POPULATION STRUCRURE, REGENERATION STATUS AND DISTRIBUTION PATTERNS OF SIX IMPORTANT TREE SPECIES ALONG ALTITUDINAL GRADIENTS AT THE KILUM-IJIM FOREST RESERVE, CAMEROON

Abstract

Tropical montane forests are considered to be one of the most species diverse ecosystems. These areas pose specific edaphic and environmental characteristics which enable these areas to habour wide varieties of organisms. Some of these organisms are threatened and others endemic. The quest for food and other resources has resulted to indiscriminate exploitation. This study aimed to investigate the population structure, distribution patterns and regeneration status of six important tree species (*Nuxia congesta*, *Pittosporum mannii*, *Podocarpu slatifolius*, *Prunus africana*, *Schefflera abyssinica* and *Syzygium guineense*) along altitudinal gradients in the Kilum-Ijim Forest Reserve, Cameroon. A total of six study plots of one hectare (100 x100m) each were laid across a 120m elevation gradient. Two plots were established at each altitudinal gradient with elevations 2377m, 2437m and 2497m. Measurements were taken diameter at breast height (DBH 1.3m) for the tree and poles. The digital vernier calipers were used to measure collar diameters of seedlings and saplings. The highest tree density of 385 stems/ha was recorded for *N. congesta* at altitude 2497m while the least was 20 stems/ha for *S. abyssinica* at altitude 2377m. The highest seedling density was 1563 stems/ha recorded for *P. mannii* at altitude 2377m while the least seedling density was noticed for *S. abyssinica* at all the three altitudinal gradients. *Nuxia congesta* had the highest basal area of 8809.23m^2/ha at altitude 2437m and the least of 74.82m^2/ha for *P. latifolius* at altitude 2437m. The highest IVI occurred in *N. congesta* of 131.91 was recorded at altitude 2377m and the least of 24.91 occurred in *P. latifolius* at altitude 2437 m. The spatial distributions of studied tree species were clumped and irregular. The regenerations were poor, though, fair regenerations were noticed for *N. congesta* and *P. mannii*. The results showed that the six tree species were highly disturbed by anthropogenic activities. It is therefore imperative to develop and implement effective conservation measures to save the biodiversity of this area.

Key words: Tree population, density, distribution, regeneration, altitudinal gradient

1. INTRIDUCTION

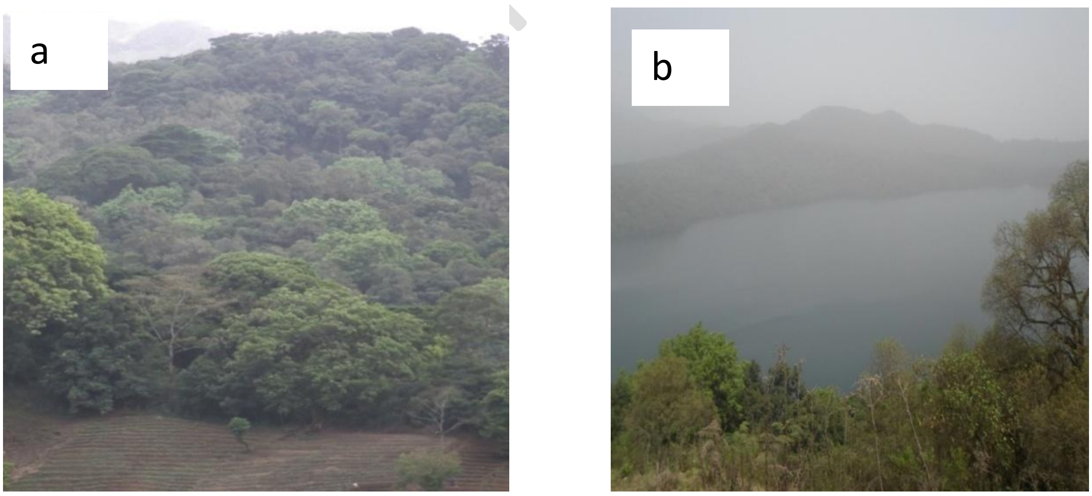
Tropical forests, which are home to about half of the terrestrial plant and animal species, are being destroyed at rates unprecedented in geological history [1]. The result is a wave of species extinctions that is leaving our planet both biologically impoverished and ecologically less stable. The degradation of forests and habitat loss due to anthropogenic activities are among the major causes of decline in biodiversity [2]. Cameroon's forest (22 million hectares) is of economic, cultural and socio-political importance to the countries of the Congo basin, and of ecological and scientific interest to the rest of the world [3]. Population structure of a species in a forest can partly convey its regeneration behaviour. However, natural regeneration of a tree species largely depends on production and germination of seeds, establishment of seedlings and saplings, their survival and growth [4]. Inadequate number of seedlings and saplings of tree species in a forest indicates poor regeneration [5]. The species existence and recruitment process in a forest mostly depends on its regeneration potential under varied climatic factors, competition between species, predation and anthropogenic disturbances [6]. Disturbances of both natural and anthropogenic origins influence forest dynamics and tree diversity at local and regional scales [7].

The Kilum-Ijim Forest Reserve is in the part of the Western Highlands of Cameroon commonly referred to as the Bamenda Highlands. The vegetation of the Bamenda Highlands, which is being increasingly cleared down, shares many species with those of East African Mountains [8]. It is estimated that about 96.5% of the original Afromontane Forest of the Bamenda Highlands has been lost due to conversion, commercial logging and loss of biodiversity [9]. Several forest and forest tree species in the country have showed decline in their population structure and regeneration due to the past and present disturbances, conversion and management [10]. Disturbance such as intensive removal of trees for timber, construction materials, conversion of forest patches into farm land and grazing field. The present study stems from this understanding. The objectives of this study were to: (i) investigate seedlings, saplings and tree population densities along altitudinal gradients for six important tree species at the Klim-Ijim forest reserve, Cameroon; (ii) examining the population structure using the diameter class distribution and (iii) identify the regeneration status of the six important tree species in the Klim-Ijim forest reserve Cameroon.

2. Materials and Methods

2.1 Study Site

The study was conducted in Kilum–Ijim Forest Reserve which is the part of the Western Highlands of Cameroon and referred to as the Bamenda Highlands. The Kilum section of the forest (also known as Mount Oku) is situated in Bui Division in the North West Region (Figure. 2). On the Western slope is the Ijim Crete, starting from the west side of Lake Oku to Kom in Boyo Division still in the North West Region. The contiguous Kilum-Ijim Mountain Forests (now known as the Kilum-Ijim Forest Reserve) are located between latitude 6°07´ and 6°17´N and longitude 10°20´ and 10°35 E. The Kilum-Ijim Forest is 20,000 hectares, the most significant remnant of Afromontane forest in Central Africa [11]. It summits is at 3,011m is only second to mount Cameroon (4100m) the highest peak in mainland in West Africa [9] and the adjoining Ijim Crete (2000-2500m) are recognized as a globally important centre of endemism and a hotspot for biodiversity conservation [12]. This forest reserve has a large crater lake called Lake Oku that is found along the Cameroon volcanic line which stretches from the Bamenda highlands in Cameroon to Jos in Nigeria [13]. The climate of the Kilum-Ijim Forest Reserve is humid with the presence of fog and mist almost throughout the year [14]. The precipitation is uni-modal [14]. The dry season begins from November to mid-March and the rainy season starts from mid-March to the month of October [15]. The total annual rainfall varies from 1800 mm^3 to 3000 mm^3 annually, with an average temperature that varies from 22°C at 1800m altitude to 16°C in the higher altitude areas and a relative humidity above 86% throughout the year [15]. The zone is a volcanic active zone with a crater lake. The geological landscape found here are mainly of Basalts, trachytes, rhyolites, gneiss and granite origin [14]. The landscape is a mosaic of grassland, forest patches, lake and steep mountain forest (Figure, 1).



