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TREE DIVERSITY PATTERNS, ABOVE-GROUND BIOMASS AND CARBON ASSESSMENT ALONG ELEVATIONAL GRADIENT IN A TROPICAL FOREST OF THE CAMEROON VOLCANIC LINE

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Abstract

Tropical forests ecosystems remain the most diverse on the planet, and store considerable amounts of biomass and carbon. Despite the importance of tropical forests, sizable knowledge gaps exist regarding species diversity, plant biomass and carbon. These knowledge gaps are particularly large in tropical systems, and even more so in the African tropics. This study provides baseline data on species composition and vegetation structure, and evaluate variation along elevational gradient transecting of four elevation-forest types: lowland, mid-elevation, sub-montane and montane forest in the Rumpi Hills Forest Reserve of Cameroon. We collected data on tree species diversity, above-ground biomass and carbon in 25 1-ha plots sampled in 500 m long x 20 m width transect. Results revealed high species diversity, particularly in lowland forest. Overall, the study enumerated 12,037 individuals (trees ≥ 10 cm dbh) of 441 species. The mean species per plot decreased with increasing elevation, 112 in lowland, 81 in mid-elevation, 60 in submontane and 38 in montane forest. Above-ground carbon averaged 162.88±50 t ha^{-1}. We found the greatest carbon storage and tree and liana species diversity at low elevations. Our results indicate that high species diversity and occurrence of larger tree species are more important in carbon storage in lowland forest than at higher elevations. These findings are useful for management and land use planning of the forests in the Rumpi Hills Forest Reserve.

Key words: Carbon, Lowland, Montane ecosystem, Tropical forest, Rumpi Hills Forest Reserve.

Introduction

Terrestrial forest ecosystems remain major carbon sinks, and hold huge stocks of biomass. They mitigate climate change through sequestration of carbon in vegetation biomass (Haggar *et al.,* 2013). The vegetation gains carbon from productivity investment in plant growth and loses carbon through aging, mortality, harvest, etc. (Myneni *et al.,* 2001). Although tropical forests have high carbon storage capacity (Pan *et al.,* 2011; Reich, 2011), they are threatened by anthropogenic activities such as deforestation, farming and urbanization. However, major knowledge gaps in tropical forest dynamics and ecology exist. These gaps may hinder reliable predictions of forest responses to global change and development of efficient management strategies to minimize anthropogenic threats and optimize carbon storage capacity of forests (Zuidema *et al.,* 2013).

Empirical findings pertaining to tropical forest ecology have revealed that biodiversity correlates broadly with above-ground biomass and carbon stocks in forests (Umunay *et al.,* 2017), and that species diversity declines along elevational gradients (Asase *et al.,* 2012; Day *et al.,* 2013; Poorter *et al.,* 2015; Imani *et al.,* 2017; Cuni-Sanchez *et al.,* 2017). Relationships between elevational gradients and carbon should be straightforward, but recent studies have revealed that it is not (Lee & Chun, 2016). Different elevational patterns of diversity have been documented, including hump-shaped, reversed hump-shaped, increasing multimodal relationships and no relationship at all (Lee & Chun, 2016, Fadrique & Homeier, 2016). In a recent study in tropical montane forests in southern Ecuador, decrease in biomass of lianas with elevation and host trees was reported (Fadrique & Homeier, 2016).

To fill these knowledge gaps and to provide additional points of information from the African tropics, we carried out measurements of biomass and carbon, tree species, tree sizes and tree densities along an elevational gradient in the Rumpi Hills Forest Reserve. The Rumpi Hills Forest Reserve is a protected tropical rainforest that is rich in endemic tree species; it is also relatively intact and understudied, and thus is an ideal choice for our investigation. The aim of this study is to establish baseline data on species composition and vegetation structure and to evaluate above-ground biomass and carbon. The present data can address questions that relate species biodiversity, elevation and carbon in the diverse and unstudied tropical forests in Cameroon.

Materials and Methods

Study sites: Our study area was in the Rumpi Hills Forest Reserve (RHFR) in Ndian Division, South West Region of Cameroon (Beckline *et al.,* 2018), stretching across latitudes 4.6-5.0°N and longitudes 8.8-9.4°E, with an elevational range of 50-1778 m. It covers an area of 453 km^2 (Sainge, 2017). The annual rainfall at the nearby village of Dikome Balue is 4933 mm, with August being the wettest month and December the driest (Thomas, 1996; Wright & Priston, 2010). A mean temperature of 22°C is reported for the reserve (Nembot & Tchanou, 1998).

The study area was stratified into four vegetation communities (Letouzey, 1985), namely lowland evergreen rainforest, mid-elevation evergreen forest, submontane forest and montane cloud forest. The lowland forest covers the southern and part of the northeastern sections of the reserve, with an approximate extent of 185 km^2 at elevations of 50-300 m and 12 one-hectare plots were established. The mid-elevation evergreen forest covers the northern part of the reserve (ca. 133 km^2), at elevations of 300-800 m; eight one-hectare plots were established. Submontane forest occurs in the central, northeastern and eastern sectors of the reserve, with an extent of ca. 132 km^2 at elevations of 800-1600; three one-hectare plots were established. Finally, the montane cloud forest was in the eastern part of the reserve near Dikome Balue village with an extent of ca. 3 km^2 at elevations of 1600-1778 m; two one-hectare plots were established (Fig. 1). Administratively, the montane cloud forest (1600-1778 m, at Mt Rata) falls outside of the Reserve, but it is a unique element in this montane system and was included in this study.

Field sampling: In all, twenty-five 1-ha plots were sampled between February and June 2015 in the four forest types. All stems (lianas and trees) ≥10 cm were measured. Precise GPS coordinates and elevations were recorded at the beginning of each plot to assure repeatable plot locations; these coordinates are available in tabular form at http://hdl.handle.net/1808/25180.

Plots comprising of 500 x 20 m transects were sub-divided into 25 quadrats of 20 x 20 m. In mountainous areas, plots were purposefully located to contain 25 quadrats of 20 x 20 m (Gary, 1995). Twenty-five plots were sampled for all trees and lianas ≥10 cm dbh. Information on vegetation, diameter at breast height, habitat, and species identification of morphospecies was recorded in the field. All live trees and lianas with dbh ≥10 cm were measured using a diameter tape, tagged using tree tag numbers and nails, and identified. Voucher specimens were collected for all morphospecies. A non-destructive method was used to estimate above-ground biomass, and carbon stock, to diameter at breast height, and wood specific density (WD). Plot data were used to estimate above-ground biomass, and carbon using the allometric equation of Chave *et al.*, 2015. The height of each individual tree was calculated (Djomo *et al.*, 2016; Sanogo *et al.*, 2016). Wood specific density (WSD) was assembled from the global wood density database (Zanne *et al.*, 2009) and the African wood density database (Carsan *et al.*, 2012). We assumed a carbon to biomass ratio of 0.5 (Hurtt *et al.*, 2004) for every individual tree, including for multiple stems. These values were summarized by plot and by forest type (Losi *et al.*, 2003). Observational data were collected within our broader survey area, representing individuals with flowers or fruits, and particularly species that were not recorded in the general plot census. Plots were not established at 600-1200 m a portion of the submontane forest type due to time constraint and accessibility.

The mean wood density of species (Wade *et al.*, 2010) in this study was 0.63 g cm^{-3} ranging from 0.21 g cm^{-3} to 0.96 g cm^{-3} (Djuikouo *et al.*, 2010) Within the entire data set, 78.7% of species had WSD ranging from >0.5 to 0.8 g cm^{-3}, (Annighöfer, 2012) 12.3% had densities 0.21-0.5 g cm^{-3} and 9% >0.8 g cm^{-3}.

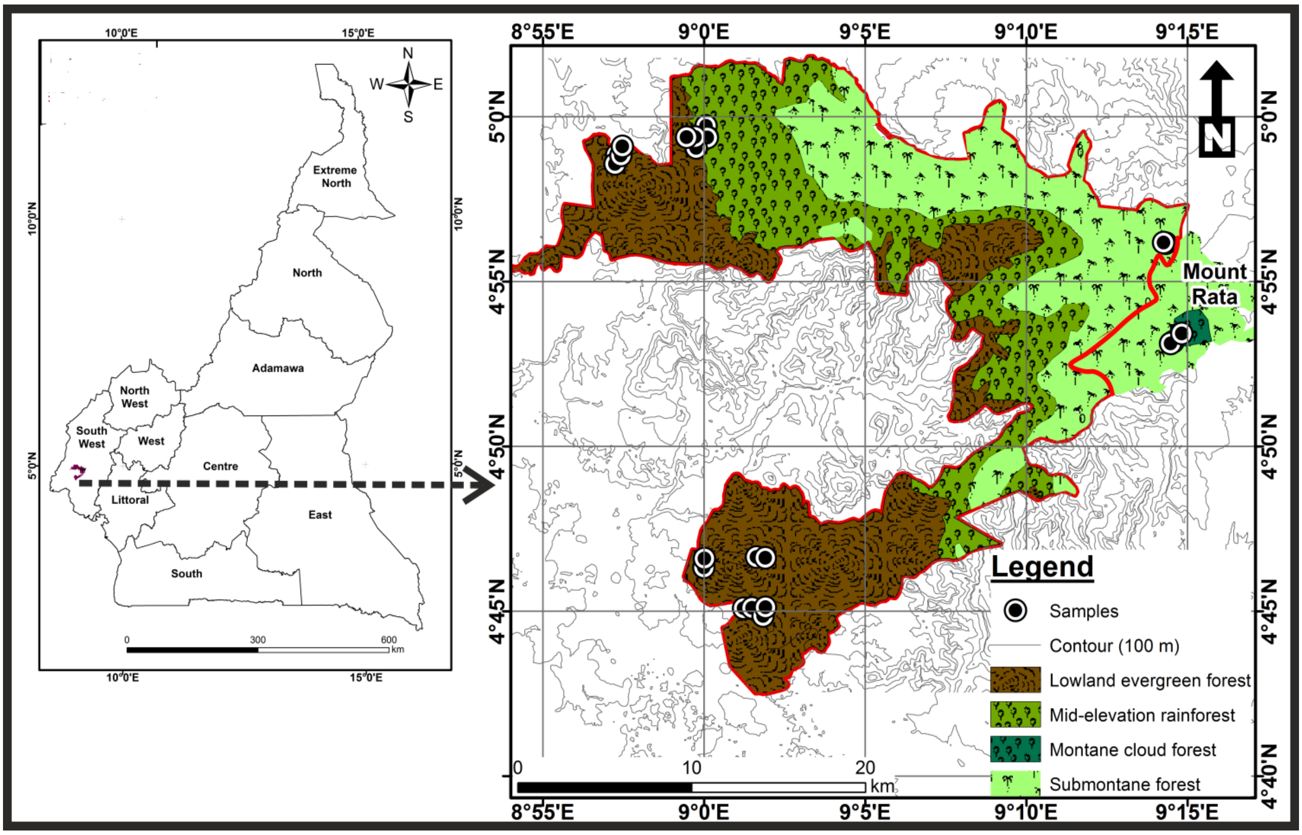

Fig. 1. Sample points and four plant communities at the Rumpi Hills Forest Reserve, Cameroon.

