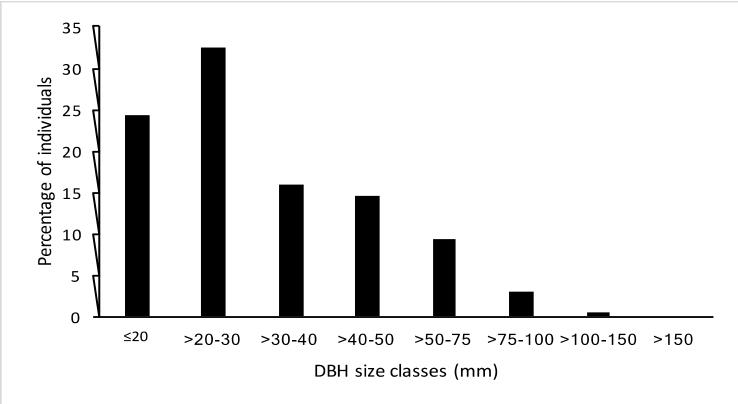
Association 2



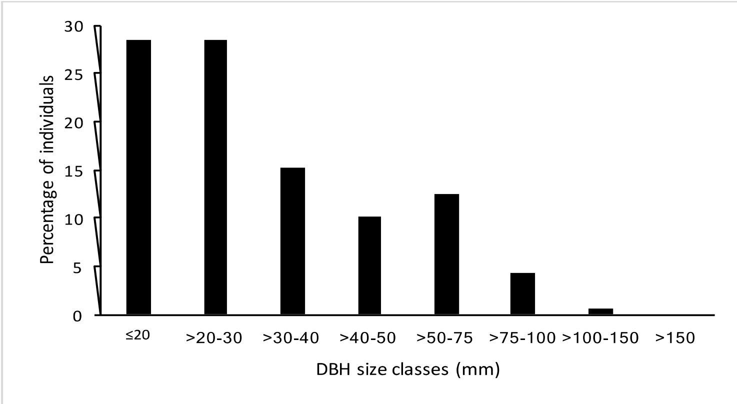
Association 4



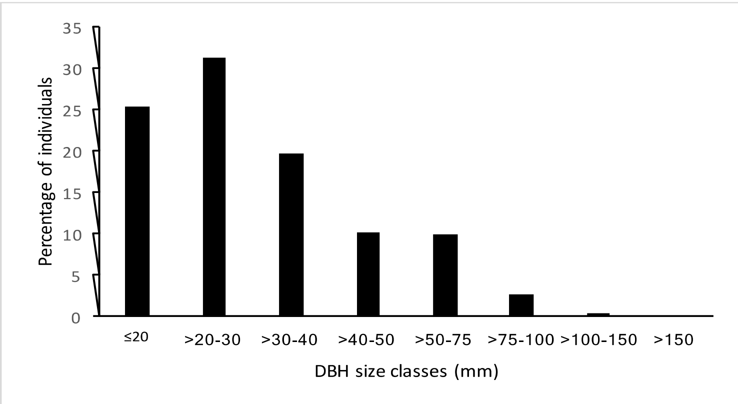
Association 5



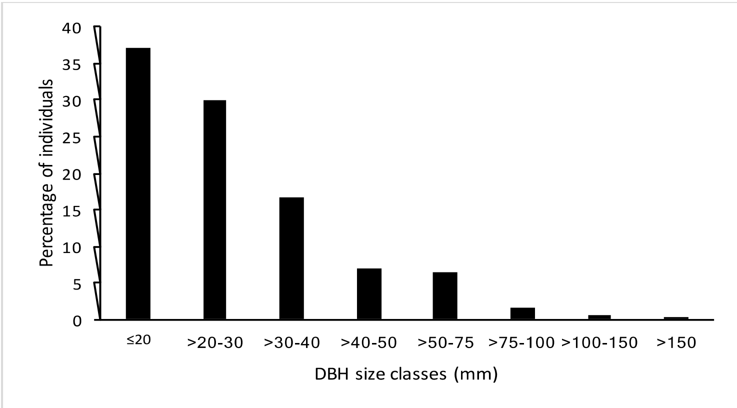
Association 6



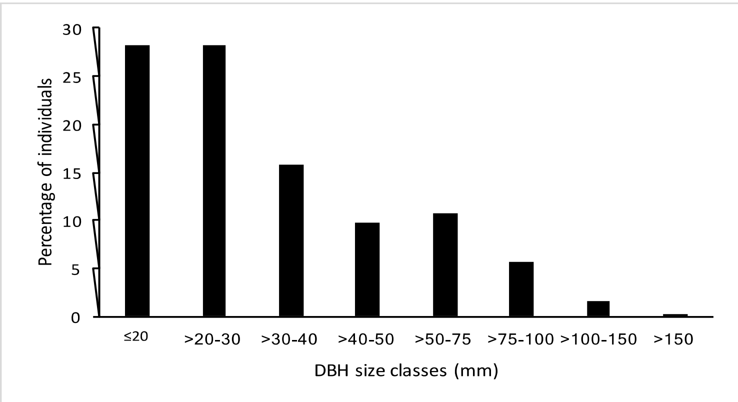
Association 8



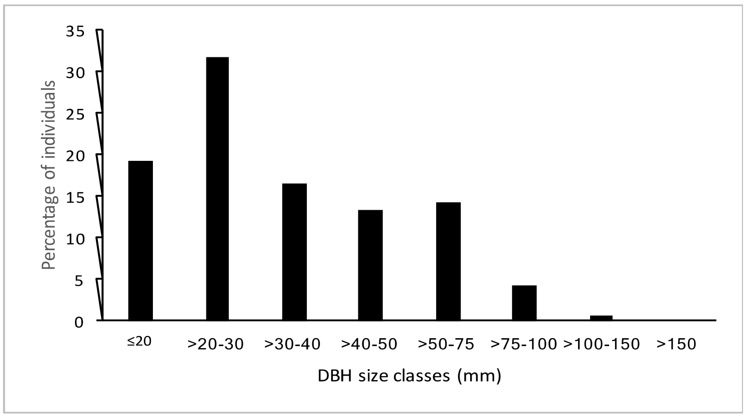
Association 9



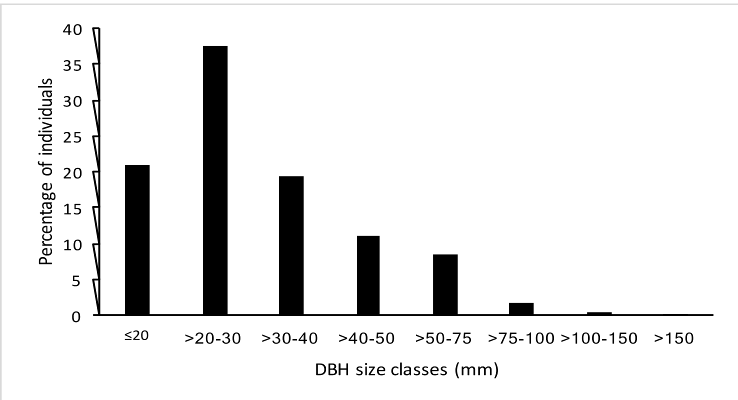
Association 10



Association 11