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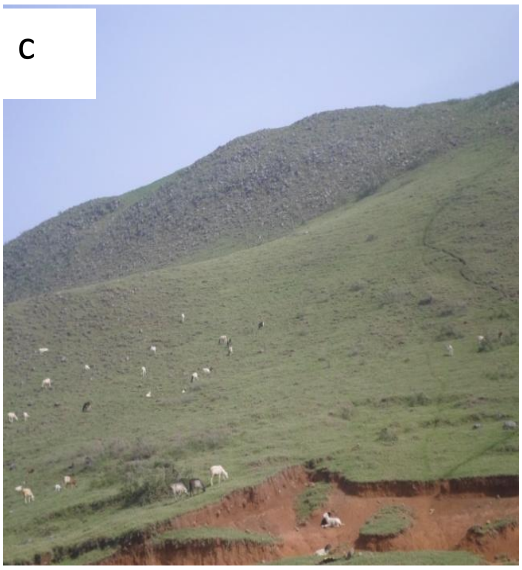
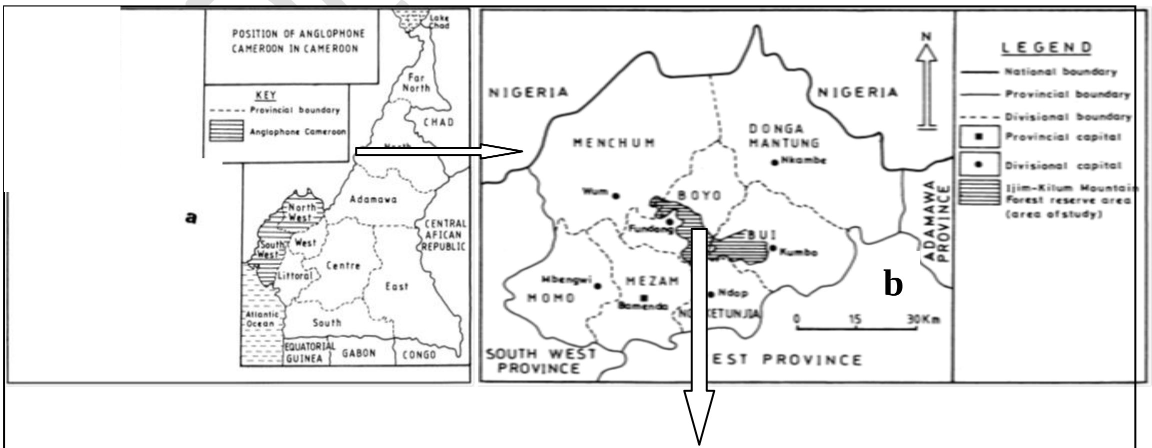


Figure 1: Overview of the study area. (a) Forest edge of Kilum mountain forest, (b) Lake Oku at altitude 2200-2300m, (c) Landscape showing vegetation and livestock grazing in the area,   (d) Kilum Mountain Forest summit



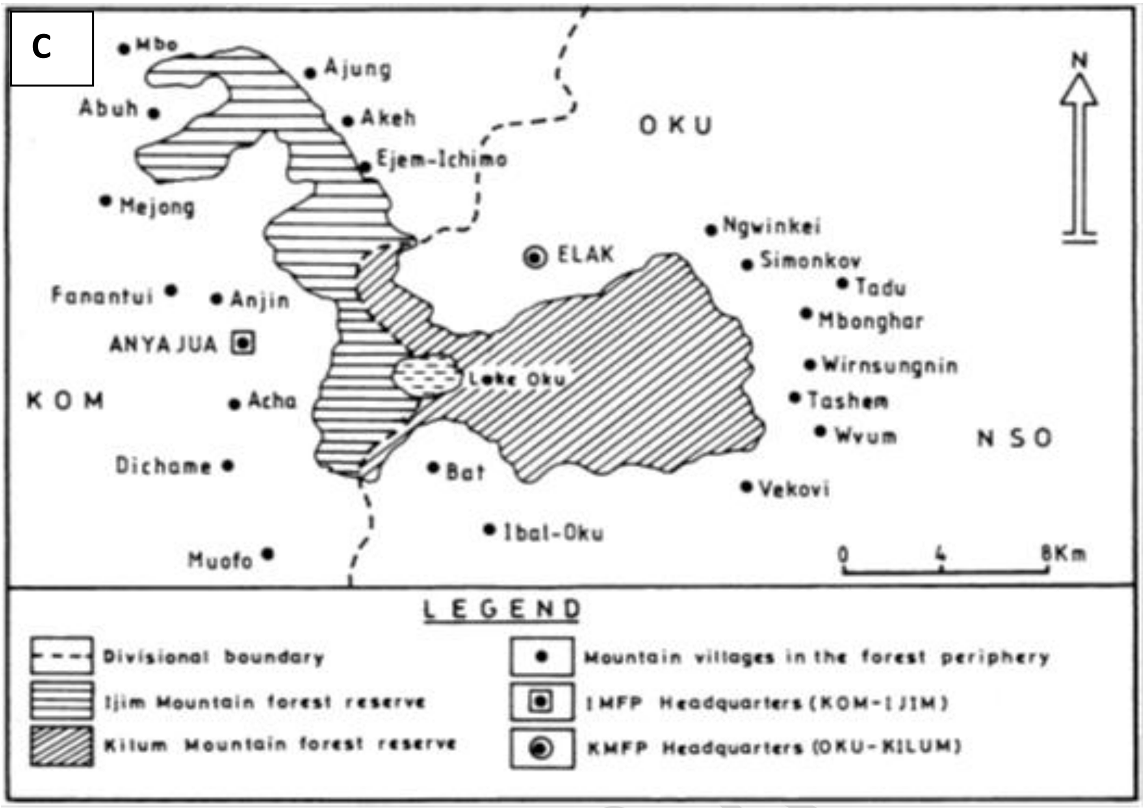


Figure 2. a) Map of Cameroon, b) Map of North West Region showing the Bui and Boyo Divisions c) Map of Kilum-Ijim Mountain Forest. Source[14].

2.2 Study Survey

A reconnaissance survey was carried out to obtain an impression and visual description of the general vegetation physiognomy and vegetation-environment relationships such as altitude, slope, and tree stands. Clearance to carry out this study work was collected from the Delegation of Forestry and Wild life and the traditional authority of the Klim –Ijim Forest Reserve. In each of the communities forest guides were identified (which could be a hunter, plant gatherer or herbalist who knows the forest and basic knowledge of the flora and fauna of the area). Focused group discussions and interviews were conducted with the local people (NTFP collectors, herbalist, hunters, etc) who are more likely to know plants and their detailed uses in their communities. During this survey, the following tree species; *Prunus* africana, *Syzygium guineense*, *Schefflera abyssinica*, *Nuxia congesta*, Pittosporum manni and *Podocarpus latifolius* were prioritized as very useful to them based on their ecological, socio-cultural, economic and medicinal uses. Five focussed groups discussions were carried across the five villages around the Kilum- Ijim Forest Reserve. A total of fifty questionnaires were administered in each of the five focused group giving a total of 250 questionnaires. The interviews were conducted by the researcher alongside a forest guide of the Kilum-Ijim Forest Reserve. Apart from the hunters, herbalist and forest gatherer some notables and farmers were also included in the discussion and interviews.

