Ecological Insight

WOODY SPECIES STRUCTURE AND REGENERATION STATUS IN MEHAL WONZ - ZEGO FOREST, N/SHEWA ZONE, AMHARA REGIONAL STATE, ETHIOPIA.

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Contents

ABSTRACT

This study was conducted on Mehalwonze- Zego forest in North Shewa zone, Amhara Regional State, Ethiopia, A Transect sampling method was used to collect vegetation data. Sixty seven(67) plots of 20m × 20m were laid each at 300m intervals and five subplots of 2m × 2m, one in the center and four in the corner of the main plots, were laid for seedling and sapling inventory. Vegetation parameters such as DBH >2.5cm, H ≥2.5m of forest, as well as seedling and sapling density with five sub plots of 2m × 2m. A total of 55 woody species belonging to 51 genera and 38 families were identified. The density of seedlings, saplings and matured woody plants in all of the plots were 1302,1517 and 905 individuals, respectively. Importance Value Index (IVI) of each species were calculated, based on this value the conservation priority classes was done which indicated that there are woody species that require urgent conservation. The total basal area of the forest was 67.96 m2/ha. DBH and height class distribution of woody species confirms that the forest is under a secondary stage of development. Based on the results of regeneration assessment, conservation priority should be given for species with poor regeneration status.

Keywords: Conservation, Mehalwonz-Zego, Vegetation Structure, Regeneration, Species

Introduction

1.1. Background of the study

Ethiopia is the center of biological diversity because of its wide range of geographical scales various topographic factors with diverse climatic conditions have created diversified vegetation types in the country [21].The topography and diverse climatic conditions of Ethiopia led to the emergence of habitats that are suitable for evolution, occurrence of some unique plant and animal species and their assemblage [14]. Ethiopia is also a tropical country with typically hot and dry lowland areas; it has varied macro- and microclimatic conditions. The rainfall is variable in different parts, highest to the highest 2200 mm in the highlands (>1500 meters) and the lowest, 250 mm in the lowlands [15].

Ethiopia belongs to the 25 biodiversity-rich countries in the world (EBI, 2014). There are 34 biodiversity hotspots worldwide, of which Ethiopia shares two, namely, Eastern Afromontane and the Horn of Africa [26]. It has a very diverse set of ecosystems ranging from humid forests and extensive wetlands to the desert of the Afar depression. This is due to the variation in climate, topography, and vegetation [13]. There are more than 6027 species of higher plant, of which about 10% are endemic in Ethiopia making the country one of the most diverse floristic regions in the world [9]. The diverse climate of various ecological regions of Ethiopia is important for the establishment of diverse vegetation, which ranges from Afroalpine vegetation in the mountains to the arid and semi-arid vegetation type in the lowlands [4]. The formation of Ethiopian vegetation is highly connected to the climate and geological history of the country.

Biological diversity has been defined as the variability of living organisms from all sources that including inter alia, terrestrial, marine, and other aquatic ecosystems [24]. Since Biodiversity of different ecosystems of the globe is not evenly distributed, some regions of the world like that of the tropics are relatively richer in biodiversity compared to other places [22]. Ethiopia is known in the world with a high level of biodiversity. This is due to a country characterized by highly diversified physiographic, altitudinal, climatic, and edaphic factors with a wide range of habitats and vegetation types which are rich in endemic flora and fauna [20].

The Ethiopian forests and woodlands are reservoirs and gene pools for several domesticated and important wild plants and wild relatives [16]. Species richness varies across forests, depending on the environmental factors characterizing the forests. Forest serves as a source of food, household energy, construction and agricultural materials, tourism and recreation values, and medicine for both people and livestock [26]. They are also important habitats in terms of the biological diversity they contain and in terms of the ecological functions they serve [5]. Many woody forests are characterized by a seasonal climate, with a dry season of months. Studying on the species structure and regeneration status of woody forest is essential for its wise management in terms of economic value, regeneration potential and the conservation of biological diversity [22]. Woody vegetation's are the one having value for the physical structure of habitats and it is a key pattern of environmental heterogeneity and structural complexity in a given ecosystem [1].

