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Peri-village Forest Retains the Highest Tree Diversity: Comparison of Forest Communities along a Livelihood Intensity Gradient in Southeast Cameroon

Masaaki Hirai[1,*], Thomas Mbang[2], Natacha Nana Afiong[2], Vice Clotèxe Tajeukem[3], Yves Wafo[2] & Hirokazu Yasuoka[1]

[1]*The Center for African Area Studies, Kyoto University*
[2]*University of Douala*
[3]*University of Buea*
*E-mail: msk.hirai@gmail.com

Abstract We compared tree diversity (diameter at breast height, DBH ≥ 10 cm), functional traits, and species composition among zones with different intensity levels of human activity in southeast Cameroon. The highest diversity, evaluated as species richness and Shannon's index, was observed in peri-village forest, where shifting cultivation was practiced. We detected little difference in functional traits (regeneration guild, leaf phenology, seed dispersal mode, woody density, basal area, and aboveground biomass) among zones for the tree species observed. Only a slight increase in the proportion of pioneer species was observed in peri-village forest, and species turnover was not detected. Previous studies have indicated that disturbances caused by creating agricultural fields introduce pioneer species and reduce tree species diversity. These studies compared diversity in fields or fallows with that in old-growth forests, which likely overestimated the negative impact of shifting cultivation on tree diversity. In contrast, we found that if shifting cultivation is practiced at moderate intensity, it can increase and maintain tree diversity without altering the quality of a landscape consisting of a mosaic of fields, young secondary forest, old secondary forest, and old-growth forest.

Keywords: Anthropogenic disturbance; Boumba-Bek National Park; Congo Basin Rainforest; Nki National Park, Shifting cultivation.

Introduction

In the Congo Basin, which contains the world's second largest tropical forest block (Nair 2002), shifting cultivation has had an impact on biodiversity conservation. Shifting cultivation, which involves the felling and burning of trees, causes massive disturbance to forests, resulting in considerable biodiversity loss and the simplification of forest structure (Norris et al. 2010). These impacts are exacerbated by the shorter fallow periods in recent years due to population growth and the development of a market economy (Tyukavina et al. 2018; Mukul &

Herbohn 2016; Van Gemerden et al. 2003a).

Shifting cultivation has negative impacts on plants, wildlife, soil nutrients, and soil physical and hydraulic properties, and is increasingly being recognized as a major cause of carbon stock loss under global warming (Mukul & Herbohn 2016). In Cameroonian rainforests, previous floristic studies have argued that shifting cultivation negatively affects tree diversity (Zapfack et al. 2002; Evariste et al. 2010; Van Gemerden et al. 2003a; Kabelong Banoho et al. 2020). In particular, the practice of burning trees negatively affects tree diversity (reviewed in Mukul & Herbohn 2016).

However, these results remain controversial, as the floristic studies compared diversity levels in fields or fallows with those in old-growth forests. Such studies have often focused on associations between short-term changes in vegetation and shifting cultivation, likely overestimating negative impacts on tree diversity. In contrast, studies focusing on seedling recruitment and long-term vegetation recovery processes after clearing fields have suggested that shifting cultivation may play a role in tree diversity retention (McNicol et al. 2015; Kassi N'Dja & Decocq 2008; Van Gemerden et al. 2003b). Shifting cultivation based on long-term fallows is an inherently sustainable forest use because the length of the fallow period exceeds that of the cropping period. The damage to the ecosystem is not necessarily severe if the soil nutrients and vegetation recover during the fallow phase (Norgrove & Beck 2016).

The impact of shifting cultivation on tree diversity varies greatly depending on the length of the fallow period. Moreover, the intensity of land clearing can also be a major factor in the success of forest recovery. Following burning, a significant number of trees remain on the cleared land, contributing to rapid vegetation recovery (Carrière et al. 2002; Shikata 2006; Hirai 2014). Therefore, when considering the impact of shifting cultivation, it is necessary to employ a spatially comprehensive approach that covers the entire landscape where shifting cultivation has been practiced, e.g., using a set of active plots, fallows, and old-growth forest, and considers the intensity of tree removal.

In this study, we conducted tree censuses at the landscape level in forest zones with different intensity levels of human activity, most of which involved shifting cultivation, in and around Boumba-Bek National Park and Nki National Park, southeast Cameroon. Based on the census data, we compared tree diversity, functional traits, and species composition among the zones and explored the positive effects of shifting cultivation on tree diversity.

Materials and Methods

I. Study sites

This study was conducted in Gribe and Zoulabot (known as Zoulabot Ancien), which are villages on the periphery of the Boumba-Bek and Nki National Parks, respectively. The two villages are located approximately 50 km apart and therefore have similar climatic conditions, topography, and vegetation. The seasons are divided into the major rainy season (September–November), major dry season (December–February), minor rainy season (March–June), and minor dry season (July–August). The annual rainfall is generally 1500–1800 mm, and the mean monthly rainfall in the major dry season is < 50 mm, whereas 100–250 mm is typical in the other three seasons. The average annual temperature is stable at approximately 24°C. The altitude is in the range of 500–700 m, and the landscape consists of gentle rolling hills, with several small (1–5 m in width) and medium-sized (5–10 m) rivers. More rivers are found near Zoulabot than Gribe (Yasuoka 2009, Hirai 2014). The vegetation is classified as mixed, moist, semi-deciduous forests of the Guineo–Congolian lowland rainforest region (White 1983; Letouzey 1985).

Both Gribe and Zoulabot are populated by Baka hunter-gatherers and Bantu-speaking farmers (mainly the Konabembe). The main settlements of these villages are located along roads, and some small settlements or farming camps have been established within 5 km of the road. The main settlement of Gribe has been in its current location since the 1930s, and Zoulabot has existed since the 1950s. The population of Gribe is approximately 800 people, whereas that of Zoulabot is approximately 200. Based on the area used by the villagers, including forest camps, the population density is < 5 individuals/km^2 in Gribe and < 1 individual/km^2 in Zoulabot. Both the Baka and Bantu people practice shifting cultivation, as well as hunting, gathering, and fishing, for their subsistence. Cacao and non-timber forest products are the main components of their cash income. The Baka rely more heavily on hunting and gathering based on extensive forest access, whereas the Bantu rely more heavily on shifting cultivation and cacao farming around their settlements (Hirai 2014; Yasuoka 2009).

According to Cameroon forest law, forests are classified as permanent forest estates (PFEs) and non-permanent forest estates (non-PFEs) (Republic of Cameroon 1994). In southeastern Cameroon, the majority of PFEs are further classified into forest management units (FMUs) and national parks (NPs). Areas where agriculture is allowed are limited to non-PFEs and agriculture may only be practiced within a 2–8-km zone on each side of the main road.

II. Plot design

The plots used for the tree censuses were designed to account for differences in land use and the intensity of shifting cultivation (Figure 1, Table 1), although the two censuses were planned separately. At the Gribe site, we established three zones: Zone G1 (high-intensity agriculture), Zone G2 (low-intensity agriculture), and Zone G3 (dominated by *Irvingia gabonensis* forest camps and timber exploitation). Shifting cultivation was practiced within an area of 8 km from the road, but the intensity changed substantially after 4 km. According to Hirai (2014), approximately 80% of the fields were distributed within 4 km of the road. Therefore, we divided this area into two zones: G1 was < 4 km from the road and G2 was 4–8 km from the road. In each zone, we established four plots of 2.5 ha (5 m wide × 5,000 m long) at 1-km intervals, parallel to the road. Zone G3, 8–16 km from the village, corresponded to an FMU where a logging company

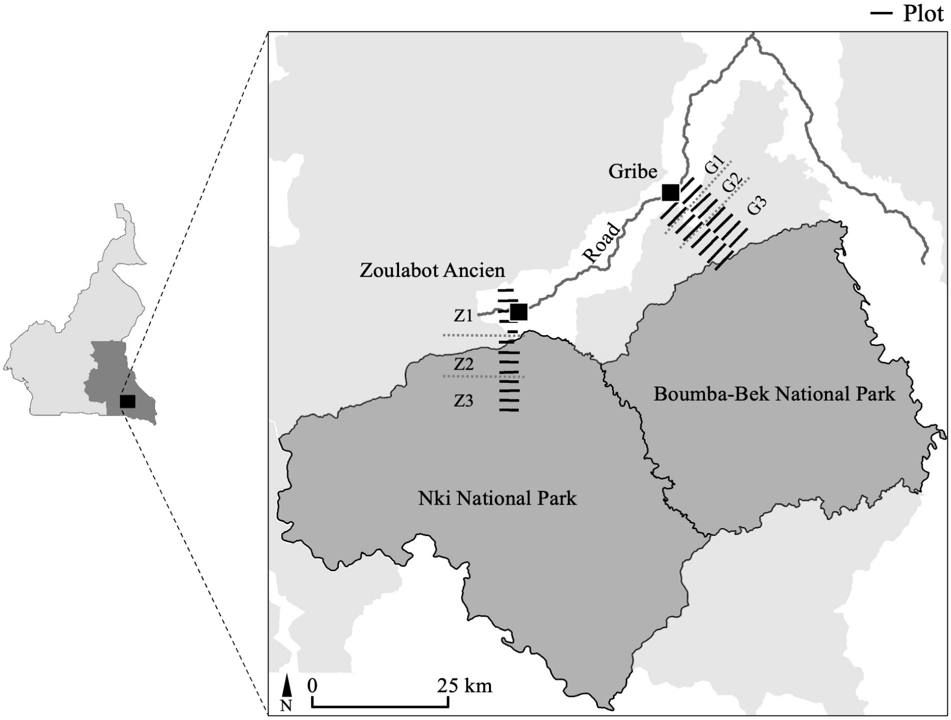

Figure 1 Study sites and plot design.

operated selective logging while the Baka intensively harvested Irvingia kernels in the minor dry season every year, except in years of poor fruit production, which occurred approximately once every 4–5 years (Hirai & Yasuoka 2020). We established eight 2.5-ha plots in G3 at 1-km intervals. The total area of the plots was 40 ha.

At the Zoulabot site, we also established three zones: Zone Z1 (agricultural zone, outside Nki NP), Zone Z2 (campsites for gathering Irvingia kernels, in Nki NP), and Zone Z3 (no intensive human activity, in Nki NP). Z1 extended 4 km from both sides of the village, with shifting cultivation practiced across the whole area. The intensity of shifting cultivation in this area was generally lower than that in Gribe because of the smaller Baka population that was less dependent on agriculture. Z2 was located 6–12 km south of the village, in an area within the Nki NP where the Baka gathered Irvingia kernels in the minor dry season almost every year. Z3 was established in an area over 13 km from the village, where the Baka had been hunter-gatherers and the Bantu had been small-scale shifting cultivators until both groups settled in the early 20th century (Yasuoka 2006, 2009). We established 14 plots of 4–9 ha (25 m wide × 1,600–3,600 m long) at 2-km intervals, parallel to the road: five plots in Z1, four in Z2, and four in Z3. The plots had a total area of 100 ha. Each plot was divided into 1-ha subplots for data analysis.

III. Data collection

(1) Tree census

We conducted a tree census at the Gribe site in 2012–2013 and at the Zoulabot site in 2019–2020. In Gribe, we recorded all trees with a diameter at breast height (DBH) ≥ 10 cm. In Zoulabot, in addition to DBH (≥ 10 cm), we recorded Global Positioning System (GPS) coordinates for all individuals. Woody vines were not recorded. Species names were first recorded as the Baka vernacular names, and then specimens of all species recorded were collected and identified according to their scientific names. Specimens collected in Gribe were identified in 2013 at the Millennium Ecologic Museum in Yaoundé, Cameroon; however, full identification was not possible because the specimens were incomplete. Therefore, specimens of all species were collected again in 2021 based on the Baka vernacular names, and identified using specimen reference images provided by the Global Biodiversity Information Facility (https://www.gbif.org/ja/) with further guidance from the National Herbarium of Cameroon. Specimens collected at the Zoulabot site were identified using the same method in 2021. The taxonomy was described based on Plants of the World Online (POWO 2023).

(2) Functional traits of each species

To determine whether the functional traits of trees varied with distance from the road (Drd) and among zones, information on the following five traits was collected: regeneration guild, leaf phenology, seed dispersal mode, wood density, and aboveground biomass.

Regeneration guilds were generally classified into pioneer (Pi), non-pioneer light demanding (NPLD), and shade tolerant (ST) species (Mbatchou 2004; Fayolle et al. 2014). Pi species require full light conditions throughout their life cycle and regenerate only in forest gaps. Their dominance therefore indicates disturbed forests. NPLD species can recruit from the understory, but require light to reach the canopy. Generally, NPLD species are abundant in old-growth disturbed forests. ST species recruit under shaded conditions, and grow, flower, and fruit in undisturbed forests. We identified the regeneration guild type for each species based on Mbatchou (2004) and Gourlet-Fleury et al. (2013), and Hawthorne (1995). Where descriptions differed among these references or a description was absent, we identified the guild type based on personal observations (Masaaki Hirai and Yves Wafo) and DBH distributions.

Leaf phenology type was classified into evergreen (EG) and deciduous or semi-deciduous (DC) based on Fayolle et al. (2014). Because leaf phenology was described at the genus level, we combined our observations to assign leaf phenology to the species level.

Seed dispersal modes are generally classified into zoochory (animal dispersal), anemochory (wind dispersal), autochory (self-dispersal), barochory (gravity dispersal), and other types of abiotic dispersal (Howe & Smallwood 1982; Seidler & Plotkin, 2006; Vittoz & Engler 2007). Autochory, barochory, and other abiotic dispersal types were excluded from the analysis because these modes are usually a combination of several different processes. Of the species classified as zoochorous, those that met the criteria of Guimaraes et al. (2008) (fleshy fruits 4–10 cm in diameter with up to 5 seeds, or fleshy fruits > 10 cm diameter with numerous small seeds) and for which elephant feeding was confirmed in the literature, were classified as having megafaunal dispersal.

Wood density values for each species were obtained from Zanne et al. (2009). For species and genera not listed in the reference, the average value of the next higher taxonomic group was used.

Aboveground biomass (AGB) was calculated based on a regression model proposed by Chave et al. (2005): AGB = $\rho \times \exp[-1.499 + 2.148 \ln(D) + 0.207 (\ln(D))^2 - 0.0281 (\ln(D))^3]$, where ρ is the wood density for each species (g/cm^3), and D is DBH (cm). This model is widely used for humid zones with an annual rainfall of 1500–4000 mm and is valid only for broadleaf trees with stem diameters in the range 5–156 cm.

IV. Data analysis

(1) Identifying the dominant taxa

For each site, we calculated the family importance value (FIV; Cottam & Curtis 1956) and the ecological importance value of the species (IVI; Curtis & McIntosh 1951). The FIV for Family A was calculated as the sum of the relative number of species of Family A, the relative number of individuals of Family A, and the relative cumulative basal area of Family A. The FIV has a range of 0–300, and the sum of FIVs for all families is 300.(1) The IVI for Species A was calculated as the sum of the relative number of individuals of Species A, the relative cumulative basal area of Species A, and the relative frequency of subunits in which Species A appeared. The IVI also had a range from 0–300, and the sum of IVIs for all species was 300.

(2) Testing effects on species diversity and abundance

We calculated the following indices for each 2.5-ha plot in zones G1–G3 at the Gribe site, and each 1-ha subplot and plot in zones Z1–Z3 of the Zoulabot: Species richness (SR), Shannon's index (H'; $-\sum_{i=1}^{S} p_i \times \ln p_i$, where p_i is the relative abundance of species i, and S is species richness), Pielou's evenness index (J'; H'/lnS), and tree density (trees/ha). To verify the sufficiency of the sampling effort, we calculated the Chao1 richness estimate (Chao et al. 2009) and ratios of observed SR to Chao1. In Gribe, we did not establish 1-ha subplots; therefore, to allow a comparison based on indicators at 1 ha between plots in Zoulabot and previous studies, we estimated SR, H', and J' at 1 ha for plots in Gribe by randomized simulations. We carried out 1,000 random extractions of trees over 1 ha from each Gribe plot, using the average density (trees/ha) of each zone (G1 = 368, G2 = 496, G3 = 440). Then, we calculated the indicators and averaged the values for each indicator.

For the Gribe site, we performed generalized linear model (GLM) analyses to examine the effects of Drd and zone on the diversity indices (SR, H', and J') and tree density. For the Zoulabot site, because subplots were nested in each plot, we performed generalized linear mixed model (GLMM) analyses with the plots as random effects. For both sites, the Poisson distribution following the log link function was used for SR, the normal distribution (i.e., linear mixed model) following the identity link function was used for H' and J', and the gamma distribution following the log link function was used for tree density. Additionally, for the Zoulabot site that included a number of water bodies (rivers, swamps, and seasonally inundated areas), the minimum distance from a river or swamp (Drs) and slope degree were estimated for all trees using a 30-m resolution digital elevation model (DEM) image (SRTM30) and geographic information system (GIS) software (ArcMap 10.1). The medians were used as representative values for the subplots and were included as fixed effects. Then, we identified the best model based on the Akaike Information Criterion (AIC). When the intercept or slope estimated by modeling was significant ($P < 0.05$), the difference between zones was tested by pairwise comparisons of the least-squares means.