2.3 Vegetation Samplings

A sampling size of 10 ha was mapped out of the study site. A total of six study plots of one hectare (100 x100 m) each were laid across a 120 m elevation gradient. The highest altitude was at the Ijim site 2497 m above sea level (ASL) and the lowest altitude was at the Kilum site 2377m ASL. The six plots of 1 hectare (ha) each was divided into three altitudinal gradients. Two plots were established at each altitudinal gradient with elevations 2377 m ASL, 2437 m ASL and 2497 m ASL. The altitude and position of each plot were measured with Garmin Colorado 400T Global Positioning System (GPS). In each of the sampling plots of 1 ha, 10 line transects of 10 m x 100 m were laid. Measurements were taken for height in meters (m) and dbh (1.3 m) for all the studied tree species. The height of trees (dbh $\geq$ 10 cm) and poles (dbh $\geq$ 5 cm to < 10 cm) was estimated using graduated measuring poles of 10 m. The initial 10 m height of 10 m was first taken after which the remaining height is estimated by noting how many 10 m length of the poles goes on the tree. The diameter was measured at

1.3 m (dbh). For plants that have buttresses the diameter was taken at 30 cm above the end of the buttress. For sapling (dbh ∠2.5cm to d∠4.9cm), the 10 m graduated pole was used to measure the height and a digital vernier calliper to measure the diameter. For seedling density, height and diameter, ten quadrats of 4 x 4 m along each line transect were laid. The number of seedlinngs in each quadrat was counted for each of the species. The heights were measured using a transparent 50 cm ruler. The collar diameter was measured with a digital vernier caliper. The following precautions were taken while measuring the dbh. If the tree is branched below breast height, the dbh must be taken for individual stems, and must be noted as separate trees. For buttress trees at 1.3m, the dbh was taken 30cm above the buttresses for uniformity. Figure 3(a) and (b) shows measurement of tree height using a range pole, 3 (c), (d) and (e) measuring dbh using a diameter tape and 3 (f) mapping out plots using a measuring tape.

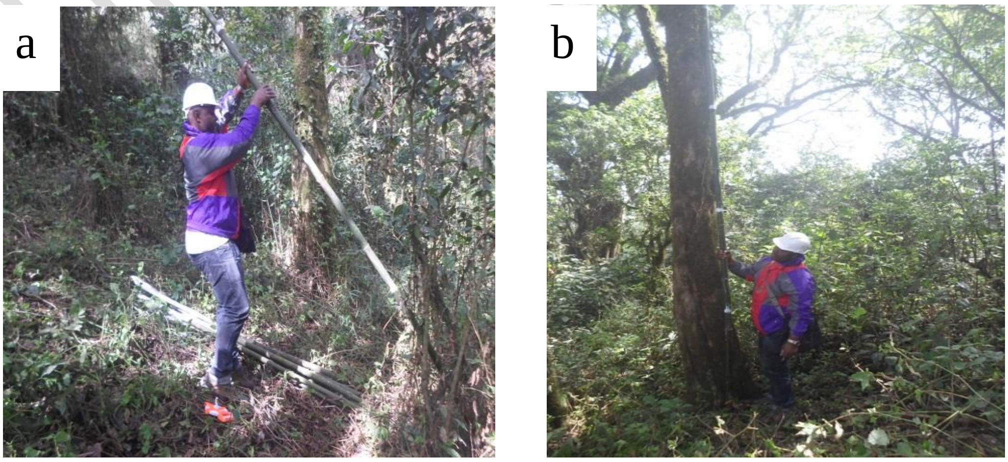


Figure 3: (a) Range pole (10 m) for taking the height of saplings and poles,(b) Taking the height of a tree using a 10 m range pole(c), (d)and (e) Measuring tree diameter at breast height (f) Mapping out the plots using a measuring tape.

2.4 Data analysis

The data analysis followed the procedures described in detail by [16]. Species richness was determined from the total number of tree species recorded in each site at the three altitudinal gradients. The diversity of the tree species at the three different altitudes was analyzed by using the Shannon Diversity Index [17, 18]. The index takes into account the species richness and proportion of each species in all sampled quadrats of each study site. Density of the tree species was calculated by converting the total number of individuals of each tree species encountered in all the quadrats and all transects used in each of the three altitudes to equivalent number per hectare. The frequency was calculated as the proportion (%) of the number of quadrats in which each tree species was recorded from the total number of quadrats in each of the sites. Dominance of the tree species, with dbh ∠10 cm and poles with dbh ∠5 cm to < 10 cm was determined from the space occupied by a species, usually its basal area. The total basal area of each tree species was converted to equivalent basal area per hectare [18]. Importance value index (IVI), which indicates the relative ecological importance of a given woody species at a particular site [18], was determined from the summation of the relative values of density, frequency and dominance of each tree species. Relative density was calculated as the percentage of the density of each species divided by the total stem number of all species ha1. Relative frequency of a species was computed as the ratio of the frequency of the species to the sum total of the frequency of all species at each study site. Relative dominance was calculated as the percentage of the total basal area of a species out of the total basal areas of all species at each study site. The Simpson index (D) and the evenness index (E=Evenness) are considered as a measure of species dominances and a measure for evenness of spread, respectively [18].

The equation used to calculate Simpson's index was

D = £(pi)2 ………………………………………………………………(i)

Where, D = Simpson index of dominance

pi = the proportion of important value of the ith species

(pi= ni / N,

ni = the important value index of ith species

N = the important value index of all the species)

The spatial distributional patterns of the seedlings, saplings, poles and tree populations at different altitudinal gradients were analyzed using the standardized Morisita's index (Ip), since it is relatively independent of population density [17]. First the Morisita's index was computed as:

Ip = n (£2 -£) / [(£) 2-£&………………..………………….. (ii)

where, n is the sample size, £□ and £□2are the sum of the quadrat counts, and the sum of the quadrat counts square, respectively. Then two critical values for the Morisita

$= n (\Sigma x^2 - \Sigma x) / [(\Sigma x)^2 - \Sigma x$………………….....………………..……..... (ii)

where, n is the sample size, Σx and Σx^2 are the sum of the quadrat counts, and the sum of the quadrat counts square, respectively. Then two critical values for the Morisita's index were calculated using the following formulae:

Uniform index; $Mu = (\chi 2\ 0.975 - n + \Sigma xi) / (\Sigma xi - 1)$ ……………………………….…(iii)

Clumped index; $Mc = (\chi 2\ 0.025 - n + \Sigma xi) / (\Sigma xi - 1)$ ………………………….……..... (iv)

where, $\chi 2\ 0.975$ and $\chi 2\ 0.025$ are values of chi-squared

with (n-1) degrees of freed

om that has 97.5% and 2.5% of the area to the right, respectively; xi = given a set of counts of organisms in a set of quadrats and n = number of quadrats. Finally, the standardized Morisita's index was calculated using the relevant formula out of the following four:

(1) $Ip = 0.5 + 0.5 (Id - Mc) / (n - Mc)$; when $Id \angle Mc > 1.0s$ ………………………(v)

(2) $Ip = 0.5 (Id \geq Mc > 1.0s$ …………………….……… (v)

(2) $Ip = 0.5 (Id - 1) / (Mu - 1)$; when $Mc \geq Id > 1.0$ ……………………………..… (vi)

(3) $Ip = - 0.5 (Id - 1) / (Mu - 1)$; when $1.0 > Id > Mu$……………………………….. (vii)

(4) $Ip = - 0.5 + 0.5 (Id - Mu) / Mu$;

When $1.0 > Mu > Id$…………………………………….…... (vii

Mu) / Mu; when $1.0 > Mu > Id$……………………………….. (viii)

The standardized Morisita index of dispersion (Ip) has a range between -1 and +1, with 95% confidence limit at ± 0.5, where values of 0.0 indicate random dispersion, above 0.0 clumped dispersion, and below 0.0 uniform dispersion.