There are threats to the biodiversity of Ethiopia. Tropical forests and woodlands are being lost at an alarming rate due to increasing human populations and corresponding land use changes. Ethiopia had experienced substantial deforestation, soil degradation and an increase in the area of bare land over the years [10]. The need for fuel wood, arable land and grazing areas have been indicated as the main causes of forest degradation; frequently leading to loss of forest cover and biodiversity, erosion, desertification and reduced water resources [10]. Deforestation is the purposeful clearing of forested land and it is a contributor to global climate change, and is often cited as one of the major causes of the enhanced greenhouse effect [23].

Understanding the diversity, distribution and extent of use of plants in a country is a basis for designing and implementing a main resource management and utilization system in a sustainable manner [11]. Detailed study on vegetation ecology is very essential because it serves as baseline data useful for the management and sustainable utilization of the forest resource in the area [7].

Method

2.1. Description of Study Site

Ankober (Amharic: አንኮበር) is one of the districts in the Amhara Region of Ethiopia. Towns in Ankober include Aliyu Amba, Ankober, Gorgo and Haramba. Ankober District, located in north Shewa Zone of Amhara National Regional State in north-central Ethiopia (Figure 1). The District is perched on the eastern escarpment of the Ethiopian highlands and situated 172 km north of Addis Ababa, the Ethiopian capital, and 42 km to the east of Debre Berhan town (the north Shewa Zone capital) at 9° 22' - 9° 45' N and 039° 40' - 039° 53' E. Ankober District is bordered in the north by Tarmaber, south by Asagirt ,and west by Basonaworana District, of Amhara Region. The Eastern part shares its border with Gachine Special District, of the Afar Region. The elevation of study area ranges from Zego area 2074 m.a.s.l. to Eme- Mihret Mountain 2988 m.a.s.l. [11]. The main administrative center of the district is located at Gorabela/Ankober town that has historical significance as it has been the seat of the Ethiopian emperors from 1270 for centuries.