(3) Testing effects on functional traits

We analyzed how the Drd and different zones affected the functional traits of the trees. First, we calculated the ratio of the number of trees associated with each type of regeneration guild, leaf phenology, and seed dispersal, to the total number of trees recorded in each plot in Gribe and each subplot in Zoulabot. In the same units, we also calculated the sum of basal area, mean wood density, and aboveground biomass. Second, for the Gribe site, we performed a GLM analysis with an offset of total number of trees per plot to examine the fixed effects of Drd and zones on the compositions of trees that were classified into the different types of each functional trait. For the Zoulabot site, we performed the GLMM with an offset of total number of trees per plot, and with a random effect of subplots for the same purpose. For both sites, the Poisson distribution following the log link function was used for the number of trees classified into each type. When significant differences ($P < 0.05$) were found in the intercept or slope estimates, differences between zones were tested by pairwise comparisons of least-squares means. The Bonferroni correction was applied to correct for multiple testing.

(4) Testing effects on species composition

To determine the effect of zones on species composition, we first performed a non-hierarchical cluster analysis on the plots in Gribe and subplots in Zoulabot, based on the IVI values for all species, using the k-medoids clustering technique with Bray–Curtis dissimilarity as the distance measure. The k-medoids clustering method is a robust technique because it minimizes the sum of dissimilarities instead of the sum of squared Euclidean distances and it tends to converge to the same solution, with a wide array of starting medoids for a given k value (Borcard et al. 2011). To determine the optimal number of clusters (k), we computed the average silhouette of observations ($k = 1$–10 for Gribe, $k = 1$–30 for Zoulabot) and adopted the k with the largest silhouette value (Rousseeuw 1987). To quantify the stability of the obtained clusters, average Jaccard coefficients were calculated from 100 bootstrapping runs. Clusters with a score < 0.6 were considered unstable; scores between 0.6 and 0.75 were stable; and scores > 0.85

were highly stable (Zumel et al. 2014).

For each cluster, we calculated the proportions of the plots or subplots belonging to each zone to the total number of plots or subplots attributed to each cluster, and performed a goodness-of-fit test to determine whether the observed proportions for each cluster were significantly different from the proportions of plots or subplots originally set in each zone (Table 1). Then, indicator values (IndVal; Dufrêne & Legendre 1997) were computed to identify the indicator species that characterized each cluster. The IndVal of a species is defined by both its abundance and dominance in a specific cluster. The value can vary between 0 and 1; no trees of a specific species were found in a cluster when its IndVal was 0, and trees of only one specific species were found in a cluster when its IndVal was 1. The IndVal results were considered significant at $P < 0.05$, and such species were considered suitable indicator species for the cluster.

To detect whether species were disproportionately distributed in specific zones, we conducted correspondence analyses based on the IVI values for all species in each zone.

Data analyses were performed using R v4.1.1 (R Core Team, Vienna, Austria).

Results

I. Dominant taxa

The census recorded a total of 17,582 trees belonging to 209 species, 153 genera, and 47 families across 16 plots (40 ha) at the Gribe site, and 35,275 trees belonging to 241 species 170 genera, and 55 families across 13 plots (100 ha) at the Zoulabot site. The total number of species identified was 289 from both sites, 161 of which were shared by the two sites. In Gribe the density was 440 trees/ha, and the basal area was 43.6 m^2/ha, whereas in Zoulabot the corresponding figures were 353 trees/ha and 28.5 m^2/ha. The ratio of observed SR to Chao1 was 79–97% at both sites (Table 1). Fabaceae, Annonaceae, Malvaceae, Meliaceae, Euphorbiaceae, Phyllanthaceae, and Rubiaceae were among the 10 families with the highest FIV in both sites (Table 2).

The 10 species with the highest IVI in Gribe were *Terminalia superba*, *Musanga cecropioides*, *Anonidium mannii*, *Celtis mildbraedii*, *Ricinodendron heudelotii*, *Trichilia rubescens*, *Greenwayodendron suaveolens*, *Albizia adianthifolia*, *Uapaca* sp., and *Triplochiton scleroxylon*. The sum of their IVI values was 61.1, or 20.4% of the total IVI (Table 3, Appendix). When considering the top 10 species in each zone, eight species were shared between G1 and G2, six species between G2 and G3, and six species between G3 and G1.

The 10 species with the highest IVI in Zoulabot were *Scorodophloeus zenkeri*, *G. suaveolens*, *A. mannii*, *T. rubescens*, *Pentaclethra macrophylla*, *Uapaca* sp., *Pycnanthus angolensis*, *Duboscia macrocarpa*, *Coelocaryon preussii*, *Irvingia gabonensis*, and *Dichostemma glaucescens*. The sum of their IVI values was 63.9, or 21.3% of the total IVI (Table 3, Appendix). When considering the top 10 species in each zone, five species were shared between Z1 and Z2, six species

Table 1 Summary of the tree census results for Gribe and Zoulabot

Site	Zone	Plot ID	Plot size (ha)	Number of subplots	Distance from the road (km)	Number of trees	Density (trees/ha)	Basal area (m^2/ha)	Species richness observed	Species richness estimator			Shannon's index (H')	Pielou's index (J')
										Chao1	SE	Coverage (%)		
Gribe	G1: Non-permanent forest estate with a higher agricultural intensity	G1-1	2.5	-	1	1,018	407	40.5	148	163	7.80	90.8	4.47	0.895
		G1-2	2.5	-	2	875	350	43.3	131	150	9.19	87.3	4.39	0.900
		G1-3	2.5	-	3	863	345	38.3	131	158	13.54	82.9	4.43	0.909
		G1-4	2.5	-	4	928	371	33.7	137	167	13.26	82.0	4.33	0.881
		Whole zone	10.0	-	1–4	3,684	368	38.9	184	191	4.52	96.4	4.58	0.879
	G2: Non-permanent forest estate with a lower agricultural intensity	G2-1	2.5	-	5	1,238	495	46.9	128	146	9.34	87.7	4.18	0.861
		G2-2	2.5	-	6	1,078	431	47.5	138	169	13.98	81.7	4.38	0.888
		G2-3	2.5	-	7	1,330	532	58.3	128	163	19.28	78.5	4.36	0.899
		G2-4	2.5	-	8	1,314	526	45.9	130	144	8.04	90.3	4.38	0.899
		Whole zone	10.0	-	5–8	4,960	496	49.7	174	183	5.55	95.3	4.53	0.878
	G3: Permanet forest estate with Irvingia camps and timber exploitation	G3-1	2.5	-	9	1,304	522	45.2	127	136	6.17	93.4	4.36	0.899
		G3-2	2.5	-	10	1,207	483	43.1	123	139	8.76	88.5	4.26	0.885
		G3-3	2.5	-	11	1,122	449	40.3	121	135	8.09	89.6	4.31	0.899
		G3-4	2.5	-	12	1,221	488	42.4	124	137	7.59	90.5	4.29	0.889
		G3-5	2.5	-	13	1,103	441	43.2	116	128	7.43	90.6	4.30	1.000
		G3-6	2.5	-	14	1,003	401	35.6	117	138	11.47	84.8	4.23	0.889
		G3-7	2.5	-	15	940	376	43.4	119	139	10.56	85.6	4.30	0.900
		G3-8	2.5	-	16	1,038	415	49.6	113	124	7.30	91.1	4.11	0.869
		Whole zone	20.0	-	9–16	8,938	447	42.9	167	194	16.50	86.0	4.44	0.867
	Whole site (G1–G3)		40.0	-	1–16	17,582	440	43.6	209	224	9.74	93.3	4.58	0.858
Zoulabot	Z1: Non-permanent forest estate with entirely lower agricultural intensity	Z1-1	7.0	7	4	2,959	423	38.4	184	201	8.86	91.5	4.59	0.880
		Z1-2	8.0	8	2	3,694	462	35.1	183	212	15.04	86.3	4.59	0.881
		Z1-3	8.0	8	0	2,867	358	22.9	169	180	7.25	93.9	4.63	0.903
		Z1-4	8.0	8	2	3,142	393	29.4	159	175	8.76	90.9	4.21	0.830
		Z1-5	4.0	4	4	1,303	326	24.2	133	155	11.14	85.8	4.23	0.865
		Whole zone	35.0	35	0–4	13,965	399	30.0	230	266	20.82	86.4	4.67	0.859
	Z2: Permanent forest estate with Irvingia camps	Z2-1	7.0	7	6	2,759	394	29.3	148	165	10.66	89.7	4.19	0.839
		Z2-2	8.0	8	8	2,849	356	24.7	140	158	10.11	88.6	4.26	0.862
		Z2-3	8.0	8	10	2,868	359	30.1	149	168	9.90	88.7	4.28	0.854
		Z2-4	8.0	8	12	2,642	330	31.6	150	185	19.28	81.1	4.35	0.867
		Whole zone	31.0	31	6–12	11,118	359	28.9	189	200	7.25	94.5	4.41	0.842
	Z3: Permanent forest estate with a lesser human intervention	Z3-1	8.0	8	13	2,645	331	22.7	148	161	7.51	91.9	4.23	0.847
		Z3-2	9.0	9	15	2,595	288	22.1	133	137	3.56	97.1	4.26	0.871
		Z3-3	8.0	8	17	2,330	291	31.6	146	169	12.47	86.4	4.35	0.872
		Z3-4	9.0	9	19	2,622	291	28.4	151	158	4.57	95.6	4.33	0.863
		Whole zone	34.0	34	13–19	10,192	300	26.2	178	193	9.73	92.2	4.40	0.850
	Whole site (Z1–Z3)		100.0	100	0–19	35,275	353	28.4	241	280	22.95	86.1	4.62	0.843

Table 2 Family importance values (FIVs) for all families recorded in Gribe and Zoulabot

Family	Gribe				Zoulabot				Mean FIV
	Relative number of species (%)	Relative number of trees (%)	Relative basal area (%)	FIV	Relative number of species (%)	Relative number of trees (%)	Relative basal area (%)	FIV	
Fabaceae	13.9	6.9	14.0	34.8	13.6	14.4	22.8	50.8	42.8
Annonaceae	6.7	11.3	6.5	24.6	5.9	12.0	8.6	26.6	25.6
Malvaceae	8.1	7.2	11.3	26.7	8.1	7.0	7.4	22.4	24.6
Meliaceae	3.8	10.1	6.5	20.5	3.8	7.6	7.4	18.8	19.6
Euphorbiaceae	4.3	5.3	5.3	14.9	5.1	5.3	3.8	14.2	14.5
Irvingiaceae	2.9	1.8	4.6	9.3	3.0	4.4	7.9	15.2	12.3
Phyllanthaceae	2.9	4.9	5.0	12.8	3.4	3.9	3.9	11.2	12.0
Rubiaceae	5.7	3.3	1.7	10.7	5.9	3.5	2.8	12.2	11.5
Cannabaceae	2.9	4.8	5.7	13.3	2.1	2.9	3.5	8.6	11.0
Myristicaceae	1.4	4.6	2.2	8.2	1.3	5.1	4.3	10.7	9.5
Sapotaceae	4.3	2.5	3.5	10.2	3.8	2.0	2.0	7.7	9.0
Moraceae	4.3	3.6	3.5	11.4	3.0	1.6	1.4	5.9	8.7
Olacaceae	2.9	4.1	2.5	9.5	2.5	3.0	2.1	7.7	8.6
Apocynaceae	2.9	1.8	3.6	8.3	3.4	1.7	3.5	8.5	8.4
Combretaceae	1.0	1.6	9.2	11.7	0.8	0.9	2.4	4.2	8.0
Putranjivaceae	2.9	2.2	0.8	5.9	3.8	4.0	1.5	9.3	7.6
Urticaceae	1.0	4.5	4.4	9.9	0.8	1.3	1.5	3.7	6.8
Ebenaceae	3.3	2.7	0.9	6.9	3.0	0.9	0.4	4.2	5.6
Anacardiaceae	1.9	1.3	0.9	4.1	2.1	1.7	1.5	5.4	4.7
Sapindaceae	2.4	1.4	0.7	4.5	2.5	1.1	0.5	4.2	4.3
Clusiaceae	2.9	1.3	0.6	4.8	2.1	1.1	0.7	3.8	4.3
Rhamnaceae	1.0	2.1	0.5	3.6	1.3	2.1	0.6	3.9	3.7
Pandaceae	0.5	1.1	0.7	2.3	0.8	1.4	1.5	3.8	3.0
Burseraceae	1.0	0.7	0.4	2.0	1.3	1.7	0.8	3.8	2.9
Violaceae	1.0	2.5	0.5	3.9	0.8	0.8	0.2	1.8	2.9
Lecythidaceae	1.0	0.7	1.0	2.6	0.4	1.0	1.5	3.0	2.8
Bignoniaceae	1.4	0.9	0.7	3.0	1.3	0.4	0.3	2.0	2.5
Huaceae	0.5	1.0	0.4	1.9	0.4	1.2	0.6	2.2	2.0
Rutaceae	1.4	0.4	0.1	1.9	1.3	0.4	0.4	2.1	2.0
Achariaceae	1.4	0.4	0.1	1.8	1.3	0.5	0.1	1.9	1.9
Lepidobotryaceae	0.5	0.7	0.3	1.5	0.4	0.9	0.4	1.7	1.6
Lamiaceae	0.5	0.6	0.4	1.4	0.4	0.5	0.4	1.3	1.4
Salicaceae	0.5	0.6	0.5	1.6	0.8	0.1	0.2	1.1	1.4
Lauraceae	0.5	0.1	0.1	0.8	0.4	0.9	0.7	2.0	1.4
Chrysobalanaceae	0.5	0.1	0.2	0.8	0.8	0.5	0.4	1.7	1.2
Passifloraceae	0.5	0.4	0.1	1.0	0.4	0.4	0.1	1.0	1.0
Rhizophoraceae	0.5	0.0	0.1	0.6	0.4	0.1	0.5	1.1	0.8
Thomandersiaceae	0.5	0.1	0.0	0.6	0.4	0.4	0.1	0.9	0.8
Ixonanthaceae	0.5	0.1	0.1	0.6	0.4	0.3	0.2	0.9	0.7
Myrtaceae	0.5	0.0	0.2	0.7	0.4	0.1	0.2	0.7	0.7
Loganiaceae	0.5	0.0	0.0	0.5	0.8	0.0	0.0	0.9	0.7
Ulmaceae	0.5	0.1	0.2	0.7	0.4	0.0	0.0	0.4	0.6
Anisophylleaceae	0.5	0.0	0.1	0.6	0.4	0.0	0.0	0.5	0.5
Boraginaceae	0.5	0.0	0.1	0.6	0.4	0.0	0.0	0.4	0.5
Menispermaceae	0.5	0.0	0.0	0.5	0.4	0.0	0.0	0.4	0.5
Calophyllaceae					0.4	0.7	0.6	1.6	0.8
Oleaceae					0.8	0.2	0.2	1.3	0.6
Melastomataceae	1.0	0.0	0.1	1.1					0.5
Ochnaceae					0.8	0.0	0.0	0.9	0.4
Polygalaceae					0.8	0.0	0.0	0.9	0.4
Asparagaceae					0.4	0.0	0.2	0.6	0.3
Thymelaeaceae	0.5	0.0	0.0	0.5					0.2

Table 3 The 10 most dominant species in terms of importance values (IVIs) in Gribe and Zoulabot

Species	Gribe				Zoulabot			
	G1	G2	G3	G1–G3	Z1	Z2	Z3	Z1–Z3
Terminalia superba	14.2	12.3	8.3	10.7	4.8	1.7	1.8	2.9
Musanga cecropioides	11.5	11.6	4.7	8.1	5.3	1.1	0.0	2.4
Anonidium mannii	4.1	4.2	9.3	6.8	7.3	9.3	6.8	7.8
Celtis mildbraedii	8.4	5.5	4.7	5.7	5.9	1.7	2.5	3.5
Ricinodendron heudelotii	4.4	4.9	6.4	5.5	5.5	1.6	1.8	3.1
Trichilia rubescens	5.2	5.0	5.2	5.1	7.2	5.6	4.7	6.0
Greenwayodendron suaveolens	4.6	4.7	5.4	5.0	4.9	8.4	12.7	8.3
Albizia adianthifolia	4.9	4.2	5.1	4.8	2.9	4.1	3.1	3.3
Uapaca spp.	4.6	4.7	4.9	4.8	3.6	5.9	4.4	4.6
Triplochiton scleroxylon	5.3	5.5	3.7	4.6	2.5	0.3	1.1	1.4
Trilepisium madagascariense	5.1	7.0	2.8	4.5	3.6	1.7	0.5	2.1
Entandrophragma cylindricum	5.9	2.4	4.8	4.3	2.8	3.7	4.6	3.6
Carapa procera	1.8	5.0	4.9	4.3	1.7	3.6	6.6	3.8
Alstonia boonei	2.8	3.7	5.2	4.3	4.5	3.2	3.3	3.7
Pentaclethra macrophylla	4.2	3.8	4.1	4.1	5.4	5.4	6.3	5.7
Dichostemma glaucescens	2.8	2.7	4.9	3.8	2.0	6.4	3.8	3.9
Duboscia macrocarpa	3.4	3.0	4.1	3.6	3.9	4.7	4.6	4.3
Klainedoxa gabonensis	1.9	4.2	4.1	3.6	3.2	3.7	4.4	3.7
Pycnanthus angolensis	3.7	2.8	3.3	3.2	3.6	5.7	4.2	4.5
Irvingia gabonensis	2.9	2.6	2.1	2.4	2.6	5.7	3.7	3.9
Scorodophloeus zenkeri	0.3	1.4	1.6	1.3	11.3	8.1	13.8	11.0
Coelocaryon preussii	4.3	0.8	0.0	1.2	4.3	5.5	2.0	4.0

between Z2 and Z3, and five species between Z3 and Z1.