Data analysis: Identification of specimens were carried out at the National Herbarium of Cameroon (YA) by matching specimens collected with existing herbarium sheets, and by consulting floras, published documents, and keys for the plants of the region (Hutchinson & Dalziel, 1954, 1958, 1963; Vivien & Faure, 1985; Keay, 1989; Thomas *et al.,* 2003; Cheek *et al.,* 2004; Harvey *et al.,* 2004; Harvey *et al.,* 2010; Onana, 2011, 2013). The final checklist was consolidated following the Angiosperm Phylogeny Group (APG III, 2009; Petersen *et al.,* 2015) classification (Judd *et al.,* 1999; Angiosperm Phylogeny Group (APG III, 2009); Gastauer *et al.,* 2012.

Basal area, relative dominance, relative density, relative frequency was calculated using the formulas below (Equation 1). Fisher's alpha, Shannon-Wiener index (H'), and Simpson index (Ewango *et al.,* 2015) were used as indices to compare species diversity among plant forms and elevations using the software package PAST version 2.17 (Hammer *et al.,* 2001; Bakke *et al.,* 2015). Fisher's alpha was not calculated for lianas in montane forest because the values were too low. The distribution of variation in tree species diversity and carbon per hectare in different forest types was analysed using analysis of variance (ANOVA). The data were converted to binomials (0 and 1) and correspondent analysis (CA) was performed to establish the relationship among elevation, species diversity and carbon. Regression analysis was conducted with the aid of PAST version 2.17.

Above-ground biomass and carbon (Udawatta & Jose, 2011) were estimated for trees (dbh ≥10 cm) across forest types using the allometric equation of Chave *et al.,* 2015 and tree height was estimated following Djomo *et al.,* (2016).

Eq. (1) Basal Area (BA) = Area occupied by plant at breast height (Valencia & Jorgensen, 1992).
(BA) = p_i*(1/2dbh)^2 = p_i*(dbh)^2/4. Basal area is the area occupied by a species (Srinivasa Rao & Narasimha Rao, 2015).

Eq (2) $$\text{Relative dominance} = \frac{\text{Basal area of species}}{\text{Basal area of all species}} \times 100$$

Eq (3) $$\text{Relative density} = \frac{\text{Number of individuals of a species}}{\text{Total number of individuals}} \times 100$$

Eq (4) $$\text{Relative frequency} = \frac{\text{Frequency of a species}}{\text{Frequency of all species}} \times 100$$

Frequency is the number of quadrats in which a species is found in the entire sample (Valencia & Jorgensen, 1992).

Eq (5) Importance Value Index (IVI) = Relative density + Relative dominance + Relative frequency (Srinivasa Rao & Narasimha Rao, 2015).

Eq (6) Shannon-Weiner index (H') is the most convenient tool to measure diversity in 1-ha plots. This was achieved through the following formula:

$$H' = -\sum pilnpi$$

where p_i is the proportion of individual of a species (Number of individual of a species/total number of all species), ln is the natural logarithm (Ali & Mattson, 2017). Thus, the natural logarithm of the number of species (lnS) is the maximum value of H' (Gormley *et al.,* 2007).

Eq (7) $$\text{AGB} = 0.0559(pD^2H)$$ (Chave *et al.,* 2015)

Eq (8) $$\text{H} = e^{1.321+0.482\ln D+0.027\ln p}$$ (Djomo *et al.,* 2016)

where AGB is above-ground dry biomass; ρ is wood density; D is dbh; ln is the natural logarithm, and e indicates the exponential function (Makana *et al.,* 2011). Wood specific density was assembled from published sources such as the Global Wood Density Database (Dryad identifier: http://hdl.handle.net/10255/dryad.235) (Zanne *et al.,* 2009, 17), and the African Wood Density Database (http://worldagroforestry.org/sea/Products/AFDbases/WD/Index.htm) (Carsan *et al.,* 2012, Djuikouo *et al.,* 2010). Species-specific wood densities were used for individuals identified to the species level (Karlson, 2015). In cases wherein species-specific wood densities were not available, mean values for the genus or family were used. For unidentified stems overall mean wood density for the data set was used (Baker *et al.,* 2004).

Results

Plant density and basal area by forest type: Density of trees decreased with increasing elevation (Fig. 2). Mean density varied across forest types and elevation: 493 trees ha^{-1} (397-559 trees) in lowland, 450 trees ha^{-1} (376-531 trees) in mid-elevation, 485 trees ha^{-1} (263-649 trees) in sub-montane and 533 trees ha^{-1} (518-549 trees) in montane (Tables 1 and 2). Mean basal area was associated with elevation: 35.3 m^2 ha^{-1} (26.8-44.2 m^2) in lowland, 26.9 m^2 ha^{-1} (20.9-32.4 m^2) in mid-elevation, 27.5 m^2 ha^{-1} (15.9-34.13 m^2) in sub-montane and 34.4 m^2 ha^{-1} (34.3-34.5 m^2) in montane forest. Overall tree density ranged from 263-649 trees per plot with no noticeable trend (Table 1, Fig. 2).

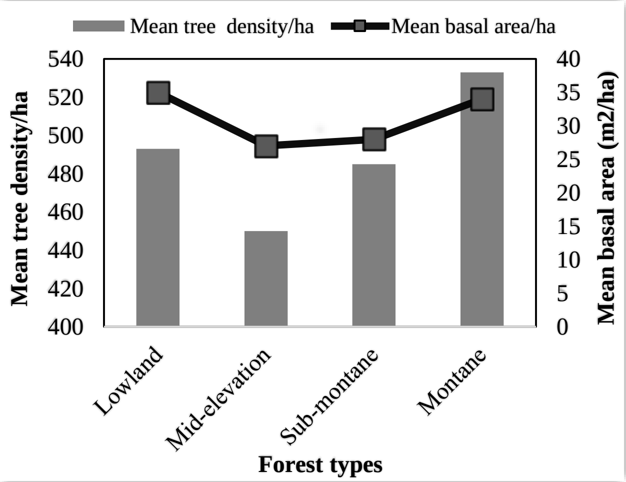

Fig. 2. Mean tree density/ha and Mean basal area m^2/ha in four forest types in the Rumpi Hills Forest Reserve, Cameroon.

Table 1. Tree diversity, above ground biomass (AGB), and carbon in lowland, mid-elevation, submontane, and montane cloud forest. BA (basal area), N (tree density), SR (species richness), SW (Shannon-Weiner index).

Plot	Forest type	Tree/ha (N)	BA (m^2/ha)	SR	SW	Elevation (m)	Carbon (t/ha)
1	Lowland	397	29	93	4.54	101	165
2	Lowland	493	44.5	140	4.95	92	293
3	Lowland	544	41.1	130	4.87	52	228
4	Lowland	538	43.1	117	4.77	71	241
5	Lowland	538	38.1	130	4.88	115	188
6	Lowland	559	37.6	129	4.87	112	211
7	Lowland	513	39.1	112	4.72	188	206
8	Lowland	503	29.2	115	4.75	193	141
14	Lowland	469	26.8	107	4.67	287	127
15	Lowland	480	27.7	102	4.63	277	137
16	Lowland	423	33.8	100	4.62	280	193
17	Lowland	459	35.1	101	4.63	296	187
9	Submontane	542	32.4	80	4.39	1344	159
10	Submontane	649	34.1	66	4.21	1335	164
13	Submontane	263	15.9	32	3.47	1422	65
11	Montane	548	34.5	40	3.71	1775	181
12	Montane	518	33.3	35	3.58	1727	177
18	Mid-elevation	475	28.1	81	4.41	544	130
19	Mid-elevation	464	21.9	75	4.33	530	94
20	Mid-elevation	490	27.8	91	4.52	506	131
21	Mid-elevation	531	31.3	89	4.5	509	158
22	Mid-elevation	447	26.7	87	4.48	488	119
23	Mid-elevation	376	21	85	4.44	496	92
24	Mid-elevation	436	32.4	85	4.45	512	155
25	Mid-elevation	381	26.9	81	4.39	536	132
Mean		481.44	31.66	92.12	4.47		163
Standard deviation		76.8348	6.88	28.59	0.38		50

Elevational patterns: All trees with dbh ≥10 cm totaled 12,037 individuals in 441 species, 229 genera, and 63 families across the four forest types. Ninety-two individuals were not identified to species and genus, and nine individuals were not identified to family. The 92 individuals corresponded to 17 morphospecies, so the complete tree species richness with dbh ≥10 cm represent 458 morphospecies. The observational data provided records of an additional 254 individual trees in 62 families, 129 genera and 210 species, of which 132 species were not recorded in the sampling plots.

The 25 1-ha plots sampled had an overall mean of 92 species ha^{-1} (ranging 36-140 tree species) with dbh ≥10 cm. The lowland forest had a mean of 115 species ha^{-1} (ranging 93-140 tree species), 84 species ha^{-1} (75-91 tree species) in mid-elevation forest, 59 species ha^{-1} (32-80 species) in submontane and 38 species ha^{-1} (35-40 species) in montane cloud forest. Lianas with dbh ≥10 cm represent a mean of 4 species ha^{-1} (0-8 species) in lowland forest, 3 species ha^{-1} (0-7 species) in mid-elevation, and 1 species ha^{-1} (1-1 species) in submontane forest, no liana species were recorded in montane cloud forest in this diameter class. Regression analysis showed a strong significant negative relationship between species richness and elevation ($r = 0.756$, $p<0.05$) across 25 1-ha plot in the Rumpi Hills Forest Reserve, Cameroon (Fig. 3). Overall we found 24 species of lianas with dbh ≥10 cm in lowland forest, 17 species in mid-elevation, two species in submontane and no species in montane forest. The number of lianas correlated strongly with the number of trees with dbh ≥60 cm along the elevational gradient (Fig. 4).

In all, at species level, 88.3% of trees and lianas were identified, at genus level 89%, and at family level 99.3%. Less than 1% of species at family level were unidentified in this study. A detailed summary of occurrence of species across different forest types is presented in Appendix 1 and 2.