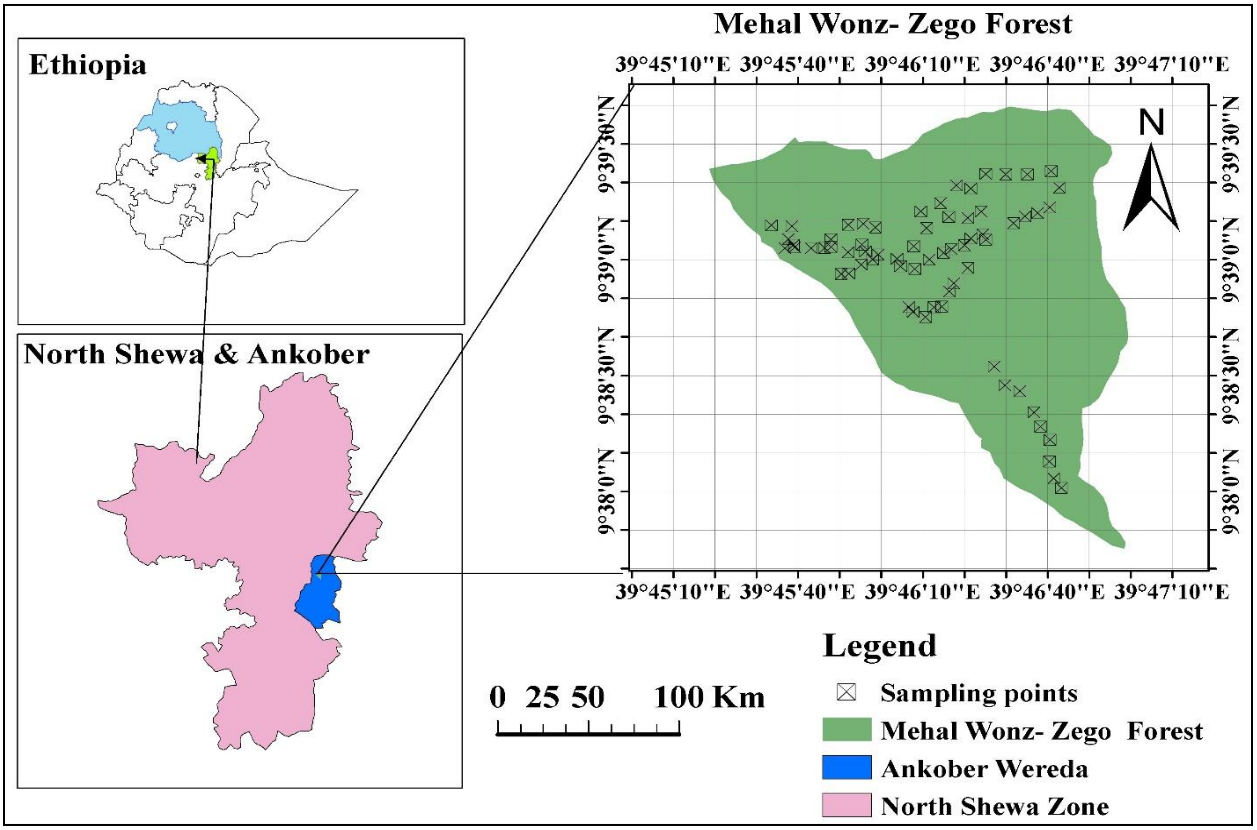

Figure 1: Map of the study area

2.1.1. Demographic

Based on the 2007 national census conducted by the Central Statistical Agency of Ethiopia, this district has a total population of 76,510, an increase of 14.09% over the 1994 census, of whom 38,790 are men and 37,720 women; 4,403 or 5.75% are urban inhabitants. With an area of 672.80 square kilometers, Ankober has a population density of 113.72, which is less than the Zone average of 115.3 persons per square kilometer. A total of 18,274 households were counted in this district resulting in an average of 4.19 persons, per household and 17,633 housing units. The majority of the inhabitants practiced Ethiopian Orthodox Christianity, with 92.73% reporting that as their religion, while 7.15% of the population said they were Muslim.

The two largest ethnic groups reported in Ankober are Amhara (92.77%), and the Argobba (7.04%). all other ethnic groups made up 0.19% of the population. Amharic was spoken as a first language by 98.94%, and Argobba was spoken by 0.9%; the remaining 0.16% spoke all other primary languages reported.

2.1.2. Climate

Meteorological data obtained from National Meteorology Service Agency (NMSA, 2022) indicates that the study area has a bimodal rainfall with a long rainy period occurring between June to September and a low rainy period from December to February as shown in (Figure 2). The mean annual rainfall of

Ankober District within eleven years (2009-2020) was 1530 mm. The highest mean annual rainfall was recorded in August while the lowest was in March. The mean annual temperature of the study area was 16.5 °C. The mean annual temperature ranges from the mean minimum 6 °C to the mean maximum 27.1 °C.