Species commonly among the 10 highest IVI values from both sites were *A. mannii*, *T. rubescens*, *G. suaveolens*, and *Uapaca* spp. These species are all dominant species in the Guineo–Congolian region (White 1983), and similar results have been reported from eastern Cameroon (Mbobda et al. 2018; Zekeng et al. 2021), southern Cameroon (Evariste et al. 2010; Gonmadje et al. 2011), Gabon (Van Valkenburg et al. 1998), and the Democratic Republic of the Congo (Philippe Boubli et al. 2004). In southeastern Cameroon, including our sites, Irvingiaceae is ranked among 10 most dominant families. Irvingiaceae includes several species that contribute to the livelihoods of local people (Hirai 2014, Toda & Yasuoka 2020).

II. Effects of zone and Drd

(1) Tree diversity

In Gribe, the zone and Drd significantly affected SR and H’. SR and H’ values were highest closer to the road. SR and H’ were significantly higher for G1 than for G3 (Figure 2, Table 4). In contrast, tree density was significantly lower in G1 than in G2 and G3. The J’ value was not affected by the Drd or zone.

Similarly, in Zoulabot, the zone and Drd significantly affected SR and H’ (Figure 2, Table 4). Both values were significantly higher in Z1 than in Z2 and Z3. The Drd and zone also significantly affected tree density, which decreased with distance

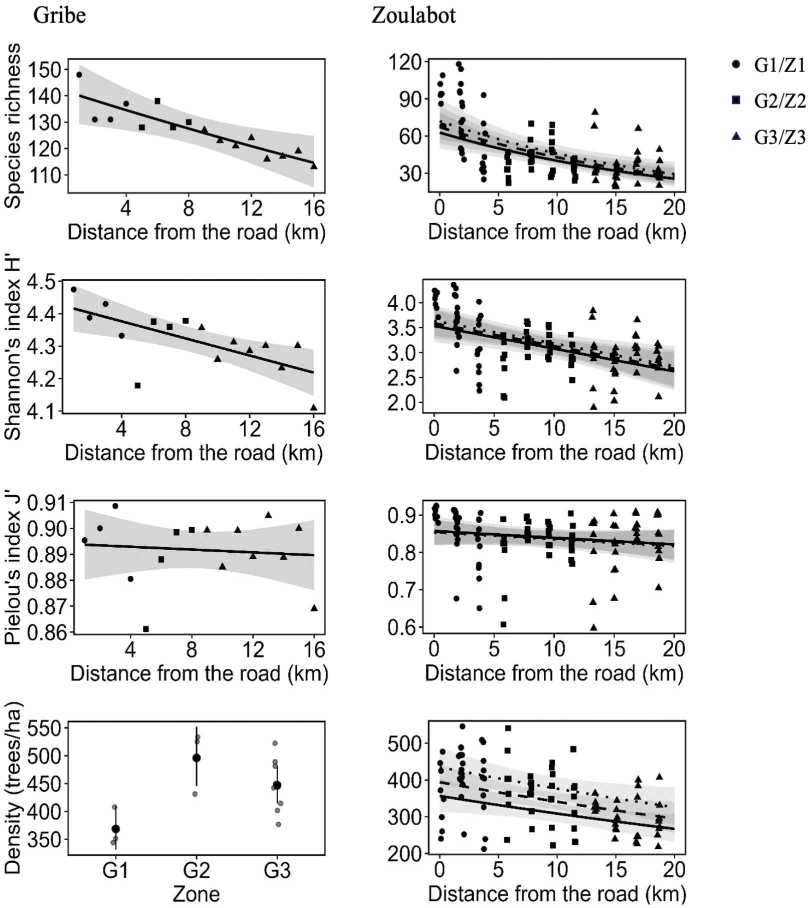

Figure 2 Effects of distance from the road (Drd) and zone on tree diversity and density. Black lines in Gribe represent relationships predicted from a generalized linear model (GLM) analysis. Solid, dashed, and dotted lines represent relationships predicted from a generalized linear mixed model (GLMM) analysis by distance from the water body (Drs) of <70 m, 70–270 m, and 270–470 m, respectively for Zoulabot. Grey areas and bars represent 95% credible intervals.

from the road. The J' value was not affected. The Drs negatively affected SR and tree density.

Given that J' values were similar among all zones at both sites, the composition of abundant and rare species was comparable in all zones. Therefore, incidental sampling of rare species did not contribute to differences in SR.

SR and H' values in Zoulabot were generally lower and their dispersions among the subplots were larger than those for Gribe. For example, the SR (1 ha) for G1 was estimated to be 106 species and the H' value was 4.23, whereas the SR for Z1 was 70 and the H' value was 3.59. However, Yasuoka (2009), who conducted a vegetation census around Zoulabot, reported an SR of 121 species,

Table 4 Summary of the effects of the distance from the road (Drd) and zone on tree diversity and density

Model	Parameter	Species richness				Shannon's index (H')				Pielou's index (J')				Density (trees/ha)			
		Coef	SE	P	AIC	Coef	SE	P	AIC	Coef	SE	P	AIC	Coef	SE	P	AIC
Gribe																	
Zone	G1	4.92	0.04	**0.000**	116.0	4.41	0.04	**0.000**	-31.8	0.90	0.01	**0.000**	-88.2	5.91	0.05	**0.000**	170.7
	G2	0.00	0.06	0.482		0.00	0.05	0.129		0.00	0.01	0.319		0.00	0.07	**0.000**	
	G3	0.00	0.05	**0.015**		0.00	0.05	**0.004**		0.00	0.01	0.603		0.00	0.06	**0.001**	
Drd	Drd	-0.01	0.00	**0.005**	112.9	-0.01	0.00	**0.001**		0.00	0.00	0.705	-89.2	0.01	0.01	0.460	182.2
Zoulabot																	
Drs		0.35	0.08	**0.000**	911.3	0.30	0.22	0.168	127.3	0.00	0.04	0.937	-247.5	0.53	0.10	**0.000**	1122.4
Slp		0.00	0.01	0.431	929.1	0.00	0.02	0.767	129.1	0.00	0.00	0.296	-248.5	0.00	0.01	0.572	1147.7
Zone	Z1	4.17	0.11	**0.000**	921.3	3.57	0.14	**0.000**	123.3	0.86	0.01	**0.000**	-247.4	5.97	0.05	**0.000**	1143.4
	Z2	0.00	0.17	**0.004**		0.00	0.21	**0.016**		0.00	0.02	0.225		0.00	0.08	0.250	
	Z3	0.00	0.17	**0.000**		0.00	0.21	**0.003**		0.00	0.02	0.213		0.00	0.08	**0.001**	
Drd		-0.30	0.01	**0.000**		-0.05	0.01	**0.002**		0.00	0.00	0.270		-0.02	0.00	**0.000**	
Zone + Drs	Z1	4.04	0.11	**0.000**	906.0	3.48	0.16	**0.000**	124.1	0.86	0.02	**0.000**	-245.6	5.77	0.06	**0.000**	1121.5
	Z2	0.00	0.17	**0.010**		0.00	0.21	**0.026**		0.00	0.02	0.197		0.00	0.08	0.987	
	Z3	0.00	0.17	**0.000**		0.00	0.21	**0.004**		0.00	0.02	0.188		0.00	0.08	**0.014**	
	Drs	0.34	0.08	**0.000**		0.24	0.22	0.281		-0.02	0.04	0.648		0.52	0.10	**0.000**	
Drd + Drs	Drd	-0.05	0.01	**0.000**	902.1	-0.05	0.01	**0.003**	122.1	0.00	0.00	0.256	-246.7	-0.01	0.01	**0.011**	1120.1
	Drs	0.34	0.08	**0.000**		0.26	0.22	0.236		-0.01	0.04	0.768		0.50	0.10	**0.000**	

Settlements and fields are distributed along the road. A generalized linear model (GLM) analysis was performed for Gribe, and a generalized linear mixed model (GLMM) analysis was performed for Zoulabot, with plots as the random effect. A Poisson distribution with log link function was assumed for species richness (SR), a normal distribution (identity) was assumed for Shannon's index (H') and Pielou's evenness index (J'), and a gamma distribution with log link function was assumed for density. Coef denotes the intercept for zone categories and the slope for Drd, hillslope (Slp), and distance from river or swamp (Drs).

which was similar to the Gribe value in the present study. The lower diversity and larger dispersion in the Zoulabot site in this study were likely caused by the abundance of rivers and swamps at the site. Raphia palms thrive in swamps, and riparian forests have many canopy gaps. Because these forest types are widely distributed in the study area, the plots generally showed low species diversity and low basal area. Similar trends have been observed in southern Cameroon (Tchouto et al. 2006) and eastern Cameroon (Kabelong Banoho et al. 2020).

(2) Functional traits

By collecting information regarding regeneration guild, leaf phenology, seed dispersal mode, and wood density from the literature, we identified these traits for at least 99.5% of all species recorded in Gribe, and 98.3% in Zoulabot (Appendix).

In Gribe, the zone and Drd significantly affected the percentage of Pi species among all trees (%Pi) and the percentage of ST species among all trees (%ST). Closer to the road, %Pi increased significantly and %ST decreased significantly (Table 5, Fig. 3). The %Pi was significantly higher in G1 than in G3 (medians: 19% for G1 and 13% for G3), and the %ST was significantly lower in G1 (55%) than in G2 (62%) and G3 (64%). There was no effect of zone or Drd on the percentage of NPLD species among all trees (%NPLD). Basal area was affected by zone, which was highest in G2 (49.7 m^2/ha), with significant differences from G1 (38.9 m^2/ha). There were no significant differences between G1 and G3. The aboveground biomass was highest in G2 (634.8 Mg/ha) and significantly different from the lowest G1 (512.3 Mg/ha). Among seed dispersal modes, a slight effect of zone was detected on the percentage of anemochory between G1 (18%) and G2 (12%). No effect of Drd or zone was detected for other seed dispersal modes, leaf phenology, or wood density.

In Zoulabot, Drd and zone significantly affected %Pi and %ST. As in Gribe, closer to the road, %Pi increased significantly and %ST decreased significantly (Table 5, Figure 3). The %Pi in Z1 (median: 13%) was significantly higher than in the other two zones (6% in Z2 and 7% in Z3). The %ST in Z1 (62%) was significantly lower than in Z2 (71%) and Z3 (73%). The %NPLD in Z1 (26%) was significantly higher than in Z3 (20%). The Drd and zone also significantly affected leaf phenology. Closer to the road, the percentage of deciduous trees among all trees (%DC) increased significantly and the percentage of evergreen trees among all trees (%EG) decreased significantly. Both %DC and %EG in Z1 differed from the corresponding values in Z2 and Z3. The percentage of zoochorous species was significantly higher in Z1 (66%) than Z2 (59%) and Z3 (57%). No effect of Drd or zone was detected for other seed dispersal modes, basal area, wood density, or aboveground biomass.

(3) Species composition

Based on the cluster analysis of species composition, the plots in Gribe were classified into three clusters (Figure 4). The stability of the clusters was rated as stable for cluster 1 (Jaccard coefficient = 0.84), unstable (0.50) for cluster 2, and somewhat stable for cluster 3 (0.66). Cluster 1 was composed of only G1 plots,

Table 5 Effects of Drd and zone on functional traits

Functional trait	Gribe				Zoulabot			
	Parmeter	Coef	SE	P	Parameter	Coef	SE	P
Regeneration guild								
Pioneer	G1	-1.59	0.14	**0.000**	Z1	-2.00	0.08	**0.000**
	G2	-1.74	0.19	0.456	Z2	-2.78	0.12	**0.000**
	G3	-2.03	0.17	**0.026**	Z3	-2.69	0.12	**0.000**
	Drd	-0.05	0.01	**0.007**	Drd	-0.05	0.01	**0.000**
Non-pioneer light demanding	G1	-1.37	0.05	**0.000**	Z1	-1.38	0.04	**0.000**
	G2	-1.51	0.07	0.082	Z2	-1.48	0.06	0.095
	G3	-1.48	0.07	0.105	Z3	-1.64	0.06	**0.000**
	Drd	-0.01	0.01	0.349	Drd	-0.02	0.00	**0.000**
Shade tolerant	G1	-0.61	0.04	**0.000**	Z1	-0.50	0.02	**0.000**
	G2	-0.51	0.05	0.068	Z2	-0.34	0.03	**0.000**
	G3	-0.44	0.05	**0.003**	Z3	-0.31	0.03	**0.000**
	Drd	0.01	0.00	**0.002**	Drd	0.01	0.00	**0.000**
Leaf phenology								
Deciduous or semi-deciduous	G1	-1.29	0.07	**0.000**	Z1	-1.40	0.06	**0.000**
	G2	-1.41	0.10	0.235	Z2	-1.87	0.08	**0.000**
	G3	-1.48	0.09	0.055	Z3	-1.93	0.08	**0.000**
	Drd	-0.01	0.01	0.166	Drd	-0.04	0.01	**0.000**
Evergreen	G1	-0.32	0.03	**0.000**	Z1	-0.28	0.01	**0.000**
	G2	-0.28	0.03	0.211	Z2	-0.17	0.02	**0.000**
	G3	-0.26	0.03	0.051	Z3	-0.16	0.02	**0.000**
	Drd	0.00	0.00	0.159	Drd	0.01	0.00	**0.000**
Seed dispersal mode								
Zoochory	G1	-0.38	0.12	**0.008**	Z1	-0.46	0.03	**0.000**
	G2	-0.39	0.16	0.958	Z2	-0.59	0.04	**0.002**
	G3	-0.39	0.15	0.981	Z3	-0.57	0.04	**0.011**
	Drd	0.01	0.01	0.366	Drd	-0.01	0.00	**0.036**
Megafaunal dispersal	G1	-2.22	0.16	**0.000**	Z1	-1.98	0.09	**0.000**
	G2	-2.03	0.21	0.369	Z2	-1.64	0.13	**0.011**
	G3	-1.98	0.19	0.216	Z3	-1.78	0.13	0.137
	Drd	0.03	0.01	0.100	Drd	0.01	0.01	0.209
Amemochory	G1	-1.78	0.09	**0.000**	Z1	-2.01	0.05	**0.000**
	G2	-2.13	0.13	**0.017**	Z2	-2.06	0.07	0.502
	G3	-1.91	0.11	0.248	Z3	-2.07	0.07	0.425
	Drd	0.00	0.01	0.827	Drd	0.00	0.01	0.935
Basal area	G1	38.94	2.24	**0.000**	Z1	30.31	2.05	**0.000**
	G2	49.65	3.17	**0.005**	Z2	28.91	3.02	0.651
	G3	42.85	2.75	0.179	Z3	26.19	2.98	0.191
	Drd	0.12	0.32	0.720	Drd	-0.15	0.22	0.514
Wood density	G1	0.57	0.01	**0.000**	Z1	0.59	0.01	**0.000**
	G2	0.58	0.01	0.299	Z2	0.59	0.01	0.686
	G3	0.57	0.01	0.893	Z3	0.61	0.01	0.114
	Drd	0.00	0.00	0.651	Drd	0.00	0.00	0.052
Aboveground biomass	G1	512.26	34.40	**0.000**	Z1	384.93	37.00	**0.000**
	G2	634.77	48.65	**0.026**	Z2	396.58	54.76	0.835
	G3	565.80	42.13	0.226	Z3	370.57	54.31	0.796
	Drd	2.28	4.35	0.609	Drd	1.68	3.76	0.663

Coef denotes the intercept for zone categories (G1–G3, Z1–Z3) and the slope for Drd.