Species richness within families: Lowland forest had the maximum number of families (53), followed by mid-elevation and submontane with 42 families each and montane with 25 families. In lowland forest, the highest number of species were recorded in the Fabaceae , with 55 species among 566 individual trees, Annonaceae had 21 species with 136 trees, Rubiaceae 21 species with 164 trees, Phyllanthaceae 17 species in 455 trees and Malvaceae 15 species in 190 trees. Rare families with one species each were Bignoniaceae (62 trees), Boraginaceae (2 trees), Cecropiaceae (55 trees), Medusandraceae (121 trees) and Erythroxylaceae (1 tree). In mid-elevation, Fabaceae was still the dominant family with 21 species in 370 trees, followed by Annonaceae 12 species in 139 trees, Malvaceae 10 species in 61 trees and Euphorbiaceae (130 trees), Phyllanthaceae (182 trees), and Rubiaceae (28 trees) in nine species each. The rarest family in this vegetation type was Vochysiaceae with one species.

Appendix 1. Species occurrence in the different forest types in the Rumpi Hills Forest Reserve, Cameroon.

Family	Species	Lowland	Mid-elevation	Montane	Submontane	IUCN Status	Endemic to Cameroon	Cameroon Volcanic Line/Guinea Forest
Achariaceae	*Dasylepis thomasii*	18	-	91	-	VU	-	Endemic
Achariaceae	*Scottellia klaineana*	7	-	-	-	LC	-	-
Alangiaceae	*Alangium chinense*	-	-	-	3	LC	-	-
Anacardiaceae	*Antrocaryon micraster*	3	-	-	-	LC	-	-
Anacardiaceae	*Antrocaryon* sp.	1	-	-	1	-	-	-
Anacardiaceae	*Pseudospondias microcarpa*	36	42	-	-	NE	-	Endemic
Anacardiaceae	*Sorindeia grandifolia*	6	-	-	-	LC	-	-
Anacardiaceae	*Sorindeia juglandifolia*	5	5	-	-	LC	-	-
Anacardiaceae	*Trichoscypha acuminata*	12	-	-	-	LC	-	-
Anacardiaceae	*Trichoscypha cf oliveri*	1	54	-	-	LC	-	-
Anacardiaceae	*Trichoscypha patens*	2	1	-	-	LC	-	-
Anacardiaceae	*Trichoscypha preussii*	16	-	-	-	-	-	-
Anacardiaceae	*Trichoscypha* sp.10	-	-	53	-	-	-	-
Anacardiaceae	*Trichoscypha* sp.12	3	-	-	-	-	-	-
Anacardiaceae	*Trichoscypha* sp.4	16	1-	-	-	-	-	-
Anacardiaceae	*Trichoscypha* sp.6	5	-	-	-	-	-	-
Anacardiaceae	*Trichoscypha* sp.9	2	-	1	-	-	-	-
Anisophylleaceae	*Anisophyllea meniaudii*	2	-	-	-	DD	-	-
Anisophylleaceae	*Anisophyllea polyneura*	2	22	-	-	LC	-	-
Anisophylleaceae	*Anisophyllea purpurascens*	2	5-	-	-	DD	-	-
Anisophylleaceae	*Anisophyllea sororia*	6	36	-	-	DD	-	-
Anisophylleaceae	*Poga oleosa*	7	-	-	-	DD	-	-
Annonaceae	*Annickia chlorantha*	37	36	-	-	LC	-	-
Annonaceae	*Cleistopholis patens*	3	2	-	-	LC	-	-
Annonaceae	*Cleistopholis staudtii*	3	6	-	-	NT	-	-
Annonaceae	*Hexalobus* sp.	1	-	-	-	-	-	-
Annonaceae	*Isolona campanulata*	1	-	-	-	LC	-	-
Annonaceae	*Monodora brevipes*	1	-	-	-	LC	-	-
Annonaceae	*Monodora myristica*	-	-	-	-	LC	-	-
Annonaceae	*Pachypodanthium staudtii*	5	-	-	-	LC	-	-
Annonaceae	*Piptostigma oyemense*	13	15	-	-	-	-	-
Annonaceae	*Piptostigma pilosum*	1	-	-	-	LC	-	-
Annonaceae	*Piptostigma* sp.	-	9	-	-	-	-	-
Annonaceae	*Polyanthia suaveolens*	28	-	2	-	LC	-	-
Annonaceae	*Polyceratocarpus parviflorus*	1	43	-	-	LC	-	-
Annonaceae	*Uvariastrum pynaertii*	1-	-	-	-	LC	-	-
Annonaceae	*Uvariodendron connivens*	13	5	-	-	NT	-	Endemic

Appendix 1. (Cont'd.).

Family	Species	Lowland	Mid-elevation	Montane	Submontane	IUCN Status	Endemic to Cameroon	Cameroon Volcanic Line/Guinea Forest
Annonaceae	*Uvariodendron giganteum*	-	-	-	-	NT	-	-
Annonaceae	*Uvariopsis korupensis*	1	5	-	-	EN	Endemic	-
Annonaceae	*Uvariopsis submontana*	-	-	-	-	EN	Endemic	-
Annonaceae	*Xylopia acutiflora*	7	9	-	-	LC	-	-
Annonaceae	*Xylopia aethiopica*	4	3	-	-	LC	-	-
Annonaceae	*Xylopia africana*	1	-	121	-	VU	-	Endemic
Annonaceae	*Xylopia hypolampra*	1	-	-	-	LC	-	-
Annonaceae	*Xylopia* sp.3	-	1	-	-	-	-	-
Annonaceae	*Xylopia* sp.I	1	-	-	-	-	-	-
Annonaceae	*Xylopia staudtii*	1	5	-	-	LC	-	-
Annonaceae	*Xylopia villosa*	3	-	-	-	LC	-	-
Apocynaceae	*Alstonia boonei*	7	3	-	-	LC	-	-
Apocynaceae	*Funtumia elastica*	21	4	-	-	LC	-	-
Apocynaceae	*Hunteria umbellata*	12	-	-	-	LC	-	-
Apocynaceae	*Pleiocarpa bicarpellata*	3	-	-	-	LC	-	-
Apocynaceae	*Pleiocarpa* sp.	-	-	1-	-	-	-	-
Apocynaceae	*Rauvolfia caffra*	-	1	-	-	LC	-	-
Apocynaceae	*Rauvolfia vomitoria*	5	4	-	-	LC	-	-
Apocynaceae	*Tabernaemontana brachyantha*	75	152	-	-	LC	-	-
Apocynaceae	*Tabernaemontana crassa*	18	16	-	-	LC	-	-
Apocynaceae	*Tabernaemontana ventricosa*	-	-	42	-	LC	-	-
Apocynaceae	*Voacanga africana*	-	-	-	-	LC	-	-
Araliaceae	*Polyscias fulva*	-	-	-	-	NT	-	-
Araliaceae	*Schefflera abyssinica*	-	-	6	-	LC	-	-
Asteraceae	*Vernonia conferta*	-	-	14	-	LC	-	-
Asteraceae	*Vernonia frondosa*	-	1	-	-	LC	-	-
Bignoniaceae	*Kigelia africana*	62	57	-	-	LC	-	-
Bombacaceae	*Bombax buenopozense*	1	-	-	-	LC	-	-
Bombacaceae	*Ceiba pentandra*	1	-	-	-	LC	-	-
Boraginaceae	*Cordia* sp.	2	6	-	-	-	-	-
Burseraceae	*Canarium schweinfurthii*	6	2	-	-	LC	-	-
Burseraceae	*Canthium* sp.	-	1	-	-	-	-	-
Burseraceae	*Dacryodes edulis*	87	49	-	-	LC	-	-
Burseraceae	*Dacryodes klaineana*	1	4	-	-	LC	-	-
Burseraceae	*Santiria balsamifera*	86	31	-	-	LC	-	-
Caricaceae	*Cylicomorpha solmsii*	-	-	-	-	VU	Endemic	-

Appendix 1. (Cont'd.).

Family	Species	Lowland	Mid-elevation	Montane	Submontane	IUCN Status	Endemic to Cameroon	Cameroon Volcanic Line/Guinea Forest
Cecropiaceae	*Musanga cecropioides*	55	59	-	-	LC	-	-
Cecropiaceae	*Myrianthus arboreus*	-	-	1	-	LC	-	-
Cecropiaceae	*Myrianthus preussii*	-	-	-	-	NT	-	Endemic
Chrysobalanaceae	*Chrysobalanus icaco*	15	-	-	-	LC	-	-
Chrysobalanaceae	*Dactyladenia pallescens*	2	-	-	-	LC	-	-
Chrysobalanaceae	*Dactyladenia staudtii*	4	1	-	-	LC	-	-
Chrysobalanaceae	*Magnistipula* aff. *cuneatifolia*	1	-	-	-	EN	-	-
Chrysobalanaceae	*Magnistipula glaberrima*	11	-	-	-	NT	-	-
Chrysobalanaceae	*Maranthes kerstingii*	-	-	-	-	LC	-	-
Chrysobalanaceae	*Parinari chrysophylla*	7	-	-	-	LC	-	-
Chrysobalanaceae	*Parinari excelsa*	1	-	-	-	LC	-	-
Clusiaceae	*Allanblackia gabonensis*	2	-	-	-	VU	-	Endemic
Clusiaceae	*Endodesmia calophylloides*	9	-	-	-	LC	-	-
Clusiaceae	*Garcinia cf polyantha*	-	-	71	-	-	-	-
Clusiaceae	*Garcinia conrauana*	3	-	-	-	NT	-	-
Clusiaceae	*Garcinia gnetoides*	1	4	-	-	LC	-	-
Clusiaceae	*Garcinia kola*	4	4	-	-	VU	-	-
Clusiaceae	*Garcinia mannii*	46	43	2	-	LC	-	-
Clusiaceae	*Garcinia polyantha*	-	-	68	-	-	-	-
Clusiaceae	*Garcinia* sp.1	-	-	8	-	-	-	-
Clusiaceae	*Garcinia staudtii*	2	-	-	-	NT	-	Endemic
Clusiaceae	*Mammea africana*	35	144	-	-	LC	-	-
Clusiaceae	*Pentadesma butryacea*	1	-	-	-	LC	-	-
Clusiaceae	*Pentadesma grandifolia*	26	-	-	-	-	-	-
Clusiaceae	*Symphonia globulifera*	15	33	2-	-	LC	-	-
Combretaceae	*Strephonema pseudocola*	22	1	-	-	LC	-	-
Combretaceae	*Terminalia ivorensis*	2	-	-	-	LC	-	-
Combretaceae	*Terminalia superba*	4	-	-	-	LC	-	-
Dichapetalaceae	*Tapura africana*	53	1	-	-	LC	-	-
Ebenaceae	*Diospyros bipindensis*	3	-	-	-	LC	-	-
Ebenaceae	*Diospyros cinnabarina*	3	-	-	-	LC	-	-
Ebenaceae	*Diospyros gabunensis*	46	-	-	-	LC	-	-
Ebenaceae	*Diospyros gracilescens*	6	-	-	-	LC	-	-
Ebenaceae	*Diospyros hoyleana*	14	-	-	-	LC	-	-
Ebenaceae	*Diospyros iturensis*	11	-	-	-	LC	-	-
Ebenaceae	*Diospyros kamerunensis*	5	-	-	-	LC	-	-
Ebenaceae	*Diospyros korupensis*	4	1	-	-	VU	Endemic	-

Appendix 1. (Cont'd.).

