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Additive influences of soil and climate gradients drive tree community composition of Central African rainforests

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Abstract:

Aim: Examining tree species-environment association can offer insight into the drivers of vegetation patterns and key information of practical relevance to forest management. Here, we aim to quantify the contribution of climate and soil gradients to variation in tropical tree species abundance and occurrence across the region in southern and eastern Cameroon.

Location: Rainforests of southern and eastern Cameroon.

Methods: We established 82 1-ha permanent plots across seven localities and censused all trees ≥ 10 cm in diameter, representing a total of 37,733 trees and 455 species. In 60 of those plots, we measured ten soil variables describing texture and nutrients levels and extracted ten bioclimatic variables from global-gridded climate databases. We synthesized the main environmental gradients by conducting principal component analyses on climate and soil data respectively. We performed unconstrained and constrained non-symmetric correspondence analyses to account for the individual and joint contributions of climate and soil on species abundance and occurrence.

Results: Climate and soil contributed similarly to variances of species abundance and occurrence (11–15 % variance for climate vs. 11–12 % variance for soil). Climate influence mostly concerns some abundant species, while less abundant species were mainly driven by soil. Fractions of species variances accounted for by climate and soil show strong correlation when assessed from species occurrence and abundance data.

Conclusion: Variation in occurrence and abundance of tropical forest trees can be partly shaped by both climate and soil gradients in Cameroon, which emphasizes the importance to jointly consider~~ing~~ soil and climate in species distribution modeling. Less abundant species may express environmental influence differently than abundant species and convey complementary information about community composition. Though showing congruent patterns here, species abundance and occurrence reflect different interacting community processes and both should be examined to better understand vegetation patterns.

Keywords: Cameroon, Climate gradient, Soil gradient, Species abundance, Species occurrence, Tropical rainforests

Nomenclature

African Plant Database (version 3.4.0)

Main text:

INTRODUCTION

A central paradigm in plant ecology is that species distribution along environmental gradients has the potential to inform on the dimensions of their realized niches (John et al. 2007; Toledo et al. 2012). For long-lived species such as trees, the presence and abundance of mature individuals can reflect their tolerance and adaptation to local abiotic conditions (Kraft et al. 2015). Tree distribution data thus represents an invaluable source of information on species environmental requirements. For most tropical tree species a better understanding of the drivers of their distribution has strong fundamental implications in vegetation science and practical relevance in forest management and conservation (Swaine 1996; Potts et al. 2002; Toledo et al. 2011; Toledo et al. 2012; Amissah et al. 2014).

From a fundamental perspective, species turnover along broad-scale gradients can provide insights on the strength of environmental filtering (Hardy & Sonké 2004; Soininen et al. 2007; Kraft et al. 2011). These studies are still too scarce to allow grasping the variety of species-environment patterns especially in diverse parts of the paleotropics. From an applied perspective, determining the relative role of environmental factors such as climate or soil in species distribution can help to classify and map vegetation types, habitats and identify indicator species of a given environmental conditions (Hall & Swaine 1976; Diekmann 2003). These outputs are important for conservation initiatives such as the sixth category of the High Conservation Value (HCV) program dedicated to rare and threatened habitats, developed and used by the Forest Stewardship Council (FSC) to support sustainable forest management. Yet, there has been too few studies on species-environment relationships at regional scale in tropical forests, most of them located in the neotropics (Pyke et al. 2001; Duivenvoorden et al. 2002; Engelbrecht et al. 2007; Slik et al. 2009; Toledo et al. 2012; Condit et al. 2013) and even scarcer in Africa (but see Réjou-Méchain et al. 2008; Amissah et al. 2014; Fayolle et al. 2014; Vleminckx et al. 2015) where most studies were at a local scale.

Most studies analyzing plot taxonomic data along broad gradients concluded that tropical tree species turnover is partly shaped by climate through rainfall, temperature and seasonality gradients (e.g. Swaine 1996; Bongers et al. 1999; Pyke et al. 2001; Poorter et al. 2004; ter Steege et al. 2006; Engelbrecht et al. 2007; Parmentier et al. 2007; Toledo et al. 2011; Toledo et al. 2012; Amissah et al. 2014). A limited number of studies also integrated information on soil, using either coarse geological proxies such as bedrock classes, bedrock-derived dominant texture (Van Rompaey 1993; Réjou-Méchain et al. 2008; Fayolle et al. 2012; Guitet et al. 2015) or more accurate, continuous soil variables assessed from local soil cores (Swaine 1996; Toledo et al. 2011; Toledo et al. 2012; Condit et al. 2013; Vleminckx et al. 2015; Vleminckx et al. 2017). The former group of studies concluded on substantial explanatory power of their substrate proxies, while the latter concluded on either strong (e.g. Condit et al. 2013) or moderate (e.g. Toledo et al. 2012) influences of soil variables. Another study described a confounding effect from correlated rainfall and soil fertility gradients (e.g. Swaine 1996). Therefore, it remains unclear ~~what is the relative contribution of~~ climate and soil gradients ~~to~~ species turnover at regional scales in tropical rainforests.

To evaluate the contributions of climate and soil on species composition, datasets of high botanical accuracy covering large spatial and ecological breadths are valuable. Such sampling remains nevertheless challenging in tropical forests. Most regional-scale studies in tropical forests were limited to a subset of tree species (but see Condit et al. 2013), often focusing on the most reliably identified and abundant species in the field (e.g. Réjou-Méchain et al. 2008; Toledo et al. 2012) or those which are frequent enough for statistical analyses (e.g. Swaine 1996; Poorter 1999; Amissah et al. 2014). Thus, studying a subset of the regional species pool may bias inferences drawn about climate and soil influences on tropical forest tree species. Expanding sampling to the whole species pool is worthwhile because it provides valuable information on rare and potentially threatened species but also additional insights on processes shaping regional-scale floristic patterns. For instance, less abundant species may respond differently to environmental gradients than more abundant species (Keddy 1992). Taking into account less abundant and less frequent species is also interesting because species occurrence (i.e. presence-absence in plots) and abundance data may inform on different community assembly processes acting simultaneously (Toledo et al. 2012; Wilson 2012). Species presence in a local community can be viewed as the results of filtering processes determining which species of the regional pool is able to establish and persist (Kraft et al. 2015). Species abundance in a local community, on the other hand, may be more influenced by other processes such as demographic stochasticity, historical contingency and biotic interactions (Keddy 1992; Cingolani et al. 2009; Raevel et al. 2012; Wilson 2012). If abundant species also tend to be frequent, this would thus suggest pervasiveness of environmental filtering against other processes for explaining species distribution. Hence, comparing patterns of species occurrence (presence-absence) and abundance across communities can provide insights about the influence of environmental gradients on community assembly (Toledo et al. 2012).

Here, we analyze an unpublished dataset of tropical trees sampled from 82 1-ha plots within a large tropical region that simultaneously features broad climatic gradients and soil variables along with thorough botanical identification at species level (91 % of the trees). To our knowledge, this represents one of the most important data collection efforts carried out to study variation in tree taxonomic composition with climate and soil along non-orographic gradients in the paleotropics. More specifically, our sampling was carried out along the southern and eastern Cameroonian plateau that is part of the continuous forest block referred to as 'Congo Basin forests'. Although this region forms part of the second most extended continuous forest area in the tropics, there is scare evaluation of species distributions along climate and soil gradients within this region. We aim to quantify the effects of climate and soil in the variation of floristic composition in a region known to display both evergreen and semi-deciduous forests (Letouzey 1985) and belonging to the broad pantropical class of "moist forests" (Fayolle et al. 2014). More specifically, we address the following questions: (i) what are the main clines of floristic variation and what is the contribution of climate and soil? (ii) To what extent is the distribution of abundant vs. less abundant species informative on climate and soil effects on the entire floristic composition? (iii) Are species occurrence and abundance displaying congruent response to climate and soil that would suggest strong environmental filtering?

METHODS

Study area

The study area spans *ca.* 110, 000 km^2 in southern and eastern parts of Cameroon and encompasses dense lowland forests of different types along a gradient of climatic and edaphic conditions (Figure 1; Appendix S1). The vegetation has been referred to as the Cameroon-Congolese forest sector or dense moist Guineo-Congolese forest (Letouzey 1985), which is interspersed with savannas, evergreen and semi-deciduous forests. This study area has been assigned to the Moist Central African floristic cluster by Fayolle et al. (2014), but likely encompasses other vegetation types that still require finer characterization. According to Letouzey (1985), for instance, the Mbam Djerem locality, located towards the north of the study area, is occupied by a forest-savanna mosaic (Appendix S1), composed of tall trees (average canopy height of 10–20 m) such as *Sterculia rhinopetala* K.Schum., *Celtis zenkeri* Engl. and *Croton sylvaticus* Hochst. (Malvaceae ex Sterculiaceae – Canabaceae ex Ulmaceae forest type). The localities of Deng-Deng and Mindourou II are occupied by semi-deciduous forests and characterized by tall and large buttressed.

The climate is equatorial, with two dry seasons (a long dry season from November to March and a short dry season from June to July), and two wet seasons (a long wet season

August to October and a short wet season from April to May). The average number of wet months receiving precipitation > 100 mm/month ranges from 6.6 – 8.2 months per year and annual mean precipitation ranges from 1300 to 1900 mm (Hijmans et al. 2005; Fick & Hijmans 2017). Annual mean temperature ranges between 20 and 25°C (Hijmans et al. 2005; Fick & Hijmans 2017), these low values compared to other lowlands of Central Africa (Figure 1) are due to the moderately high elevation of the study area (between 500 and 800 m above sea level).

The soils in the study area are generally 'ferralitic soils' (Ségalen 1967) , i.e. Ferralsols (FAO-UNESCO 1977) showing medium to high levels of weathering and desaturation. This area is also typical of Orthic, Xanthic, Rhodic and Plinthic Ferralsols with Dystric Gleysols predominate in low-lying areas (FAO-UNESCO 1977). Though derived from different parent materials such as granites and schists, they share common characteristics, among which a strong dominance of clay content. The rocks which constitute the subsurface soil profile are essentially acidic crystalline rocks (various granites, embrechites, etc.), considered to originate from the lower Precambrian, though rocks of metamorphic origins have been attributed to the middle and upper Precambrian (Curis et al. 1955; Martin & Ségalen 1966).

Plot floristic inventory

Permanent sampling plots (PSP) were established following a stratified design to represent the main climatic regions within the study area. We established a total of 82 non-contiguous 1-ha PSP distributed in seven localities of the study area (Figure 1; Appendix S1): 4 in the Mbam Djerem National Park; 15 in the Deng-Deng National Park; 21 in Mindourou II; 17 in Mindourou I; 14 in Lomie; 3 in Ngoila and 8 in Somalomo. In each locality, we chose plot locations to sample mesic soil conditions, avoiding seasonally waterlogged areas as well as rocky or petroferric outcrops. We also avoided monodominant stands (e.g. *Gilbertiodendron dewevrei*), young secondary forests and all vegetation dominated by short-lived pioneer species (notably *Musanga cecropioides*). To establish a 1-ha PSP, we subdivided a 100 m^2 area into 20 × 20 m^2 quadrats (Appendix S2). We set poles at each quadrat corner and at the plot corners (Appendix S2). A total of 25 GPS points were recorded along the plot contour using a high precision Trimble® Geo 7X. Within each 1-ha PSP, we measured all trees with diameter at breast height (DBH) ≥ 10 cm. Large trees with buttresses or deformations were measured at 30 cm below or above the deformations. Taxonomic identifications were first conducted in the field at the time of tree measurement by observing leaves, flowers, trunk slash, habit and other diagnostic characters. A second taxonomic identification was realized at our mini herbarium of the Plant Systematics and Ecology laboratory and the Herbarium of the Université Libre de Bruxelles. Herbarium acronym follow Thiers (2019) where voucher specimens for each species are deposited. In total, we collected 2045 voucher specimens to ensure correct, verifiable and homogenous identification. Nomenclature for families and genera follows the APG IV (2016) classification while species names were corrected using the African Plant Database (version 3.4.0) (https://www.ville-ge.ch/musinfo/bd/cjb/africa/recherche.php).

Plot soil variables

Soil samples were analysed for a subset of 60 1-ha plots following standard protocols. Samples from seven 1-ha plots in Somalomo and Mbam Djerem were analysed as in Quesada et al. (2010) while for the other 53 1-ha plots are described below.

We collected soil samples at four locations along the right angle diagonal within each 1-ha PSP (Appendix S2). For each of these locations, we dug four soil cores (excluding litter) at 10 cm intervals (0–10, 10–20, 20–30 and 30–40 cm) and air-dried separately. Equal proportions from each core were taken and pooled to form one sample for analysis. In total, four samples were analysed per 1-ha plots. Each pooled soil sample was ground to pass through a 2 mm sieve. For Nitrogen and Carbon analyses, samples were further ground to pass through a 0.5 mm sieve using a motorized – Retch RM200® grinder. Soil pH in water was determined in a 1:2.5 (w/v) soil: water suspension. Total nitrogen (µg.g^{-1}) was determined from a wet acid digest and analyzed by colorimetry (Buondonno et al. 1995; Anderson, J. M. & Ingram 1998). Total phosphorus (µg.g^{-1}) was determined from wet acid digest and also analyzed by colorimetry using the molybdate blue procedure described by Murphy & Riley (1962). Available phosphorus (µg.g^{-1}) was extracted using Bray extractant and the resulting extract analyzed using the molybdate blue procedure. Moisture content (%) was determined by gravimetry using: 100-(100*weight of oven dried sample at 105 °C divided by weight of air dried sample). Organic carbon (%) was determined by chromic acid digestion and spectrophotometric analysis using a Genesys 10S UV/Vis spectrophotometer. Particle sizes (% Sand, % Silt, and % Clay) were determined by the Bouyoucos hydrometry

(Bouyoucos 1951; Day 1953). Soil analyses were conducted at the soil & plant laboratory of the International Institute of Tropical Agriculture (IITA)-Yaoundé.