The regeneration status of key trees species in Kilum-Ijim forest was categorized as: (i) Good regeneration i.e. if number of seedlings > saplings > adults. (ii) Fair regeneration i.e. if number of seedlings> or∠ saplings ∠adults. (iii) Poor regeneration i.e. if the species was found as sapling, but no seedlings (Number of saplings maybe more, less or equal that of adults). (iv) No regeneration i.e. if individuals of species are present only as adults. (v) New regeneration i.e. if individuals of species have no adults but present as seedlings or saplings. Seedlings, saplings, poles and tree stems were counted per ha to determine regeneration status.

3. Results

3.1 Tree species Density, Basal area and IVI at three altitudinal gradients

Nuxia congesta had the highest tree species density at altitude 2377 m, with 243 individual/ha (Table 1). The lowest tree species density of 20.00 individuals/ha was noted for *Schefflera abyssinica* (Table 1). The highest pole density at altitude 2377 m was 15.00 individuals/ha for *Pittosporum mannii* while we noticed none individuals/ha for *Prunus africana*, *Schefflera abyssinica* and Syzygium guineense (Table 1). The highest sapling density recorded at altitude 2377 m was 2813 individuals /ha noted for *Podocarpus latifolius* (Table 1) while the lowest sapling density were recorded for *Prunus africana*, *Schefflera abyssinica* and *Syzygium guineense* with none of the individuals /ha (Table 1). The highest seedling density was obtained at altitude 2377 m was 1563 individuals/ha noted for *Pittosporum manni* (Table 1) while *Podocarpus latifolius, Prunus africana*, and *Schefflera abyssinica* had no individuals /ha (Table 1).

The highest basal area of these studied tree species at altitude 2377 m was observed for *Nuxia* *congesta* which recorded 7141.47 m^2/ha while the lowest basal area was 164.92 m2/ha noticed for *Podocarpus latifolius* (Table 1).

	ALTITUDE 2377 m	ALTITUDE 2437 m	ALTITUDE 2497 m

The highest importance value index (IVI) at altitude 2377 m was noted for Nuxia congesta which recorded 131.91 while the lowest IVI at altitude 2377 m was obtained for *Schefflera abyssinica* which noted 25.57 (Table 1). The highest IVI for poles at altitude 2377 m was 142.41 recorded for *Pittosporum mannii* (Table 1). *Prunus africana, Schefflera abyssinica* and *Syzygium guineense* had no values for IVI for poles at this altitude (Table 1).

Tree species	Form	Density/ ha	BA(m^2/ha))	IVI	Density/ Ha	BA(m^2/ha)	IVI	Density/ ha	BA(m^2/ha)	IVI
Nuxia congesta	Tree	242.5	7141.47	131.91	220	8809.23	123.48	385	13154.7	114.02
(R.Br.Ex.Fresen.)	Pole	12.5	0.17	127.86	7.5	0.05	67.44	30	0.97	110.99
	Sapling	937.50	-	-	937.50	-	-	-	-	-
	Seedling	937.50	-	-	1250.0	-	-	2187.50	-	-
Pittosporum mannii	Tree	122.5	192.39	38.11	75	323.7	25.71	145	446.81	34.24
(Hook.f.)	pole	15	0.19	142.41	2.5	0.01	36.36	20	1.25	108.12
	Sapling	937.50	-	-	-	-	-	-	-	-
	Seedling	1562.50	-	-	-	-	-	2500.0	-	-
Podocarpus latifolius	Tree	87.5	164.92	32.28	32.5	74.82	24.91	122.5	608.81	32.49
(Thunb.) R. Br. Ex Mirb.	pole	2.5	0.01	29.73	-	-	-	2.5	-	17.97
	Sapling	2812.50	-	-	-	-	-	-	-	-
	Seedling	-	-	-	-	-	-	625.00	-	-
Prunus africana	Tree	77.5	418.06	33.42	45	356.04	29.32	70	348.72	25.71
(Hook.f.) Kalman	pole	-	-	-	5	0.02	48.48	2.5	0.01	18.18
	Sapling	-	-	-	312.50	-	-	-	-	-
	Seedling	-	-	-	312.50	-	-	-	-	-
Schefflera abyssinica	Tree	20	533.04	25.57	25	1593.47	34.41	42.5	2475.66	31.75
(Hochst. ex A. Rich.)	pole	-	-	-	-	-	-	-	-	-
	Sapling	-	-	-	-	-	-	-	-	-
	Seedling	-	-	-	-	-	-	-	-	-
Syzygium guineense	Tree	82.5	836.85	38.72	127.5	2739.89	62.18	160	6570.65	61.8
(willd.) DC	pole	-	-	-	15	0.19	147.71	15	0.22	44.73
	Sapling	-	-	-	-	-	--	-	-	-
	Seedling	312.50	-	-	-	-		625.50	-	-

Table 1. Density, Basal area (BA), and Importance Value Index (IVI) of six tree species at three different altitudinal gradients

3.2 The population structure of six important tree species at altitude 2377 m

At altitude 2377 m, the population structure showed a J- shape structure for *Nuxia congesta* and *Schefflera abyssinica*. We noticed a low number of and /or complete absented of individuals in the lower diameter classes and observed increase in number of individuals in the upper diameter classes (Figure 4). *Pittosporum mannii* showed an irregular structure of individuals in the different diameter classes. We noticed high number of individual in the lower diameter classes and a gradual decrease in number of individuals in the higher classes (Figure 4). *Podocarpus latifolius, Syzyguim guineense* and *Prunus africana* both showed an Irregular population structure of individuals in the different diameter classes. However, individuals were observed in all diameter classes (Figure 4).