Family	Species	Lowland	Mid-elevation	Montane	Submontane	IUCN Status	Endemic to Cameroon	Cameroon Volcanic Line/Guinea Forest
Ebenaceae	*Diospyros* sp.	2	-	-	-	-	-	-
Ebenaceae	*Diospyros* sp.4	14	-	-	-	-	-	-
Ebenaceae	*Diospyros* sp.5	11	-	-	-	-	-	-
Ebenaceae	*Diospyros suaveolens*	2	4	-	-	LC	-	-
Ebenaceae	*Diospyros zenkeri*	17	2	-	-	LC	-	-
Erythroxylaceae	*Erythroxylum mannii*	1	-	-	-	LC	-	-
Euphorbiaceae	*Cleistanthus letouzeyi*	31	33	-	-	VU	-	Endemic
Euphorbiaceae	*Croton sylvaticus*	-	1	-	-	LC	-	-
Euphorbiaceae	*Dichostemma glaucescens*	88	3	-	-	LC	-	-
Euphorbiaceae	*Discoclaoxylon hexandrum*	1	4	-	-	LC	-	-
Euphorbiaceae	*Discoglypremna caloneura*	7	7	-	-	LC	-	-
Euphorbiaceae	*Elaeophorbia drupifera*	-	-	-	-	LC	-	-
Euphorbiaceae	*Euphorbia* sp.2	-	-	-	-	-	-	-
Euphorbiaceae	*Jatropha curcas*	-	-	-	-	LC	-	-
Euphorbiaceae	*Klaineanthus gaboniae*	63	6	-	-	LC	-	-
Euphorbiaceae	*Macaranga monandra*	23	27	-	-	LC	-	-
Euphorbiaceae	*Macaranga* sp.	-	-	1	-	-	-	-
Euphorbiaceae	*Macaranga spinosa*	2	-	-	-	LC	-	-
Euphorbiaceae	*Mareya micrantha*	5	-	-	-	LC	-	-
Euphorbiaceae	*Mareyopsis longifolia*	33	68	-	-	LC	-	-
Euphorbiaceae	*Neoboutonia glabrescens*	1	12	-	-	-	-	-
Euphorbiaceae	*Ricinodendron heudelotii*	2	-	-	-	LC	-	-
Euphorbiaceae	*Sapium ellipticum*	3	2	9	-	-	-	-
Euphorbiaceae	*Tetrorchidium didymostemon*	2	-	-	-	LC	-	-
Fabaceae	*Afzelia bella*	2	1	-	-	LC	-	-
Fabaceae	*Afzelia bipindensis*	1	-	-	-	VU	-	-
Fabaceae	*Afzelia pachyloba*	1	-	-	-	VU	-	-
Fabaceae	*Albizia adianthifolia*	23	23	-	-	LC	-	-
Fabaceae	*Albizia ferruginea*	4	1	-	-	LC	-	-
Fabaceae	*Albizia* sp.	1	-	-	-	-	-	-
Fabaceae	*Albizia* sp.4	-	5	-	-	-	-	-
Fabaceae	*Albizia zygia*	-	1	-	1	LC	-	-
Fabaceae	*Amphimas ferrugineus*	4	2	-	-	LC	-	-
Fabaceae	*Angylocalyx oligophyllus*	2	-	-	-	LC	-	-
Fabaceae	*Anthonotha cladantha*	9	-	-	-	LC	-	-
Fabaceae	*Anthonotha fragrans*	13	-	-	-	LC	-	-

Appendix 1. (Cont'd.).

Family	Species	Lowland	Mid-elevation	Montane	Submontane	IUCN Status	Endemic to Cameroon	Cameroon Volcanic Line/Guinea Forest
Fabaceae	*Anthonotha lamprophylla*	17	3	-	-	LC	-	-
Fabaceae	*Anthonotha macrophylla*	73	59	-	-	LC	-	-
Fabaceae	*Aphanocalyx microphyllus*	-	-	-	1	LC	-	-
Fabaceae	*Baikiaea insignis*	1	-	-	-	LC	-	-
Fabaceae	*Baphia buettneri*	9	1	-	-	NT	-	Endemic
Fabaceae	*Baphia capparidifolia*	15	1	-	-	LC	-	-
Fabaceae	*Baphia laurifolia*	11	3	-	-	LC	-	-
Fabaceae	*Baphia* sp.	2	-	-	-	-	-	-
Fabaceae	*Berlinia auriculata*	36	-	-	-	LC	-	-
Fabaceae	*Berlinia bracteosa*	35	24	-	-	LC	-	-
Fabaceae	*Berlinia hollandii*	3	-	-	-	LC	-	-
Fabaceae	*Calpocalyx dinklagei*	5	-	-	-	LC	-	-
Fabaceae	*Calpocalyx heitzii*	8	-	-	-	NT	-	Endemic
Fabaceae	*Copaifera mildbraedii*	1	-	-	-	LC	-	-
Fabaceae	*Crudia* sp.	5	-	-	-	-	-	-
Fabaceae	*Cryptosepalum cougolanum*	1	-	-	-	-	-	-
Fabaceae	*Dialium bipindense*	1	-	-	-	LC	-	-
Fabaceae	*Dialium dinklagei*	1	-	-	-	LC	-	-
Fabaceae	*Dialium pachyphyllum*	15	5	-	-	LC	-	-
Fabaceae	*Didelotia africana*	5	-	-	-	LC	-	-
Fabaceae	*Didelotia morelii*	2	-	-	-	LC	-	-
Fabaceae	*Distemonanthus benthamianus*	1	-	-	-	LC	-	-
Fabaceae	*Erythrina milbraedii*	1	-	-	-	LC	-	-
Fabaceae	*Erythrophleum ivorensis*	3	-	-	-	LC	-	-
Fabaceae	*Gilbertiodendron demonstrans*	1	-	-	-	NT	-	Endemic
Fabaceae	*Gilbertiodendron dewevrei*	7	-	-	-	LC	-	-
Fabaceae	*Gilbertiodendron* sp.2	15	-	-	-	-	-	-
Fabaceae	*Hylodendron gabunense*	1	-	-	-	LC	-	-
Fabaceae	*Hymenostegia korupensis*	17	-	-	-	LC	-	-
Fabaceae	*Leonardoxa africana*	4	192	-	-	LC	-	Endemic
Fabaceae	*Microberlinia bisulcata*	1	-	-	-	VU	-	Endemic
Fabaceae	*Newtonia griffoniana*	3	7	-	-	LC	-	-
Fabaceae	*Parkia bicolor*	6	-	-	-	LC	-	-
Fabaceae	*Parkia* sp.	3	-	-	-	-	-	-
Fabaceae	*Pellegriniodendron diphyllum*	19	-	-	-	LC	-	-
Fabaceae	*Pentaclethra macrophylla*	1	-	-	-	LC	-	-
Fabaceae	*Piptadeniastrum africanum*	36	4	-	-	LC	-	-

Appendix 1. (Cont'd.).

Family	Species	Lowland	Mid-elevation	Montane	Submontane	IUCN Status	Endemic to Cameroon	Cameroon Volcanic Line/Guinea Forest
Fabaceae	*Plagiosiphon longitubus*	-	3	-	-	LC	-	Endemic
Fabaceae	*Pterocarpus soyauxii*	3	-	-	-	LC	-	-
Fabaceae	*Talbotiella korupensis*	59	32	-	-	EN	Endemic	-
Fabaceae	*Tetraberlinia bifoliolata*	12	-	-	-	LC	-	-
Fabaceae	*Tetraberlinia korupensis*	11	-	-	-	EN	Endemic	-
Fabaceae	*Tetraberlinia polyphylla*	1	-	-	-	-	-	-
Fabaceae	*Tetrapleura tetraptera*	-	1	-	-	LC	-	-
Fabaceae	*Zenkerella citrina*	6	1	3	-	NT	-	Endemic
Gentianaceae	*Anthocleista schweinfurthii*	3	-	-	-	LC	-	-
Hoplestigmataceae	*Hoplestigma klaineanum*	4	-	-	-	NT	-	Endemic
Huaceae	*Afrostyrax kamerunensis*	-	1	-	-	LC	-	-
Huaceae	*Afrostyrax lepidophyllus*	-	73	-	-	LC	-	-
Humiriaceae	*Saccoglottis gabonensis*	6	-	-	-	LC	-	-
Hypericaceae	*Harungana madagascariensis*	-	-	-	-	LC	-	-
Irvingaceae	*Desbordesia glaucescens*	4	-	-	-	LC	-	-
Irvingaceae	*Irvingia gabonensis*	56	3	-	-	LC	-	-
Irvingaceae	*Irvingia grandifolia*	1	1	-	-	LC	-	-
Irvingaceae	*Klainedoxa gabonensis*	4	1	-	-	LC	-	-
Irvingaceae	*Klainedoxa trillesii*	7	-	-	-	LC	-	-
Lamiaceae	*Vitex grandifolia*	57	6	-	-	LC	-	-
Lamiaceae	*Vitex* sp.2	2	-	-	-	-	-	-
Lamiaceae	*Vitex* sp.3	33	-	-	-	-	-	-
Lamiaceae	*Vitex* sp.5	4	-	-	-	-	-	-
Lauraceae	*Beilschmiedia acuta*	4	2	-	-	DD	-	Endemic
Lauraceae	*Beilschmiedia gabonensis*	-	-	-	5	DD	-	Endemic
Lauraceae	*Beilschmiedia mannii*	7	3	-	-	LC	-	-
Lauraceae	*Beilschmiedia* sp.	11	1	-	-	-	-	-
Lauraceae	*Beilschmiedia* sp.2	4	13	-	-	-	-	-
Lauraceae	*Beilschmiedia* sp.22	-	-	-	1	-	-	-
Lauraceae	*Beilschmiedia* sp.6	29	33	-	-	-	-	-
Lauraceae	*Beilschmiedia talbotiae*	-	6	-	-	LC	-	-
Lauraceae	*Hypodaphnis zenkeri*	27	18	-	-	LC	-	-
Lauraceae	*Persea americana*	-	-	-	-	LC	-	-
Lecythidaceae	*Crateranthus talbotii*	114	-	-	-	VU	-	Endemic
Lecythidaceae	*Napoleonaea cf heudelotii*	7	66	-	-	-	-	-
Lecythidaceae	*Napoleonaea ergortonii*	-	-	-	-	VU	-	Endemic

Appendix 1. (Cont'd.).