In total, we measured ten soil variables, which varied between localities (Appendix S3). These soil variables confirm the main common characteristics of the reddish ferralitic soils (Segalen 1967) with the exception of Mbam-Djerem that is largely dominated by clay (40-60%), acidic pH (4 – 5), and low rates of organic carbon (1 – 2%) in spite of enduring forest cover (Appendix S3). A Principal Component Analysis (PCA) was used to determine the main dimensions of soil variables. We used the *Broken-stick* model (Jackson 1993) to select the number of interpretable PCA axes and kept the plot scores to reflect soil gradients.

Plot climatic variables

A set of eight climatic variables were selected after a preliminary screening (based on their spatial patterns) from an initial 21 variables. We discarded variables that were spatially overlapping and strongly correlated. Climatic variables were obtained at 30 arc-second (*ca.* 900 m) ground resolution from Climatologies at High Resolution for the Earth's Land Surface Areas (CHELSA v1.2; http://chelsa-climate.org/), based on a quasi-mechanistical statistical downscaling of the climatic reanalysis interim global circulation model (Karger et al. 2017). To account for variation in the radiative budget, we retrieved two variables related to cloud frequency (i.e. mean and yearly standard deviation) from Wilson and Jetz' EarthEnv dataset (Wilson & Jetz 2016). The latter are derived from Moderate Resolution Imaging Spectroradiometer (MODIS) satellite optical data over a 12-year period (2001-2013). In total, we assembled ten climatic variables: Annual Mean Temperature, Temperature Annual Range, Annual Precipitation, Precipitation Seasonality (coefficient of variation over months), Mean Temperature of Warmest and Coldest Quarters, Precipitation of Wettest and Driest Quarters, Mean cloud frequency and yearly standard deviation of cloud frequency.

A regional-level PCA was performed for the broader zone covered by broadleaved evergreen and semi-deciduous forest for tropical Africa (zone determined in the Global Land Cover Map for 2009; (Arino et al. 2012)). We extracted PCA scores using the GPS coordinates (i.e. plot centroids) for each 1-ha PSP to reflect predictor variables for climate.

Statistical analyses

Species abundance and occurrence

For each species, we defined (i) regional abundance as the total number of individuals over the plots, (ii) local abundance as the average number of individuals over the plots where the species was present and (iii) occurrence as the number of plots in which the species was present.

Variance partitioning

We partitioned variance in species abundance and occurrence across plots with soil and climate variables (Couteron & Pélissier 2004). Variance partitioning relates to both constrained ordination and diversity measurement involving classical indices. Hence, for a given species *j*, the individual species variance corresponds to $f_{+j}(1 - f_{+j})$, where f_{+j} denotes relative abundance (i.e. number of individuals belonging to species *j* relative to all the individuals sampled). Individual variance translates from species abundance to species occurrence by considering f_{+j} as the relative number of plots in which the species *j* is present. In line with diversity indices, direct summing of individual variances of abundance over species is the Simpson-Gini index (Hill 1973). Weighting species variances by the inverse of individual species relative abundances brings increased sensitivity to scarce species because the total weighted sum equates species richness minus one (Pélissier et al. 2003; Couteron & Pélissier 2004). In line with ordination methods, these two options correspond to Non-Symmetric Correspondence Analysis (NSCA) and to classical Correspondence Analysis (CA), respectively (Pélissier et al. 2003; Couteron & Ollier 2005). The relationship also applies to their constrained versions, that is, Non-Symmetric Correspondence Analysis with Instrumental Variables (NSCAIV; *sensu* Couteron et al. 2003), which is a particular case of Redundancy Analysis and CCA (Ter Braak 1986). These constrained analyses rely on the same multivariate linear models of apportioning inter-plot variances (inertia) of individual species abundance with-respect-to environmental descriptors (Couteron et al. 2003; Pélissier & Couteron 2007).

Here, we used unconstrained NSCA on our floristic table (82 1-ha plots, 455 tropical tree species) to analyze variations of species abundance and occurrence across forest communities (plots). We presented the results of NSCA but not CA because the latter presented similar results for species abundance. We repeated the unconstrained analysis on a reduced floristic table (60 1-ha plots, 416 species) corresponding to plots with both soil and climate data. Preliminary analyses revealed no substantial changes in the main clines of floristic variation when switching the floristic tables (see Appendix S4 and Figure 2 for results with 82 and 60 plots, respectively). We further conducted the deriving constrained analyses (NSCAIV) on the reduced floristic table via variance partitioning.

To assess the individual and joint influence of soil and climate on species abundance and occurrence, we apportioned inter-plots variation with respect to soil gradients (S_{IV}), climate gradients (C_{IV}) and their joint contributions ($S_{IV} + C_{IV}$). The variance apportioning calculates the shares of individual species variances explained by climate, soil and both. Further, we performed a partial ordination with respect to soil after factoring out the effects of climate, and vice versa. The partial ordination allowed synthesizing multi-species floristic gradients from the species abundance and occurrence tables. We calculated the proportion of variance accounted for by climate when the effects of soil were factored out ($C_{IV} - S_{IV}$) and the proportion of variance accounted for by soil when the effects of climate were factored out ($S_{IV} - C_{IV}$). Finally, we tested the statistical significance of the variance portions obtained at both individual and multi-species scales using Monte-Carlo permutation tests (i.e. by randomizing the rows of the floristic table irrespective of the values of the environmental gradients). This randomization aimed to break the relationship between floristic composition and environmental variables. Each test was considered statistically significant at a *P* value less than 0.05 after 1000 randomizations.

All statistical analyses were performed with the *R* statistical software version 3.5.2 (R Core Team. 2019), using routine *R* functions and the *diversity.R* package (Pélissier 2013).

RESULTS

Floristic diversity

The 82 1-ha plots comprised 37,733 trees belonging to 455 species and 257 genera, grouped in 61 families. The subset of 60 1-ha plots for which both soil and climate were available contained 26,726 trees belonging to 416 species and 234 genera, grouped in 60 families. The 60 1-ha plot data excluded 798 (2.7%) unidentified individuals and 1741 (5.9 %) individuals identified at genus level only. The genus-level identified individuals represented species that can be distinguished in the field while names cannot be attributed.

Correlations between species regional abundance and occurrence

We found a strong correlation between species regional abundance and occurrence across the 60 1-ha plots (r = 0.71; df = 414; t = 20.46), but a weak correlation between species local abundance and occurrence (r = 0.23; df = 414; t = 4.91). The results were similar for the 82 1-ha plots, that is, strong correlation for regional abundance and occurrence (r = 0.72; df = 453; t = 22.38) and weak correlation for local abundance and occurrence (r = 0.21; df = 453; t = 4.46). Frequent species (i.e. present in more than 80 % of plots) such as *Tabernaemontana crassa*, *Anonidium mannii* and *Greenwayodendron suaveolens* were also highly abundant at regional scale (i.e. recorded from more than 1000 individuals each; Appendices S5A, S6). Other species (e.g. *Plagiostyles africana*, *Baphia leptobotrys*, *Parkia biglobosa*) were less frequent and, when present, showed high local abundance (Appendix S5B).

Patterns of floristic composition

Both occurrence and abundance datasets reveal congruent patterns of localities according to axes defined by species that were either regionally frequent or abundant, respectively (Figure 2). NSCA on the species occurrence matrix for 60 1-ha plots revealed a first axis (8.65 % variance) mostly determined by regionally abundant species such as *Albizia adianthifolia*, *Celtis adolfi-friderici* and *Mansonia altissima* with positive values and *Panda oleaosa*, *Carapa procera* and *Cylicodiscus gabunensis* with negative values (Figure 2A). This first axis opposed plots from the drier localities (Mbam-Djerem, Deng-Deng and Mindourou II) to plots from wetter localities (Lomié, Mindourou I and Somalomo) (Figure 2B). The second axis (7.14 % variances) was characterised by species such as *Celtis zenkeri* with negative score and species such as *Drypetes leonensis* and *Phyllocosmus africanus* with positive scores (Figure 2A). This axis opposed plots from the Mbam Djerem (positive scores) against those of Lomie (negative scores) localities.

NSCA on species abundance matrix for 60 1-ha plots revealed a first axis (12.17 % of total variance) driven by regionally abundant species (Figure 2C) such as *Anonidium mannii* (1253 individuals), *Greenwayodendron suaveolens* (1098 individuals), *Funtumia africana* (495 individuals), *Plagiostyles africana* (459 individuals), *Uapaca guineensis* (452 individuals), *Heisteria parviflora* (346 individuals), *Strombosia grandifolia* (651 individuals). This first axis represented a dry to wet gradient of localities including Lomie, Somalomo and

Deng-Deng. The second axis (9.95 % of total variance) featured species of young dry forests (e.g. *Markhamia lutea* and *Parkia biglobosa*) in the Mbam Djerem locality and a blurring effect of the pioneer *Musanga cecropioides* (417 individuals) in one plot of the Mindourou I locality (Figure 2D).

Gradients of soil and climate

The main gradients in soil variables were summarized by the first three axes of the PCA that together explained 64.5 % of variance. The first axis (27.6 % variance) corresponds to a texture gradient, the second axis (22.3 % variance) to a fertility gradient and the third axis (14.7 % variance) to an organic content gradient (Figure 3A & 3B).

PCA on climate variables was less interpretable in terms of single climatic factors because of the patterns of covariation between climate variables. The climate variables from the first three axes were reduced to a 3-dimensional space and this together explained 84.9 % of total variance (Figure 3C & 3D) while entailing: (1) seasonality (in temperature, precipitation and cloud frequency); (2) mean annual temperature (with a weak link to seasonality) and (3) precipitation (with a loose correlation between total, wet and dry season precipitations).

Variance partitioning of species local abundance and occurrence with respect to climate and soil

Partitioning variance in species abundance and occurrence with soil and climate, we found comparable levels of explained variances (Table 1). Climate alone explained 15.2 % species variance for abundance and 12.4 % for occurrence. Soil alone explained almost equal fraction of variance of abundance and occurrence (11.6 % and 11.2%, respectively). The joint effect of soil and climate accounted for 25.8 % of variance of the abundance matrix and 23.0 % variance of the occurrence matrix (Table 1).

The proportion of unexplained variance once either soil or climate effects were factored-out revealed that soil and climate gradients appeared fairly additive (i.e. small fractions of shared explained variances) for species abundance and occurrence (Table 1). Factoring out the effects of soil, climate explained 10.2–11.3 % variance and factoring out the effects of climate, soil explained 8.2–9.1 % variance of species distribution.

Interaction between soil and climate based on pairwise multiplicative effects of explanatory variables ($C_{IV} * S_{IV}$) was very low (i.e. < 2 % variance).

Monte Carlo permutation tests at *P*-value < 0.05 revealed that 26 % (108 out of 416) species associated with climate alone, 14.9 % (62 out of 416) species associated with soil alone, and only 6.3 % (26 out of 416) species associated with both climate and soil (Appendix S6) for species abundance. Larger proportions of sensitive species were observed for species occurrence (i.e. 131, 110 and 96 out of 416, for climate alone, soil alone and both climate and soil, respectively) (Appendix S6).

We found species-specific affinity to climate or soil gradients (Figure 4). For some species, the variance in their abundance was well explained by climate but not soil (e.g. *Stombosiopsis tetrandra*, *Desbordesia insignis*). For other species, the variance in abundance was well explained by soil but not climate (e.g. *Dialium angolense*, *Pentaclethra eetveldeana*, *Monodora myristica*). The former group of species tends to be regionally abundant (fairly large circles in figure 4), while the latter encompasses less abundant species (Figure 4). Few species (located along plot diagonal in Figure 4) simultaneously displayed high levels of explained variances for both factors and were mostly not abundant (e.g. *Khaya ivoriensis*, *Markhamia lutea*, and *Vitex doniana*).

We found positive relationships between explained variance in species abundance and occurrence: $R^2 = 0.58$ for soil gradient (Figure 5B) and $R^2 = 0.53$ for climate gradient (Figure 5A). Despite these strong relationships, several species deviated from the regression trends. For example, for *Greenwayodendron suavolens*, one of the most abundant and frequent species of our dataset (Appendix S5), soil well explained variance in its occurrence, but not its abundance. *Parkia biglobosa*, an infrequent species that tends to be locally abundant within dry forests (Appendix S5B), exhibits the same pattern. *Funtumia africana*, one of the regionally abundant and frequent species (Appendix S5A), climate well explained its abundance but not its occurrence. ~~Converely,~~ for *Panda oleosa*, also regionally abundant (Appendix S6), climate well explained its occurrence but not its abundance.

DISCUSSION

This study contributes to a better understanding of floristics turnover according to both soil and climate which has ~~insofar~~ not been sufficiently addressed in the tropics (but see Swaine 1996; Toledo et al. 2012; Condit et al. 2013) and African rainforests in particular. Our dataset encompasses high botanical accuracy and sampling of soil composition alongside the main rainfall gradients (e.g. climate PCA axis 1; Figure 1), stretching over *ca.*110, 000 km2 of rainforests in the Congo Basin (Figure 1).

Relative importance of climate and soil gradients

Climate and soil explained similar proportions of variances of species abundance and occurrence, with low shared explained variances (1 – 3 %), suggesting that climate and soil were non-redundant in explaining species distribution. This result is in line with findings from Condit et al. (2013) who reported that both rainfall and soil phosphorus shape the tree community of Panamanian forest. The relative importance of soil and climate on biomass and forest structure has also been highlighted for other African (Lewis et al. 2013) and Amazonian (Quesada et al. 2012) forests.

Studies that emphasized stronger importance of climate over soil occur in drought-sensitive regions, where water availability is a limiting factor (Toledo et al. 2011; Toledo et al. 2012). Conversely, soil (or geology) can trump climate in areas of extreme soil conditions (e.g. sandstone, alluvium) (Réjou-Méchain et al. 2008; Fayolle et al. 2012). Extreme soil conditions may develop distinct textural (e;g. very sandy or clayey), chemical and structural properties (e.g. ferruginous nodules and duricrust as in some forests: Gourlet-Fleury et al. (2011)), and consequently have different levels of nutrients and water availability. Soil conditions can also be a stronger driver of species distribution in regions of weak climatic heterogeneity (Clark et al. 1999; Harms et al. 2001). However, in the present study, precipitation and temperature gradients show substantial amplitude (Figure 1; Appendix S3). We did not sample extreme soil conditions and drought-prone forests are not common in the study area (apart from the Mbam-Djerem locality). These might indirectly contribute to balanced effects of climate and soil on community composition.