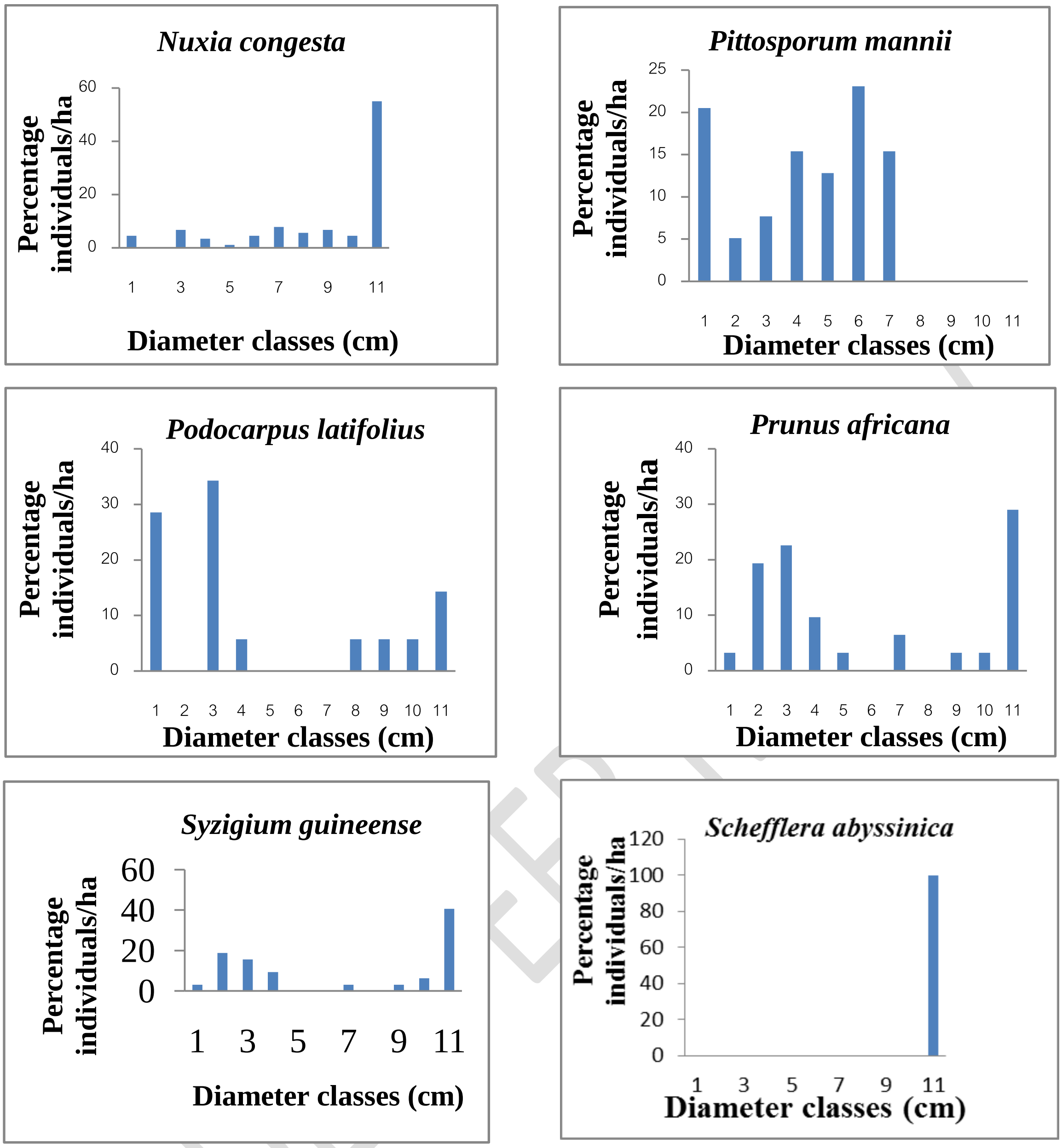


Figure 4.The population structure of important tree species at altitude 2377 m in the Kilum-Ijim Forest Reserve [Note DBH class distribution] where, 1) 00-10 cm, 2) 11-20 cm, 3) 21-30 cm, 4) 31-40 cm, 5) 41-50 cm, 6) 51-60 cm, 7) 61-70 cm, 8) 71-80 cm, 9) 81-90 cm, 10) 91-100 cm, 11) > 100 cm.

The population structure of six important tree species at altitude 2437 m

At altitude 2437 m, the population structure showed a J- shaped structure for *Nuxia congesta*, *Prunus africana*, *Schefflera abyssinica* and *Syzyguim guineense* (Figure 5). We recorded a low number of and /or complete absented of individuals in the lower diameter classes and observed increase in number of individuals in the upper diameter classes (Figure 5). *Pittosporum mannii* and *Podocarpus latifolius* showed an Irregular population structure.

Individuals were recorded in all the diameter classes (Figure 5).

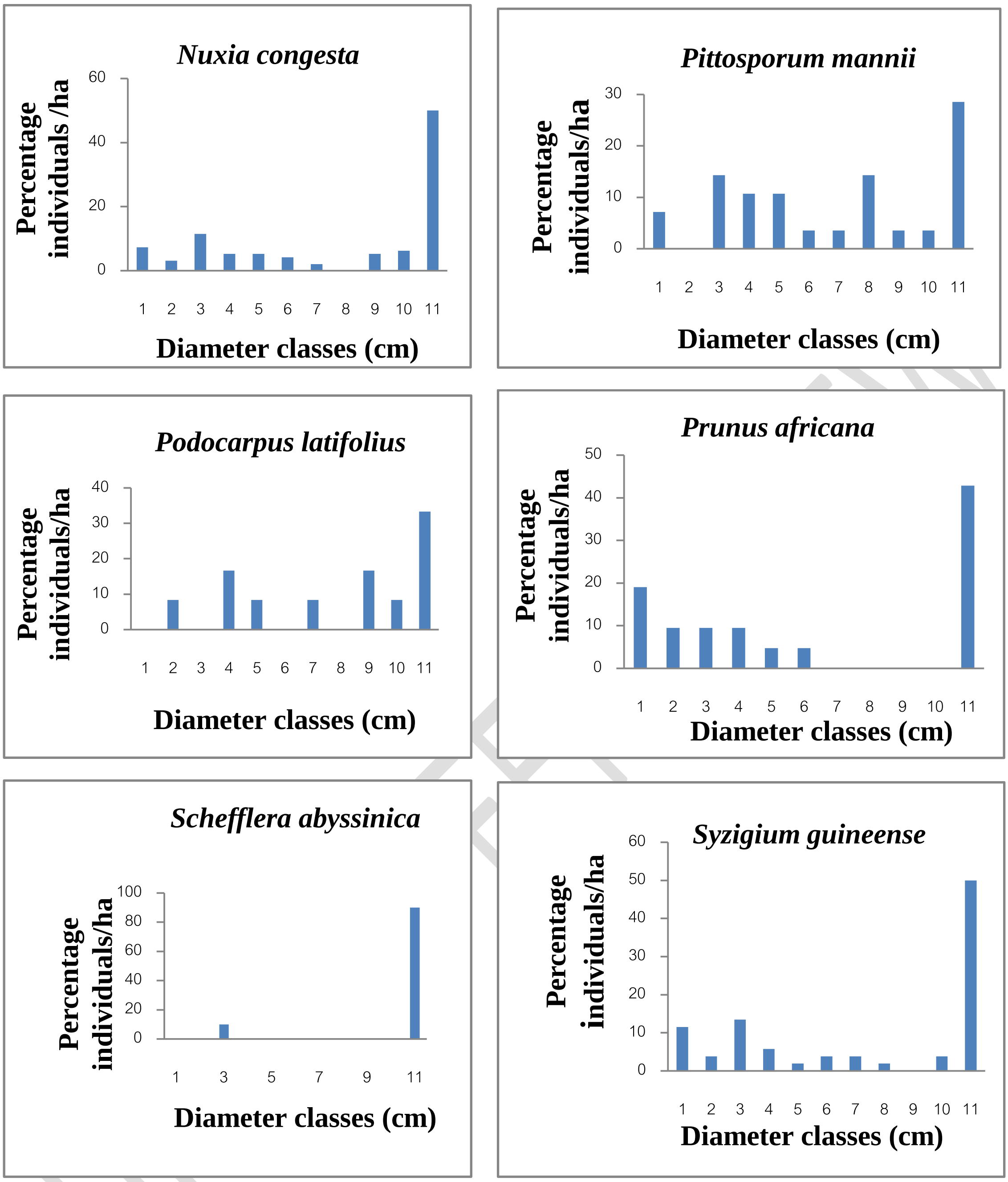


Figure 5.The population structure of important tree species at altitude 2437 m in the Kilum-Ijim Forest Reserve [Note DBH class distribution] where1) 00-10 cm, 2) 11-20 cm, 3) 21-30 cm, 4) 31-40 cm, 5) 41-50 cm, 6) 51-60 cm, 7) 61-70 cm, 8) 71-80 cm, 9) 81-90 cm, 10) 91-100 cm, 11) > 100 cm.