Family	Species	Lowland	Mid-elevation	Montane	Submontane	IUCN Status	Endemic to Cameroon	Cameroon Volcanic Line/Guinea Forest
Lecythidaceae	*Napoleonaea talbotii*	2	-	-	-	NT	-	Endemic
Lecythidaceae	*Oubanguia alata*	617	154	-	-	LC	-	-
Lecythidaceae	*Oubanguia laurifolia*	23	-	-	-	LC	-	-
Lecythidaceae	*Rhaptopetalum coriaceum*	5	-	-	-	NT	-	Endemic
Lecythidaceae	*Rhaptopetalum depressum*	-	-	-	-	CR	Endemic	-
Lecythidaceae	*Rhaptopetalum geophylax*	-	-	-	-	EN	Endemic	-
Lecythidaceae	*Rhaptopetalum* sp.	2	-	-	-	-	-	-
Lecythidaceae	*Rhaptopetalum* sp.nov.	11	1-	-	-	-	-	-
Lecythidaceae	*Scytopetalium klaineanum*	24	-	-	-	LC	-	-
Lepidobotryaceae	*Lepidobotrys staudtii*	2	-	-	-	LC	-	-
Leptaulaceae	*Leptaulus daphnoides*	6	-	1	-	LC	-	-
Leptaulaceae	*Leptaulus grandifolius*	-	-	-	-	VU	-	Endemic
Loganiaceae	*Strychnos congolana*	3	-	-	-	LC	-	-
Malvaceae	*Cola altissima*	1	-	-	-	LC	-	-
Malvaceae	*Cola cauliflora*	5	7	-	-	LC	-	Endemic
Malvaceae	*Cola chlamydantha*	4	-	-	-	LC	-	-
Malvaceae	*Cola flaviflora*	1	-	-	-	NT	-	Endemic
Malvaceae	*Cola lateritia*	5	-	-	-	LC	-	-
Malvaceae	*Cola lepidota*	24	8	-	-	LC	-	-
Malvaceae	*Cola megalophylla*	12	2	-	-	EN	-	Endemic
Malvaceae	*Cola nitida*	7	-	5	-	LC	-	-
Malvaceae	*Cola pachycarpa*	4	-	-	-	-	-	-
Malvaceae	*Cola rostrata*	74	5	-	-	LC	-	Endemic
Malvaceae	*Cola semecarpophylla*	-	1	-	-	LC	-	Endemic
Malvaceae	*Cola* sp.	2	-	-	-	-	-	-
Malvaceae	*Cola* sp.nov.	2	1	-	-	-	-	-
Malvaceae	*Cola verticillata*	24	2-	41	-	LC	-	-
Malvaceae	*Leptonychia lasiogyne*	-	-	-	-	LC	-	-
Malvaceae	*Leptonychia macrantha*	-	-	1	-	LC	-	-
Malvaceae	*Microcos coriacea*	18	8	-	-	LC	-	-
Malvaceae	*Octolobus spectabilis*	-	3	-	-	LC	-	-
Malvaceae	*Sterculia tragacantha*	7	6	-	-	LC	-	-
Melastomataceae	*Memecylon afzelii*	4	-	-	-	LC	-	-
Melastomataceae	*Memecylon candidum*	-	-	-	-	LC	-	-
Melastomataceae	*Memecylon lateriflorum*	1	8	-	-	-	-	-
Melastomataceae	*Memecylon laurentii*	-	1	-	-	LC	-	-
Melastomataceae	*Memecylon* sp.2	-	-	3	-	-	-	-

Appendix 1. (Cont'd.).

Family	Species	Lowland	Mid-elevation	Montane	Submontane	IUCN Status	Endemic to Cameroon	Cameroon Volcanic Line/Guinea Forest
Melastomataceae	*Warneckea cinnamomoides*	6	-	-	-	LC	-	-
Melastomataceae	*Warneckea jasminoides*	9	2	-	-	LC	-	-
Melastomataceae	*Warneckea membranifolia*	2	-	-	-	LC	-	-
Melastomataceae	*Warneckea pulcherrima*	6	8	-	-	LC	-	-
Melastomataceae	*Warneckea* sp.I	1	-	-	-	-	-	-
Meliaceae	*Carapa angustifolia*	8	-	-	-	VU	-	Endemic
Meliaceae	*Carapa cf dinklagei*	-	-	-	-	NE	-	-
Meliaceae	*Carapa oreophila*	-	-	125	-	NT	-	Endemic
Meliaceae	*Carapa parviflora*	31	2	-	-	NE	-	-
Meliaceae	*Carapa zemagoana*	1	-	-	-	VU	Endemic	-
Meliaceae	*Entandrophragma cylindricum*	1	-	-	-	VU	-	-
Meliaceae	*Guarea cedrata*	1	-	11	-	VU	-	-
Meliaceae	*Guarea* sp.	-	-	-	-	-	-	-
Meliaceae	*Guarea thompsonii*	7	-	-	-	LC	-	-
Meliaceae	*Khaya ivorensis*	-	-	-	-	VU	-	-
Meliaceae	*Trichilia aff.gilgiana*	35	29	-	-	LC	-	-
Meliaceae	*Trichilia prieureana*	75	161	-	-	LC	-	-
Meliaceae	*Turraeanthus africanus*	-	-	-	-	LC	-	-
Melianthaceae	*Bersama abyssinica*	1	-	-	-	LC	-	-
Monimiaceae	*Glossocalyx brevipes* var letouzeyi	5	-	-	-	NT	Endemic	-
Moraceae	*Ficus mucuso*	-	1	-	-	LC	-	-
Moraceae	*Ficus* sp.	-	-	-	-	-	-	-
Moraceae	*Ficus* sp.3	12	4	-	-	-	-	-
Moraceae	*Ficus sur*	-	-	-	-	LC	-	-
Moraceae	*Milicia excels*	3	-	-	-	LC	-	-
Moraceae	*Treculia africana*	3	3	-	-	LC	-	-
Moraceae	*Treculia obovoidea*	13	-	-	-	LC	-	-
Myristicaceae	*Coelocaryon preussii*	33	13	-	-	LC	-	-
Myristicaceae	*Pycnanthus angolensis*	75	112	-	-	LC	-	-
Myristicaceae	*Scyphocephalium mannii*	43	9	-	-	LC	-	-
Myristicaceae	*Staudtia gabunensis*	35	1	-	-	LC	-	-
Myristicaceae	*Staudtia kamerunensis*	7	1	-	-	LC	-	-
Myristicaceae	*Staudtia* sp.	1	-	-	-	-	-	-
Myrsinaceae	*Maesa kamerunensis*	-	-	1	-	LC	-	-
Myrsinaceae	*Maesa lanceolata*	-	-	4	-	LC	-	-
Myrtaceae	*Eugenia callophyloides*	-	1	-	-	-	-	-

Appendix 1. (Cont'd.).

Family	Species	Lowland	Mid-elevation	Montane	Submontane	IUCN Status	Endemic to Cameroon	Cameroon Volcanic Line/Guinea Forest
Myrtaceae	*Eugenia* sp.2	-	-	-	-	-	-	-
Myrtaceae	*Eugenia talbotii*	-	1	-	-	-	-	-
Myrtaceae	*Syzygium rowlandii*	2	1	14	-	LC	-	-
Myrtaceae	*Syzygium staudtii*	-	-	29	-	LC	-	-
Ochnaceae	*Campylospermum calanthum*	1	-	-	-	CR	Endemic	-
Ochnaceae	*Lophira alata*	7	-	-	-	VU	-	-
Ochnaceae	*Rhabdophyllum affine*	11	-	-	-	LC	-	-
Octoknemataceae	*Octoknema affinis*	65	43	-	-	LC	-	-
Octoknemataceae	*Octoknema anuwinlencis*	2	-	-	-	-	-	-
Octoknemataceae	*Octoknema bakosiensis*	59	-	-	-	EN	Endemic	-
Olacaceae	*Coula edulis*	45	-	-	-	LC	-	-
Olacaceae	*Diogoa* sp.	-	-	-	-	-	-	-
Olacaceae	*Diogoa zenkeri*	-	6	-	-	LC	-	-
Olacaceae	*Engomegoma gordonii*	2	-	-	-	LC	-	-
Olacaceae	*Strombosia grandifolia*	34	324	-	-	LC	-	-
Olacaceae	*Strombosia pustulata*	83	67	-	-	LC	-	-
Olacaceae	*Strombosia scheffleri*	45	62	-	-	LC	-	-
Olacaceae	*Strombosia* sp.	4	78	-	-	-	-	-
Olacaceae	*Strombosia* sp.1	-	-	146	-	-	-	-
Olacaceae	*Strombosiopsis tetrandra*	89	83	-	-	LC	-	-
Pandaceae	*Panda oleosa*	7	-	-	-	LC	-	-
Passifloraceae	*Barteria fistulosa*	23	11	-	-	LC	-	-
Peridiscaceae	*Soyauxia gabunensis*	121	23	-	-	VU	-	Endemic
Peridiscaceae	*Soyauxia talbotii*	-	-	-	-	VU	-	Endemic
Phyllanthaceae	*Antidesma chevaleri*	-	-	-	7	LC	-	-
Phyllanthaceae	*Antidesma laciniatum*	2	-	-	-	LC	-	-
Phyllanthaceae	*Antidesma* sp.	1	-	-	5	-	-	-
Phyllanthaceae	*Antidesma vogelianum*	27	19	-	-	LC	-	-
Phyllanthaceae	*Bridelia grandis*	3	1	12	-	LC	-	-
Phyllanthaceae	*Bridelia micrantha*	6	2	-	-	LC	-	-
Phyllanthaceae	*Keayodendron bridelioides*	3	-	-	-	LC	-	-
Phyllanthaceae	*Maesobotrya barteri*	5	-	-	-	LC	-	-
Phyllanthaceae	*Maesobotrya dusenii*	11	5	-	-	-	-	-
Phyllanthaceae	*Maesobotrya* sp.	-	-	-	-	-	-	-
Phyllanthaceae	*Maesobotrya staudtii*	3	4	-	-	LC	-	-
Phyllanthaceae	*Margaritaria discoidea*	2	6	-	-	LC	-	-
Phyllanthaceae	*Protomegabaria stapfiana*	275	54	-	-	LC	-	-

Appendix 1. (Cont'd.).