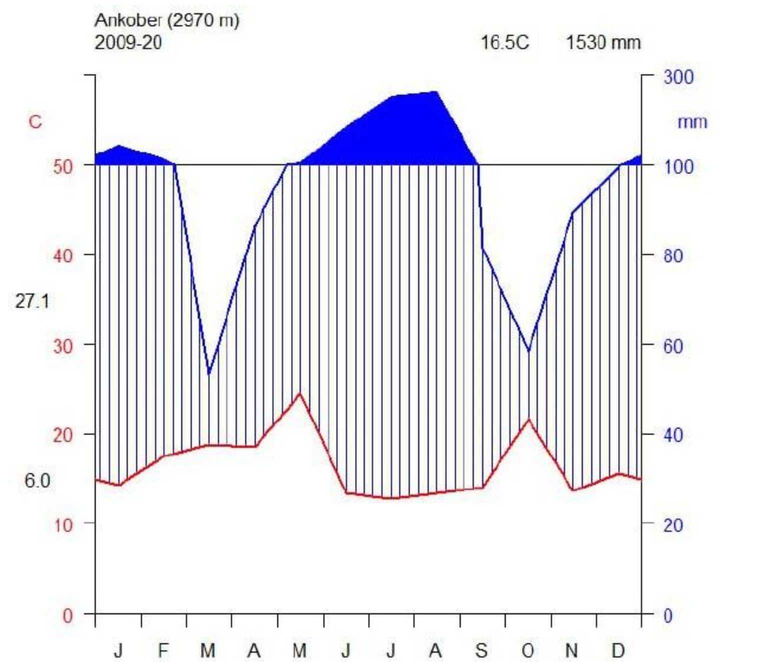

Figure 2: Climate diagram showing rainfall distribution and temperature variation from 2009-2020 at the study sites. Source: Data obtained from National Meteorological Service Agency (2022).

2.2. Materials used

A caliper and a calibrated stick were used to measure DBH and height of the tree, respectively, whereas meter was used to make transect lines as well as quadrants (plots). Environmental variables such as altitude, slope, and aspect were collected using GPS, clinometer, and compass, respectively as well as grazing and disturbance data were collected visually**.**

2.3. Reconnaissance Survey and sampling site selection

The reconnaissance survey of the study area was made for two weeks in October 2021. This survey was used to make familiarize me with the study area, to assess the general view of the forest, and to make contact with the community around the forest to get information about the condition that is difficult in the study area. Additionally, this survey was used to prepare ourselves and the material which is necessary for data collection and to select sampling sites. Sampling site was with varied topography and diversified species which inspires me to do in this district, security of the area was also the other reason to select this site.

2.4. Sampling Design

A transect sampling method was used to take samples. Sample plots were laid along line transects that established a long altitudinal gradient. Sampling plots of 20m x 20m were used systematically at every 100m intervals for the tree/shrub inventory and five 2m x 2m subplots at each corner of the plot and one at the center of the plot were used for seedling and sapling inventory [17]. Sample plots were laid along 5 transects that were apart 300m from each other. A total of about 67 sample plots were established to collect samples of woody plant species and for documentation of trees, seedlings, and saplings of the study site.

2.4.1. Structural data collection

Detailed woody vegetation data was collected in each plot. The circumference at breast height, 1.3m, of all trees and shrubs with DBH ≥ 2.5 cm was measured, and later it was changed into diameter and the heights of all trees and shrub species ≥ 2,5c.m were measured using calibrated stick and then the other part of tree heights was visually estimated and recorded. Later on, it was grouped into height classes. For this study “seedlings”, “saplings” and “mature trees/shrubs” were defined as plants with heights less than 1 m, 1-2.5 m, and greater than 2.5 m, respectively as well as DBH less than 2.5c.m for seedlings and saplings) [19]. At the time of data collection, the number of seedlings and saplings was counted by using five 2m x 2m subplots at the four corners of the major plot and one at the center of it.

Environmental data collection variables such as altitude, slope, and aspect were collected in each sampling plot using GPS, clinometer, and compass, respectively, The values for aspect were codified (N = 0, NE = 1, E = 2, SE = 3, S = 4, SW = 3.25, W = 2.5, NW = 1.25) [25]. A disturbance was determined on the basis a five point scales of disturbance scores on visible signs of tree cutting and grazing. The points of scale 0 = (No disturbance), 1= (1-20% of the quadrat disturbed), 2= (21-40%), 3= (41-60%), 4= (61- 80%), 5 = (81- 100% of the quadrat disturbed).

Diameter at Breast Height (DBH): DBH measurement was taken at about 1.3 m from the ground using a diameter tape. Trees and shrubs with DBH ≥ 2,5c.m were measured and recorded for diameter at breast height (DBH). Trees/shrubs with multiple stems or forks below 1.3 m in height are treated as a single individual [3]. For trees and shrubs that are branched around breast height, the circumference was measured separately and averaged. The diameter class frequency distributions of selected tree species in the area were classified into ten classes

Height: it is one of the parameters that are measured straightforwardly. Like that of the DBH distribution of plants, the height distribution of plants was also classified into different classes. The height class frequency distribution of trees and shrubs in the area was also classified into different height classes [26].