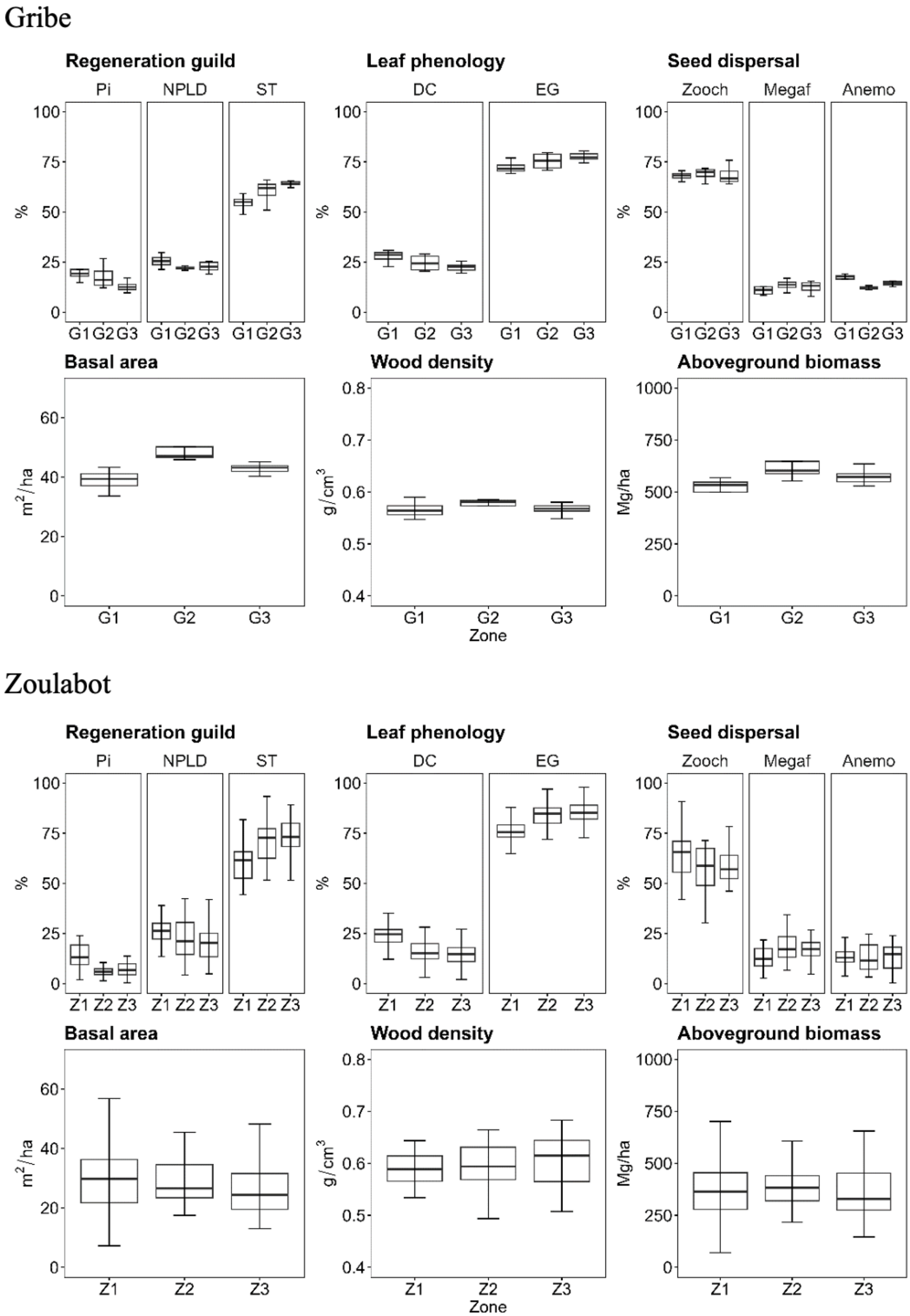

Figure 3 Box plots showing the proportion of trees assigned to each type of functional trait (regeneration guild, leaf phenology, and seed dispersal) to total individuals, and basal area, wood density, and aboveground biomass by zone.

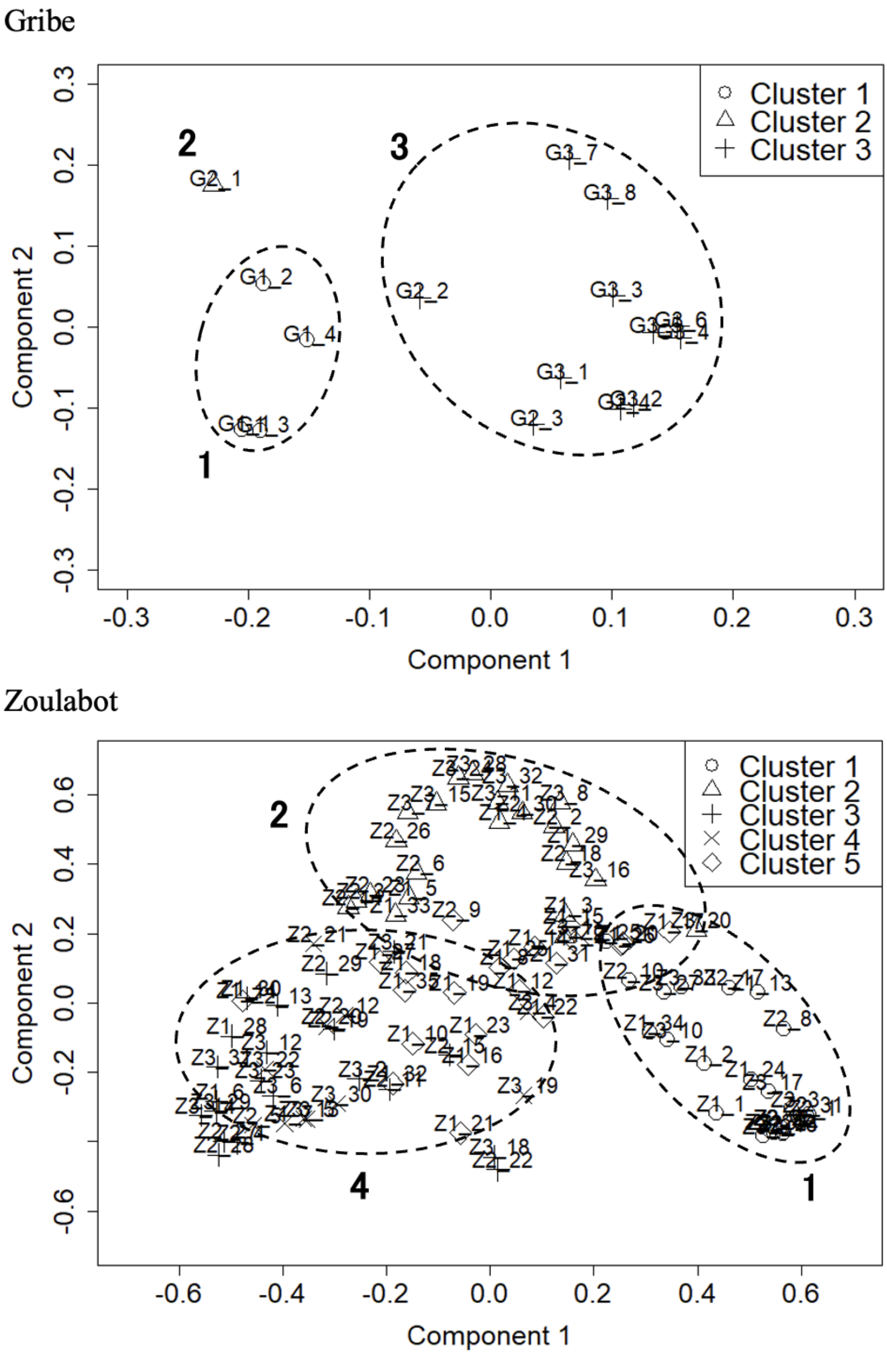

Figure 4 Results of cluster analyses of species composition in the plots (Gribe) and subplots (Zoulabot) using the k-medoids method with Bray–Curtis dissimilarity as the distance measure. These two components explain 44.9% of the point variation for Gribe and 25.9% for Zoulabot. Dotted circles indicate clusters with a Jaccard coefficient of 0.6 or higher.

cluster 2 was composed of only G2 plots, and cluster 3 was composed of G2 plots (27%) and G3 plots (73%) (Table 6). These results indicate that the species composition of G1 differed from that of the other two zones, but was similar for G2 and G3. For cluster 1, five indicator species were identified (Table 6). Of these, one was a Pi species and the other four were ST species. For cluster 2, nine indicators were identified; two were Pi species, one was an NPLD species, and six were ST species. For cluster 3, 22 species were listed; two Pi, eight NPLD, and 12 ST. Notably, all clusters included the Pi and ST indicator species.

The subplots in Zoulabot were classified into five clusters (Figure 4). The stability was rated as unstable (Jaccard coefficient: 0.51–0.59) for clusters 3 and 5, and somewhat stable (0.60–0.72) for the other three clusters. The distribution of each cluster overlapped those of the other clusters, where greater overlap indicated lower stability. The majority (95.5%) of cluster 5 consisted of Z1 subplots, and 60% of all Z1 subplots were included in cluster 5 (Table 7), indicating that cluster 5 and Z1 were strongly correlated. The indicator species of cluster 5 was *M. cecropioides*, a typical Pi species that grows in fields and settlements. Each of the remaining four clusters was composed of a mixture of subplots of the three zones, consisting of 10–20% of Z1 subplots and 40–45% of each of the Z2 and Z3 subplots. The indicators of cluster 2 were all ST species. Among the other clusters, the indicators included all regeneration guild types. Although cluster 5 was distinguished by having *M. cecropioides* as an indicator, the subplots classified into cluster 5 were distributed in the middle of, and overlapped with, all clusters (Figure 4). The subplots of Z1 were distributed in all the other clusters. These results suggest that Z1 is not clearly distinct from the other zones.

The results of the correspondence analyses based on IVI values showed that in both sites, a high number of species were shared between the three zones (Figure 5): 67% of the 209 species in Gribe and 68% of the 241 species in Zoulabot. In Gribe, the percentage of species that appeared only in a specific zone was highest for G1 (9.1%) and lowest for G2 (3.8%) and G3 (2.9%). There was no zone where the proportional distribution of Pi, NPLD, and ST was significantly different from the overall distribution; Pi: 26%, NPLD: 24%, ST: 51% in G1 ($P > 0.05$; goodness-of-fit test), 26%, 25%, and 49% in G2 ($P > 0.05$), and 26%, 26%, and 48% in G3 ($P > 0.05$). Similar results were found for Zoulabot (23%, 25%, and 52% in Z1, 23%, 24%, and 53% in Z2, and 22%, 25%, and 53% in Z3).

Discussion

I. Accumulation of tree species in the peri-village forests

We examined the effects of Drd and zone, which represented the impacts of land use patterns and livelihood activities on tree diversity, and found that for both sites, greater intensity of shifting cultivation was associated with higher tree diversity (Table 4, Figure 2).[2] Among the functional traits, %Pi and %ST were

Table 6 Summary of species composition analyses of the plots in Gribe

Cluster	Percentage (number) of plots belonging to each zone	Species with IndVal > 0.5	IndVal	P value	freq	Regeneration guild
1	G1: 100 (4)	*Klainedoxa trillesii*	1.000	0.001	4	ST
	G2: 0 (0)	*Calpocalyx dinklagei*	0.810	0.003	12	ST
	G3: 0 (0)	*Beilschmiedia mannii*	0.749	0.012	11	ST
	χ^2: 12.0***	*Milicia excelsa*	0.714	0.004	15	Pi
		Diospyros iturensis	0.647	0.029	15	ST
2	G1: 0 (0)	*Dicranolepis disticha*	0.957	0.047	2	ST
	G2: 100 (1)	*Lindackeria dentata*	0.829	0.010	13	Pi
	G3: 0 (0)	*Strombosia grandifolia*	0.785	0.041	8	ST
	χ^2: 1.5^{ns}	*Markhamia lutea*	0.755	0.001	16	Pi
		Celtis philippensis	0.693	0.040	16	NPLD
		Lecaniodiscus cupanioides	0.629	0.027	16	ST
		Drypetes bipindensis	0.569	0.035	16	ST
		Strombosia pustulata	0.532	0.007	16	ST
		Funtumia africana	0.530	0.039	16	ST
3	G1: 0 (0)	*Neoboutonia mannii*	0.952	0.001	12	Pi
	G2: 27.3 (3)	*Cola nitida*	0.909	0.002	10	ST
	G3: 72.7 (8)	*Dialium pachyphyllum*	0.800	0.002	12	ST
	χ^2: 8.0*	*Cylicodiscus gabunensis*	0.781	0.002	14	NPLD
		Bridelia grandis	0.761	0.001	13	Pi
		Ophiobotrys zenkeri	0.738	0.000	16	NPLD
		Sterculia dawei	0.726	0.003	13	ST
		Petersianthus macrocarpus	0.704	0.000	15	NPLD
		Carapa procera	0.702	0.011	16	ST
		Garcinia epunctata	0.684	0.002	16	ST
		Afrostyrax lepidophyllus	0.674	0.001	16	ST
		Xylopia phloiodora	0.668	0.005	16	NPLD
		Dichostemma glaucescens	0.667	0.009	16	ST
		Anonidium mannii	0.663	0.039	16	ST
		Diospyros crassiflora	0.656	0.004	16	ST
		Trichilia tessmannii	0.635	0.001	16	ST
		Duguetia staudtii	0.616	0.034	16	NPLD
		Gambeya lacourtiana	0.616	0.026	15	NPLD
		Leplaea thompsonii	0.603	0.000	16	NPLD
		Corynanthe macroceras	0.594	0.010	15	ST
		Erythrophleum suaveolens	0.553	0.022	15	NPLD
		Greenwayodendron suaveolens	0.545	0.004	16	ST

Species with indicator values (IndVal) > 0.5, and their functional traits in terms of regeneration guild are listed, where Pi = pioneer; ST = shade tolerant; NPLD = non-pioneer light demanding species (*P < 0.05, ***P < 0.01; goodness-of-fit test between observed and expected zone proportions). The numbers of indicators containing species with both IndVal ≤ 0.5 and > 0.5 (P < 0.05) were 5 for cluster 1, 9 for cluster 2, and 22 for cluster 3.

Table 7 Summary of species composition analyses of the subplots in Zoulabot

Cluster	Percentage (number) of plots belonging to each zone	Species with IndVal > 0.5	IndVal	P value	freq	Regeneration guild
1	Z1: 21.7 (5)	*Irvingia excelsa*	0.659	0.000	32	ST
	Z2: 39.1 (9)	*Irvingia gabonensis*	0.657	0.000	38	ST
	Z3: 39.1 (9)	*Calpocalyx dinklagei*	0.646	0.000	29	ST
	χ^2: 1.6^{ns}	*Cola lateritia*	0.641	0.000	43	ST
		Pterocarpus soyauxii	0.631	0.000	44	NPLD
		Hexalobus crispiflorus	0.581	0.000	40	ST
		Barteria fistulosa	0.542	0.000	34	NPLD
		Fernandoa adolfi-friderici	0.519	0.000	29	ST
		Tessmannia africana	0.501	0.000	32	NPLD
2	Z1: 21.7 (5)	*Keayodendron bridelioides*	0.573	0.000	43	ST
	Z2: 34.8 (8)	*Mammea africana*	0.542	0.000	43	ST
	Z3: 43.5 (10)	*Anonidium mannii*	0.527	0.000	50	ST
	χ^2: 1.5^{ns}	*Trichilia rubescens*	0.521	0.000	51	ST
3	Z1: 14.3 (3)	*Lasiodiscus mannii*	0.699	0.000	40	ST
	Z2: 42.9 (9)	*Duboscia macrocarpa*	0.692	0.000	44	NPLD
	Z3: 42.9 (9)	*Vitex doniana*	0.670	0.000	36	NPLD
	χ^2: 3.7^{ns}	*Carapa procera*	0.663	0.000	44	ST
		Anthonotha macrophylla	0.657	0.000	33	ST
		Annickia affinis	0.633	0.000	32	ST
		Afrostyrax lepidophyllus	0.618	0.000	39	ST
		Alstonia boonei	0.575	0.000	39	Pi
		Pycnanthus angolensis	0.543	0.000	44	NPLD
4	Z1: 9.1 (1)	*Caloncoba glauca*	0.772	0.000	24	ST
	Z2: 36.4 (4)	*Maranthes glabra*	0.765	0.000	25	ST
	Z3: 54.5 (6)	*Drypetes gossweileri*	0.762	0.000	27	ST
	χ^2: 3.3^{ns}	*Strombosia pustulata*	0.757	0.000	30	ST
		Diospyros hoyleana	0.745	0.000	22	ST
		Klainedoxa gabonensis	0.728	0.000	34	ST
		Zanthoxylum leprieurii	0.721	0.000	32	Pi
		Strombosiopsis tetrandra	0.680	0.000	36	ST
		Cylicodiscus gabunensis	0.657	0.000	35	NPLD
		Gambeya lacourtiana	0.647	0.000	30	NPLD
		Coelocaryon preussii	0.599	0.000	34	ST
		Greenwayodendron suaveolens	0.512	0.000	44	ST
		Anopyxis klaineana	0.511	0.000	18	Pi
		Cola ballayi	0.500	0.000	17	ST
5	Z1: 95.5 (21)	*Musanga cecropioides*	0.570	0.000	28	Pi
	Z2: 4.5 (1)					
	Z3: 0 (0)					
	χ^2: 37.1***					

Species with indicator values (IndVal) > 0.5, and their functional traits in terms of regeneration guild are listed, where Pi = pioneer; ST = shade tolerant; NPLD = non-pioneer light demanding species (*P < 0.05, ***P < 0.01; goodness-of-fit test between observed and expected zone proportions). The numbers of indicators containing species with both IndVal ≤ 0.5 and > 0.5 (P < 0.05) were 33 for cluster 1, 21 for cluster 2, 28 for cluster 3. 28 for cluster 4, and 43 for cluster 5.