Climate and soil left an apparently considerable unexplained fraction (74 – 77 %) of variance of species abundance and occurrence in this study. But large shares of unexplained variance is common in studies applying variance decomposition to species-rich tropical forests (e.g. Réjou-Méchain et al. (2008); Guitet et al. (2016)). In addition to community diversity itself, unexplained variances can result from unmeasured factors (e.g. human and natural disturbances and biotic interactions) and stochastic processes (e.g. dispersal limitation and demographic stochasticity). Bearing this in mind, we concluded on rather high fractions of explained variances for a tropical forest dataset that did not sample extreme conditions, and this pleads for considerable climate and soil influences on forest composition in our region.

Forest gaps are legacies of past natural or human disturbances and are rapidly colonized by light-demanding and short-lived pioneer species (Gourlet-Fleury et al. 2013). Even though our sampling avoided recently disturbed forests, pioneers such as *Musanga cecropiodes* (Figure 2C) and light-demanders like *Sterculia rhinopetala* and *Desbordesia insignis* (Figure 2C) were noticeable. Hence, different degrees of disturbances across the sampled forest are likely to be an influential factor we did not take into account. Accounting for such effect may not be possible without historical records or ~~long term~~ observation of the forest dynamics. It is also likely that variation in forest composition reflects to some extent historical events on long time-scale such as anthropogenic disturbances during the last centuries. For instance, the upper strata of a large part of forests in Cameroon are indeed dominated by long-lived, light-demanding species without apparent regeneration, suggesting past large-scale disturbances (Vleminckx et al. 2014; Morin-Rivat et al. 2017).

Inter-site variation is a sound basis for assessing neutral-like migration limitation (*sensu* Munoz et al. (2007); Munoz, Couteron & Ramesh (2008)), but it also exlplained climate variation and both are thus difficult to disentangle. However, Hardy & Sonké (2004) noted that ~~though~~ habitats explain species distribution in the Dja Biosphere Forest Reserve (a section of Somalomo locality, Figure 1, Appendix S1), data strongly agree with a model of limited dispersal. Studies detailing population genetics and dispersal ability of species could also help reveal the role of neutral-like processes in these tropical forests.

Insights from abundant and less abundant species

It has been frequently observed that diverse tropical forests are dominated by a small suite of species showing very high abundance, while the majority of other species are less abundant or rare (Gaston et al. 2000; Pitman et al. 2001; ter Steege et al. 2013). Drivers of this abundance pattern include habitat (ter Steege et al. 2013), demographic stochasticity (Hubbell 2011), intra-specific competition, herbivory and other density-dependent mortality (Janzen 1970; Comita et al. 2010). We show in this study that climate explained the variance of mainly abundant species while soil explained the variance of mainly less abundant species (Figure 4). In fact, climate well explained 108 species of which 38 % were abundant (> 100 individuals), representing 39 % of all stems. Also, soil explained 62 species of which 66 % were less abundant (< 100 individuals) corresponding to only 4 % of all stems (Appendix S6) and both climate and soil only explained 6 % (i.e. 26 species). These proportions in climate- and soil-sensitive species follow the habitat- species associations that has been reported for other tropical forest sites in Korup, Cameroon (Chuyong et al. 2011), Ecuador (Valencia et al. 2004) and Bolivia (Toledo et al. 2012). Our results therefore suggest climate fitness for the abundant and soil fitness for the less abundant species.

Informativeness of species occurrence versus local abundance across environments

We found strong positive relationship between explained variance fractions of species occurrence and abundance for climate and soil gradients. Species presence reflect primarily the result of species environmental requirements and tolerance (Brown 1984; Kraft et al. 2015). In this study, species presence means its ability to overcome environmental filtering. Species abundance, on its part, contains more quantitative component and incorporates species presence. Species abundance can reflect diverse processes operating simultaneously at the community level. However, the regression strength in our case means that species abundance and occurrence provide overall congruent insight on species environment relationship in our study area. This result has not been previously reported for rainforest tree communities. But studies on dessert annuals also found positive correlations between occurrence and abundance (Boeken & Shachak 1998; Guo et al. 2000). Despite strong agreements between occurrence and abundance, individual species deviated from the average regression slopes, suggesting species with distinct phylogenetic relatedness responding to climate and soil. For instance, species that respond to soil like *Anonidium manni*, *Anickia affinis* and *Greenwayodendron suaveolens* (Figure 5B) are Annonaceaes that are widely distributed in wet old-growth forests in central Africa. In addition, *Celtis* spp, *Cola lateritia* and *Sterculia rhinopetala* belong to former Ulmaceae (now Canabaceae) and former Sterculiaceae (now Malvaceae) are sensitive to climate and widely distributed in dry forests

(Figure 5A). The deviating species maybe indicators of environmental response to forest deciduousness (Ouédraogo et al. 2016). For instance, species that respond to climate such as *Funtumia africana*, *Celtis* spp, *Cola lateritia* and *Sterculia rhinopetala* (Figure 5A) are prominent long-lived pioneers of old-growth forests in Central and West Africa. These long-lived pioneers regularly shade their leaves with the severity of the dry season (Ouédraogo et al. 2016).

Practical information for positive species occurrence-abundance relationships have been reviewed (Gaston et al. 2000; Wilson 2012) with major emphasis on cost effectiveness of sampling effort in favor of presence/absence (Joseph et al. 2006). But, practically, this is not so true in tropical forests since plots are to be large and it is not possible to rapidly grasp the list of present species. Support for abundance sampling is highlighted for analyzing conservation status for species with increasing extinction risk from reductions in abundance (Lawton 1996). Sampling species abundance may also be particularly important for multi-purpose collections and high quality data (e.g. biomass and carbon stock assessment) for forest dynamics. However species presence/absence and species abundance should be analyzed separately as they result from different but closely related filtering processes (Cingolani et al. 2009).

Conclusion

Based on an exceptional dataset collected at regional scale in tropical rainforests in the Congo Basin, we found that climate and soil strongly explain the variance in tree species composition (abundance and occurrence). We showed that climate explains only slightly higher fraction (≈ 2.5 %) of variance on species composition compared to soil, which challenges the notion of strong climate hierarchy over soil for tropical rainforests in Cameroon. Climate and soil jointly explain very small proportion of variance in species composition, indicating that they have complementary and additive effects on species composition. We equally noticed that climate-explained variance mainly concern species of high abundance while soil-explained variance mainly concern species of less abundance. Finally, we found that species abundance and occurrence show congruent patterns across the soil and climate gradients although some species depart from the overall trend. Beyond the fundamental implication of unraveling environmental processes that underlie tree species abundance and occurrence, our results highlight that considering both climate and soil in modeling species distribution can improve mapping species range and distribution for tropical rainforests.

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Table with legend:

TABLE 1 Variance proportions of species abundance (i.e. relating to Simpson beta-diversity) and occurrence apportioned with-respect-to soil and/or climate gradients.

		Constrained ordination			Partial ordination		Residual ordination
	Total	S_{IV}	C_{IV}	$S_{IV} + C_{IV}$	$C_{IV} - S_{IV}$	$S_{IV} - C_{IV}$	$total - (S_{IV} + C_{IV})$
Variance for species abundance (Simpson beta-diversity)	0.987	0.003**	0.001**	0.005**	0.0005**	0.003**	0.982*
Variance for species occurrence (Simpson beta-diversity)	0.995	0.0006**	0.0002**	0.0008**	0.0001**	0.0005**	0.994
Fractions for species abundance (%)	100	11.6	15.2	25.8	11.3	8.2	74.2
Fractions for species occurrence	100	11.2	12.4	23.0	10.2	9.1	77.0

(%)

Environmental descriptors (Instrumental variables (IV)) i.e. first three PCA axes for soil (S_{IV}) and climate (C_{IV}) are used to explain multi-species diversity (from species abundance and occurrence) determined via Non-symmetric correspondence analysis (NSCA). Entries denote values or fractions of Simpson-Gini diversity and species variance explained by soil (S_{IV}), climate (C_{IV}), soil and climate ($C_{IV} + S_{IV}$), climate without soil ($C_{IV} - S_{IV}$), soil without climate ($S_{IV} - C_{IV}$) and the residuals [$total - (S_{IV} + C_{IV})$]. Monte-Carlo permutation test of significance (1000 repetitions) for each operation is denoted by * (*= $P < 0.05$, ** = $P < 0.01$).

Figures with legends:

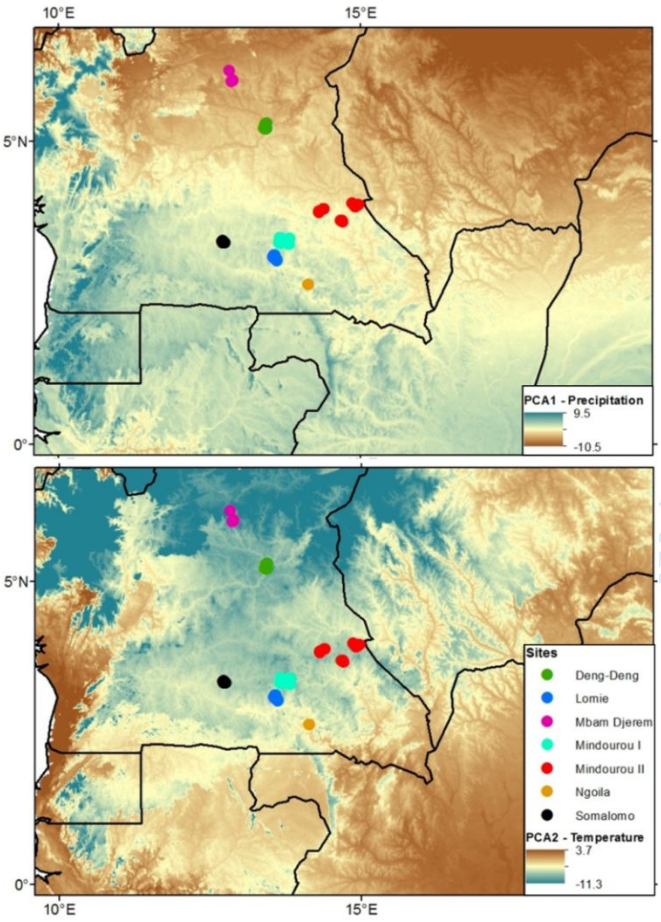


Fig. 1. Spatial distribution of 1-ha permanent sampling plots in the study area in Cameroon, projected over regional climatic gradients. Dots of the same color denote plots within a locality. Background rasters are precipitation (upper panel) and temperature (lower panel) from Climatologies at High Resolution for the Earth's Land Surface Areas (CHELSA v1.2; http://chelsa-climate.org/), gradients depicted by the first two axes of a Principal Component Analysis on ten climatic variables across the study area.

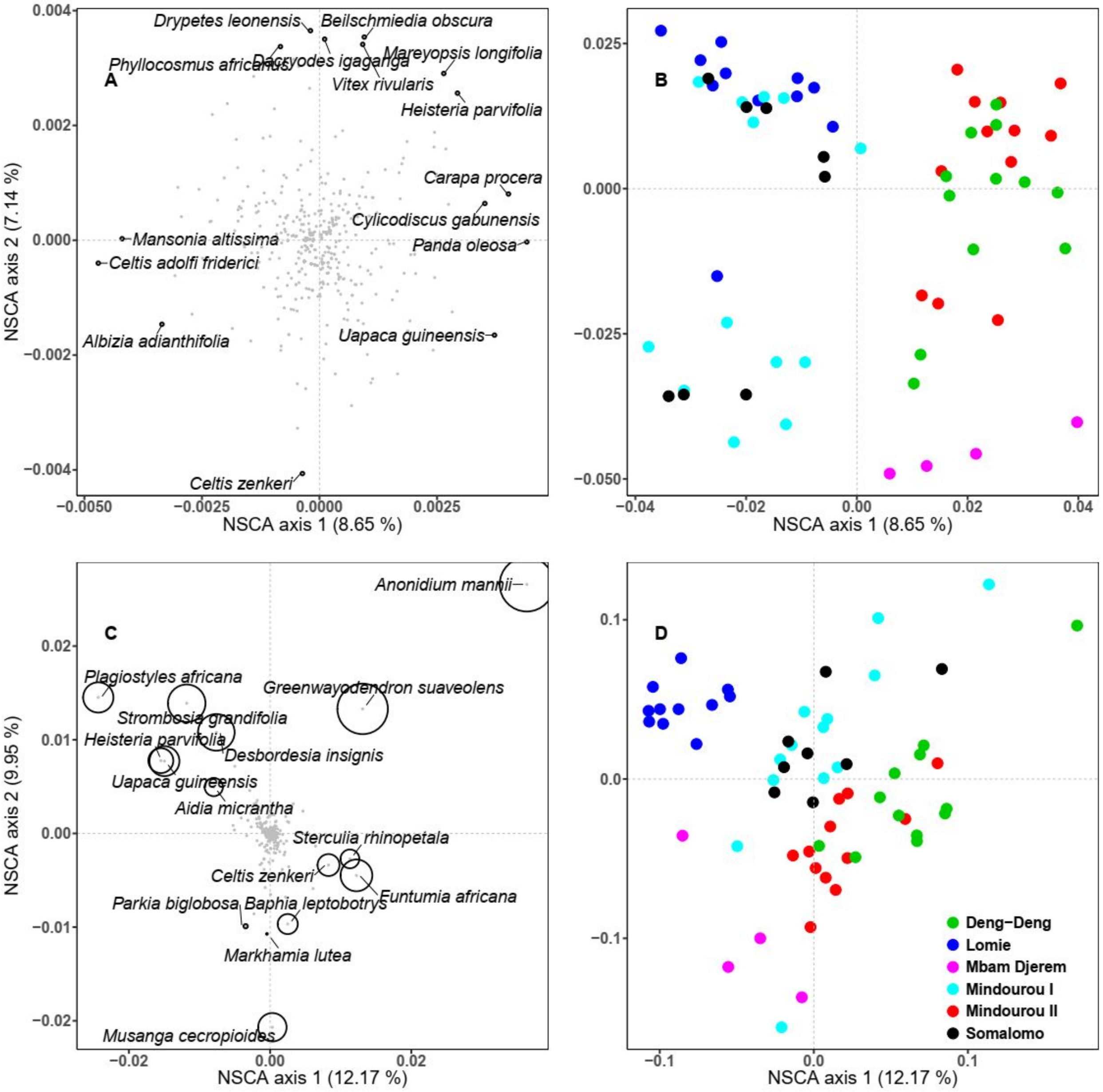


Fig. 2. Variation in tree species composition in sixty 1-ha plots from southern and eastern Cameroon depicted by Non-symmetric Correspondence Analysis (NSCA). First two ordination axes based on species occurrence (A & B) and on species abundance data (C & D). Dots of the same color denote 1-ha plots within the same locality (B & D) and sizes of circles are proportional to species abundance for C. Only the 15 most discriminating species out of 416 are labeled for B & D to improve legibility.