2.5. Data Analysis

2.5.1. Structural Data Analysis

Population structure refers to the spreading of individual species in random diameter-height size classes to provide the overall regeneration profile of woody and shrub species. The structural pattern of the population was understood as an indication of variation in population dynamics that may occur because of natural factors or due to human and livestock interventions. In this study, an analysis of population structure in both forests was carried out using individual tree species in different heights and diameters at breast height (DBH) classes [12].

All individuals of woody plant species recorded in all 67 quadrats were used in the analysis of vegetation structure. The Diameter at Breast Height (DBH), basal area, tree density, height, frequency, and importance value index were used for the description of vegetation structure. The diameter at Breast Height (DBH) was calculated from circumference (C) = πd where d is the diameter at breast height. The number of “seedlings”, “saplings” and “mature trees/ shrubs” was used to analyze the regeneration status of the forest [12].

The vegetation data were organized and the analysis was carried out in the Microsoft Excel spreadsheet program and presented in descriptive statistics. The structure of the vegetation was described using a frequency distribution of height, DBH, and Importance Value Index (IVI).

Diameter at Breast Height (DBH): The DBH distribution of the studied forests was classified into ten classes. Those classes are (2.5-10,10.1-20,20.1-30,30.1-40,40.1-50,50.1-70,70.1-90,90.1-110,110.1-130 and above 130.1 c.m)

Height: The Tree height was also classified into nine classes (2.5 m- 5 m,5.1 -10 m, 10.1-15 m, 15.1-20 m, 20.1-25 m, 25.1-30 m,30.1-35m,35.1-40 m, >40.1m).

Importance value index (IVI): Tree or shrub density and basal area value were calculated on a per-hectare basis. For all species, IVIs was calculated as the sum of their relative density (RD), relative frequency (RF), and relative dominance (RDO) [8].

Analysis of importance value index (IVI) is used for setting conservation priority. Those species with lower IVI values need high conservation efforts while those with higher IVI values need monitoring management. The importance value index (IVI) of the most dominant species of the forests was calculated.

Where: RD is Relative Density, RF is Relative Frequency, and RDO is Relative Dominance.

$$RD = \frac{the\ total\ n\underline{o}\ of\ all\ indvidual\ of\ aspecies}{the\ total\ n\underline{o}\ of\ all\ indvidual} \times 100$$

$$RDO = \frac{the\ basal\ area\ of\ a\ species}{total\ basal\ area} \times 100$$

Basal area is the area outline of a plant near the ground surface. It is expressed in square m/hectare [8]. Basal area is also used to calculate the dominance of species. BA = $\pi d^2/4$ where (π = 3.14; d = diameter at breast height).

Frequency (F) and density (D) was calculated as follows

Frequency is defined as the probability or chance of finding a species in a given sample area or quadrat. It is dependent on quadrat size, plant size and patterning in the vegetation (Kent and Coker, 1992). It is calculated with this formula:

$$F(\%) = \frac{n\underline{o}\ of\ quadrats\ in\ which\ a\ species\ occurs}{total\ no\ of\ quadrats\ examined} \times 100$$

Based on the percentage frequency values, the tree/shrub species were classified into five frequency classes: A = 0-20, B = 21-40, C = 41-60, D = 61-80, and E = 81 – 100..

The frequencies of the tree species in all 67 quadrats were computed. The higher the frequency, the more important the plant is in the community. Although a high frequency value means that the plant is widely distributed through the study area, the same is not necessarily true for a high abundance value. This abundance is not always an indicator of the importance of a plant in a community. A better idea of the importance of a species on frequency can be obtained by comparing the frequency of occurrences of tree species present. The result is called the relative frequency and is given by the formula:

$$\text{RF} = \frac{the\ n\underline{o}\ of\ plots\ where\ a\ species\ occurs}{the\ total\ occurences\ of\ all\ species\ in\ all\ plots} \times 100$$

Density is a count of the number of individuals of a species within the quadrat (Kent and Coker, 1992). It is closely related to abundance but more useful in estimating the importance of a species. Counting is usually done in quadrats placed several times in the vegetation communities under study. Afterwards, the sum of individuals per species is calculated in terms of species density per convenient area unit such as a hectare [8].

$$\text{D} = \frac{total\ n\underline{o}\ of\ individuals\ a\ species\ found}{total\ area\ examined}$$

Vertical Stratification: it is formed because trees and shrubs in a forest will have different heights. So, two or more layers of tree crowns can be found in forests. These layers are called forest stores or strata. The top-most stratum is made of emergent trees; below them are the canopy trees, which are usually present as a continuous layer. The tree strata below them are called the sub-canopy and the understory. Next, close to the ground could be shrubs, herbs, and grasses [18].