Family	Species	Lowland	Mid-elevation	Montane	Submontane	IUCN Status	Endemic to Cameroon	Cameroon Volcanic Line/Guinea Forest
Phyllanthaceae	*Thecacoris leptobotrya*	2	-	-	-	LC	-	-
Phyllanthaceae	*Uapaca acuminata*	3	-	-	-	LC	-	-
Phyllanthaceae	*Uapaca guineensis*	1	-	-	-	LC	-	-
Phyllanthaceae	*Uapaca staudtii*	79	49	-	-	LC	-	-
Putranjivaceae	*Drypetes aframensis*	6	-	-	-	-	-	-
Putranjivaceae	*Drypetes afzelii*	-	2	-	-	-	-	-
Putranjivaceae	*Drypetes gossweileri*	-	14	-	-	-	-	-
Putranjivaceae	*Drypetes ivorensis*	2	1	-	-	-	-	-
Putranjivaceae	*Drypetes laciniata*	1	-	-	-	LC	-	-
Putranjivaceae	*Drypetes molunduana*	1	1	-	-	NT	-	-
Putranjivaceae	*Drypetes paxii*	1	1	-	-	LC	-	-
Putranjivaceae	*Drypetes* sp.3	-	-	-	-	-	-	-
Putranjivaceae	*Drypetes* sp.6	1	-	-	-	-	-	-
Putranjivaceae	*Drypetes* sp.7	-	-	37	-	-	-	-
Putranjivaceae	*Sibangea similis*	8	-	-	-	LC	-	-
Rhamnaceae	*Maesopsis eminii*	2	2	-	-	LC	-	-
Rubiaceae	*Aoranthe cladantha*	9	-	-	-	LC	-	-
Rubiaceae	*Aulacocalyx jasminiflora*	13	-	-	-	LC	-	-
Rubiaceae	*Aulacocalyx talbotii*	3	2	-	11	LC	-	-
Rubiaceae	*Bertiera racemosa*	2	-	-	-	LC	-	-
Rubiaceae	*Calycosiphonia spathicalyx*	1	-	-	-	LC	-	-
Rubiaceae	*Coffea* sp.	-	-	1	-	-	-	-
Rubiaceae	*Craterispermum aristatum*	21	-	-	-	VU	-	Endemic
Rubiaceae	*Cuviera subuliflora*	4	11	-	-	LC	-	-
Rubiaceae	*Hallea ledermannii*	4	-	-	-	-	-	-
Rubiaceae	*Heinsia crinite*	4	-	-	-	LC	-	-
Rubiaceae	*Ixora guineensis*	-	-	2	-	LC	-	-
Rubiaceae	*Morelia senegalensis*	2	-	-	-	LC	-	-
Rubiaceae	*Morinda lucida*	2	-	-	-	LC	-	-
Rubiaceae	*Nauclea diderrichii*	1	-	-	-	VU	-	-
Rubiaceae	*Nauclea* sp.	-	2	-	-	-	-	-
Rubiaceae	*Pauridiantha floribunda*	2	-	1	-	LC	-	-
Rubiaceae	*Pauridiantha* sp.	-	-	-	-	-	-	-
Rubiaceae	*Pauridiantha viridiflora*	3	3	-	-	LC	-	-
Rubiaceae	*Pausinystalia macroceras*	44	-	-	-	LC	-	-
Rubiaceae	*Pavetta staudtii*	-	-	-	-	LC	-	Endemic

Appendix 1. (Cont'd.).

Family	Species	Lowland	Mid-elevation	Montane	Submontane	IUCN Status	Endemic to Cameroon	Cameroon Volcanic Line/Guinea Forest
Rubiaceae	*Petitiocodon parviflorum*	3	-	-	-	LC	-	Endemic
Rubiaceae	*Psychotria bimbiensis*	1	-	-	-	CR	Endemic	-
Rubiaceae	*Psychotria brachyantha*	-	-	1	-	LC	-	-
Rubiaceae	*Psychotria peduncularis*	-	-	-	-	LC	-	-
Rubiaceae	*Psychotria* sp.9	1	-	-	-	-	-	-
Rubiaceae	*Psydrax* sp.	-	-	-	-	-	-	-
Rubiaceae	*Rothmannia hispida*	1	1	-	-	LC	-	-
Rubiaceae	*Rothmannia* sp.	1	1	-	-	-	-	-
Rubiaceae	*Schumanniophyton magnificum*	-	5	2	-	LC	-	-
Rubiaceae	*Tarenna baconoides*	-	-	-	-	EN	-	Endemic
Rubiaceae	*Tarenna grandiflora*	6	-	-	-	LC	-	-
Rubiaceae	*Tricalysia amplexicaulis*	-	-	11	-	-	-	-
Rubiaceae	*Tricalysia coriacea*	-	2	-	-	LC	-	-
Ruscaceae	*Dracaena arborea*	-	-	-	-	LC	-	-
Ruscaceae	*Dracaena deisteliana*	2	-	-	-	NT	-	Endemic
Rutaceae	*Vepris adamaoua*	2	-	-	-	-	-	-
Rutaceae	*Vepris lecomteana*	-	-	49	-	NT	-	Endemic
Rutaceae	*Vepris soyauxii*	27	-	-	-	VU	-	Endemic
Rutaceae	*Vepris* sp.	-	-	-	-	-	-	-
Rutaceae	*Zanthoxylon gilletii*	27	44	-	-	LC	-	-
Rutaceae	*Zanthoxylon heitzii*	5	1	-	-	LC	-	-
Rutaceae	*Zanthoxylon lemairei*	-	-	2	-	LC	-	-
Rutaceae	*Zanthoxylon* sp.2	1	-	-	-	-	-	-
Rutaceae	*Zanthoxylon* sp.I	2	-	-	-	-	-	-
Salicaceae	*Casearia barteri*	2	2	-	-	LC	-	-
Salicaceae	*Homalium africanum*	36	6	-	-	LC	-	-
Salicaceae	*Homalium letestui*	27	-	-	-	LC	-	-
Salicaceae	*Homalium longistylum*	59	5	1	-	LC	-	-
Salicaceae	*Homalium macroptenum*	-	-	2	-	-	-	-
Salicaceae	*Homalium* sp.1	-	-	-	-	-	-	-
Salicaceae	*Oncoba glauca*	18	26	-	-	LC	-	-
Salicaceae	*Oncoba lophocarpa*	-	-	9	-	VU	Endemic	-
Salicaceae	*Oncoba mannii*	6	2	-	-	LC	-	-
Salicaceae	*Oncoba* sp.	-	-	1	-	-	-	-
Sapindaceae	*Allophylus africanus*	2	5	-	-	LC	-	-
Sapindaceae	*Allophylus grandifolius*	-	1	-	-	LC	-	-
Sapindaceae	*Allophylus* sp.2	-	-	1	-	-	-	-

Appendix 1. (Cont'd.).

Family	Species	Lowland	Mid-elevation	Montane	Submontane	IUCN Status	Endemic to Cameroon	Cameroon Volcanic Line/Guinea Forest
Sapindaceae	*Allophylus* sp.3	-	-	-	4	-	-	-
Sapindaceae	*Blighia sapida*	6	2	-	-	LC	-	-
Sapindaceae	*Blighia welwitschii*	2	-	-	-	LC	-	-
Sapindaceae	*Chytranthus angustifolius*	1	-	-	-	LC	-	-
Sapindaceae	*Chytranthus talbotii*	-	1	-	-	LC	-	-
Sapindaceae	*Deinbollia pycnophylla*	5	5	-	-	EN	-	Endemic
Sapindaceae	*Eriocoelum kerstingii*	-	-	-	-	LC	-	-
Sapindaceae	*Eriocoelum macrocarpum*	29	47	-	-	LC	-	-
Sapindaceae	*Laccodiscus pseudostipularis*	-	2	-	-	LC	-	-
Sapindaceae	*Placodiscus cf. caudatus*	39	1	-	-	EN	-	Endemic
Sapotaceae	*cf Pradosia spinosa*	1	-	-	-	NE	-	-
Sapotaceae	*Englerophytum kennedyi*	3	-	-	-	-	-	-
Sapotaceae	*Englerophytum* sp.nov.	91	4	-	-	-	-	-
Sapotaceae	*Gambeya africanum*	27	-	-	-	LC	-	-
Sapotaceae	*Gambeya boukokoensis*	-	1	-	-	LC	-	-
Sapotaceae	*Gambeya delevoyi*	5	-	-	-	-	-	-
Sapotaceae	*Gambeya korupensis*	3	-	-	-	VU	Endemic	-
Sapotaceae	*Gambeya lacourtianum*	-	-	23	-	LC	-	-
Sapotaceae	*Gambeya subnudum*	5	8-	-	-	LC	-	-
Sapotaceae	*Lecomtedoxa klaineana*	4	-	-	-	VU	-	Endemic
Sapotaceae	*Manilkara argentea*	-	-	-	-	-	-	-
Sapotaceae	*Manilkara lososiana*	1	-	-	-	cr	Endemic	-
Sapotaceae	*Manilkara pellegriniana*	-	-	4	-	DD	-	-
Sapotaceae	*Omphalocarpum cf elatum*	12	-	-	-	LC	-	-
Sapotaceae	*Omphalocarpum elatum*	12	3	-	-	LC	-	-
Sapotaceae	*Pouteria* sp.	3	-	-	-	-	-	-
Sapotaceae	*Synsepalum letouzeyi*	-	-	-	-	EN	Endemic	-
Sapotaceae	*Synsepalum longecuneatum*	2	1	-	-	-	-	-
Simaroubaceae	*Odyendya gabonensis*	1	-	-	-	LC	-	-
Simaroubaceae	*Pierreodendron africanum*	14	1	-	-	LC	-	-
Simaroubaceae	*Quassia silvestris*	6	6	-	-	LC	-	-
Thymelaeaceae	*Dicranolepis pulcherrima*	-	-	1	-	LC	-	-
Ulmaceae	*Trema orientalis*	-	-	-	46	LC	-	-
Violaceae	*Alexis* cf *cauliflora*	2	-	-	-	LC	-	-
Violaceae	*Rinorea dentata*	1	1	-	-	LC	-	-
Violaceae	*Rinorea oblongifolia*	157	46	-	-	LC	-	-
Vochysiaceae	*Erismadelphus exsul*	8	8	-	-	LC	-	-
Vochysiaceae	*Korupiodendron songweanum*	164	-	-	-	EN	-	Endemic

Key: LC, ED, EN, V etc.

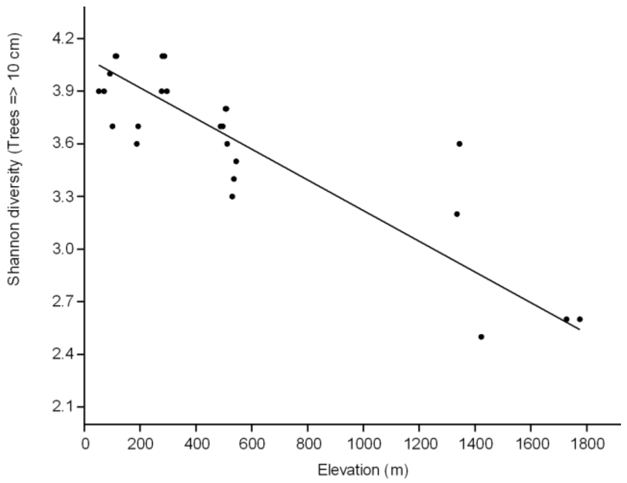

Fig. 3. Correlation between species richness and elevation ($r^2 = 0.756$, $p<0.05$); across 25 ha plot in the Rumpi Hills Forest Reserve, Cameroon.