3.3 The population structure of six important tree species at altitude 2497 m

At altitude 2497 m, *Nuxia congesta*, *Schefflera abyssinica*, *Syzyguim guineense*, *Podocarpus latifolius* and *Pittosporum mannii* showed a J- shaped population structure (Figure 6). We observed low number of individuals or complete absented of individuals in the lower diameter classes. The numbers of individuals in the upper diameter classes were noted to be higher as compared with the lower diameter classes (Figure 6). *Prunus africana* showed an Irregular population structure. Individuals were recorded in all the different diameter classes (Figure 6).

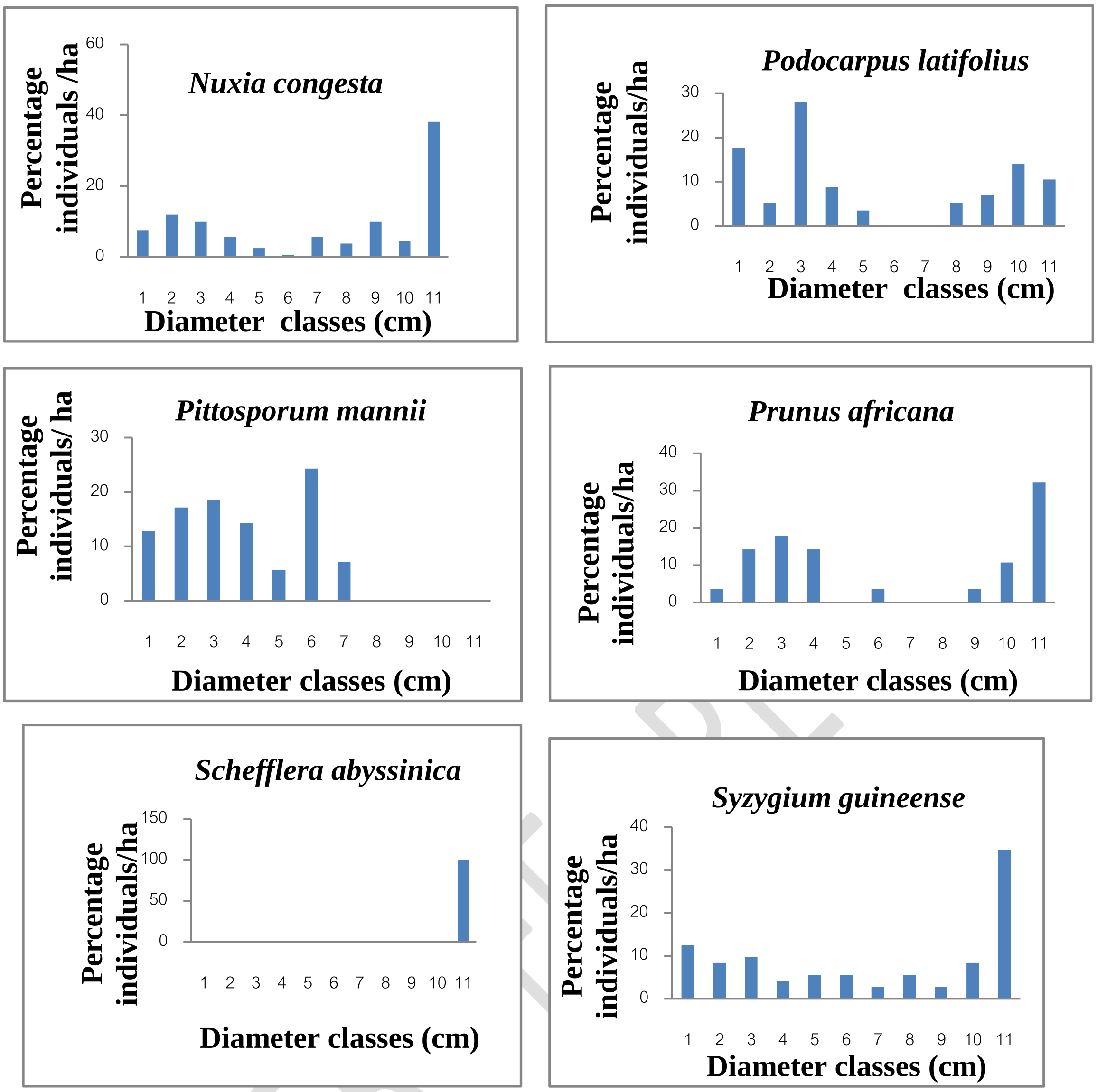


Figure 6.The population structure of important tree species at altitude 2497 m in the Kilum-Ijim Forest Reserve [Note DBH class distribution] where, 1) 00-10.cm, 2) 11-20cm, 3) 21-30cm, 4) 31-40cm, 5) 41-50cm, 6) 51-60cm, 7) 61-70cm, 8) 71-80cm, 9) 81-90cm, 10) 91-100cm, 11) > 100 cm.

3.4 Tree, pole, sapling and seedling distribution patterns at three altitudinal gradients

At altitude 2377 m, the trees of *Nuxia congesta* showed clump distribution pattern (Table 2). The trees of *Pittosporum mannii*, *Podocarpus latifolius*, *Prunus africana*, *Schefflera abyssinica* and *Syzygium guineense* showed a uniform distribution pattern (Table 2). The poles of *Nuxia congesta* we observed random distribution pattern while the poles of *Pittosporum mannii* recorded uniform distribution pattern (Table 2). The poles of *Podocarpus latifolius*, *Prunus africana*, *Schefflera abyssinica* and *Syzygium guineense* were not noticed at this altitudinal gradient (Table 2). The saplings of *Nuxia congesta*, *Pittosporum manni*, *Podocarpus latifolius* were reported uniform distribution pattern (Table 2). The saplings of *Prunus africana*, *Schefflera abyssinica* and *Syzygium guineense* were not noticed at altitude 2377 m (Table 2). The seedlings of *Nuxia congesta* and *Pittosporum mannii* showed uniform distribution pattern (Table 2). The seedlings of *Syzygium guineense* displayed clumped distribution pattern while the seedlings of *Podocarpus latifolius*, *Prunus africana, Schefflera abyssinica* were not observed at this altitude (Table 2).

At altitude 2437 m, the trees of *Nuxia congesta*, *Podocarpus latifolius* and *Prunus africana* showed uniform distribution pattern (Table 2). The trees of *Pittosporum mannii*, *Schefflera abyssinica* and *Syzygium guineense* we observed clumped dispersion pattern (Table 2). The trees of *Pittosporum mannii*, *Schefflera abyssinica* and *Syzygium guineense* showed clumped distribution pattern (Table 2). The poles of *Nuxia congesta*, *Prunus africana* and *Syzygium guineense* showed uniform distribution pattern while the poles of *Pittosporum mannii* had clumped distribution pattern (Table 2). The poles of *Podocarpus latifolius* and *Schefflera abyssinica* were not noticed at this altitude (Table 2).

The sapling of *Nuxia congesta* showed uniform distribution at this altitude 2437 m (Table 2). The saplings of *Prunus africana* had clumped distribution pattern while those of *Pittosporum mannii*, *Podocarpus latifolius, Schefflera abyssinica* and *Syzygium guineense* were not noticed at this altitude . At this altitude the seedling of *Nuxia congesta* displayed uniform distribution pattern (Table 2) while the seedling of *Prunus africana* showed clumped distribution (Table 2). The seedlings of *Pittosporum mannii*, *Podocarpus latifolius*, *Schefflera abyssinica* and *Syzygium guineense* were absent (Table 2).