Vertical stratification of trees in the Forest was examined using the following IUFRO classification scheme [18]. Where three simplified vertical structures are distinguished: the upper (individuals > 2/3 top height), middle (individuals between 1/3 and 2/3 top height), and lower (individuals < 1/ 3 top height) stories.

2.5.2. Regeneration Analysis

Regeneration status of woody species was analyzed by comparing the number of seedlings and saplings with that of matured trees. The regeneration pattern of woody species was assessed by employing a total count of seedlings (woody species of height ≤ 1.3 cm and DBH ≤ 2.5 cm) and saplings (woody species of height > 1.3 and DBH ≥ 2.5 cm) within the main quadrates [19].

Regeneration status can be represented with the distribution patterns of one of the following [12]. If the regeneration results of woody species show seedlings > sapling > adults, it indicates that the forest (study site) has "good regeneration" if seedlings > or ≤ saplings ≤ adults shows the forest has, "fair regeneration", and If the woody species survive only in the sapling stages, "poor regeneration". If a woody species is present only in the adult stage, it is considered as not regenerating ("not regenerated").

Result

3.1. Woody Species Composition

A total of 55 woody species belonging to 51 genera and 38 families were recorded from both forests. The collected species were composed of 59% (33 in number) trees 39% (21 in number) shrubs and 2% (1 in number) woody climbers, respectively (Figure 3). Asteraceae was the most dominant family with 3 (5.66%) genera and 5 (10.91%) species, Euphorbiaceae and Apocynaceae are the second each with 3 (5.66%) genera and 3 (5.45%) species followed by Rosaceae 3 (5.66%) genera and 2(3.64%) species, Oleaceae 2 (3.77 %) genera 4 (7.27%) species, Myrsinaceae 2 (3.77%) genera 3 (5.45%) species, and Cupresaceae 2 (3.77%) genera and 2 (3.64%) species ranked fourth whereas the other 33 families each with 1 (1.96) genera and 1(1.82) species ranked fifth (Appendix 2).

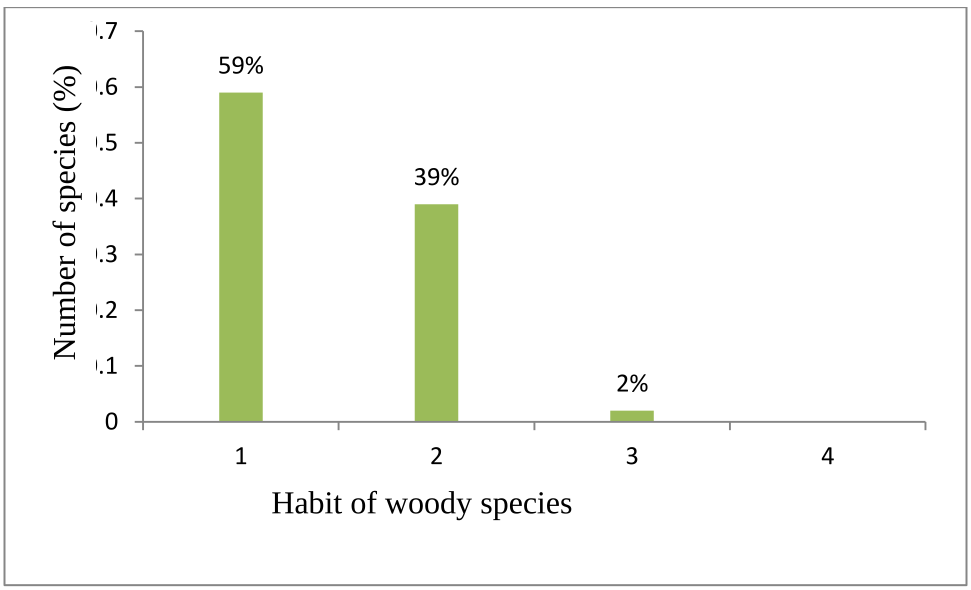

Figure 3: Percentage of woody species composition in the study sites.