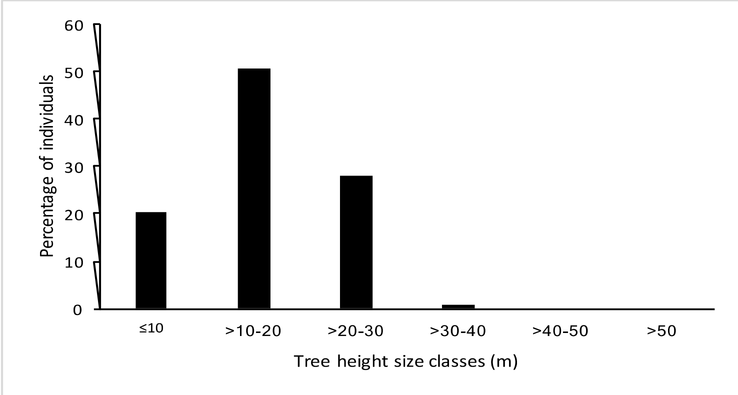


Association 12

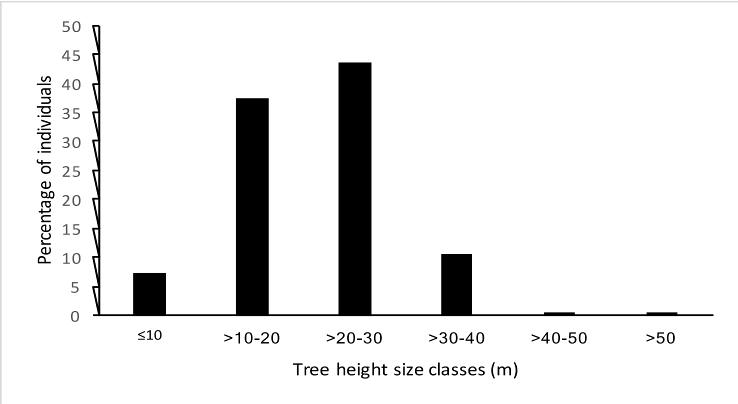


Association 2

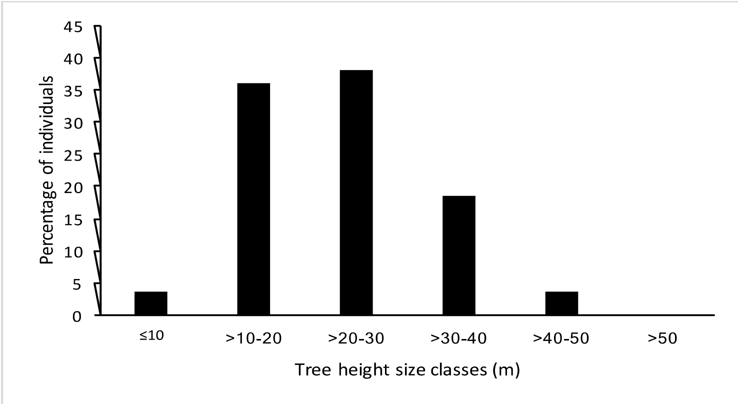
Association 4



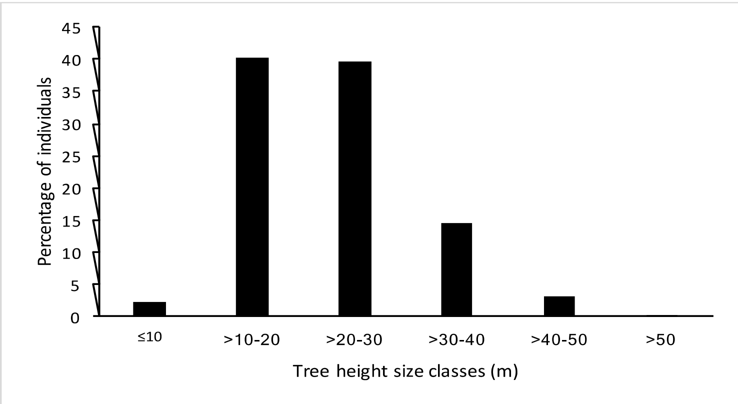
Association 5



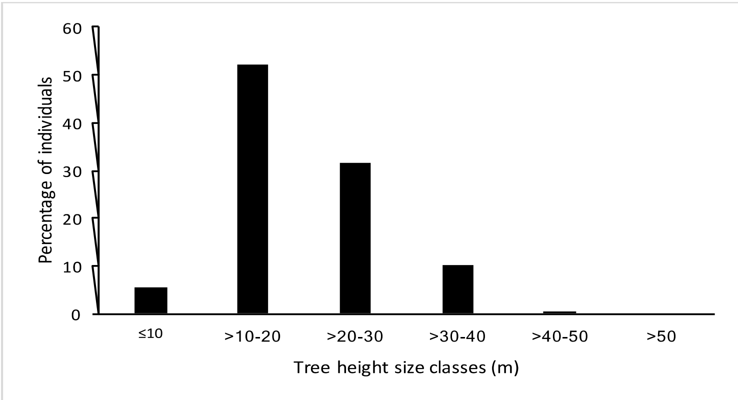
Association 6



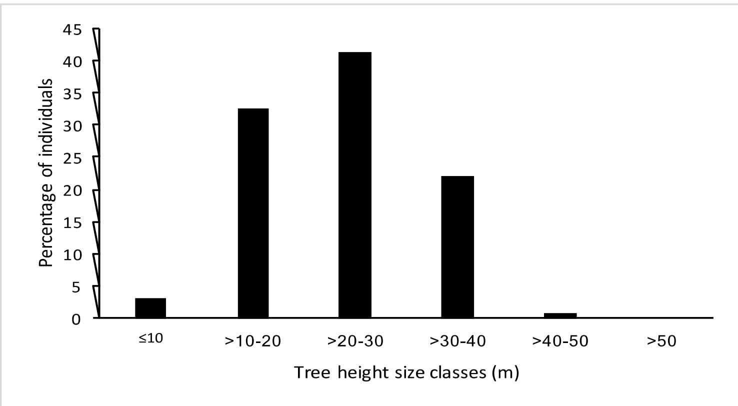
Association 8



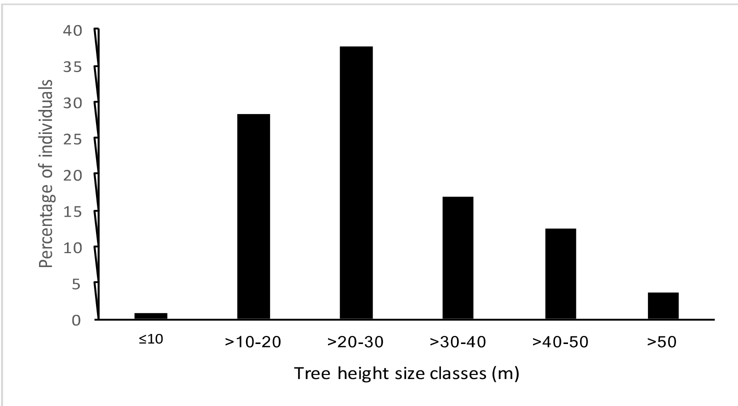
Association 9



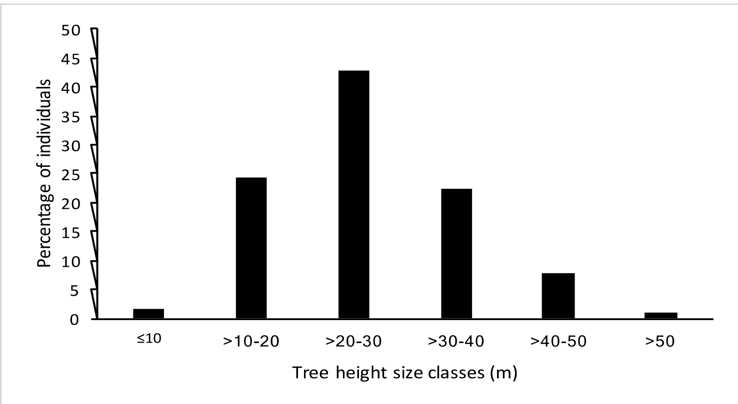