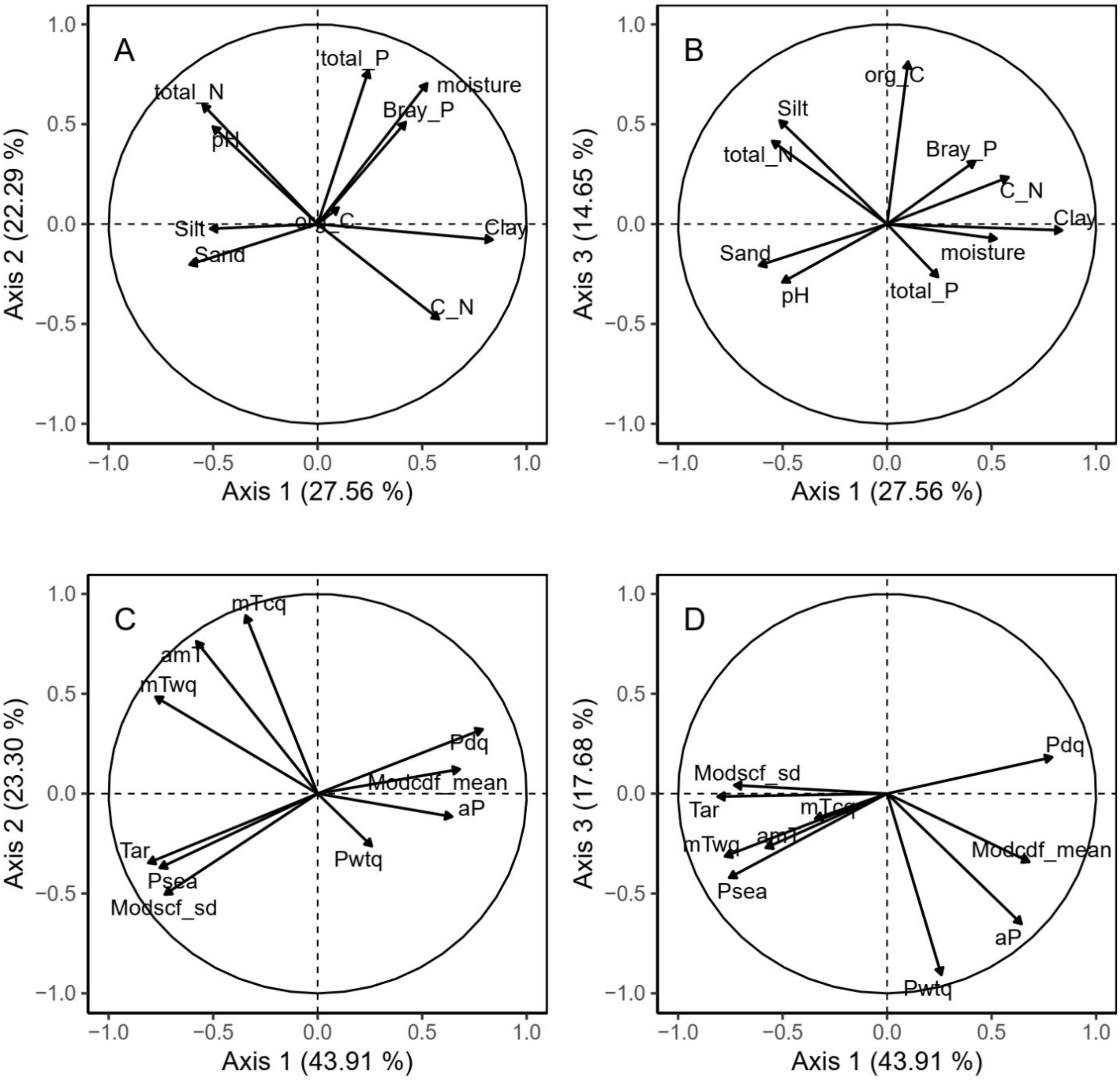


Fig. 3. Correlation circles of Principal Component Analysis on soil composition and bioclimatic variables. Variables of first three axes for soil (A & B): *moisture* = Soil moisture content; *Org_C* = Organic carbon; *total_N* = Total nitrogen; *total_P* = Total phosphorus; *Bray_P* = Assimilable phosphorus; *C_N* = Carbon/nitrogen ratio; pH; Clay, Sand and Silt contents and for climate (C & D): *amT* = Annual Mean Temperature; *Tar* = Temperature Annual Range; *aP* = Annual Precipitation; *Psea* = Precipitation Seasonality; *mTwq* & *mTcq* = Mean Temperature of Warmest and Coldest Quarters; *Pwtq* & *Pdq* = Precipitation of Wettest and Driest Quarters. *Modscf_mean* = mean of cloud frequency; *Modscf_sd* = standard deviation of cloud frequency. A quarter is a period of three successive months, i.e. 1/4 of the year.

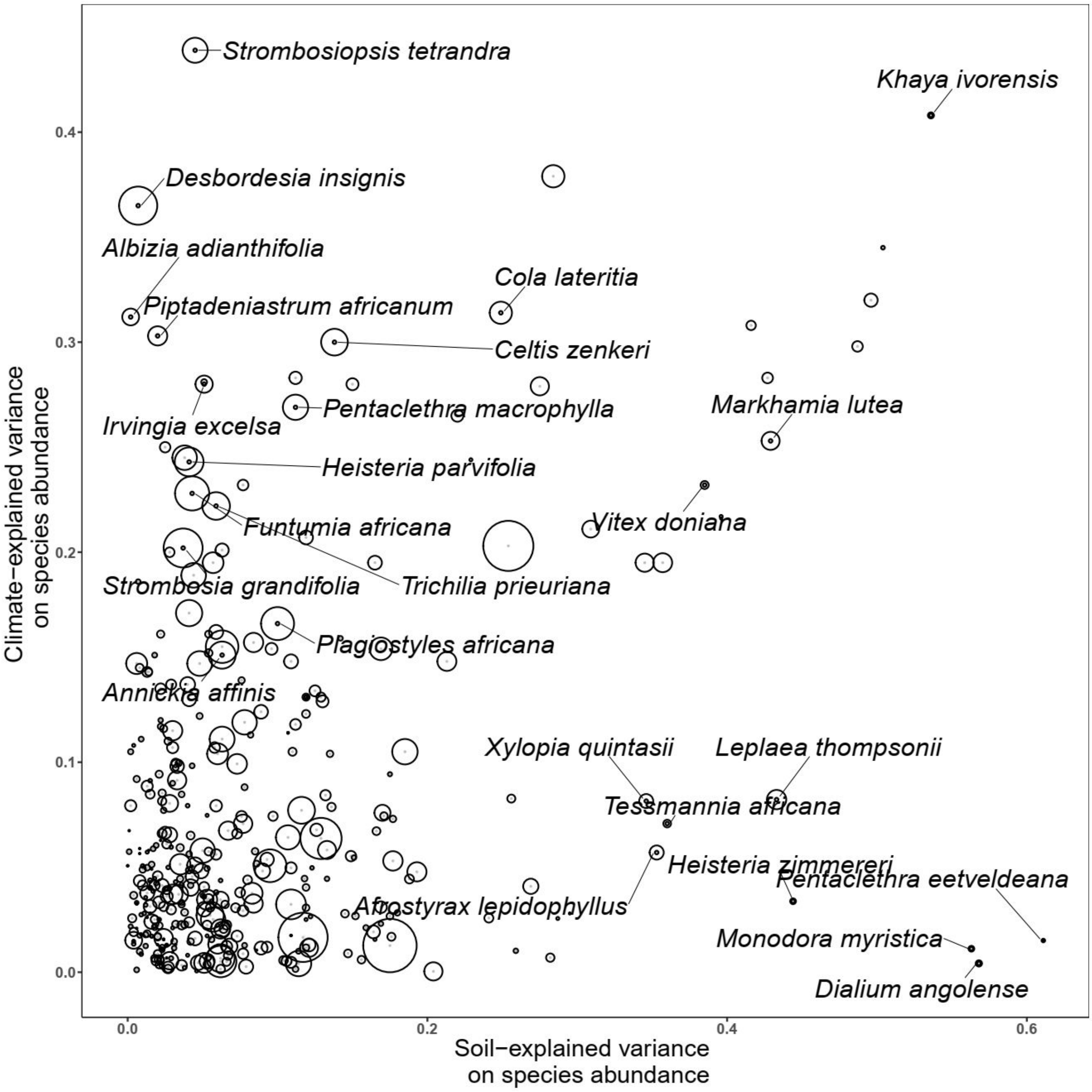


Fig. 4. Variance fractions of species abundance explained by climate or soil gradients. Sizes of circles are proportional to species abundance (total number of individuals sampled). Only the best explained of the 416 species are labeled to improve legibility.

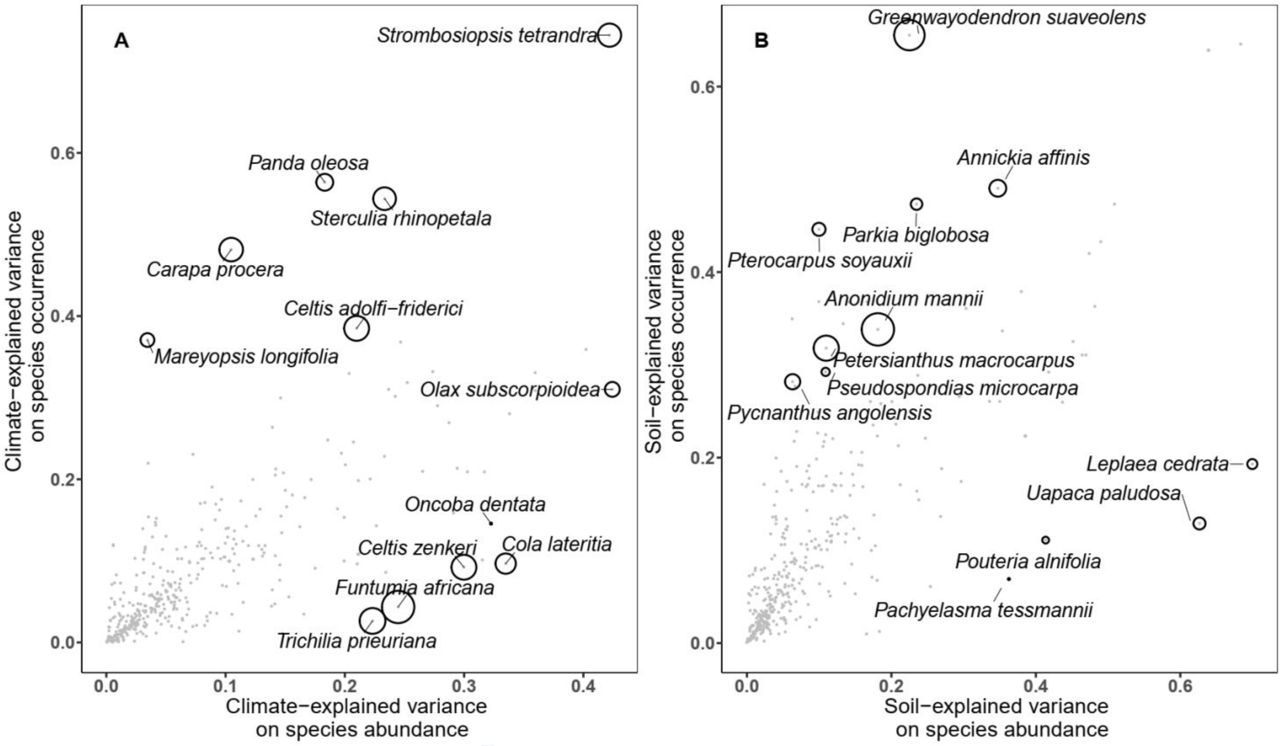


Fig. 5. Relationships of explained variances between species abundance and species occurrence. Climate-explained variance (A: regression slope = 0.53) and Soil-explained variance (B: regression slope = 0.58). To improve legibility, only species (12 out of 416) departing from main regression trend are labeled on both graphs and their circles are proportionate to abundance.

List of appendices with shortened captions

Appendix S1. Location of eighty-two 1-ha permanent sampling plots projected over different forest types of southern and eastern Cameroon. Dots of the same colors are plots within the same locality. Forest types according to Letouzey (1985).

Appendix S2. Design of a 1-hectare (100-m x 100-m) permanent sampling plot for tree census and soil sampling.