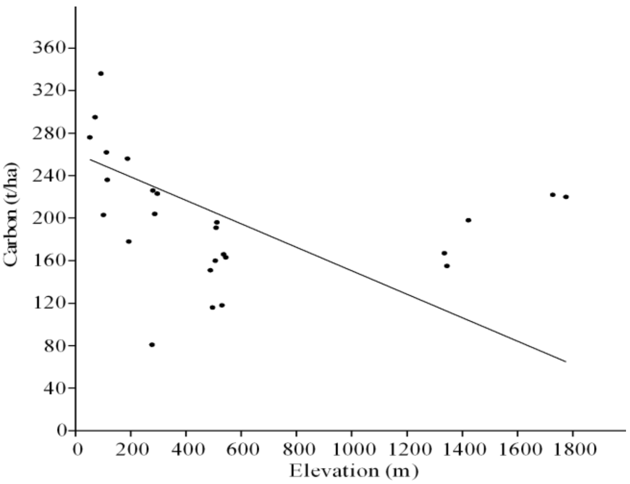

Fig. 4. Association between carbon (tC/ha) and elevation (m) of trees with dbh $\geq$10 cm recorded in 25 1-ha plots in the Rumpi Hills Forest Reserve, Cameroon. The relationship has a correlation coefficient of 0.061, which is significantly different from a slope of zero ($p<0.05$), $y=-0.11x+260.9$.

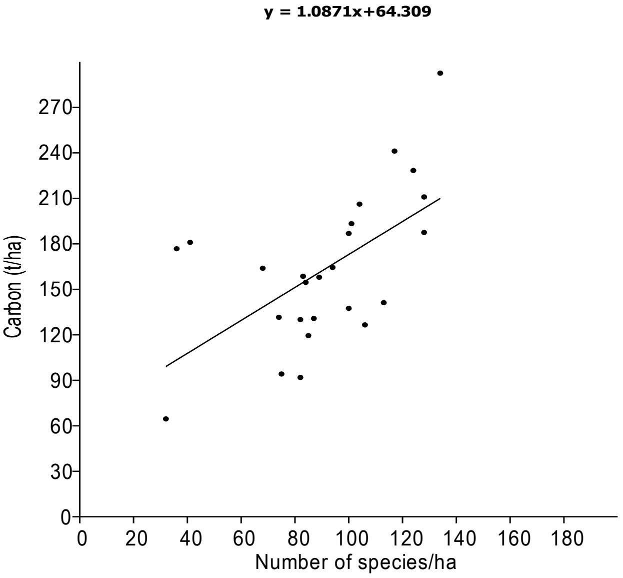

Fig. 5. Association between carbon (tC/ha) and number of species/ha with dbh $\geq$10 cm recorded in 25 1-ha plots in the Rumpi Hills Forest Reserve, Cameroon; $r^2 = 0.34$; $y = 1.0871x + 64.30$.

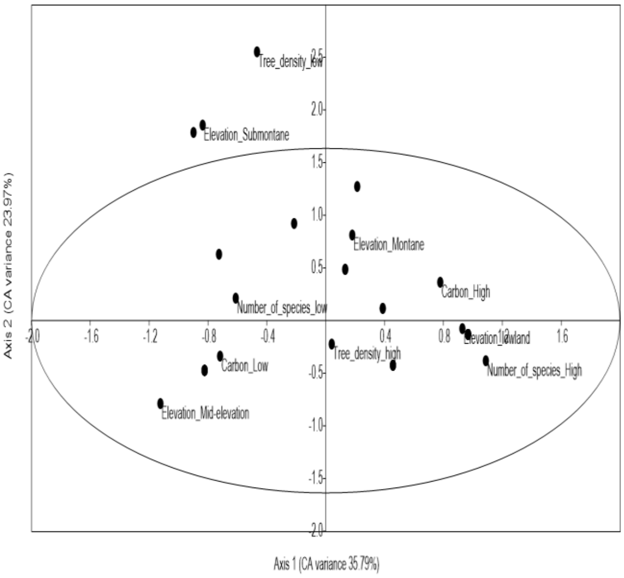

Fig. 6. Correspondence analysis reflecting high tree density, number of species, carbon in lowland and Montane forest and low tree density, number of species, and carbon in mid-elevation and submontane forest of the Rumpi Hills forest Reserve in Cameroon.

In submontane vegetation, Rubiaceae was the dominant family with 14 species in 100 trees, Euphorbiaceae nine species (97 trees), Meliaceae eight species (125 trees), Annonaceae (24 trees) and Apocynaceae (160) with 6 species each. The rarest families in this vegetation type with one species each were Achariaceae (68 trees), Alangiaceae (three trees), Medusandraceae (11 trees), Ochnaceae (one tree), Octoknemaceae (eight trees), and Simaroubaceae (eight trees). In montane cloud forest, Rubiaceae was the dominant family with six species in 18 trees, Clusiaceae (169 trees) of five species, Salicaceae (13 trees) of four species and Malvaceae (47 trees) of three species. The smallest families with one species each were Achariaceae 91 trees; Anacardiaceae 54 trees; Putranjivaceae 37 trees; Asteraceae 14 trees; Phyllanthaceae 12 trees; Araliaceae six trees; Fabaceae and Melastomataceae with three trees each; and Cecropiaceae, Leptaulaceae, Sapindaceae, and Thymelaeaceae with one tree each.

Above-ground biomass and carbon estimation: Overall, above-ground biomass in the 25 1-ha of Rumpi Hills was 8144.06 tons. There was great variation among the twenty-five hectares at different forest types (Table 1): mean AGB per hectare was 325.76 t ha^{-1} fluctuating from 129.1 t ha^{-1} in submonane (lowest plot value) to 585.3 t ha^{-1} in lowland forest (highest plot valve). In lowland forest, the mean was 386.1±95.5 t ha^{-1} ranging from 282.4 t ha^{-1} to 585.3 t ha^{-1}, at mid-elevation, the mean was 252.64±48.58 t ha^{-1} (183.84-316.03 t ha^{-1}), the mean in submontane was 258.09±111.84 t ha^{-1}(129.1-327.84 t ha^{-1}) and montane forest records a mean of 357.76±5.96 t ha^{-1} (353.54-361.97 t ha^{-1}). These values varied significantly among forest types (ANOVA, $F_{8.414}=10.14$, $p<0.01$): biomass of mid-elevation and submontane forest was significantly lower than the biomass of the other forest types (Welch F test of unequal variances, df=15.4, $p<0.02$).

Table 2. Summary of total number of individuals, basal area, number of species, and Shannon diversity for the different life forms recorded in four forest types at various size classes in the Rumpi Hills Forest Reserve, Cameroon.

Forest type	Life form	Size class (cm dbh)	N	BA	S	Fisher's alpha	H'
Lowland	Lianas	≥10	51	0.96	24	17.69	2.96
Lowland	Trees	≥10	4617	106.94	308	74.3	4.67
Lowland	Trees	≥30	1008	135.79	165	56.06	4.32
Lowland	Trees	≥60	288	183.20	83	39.06	3.79
Mid-elevation	Lianas	≥10	38	0.56	17	11.81	2.19
Mid-elevation	Trees	≥10	2836	68.19	172	40.3	4.03
Mid-elevation	Trees	≥30	621	82.66	83	25.75	3.79
Mid-elevation	Trees	≥60	143	68.67	41	19.22	3.01
Submontane	Lianas	≥10	2	0.03	2	0	0.69
Submontane	Trees	≥10	1181	29.48	116	31.88	3.94
Submontane	Trees	≥30	219	28.49	55	23.61	3.45
Submontane	Trees	≥60	54	27.25	21	12.62	2.66
Montane	Lianas	≥10	0	0	0	0	0
Montane	Trees	≥10	786	22.87	46	10.66	2.98
Montane	Trees	≥30	245	30.76	24	6.59	2.42
Montane	Trees	≥60	34	16.6	13	7.69	2.25

Fisher's alpha was based on 12 ha in lowland, 8 ha in mid-elevation, 3 ha in submontane and 2 ha in montane forest. Fisher's alpha was not calculated for lianas in montane forest (0) because the values were too low

N= Number of individuals stands, BA= Basal area, S= Number of species, Fisher's= Fisher's alpha, H'= Shannon-wiener diversity index. Basal area includes all multiple stems for each individual stem. Multiple stems excluded in all other parameters

Table 3. Summary of biomass, and carbon in four forest types across Rumpi Hills Forest Reserve, Cameroon.

Plot	Forest types	AGB (t ha^{-1})	Carbon (t ha^{-1})
1	Lowland	329	165
2	Lowland	585	293
3	Lowland	456	228
4	Lowland	483	241
5	Lowland	375	188
6	Lowland	422	211
7	Lowland	413	206
8	Lowland	282	141
14	Lowland	253	127
15	Lowland	275	137
16	Lowland	387	193
17	Lowland	374	187
Mean		386.1	193.1
Standard deviation		95.5	48
18	Mid-Elevation	260	130
19	Mid-Elevation	188	94
20	Mid-Elevation	262	131
21	Mid-Elevation	316	158
22	Mid-Elevation	239	119
23	Mid-Elevation	184	92
24	Mid-Elevation	309	155
25	Mid-Elevation	263	132
Mean		252.6	126.3
Standard deviation		48.6	24.3
9	Submontane	317	159
10	Submontane	328	164
13	Submontane	129	65
Mean		258	129
Standard deviation		112	56
11	Montane	362	181
12	Montane	354	177
Mean		357.8	178.9
Standard deviation		6	3

The overall total carbon in individual plots ranged from 64.55 t in submontane forest to 292.6 t in lowland forest; overall mean was 162.88±50.42 t per hectare. A weak significant negative association between carbon and elevation (r^2= 0.0618, p<0.05; Fig. 5) was observed, with the amount of carbon declining from (292.6) tC ha^{-1} in lowland forest to (64.55) tC ha^{-1} in submontane forest (Table 1). Thus, the four forest types presented a mean carbon density of 193.06 t ha^{-1} (ranging 126.57-292.6 t ha^{-1}) in lowland forest, mean carbon density of 126.32 t ha^{-1} (ranging 91.92-154.6 t ha^{-1}) in mid-elevation, mean carbon density of 129.03 t ha^{-1} (ranging 64.55-163.92 t ha^{-1}) in submontane, and a mean carbon density of 178.88 t ha^{-1} (ranging 176.77-180.00 t ha^{-1}) in montane forest (Table 3). A strong positive relationship was manifested between carbon and number of species per hectare (r^2 = 0.34, p<0.05; Fig. 5). Correspondence analysis indicated axes 1 and 2 accounted for 60% of the total variance of the data, and it revealed two opposite associations: the correlations among lowland forest, high species diversity and high carbon in axis 1, and on the other hand mid-elevation, low species diversity and low carbon correlated (Fig. 6).