Association 10



Association 11



Association 12



Association 2

Association 4

Association 5

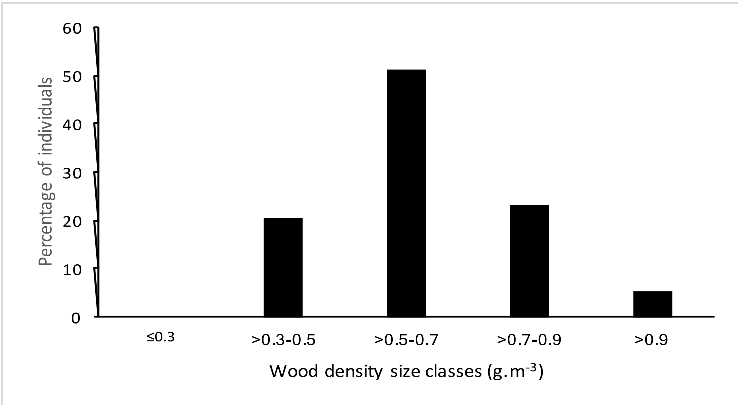
Association 6

Association 8

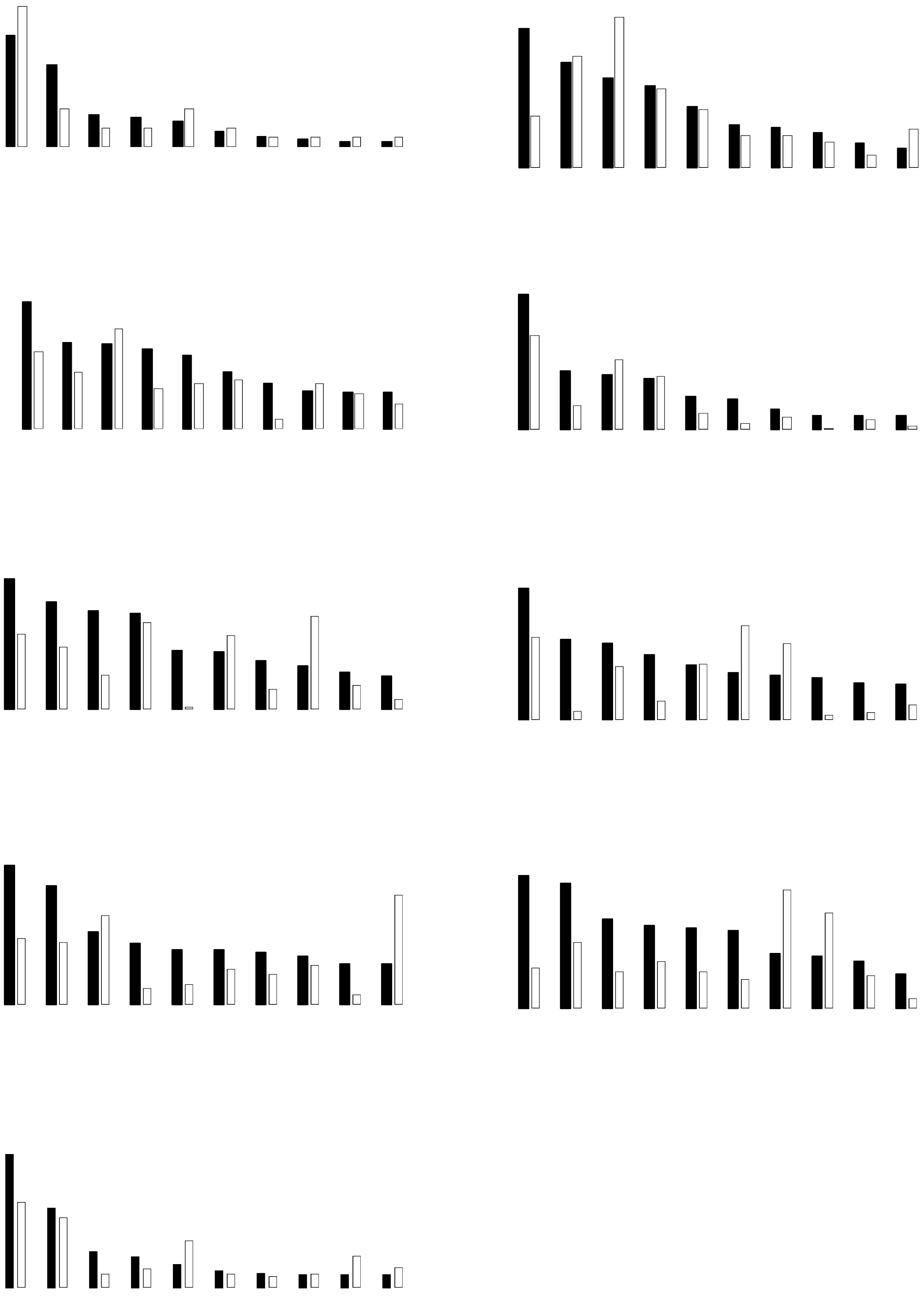
Association 9

Association 10

Association 11



Association 12



Supplementary Text Material 1

Title: Carbon of Chaillu Forests based on a phytosociological analysis in Republic of Congo, more than meets the eye?