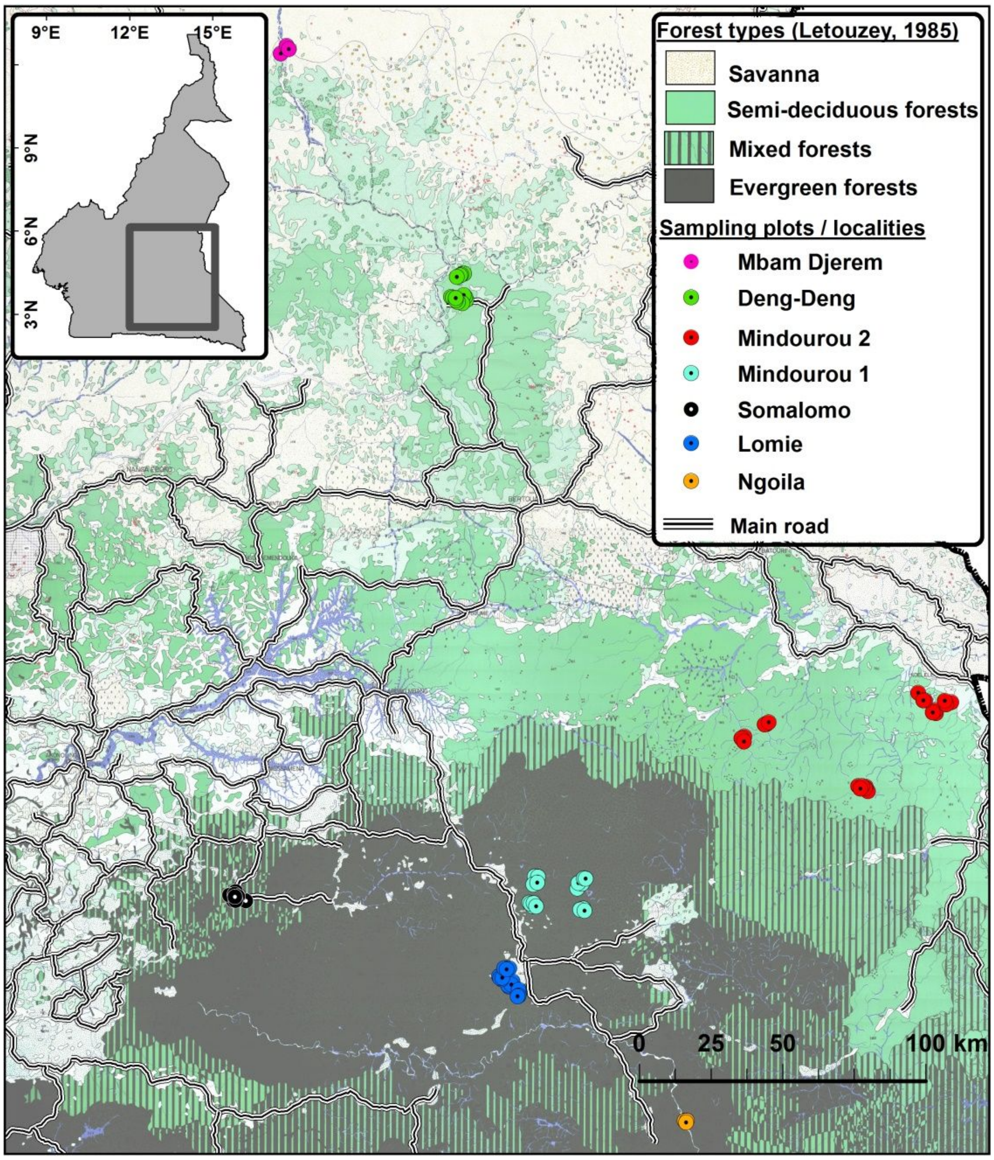
Appendix S3. Variation of individual soil and bioclimate variables between six localities in southern and eastern Cameroon.

Appendix S4. Regional distribution in species abundance and occurrence depicted by Non-symmetric Correspondence Analysis (NSCA; *sensu* Pélissier et al. (2003)) applied to 82 plots. NSCA based on species abundance data (A & B) and on species occurrence data (C & D).

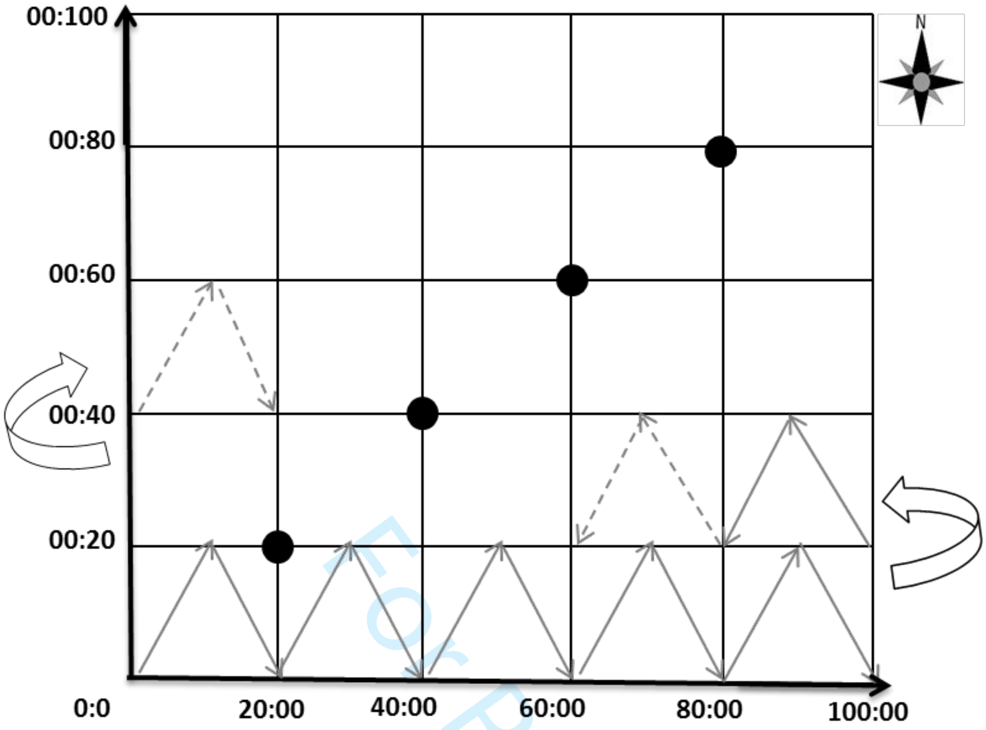
Appendix S5. Relationship between species abundance and frequency at regional (A) and local (B) scales.

Appendices with legends:

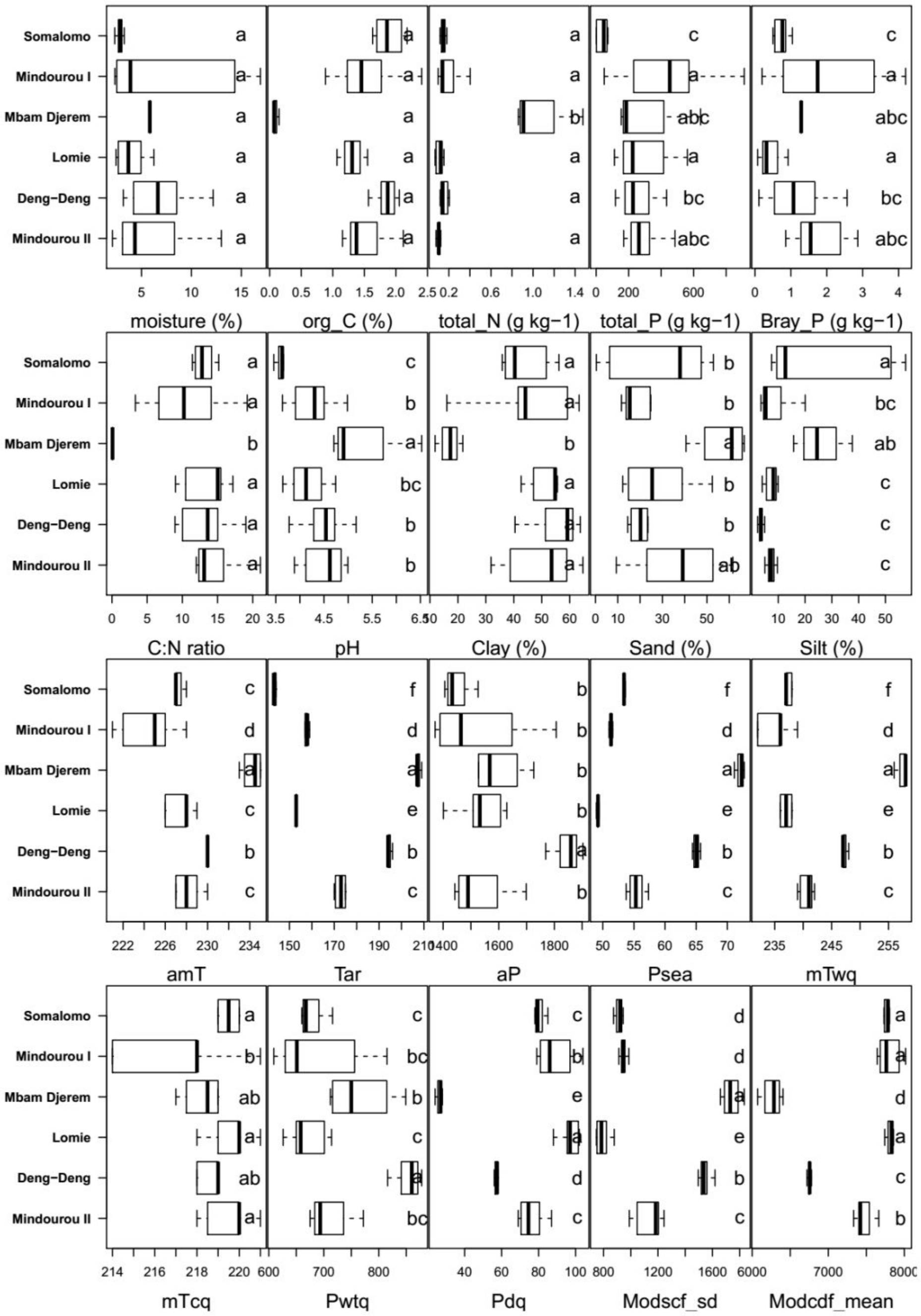
Supporting information to the paper Libalah, M.B. et al. Additive influences of soil and climate gradients drive tree community composition of Central African moist rainforests. *Journal of Vegetation Science*



Appendix S1. Location of eighty-two 1-ha permanent sampling plots projected over different forest types of southern and eastern Cameroon. Dots of the same colors are plots within the same locality. Forest types according to Letouzey (1985).

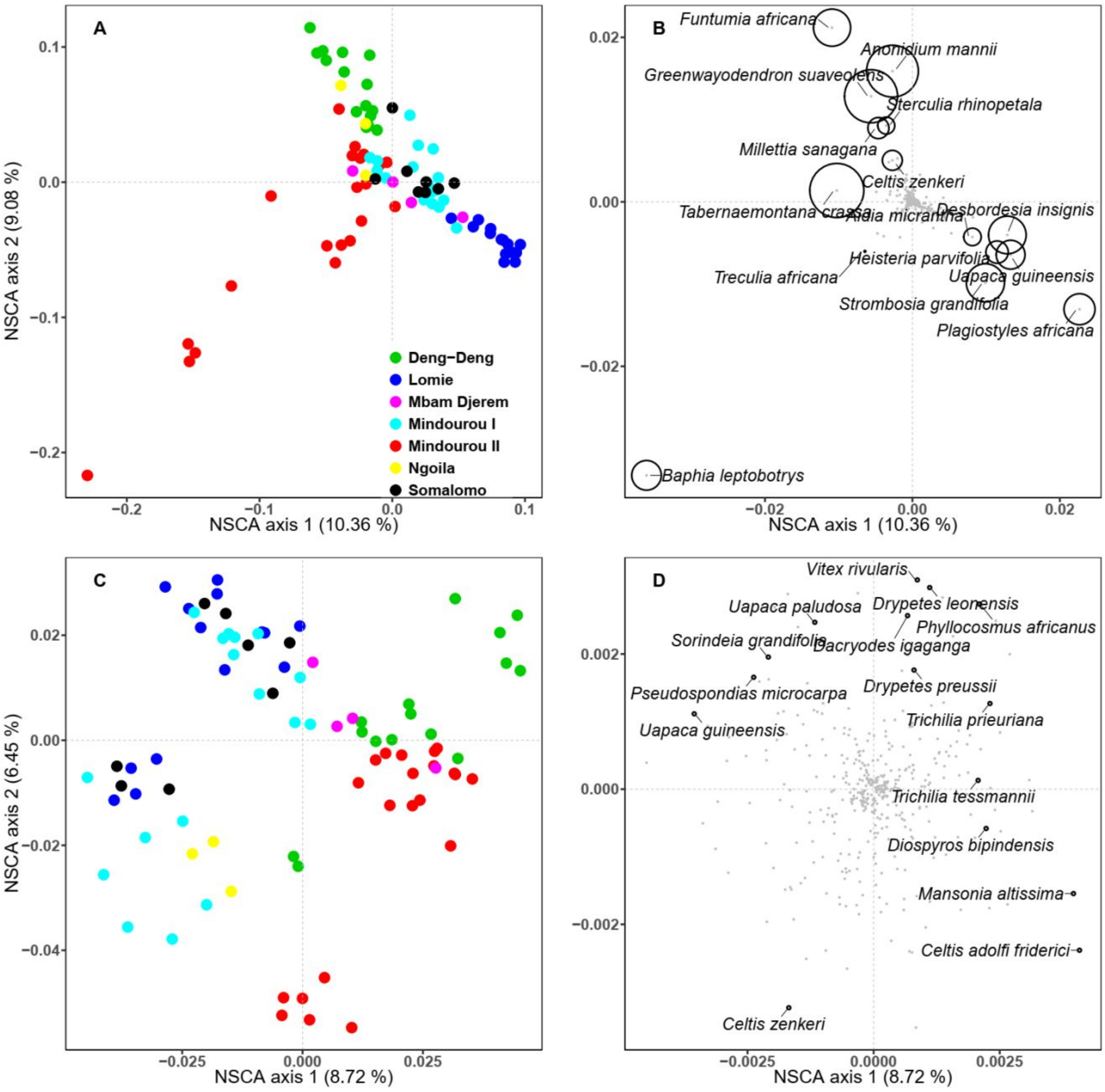


Appendix S2. Design of a 1-hectare (100-m x 100-m) permanent sampling plot for tree census and soil sampling. Trees are systematically sampled within quadrats (20-m x 20-m) and intra-quadrats displacement for tree sampling follows the grey full arrows and grey broken arrows are further continuation within the 1-ha plot; inter-quadrat transition follows the white arrows. Black dots are points of four soils sampling.