At altitude 2497 m the trees of *Nuxia congesta*, *Pittosporum mannii* and *Prunus africana* showed a clumped distribution pattern (Table 2). The trees of Podocarpus latifolius, *Schefflera abyssinica* and *Syzygium guineense* showed uniformed distribution pattern (Table

2). The poles of *Nuxia congesta*, *Pittosporum mannii* and *Syzygium guineense* showed a uniformed distribution pattern (Table 2). The poles of *Podocarpus latifolius* and *Prunus africana* showed clumped distribution pattern (Table 2). The poles of *Schefflera abyssinica* were not noticed at this altitude. At altitude 2497 m, the saplings of *Nuxia congesta*, *Prunus africana*, and *Syzygium guineense* had a clumped distribution pattern (Table 2) while those of *Podocarpus latifolius* showed uniform distribution pattern. The saplings of *Pittosporum mannii* and *Schefflera abyssinica* were absented (Table 2). The seedlings of *Nuxia congesta* showed uniformed distribution pattern (Table 2) while seedlings of *Podocarpus latifolius* and *Syzygium guineense* observed clumped distribution pattern. The seedlings of *Pittosporum mannii*, *Prunus africana* and *Schefflera abyssinica* were not noticed at this altitude (Table 2).

At altitude 2377 m, the trees of *Nuxia congesta* showed clump distribution pattern. The trees of *Pittosporum mannii*, *Podocarpus latifolius*, *Prunus africana*, *Schefflera abyssinica* and *Syzygium guineense* showed a uniform distribution pattern.

Table 2. Distribution patterns of six tree species at three different altitudinal gradients

- Indicate absence of species, U= Uniform dispersion, C=Clumped dispersion, Ra=

		Altitude 2377 m		**Altitude 2437 m**		**Altitude 2497 m**	
Tree species	Form	Ip	DP	Ip	DP	Ip	DP
Nuxia congesta	Tree	0.61	C	-1.87	U	0.66	C
	Pole	0	Ra	-1.05	U	-0.18	U
	Sapling	-1.58	U	-0.35	U	0.24	C
	Seedlings	-1.05	U	-2.11	U	-0.32	U
Pittosporum mannii	Tree	-0.5	U	1	C	0.5	C
	Pole	-0.18	U	1	C	-0.53	U
	Sapling	-0.35	U	-	-	-	-
	Seedlings	-2.11	U	-	-	-	-
Podocarpus latifolius	Tree	-0.5	U	-2.76	U	-0.43	U
	Pole	-	-	-	-	0.03	C
	Sapling	-0.32	U	-	-	-0.5	U
	Seedlings	-	-	-	-	0.08	C
Prunus africana	Tree	-0.85	U	-0.6	U	0.72	C
	Pole	-	-	-0.53	U	0.03	C
	Sapling	-	-	1	C	0.24	C
	Seedlings	-	-	1	C		-
Schefflera abyssinica	Tree	-1.84	U	0.73	C	-0.25	U
	Pole	-	-	-	-	-	-
	Sapling	-	-	-	-	-	-
	Seedlings		-	-	-	-	-
Syzygium guineense	Tree	-0.26	U	0.51	C	-0.66	U
	Pole	-	-	-2.63	U	-2.63	U
	Sapling	-	-	-	-	0.24	C
	Seedlings	1	C	-	-	0.08	C

- Indicate absence of species, U= Uniform dispersion, C=Clumped dispersion, Ra= Random, Ip = standardised Morisita's index

3.5 The regeneration status of six important tree species along altitudinal gradients

At altitude of 2377 m, the regeneration status of *Nuxia congesta* and *Pittosporum mannii* were fair (Table 3). *Podocarpus latifolius* and *Syzygium guineense* had poor regeneration while *Prunus africana* and *Schefflera abyssinica* had no regeneration (Table 3). At altitude 2437 m, *Nuxia congesta* showed fair regeneration while the regeneration status of *Prunus africana* was poor (Table 3). *Pittosporum mannii*, *Podocarpus latifolius*, *Schefflera abyssinica* and *Syzygium guineense* recorded no regeneration (Table 3).

At altitude 2497 m, the regeneration status of *Nuxia congesta*, *Pittosporum mannii*, *Podocarpus latifolius* and *Syzygium guineense* showed fair regeneration (Table 3). *Prunus africana* showed poor regeneration at this altitude while *Schefflera abyssinica* had no regeneration (Table 3).

Table 3. The regeneration status of six important tree species / ha along altitudinal gradients in selected sites in the Kilum-Ijim Forest Reserve.

		Elevation (m)		
Species	Forms	**2377 m**	**2437 m**	**2497 m**
Nuxia congesta	Tree	54	88	86
	Pole	12	8	6
	Sapling	4	1	3
	Seedling	7	4	3
	Status	F	F	F
Pittosporum mannii	Tree	58	29	35
	Pole	8	2	6
	Sapling	-	-	3
	Seedling	8	-	5
	Status	F	N	F
Podocarpus latifolius	Tree	49	13	25
	Pole	1	-	1
	Sapling	8	-	9
	Seedling	2	-	-
	Status	F	N	P
Prunus africana	Tree	29	18	31
	Pole	1	4	-
	Sapling	1	2	-
	Seedling	-	-	-
	Status	P	P	N
Schefflera abyssinica	Tree	17	10	8
	Pole	-	1	-
	Sapling	-	-	-
	Seedling	-	-	-
	Status	N	N	N
Syzygium guineense	Tree	64	51	32
	Pole	6	6	-
	Sapling	1	-	-
	Seedling	2	-	1
	status	F	N	P

-absence of species, G = good regeneration, F = fair regeneration, P = poor regeneration, N = no regeneration

4. Discussion

Information on species composition, population structure and diversity patterns are fundamentals for the conservation of natural areas; these patterns have frequently been the focus on ecological studies. The knowledge of the floristic compositions of plant community is a prerequisite to understand the overall structure and functioning of the ecosystem.

However, Regular human interventions like overgrazing, timber exploitation, non timber forest products collection (NTFPS) and encroachments of forest areas for (settlement, agriculture) are among the key regulatory factor controlling the distribution of species [19]. Furthermore altitude is also one of the most important factors which determine the distribution of tree species due to its direct effect on the microclimatic conditions of the habitat [20].