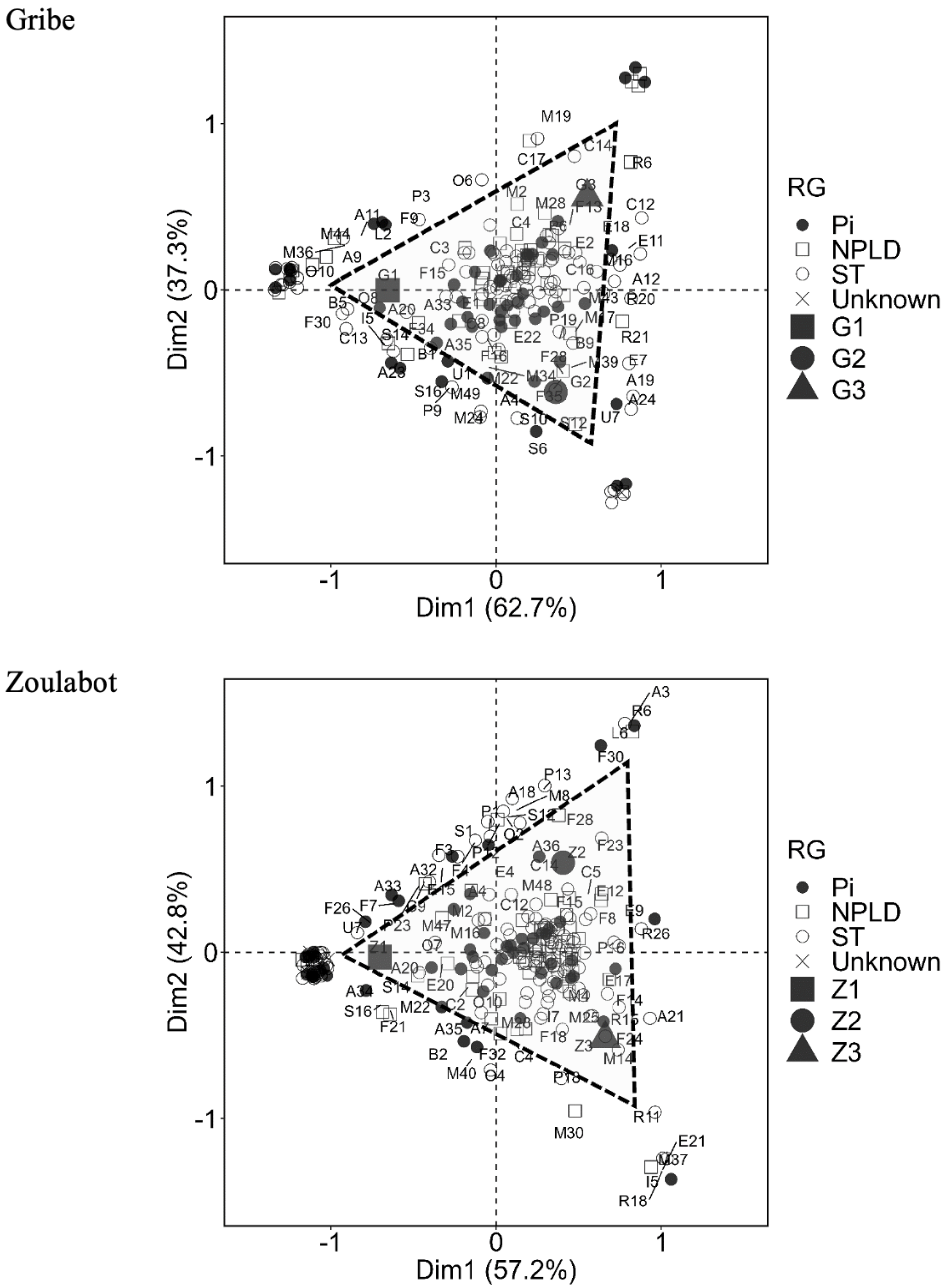

Figure 5 Results of correspondence analysis for 209 species in Gribe and 241 species in Zoulabot, with species importance values (IVIs) used to indicate species dominance in the zones (G1–G3, Z1–Z3). Species are indicated by codes consisting of the first letter of the family name and a number (Appendix), and by regeneration guild type (Pi = pioneer; ST = shade tolerant; NPLD = non-pioneer light demanding species). Species within triangles are shared among the three zones.

significantly affected by zone within both sites (Table 5, Figure 3). In zones G1 and Z1 (i.e., those with the most intensive livelihood activity), %Pi was higher and %ST was lower than in G2–G3 and Z2–Z3, respectively.

As summarized in Table 8, H' per ha values in G1 and Z1 were slightly lower than those of terra firme forests in Deng-Deng NP, Cameroon (Kabelong Banoho et al. 2020), and experimental forests in M'baiki, Central African Republic (Gourlet-Fleury et al. 2013), but considerably higher than in Dja Faunal Reserve, Cameroon (Djuikouo et al. 2010) and Waka National Park, Gabon, and Nouabelé Ndoki NP, Republic of Congo (Day et al. 2014). The values were comparable to those reported in a communal forest in Doume (Zekeng et al. 2021), where agriculture is officially banned (Poissonnet & Lescuyer 2005).

Reviewing studies on land use and biodiversity in forest areas of west and central Africa, Norris (2010) noted that higher disturbance intensity was linked to lower SR, and reported a considerable turnover of species between disturbed forests and baseline forests (primary or old-growth forest); generally, vegetation disturbances associated with shifting cultivation induced rapid invasion by Pi species, which dominated succession for much longer than natural disturbances. It has been previously argued that even if SR due to shifting cultivation is similar in disturbed forests to that in old-growth forests, floristically they are very different (Zapfack et al. 2002; Van Gemerden et al. 2003a; Kabelong Banoho 2022). In the two sites investigated in the present study, G1 and Z1 (peri-village zones) contained some distinct features compared to other zones where the intensity of human activity was relatively low. (Figure 4, Table 6).

We also confirmed that the species compositions were common between zones to a significant degree, such that species turnover did not occur. In G1 and Z1, %Pi was 19% and 13%, respectively. These values were much lower than those estimated in disturbed forests in previous studies. Kabelong Banoho (2022) reported a %Pi of 32.7–35.4% in peri-village forests in southern and eastern Cameroon. Data obtained from logging concessions in Cameroon, Central African Republic, and the Republic of Congo showed a %Pi of 30–60% in secondary *Musanga* forests (Fayolle et al. 2014). Our study sites also contained secondary *Musanga* forests, but it was considered that their influence on the increase in %Pi was limited in our study sites. This difference was confirmed by an analysis of the IVI of species at each site (Figure 5). In both Gribe and Zoulabot, 67% and 68% of the total number of species, respectively, were shared in the three zones. The number of species that were specific to a zone was largest in G1 at 19 species and Z1 at 41 species. And, only five of the 19 species in G1 and nine of the 41 species in Z1 were Pi species. This indicates that Pi species were a minority among the species recorded only in G1 or Z1 despite being more disturbed by shifting cultivation.

In summary, more intense human activity was found to be associated with higher tree diversity, because both Pi and non-Pi species recruited in the peri-village forests were maintained in mature and old-growth forests. If the degree of disturbance due to shifting cultivation exceeds a certain threshold, species turnover will occur, as suggested by previous studies. However, we argue that this threshold is much higher than expected when the impact of shifting cultivation

Table 8 Comparison of tree diversity (SR, H', and J') per ha (diameter at breast height, DBH ≥ 10 cm) within the semi-deciduous forest of the Guineo–Congolian region

Country (region)	Rainfall (mm/year)	Site	Land category	Habitat	Forest use	Succession stage	Species richness	Shannon's index (H')	Pielou's index (J')	Density (trees/ha)	Basal area (m^2/ha)
Cameroon, East (this study)	1500–1800	Periphery of Boumba-Bek NP	nPFE (G1)	TFF	SC, AG, EF	M1	105 (101–112)	4.27 (4.20–4.32)	0.918 (0.905–0.925)	368 (345–407)	38.9 (33.7–43.3)
			nPEF (G2)	TFF	SC, AG, EF	M1	106 (102–111)	4.23 (4.09–4.29)	0.907 (0.885–0.917)	496 (431–532)	49.7 (45.9–58.3)
			PFE (G3)	TFF	IC, TE, EF	M2	98 (94–102)	4.18 (4.02–4.25)	0.911 (0.885–0.922)	447 (376–522)	42.9 (35.6–49.6)
		Periphery of Nki NP	nPEF (Z1)	RF > TFF	SC, AG, EF	M1	70 (25–118)	3.59 (2.23–4.36)	0.858 (0.650–0.925)	399 (326–546)	30.4 (7.2–66.7)
		Nki NP	PFE (Z2)	RF > TFF	IC, EF	OGF	41 (22–70)	3.05 (2.09–3.62)	0.831 (0.607–0.904)	359 (222–541)	28.9 (17.5–45.4)
			PFE (Z3)	RF > TFF	EF, TEP	OGF	35 (19–79)	2.90 (1.90–3.84)	0.829 (0.597–0.908)	300 (218–407)	26.2 (13.0–48.3)
Cameroon, East (Yasuoka 2009)	1500–1800	Periphery of Nki NP	nPFE	TFF > RF	SC, AG, EF	M1	121 (110–132)	-	-	539 (466–656)	34.3 (27.4–42.1)
		Nki NP	PFE	TFF > RF	EF, TEP	OGF	99 (91–106)	-	-	397 (357–444)	27.0 (24.1–30.0)
Cameroon, East (Kabelong Banoho et al. 2020)	1500–2000	Periphery of Deng-Deng NP	nPFE	-	SC	YF	24 (2.00)	3.00 (0.23)	-	-	24 (3.8)
					AG	-	37 (1.41)	3.36 (0.09)	-	-	41.7 (29.1)
		Deng-Deng NP	PFE	RF	-	-	19	2.62	-	-	26.6
				TFF	-	SF	136 (4.00)	4.27 (0.17)	-	-	45.9 (24.1)
				TFF	-	OSF	125 (5.00)	4.12 (0.30)	-	-	38.3 (17.5)
Cameroon, East (Zekeng et al. 2021)	1300-1800	Doume	CnalF	TFF	-	-	105 (12)	3.99 (0.19)	-	506	-
Cameroon, East (Djuikouo et al. 2010)	1500	Dja Faunal Reserve	PFE	TFF	-	-	98 (78–108)	3.95 (3.64–4.10)	-	460 (388–547)	30.5 (28.7–34.4)
				PFF	-	-	94 (75–111)	3.86 (3.67–4.04)	-	450 (338–589)	29.0 (24.1–35.1)
				MF	-	-	45 (37–56)	1.59 (1.28–2.03)	-	352 (297–408)	37.5 (31.5–42.0)
Gabon (Day et al. 2014)	1400	Waka NP	-	-	TEP	-	74 (71–78)	3.79 (3.68–3.95)	-	-	28.1 (10.2–47.7)
Congo (Day et al. 2014)	1750	Nouabelé-Ndoki NP	-	MF	-	-	10	0.44	-	-	29.2
				-	TEP	-	68 (60–73)	3.70 (3.63–3.76)	-	-	25.3 (23.0–29.7)
Central Africa Republic (Gourlet-Fleury et al. 2013)	1750	M'baiki	Expeimental forest	-	Control	OGF	134 (125–154)	4.10 (4.01–4.23)	0.881 (0.867–0.898)	633 (547–711)	-
				-	ExL	M2	126 (114–144)	4.01 (3.87–4.11)	0.873 (0.855–0.890)	591 (504–651)	-
				-	ExLT	M2	133 (126–137)	4.08 (3.91–4.21)	0.880 (0.847–0.901)	679 (613–721)	-

NP = national park; nPFE = non-permanent forest estate; PEF = permanent forest estate; CnalF = communal forest, where agriculture is prohibited (Poissonnet & Lescuyer 2005); TFF = terra firme forest; RF = riparian forest; PFF = periodically flooded forest; MF = monodominant forest of *Gilbertiodendron dewevrei*; SC= shifting cultivation; AG = agroforest; IC = *Irvingia* kernel gathering; TE = timber exploitation, TEP = past timber exploitation, ExL = experimentally logged; ExLT = experimentally logged and thinned; EF = extensive forest use for livelihoods; M1 = mosaic of active plots, cacao agroforest, different ages of fallow, and mature forest; M2 = mosaic of young secondary forests to mature forest; SF = secondary forest; OSF = old secondary forest; OGF = old growth forest; YF = young fallow.

Means and standard error or range of indices are shown for SR, H', J', density, and basal area. The base of the natural logarithm was used to calculate H'. In Kabelong Banoho et al. (2020), the sampling unit area was originally 0.625 ha. The method used for estimating SR per ha is not shown. For Gribe, see Data analysis is analyzed at the landscape level. Therefore, species turnover is not connected to the current intensity of shifting cultivation, which results in an accumulation of tree species in the peri-village forests.

II. Effects of shifting cultivation on tree diversity

Van Gemerden et al. (2003a), who studied the impacts of shifting cultivation on forest vegetation in south Cameroon, estimated that it would take 50–60 years for diversity, density, and basal area to recover to their initial levels after cultivation. Based on Hirai (2014), the area cleared for fields annually was 1.1% (40.3 ha/year) of the area where G1 was located and 0.3% (2.4 ha/year) for G2; these percentages were calculated based on the total area where the people of the village have the legal right to create fields. If all land were used homogeneously, the cultivation cycle would be approximately 100 years for G1. In Zoulabot, where the population is smaller, the cycle would be even longer. In summary, the cultivation cycle is far longer than the period required for vegetation recovery. As a result, the land in the study sites was not composed of only fields and secondary forests, but formed a mosaic of fields, young fallows, old fallows, and old-growth forests. This was the main ecological reason for the retention of a high tree diversity, with no major changes in the quality of peri-village forests.

Additionally, we hypothesized that less intensified shifting cultivation has contributed to recruitment and maintenance of tree species in peri-village forests. Zapfack et al. (2002) compared the species composition of primary and secondary forests in southern Cameroon and found that secondary forests retained seedlings of primary forest species and sometimes those of Pi species. In contrast, primary forests contained fewer seedlings but many shrubs. Therefore, creating fields encourages the germination of a variety of species. In southern Cameroon, Van Gemerden et al. (2003b) studied the preferred habitats (old-growth forests, logging gaps, or shifting cultivation fields) for seedling recruitment and found that, of the 142 species observed, 65.5% had no preferred habitat, 16.2% preferred fields, 9.2% preferred logging gaps, and 9.2% preferred old-growth forests. They also argued that most of the existing old trees were recruited through shifting cultivation over the past 100 years. Carrière et al. (2002), Shikata (2006), and Hirai (2014), reported that a significant number of trees are left on fields during shifting cultivation, which contributes to vegetation recovery. These studies have indicated that if shifting cultivation is practiced at a moderate intensity, it can maintain and even increase tree diversity. Furthermore, the lower %Pi in the peri-village forests in our study sites was likely a consequence of the agricultural practices of local people. Participatory observations and interviews suggested that local people selectively remove seedlings of *Musanga* and *Macaranga*, which are typical Pi species that emerge in the fields. They recognize that these species consume large volumes of water from the soil, they grow fast and block out light, and they are prone to windfall, causing damage to crops. The thinning of Pi species could contribute to the recruitment of a diverse range of species, the survival of remnant trees in the field, and stump renewal.

Forests in zones G1, G2, and Z1, i.e., peri-village forests, consisted of a mosaic of active fields immediately after clearing, a cocoa agroforest, fallows at different stages of succession, and old-growth forests. As long as this mosaic composition is not substantially modified, shifting cultivation will not necessarily result in species turnover and diversity loss.

CONCLUSIONS

Shifting cultivation is the major form of agriculture in African rainforests, with considerable variation among regions. Therefore, a comprehensive approach is needed to describe the impact of shifting cultivation on these forests, considering the basic parameters of the system such as land use cycles, fallow periods, the proportion of area in use, and approaches taken for tree removal.

In recent decades, several studies have evaluated the conservation effectiveness of community-managed forests that have been maintained for many years by local communities worldwide (Porter-Bolland et al. 2012). However, many of the conventional approaches to conservation have regarded human activities only as a destructive factor (Ichikawa 2006). Protected areas have been established to conserve biodiversity against various human threats such as logging, mining, hunting, and livelihood activities, including shifting cultivation (Bhagwat et al. 2008; Fa & Brown 2009; Abernethy et al. 2013; Ichikawa 2014). This approach has resulted in restrictions on the use of forest resources by local people who are highly dependent on forests for their livelihoods and has generated conflicts between local people and conservation actors (Lele et al. 2010; Pyhälä et al. 2016; Ichikawa 2012). Under the current conservation schemes in Cameroon, local people are marginalized and expected to simply follow the decisions of the government and conservation actors. However, such top-down measures are often unsuccessful in biodiversity conservation. Therefore, developing an alternative scheme that enables community participation has become an urgent issue (Galford et al. 2015).