Appendix S3. Variation of individual soil and bioclimate variables between six localities in southern and eastern Cameroon. Least Significant Difference test with a Bonferroni-adjustment was applied on soil composition (upper two columns) and bioclimatic variables (lower two columns) collected from six localities for which both soil and climate data were available. Meaning of soil variables: moisture = Soil moisture content; Org_C = Organic carbon; total_N = Total nitrogen; total_P = Total phosphorus; Bray_P = Assimilable phosphorus; C_N = Carbon/nitrogen ratio; pH; Clay, Sand and Silt contents. Meaning of bioclimatic variables: amT = Annual Mean Temperature; Tar = Temperature Annual Range;

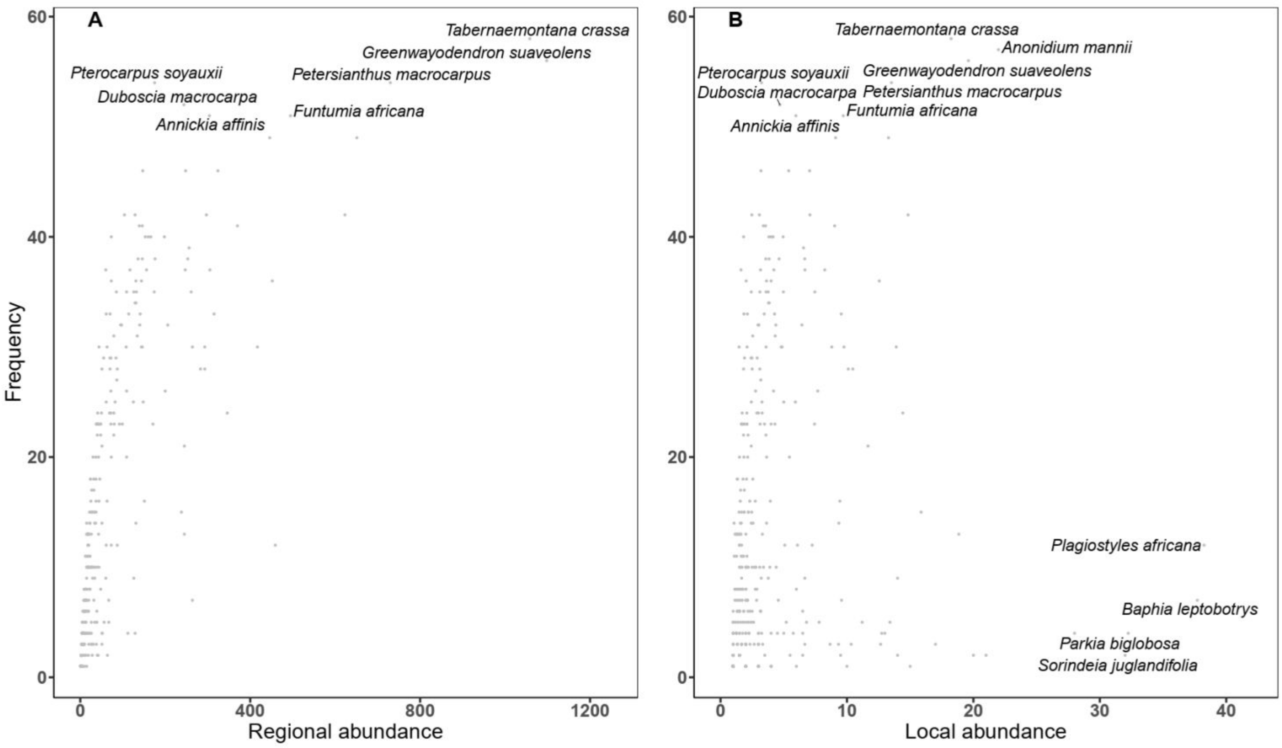
aP = Annual Precipitation; Psea = Precipitation Seasonality; mTwq & mTcq = Mean Temperature of Warmest and Coldest Quarters; Pwtq & Pdq = Precipitation of Wettest and Driest Quarters. Modscf_mean = mean of cloud frequency; Modscf_sd = standard deviation of cloud frequency. A quarter is a period of three successive months, i.e. 1/4 of the year.



Appendix S4. Regional distribution in species abundance and occurrence depicted by Non-symmetric Correspondence Analysis (NSCA; *sensu* Pélissier et al. (2003)) applied to 82 plots. NSCA based on species abundance data (A & B) and on species occurrence data (C & D). Dots of the same color denote 1-ha plots within the same locality (A & C) and sizes of circles are proportionate to species abundance for B. Only the 15 most discriminating species out of 455 are labeled for B & D to improve legibility.

Floristic composition of 82 1-ha plots

In total, 82 1-ha PSP were established within seven localities in center and eastern Cameroon (Figure 1 main text) hosting 39,942 trees with dbh ≥ 10 cm. After excluding 1024 (2.5 %) unidentified individuals and 2209 (5.5 %) individuals identified at genus level only, the final dataset comprised 37,733 trees belonging to 455 species and 257 genera, grouped in 61 families. The five most important species in terms of number of individuals were *Tabernaemontana crassa* Benth. (Apocynaceae; 1561 trees), *Greenwayodendron suaveolens* (*senso lato*) (Engl. & Diels) Verdc. (Annonaceae; 1508 trees), *Anonidium mannii* (Oliv.) Engl. & Diels (Annonaceae; 1442 trees), *Petersianthus macrocarpus* (P.Beauv.) Liben (Lecythidaceae; 870 trees) and *Strombosia grandifolia* Hook.f. ex Benth. (Olacaceae; 826 trees); together representing 16.4 % of all individuals sampled. The three most diverse families were Fabaceae (77 species), Rubiaceae (40 species) and Malvaceae (38 species).



Appendix S5. Relationship between species abundance and frequency at regional (A) and local (B) scales. X-axes denote regional abundance (i.e. number of individuals of a species across all plots (A)) and local abundance (i.e. average number of individuals of a species across all plots (B)), and Y-axis denote species frequency defined as number of plots in which the species is present (A and B). Only species with frequency more than 50 and abundance more than 1000 (30 for local abundance) individuals are labeled to improve legibility.

Supporting information to the paper

Libalah, M.B. et al. Additive influences of soil and climate gradients drives tree community composition of Central African rainforests. *Journal of Vegetation Science*

Appendix S6 Species variance partitioning test with-respect-to climate and soil gradients. Monte Carlo permutation test of significance ($P < 0.05$) are provided for each species. Species are arranged in alphabetical order and species nomenclature follows the African Plant Database (version 3.4.0) (https://www.ville-ge.ch/musinfo/bd/cjb/africa/recherche.php).

	Occurrence		Abundance			
Species	**Sig. test with Climate**	**Sig. test with Soil**	**Sig. test with Climate**	**Sig. test with Soil**	**Nº. individuals**	**Families**
Afrostyrax lepidophyllus	0.03	0.01	0.18	0	73	Huaceae
Afzelia africana	0.08	0.57	0.08	0.66	3	Fabaceae
Afzelia bipindensis	0.84	0.34	0.96	0.3	24	Fabaceae
Afzelia pachyloba	0.02	0.05	0.03	0.07	3	Fabaceae
Aidia micrantha	0.99	0.66	0.16	0.19	238	Rubiaceae
Albizia adianthifolia	0	0.31	0	0.84	108	Fabaceae
Albizia ferruginea	0.02	0.68	0.05	0.52	23	Fabaceae
Albizia glaberrima	0.04	0.24	0.02	0.31	82	Fabaceae
Albizia gummifera	0.01	0.79	0.01	0.66	6	Fabaceae
Albizia zygia	0.02	0.2	0.08	0.2	10	Fabaceae
Alchornea cordifolia	0.04	0.06	0.04	0.13	1	Euphorbiaceae
Allanblackia floribunda	0.37	0	0.41	0.02	51	Clusiaceae
Allanblackia gabonensis	0.84	0.34	0.83	0.32	1	Clusiaceae
Allanblackia kisonghi	0.34	0.11	0.33	0.18	32	Clusiaceae
Allophylus africanus	0.51	0.3	0.3	0.42	8	Sapindaceae
Alstonia boonei	0	0.23	0.37	0.44	104	Apocynaceae
Amphimas ferrugineus	0.89	0.99	0.96	0.97	6	Fabaceae

Amphimas pterocarpoides	0.17	0.74	0.31	0.8	60	Fabaceae
Angylocalyx oligophyllus	0.2	0.86	0.22	0.87	1	Fabaceae
Angylocalyx pynaertii	0.04	0.03	0.43	0.46	160	Fabaceae
Angylocalyx talbotii	0.36	0.02	0.35	0.02	1	Fabaceae
Annickia affinis	0.01	0	0.01	0.23	178	Annonaceae
Annickia chlorantha	0.47	0	0.09	0	126	Annonaceae
Anonidium mannii	0.16	0	0.7	0.04	1253	Annonaceae
Anopyxis klaineana	0.3	0.21	0.14	0.16	32	Rhizophoraceae
Anthocleista schweinfurthii	0.44	0	0.43	0	1	Gentianaceae
Anthonotha cladantha	0.02	0.22	0.11	0.06	19	Fabaceae
Anthonotha ferruginea	0.25	0.05	0.33	0.09	13	Fabaceae
Anthonotha fragrans	0.19	0.72	0.04	0.15	20	Fabaceae
Anthonotha macrophylla	0.33	0.7	0.3	0.39	166	Fabaceae
Antiaris toxicaria	0.66	0.48	0.64	0.87	5	Moraceae
Antidesma laciniatum	0.08	0.29	0.79	0.09	125	Phyllanthaceae
Antidesma membranaceum	0.02	0.77	0.87	0.34	79	Phyllanthaceae
Antidesma vogelianum	0.36	0.02	0.35	0.02	1	Phyllanthaceae
Antrocaryon klaineanum	0.97	0.16	0.59	0.27	28	Anacardiaceae
Antrocaryon micraster	0.11	0.77	0.12	0.8	1	Anacardiaceae
Aoranthe cladantha	0.48	0.61	0.54	0.48	23	Rubiaceae
Aulacocalyx jasminiflora	0.26	0.58	0.29	0.64	4	Rubiaceae
Baikiaea insignis	0.61	0.71	0.97	0.53	6	Fabaceae
Baillonella toxisperma	0.03	0.84	0.04	0.71	15	Sapotaceae
Balanites wilsoniana	0.08	0.36	0.05	0.23	4	Zygophyllaceae
Baphia leptobotrys	0.81	0.31	0.9	0.07	264	Fabaceae
Baphia nitida	0.66	0.24	0.66	0.24	1	Fabaceae
Baphia pubescens	0.15	0.16	0.08	0.37	131	Fabaceae
Barteria fistulosa	0.81	0.12	0.74	0.17	136	Passifloraceae
Beilschmiedia anacardioides	0.15	0.58	0.19	0.51	3	Lauraceae
Beilschmiedia obscura	0.01	0	0	0.06	55	Lauraceae
Berlinia grandiflora	0	0	0	0	38	Fabaceae

Blighia sapida	0.21	0.06	0.83	0.04	22	Sapindaceae
Blighia welwitschii	0.01	0.75	0.87	0.33	117	Sapindaceae
Bobgunnia fistuloides	0.48	0.29	0.45	0.3	22	Fabaceae
Bombax brevicuspe	0.03	0.27	0.37	0.98	20	Malvaceae
Bombax buonopozense	0.05	0.48	0.03	0.4	10	Malvaceae
Borassus aethiopum	0	0.03	0	0.04	2	Arecaceae
Brenania brieyi	0.63	0.19	0.6	0.27	20	Rubiaceae
Bridelia grandis	0.36	0.44	0.36	0.56	4	Phyllanthaceae
Bridelia micrantha	0.02	0.87	0	0.52	14	Phyllanthaceae
Buchholzia coriacea	0.17	0.96	0.19	0.99	1	Capparaceae
Calpocalyx dinklagei	0.2	0.45	0.27	0.14	25	Fabaceae
Canarium schweinfurtii	0.02	0.05	0.06	0.59	22	Burseraceae
Canthium rheedei	0.75	0.34	0.94	0.31	3	Rubiaceae
Carapa grandiflora	0.46	0.59	0.42	0.59	2	Meliaceae
Carapa procera	0	0.89	0.05	0.04	264	Meliaceae
Casearia aculeata	0.47	0.7	0.78	0.65	9	Salicaceae
Cassia javanica	0.01	0.49	0.02	0.54	5	Fabaceae
Cavacoa quintasii	0.27	0.46	0.32	0.49	3	Euphorbiaceae
Ceiba pentandra	0	0.98	0.01	0.92	19	Malvaceae
Celtis adolfi-friderici	0	0.18	0	0.71	293	Cannabaceae
Celtis africana	0.02	0.76	0.42	0.63	28	Cannabaceae
Celtis conferta	0.14	0.46	0.15	0.51	1	Cannabaceae
Celtis gomphophylla	0.66	0.64	0.65	0.63	2	Cannabaceae
Celtis mildbraedii	0.5	0.05	0.14	0.28	245	Cannabaceae
Celtis philippensis	0.07	0	0.21	0.13	67	Cannabaceae
Celtis tessmannii	0.31	0.12	0.07	0.02	153	Cannabaceae
Celtis zenkeri	0.06	0	0	0.08	293	Cannabaceae
Centroplacus glaucinus	0.01	0	0.01	0.12	146	Centroplacaceae
Chrysophyllum africanum	0.87	0.04	0.78	0.06	12	Sapotaceae
Chrysophyllum beguei	0.47	0.64	0.56	0.8	8	Sapotaceae
Chrysophyllum boukokoense	0	0	0	0.49	247	Sapotaceae