Margaretha W. van Rooyen[1,2], Edmond S. Miabangana[1,4], Gilbert Nsongola[1,4], Noel van Rooyen[1,3], Ben Orban[1], Alain Thomas[1], Karsten Drescher[1], Caroline Vasicek Gaugris[1,5], Jérôme Y. Gaugris[1,5]*

Characterization of associations

Cluster 1: Human impacted vegetation and young secondary forests

A1. *Nephrolepis biserrata* – *Elaeis guineensis* Anthropogenic Vegetation
A2. *Anthocleista schweinfurthii* – *Musanga cecropioides* Degraded Forest and Fern Glades
A3. *Dinophora spenneroides* – *Selaginella myosurus* – *Scleria secans* Young Secondary Forest

Cluster 2: Wetland associations

A4. *Anthocleista vogelii* – *Acroceras zizanoides* Swamp Forest
A5. *Berlinia bracteosa* – *Raphia vinifera* Swamp or Riverine Forest
A6. *Sterculia tragacantha* – *Agelaea paradoxa* Riverine and Temporary Inundated Forest
A7. *Lonchitis currori* – *Ctenitis protensa* Wetland/*Terra firme* Transitional Forest

Cluster 3: *Terra firme* associations

A8. *Syzygium staudtii* – *Pseudospondias longifolia* degraded *Terra firme* Forest
A9. *Scaphopetalum zenkeri* – *Guaduella oblonga Terra firme* Forest on the iron formation
A10. *Greenwayodendron suaveolens* – *Alchornea floribunda* Mature *Terra firme* Forest on steep slopes
A11. *Guarea cedrata* – *Celtis adolfi-friderici* – *Santiria trimera* Mature *Terra firme* Forest
A12. *Uapaca guineensis* – *Aucoumea klaineana Terra firme* Forest with degradation

Brief summary of habitat and floristics of associations

A1. *Nephrolepis biserrata* – *Elaeis guineensis* Anthropogenic Vegetation

A1 and A2 represented a highly transformed anthropogenic zone within the moist tropical forest composed of heavily degraded forests; secondary regrowth forests; fern glades; old and new cropland and gardens.
Nature: Village garden vegetation
Edible (utilized) species: *Mangifera indica, Musa paradisiaca, Ananas comosus, Dacryodes edulis, Persea americana, Elaeis guineensis*
Tree layer: Poorly developed – *Heisteria parvifolia, Sterculia tragacantha, Trichilia monadelpha, Coelocaryon preussii*
Herbaceous layer: *Nephrolepis biserrata* (fern) dominant

A2. *Anthocleista schweinfurthii* – *Musanga cecropioides* Degraded Forest and Fern Glades

Nature: Degraded forests and fern glades associated with agriculture and settlements
Habitat: Plains, occasionally footslopes; mean altitude of 660 m above sea level (a.s.l.); terrain generally flat or gently sloping northwesterly or southwesterly; soil occasionally waterlogged, but rarely swampy
Diagnostic species: *Anthocleista schweinfurthii* (tall tree), *Vernonia conferta* (shrub), *Pteridium aquilinum* (fern)
Tree layer: ≥25 m layer: poorly developed – *Pentaclethra macrophylla, Albizia zygia, Musanga cecropioides, Anthocleista schweinfurthii;* <25 m layer – pioneer species dominant – *Harungana madagascariensis, Albizia adianthifolia, Hymenocardia ulmoides*
Shrub & scandent shrub layer: *Vernonia conferta, Alchornea cordifolia, Lantana camara* (alien), *Chromolaena odorata* (alien)
Herbaceous layer: *Pteridium aquilinum* (fern) dominant; *Aframomum alboviolaceum*, *Ipomoea mauritiana, Costus afer*; grass layer – poorly developed – *Megastachya mucronata*.

A3. *Dinophora spenneroides* – *Selaginella myosurus* – *Scleria secans* Young Secondary Forest

Nature: Young secondary regrowth
Habitat: Along roads and tracks cutting through forest and clear-cut sites
Diagnostic species: *Scleria secans* (sedge), *Clappertonia polyandra* (shrub) and *Setaria sphacelata* (grass)
Tree layer: ≥25 m layer: poorly developed; <25 m layer – pioneer species dominant – *Musanga cecropioides, Harungana madagascariensis, Macaranga* spp., *Xylopia aethiopica*
Shrub & scandent shrub layer: *Dinophora spenneroides, Oncoba glauca, Clappertonia polyandra*
Herbaceous layer: Well-developed – *Selaginella myosurus* (fern), *Lycopodiella cernua* (fern) *Scleria secans* (sedge); grasses – *Setaria sphacelata , Panicum parvifolium, Guaduella oblonga*

A4. *Anthocleista vogelii* – *Acroceras zizanoides* Swamp Forest

Nature: True swamp forest with inundated conditions
Habitat: Terrain generally flat or with slight slope in northwesterly direction; mean altitude 684 m a.s.l.
Diagnostic species: *Anthocleista vogelii* (tall tree), *Acroceras zizanoides* (grass), *Scleria racemosa* (sedge), *Ludwigia abyssinica* (herb)
Tree layer: ≥25 m layer: – *Alstonia boonei, Aucoumea klaineana, Symphonia globulifera*; <25 m layer – *Dichaetanthera strigosa, Harungana madagascariensis, Anthocleista vogelii, Xylopia aethiopica*
Shrub & scandent shrub layer: *Dinophora spenneroides, Gardenia imperialis, Alchornea cordifolia, Alchornea floribunda, Cryptolepis oblongifolia*
Palms: *Raphia vinifera* (d), *Elaeis guineensis* (d), *Eremospatha haullevilleana, Eremospatha wendlandiana, Laccosperma secundiflorum*
Herbaceous layer: ferns prominent – *Selaginella myosurus , Lycopodiella cernua, Azolla pinnata, Christella dentata, Lygodium microphyllum, Nephrolepis biserrata*; graminoids – *Leersia hexandra, Panicum brevifolium, Acroceras zizanoides, Panicum parvifolium, Rhynchospora corymbosa, Cyperus pectinatus, Scleria boivinii, Scleria racemosa, Fuirena umbellata*; forbs – *Aframomum citratum, Costus afer, Halopegia azurea Ceratophyllum demersum, Nymphaea nouchali, Ludwigia adscendens*

A5. *Berlinia bracteosa* – *Raphia vinifera* Swamp or Riverine Forest

Nature: Swamp or riverine forest
Habitat: Low-lying areas; poor drainage conditions; soil usually waterlogged for most of the year; terrain generally flat; mean altitude 594 m a.s.l.
Diagnostic species: *Berlinia bracteosa* (tall tree), *Millettia griffoniana* (tree)
Tree layer: ≥25 m layer: well developed – *Gilbertiodendron dewevrei, Gilbertiodendron ogoouense, Berlinia bracteosa, Mitragyna stipulosa, Symphonia globulifera, Pseudospondias microcarpa, Coelocaryon preussii, Uapaca guineensis*; <25 m layer – *Sterculia tragacantha, Homalium africanum, Macaranga schweinfurthii, Xylopia rubescens, Carapa procera*
Shrub & scandent shrub layer: *Millettia griffoniana, Argocoffeopsis eketensis, Leea guineensis, Alchornea floribunda, Combretum racemosum*
Palms: *Raphia vinifera, Eremospatha wendlandiana , Laccosperma laeve*
Herbaceous layer: Ferns – *Christella dentata, Microsorum punctatum*; grass layer – poorly developed – *Leptaspis zeylanica, Mapania heteromorpha*; forbs – *Acanthus* sp., *Halopegia azurea*.