Large trees (dbh ≥10 cm) in our study plots ranged from 10-215 cm, with most trees representing dbh <50 cm (93.3%); only 6.7% of trees had dbh ≥50 cm. This difference reveals a high rate of regeneration of trees in the Reserve, which brings us to an assumption that the level of disturbance in the RHFR is high. However, of the 441 species with dbh ≥10 cm, 52 species had 5070 individuals out of the 12037 stems (42.1%), representing 66.6% of above-ground biomass; and 66.6% of carbon in the entire 25 ha plots (Table 4).

Discussion

Many authors have documented fairly similar tree densities across the different landscapes in Cameroon (Newberry & Gartlan, 1996; Thomas *et al.,* 2003;

Kenfack *et al.,* 2007; Gonmadje *et al.,* 2011; Djuikouo *et al.,* 2014), except the study of Newberry and Gartlan, 1996 in Douala Edea reserve. Newberry & Gartlan, 1996 worked in Korup National Park (200-300 m asl) and Douala-Edea reserve (50-200 m), documenting tree densities of 461-481 trees ha^{-1} and 295 trees ha^{-1} respectively. Thomas *et al.,* (2003) and Kenfack *et al.,* (2007), in their studies of a 50-ha plot in Korup National Park (Kenfack *et al.,* 2014), registered a mean tree density of 487 trees ha^{-1}. Generally, these results are in agreement with the overall mean density of stands (481 trees ha^{-1}) in the Rumpi Hills (lowland to montane forest).

Table 4. Summary of 52 species with biomass, and carbon in the Rumpi Hills Forest Reserve, Cameroon.

Species	Abundance	AGB (t ha^{-1})	Carbon (t ha^{-1})
Scyphocephalium mannii	53	520.5	260.3
Pycnanthus angolensis	187	429.4	214.7
Cola verticilata	168	227.4	113.7
Oubanguia alata	813	296.7	148.4
Korupiodendron songweanum	165	216.5	108.2
Protomegabaria stapfiana	339	198.8	99.4
Piptadeniastrum africanum	40	177.8	88.9
Vepris soyauxii	27	166.3	83.1
Berlinia brateosa	60	133.6	66.8
Santiria balsamifera	156	132.3	66.1
Syzygium rowlandii	55	121.9	60.9
Strombosia sp.1	184	129.1	64.5
Irvingia gabonensis	61	113.1	56.5
Pseudospondias microcarpa	79	103.3	51.6
Erythrophleum ivorensis	3	124.8	62.4
Strombosiopsis tetrandra	175	117.6	58.8
Strombosia grandifolia	138	139.1	69.5
Eriocoelum macrocarpum	95	109.4	54.7
Staudtia kamerunensis	71	85.3	42.6
Carapa oreophilia	137	81.8	40.9
Pellegriniodendron diphyllum	19	65.2	32.6
Coula edulis	46	65.7	32.8
Homalium longistylum	82	66	33
Xylopia africana	133	80	40
Vitex grandifolia	119	68.1	34
Margaritaria discoidea	37	62	31
Lecomtedoxa klaineana	4	66	33
Trichoscypha cf oliveri	55	60.5	30.3
Anthonotha macrophylla	161	69.3	34.7
Coelocaryon preussi	46	55.9	28
Albizia adianthifolia	46	58	29
Hypodaphnis zenkeri	45	55	27.5
Sapium ellipticum	19	54.8	27.4
Trichoscypha sp.10	59	54.8	27.4
Desbordesia glaucescens	4	56.4	28.2
Gambeya africanum	28	53.3	26.7
Musanga cecropioides	118	56.4	28.2
Gambeya subnudum	104	52.6	26.3
Poga oleosa	7	53.4	26.7
Terminalia ivorensis	2	60.1	30.1
Dacryodes edulis	136	52	26
Mammea africana	179	55.7	27.9
Vitex sp.3	33	50.9	25.5
Strombosia pustulata	151	58.2	29.1
Alstonia boonei	10	50.2	25.1
Talbotiella korupensis	94	47	23
Zanthoxylon gilletii	72	46.6	23.4
Afrostyrax lepidophyllus	73	42	21
Staudtia gabunensis	36	46	23
Barteria fistulosa	33	50.5	25.3
Omphalocarpum elatum	30	41.4	20.7
Symphonia globulifera	83	44	22
Total	5070	5422.7	2711.4
General total in survey	12036	8144.1	4072.1
Percentage	42.1	66.6	66.6

Appendix 2. Summary table of distribution of biomass, and carbon Sequestered per hectare using Allometric models in four Tropical forest types in the Rumpi Hills Forest Reserve, Cameroon.

Plot	Forest types	AGB (t/ha)	Carbon (t/ha)
1	Lowland	328.8	164.4
2	Lowland	585.3	292.6
3	Lowland	456.4	228.4
4	Lowland	482.5	241.2
5	Lowland	375.0	187.5
6	Lowland	421.9	211.0
7	Lowland	412.5	206.2
8	Lowland	282.4	141.2
14	Lowland	253.1	126.6
15	Lowland	274.9	137.5
16	Lowland	386.6	193.3
17	Lowland	373.8	186.9
18	Mid-Elevation	260.1	130.1
19	Mid-Elevation	188.3	94.2
20	Mid-Elevation	261.5	130.8
21	Mid-Elevation	316.0	158.0
22	Mid-Elevation	238.9	119.5
23	Mid-Elevation	183.8	91.9
24	Mid-Elevation	309.2	154.6
25	Mid-Elevation	263.1	131.6
9	Submontane	317.4	158.6
10	Submontane	327.8	163.9
13	Submontane	129.1	64.6
11	Montane	362.0	181.0
12	Montane	353.5	176.8
Total		8,144.1	4,072.1
Mean		325.8	162.9
Standard deviation		100.8	50.4

This study revealed that the RHFR was rich in species endemic to Cameroon. In total, 17 species were endemic to Cameroon including *Deinbollia angustifolia*, and *Gambeya korupensis* that are endemic to the Korup and Rumpi Hills area. A further 43 species were endemic to the Lower Guinea Forest Block (Appendix 1). This high level of species diversity and endemism (Osaki & Tsuji, 2016) corroborates (Mittermeier *et al.,* 1999; Myers *et al.,* 2000; Bergl *et al.,* 2007; Marchese, 2015) who classified the lowland and highland forests of West and Central Africa as a global biodiversity hotspot and concentration of endemic species. We found a decrease in overall tree density and tree species diversity with elevation (Fig. 2). Although species richness patterns generally decrease monotonically with elevation, some previous studies have found that species richness peaks at mid-elevational (McCain & Grytnes, 2010). It is worth noting that methodological factors including scale and sampling, and geographic factors can strongly influence elevational species richness. Elevational gradients are modulated by cascading and interlinked effects of biotic and abiotic factors such as rainfall, temperature and humidity, which vary among ecosystems and with spatial and temporal scale (Ali & Yan, 2017).

The present study demonstrated a strong correlation between lianas and large tree diversity (Fig. 6), suggesting a liana–host tree interaction, which is in agreement with studies that show that large trees are important for liana abundance in tropical forest (Ewango, 2010; Ewango *et al.,* 2015; Fadrique & Homeier, 2016). Lianas as structural parasites generally rely on trees for support

(Parren, 2003; Ewango, 2010). This findings aligns with the niche complementarity and mass ratio hypotheses (Ali & Yan, 2017), which explain the effect of functional diversity on carbon stock.

Most previous studies on biomass and carbon have been carried out in lowland forest (Brown, 1997; Djomo, 2010; Djomo *et al.,* 2010; Djuikouo *et al.,* 2010; Day *et al.,* 2013; Chave *et al.,* 2015; Djomo *et al.,* 2016; Memiahge *et al.,* 2016). The present study covers different forest types at different elevations, from the lowlands at 50 m to montane forest at 1778 m. Although biomass and carbon decreases with elevation, our results were not straight forward as lowland and montane forest shad high biomass and carbon than mid-elevation and submontane forest (Fig. 6). Based on the results obtained in this study, it plausible to suggest that lowland elevation, high species diversity and high carbon are associated while low carbon and low species diversity are associated.

Generally, the overall totals for biomass and carbon were high in RHFR per hectare compared to other sites in Africa (Sonwa *et al.,* 2011). Our lowland forest with a mean biomass of 386.1 t ha^{-1} was slightly lower (Dagar *et al.,* 2014) compared to other lowland tropical forest, with 402 t ha^{-1} (Djuikouo *et al.,* 2010, Gautam & Pietsch, 2012), 404 t ha^{-1} (Lewis *et al.,* 2009), and 429 t ha^{-1} in the Congo Basin (Lewis *et al.,* 2013, Pena *et al.,* 2011). This is not surprising as previous studies used the earlier formula (Chave *et al.,* 2005), which differs from the more recently revised version of Chave *et al.,* 2015 that was used in this study. Discrepancies are not uncommon when the same data set is analyzed with different allometric equations (Brown *et al.,* 1989; Brown, 1997; Chave *et al.,* 2005; Djomo, 2010; Chave *et al.,* 2015; Djomo *et al.,* 2016, Djomo & Chimi, 2017).

Although mid-elevation and submontane forest in this study showed lower values compared to lowland and montane forest, they still fall within the high end of the range among other studies in Africa (Brown, 1997; Makana, 2010; Djuikoko *et al.,* 2010; Lewis *et al.,* 2009; Lewis *et al.,* 2013; Kupsch *et al.,* 2014; Ekoungoulou *et al.,* 2014; Memiaghe *et al.,* 2016, Umunay *et al.,* 2017). The Rumpi Hills, on a per hectare basis, had its maximum biomass of 585.3 t ha^{-1} in a lowland plot, which is closer to data obtained from Monts de Cristal National Park in Gabon (619 t ha^{-1}) (Day *et al.,* 2013). In the Albertine Rift (Imani *et al.,* 2017), biomass ranged from 168 t ha^{-1} in upper montane to 290 t ha^{-1} in middle montane forest, lower than the values we recorded. Thus, the intact lowland to montane forest continuum in the Rumpi Hills is a potential carbon sink and site for the implementation of REDD+ mechanisms, climate change and forest dynamics.

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