Our study revealed that more intense human activity is related to higher tree diversity, as long as a mosaic of different forest types is maintained. Describing such positive impacts of the activity of local people on forest conservation and determining the conditions where their activities remain positive will empower and encourage them to participate substantively in the decision-making process of conservation.

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Notes

(1) Tajeukem et al. (2014) performed a similar analysis based on Gribe plot data. However, there was an obvious miscalculation in their work: the FIV and IVI totals each exceeded 300.

(2) It is necessary to consider that the diversity in G3 may have been reduced by past selective logging. Selective logging is not expected to affect diversity in the short or medium term (Gourlet-Fleury et al. 2013, Sullivan et al. 2022). However, logging sites often remain in a state of invasion by lianas, which dominate the understory for at least 10 years (Lianification; Perring et al. 2021). During this time, the seedling recruitment of various species is hindered, raising concerns about negative cascading effects on diversity and biomass in future forest communities (Sullivan et al. 2022). The occurrence of such a phenomenon in G3 would lead to increased relative diversity in G1.

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Appendix Species recorded in the Gribe and Zoulabot sites

Family	Species	ID	Vernacular in Baka		IVI		Number of trees		Basal area (m^2)		Regeneration guild	Leaf phenology	Seed dispersal		Wood density (m^3/cm)
			Gribe	Zoulabot	Gribe	Zoulabot	Gribe	Zoulabot	Gribe	Zoulabot			Mode	Ref.	
Achariaceae	*Caloncoba glauca* (P.Beauv.) Gilg	A1	gbagolo	gbagolo	0.83	1.13	28	164	0.45	3	ST	EG	Megafaunal	7	0.57
	Caloncoba welwitschii (Oliv.) Gilg	A2	yangale, yangalo, noko gbagolo	yangale	0.06	0.05	1	1	0.02	0.02	ST	EG	Megafaunal	7	0.57
	Lindackeria dentata (Oliv.) Gilg	A3	lo a bie	lo a bie	0.86	0.11	34	2	0.47	0.03	Pi	DC	Zoochory	14	0.57
Anacardiaceae	*Antrocaryon klaineanum* Pierre	A4	gongó, gongu (k)	gongó, gongu (k)	0.99	0.71	46	31	1.54	4.87	Pi	DC	Zoochory	24	0.53
	Lannea welwitschii (Hiern) Engl.	A5	kuwa	kuwa	1.51	1.45	67	97	6.87	16.41	Pi	DC	Zoochory	17	0.41
	Pseudospondias microcarpa (A.Rich.) Engl.	A6	ewongu	ewungu	1.31	1.23	66	107	6.01	9.34	NPLD	DC	Zoochory	8	0.50
	Trichoscypha acuminata Engl.	A7	-	mongola	-	0.53	-	23	-	3.24	ST	EG	Zoochory	14	0.64
	Trichoscypha oddonii De Wild.	A8	ngoyo	ngoyo	1.13	1.99	48	350	1.12	9.89	ST	EG	Zoochory	11	0.64
Anisophylleaceae	*Poga oleosa* Pierre	A9	po	po	0.28	0.19	4	10	1.85	0.45	NPLD	EG	Megafaunal	21	0.39
Annonaceae	*Annickia affinis* (Exell) Versteegh & Sosef	A10	-	epue	-	1.10	-	84	-	5.97	ST	EG	Zoochory	32	0.44
	Annickia chlorantha (Oliv.) Setten & Maas	A11	epue	-	1.29	-	62	-	3.53	-	ST	EG	Zoochory	24	0.44
	Anonidium mannii (Oliv.) Engl. & Diels	A12	mbe	mbe	6.77	7.79	707	1592	34.14	74.74	ST	EG	Megafaunal	4	0.29
	Cleistopholis glauca Pierre ex Engl. & Diels	A13	-	sembeki	-	0.05	-	1	-	0.04	Pi	EG	Zoochory	11	0.31
	Cleistopholis patens (Benth.) Engl. & Diels	A14	kiyo	kiyo	1.31	1.60	55	194	3.69	11.35	Pi	EG	Zoochory	22	0.34
	Duguetia staudtii (Engl. & Diels) Chatrou	A15	molombo	molombo	1.66	0.99	121	97	3.12	4.69	NPLD	DC	Zoochory	24	0.64
	Greenwayodendron suaveolens (Engl. & Diels) Verdc.	A16	botunga	botunga	5.00	8.31	433	1512	30.50	96.03	ST	EG	Zoochory	14	0.50
	Hexalobus crispiflorus A.Rich.	A17	pota	pota	3.06	2.82	229	352	16.88	33.34	ST	EG	Megafaunal	14	0.48
	Meiocarpidium oliverianum (Baill.) D.M.Johnson & N.A.Murray	A18	mambelenge	mambelenge	2.31	1.07	217	171	5.91	3.86	ST	EG	Zoochory	24	0.50
	Monanthotaxis enghiana (Diels) P.H.Hoekstra	A19	mafembenye	-	0.06	-	1	-	0.05	-	ST	EG	Zoochory	18	0.50
	Monodora myristica (Gaertn.) Dunal	A20	jingo	jingo	0.82	0.44	30	18	1.03	0.96	ST	DC	Zoochory	2	0.50
	Uvariopsis congensis Robyns & Ghesq.	A21	-	makasa	-	0.17	-	4	-	0.31	ST	EG	Zoochory	-	0.50
	Xylopia aethiopica (Dunal) A.Rich.	A22	bambamisambo	bambamisambo	0.43	0.67	9	35	1.47	3.51	Pi	EG	Zoochory	14	0.44
	Xylopia cupularis Mildbr.	A24	gbegbele	-	0.17	-	3	-	0.04	-	Pi	EG	Zoochory	18	0.74
	Xylopia hypolampra Mildbr.	A25	monjie	monjie	0.44	0.52	8	23	2.65	2.89	NPLD	EG	Zoochory	14	0.64
	Xylopia phloiodora Mildbr.	A26	sange	sange	1.66	1.16	69	116	8.43	6.52	NPLD	EG	Zoochory	22	0.63
	Xylopia quintasii Pierre ex Engl. & Diels	A27	lo a mbano, mboko	lo a mbano	1.10	0.65	49	44	2.22	1.96	ST	EG	Zoochory	14	0.76
Apocynaceae	*Alstonia boonei* De Wild.	A28	guga	guga	4.26	3.73	93	150	51.29	75.63	Pi	DC	Anemochory	1	0.32
	Funtumia africana (Benth.) Stapf	A29	noko-ndo, kondu	noko-ndo	1.79	0.05	114	1	6.21	0.01	ST	EG	Anemochory	1	0.42
	Funtumia elastica (Preuss) Stapf	A30	-	ndóò, ndama (k)	-	1.60	-	195	-	11.30	ST	EG	Anemochory	15	0.42
	Picralima nitida (Stapf) T.Durand & H.Durand	A31	mondanga, motokotoko	motokotoko	0.55	0.85	14	56	0.40	2.53	ST	EG	Megafaunal	4	0.77
	Pleiocarpa bicarpellata Stapf	A32	-	motenge	-	0.17	-	5	-	0.23	ST	EG	Zoochory	24	0.43
	Rauvolfia caffra Sond.	A33	bonga, mboò	mbonga	1.25	0.63	63	44	4.41	4.52	Pi	EG	Zoochory	12	0.47
	Rauvolfia vomitoria Wennberg	A34	loli	kpanchel	0.37	0.41	10	28	0.32	0.80	Pi	EG	Zoochory	18	0.47
	Tabernaemontana crassa Benth.	A35	pando	pando	0.58	0.90	26	114	0.59	3.51	Pi	EG	Barochory	18	0.55
Asparagaceae	*Dracaena arborea* (Willd.) Link	A36	-	mbiato	-	0.60	-	14	-	4.48	Pi	EG	Zoochory	18	0.59
Bignoniaceae	*Fernandoa adolfi-friderici* Gilg & Mildbr.	B1	bongo	fiambe	0.55	1.13	19	106	2.48	5.00	ST	DC	Zoochory	17	0.47
	Markhamia lutea (Benth.) K.Schum.	B2	ngonja	ngonja	1.89	0.17	113	3	8.08	0.27	Pi	EG	Anemochory	24	0.47

	Newbouldia laevis (P.Beauv.) Seem. ex Bureau	B3	-	bototo	-	0.54	-	28	-	3.04	Pi	DC	Anemochory	1	0.47
	Spathodea campanulata P.Beauv.	B4	mbeleme	-	0.44	-	19	-	1.57	-	Pi	DC	Anemochory	24	0.23
Boraginaceae	*Cordia africana* Lam.	B5	ngbabi	-	0.29	-	4	-	1.14	-	Pi	DC	Zoochory	17	0.47
	Cordia platythyrsa Baker	B6	-	ngbabi	-	0.06	-	1	-	0.11	Pi	DC	Zoochory	17	0.38
Burseraceae	*Canarium schweinfurthii* Engl.	B7	sene	sene	0.92	0.30	21	21	3.61	1.10	NPLD	DC	Zoochory	2	0.41
	Pachylobus edulis G.Don	B8	-	sene a demgbe, sanabele, bohao (b)	-	0.06	-	3	-	0.07	NPLD	DC	Zoochory	5	0.52
	Santiria trimera (Oliv.) Aubrév.	B9	libaba, boó	libaba	1.21	3.06	97	577	2.94	22.00	ST	EG	Zoochory	14	0.55
Calophyllaceae	*Mammea africana* Sabine	C1	-	meboto	-	1.87	-	235	-	15.81	ST	EG	Megafaunal	2	0.63
Cannabaceae	*Celtis adolfi-friderici* Engl.	C2	kakala	kakala	3.46	2.55	220	352	24.76	25.79	NPLD	DC	Zoochory	27	0.58
	Celtis mildbraedii Engl.	C3	ngombe	ngombe	5.70	3.55	375	440	48.47	46.99	NPLD	DC	Zoochory	22	0.59
	Celtis philippensis Blanco	C4	gbege	gbege	2.51	0.87	129	51	17.24	6.24	NPLD	DC	Zoochory	18	0.70
	Celtis tessmannii Rendle	C5	kekele	kekele	1.77	1.60	94	116	7.82	19.15	NPLD	DC	Zoochory	24	0.66
	Celtis zenkeri Engl.	C6	kongombe	-	0.06	-	1	-	0.09	-	NPLD	DC	Zoochory	30	0.61
	Trema orientale (L.) Blume	C7	mesiyongo	mesiyongo	0.36	0.45	23	79	0.62	2.14	Pi	EG	Zoochory	30	0.42
Chrysobalanaceae	*Maranthes glabra* (Oliv.) Prance	C8	bokanja	bokanja	0.42	1.47	9	158	3.93	10.60	ST	EG	Zoochory	24	0.88
	Parinari excelsa Sabine	C9	-	mombokola	-	0.22	-	4	-	0.31	NPLD	EG	Megafaunal	2	0.70
Clusiaceae	*Allanblackia floribunda* Oliv.	C10	kpom	kpom	1.02	1.51	53	151	2.22	12.28	ST	EG	Megafaunal	7	0.69
	Garcinia afzelii Engl.	C11	-	ngambe	-	1.02	-	110	-	2.97	ST	EG	Zoochory	17	0.77
	Garcinia epunctata Stapf	C12	njeke	njeke	2.02	0.80	150	88	6.53	2.83	ST	EG	Zoochory	32	0.84
	Garcinia kola Heckel	C13	mgbel	mgbel	0.12	0.11	3	4	0.08	0.07	ST	EG	Megafaunal	2	0.73
	Garcinia mannii Oliv.	C14	bambi	ngambe	0.31	0.33	7	22	0.36	0.58	ST	EG	Zoochory	11	0.82
	Garcinia punctata Oliv.	C15	ngambe	-	0.26	-	9	-	0.16	-	ST	EG	Zoochory	23	0.82
	Symphonia globulifera L.f.	C16	gbongoli	-	0.32	-	15	-	0.60	-	ST	EG	Zoochory	14	0.59
Combretaceae	*Terminalia hylodendron* (Mildbr.) Gere & Boatwr.	C17	mobito	mobito	1.45	1.78	40	95	11.08	24.46	NPLD	DC	Anemochory	23	0.47
	Terminalia superba Engl. & Diels	C18	ngolu	ngolu	10.71	2.90	247	238	148.48	44.93	Pi	DC	Anemochory	15	0.46
Ebenaceae	*Diospyros abyssinica* (Hiern) F.White	E1	njama	-	0.07	-	3	-	0.07	-	ST	EG	Zoochory	17	0.81
	Diospyros canaliculata De Wild.	E2	mboloa	mboloa	2.15	0.81	201	62	3.86	1.05	ST	EG	Zoochory	23	0.81
	Diospyros crassiflora Hiern	E3	lembe	lembe	2.05	1.19	141	108	8.09	6.47	ST	EG	Zoochory	24	0.86
	Diospyros gracilescens Gürke	E4	konya	mondumba	0.06	0.54	1	53	0.01	1.09	ST	EG	Zoochory	31	0.81
	Diospyros hoyleana F.White	E5	-	bokembe	-	0.85	-	56	-	1.09	ST	EG	Zoochory	11	0.81
	Diospyros iturensis (Gürke) Letouzey & F.White	E6	babango	-	1.22	-	70	-	1.41	-	ST	EG	Zoochory	24	0.81
	Diospyros mannii Hiern	E7	bandongile	bandongile	0.45	0.17	13	5	0.62	0.11	ST	EG	Megafaunal	7	0.81
	Diospyros monbuttensis Gürke	E8	mbela	mbela	0.96	0.24	37	8	1.08	0.41	ST	EG	Zoochory	18	0.81
	Diospyros zenkeri (Gürke) F.White	E9	-	nganda	-	0.34	-	11	-	1.69	ST	EG	Zoochory	24	0.81
Euphorbiaceae	*Croton oligandrus* Pierre ex Hutch.	E10	-	ndengo	-	0.06	-	1	-	0.17	Pi	DC	Zoochory	14	0.57
	Croton penduliflorus Hutch.	E11	mbatama	-	0.06	-	1	-	0.08	-	Pi	DC	Zoochory	19	0.50
	Dichostemma glaucescens Pierre	E12	mongamba	mongamba	3.84	3.90	453	949	8.23	15.93	ST	EG	Other abiotic factor	32	0.45
	Discoglypremna caloneura (Pax) Prain	E13	jila	jila	1.16	1.03	45	94	2.81	4.49	Pi	DC	Zoochory	17	0.34
	Euphorbia drupifera Thonn.	E14	songolibila	songolibila	0.17	0.11	4	3	0.04	0.09	Pi	EG	Zoochory	24	0.45
	Grossera macrantha Pax	E15	-	bodaba	-	0.18	-	8	-	0.32	ST	EG	Zoochory	22	0.45
	Macaranga spp.	E16	musasa	musasa	2.34	2.02	204	280	6.91	16.41	Pi	EG	Zoochory	17	0.39
	Maprounea membranacea Pax & K.Hoffm.	E17	-	bongoy	-	0.41	-	18	-	1.58	ST	EG	Other abiotic factor	11	0.45
	Neoboutonia mannii Benth.	E18	tubu	tubu	1.10	0.77	56	37	3.39	1.79	Pi	DC	Zoochory	24	0.33
	Plagiostyles africana (Müll.Arg.) Prain	E19	ngole	ngole	0.49	1.47	13	241	0.34	5.34	ST	EG	Zoochory	24	0.74