A6. *Sterculia tragacantha* – *Agelaea paradoxa* Riverine and Temporary Inundated Forest

Nature: Riverine or temporary inundated forest
Habitat: Associated with small river courses and temporarily inundated sites/seepage zones; terrain flat or gently sloping, mostly northeasterly; mean altitude 628 m a.s.l.
Diagnostic species: None
Tree layer: ≥25 m layer: – *Greenwayodendron suaveolens, Mitragyna stipulosa, Aucoumea klaineana, Pentaclethra macrophylla, Pycnanthus angolensis, Symphonia globulifera, Uapaca guineensis;* <25 m layer – *Sterculia tragacantha, Tabernaemontana crassa*
Shrub & scandent shrub layer: *Alchornea floribunda, Agelaea paradoxa, Agelaea pentagyna, Rourea obliquifoliolata*

Palms: *Eremospatha macrocarpa, Eremospatha wendlandiana, Laccosperma leave, Laccosperma secundiflorum*
Herbaceous layer: Ferns – *Cyathea manniana, Selaginella myosurus, Nephrolepis bisserata*; grasses – *Guaduella oblonga, Leptaspis zeylanica*; forbs – *Begonia elatostemma, Begonia ampla, Marantochloa congensis, Marantochloa conferta, Trachyphrynium braunianum, Palisota ambigua, Geophila afzelii*

A7. *Lonchitis currori* – *Ctenitis protensa* Wetland/*Terra firme* Transitional Forest

Nature: Wetland/*terra firme* transitional forest
Habitat: terrain predominantly flat; soil generally well drained, except for swampy sites in one subassociation; signs of logging prominent
Diagnostic species: *Lonchitis currori* (fern), *Ctenitis protensa* (fern), *Agelaea poggeana* (liana), *Eremospatha korthalsiifolia* (palm), *Podococcus acaulis* (palm), *Corynanthe mayumbensis* (tree)
Tree layer: ≥25 m layer: – *Greenwayodendron suaveolens, Dacryodes pubescens, Dialium pachyphyllum, Hylodendron gabunense, Piptadeniastrum africanum, Uapaca guineensis*; <25 m layer – *Corynanthe mayumbensis, Aphanocalyx microphyllus, Tabernaemontana crassa, Trichoscypha acuminata, Plagiostyles africana, Santiria trimera, Treculia obovoidea*
Shrub & scandent shrub layer: *Scaphopetalum blackii, Alchornea floribunda, Olax gambecola, Alchornea hirtella, Microdesmis camerunensis, Manniophyton fulvum, Manotes expansa, Ancistrocarpus densispinosus*
Palms: *Podococcus acaulis, Eremospatha korthalsiifolia, Eremospatha wendlandiana, Laccosperma secundiflorum*
Herbaceous layer: Ferns – *Lonchitis currorii, Ctenitis protensa, Cyathea camerooniana, Marattia fraxinea*; graminoids – *Guaduella oblonga, Leptaspis zeylanica, Hypolytrum heteromorphum, Mapania mannii*; forbs – *Begonia microsperma, Palisota schweinfurthii, Trachyphrynium braunianum, Geophila afzelii, Agelaea pentagyna, Afrocalathea rhizantha, Impatiens irvingii, Costus afer, Halopegia azurea*

A8. *Syzygium staudtii* – *Pseudospondias longifolia* Degraded *Terra firme* Forest

Nature: Degraded *terra firme* forest
Habitat: Middle to upper slopes and rounded summits of undulating and gently sloping terrain
Diagnostic species: *Syzygium staudtii* (tree), *Pseudospondias longifolia* (tree), *Scorodophloeus zenkeri* (tree), *Funtumia africana, Aporrhiza* sp. (tree)
Tree layer: ≥25 m layer: – *Syzygium staudtii, Aucoumea klaineana, Distemonanthus benthamianus, Pentaclethra macrophylla, Uapaca guineensis*; <25 m layer – *Hymenocardia ulmoides, Maesobotrya* sp., *Strombosia grandifolia, Tabernaemontana crassa, Shirakiopsis elliptica, Dichostemma glaucescens, Heisteria parvifolia, Plagiostyles africana, Santiria trimera*
Shrub & scandent shrub layer: *Alchornea floribunda, Microdesmis camerunensis, Dalhousiea africana, Rourea obliquifoliolata*
Palms: *Raphia regalis, Eremospatha macrocarpa, Eremospatha wendlandiana, Sclerosperma mannii, Laccosperma secundiflorum*
Herbaceous layer: Grasses – *Leptaspis zeylanica, Guaduella oblonga*; forbs – *Agelaea pentagyna, Sarcophrynium schweinfurthianum Trachyphrynium braunianum, Marantochloa conferta, Palisota ambigua*

A9. *Scaphopetalum zenkeri* – *Guaduella oblonga Terra firme* Forest on the iron formation

Nature: *Terra firme* forest on the iron formation
Habitat: Moderately steep midslopes facing a southerly direction; mean altitude 700 m a.s.l.
Diagnostic species: *Scaphopetalum zenkeri* (shrub), *Oxyanthus speciosus* (shrub/small tree), *Tiliacora funifera* (liana), *Antrocaryon micraster* (tall tree)
Tree layer: ≥25 m layer: – *Greenwayodendron suaveolens, Coelocaryon preussii, Aucoumea klaineana, Pentaclethra macrophylla, Strombosia grandiflora, Symphonia globulifera, Uapaca guineensis*; <25 m layer – *Santiria trimera, Heisteria parvifolia, Treculia obovoidea, Plagiostyles africana*
Shrub & scandent shrub layer: *Alchornea floribunda, Agelaea paradoxa, Agelaea pentagyna, Tiliacora funifera, Landolphia ligustrifolia, Rourea obliquifoliolata*
Palms: *Raphia regalis, Eremospatha macrocarpa, Eremospatha wendlandiana, Podococcus barteri, Laccosperma secundiflorum*

Herbaceous layer: Ferns notably absent; grasses – *Guaduella oblonga, Leptaspis zeylanica*; forbs – *Marantochloa conferta, Trachyphrynium braunianum, Palisota ambigua, Palisota hirsuta, Palisota satabiei, Geophila afzelii*.

A10. *Greenwayodendron suaveolens – Alchornea floribunda* Mature *Terra firme* Forest on steep slopes

Nature: Mature *terra firme* forest on steep slopes
Habitat: Valleys to upper slopes; slopes mostly northeasterly; inclines gentle to steep; mean altitude 697 m a.s.l.
Diagnostic species: *Xylopia staudtii* (tall tree), *Strombosiopsis tetrandra* (tree), *Quassia africana* (shrub), *Garcinia smeathmanii* (tree)
Tree layer: ≥25 m layer: – *Greenwayodendron suaveolens, Coelocaryon preussii, Aucoumea klaineana, Strombosia grandiflora, Dialium pachyphyllum, Petersianthus macrocarpus, Uapaca guineensis;* <25 m layer – *Santiria trimera, Heisteria parvifolia, Treculia obovoidea, Plagiostyles africana*
Shrub & scandent shrub layer: *Alchornea floribunda, Agelaea paradoxa, Agelaea pentagyna, Landolphia ligustrifolia, Rourea obliquifoliolata*
Palms: *Raphia regalis, Eremospatha macrocarpa, Eremospatha wendlandiana, Podococcus barteri, Laccosperma leave, Laccosperma secundiflorum*
Herbaceous layer: Ferns notably absent; grasses – *Guaduella oblonga, Leptaspis zeylanica;* forbs – *Marantochloa conferta, Trachyphrynium braunianum, Palisota ambigua, Palisota satabiei, Geophila afzelii*