3.2. Vegetation Structure

3.2.1. Density of Woody Species.

A total of 1389.55 individuals/ha were recorded with DBH ≥ 2.5 cm in Mehalwonze-Zego forest between the altitudinal ranges of 1300m and 3700m a.s.l. Of these, *Podocarpus falcatus* was the dominant species in the study area covering 29.5% (267 stems). *Maesa lanceolata* is the second dominant species with 22.9% (207 stems). *Bersama abyssinica*, *Discopodium penninervium* and Olea europeae subsp. *cuspidata* covered (86 stems) 9.5%, (75 stems) 8.3%, and (37 stems) 4.1%, respectively.

Acokanthera schimperi, Cupressus lusitanica, Hagenia abyssinica, Ilex mitis, Myrsine melanophloeos, Polyscias fulva, Premna schimperii, Prunus africana, Vernonia auriculifera and Vernonia rueppellii were the least dominant species with equal coverage of 0.11% (1 stem) in the study forests. W**here**as *Salix subserrata, Osyris quadripartita* and *Nuxia congesta* each covering 0.22% (2 stems), *Olea welwitschii* 0.3% (3 stems), and *Hypericum revolutum, Myrica salicifolia* 0.4% (4 stems).

Trees and shrub densities with DBH > 10 cm (a) to DBH > 20 cm (b) were computed and the (a/b)ratio of the present study was compared with 7 other dry Afromontan forests in Ethiopia (Table 1) and the a/b value of the present study is lower than the other compared forests this is due to Altitudinal differences and environmental factors that appeared in the forest.

Table 1: Comparisons of tree densities with DBH 10–20 cm (a) and DBH > 20 cm (b): with other dry Afromontan forests in Ethiopia.

Forest	DBH > 10 cm (a)	DBH > 20 cm (b)	Ratio (a/b)	*Sources*
Weieramba forest	1343	113	11.94	*Zelalem Teshager et al.(2018)*
Majang forest	617.5	450.3	1.37	*Semegnew Tadese et al.(2021)*
Menagesha Amba Mariam	155.5	197	0.8	*Abiyou Tilahun (2009)*
Dodola	521	351	1.5	*Kitessa Hundera (2008)*
Wof-Washa	329	215	1.5	*Abiyou Tilahun (2018)*
Angada	372.8	252	1.47	*Shambel Alemu (2011)*
Menagesha Suba	482	208	2.3	*Dinkissa Beche Benti (2011)*
Mehalwonz-Zego forest	191	524	0.36	*Present study site*

Table 2: Density of tree species by DBH classes in the study site.

DBH (cm)	No. of individuals(ha-)	Percentage (%)	Ratio a/b
2.5-10	190	20.99	0.36
10.1-20 (a)	191	21.10	
>20 (b)	525	58.01	
Total		100.00	

3.2.2. DBH class distribution

DBH distribution of trees and shrub species in the study site is classified into ten DBH classes. As indicated in figure 4 below, a relatively larger number of individuals are found in the first and second DBH classes. As the DBH class increases the number of individuals gradually decreases towards the higher DBH classes. This indicates that the majority of the lower DBH class has the highest number of individuals which shows that the forest's vegetation has good reproduction and recruitment potential.

Accordingly, the cumulative density of trees in lower and intermediate DBH classes is higher when compared to the cumulative density of the higher ones. The mean maximum DBH value in the study area was recorded for *Podocarpus falcatus* with an average DBH value of 223 cm followed by *Ficus sur* and *Juniperus procera* with an average DBH value of 175 cm and 146.5 cm, respectively.