	Ricinodendron heudelotii (Baill.) Heckel	E20	gòbò	gòbò	5.53	3.13	126	146	70.10	60.15	Pi	DC	Zoochory	30	0.21
	Shirakiopsis elliptica (Hochst.) Esser	E21	-	bosomba	-	0.06	-	1	-	0.17	Pi	EG	Zoochory	24	0.51
	Tetrorchidium didymostemon (Baill.) Pax & K.Hoffm.	E22	njene	njene	0.70	0.80	28	79	0.89	2.13	Pi	EG	Zoochory	11	0.44
Fabaceae	*Afzelia* sp.	F1	-	madjabo, madjagba	-	0.67	-	24	-	4.39	NPLD	DC	Zoochory	31	0.70
	Albizia adianthifolia (Schumach.) W.Wight	F2	bamba	sa'a (k)	4.81	3.33	163	217	53.96	58.76	Pi	DC	Anemochory	1	0.51
	Albizia altissima Hook.f.	F3	-	bekesi	-	0.17	-	8	-	1.32	Pi	DC	Anemochory	11	0.53
	Albizia dinklagei (Harms) Harms	F4	bokondo	bokondo	0.25	0.33	17	8	1.02	1.60	Pi	DC	Anemochory	1	0.53
	Albizia ferruginea (Guill. & Perr.) Benth.	F5	londa	londa	0.16	1.32	2	57	0.87	14.32	Pi	DC	Anemochory	17	0.49
	Albizia glaberrima (Schumach. & Thonn.)	F6	ndembe	bamba	0.56	0.14	13	7	5.05	0.68	Pi	DC	Anemochory	18	0.54
	Albizia sp.	F7	-	tongia	-	0.27	-	6	-	1.59	Pi	DC	Anemochory	11	0.53
	Amphimas pterocarpoides Harms	F8	kànga	kànga	1.51	0.66	42	32	13.50	9.05	NPLD	DC	Anemochory	19	0.62
	Angylocalyx pynaertii De Wild.	F9	yonga, bitongo	yonga, bitongo	2.22	1.87	158	237	9.33	15.54	ST	EG	Zoochory	32	0.64
	Anthonotha macrophylla P.Beauv.	F10	popolo	popolo	0.11	1.41	2	205	0.07	4.98	ST	EG	Zoochory	18	0.84
	Baphia laurifolia Baill.	F11	punge	-	0.06	-	1	-	0.02	-	ST	EG	Anemochory	19	0.70
	Baphia leptobotrys Harms	F12	-	sawe	-	0.11	-	2	-	0.03	ST	EG	Anemochory	11	0.70
	Bobgunnia fistuloides (Harms) J.H.Kirkbr. & Wiersema	F13	eluku	eluku	0.12	0.97	2	63	0.14	5.54	ST	EG	Zoochory	24	0.87
	Calpocalyx dinklagei Harms	F14	pandako	pandako	0.79	1.22	28	180	0.67	4.42	ST	EG	Autochory	24	0.72
	Cylicodiscus gabunensis Harms	F15	boluma	boluma	1.92	3.09	54	209	16.02	52.69	NPLD	DC	Anemochory	11	0.79
	Detarium macrocarpum Harms	F16	mbili	mbili	0.62	0.65	5	17	6.96	4.24	Pi	DC	Megafaunal	7	0.71
	Dialium dinklagei Harms	F17	-	mokombe	-	0.30	-	11	-	0.42	ST	EG	Zoochory	2	0.72
	Dialium pachyphyllum Harms	F18	belenge	belenge	0.78	1.08	24	131	0.99	4.51	ST	EG	Zoochory	13	0.92
	Dialium tessmannii Harms	F19	mokombe	-	0.28	-	5	-	0.96	-	ST	EG	Zoochory	32	0.82
	Erythrina spp.	F20	jumgbe	-	0.06	-	1	-	0.12	-	Pi	DC	Autochory	11	0.40
	Erythrophleum ivorense A.Chev.	F21	-	kopaka	-	0.34	-	13	-	4.33	NPLD	DC	Autochory	17	0.77
	Erythrophleum suaveolens (Guill. & Perr.) Brenan	F22	ngbanda	ngbanda	2.18	2.35	44	90	20.72	41.23	NPLD	DC	Zoochory	17	0.87
	Gilbertiodendron dewevrei (De Wild.)	F23	-	bemba	-	0.35	-	29	-	3.41	ST	EG	Autochory	24	0.71
	Lebruniodendron leptanthum (Harms) J.Léonard	F24	-	ngando	-	0.71	-	33	-	4.64	ST	EG	Other abiotic factor	32	0.64
	Mildbraediodendron excelsum Harms	F25	ekela	-	0.40	-	6	-	2.04	-	ST	DC	Zoochory	16	0.64
	Millettia griffoniana Baill.	F26	-	timi	-	0.40	-	47	-	0.41	ST	EG	Autochory	11	0.74
	Millettia sanagana Harms	F27	nganda	nganda	0.33	0.44	13	26	0.12	0.36	ST	EG	Autochory	11	0.74
	Pachyelasma tessmannii (Harms) Harms	F28	mbò	mbò	0.57	1.20	4	52	6.15	17.05	NPLD	DC	Zoochory	13	0.74
	Pentaclethra macrophylla Benth.	F29	mbalaka	mbalaka	4.06	5.66	219	544	35.28	98.69	NPLD	EG	Autochory	2	0.84
	Pericopsis elata (Harms) Meeuwen	F30	mobaye	mobaye	0.78	0.50	14	16	6.24	8.56	Pi	DC	Anemochory	24	0.64
	Piptadeniastrum africanum (Hook.f.) Brenan	F31	kungu	kungu	2.01	2.41	60	167	16.27	36.59	NPLD	DC	Anemochory	2	0.61
	Prioria balsamifera (Vermoesen) Breteler	F32	-	gondo	-	1.19	-	30	-	21.36	NPLD	DC	Anemochory	24	0.41
	Prioria oxyphylla (Harms) Breteler	F33	gondo	-	0.70	-	8	-	5.47	-	NPLD	DC	Zoochory	32	0.57
	Pterocarpus soyauxii Taub.	F34	ngele	ngele	3.40	3.61	184	426	27.27	49.87	NPLD	DC	Anemochory	24	0.66
	Scorodophloeus zenkeri Harms	F35	mingenye	mingenye	1.26	11.00	84	1899	8.53	141.58	ST	EG	Autochory	4	0.72
	Stemonocoleus micranthus Harms	F36	gondu	-	0.21	-	4	-	1.48	-	NPLD	EG	Anemochory	24	0.58
	Tessmannia anomala (Micheli) Harms	F37	mondumba	-	0.17	-	3	-	0.11	-	NPLD	EG	Other abiotic factor	32	0.82
	Tessmannia africana Harms	F38	paka	paka	0.33	2.06	5	171	1.01	26.31	NPLD	DC	Other abiotic factor	26	0.82
	Tetrapleura tetraptera (Schumach. & Thonn.) Taub.	F39	jaga	jaga	1.31	1.40	53	124	3.89	11.29	NPLD	DC	Megafaunal	2	0.53

Huaceae	*Afrostyrax lepidophyllus* Mildbr.	H1	ngimba	ngimba	2.18	2.39	171	425	7.36	16.58	ST	EG	Zoochory	32	0.59
Irvingiaceae	*Desbordesia glaucescens* (Engl.) Tiegh.	I1	-	melea, ndoò	-	3.02	-	426	-	33.18	NPLD	EG	Anemochory	9	0.91
	Irvingia excelsa Mildbr.	I2	gangendi, payo	gangendi, payo	1.18	2.66	31	187	6.39	42.24	ST	EG	Megafaunal	14	0.78
	Irvingia gabonensis (Aubry-Lecomte ex O'Rorke) Baill.	I3	peke	peke	2.37	3.94	106	498	17.10	53.39	ST	EG	Megafaunal	14	0.77
	Irvingia grandifolia (Engl.) Engl.	I4	solia	solia	1.92	2.05	47	114	15.98	30.72	NPLD	EG	Megafaunal	4	0.80
	Irvingia robur Mildbr.	I5	kombele	kombele	0.25	0.08	3	1	1.42	0.74	ST	EG	Megafaunal	31	0.78
	Klainedoxa gabonensis Pierre ex Engl.	I6	bokoko	bokoko	3.62	3.70	123	320	37.24	60.92	ST	EG	Megafaunal	14	0.93
	Klainedoxa trillesii Pierre ex Tiegh.	I7	bondulu	bondulu	0.36	0.53	8	15	2.01	2.53	ST	DC	Megafaunal	14	0.92
Ixonanthaceae	*Phyllocosmus africanus* (Hook.f.) Klotzsch	I8	likoumbi	likoumbi	0.33	0.98	13	91	1.06	4.93	NPLD	DC	Zoochory	24	0.78
Lamiaceae	*Vitex doniana* Sweet	L1	pulu	pulu	1.74	1.55	105	183	6.17	10.81	NPLD	DC	Zoochory	24	0.40
Lauraceae	*Beilschmiedia mannii* (Meisn.) Benth. & Hook.f. ex B.D.Jacks.	L2	mobakoso	mobakoso	0.83	2.18	25	301	2.55	19.29	ST	EG	Zoochory	32	0.57
Lecythidaceae	*Brazzeia congoensis* Baill.	L3	mombokola	-	0.06	-	1	-	0.01	-	Unknown	EG	Zoochory	19	0.65
	Petersianthus macrocarpus (P.Beauv.) Liben	L4	boso	boso	2.42	3.23	128	366	16.67	43.95	NPLD	DC	Zoochory	14	0.68
Lepidobotryaceae	*Lepidobotrys staudtii* Engl.	L5	musakoaseko	musakoaseko	1.85	1.90	128	308	5.80	10.70	ST	EG	Zoochory	22	0.59
Loganiaceae	*Strychnos* sp.	L6	-	lo a dunga	-	0.05	-	1	-	0.03	NPLD	DC	Zoochory	30	0.72
	Strychnos ternata Gilg ex Leeuwenb.	L7	dimgba	dimgba	0.18	0.05	4	1	0.09	0.01	NPLD	DC	Zoochory	18	0.72
Malvaceae	*Bombax buonopozense* P.Beauv.	M1	ndombi	ndombi	0.23	0.49	4	8	1.12	3.44	Pi	DC	Anemochory	18	0.32
	Ceiba pentandra (L.) Gaertn.	M2	kulo	kulo	1.02	0.73	11	18	12.43	9.43	Pi	DC	Anemochory	19	0.28
	Cola acuminata (P.Beauv.) Schott & Endl.	M3	ligo	ligo	1.92	2.52	158	504	4.01	12.47	ST	EG	Zoochory	18	0.51
	Cola ballayi Cornu ex Heckel	M4	mbanga, bakoo	mbanga	0.87	0.97	31	63	1.71	6.74	ST	EG	Megafaunal	7	0.58
	Cola gigantea A.Chev.	M5	-	mbòle	-	0.24	-	6	-	0.57	ST	EG	Zoochory	18	0.48
	Cola lateritia K.Schum.	M6	popoko	popoko	3.95	2.54	218	411	33.47	20.52	ST	EG	Zoochory	24	0.51
	Cola nitida (Vent.) Schott & Endl.	M7	golo	golo	0.78	0.05	39	1	1.17	0.01	ST	EG	Zoochory	18	0.58
	Cola rostrata K.Schum.	M8	-	mekoo, gammaa	-	0.59	-	58	-	3.51	ST	EG	Zoochory	3	0.58
	Desplatsia dewevrei (De Wild. & T.Durand) Burret	M9	liamba	liamba	1.82	1.60	132	216	4.89	9.64	ST	EG	Megafaunal	14	0.59
	Desplatsia subericarpa Bocq.	M10	buku	-	0.06	-	1	-	0.03	-	ST	EG	Megafaunal	28	0.51
	Duboscia macrocarpa Bocq.	M11	guluma	guluma	3.64	4.33	172	540	32.65	61.24	NPLD	EG	Megafaunal	14	0.51
	Glyphaea brevis (Biehler) Monach.	M12	andaka	-	0.69	-	38	-	0.51	-	ST	EG	Zoochory	18	0.51
	Mansonia altissima (A.Chev.) A.Chev.	M13	bambanja	bambanja	1.97	0.79	65	33	16.68	5.44	Pi	DC	Anemochory	1	0.56
	Microcos coriacea Burret	M14	-	ebuku	-	0.64	-	52	-	2.64	ST	EG	Zoochory	24	0.44
	Nesogordonia papaverifera (A.Chev.) Capuron ex N.Hallé	M15	teteke, tekeleke	teteke, tekeleke	1.96	2.03	137	263	6.91	18.04	ST	DC	Anemochory	1	0.65
	Octolobus spectabilis Welw.	M16	gangulu	gangulu	0.45	0.40	17	30	0.23	0.53	ST	EG	Zoochory	32	0.51
	Pterygota bequaertii De Wild.	M17	mauya	mauya	0.25	1.19	7	49	1.11	12.93	NPLD	DC	Zoochory	24	0.53
	Rhodognaphalon brevicuspe (Sprague) Roberty	M18	-	tenonu	-	0.05	-	1	-	0.02	Pi	DC	Anemochory	24	0.42
	Sterculia dawei Sprague	M19	yebolo	-	1.51	-	85	-	6.68	-	ST	DC	Zoochory	17	0.39
	Sterculia oblonga Mast.	M20	eboyo	eboyo	1.75	1.36	70	76	9.77	14.06	ST	DC	Zoochory	18	0.58
	Sterculia tragacantha Lindl.	M21	-	yebolo	-	0.96	-	80	-	5.18	ST	DC	Zoochory	14	0.58
	Triplochiton scleroxylon K.Schum.	M22	gbado	gbado	4.58	1.37	87	56	63.55	24.61	Pi	DC	Anemochory	24	0.33
Melastomataceae	*Dichaetanthera africana* (Hook.f.) Jacq.-Fél.	M23	unidentified1	-	0.06	-	1	-	0.01	-	Pi	EG	Zoochory	25	0.81
	Warneckea wildeana Jacq.-Fél.	M24	nbondo	-	0.31	-	7	-	1.22	-	ST	EG	Anemochory	18	0.81
Meliaceae	*Carapa procera* DC.	M25	gojo	gojo	4.26	3.80	421	545	18.78	45.55	ST	EG	Zoochory	27	0.60
	Carapa sp.	M26	unidentified	-	0.06	-	1	-	0.02	-	ST	EG	Zoochory	24	0.60

	Entandrophragma angolense (Welw.) Panshin	M27	-	kaki, kangamgbomu	-	1.48	-	46	-	24.06	NPLD	DC	Anemochory	1	0.48
	Entandrophragma candollei Harms	M28	káàngà	káàngà	0.89	0.68	30	54	2.18	4.88	NPLD	DC	Anemochory	18	0.57
	Entandrophragma cylindricum (Sprague) Sprague	M29	mboyo	mboyo	4.35	3.64	118	239	50.37	65.72	NPLD	DC	Anemochory	11	0.57
	Entandrophragma utile (Dawe & Sprague)	M30	bokulo	bokulo	0.27	0.18	1	2	3.67	2.08	NPLD	DC	Anemochory	24	0.54
	Leplaea cedrata (A.Chev.) E.J.M.Koenen & J.J.de Wilde	M31	-	benya	-	0.56	-	19	-	4.48	NPLD	EG	Zoochory	17	0.52
	Leplaea thompsonii (Sprague & Hutch.)	M32	jombo, mobeka	jombo	2.99	2.06	258	324	12.76	14.04	NPLD	EG	Zoochory	24	0.52
	Lovoa trichilioides Harms	M33	-	gobemba	-	1.07	-	119	-	5.08	NPLD	DC	Zoochory	24	0.45
	Trichilia rubescens Oliv.	M34	mayimbo	mayimbo	5.12	5.98	633	1324	12.76	44.74	ST	EG	Zoochory	5	0.51
	Trichilia tessmannii Harms	M35	mayimbonagbanga	-	3.36	-	318	-	13.33	-	ST	EG	Zoochory	5	0.51
Menispermaceae	*Penianthus longifolius* Miers	M36	jifi	-	0.06	-	1	-	0.01	-	ST	EG	Zoochory	24	0.59
	Penianthus zenkeri (Engl.) Diels	M37	-	sombolo	-	0.05	-	1	-	0.05	ST	EG	Zoochory	24	0.59
Moraceae	*Antiaris toxicaria* (J.F.Gmel.) Lesch.	M38	libea	-	0.48	-	27	-	0.49	-	NPLD	DC	Zoochory	18	0.39
	Ficus exasperata Vahl	M39	sumbem	sumbem	0.52	0.31	22	31	0.84	2.09	Pi	DC	Zoochory	18	0.44
	Ficus mucuso Welw. ex Ficalho	M40	ngey, lingembe	ewawa	0.24	0.28	17	10	0.72	1.58	Pi	DC	Zoochory	30	0.40
	Ficus pseudomangifera Hutch.	M41	-	bòngo	-	0.67	-	25	-	2.71	Pi	DC	Zoochory	11	0.44
	Ficus sp.	M42	bòngo, djolo	-	0.08	-	2	-	0.39	-	Pi	DC	Zoochory	18	0.44
	Ficus spp.	M43	bòngo	-	1.45	-	53	-	8.94	-	Pi	DC	Zoochory	11	0.44
	Milicia excelsa (Welw.) C.C.Berg	M44	bangi	bangi	1.61	0.72	51	24	10.12	4.26	Pi	DC	Zoochory	1	0.58
	Sloetiopsis usambarensis Engl.	M45	dundu	dundu	1.58	1.18	132	193	1.53	2.17	ST	EG	Zoochory	6	0.53
	Treculia africana Decne. ex Trécul	M46	pusa	pusa	1.05	0.62	47	39	1.62	1.63	NPLD	EG	Megafaunal	2	0.53
	Trilepisium madagascariense DC.	M47	pongi	pongi	4.47	2.09	284	227	35.94	25.61	NPLD	DC	Zoochory	17	0.53
Myristicaceae	*Coelocaryon preussii* Warb.	M48	bambayoko	bambayoko	1.19	3.97	104	715	6.11	36.69	ST	EG	Zoochory	14	0.50
	Pycnanthus angolensis (Welw.) Warb.	M49	tenge, tengen a pasa	etenge, tenge	3.23	4.46	222	497	20.61	68.24	NPLD	EG	Zoochory	14	0.41
	Staudtia kamerunensis Warb.	M50	malanga	malanga	4.15	2.98	474	595	11.67	18.15	ST	EG	Zoochory	17	0.80
Myrtaceae	*Syzygium rowlandii* Sprague	M51	esosi	esosi	0.44	0.80	5	28	3.78	4.88	ST	EG	Zoochory	29	0.63
Ochnaceae	*Rhabdophyllum affine* (Hook.f.) Tiegh.	O1	-	lo a ngo	-	0.06	-	3	-	0.09	ST	EG	Zoochory	11	0.83
	Rhabdophyllum calophyllum (Hook.f.)	O2	-	ngokele	-	0.13	-	8	-	0.11	ST	EG	Zoochory	18	0.83
Olacaceae	*Heisteria parvifolia* Sm.	O3	molomba na gbengbe	molomba na gbengbe	0.90	1.71	43	275	1.15	9.48	ST	EG	Zoochory	32	0.82
	Heisteria zimmereri Engl.	O4	-	bibilibi	-	0.28	-	7	-	0.16	ST	EG	Zoochory	17	0.82
	Olax subscorpioidea Oliv.	O5	-	mboke	-	0.08	-	8	-	0.22	ST	EG	Zoochory	18	0.82
	Olax subscorpioidea var. *subscorpioidea* Oliv.	O6	mboke, semboke	-	0.18	-	4	-	0.09	-	ST	EG	Zoochory	18	0.82
	Strombosia grandifolia Hook.f. ex Benth.	O7	pindo	pndo	0.80	0.66	44	62	2.79	2.48	ST	EG	Zoochory	14	0.82
	Strombosia pustulata Oliv.	O8	bonbongo	bonbongo	4.05	2.21	384	333	18.85	17.62	ST	EG	Zoochory	17	0.83
	Strombosiopsis tetrandra Engl.	O9	bosiko	bosiko	3.21	2.81	241	383	18.30	30.49	ST	EG	Zoochory	14	0.66
	Ongokea gore (Hua) Pierre	O10	bosolo	bosolo	0.36	0.53	8	24	1.99	3.15	NPLD	EG	Zoochory	14	0.82
	Schrebera arborea A.Chev.	O11	-	ngolombe	-	0.40	-	47	-	3.45	NPLD	DC	Zoochory	18	0.66
Pandaceae	*Microdesmis puberula* Hook.f. ex Planch.	P1	-	pipi	-	0.23	-	10	-	0.14	ST	EG	Zoochory	24	0.57
	Panda oleosa Pierre	P2	kana	kana	2.61	3.54	197	501	12.31	41.80	ST	EG	Megafaunal	2	0.57
Passifloraceae	*Barteria fistulosa* Mast.	P3	pambo	pambo	1.27	1.18	72	143	1.35	3.47	NPLD	DC	Zoochory	24	0.59
Phyllanthaceae	*Antidesma membranaceum* Müll.Arg.	P4	lo a pula	lo a pula	0.35	1.40	26	219	1.02	6.55	ST	EG	Zoochory	18	0.61
	Antidesma sp.	P5	-	lo a undo	-	0.13	-	9	-	0.12	ST	EG	Zoochory	11	0.61
	Antidesma vogelianum Müll.Arg.	P6	tesende	tesende	2.90	0.05	281	1	9.79	0.05	ST	EG	Zoochory	9	0.61
	Bridelia grandis Pierre ex Hutch.	P7	taku	taku	1.14	0.97	39	62	4.93	5.45	Pi	EG	Zoochory	24	0.52
	Keayodendron bridelioides Leandri	P8	mbòndo	mbòndo	3.18	2.92	186	393	23.18	32.80	ST	EG	Zoochory	24	0.61
	Margaritaria discoidea (Baill.) G.L.Webster	P9	kango, jikili (b)	kango	1.23	0.97	38	64	6.60	5.29	Pi	DC	Zoochory	17	0.72