A11. *Guarea cedrata – Celtis adolfi-friderici – Santiria trimera* Mature *Terra firme* Forest

Nature: Mature *terra firme* forest
Habitat: Foot to upper slopes; gentle to steep slopes; mean altitude 663 m a.s.l.; tree logging prominent
Diagnostic species: *Engomegoma gordonii* (tall tree)
Tree layer: ≥25 m layer: – *Dacryodes pubescens, Guarea cedrata, Strombosia pustulata, Pentaclethra macrophylla, Coelocaryon preussii, Pycnanthus angolensis, Aucoumea klaineana;* <25 m layer – *Celtis adolfi-friderici, Heisteria parvifolia, Plagiostyles africana, Santiria trimera*
• No floristic survey of the shrub or herbaceous layer was undertaken

A12. *Aucoumea klaineana – Uapaca guineensis Terra firme* Forest with degradation

Nature: Degraded *terra firme* forest
Habitat: Fairly close proximity to villages and towns high level of disturbance particularly tree logging; gently undulating terrain; slope generally faced westerly; mean altitude 658 m a.s.l.
Diagnostic species: None
Tree layer: ≥25 m layer: – *Pentaclethra macrophylla, Petersianthus macrocarpus, Coelocaryon preussii, Dialium pachyphyllum, Piptadeniastrum africanum, Pycnanthus angolensis, Uapaca guineensis, Aucoumea klaineana;* <25 m layer – *Celtis adolfi-friderici, Albizia ferruginea, Greenwayodendron suaveolens, Plagiostyles africana, Santiria trimera*
• No floristic survey of the shrub or herbaceous layer was undertaken

Supplementary Material – Supplementary Table 1

Title: Carbon of Chaillu Forests based on a phytosociological analysis in Republic of Congo, more than meets the eye?

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Table S1. List of survey sites where phytosociological plots were conducted, with further separation between plots where AGB data was recorded from plots where AGB was not recorded, Mayoko study area, Republic of Congo

N°	Plot name	Latitude	Longitude	AGB data	N°	Plot name	Latitude	Longitude	AGB data	N°	Plot name	Latitude	Longitude	AGB data
1	127	-2.444243	12.970557	***No***	80	B45	-2.420422	12.997703	Yes	159	BJT04	-2.423859	12.930768	Yes
2	A8-1	-2.263100	12.816260	***No***	81	B46	-2.426904	12.998774	Yes	160	BJT04	-2.423703	12.930696	Yes
3	ANGE	-2.402158	12.930645	***No***	82	B47	-2.429548	12.987898	Yes	161	BK03	-2.303040	12.811440	Yes
4	Apitt08	-2.309710	12.822070	***No***	83	B48	-2.392560	12.940807	Yes	162	BL10-1	-2.305079	12.840866	Yes
5	Apitt09	-2.314212	12.813026	***No***	84	B49	-2.391373	12.918554	Yes	163	BL10-2	-2.303632	12.839218	Yes
6	Apitt10	-2.316822	12.826065	***No***	85	B51	-2.481917	12.955919	Yes	164	BM08-1	-2.309600	12.835770	Yes
7	Apitt11	-2.316028	12.809237	***No***	86	B52	-2.484248	12.954425	Yes	165	BM08-2	-2.306890	12.834758	Yes
8	Apitt12	-2.324065	12.811653	***No***	87	B53	-2.417389	12.987043	Yes	166	BMP02	-2.416204	12.869703	Yes
9	Apitt13	-2.323950	12.817509	***No***	88	B54	-2.413430	12.990612	Yes	167	BMP11	-2.365568	12.770932	Yes
10	Apitt14	-2.331565	12.806715	***No***	89	B55	-2.412314	12.852553	Yes	168	BNB1	-2.244024	12.802260	Yes
11	Apitt15	-2.327133	12.811881	***No***	90	B61	-2.402362	12.985594	Yes	169	BP05-1	-2.324658	12.822574	Yes
12	Apitt16	-2.343686	12.794362	***No***	91	B62	-2.404702	12.984268	Yes	170	BP05-2	-2.326507	12.822208	Yes
13	Apitt17	-2.344790	12.778130	***No***	92	B63	-2.510084	12.922914	Yes	171	BRA4	-2.343481	12.776090	Yes
14	Apitt18	-2.353430	12.779659	***No***	93	B64	-2.513298	12.927946	Yes	172	BRA8-1	-2.344058	12.793903	Yes
15	Apitt19	-2.354744	12.773888	***No***	94	B65	-2.497455	12.937393	Yes	173	BRA8-2	-2.343207	12.793828	Yes
16	Apitt20	-2.373046	12.768941	***No***	95	B66	-2.494523	12.950367	Yes	174	BRA9	-2.343890	12.798450	Yes
17	BB12-2	-2.264799	12.851141	***No***	96	B67	-2.494134	12.945585	Yes	175	BRC6-1	-2.352725	12.784903	Yes
18	BE07-1	-2.273720	12.828040	***No***	97	B68	-2.437234	13.000965	Yes	176	BRC6-2	-2.352595	12.783299	Yes
19	BH03	-2.213278	12.835000	***No***	98	B69	-2.410485	13.017693	Yes	177	BRD4	-2.357224	12.775911	Yes
20	BH04	-2.291917	12.808167	***No***	99	B70	-2.406846	13.016258	Yes	178	BRG4-1	-2.370610	12.775940	Yes
21	BH05	-2.243472	12.823389	***No***	100	BB12-1	-2.262482	12.853830	Yes	179	BRG4-2	-2.371480	12.773910	Yes
22	BH06	-2.318167	12.826278	***No***	101	BC09-1	-2.265597	12.837995	Yes	180	BSC6	-2.168355	12.785262	Yes
23	BSM17	-2.213190	12.834007	***No***	102	BC09-2	-2.264430	12.837802	Yes	181	BSG09	-2.222060	12.798510	Yes
24	D12-1	-2.272010	12.848180	***No***	103	BC15-1	-2.265798	12.863507	Yes	182	BSG3-1	-2.187970	12.773330	Yes
25	E3-1	-2.277960	12.812640	***No***	104	BE07-2	-2.272546	12.826441	Yes	183	BSG3-2	-2.188490	12.774030	Yes
26	Fog site 03	-2.253745	12.898936	***No***	105	BFM1	-2.411572	12.841232	Yes	184	BSG9	-2.222060	12.798510	Yes
27	Foug1-1	-2.266151	12.833191	***No***	106	BFR1	-2.415410	12.869520	Yes	185	BSI5	-2.195524	12.780560	Yes
28	Foug2-1	-2.263919	12.838808	***No***	107	BFR2	-2.423319	12.779579	Yes	186	BSI8-1	-2.195740	12.794040	Yes
29	I8-1	-2.295710	12.834850	***No***	108	BFR3	-2.419519	12.872732	Yes	187	BSL8-1	-2.208749	12.793772	Yes
30	LH01	-2.288273	12.821995	***No***	109	BFR4	-2.419954	12.871614	Yes	188	BSL8-2	-2.209170	12.793399	Yes
31	LH02	-2.272542	12.825952	***No***	110	BFTF1	-2.412564	12.852160	Yes	189	BSR13	-2.235423	12.816647	Yes
32	LH03	-2.337013	12.814850	***No***	111	BFTF10	-2.418950	12.842988	Yes	190	BSR16-1	-2.235120	12.829540	Yes
33	LH09	-2.303554	12.828854	***No***	112	BFTF11	-2.419182	12.842494	Yes	191	BSR9	-2.235752	12.798298	Yes
34	LH10	-2.307620	12.830241	***No***	113	BFTF2	-2.408177	12.844076	Yes	192	BTSINGUIDIVILLAGE	-2.402604	12.746552	Yes
35	LH11	-2.327094	12.812561	***No***	114	BFTF3	-2.415006	12.843003	Yes	193	BW013	-2.264957	12.932888	Yes
36	M8-1	-2.309600	12.835770	***No***	115	BFTF4	-2.415173	12.844928	Yes	194	BW04-1	-2.263220	12.893310	Yes
37	MP01	-2.327114	12.792959	***No***	116	BFTF5	-2.411461	12.841720	Yes	195	BWDP16	-2.227140	12.945580	Yes
38	MP04	-2.282821	12.818885	***No***	117	BFTF6	-2.410216	12.839412	Yes	196	BWE14	-2.217950	12.936394	Yes
39	MP09	-2.282933	12.806482	***No***	118	BFTF7	-2.416823	12.849047	Yes	197	BWG13	-2.227021	12.932639	Yes
40	MP12	-2.295440	12.854109	***No***	119	BFTF8	-2.417151	12.848294	Yes	198	BWG16	-2.226900	12.945743	Yes
41	MP13	-2.301757	12.845117	***No***	120	BFTF9	-2.416558	12.843822	Yes	199	BWI15	-2.235897	12.941710	Yes
42	MP14	-2.318602	12.829635	***No***	121	BG05-1	-2.282783	12.819790	Yes	200	BWJ13-1	-2.240730	12.932790	Yes
43	N2-1	-2.317070	12.809320	***No***	122	BG05-2	-2.283062	12.818157	Yes	201	BWJ13-2	-2.241716	12.934309	Yes
44	O7-1	-2.318820	12.828340	***No***	123	BGOOD170-1	-2.120410	12.685941	Yes	202	BWL02-1	-2.249860	12.883740	Yes
45	P5-1	-2.324660	12.822570	***No***	124	BGOOD170-10	-2.119661	12.683899	Yes	203	BWM05	-2.253518	12.897518	Yes
46	B01	-2.417280	12.873035	Yes	125	BGOOD170-12	-2.122210	12.683030	Yes	204	BWM9	-2.254234	12.916110	Yes
47	B02	-2.413529	12.865974	Yes	126	BGOOD170-13	-2.122252	12.686868	Yes	205	BWN7-1	-2.258403	12.905441	Yes