Chrysophyllum giganteum	0.68	0.24	0.67	0.25	2	Sapotaceae
Chrysophyllum lacourtianum	0.96	0	0.99	0.02	129	Sapotaceae
Chrysophyllum perpulchrum	0.92	0.85	0.85	0.87	3	Sapotaceae
Chrysophyllum pruniforme	0.21	0.36	0.23	0.25	12	Sapotaceae
Chrysophyllum ubanguiense	0.47	0.94	0.55	0.93	1	Sapotaceae
Citropsis articulata	0.15	0.69	0.17	0.71	3	Rutaceae
Cleistanthus itsoghensis	0.02	0.45	0.06	0.53	67	Phyllanthaceae
Cleistopholis glauca	0.74	0	0.67	0	40	Annonaceae
Cleistopholis patens	0.8	0.98	0.96	0.86	48	Annonaceae
Coelocaryon preussii	0.04	0.69	0.43	0.39	370	Myristicaceae
Cola acuminata	0.35	0.01	0.43	0.12	40	Malvaceae
Cola altissima	0.21	0.03	0.21	0.12	10	Malvaceae
Cola ballayi	0.77	0.34	0.75	0.37	2	Malvaceae
Cola chlamydantha	0.41	0.87	0.82	0.64	14	Malvaceae
Cola cordifolia	0.01	0.2	0.05	0.28	9	Malvaceae
Cola ficifolia	0.05	0.96	0.07	0.97	2	Malvaceae
Cola heterophylla	0.53	0.05	0.51	0.06	1	Malvaceae
Cola lateritia	0.04	0.02	0	0.01	198	Malvaceae
Cola nitida	0.05	0.04	0.03	0.07	51	Malvaceae
Cola reticulata	0.04	0.06	0.04	0.13	1	Malvaceae
Cola verticillata	0.26	0.19	0.17	0.69	19	Malvaceae
Cordia africana	0	0.02	0	0.02	2	Boraginaceae
Cordia aurantiaca	0.77	0.34	0.73	0.37	1	Boraginaceae
Cordia platythyrsa	0.62	0.79	0.95	0.62	19	Boraginaceae
Corynanthe pachyceras	0.01	0	0.03	0.31	253	Rubiaceae
Coula edulis	0.96	0.31	0.95	0.31	1	Olacaceae
Croton oligandrus	0.01	0.93	0.04	0.86	6	Euphorbiaceae
Croton sylvaticus	0	0.77	0	0.92	5	Euphorbiaceae
Cuviera longiflora	0.02	0.05	0.03	0.07	2	Rubiaceae
Cylicodiscus gabunensis	0	0.32	0	0.61	37	Fabaceae
Cyrtogonone argentea	0.38	0.07	0.4	0.08	2	Euphorbiaceae

Dacryodes buettneri	0.27	0.86	0.3	0.87	1	Burseraceae
Dacryodes edulis	0.75	0	0.4	0	13	Burseraceae
Dacryodes igaganga	0.06	0	0	0.01	70	Burseraceae
Dacryodes klaineana	0	0.29	0	0.32	9	Burseraceae
Daniellia ogea	0.07	0.24	0.1	0.32	1	Fabaceae
Desbordesia insignis	0	0.83	0	0.85	623	Irvingiaceae
Desplatsia dewevrei	0.26	0	0.55	0.27	146	Malvaceae
Desplatsia chrysochlamys	0.53	0.02	0.54	0.06	5	Malvaceae
Detarium macrocarpum	0.82	0.75	0.2	0.32	30	Fabaceae
Dialium angolense	0.45	0.02	0.92	0.1	11	Fabaceae
Dialium bipindense	0.02	0.1	0.01	0.12	72	Fabaceae
Dialium dinklagei	0.63	0.49	0.43	0.49	7	Fabaceae
Dialium guineense	0.87	0.38	0.87	0.27	34	Fabaceae
Dichrostachys cinerea	0.2	0.66	0.23	0.68	2	Fabaceae
Dictyandra arborescens	0.01	0.85	0.3	0.97	15	Rubiaceae
Diospyros bipindensis	0.01	0.2	0.31	0.84	73	Ebenaceae
Diospyros canaliculata	0.02	0.05	0.03	0.07	15	Ebenaceae
Diospyros cinnabarina	0.19	0.58	0.22	0.82	9	Ebenaceae
Diospyros conocarpa	0.25	0.67	0.29	0.73	2	Ebenaceae
Diospyros crassiflora	0.42	0.01	0.44	0.03	18	Ebenaceae
Diospyros dendo	0.04	0.21	0.09	0.38	6	Ebenaceae
Diospyros heudelotii	0.59	0.8	0.63	0.83	1	Ebenaceae
Diospyros hoyleana	0.06	0.07	0.1	0.07	22	Ebenaceae
Diospyros iturensis	0.53	0.07	0.18	0.08	3	Ebenaceae
Diospyros mannii	0.25	0.17	0.27	0.18	3	Ebenaceae
Diospyros monbuttensis	0	0	0	0.01	3	Ebenaceae
Diospyros preussii	0.24	0.81	0.3	0.76	4	Ebenaceae
Diospyros sanza-minika	0	0.04	0	0.06	2	Ebenaceae
Diospyros suaveolens	0.06	0.58	0.14	0.6	52	Ebenaceae
Diospyros zenkeri	0.19	0.44	0.25	0.56	1	Ebenaceae
Discoglypremna caloneura	0.6	0.09	0.67	0.13	43	Euphorbiaceae

Distemonanthus benthamianus	0.1	0	0.39	0.06	48	Fabaceae
Dovyalis zenkeri	0.09	0.99	0.05	0.99	7	Salicaceae
Dracaena arborea	0.71	0.09	0.7	0.09	5	Asparagaceae
Drypetes chevalieri	0.94	0.66	0.81	0.96	3	Putranjivaceae
Drypetes gossweileri	0.95	0.71	0.9	0.77	28	Putranjivaceae
Drypetes klainei	0.11	0.2	0	0.15	39	Putranjivaceae
Drypetes laciniata	0.51	0.12	0.47	0.16	5	Putranjivaceae
Drypetes leonensis	0.37	0	0.13	0.23	131	Putranjivaceae
Drypetes preussii	0.15	0.01	0.5	0.53	79	Putranjivaceae
Duboscia macrocarpa	0.66	0	0.03	0.13	244	Malvaceae
Duguetia staudtii	0.36	0	0.01	0.34	73	Annonaceae
Empogona crepiniana	0.44	0	0.43	0	1	Rubiaceae
Endodesmia calophylloides	0.47	0.25	0.34	0.2	3	Calophyllaceae
Entandrophragma angolense	0.77	0.92	0.68	0.75	13	Meliaceae
Entandrophragma candollei	0.31	0.8	0.23	0.62	38	Meliaceae
Entandrophragma congoense	0.02	0.46	0.05	0.55	9	Meliaceae
Entandrophragma cylindricum	0.26	0.07	0.8	0.28	85	Meliaceae
Entandrophragma utile	0.17	0.64	0.26	0.7	3	Meliaceae
Eribroma oblongum	0.13	0.37	0.15	0.08	37	Malvaceae
Eriocoelum macrocarpum	0.72	0.05	0.5	0.03	26	Sapindaceae
Eriocoelum oblongum	0.59	0.46	0.55	0.56	13	Sapindaceae
Erismadelphus exsul	0.39	0.81	0.08	0.97	11	Vochysiaceae
Erythrina excelsa	0.2	0.29	0.26	0.88	9	Fabaceae
Erythrophleum ivorense	0.97	0.09	0.92	0.26	15	Fabaceae
Erythrophleum suaveolens	0.29	0.01	0.95	0.17	73	Fabaceae
Erythroxylum mannii	0.02	0.1	0.04	0.14	8	Erythroxylaceae
Euphorbia drupifera	0.55	1	0.55	1	4	Euphorbiaceae
Fernandoa adolfi-friderici	0.02	0.02	0.19	0.53	46	Bignoniaceae
Fernandoa ferdinandi	0.4	0.24	0.38	0.33	5	Bignoniaceae
Ficus exasperata	0	0.09	0.02	0.13	11	Moraceae
Ficus mucuso	0.32	0.3	0.24	0.3	11	Moraceae

Ficus variifolia	0	0.02	0	0.02	1	Moraceae
Fillaeopsis discophora	0.15	0.69	0.17	0.71	1	Fabaceae
Fleroya ledermannii	0.63	0.33	0.65	0.39	1	Rubiaceae
Funtumia africana	0.22	0.03	0	0.31	495	Apocynaceae
Funtumia elastica	0.03	0.02	0.09	0.04	12	Apocynaceae
Garcinia epunctata	0.59	0.73	0.44	0.44	11	Clusiaceae
Garcinia kola	0.8	0.37	0.84	0.59	4	Clusiaceae
Garcinia mannii	0.9	0.06	0.92	0.07	43	Clusiaceae
Garcinia ovalifolia	0	0.02	0	0.02	1	Clusiaceae
Garcinia staudtii	0.27	0.86	0.3	0.87	1	Clusiaceae
Gilbertiodendron brachystegioides	0.7	0.94	0.73	0.94	1	Fabaceae
Gilletiodendron pierreanum	0.35	0.04	0.36	0.06	13	Fabaceae
Glyphaea brevis	0.05	0.35	0.01	0.8	33	Malvaceae
Greenwayodendron suaveolens	0	0	0	0	1098	Annonaceae
Grewia coriacea	0.99	0.89	0.81	0.75	5	Malvaceae
Grossera macrantha	0.07	0.24	0.1	0.32	10	Euphorbiaceae
Harungana madagascariensis	0.15	0.69	0.17	0.71	1	Hypericaceae
Heisteria parvifolia	0	0.06	0	0.4	346	Olacaceae
Heisteria trillesiana	0.29	0	0.27	0	26	Olacaceae
Heisteria zimmereri	0.32	0.14	0.31	0.2	9	Olacaceae
Hexalobus crispiflorus	0.04	0.76	0.19	0.86	84	Annonaceae
Holoptelea grandis	0.06	0.64	0.07	0.72	15	Ulmaceae
Homalium laurentii	0.24	0.26	0.26	0.28	1	Salicaceae
Homalium le-testui	0.03	0.02	0.38	0.17	72	Salicaceae
Homalium longistylum	0.17	0.61	0.19	0.6	6	Salicaceae
Hylodendron gabunense	0.41	0.24	0.89	0.5	324	Fabaceae
Hymenocardia heudelotii	0.09	0.35	0.11	0.45	3	Phyllanthaceae
Hymenocardia lyrata	0.93	0.22	0.81	0.91	9	Phyllanthaceae
Irvingia excelsa	0	0.85	0	0.84	114	Irvingiaceae
Irvingia gabonensis	0.57	0.02	0.42	0.04	8	Irvingiaceae
Irvingia grandifolia	0.02	0.82	0.05	0.96	44	Irvingiaceae

Irvingia robur	0.02	0.18	0.07	0.16	37	Irvingiaceae
Irvingia smithii	0.24	0.26	0.26	0.28	1	Irvingiaceae
Isolona hexaloba	0.26	0.98	0.17	0.99	6	Annonaceae
Isolona thonneri	0.2	0.65	0.23	0.68	2	Annonaceae
Keayodendron bridelioides	0.61	0.03	0.16	0.04	126	Phyllanthaceae
Khaya anthotheca	0.01	0.64	0.01	0.69	16	Meliaceae
Khaya grandifoliola	0.29	0.66	0.62	0.57	8	Meliaceae
Khaya ivorensis	0	0	0	0	10	Meliaceae
Kigelia africana	0.02	0.05	0.03	0.07	2	Bignoniaceae
Klaineanthus gabonii	0.03	0.01	0.07	0.03	20	Euphorbiaceae
Klainedoxa gabonensis	0.31	0.79	0.04	0.61	147	Irvingiaceae
Laccodiscus pseudostipularis	0.29	0.54	0.31	0.49	5	Sapindaceae
Lannea welwitschii	0.12	0.61	0.88	0.51	38	Anacardiaceae
Lasiodiscus fasciculiflorus	0.17	0.96	0.19	0.99	1	Rhamnaceae
Lasiodiscus mannii	0.06	0.16	0.17	0.08	44	Rhamnaceae
Lasiodiscus marmoratus	0.67	0.72	0.52	0.77	14	Rhamnaceae
Lecaniodiscus cupanioides	0.18	0.01	0.38	0.07	131	Sapindaceae
Leonardoxa africana	0.1	0.96	0.11	0.96	1	Fabaceae
Lepidobotrys staudtii	0	0	0.13	0.08	97	Lepidobotryaceae
Leplaea cedrata	0.41	0	0.21	0	95	Meliaceae
Leplaea thompsonii	0.53	0	0.09	0	146	Meliaceae
Leptactina involucrata	0.04	0.06	0.04	0.13	1	Rubiaceae
Letestua durissima	0.53	0.05	0.51	0.06	1	Sapotaceae
Lovoa trichilioides	0.29	0.36	0.03	0.31	72	Meliaceae
Macaranga barteri	0.18	0.33	0.67	0.69	134	Euphorbiaceae
Macaranga hurifolia	0.27	0.86	0.3	0.87	3	Euphorbiaceae
Macaranga monandra	0.7	0.04	0.23	0.08	9	Euphorbiaceae
Macaranga spinosa	0.7	0.18	0.02	0.94	176	Euphorbiaceae
Maesobotrya griffoniana	0.77	0.5	0.67	0.67	15	Phyllanthaceae
Maesobotrya klaineana	0	0.02	0	0.31	63	Phyllanthaceae
Maesopsis eminii	0.44	0.67	0.91	0.77	16	Rhamnaceae

Majidea forsteri	0	0.66	0	0.55	31	Sapindaceae
Mallotus oppositifolius	0.04	0.68	0.25	0.63	34	Euphorbiaceae
Mammea africana	0.04	1	0.2	0.61	25	Calophyllaceae
Manilkara obovata	0	0.04	0.04	0.11	40	Sapotaceae
Mansonia altissima	0	0.05	0	0.36	171	Malvaceae
Maprounea membranacea	0	0.04	0.03	0.06	42	Euphorbiaceae
Maranthes chrysophylla	0.12	0.55	0.16	0.55	5	Chrysobalanaceae
Maranthes glabra	0.01	0.18	0.03	0.13	69	Chrysobalanaceae
Mareyopsis longifolia	0	0.08	0.37	0.29	99	Euphorbiaceae
Margaritaria discoidea	0.08	0.43	0.23	0.97	48	Phyllanthaceae
Markhamia lutea	0	0	0	0.02	126	Bignoniaceae
Markhamia tomentosa	0.13	0.42	0.72	0.14	61	Bignoniaceae
Massularia acuminata	0.69	0.86	0.8	0.97	15	Rubiaceae
Meiocarpidium lepidotum	0.16	0.43	0.23	0.31	7	Annonaceae
Memecylon aberrans	0.32	0.84	0.39	0.81	3	Melastomataceae
Memecylon amshoffae	0.41	0.56	0.48	0.65	1	Melastomataceae
Microdesmis puberula	0.62	0.33	0.64	0.94	23	Pandaceae
Mildbraediodendron excelsum	0.26	0.58	0.29	0.64	1	Fabaceae
Milicia excelsa	0	0.01	0	0.04	51	Moraceae
Millettia barteri	0.7	0.15	0.66	0.16	12	Fabaceae
Millettia laurentii	0.85	0.38	0.84	0.37	2	Fabaceae
Millettia mannii	0.36	0.9	0.55	0.06	60	Fabaceae
Millettia sanagana	0.09	0.63	0.23	0.39	61	Fabaceae
Monodora myristica	0.57	0.51	0.76	0.55	9	Annonaceae
Monodora tenuifolia	0.04	0.24	0.54	0.47	36	Annonaceae
Morinda lucida	0.29	0.82	0.32	0.82	2	Rubiaceae
Morus mesozygia	0.13	0.33	0.24	0.42	3	Moraceae
Musanga cecropioides	0.19	0.11	0.9	0.18	417	Urticaceae
Myrianthus arboreus	0.18	0.43	0.29	0.53	139	Urticaceae
Myrianthus preussii	0.78	0.05	0.81	0.05	6	Urticaceae
Nauclea diderrichii	0.33	0.56	0.16	0.32	20	Rubiaceae