In this present study the tree, poles saplings and seedlings densities of *Nuxia congesta*, *Pittosporum mannii*, *Podocarpus latifolius*, *Schefflera abyssinica* and *Syzygium guineense* increased with increase in altitude. Such trends were also reported by [21], in various forest communities in Great Himalayan National Park (GHNP) in north western Himalaya. The increase in densities for these species with altitudes may be due to little anthropogenic activities at higher altitudes as compared to the lower altitudinal gradients. However, *Prunus africana* did not show any trends in trees, poles, saplings, and seedlings densities along altitudinal gradients. It was noticed to be higher at the lower altitude and slightly higher in the higher altitudes. The densities were lowest at the mid altitudinal gradients. [22], in their work along the slopes of mount Cameroon mentioned the unsustainable harvesting of the backs of the trees could have resulted to the dead of the trees leading to low densities of the trees and seedlings. In a similar work in Adamawa region [23], also reported poor tree densities at the different altitudinal levels. They mentioned that most of the tree stands were totally debarked or felt for their barks resulting in low trees and seedling densities at the different altitudinal gradients. The basal areas of *Nuxia congesta*, *Pittosporum mannii* and *Schefflera abyssinica* increased with increase in altitude. Similar trends were reported by [24], who worked on tree species composition and richness along altitudinal gradients. Probably, the high basal area at the high altitudes could be due to the remote nature of the area which limited access and reduced extractions of materials. On the other hand the basal area of *Prunus africana* decreased with increase in altitudinal gradients. This results is in contrast with that of [23] who noticed a decreased in *Prunus africana* at lower altitudes than at higher altitudes in the Adamawa plateau. [22], working along the slopes of mount Cameroon mentioned that other factors influenced the basal area distribution along the slopes. These factors include accessibility, market demand and suitable climatic conditions for the growth of the species. The basal area of *Podocarpus latifolius* did not showed any trend with change in altitude. [6], along altitudinal gradients in different forest cover of Darhal reported similar observation. They attributed to human influence along the different altitudes. In this present study the IVI of *Nuxia congesta* and *Prunus africana* decreased with increased altitudinal gradients. On the other hand IVI of *Syzygium guineense* increased with increase altitudinal gradients. While *Pittosporum mannii Schefflera abyssinica* and *Podocarpus latifolius* did not show any trend with change in altitudinal gradients. [25], on the effects of altitudes and climate in shaping forest composition reported that IVI represented the dominant species at the different altitudes. The IVI of the different species were higher at altitudinal gradients which suited the tree species to grow and established. This is in line with the findings of [25], on the effects of altitudes and climate in shaping forest composition.

At altitude 2377 m, the population structure showed a J- shape structure for *Nuxia congesta* and *Schefflera abyssinica.* We noticed a low number of and /or complete absented of individuals in the lower diameter classes and observed increase in number of individuals in the upper diameter classes. The findings were different from that of [23] who noticed a reversed J shaped structure of individual at the different diameter classes. The J shaped structured noticed by *Nuxia congesta* and *Schefflera abyssinica* could be attributed by anthropogenic activities occurring within and beyond the forest reserve. The high pastoral activities by the Fulani and some natives (cattle grazing, bush fire and nomadic movements) could have resulted to this structure. This finding is in line with [6], who reported distortion of population structures by anthropogenic activities. *Podocarpus latifolius*, *Syzyguim guineense* and *Prunus africana* both showed an Irregular population structure of individuals in the different diameter classes. However, individuals were observed in all diameter classes. Probably the irregular population structure could be as result of illegal timber exploitation and NTFPS gathering within the forest reserve could have affected the population structure. This is in line with works of [26] on population ecology and regeneration noticed that illegal exploitation and indiscriminate collection of NTFPS could have an influence on the population structure.

At altitude gradients 2437 m and 2497 m, the population structure showed a J- shaped structure for *Nuxia congesta*, *Prunus africana*, *Schefflera abyssinica* and *Syzyguim guineense*. We recorded a low number of and /or complete absented of individuals in the lower diameter classes and observed increase in number of individuals in the upper diameter classes. Probably, the difficult terrain at the mid altitude reduced the illegal exploitation of timber and the indiscriminate harvesting of the forest products, thus most of the trees, poles and saplings could not be harvested. [27], mentioned that altitudinal changes can influences the composition and structure of the population. The complete absence of some individuals in the low class diameters could be linked to poor seed production, low viability of the seeds and absence of suitable condition for seed germination. This finding is in line with works of [28], on ecology of regeneration of seven indigenous trees noticed poor seed viability at the different altitudinal levels.

It was observed that the spatial distribution pattern of trees, poles, saplings and seedlings of important tree species studied were generally clumped. The clumped or aggregated spatial pattern is very common among tropical tree species with minimal perturbations. Most of the saplings, poles and seedlings were adapted to grow close to the mother plant. This is in accordance with the findings of [10] who worked on the spatial distribution of non-timber forest products in the Takamanda National Park. The clumped pattern of distribution may also be attributed to gaps in the forest caused either by natural (wind and landslide) and anthropogenic (bush fire or timber harvest) activities which enabled the species to colonize most disturbed areas. This corroborates the findings [29], who worked on gaps and recruitment of species in disturbed African rainforest at Korup National Park. Poor seed dispersal and poor conditions (moisture levels, temperature, nutrients, light etc) may lead to such patterns [30]. The clumped pattern of some of these important tree species could be attributed to a resource base-niche differentiation resulting to habitat specialization, so that different species are best suited to different habitats, where they are competitively dominant and relatively more abundant [31].

However, some of the Poles, saplings and seedlings species recorded random patterns of distribution at different altitudinal gradients. This may be probably due to the topography of the terrain which provided suitable conditions for growth of species at different altitudinal gradients in the forest. This is in conformity with findings of [10] who worked on the spatial distribution of non-timber forest products in the Takamanda National Park. Perhaps these seedling populations are not dispersal- limited and /or seed to seedling establishment is not limited by both biotic and abiotic factors. This finding is in line with the work of [32] who reported on spatial patterns of trees, sapling and seedling species in tropical forest in West Polynesia. Furthermore, the topography, a major physical factor, plays a vital role in seedling composition, growth and distribution in tropical forest. This is attributed to the fact that in many parts of the tropical montane forests, an extraordinary variety of wet and dry habitats exist in close proximity due to extremely broken terrain with differently exposed slopes. In this case the upper and lower part of the forest may be receiving different amounts of rainfall, sunshine and windy conditions leading to different vegetation types and contributing to high species richness in mountain forests.

The occurrence of a sufficient number of poles, saplings and seedlings in a given forest population indicates successful regeneration [6]. The above three life stages for important tree species signify the probable forest structure in future. The present study showed that regeneration of the six tree species in the Kilum-Ijim forest reserve along the three altitudinal gradients is generally poor. Though the regeneration status of the six tree species along altitudinal gradients were generally low, it has been observed that there were some of the tree species which were regenerating fairly (*N. congesta* and *P. mannii*) or not regenerating at all (*S. abyssinica*). This finding is in line with that of [6] who reported that the regeneration status was poor in the forests as survival from saplings to poles was found to be almost absence in all the studied sites of dominant tree species along altitudinal gradient. The poor seed germination along altitudinal gradients in this study could be attributed to anthropogenic pressures and natural disturbances along the different altitudinal gradients.

5. Conclusion

The present study revealed that the six tree (seedlings, saplings, poles and trees) species along altitudinal gradients showed a minor increase with increase in altitudinal gradients. The basal area generally increased with increase in altitudinal gradients which indicated minimal disturbances with increase in altitudinal gradients. The importance value index of the tree species generally decreased with increase in altitudinal gradients. Most of the species showed a steady decrease in trends along the altitudinal gradients. The diameter size class distribution of tree species was characterized by the absence of some diameter size classes at different altitudinal gradients. This suggests that recruitment has been hampered during the course of establishment of the current population structure of the six importance tree species. The spatial distribution patterns showed clumped, irregular and regular distribution patterns. We noticed at the lower and mid elevation levels the distribution patterns were mostly irregular. The present study showed that the regeneration of the Kilum-Ijim forest is generally poor.

Though the regeneration status of the forest is generally poor, it has been observed that there were few tree species which are either regenerating fairly (example; *N. congesta* and *P. mannii*) or no regeneration at all (*S. abyssinica*). The poor regeneration of these tree species warrants the immediate attention of forest managers and local forest dependent communities to look into reforestation and afforestation programs for these species.

6. Recommendation

This study recommends a regular patrol by the authorities concern to check illegal harvesting and punish defaulters. This study also recommends that there should be enrichment planting of these six important trees in the reserve and other parts of the community. This study also recommended the establishment of forest or community nursery and a seed bank for all the targeted tree species.

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