48	B03	-2.427796	12.891579	Yes
49	B04	-2.409672	12.882483	Yes
50	B06	-2.422524	12.864579	Yes
51	B08	-2.406056	12.840429	Yes
52	B09	-2.423591	12.886866	Yes
53	B10	-2.403919	12.898543	Yes
54	B11	-2.408340	12.909685	Yes
55	B12	-2.415111	12.909720	Yes
56	B13	-2.407962	12.914112	Yes
57	B14	-2.416865	12.916803	Yes
58	B15	-2.399265	12.925711	Yes
59	B16	-2.396435	12.922055	Yes
60	B17	-2.402719	12.911455	Yes
61	B18	-2.422021	12.930103	Yes
62	B19	-2.437113	12.955121	Yes
63	B20	-2.435093	12.934954	Yes
64	B21	-2.449947	12.923956	Yes
65	B22	-2.444910	12.926411	Yes
66	B23	-2.452235	12.939162	Yes
67	B24	-2.440545	12.967249	Yes
68	B25	-2.444244	12.970558	Yes
69	B27	-2.470720	12.957725	Yes
70	B32	-2.447956	12.973706	Yes
71	B33	-2.453628	12.970924	Yes
72	B34	-2.409383	12.994538	Yes
73	B35	-2.402881	12.994172	Yes
74	B36	-2.406254	12.947662	Yes
75	B38	-2.391511	12.950926	Yes
76	B39	-2.389067	12.961415	Yes
77	B42	-2.403298	12.960711	Yes
78	B43	-2.404061	12.969374	Yes
79	B44	-2.403915	12.930592	Yes
127	BGOOD170-2	-2.120859	12.685111	Yes
128	BGOOD170-3	-2.123313	12.685627	Yes
129	BGOOD170-4	-2.117754	12.688762	Yes
130	BGOOD170-5	-2.104341	12.683375	Yes
131	BGOOD170-6	-2.103514	12.683811	Yes
132	BGOOD170-7	-2.101211	12.681515	Yes
133	BGOOD170-8	-2.119432	12.688136	Yes
134	BGOOD170-9	-2.101563	12.683451	Yes
135	BH01	-2.365944	12.771139	Yes
136	BH02	-2.344778	12.777667	Yes
137	BH07	-2.166556	12.785806	Yes
138	BH09	-2.249667	12.882972	Yes
139	BI05-1	-2.295747	12.822943	Yes
140	BI05-2	-2.295879	12.821279	Yes
141	BJ10-1	-2.296510	12.843742	Yes
142	BJ10-2	-2.295099	12.842614	Yes
143	BJ3	-2.298642	12.811890	Yes
144	BJH01	-2.451796	12.932177	Yes
145	BJH02	-2.427741	12.938995	Yes
146	BJH02	-2.427610	12.939025	Yes
147	BJH03	-2.425680	12.925032	Yes
148	BJH04	-2.425560	12.924829	Yes
149	BJL01	-2.421185	12.887778	Yes
150	BJL01	-2.421438	12.887756	Yes
151	BJL02	-2.408555	12.837071	Yes
152	BJL02	-2.408716	12.836953	Yes
153	BJL03	-2.415539	12.843923	Yes
154	BJL03	-2.415341	12.843902	Yes
155	BJT01	-2.450128	12.924240	Yes
156	BJT01	-2.450014	12.924131	Yes
157	BJT03	-2.424425	12.884940	Yes
158	BJT03	-2.424589	12.884969	Yes
206	BWN7-2	-2.256166	12.905604	Yes
207	BWP11	-2.265272	12.924734	Yes
208	BWP16-1	-2.267230	12.946500	Yes
209	BWP17	-2.249362	12.950764	Yes
210	E10-1	-2.273500	12.844330	Yes
211	E16-1	-2.277170	12.870200	Yes
212	F15-1	-2.283520	12.867610	Yes
213	G10-1	-2.287150	12.845080	Yes
214	H16-1	-2.286850	12.869460	Yes
215	I13-1	-2.291280	12.855610	Yes
216	I15-1	-2.291310	12.865620	Yes
217	I5-1	-2.295880	12.821280	Yes
218	K4-1	-2.300700	12.817660	Yes
219	LH04	-2.263987	12.930820	Yes
220	LH05	-2.246816	12.883324	Yes
221	LH06	-2.254053	12.899177	Yes
222	LH07	-2.225393	12.937580	Yes
223	LH08	-2.262986	12.893536	Yes
224	M4-1	-2.314190	12.816620	Yes
225	MP02	-2.416423	12.869728	Yes
226	MP03	-2.157145	12.763972	Yes
227	MP05	-2.259919	12.942824	Yes
228	MP06	-2.241513	12.793959	Yes
229	MP07	-2.290873	12.792333	Yes
230	MP08	-2.224387	12.819391	Yes
231	MP10	-2.252511	12.880608	Yes
232	MP11	-2.365908	12.771165	Yes
233	MP15	-2.294059	12.865772	Yes
234	MP16	-2.297801	12.867297	Yes
235	MP17	-2.303541	12.974557	Yes

Supplementary Material – Supplementary Table 2

Title: Carbon of Chaillu Forests based on a phytosociological analysis in Republic of Congo, more than meets the eye?