Neoboutonia mannii	0	0.02	0	0.02	1	Euphorbiaceae
Nesogordonia kabingaensis	0.55	0.01	0.49	0.17	87	Malvaceae
Nesogordonia papaverifera	0.02	0.05	0.03	0.07	1	Malvaceae
Newtonia duparquetiana	0.7	0.94	0.73	0.94	1	Fabaceae
Newtonia glandulifera	0.41	0.56	0.48	0.65	1	Fabaceae
Newtonia griffoniana	0.37	0.97	0.54	0.91	3	Fabaceae
Ochna afzelii	0.28	0.88	0.2	0.15	14	Ochnaceae
Ochna calodendron	0.25	0.53	0.15	0.69	6	Ochnaceae
Octolobus spectabilis	0.59	0.8	0.58	0.79	4	Malvaceae
Olax subscorpioides	0	0	0	0	112	Olacaceae
Omphalocarpum elatum	0.95	0.17	0.9	0.27	21	Sapotaceae
Omphalocarpum procerum	0.01	0.63	0.12	0.63	8	Sapotaceae
Oncoba dentata	0	0	0	0	29	Salicaceae
Oncoba gilgiana	0.2	0.66	0.23	0.68	1	Salicaceae
Oncoba glauca	0.28	0	0.11	0.01	148	Salicaceae
Oncoba mannii	0.07	0.24	0.1	0.32	1	Salicaceae
Oncoba welwitschii	0.38	0.33	0.65	0.34	9	Salicaceae
Ongokea gore	0	0.01	0	0.05	51	Olacaceae
Oubanguia africana	0.79	0.24	0.89	0.29	1	Lecythidaceae
Pachyelasma tessmannii	0.08	0.26	0.18	0.02	8	Fabaceae
Pancovia laurentii	0.07	0.04	0.01	0.46	283	Sapindaceae
Pancovia pedicellaris	0.86	0.13	0.85	0.13	1	Sapindaceae
Panda oleosa	0	0.05	0	0.12	140	Pandaceae
Parinari excelsa	0.01	0.36	0.07	0.6	43	Chrysobalanaceae
Parkia bicolor	0.94	0.13	0.98	0.1	9	Fabaceae
Parkia biglobosa	0	0	0	0.03	129	Fabaceae
Parkia filicoidea	0	0.82	0.02	0.8	15	Fabaceae
Paropsia grewioides	0.44	0	0.43	0	3	Passifloraceae
Pauridiantha floribunda	0.79	0.34	0.72	0.18	6	Rubiaceae
Pausinystalia macroceras	0	0.1	0.01	0.03	206	Rubiaceae
Pentaclethra eetveldeana	0.61	0.62	0.61	0.63	1	Fabaceae

Pentaclethra macrophylla	0	0.25	0	0.03	261	Fabaceae
Persea americana	0.36	0.68	0.4	0.71	3	Lauraceae
Petersianthus macrocarpus	0.06	0	0.17	0.1	730	Lecythidaceae
Phoenix reclinata	0	0	0.04	0.07	28	Arecaceae
Phyllocosmus africanus	0.12	0	0.05	0.23	174	Ixonanthaceae
Phyllocosmus calothyrsus	0.23	0.09	0.37	0.07	3	Ixonanthaceae
Picralima nitida	0.38	0.43	0.25	0.61	63	Apocynaceae
Pierreodendron africanum	0.02	0.05	0.03	0.07	3	Simaroubaceae
Pinacopodium congolense	0.27	0.86	0.3	0.87	1	Erythroxylaceae
Piptadeniastrum africanum	0.04	0.96	0	0.84	144	Fabaceae
Piptocarpha riedelii	0.25	0.18	0.25	0.21	1	Compositae
Pittosporum viridiflorum	0.08	0.06	0.11	0.11	4	Pittosporaceae
Plagiostyles africana	0	0.8	0.01	0.66	459	Euphorbiaceae
Poga oleosa	0.34	0.05	0.39	0.04	13	Anisophylleaceae
Pouteria alnifolia	0	0.08	0	0.02	39	Sapotaceae
Pouteria altissima	0.01	0.64	0.06	0.7	44	Sapotaceae
Pouteria pierrei	0.63	0.33	0.65	0.39	1	Sapotaceae
Premna angolensis	0.15	0.69	0.17	0.71	1	Lamiaceae
Pseudospondias microcarpa	0.71	0	0.72	0.1	61	Anacardiaceae
Psydrax arnoldiana	0.26	0.58	0.29	0.64	1	Rubiaceae
Psydrax subcordata	0.14	0.51	0.18	0.54	16	Rubiaceae
Pteleopsis hylodendron	0.06	0.52	0.11	0.32	48	Combretaceae
Pterocarpus mildbraedii	0.71	0.15	0.47	0.37	14	Fabaceae
Pterocarpus soyauxii	0.04	0	0.39	0.15	175	Fabaceae
Pterygota bequaertii	0.01	0.07	0.01	0.07	5	Malvaceae
Pterygota macrocarpa	0.66	0.54	0.57	0.51	14	Malvaceae
Pycnanthus angolensis	0.04	0	0.51	0.25	243	Myristicaceae
Quassia gabonensis	0.93	0.03	0.75	0.06	37	Simaroubaceae
Quassia undulata	0.04	0.06	0.04	0.13	1	Simaroubaceae
Radlkofera calodendron	0.63	0.33	0.65	0.39	1	Sapindaceae
Rauvolfia caffra	0.02	0.58	0.03	0.63	9	Apocynaceae

Rauvolfia vomitoria	0.26	0.3	0.46	0.26	27	Apocynaceae
Ricinodendron heudelotii	0.11	0.01	0.01	0.14	50	Euphorbiaceae
Rinorea cuspa	0.62	0.29	0.8	0.4	18	Violaceae
Rinorea dentata	0.94	0.26	0.84	0.15	23	Violaceae
Rinorea grandifolia	0.12	0.23	0.15	0.33	2	Violaceae
Rinorea leiophylla	0.24	0.03	0.33	0.14	26	Violaceae
Rinorea oblongifolia	0.96	0.38	0.75	0.99	109	Violaceae
Rothmannia hispida	0.94	0.32	0.82	0.3	5	Rubiaceae
Rothmannia lujae	0.43	0.07	0.15	0.02	132	Rubiaceae
Rothmannia talbotii	0.56	0.5	0.59	0.48	2	Rubiaceae
Sacoglottis gabonensis	0.18	0.08	0.24	0.06	5	Humiriaceae
Santiria trimera	0.01	0	0.01	0.28	446	Burseraceae
Scottellia klaineana	0.56	0.16	0.11	0.26	41	Achariaceae
Shirakiopsis elliptica	0.2	0.17	0.4	0.14	17	Euphorbiaceae
Sloetiopsis usambarensis	0.22	0.63	0.3	0.97	87	Moraceae
Sorindeia africana	0.36	0.02	0.35	0.02	1	Anacardiaceae
Sorindeia grandifolia	0.22	0.4	0.03	0.28	248	Anacardiaceae
Sorindeia juglandifolia	0	0	0	0.02	64	Anacardiaceae
Spathodea campanulata	1	0.22	0.99	0.26	2	Bignoniaceae
Spondias cytherea	0.08	0.06	0.11	0.11	1	Anacardiaceae
Spondias mombin	0	0.04	0.02	0.07	28	Anacardiaceae
Staudtia kamerunensis	0.03	0.03	0.13	0.6	297	Myristicaceae
Sterculia micrantha	0.34	0.92	0.19	0.76	11	Malvaceae
Sterculia rhinopetala	0	0.26	0.01	0.46	245	Malvaceae
Sterculia tragacantha	0.04	0	0	0.01	129	Malvaceae
Strephonema pseudocola	0.31	0.14	0.23	0.4	12	Combretaceae
Strephonema sericeum	0.49	0.6	0.5	0.68	1	Combretaceae
Strombosia grandifolia	0	0.04	0	0.42	651	Olacaceae
Strombosia pustulata	0.51	0.06	0.56	0.07	7	Olacaceae
Strombosia scheffleri	0.8	0.56	0.66	0.18	8	Olacaceae
Strombosia zenkeri	0.5	0.16	0.46	0.15	2	Olacaceae

Strombosiopsis tetrandra	0	0.54	0	0.38	256	Olacaceae
Strychnos staudtii	0.69	0.98	0.73	0.98	2	Loganiaceae
Symphonia globulifera	0.17	0.18	0.28	0.85	33	Clusiaceae
Synsepalum dulcificum	0.55	0.1	0.31	0.1	86	Sapotaceae
Syzygium guineense	0	0.04	0.04	0.09	19	Myrtaceae
Syzygium rowlandii	0.35	0.01	0.04	0.07	12	Myrtaceae
Tabernaemontana crassa	0.11	0	0.7	0.13	1058	Apocynaceae
Terminalia superba	0.1	0.44	0.83	0.28	156	Combretaceae
Tessmannia africana	0.14	0	0.1	0	18	Fabaceae
Tessmannia anomala	1	0.74	0.89	0.75	25	Fabaceae
Tetrapleura tetraptera	0.63	0.84	0.68	0.63	70	Fabaceae
Tetrorchidium didymostemon	0.91	0.33	0.79	0.06	19	Euphorbiaceae
Tetrorchidium oppositifolium	0.77	0.34	0.75	0.37	1	Euphorbiaceae
Thomandersia hensii	0.66	0.64	0.65	0.63	2	Thomandersiaceae
Treculia africana	0.36	0.73	0.77	0.14	92	Moraceae
Treculia obovoidea	0.08	0.55	0.3	0.55	51	Moraceae
Trema orientalis	0.16	0.64	0.21	0.54	3	Cannabaceae
Tricalysia discolor	0.72	0.05	0.7	0.06	2	Rubiaceae
Tricalysia pangolina	0.05	0.55	0.03	0.6	39	Rubiaceae
Trichilia dregeana	0.09	0.06	0.12	0.07	56	Meliaceae
Trichilia prieuriana	0.46	0.01	0	0.11	315	Meliaceae
Trichilia rubescens	0.01	0.24	0	0.03	109	Meliaceae
Trichilia tessmannii	0.58	0.01	0.1	0.43	109	Meliaceae
Trichilia welwitschii	0.01	0	0.49	0.11	305	Meliaceae
Trichoscypha acuminata	0	0.34	0.02	0.01	141	Anacardiaceae
Trichoscypha arborea	0.11	0	0.1	0.03	17	Anacardiaceae
Trichoscypha oddonii	0.01	0.61	0.1	0.88	26	Anacardiaceae
Tridesmostemon omphalocarpoides	0.69	0.64	0.17	0.66	27	Sapotaceae
Trilepisium madagascariense	0	0.01	0	0.01	200	Moraceae
Triplochiton scleroxylon	0.22	0.22	0.36	0.51	151	Malvaceae

Turraeanthus africana	0	0.8	0.02	0.9	34	Meliaceae
Uapaca acuminata	0.53	0.02	0.64	0.04	20	Phyllanthaceae
Uapaca guineensis	0.01	0.7	0.16	0.1	452	Phyllanthaceae
Uapaca heudelotii	0.11	0.54	0.27	0.61	31	Phyllanthaceae
Uapaca paludosa	0.35	0.04	0.23	0	144	Phyllanthaceae
Uapaca staudtii	0.02	0.12	0.28	0.29	34	Phyllanthaceae
Uapaca vanhouttei	0.16	0.11	0.5	0.05	20	Phyllanthaceae
Usteria guineensis	0.41	0.56	0.48	0.65	1	Loganiaceae
Uvariastrum pierreanum	0.51	0.01	0.75	0.15	43	Annonaceae
Uvariastrum zenkeri	0.24	0.27	0.02	0.23	18	Annonaceae
Uvariopsis bakeriana	0.02	0.05	0.03	0.07	1	Annonaceae
Vepris louisii	0.61	0.28	0.48	0.64	21	Rutaceae
Vitex dentata	0.08	0.06	0.11	0.11	2	Lamiaceae
Vitex doniana	0	0	0	0	20	Lamiaceae
Vitex grandifolia	0.92	0	0.87	0	18	Lamiaceae
Vitex rivularis	0.01	0	0.01	0.03	70	Lamiaceae
Voacanga africana	0	0.51	0.06	0.5	16	Apocynaceae
Xylopia aethiopica	0.44	0.64	0.06	0.12	80	Annonaceae
Xylopia aurantiiodora	0.06	0.1	0.03	0.17	39	Annonaceae
Xylopia hypolampra	0.12	0.2	0.36	0.27	32	Annonaceae
Xylopia parviflora	0	0.84	0.01	0.21	6	Annonaceae
Xylopia quintasii	0.02	0.89	0.08	0.34	72	Annonaceae
Xylopia rubescens	0.41	0.02	0.75	0.12	5	Annonaceae
Xylopia staudtii	0.87	0.04	0.89	0.07	24	Annonaceae
Zanthoxylum gilletii	0.25	0.38	0.43	0.28	79	Rutaceae
Zanthoxylum heitzii	0.73	0	0.75	0.01	5	Rutaceae
Zanthoxylum leprieurii	0.01	0.61	0.06	0.48	16	Rutaceae
Zanthoxylum rubescens	0.25	0.18	0.25	0.21	4	Rutaceae