	Uapaca sp.	P10	-	sengi a bele	-	0.06	-	1	-	0.23	NPLD	EG	Zoochory	33	0.63
	Uapaca spp.	P11	sengi	sengi	4.78	4.56	292	622	41.53	61.24	NPLD	EG	Zoochory	33	0.63
Polygalaceae	*Carpolobia alba* G.Don	P12	-	monono	-	0.11	-	2	-	0.09	ST	EG	Zoochory	32	0.59
	Carpolobia lutea G.Don	P13	-	mbambe	-	0.17	-	6	-	0.16	ST	EG	Zoochory	18	0.59
Putranjivaceae	*Drypetes aframensis* Hutch.	P14	-	masepa	-	2.05	-	422	-	7.19	ST	EG	Zoochory	32	0.70
	Drypetes bipindensis (Pax) Hutch.	P15	masepa	-	2.33	-	230	-	4.16	-	ST	EG	Zoochory	32	0.70
	Drypetes chevalieri Beille ex Hutch. & Dalziel	P16	-	kpaso	-	0.53	-	24	-	0.29	ST	EG	Zoochory	17	0.70
	Drypetes gossweileri S.Moore	P17	bologa	bologa	1.55	1.51	71	195	6.25	8.56	ST	EG	Megafaunal	14	0.67
	Drypetes ituriensis Pax & K.Hoffm.	P18	ngongo	ngongo	0.85	1.42	36	270	0.93	5.82	ST	EG	Zoochory	32	0.70
	Drypetes laciniata (Pax) Hutch.	P19	mototombo	-	0.06	-	1	-	0.02	-	ST	EG	Zoochory	32	0.70
	Drypetes occidentalis (Müll.Arg.) Hutch.	P20	tembo	tembo	0.94	2.19	47	380	2.28	14.67	ST	EG	Zoochory	32	0.70
	Drypetes paxii Hutch.	P21	-	kpaya	-	0.46	-	17	-	0.40	ST	EG	Zoochory	11	0.70
	Drypetes spinosodentata (Pax) Hutch.	P22	-	tandi	-	0.26	-	16	-	0.40	ST	EG	Zoochory	32	0.70
	Drypetes sp.1	P23	unknown2	mogaja	0.06	0.85	2	83	0.02	6.08	ST	EG	Zoochory	32	0.70
	Drypetes sp.2	P24	-	mokukuma	-	0.11	-	4	-	0.04	ST	EG	Zoochory	14	0.70
Rhamnaceae	*Lasiodiscus mannii* Benth. & Hook.f.	R1	-	suma, esuma	-	3.03	-	683	-	12.71	ST	EG	Anemochory	18	0.58
	Lasiodiscus marmoratus C.H.Wright	R2	suma, esuma	-	3.15	-	346	-	6.95	-	ST	EG	Anemochory	11	0.58
	Lasiodiscus sp.	R3	-	noko-suma	-	0.05	-	1	-	0.04	ST	EG	Anemochory	11	0.58
	Maesopsis eminii Engl.	R4	londo	londo	0.77	0.83	21	41	1.90	4.70	Pi	DC	Zoochory	24	0.40
Rhizophoraceae	*Anopyxis klaineana* (Pierre) Engl.	R5	boma	boma	0.42	1.19	7	43	1.48	14.65	Pi	EG	Anemochory	2	0.80
Rubiaceae	*Aidia genipiflora* (DC.) Dandy	R6	molomba	molomba	0.57	0.07	24	5	0.64	0.12	ST	DC	Anemochory	1	0.82
	Aoranthe cladantha (K.Schum.) Somers	R7	ngobò	ngobò	0.06	0.14	1	10	0.01	0.32	Pi	EG	Zoochory	27	0.81
	Bertiera racemosa var. *elephantina* N.Hallé	R8	welaleko	-	0.59	-	22	-	0.38	-	ST	EG	Zoochory	18	0.60
	Brenania brieyi (De Wild.) E.M.A.Petit	R9	molonjo	molonjo	0.13	0.05	2	1	0.29	0.05	Pi	EG	Megafaunal	7	0.60
	Coffea canephora Pierre ex A.Froehner	R10	-	kopi	-	0.06	-	3	-	0.03	ST	EG	Zoochory	20	0.60
	Corynanthe johimbe K.Schum.	R11	-	ajajo	-	0.38	-	49	-	2.65	ST	EG	Anemochory	24	0.67
	Corynanthe macroceras K.Schum.	R12	wasasa, toboli	wasasa, toboli	2.55	2.07	216	330	10.22	15.29	ST	EG	Anemochory	24	0.67
	Corynanthe pachyceras K.Schum.	R13	moka	moka	3.08	2.11	276	365	12.53	12.17	ST	EG	Anemochory	19	0.67
	Massularia acuminata (G.Don) Bullock ex Hoyle	R14	-	mindo	-	0.95	-	90	-	1.12	ST	EG	Megafaunal	2	0.60
	Mitragyna stipulosa (DC.) Kuntze	R15	langango	langago	0.83	1.47	26	65	4.21	22.48	Pi	EG	Anemochory	24	0.53
	Mussaenda sp.	R16	lipete	-	0.14	-	5	-	0.30	-	Pi	Unknown	Zoochory	18	0.60
	Nauclea diderrichii (De Wild.) Merr.	R17	mose, moese	mose	0.11	1.82	2	160	0.04	20.39	Pi	EG	Zoochory	14	0.68
	Oxyanthus schumannianus De Wild. & T.Durand	R18	-	nagbangalo	-	0.21	-	10	-	0.90	NPLD	EG	Zoochory	32	0.60
	Pauridiantha rubens (Benth.) Bremek.	R19	-	bondjinga	-	0.13	-	7	-	0.14	ST	EG	Zoochory	11	0.60
	Psychotria subobliqua Hiern	R20	adjomba	-	0.13	-	5	-	0.09	-	ST	EG	Zoochory	18	0.60
	Psychotria vogeliana Benth.	R21	golombe	-	0.18	-	4	-	0.17	-	ST	EG	Zoochory	17	0.60
	Rothmannia octomera (Hook.) Fagerl.	R22	noko-mindo	-	0.08	-	4	-	0.09	-	ST	EG	Zoochory	32	0.60
	Rothmannia spp.	R23	-	welaleko	-	1.00	-	138	-	3.18	ST	EG	Zoochory	32	0.60
	Tricalysia pallens Hiern	R24	-	kopi na bele	-	0.05	-	1	-	0.01	ST	EG	Zoochory	18	0.60
Rutaceae	*Vepris louisii* G.C.C.Gilbert	R25	tanda	tanda	0.50	0.30	15	12	0.31	0.32	ST	EG	Zoochory	5	0.74
	Zanthoxylum gilletii (De Wild.) P.G.Waterman	R26	bolongo	bolongo	1.11	0.13	45	3	2.06	0.47	Pi	DC	Zoochory	24	0.69
	Zanthoxylum lemairei (De Wild.) P.G.Waterman	R27	tumbakise	-	0.13	-	3	-	0.20	-	Pi	DC	Zoochory	5	0.59
	Zanthoxylum leprieurii Guill. & Perr.	R28	-	bolongo	-	1.39	-	134	-	10.19	Pi	DC	Zoochory	11	0.52
Salicaceae	*Homalium longistylum* Mast.	S1	-	bambi	-	0.12	-	5	-	0.26	ST	EG	Anemochory	24	0.73
	Ophiobotrys zenkeri Gilg	S2	mogbala	mogbala	1.89	0.83	102	36	9.09	4.93	NPLD	EG	Zoochory	5	0.59
Sapindaceae	*Blighia* sp.	S3	-	noko-toko	-	0.06	-	2	-	0.04	ST	EG	Zoochory	31	0.71

	Blighia welwitschii (Hiern) Radlk.	S4	bodaba	toko	1.97	1.53	139	187	7.71	10.03	ST	EG	Zoochory	14	0.79
	Chytranthus gilletii De Wild.	S5	-	ngesua, tengesua	-	0.16	-	3	-	0.04	ST	EG	Zoochory	10	0.69
	Chytranthus macrobotrys (Gilg) Exell & Mendonça	S6	tokomboli	tokomboli	0.06	0.11	1	4	0.01	0.05	ST	EG	Megafaunal	7	0.69
	Chytranthus stenophyllus Gilg	S7	tenguesua, mbusua	-	0.11	-	2	-	0.02	-	ST	EG	Zoochory	32	0.69
	Deinbollia pynaertii De Wild.	S8	-	mongasa	-	1.00	-	104	-	2.82	ST	EG	Zoochory	31	0.69
	Lecaniodiscus cupanioides Planch. ex Benth.	S9	bimba	bimba	1.54	0.86	94	82	3.84	2.26	ST	EG	Zoochory	1	0.69
	Pancovia laurentii (De Wild.) Gilg ex De Wild.	S10	linga, elinga	-	0.34	-	12	-	0.36	-	ST	EG	Zoochory	4	0.69
Sapotaceae	*Aningeria altissima* (A.Chev.) Aubrév. & Pellegr.	S11	-	konya	-	0.15	-	14	-	0.40	NPLD	EG	Zoochory	24	0.44
	Baillonella toxisperma Pierre	S12	mabe	mabe	0.66	0.67	3	13	8.68	9.41	NPLD	DC	Megafaunal	24	0.72
	Gambeya beguei (Aubrév. & Pellegr.) Aubrév. & Pellegr.	S13	majeje	majeje	0.70	0.83	18	71	2.66	2.16	NPLD	EG	Zoochory	14	0.62
	Gambeya boukokoensis Aubrév. & Pellegr.	S14	mondonge	mondonge	0.52	0.77	26	101	1.34	3.64	NPLD	EG	Zoochory	14	0.62
	Gambeya lacourtiana (De Wild.) Aubrév. & Pellegr.	S15	bambu	bambu	2.07	1.74	131	163	10.16	17.90	NPLD	EG	Megafaunal	4	0.63
	Gambeya perpulchra (Mildbr. ex Hutch. & Dalziel) Aubrév. & Pellegr.	S16	koloka	koloka	1.71	0.55	97	71	7.32	4.36	NPLD	EG	Zoochory	14	0.71
	Mimusops andongensis Hiern	S17	bekesi	-	1.11	-	87	-	4.72	-	ST	EG	Zoochory	24	0.78
	Omphalocarpum procerum P.Beauv.	S18	mbate	mbate	0.06	0.70	1	38	0.01	2.61	NPLD	EG	Megafaunal	4	0.55
	Synsepalum brevipes (Baker) T.D.Penn.	S19	-	bogenja	-	0.79	-	71	-	5.43	ST	EG	Zoochory	11	0.82
	Tieghemella africana Pierre	S20	kolo	-	1.89	-	15	-	23.65	-	NPLD	EG	Megafaunal	24	0.65
	Tridesmostemon omphalocarpoides Engl.	S21	tuba	tuba	1.21	1.43	56	149	1.74	9.99	ST	EG	Megafaunal	4	0.68
Thomandersiaceae	*Thomandersia hensii* De Wild. & T.Durand	T1	-	ngoka	-	1.07	-	140	-	1.97	ST	EG	Other abiotic factor	22	0.59
	Thomandersia laurifolia (T.Anderson ex Benth.) Baill.	T2	ngoka	-	0.63	-	21	-	0.26	-	ST	EG	Zoochory	34	0.59
Thymelaeaceae	*Dicranolepis disticha* Planch.	T3	ngbi, ngbi a lo, kiyo a pame	-	0.12	-	3	-	0.05	-	ST	EG	Zoochory	13	0.59
Ulmaceae	*Holoptelea grandis* (Hutch.) Mildbr.	U1	bele	bele	0.56	0.28	9	5	2.92	0.34	Pi	DC	Anemochory	24	0.59
unidentified 1	unidentified 1	U2	-	bisaka	-	0.07	-	1	-	0.62	Unknown	Unknown	Unknown	-	0.59
unidentified 2	unidentified 2	U3	-	loayeyi	-	0.05	-	1	-	0.04	Pi	EG	Unknown	-	0.59
unidentified 3	unidentified 3	U4	-	njoyi	-	0.05	-	1	-	0.02	Unknown	Unknown	Unknown	-	0.59
unidentified 4	unidentified 4	U5	-	noko-buku	-	0.05	-	1	-	0.02	Unknown	Unknown	Unknown	-	0.59
unidentified 5	unidentified 5	U6	-	noko-pota	-	0.05	-	1	-	0.02	Unknown	Unknown	Unknown	-	0.59
Urticaceae	*Musanga cecropioides* R.Br. ex Tedlie	U7	kombo	kombo	8.10	2.37	599	255	68.09	34.20	Pi	EG	Zoochory	14	0.24
	Myrianthus arboreus P.Beauv.	U8	ngata	ngata	2.38	1.55	193	208	8.65	8.64	Pi	DC	Zoochory	14	0.43
Violaceae	*Rinorea oblongifolia* (C.H.Wright) C.Marquand ex Chipp	V1	sanjanbongo	sanjanbongo	3.61	1.21	420	194	7.51	3.07	ST	EG	Zoochory	22	0.59
	Rinorea subsessilis M.Brandt	V2	ngindi	ngindi	0.61	0.82	24	92	0.52	1.60	ST	EG	Zoochory	5	0.59

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