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Table S2. The 10 plant families contributing most to the total above ground carbon and to the measured individuals (≥15 cm DBH) in the 190 plots surveyed at the Mayoko study area, Republic of Congo

Family	% of total aboveground carbon	% of total number of individuals
Fabaceae	22.4	13.2
Burseraceae	16.7	13.1
Phyllanthaceae	10.6	7.9
Olacaceae	8.3	7.9
Myristicaceae	8.0	10.2
Irvingiaceae	5.1	
Euphorbiaceae	4.3	10.2
Cannabaceae	3.0	
Lecythidaceae	2.4	2.4
Clusiaceae	2.3	2.6
Rubiaceae		3.4
Annonaceae		5.5
Total	**85.84**	**76.4**

Supplementary Material – Supplementary Table 3

Title: Carbon of Chaillu Forests based on a phytosociological analysis in Republic of Congo, more than meets the eye?

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Table S3: Authorities for the plant species surveyed at the Mayoko study area, Republic of Congo, and named in the paper, either in the body of the manuscript or in tables

	Genus and species	**Author citations**
1	*Allanblackia floribunda*	Oliv.
2	*Alstonia congensis*	Engl.
3	*Anthocleista schweinfurthii*	Gilg
4	*Anthocleista vogelii*	Planch.
5	*Anthonotha macrophylla*	P.Beauv.
6	*Aucoumea klaineana*	Pierre
7	*Berlinia grandiflora*	(Vahl) Hutch. & Dalziel
8	*Canarium schweinfurthii*	Engl.
9	*Carapa procera*	DC.
10	*Celtis adolfi-friderici*	Engl.
11	*Coelocaryon preussii*	Warb.
12	*Dacryodes pubescens*	Vermoesen
13	*Dialium pachyphyllum*	Harms
14	*Dichaetanthera strigosa*	(Cogn.) Jacq.-Fél.
15	*Dichostemma glaucescens*	Pierre
16	*Distemonanthus benthamianus*	Baill.
17	*Engomegoma gordonii*	Breteler
18	*Gardenia imperialis*	K.Schum.
19	*Gilbertiodendron dewevrei*	(De Wild.) J.Léonard
20	*Greenwayodendron suaveolens*	(Engl. & Diels) Verdc.
21	*Harungana madagascariensis*	Lam. ex Poir.
22	*Heisteria parvifolia*	Sm.
23	*Homalium africanum*	(Hook.f.) Benth.
24	*Hylodendron gabunense*	Taub.
25	*Klainedoxa gabonensis*	Pierre ex Engl.
26	*Macaranga monandra*	Müll.Arg.
27	*Macaranga spinosa*	Müll.Arg.
28	*Mitragyna stipulosa*	(DC.) Kuntze
50	*Monosis conferta*	(Benth.) C.Jeffrey
29	*Musanga cecropioides*	R.Br. ex Tedlie
30	*Myrianthus preussii*	Engl.
31	*Nauclea pobeguinii*	(Hua ex Pobég.) Merr.
32	*Ongokea gore*	(Hua) Pierre
33	*Parkia bicolor*	A.Chev.
34	*Pentaclethra eetveldeana*	De Wild. & T.Durand
35	*Pentaclethra macrophylla*	Benth.
36	*Petersianthus macrocarpus*	(P.Beauv.) Liben
37	*Piptadeniastrum africanum*	(Hook.f.) Brenan
38	*Plagiostyles africana*	(Müll.Arg.) Prain
39	*Pseudospondias microcarpa*	(A.Rich.) Engl.
40	*Pterocarpus soyauxii*	Taub.
41	*Pycnanthus angolensis*	(Welw.) Warb.
42	*Santiria trimera*	(Oliv.) Aubrév.
43	*Shirakiopsis elliptica*	(Hochst.) Esser
44	*Sterculia tragacantha*	Lindl.
45	*Strombosia grandifolia*	Hook.f. ex Benth.

46	*Symphonia globulifera*	L.f.
47	*Tetrorchidium didymostemon*	(Baill.) Pax & K.Hoffm.
48	*Treculia obovoidea*	N.E.Br.
49	*Uapaca guineensis*	Müll.Arg.
51	*Voacanga thouarsii*	Roem. & Schult.
52	*Xylopia rubescens*	Oliv.

Supplementary Material – Supplementary Table 4

Title: Carbon of Chaillu Forests based on a phytosociological analysis in Republic of Congo, more than meets the eye?

Margaretha W. van Rooyen[1,2], Edmond S. Miabangana[1,4], Gilbert Nsongola[1,4], Noel van Rooyen[1,3], Ben Orban[1], Alain Thomas[1], Karsten Drescher[1], Caroline Vasicek Gaugris[1,5], Jérôme Y. Gaugris[1,5]*

Table S4. The 20 plant species contributing most to the aboveground carbon and to the measured individuals (≥15 cm DBH) and Importance Values Index in the 190 plots surveyed at the Mayoko study area, Republic of Congo

Species	% of total aboveground carbon	% of total number of individuals	Importance Value Index (IVI)
Aucoumea klaineana	11.1	6.3	6.8
Uapaca guineensis	10.3	6.9	6.6
Coelocaryon preussii	5.8	7.8	7.2
Klainedoxa gabonensis	3.4		
Piptadeniastrum africanum	3.3	1.2	1.6
Celtis adolfi-friderici	2.9	1.7	2.0
Dialium pachyphyllum	2.9	1.5	1.6
Plagiostyles africana	2.8	6.6	5.7
Santiria trimera	2.7	4.3	4.1
Engomegoma gordonii	2.5		
Petersianthus macrocarpus	2.5	2.5	2.6
Berlinia grandiflora	1.9		
Pentaclethra eetveldeana	1.8	1.4	1.5
Heisteria parvifolia	1.7	3.8	3.1
Pentaclethra macrophylla	1.7	1.4	1.7
Allanblackia floribunda	1.7	1.1	1.1
Pycnanthus angolensis	1.7	1.9	2.2
Mitragyna stipulosa	1.6	1.9	1.6
Pterocarpus soyauxii	1.5		
Parkia bicolor	1.3		
Musanga cecropioides		1.9	1.3
Greenwayodendron suaveolens		2.4	2.1
Dichostemma glaucescens		1.5	1.3
Strombosia grandifolia		1.5	1.6
Treculia obovoidea		1.3	
Myrianthus preussii			1.0
Total	**65.4**	**58.8**	**56.6**