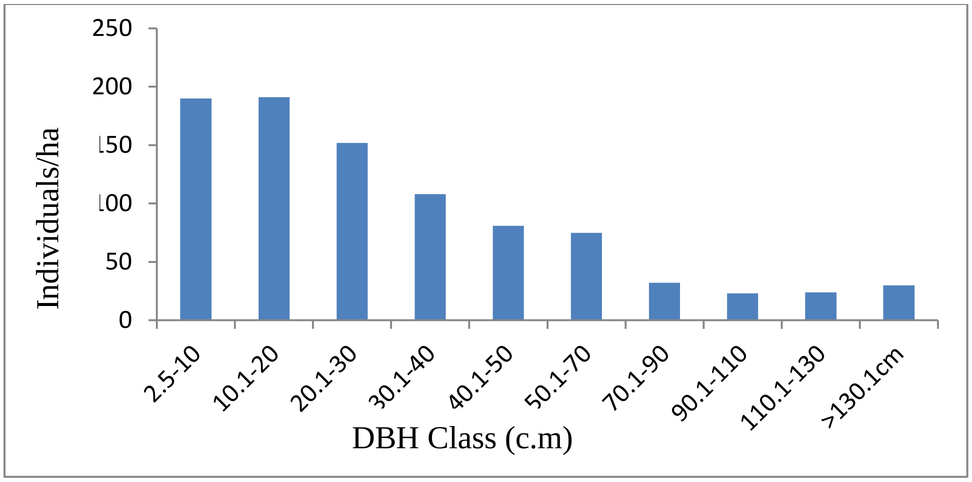

Figure 4: DBH class distribution of all trees recorded in the study area.

3.2.3. Height class distribution

Height distribution of plants was classified into nine classes (2.5-5 m), (5.1-10 m), (10.1-15m), (15.1-20 m), (20.1-25m), (25.1-30m),(30.1-35), (35.1-40) and (>40.1 m). The number of individuals in the lower classes is higher than that of the middle and higher classes. From those of the nine classes' height class II has the highest number of individuals as shown in figure 5.

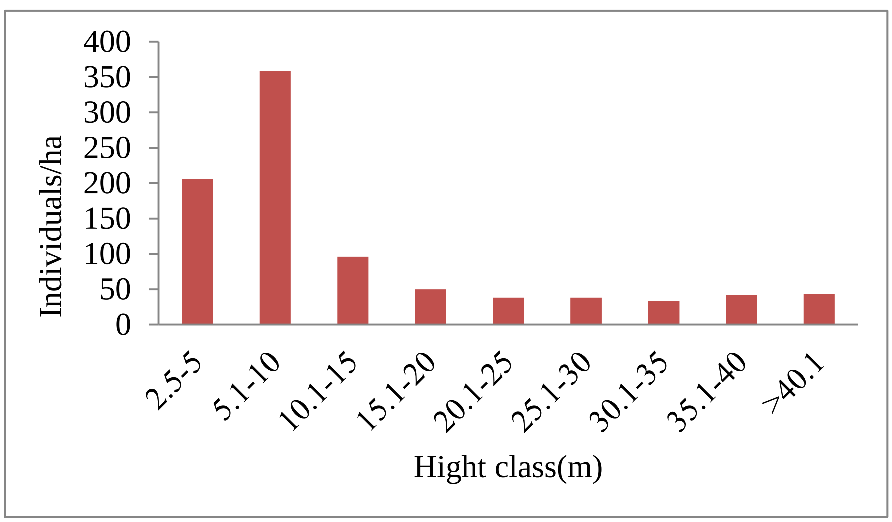

Figure 5 Height class distribution recorded in the study area**.**

3.2.4. Vertical stratification

The number of individuals in the lower story (2.5-15.2) is higher than that of the middle (15.3-30.5) and the upper story (> 30.6). Almost all woody individuals were found in the lower story as shown in figure 6 (73.37%). The lower and middle story contains about 818 woody individuals (90.3%) while the upper story occupied 87 individuals (9.61%). Of which 31 individuals (3.42%) are covered by the species *Podocarpus falcatus (Thunb.) R. B. ex. Mirb* with the highest coverage in the upper story followed by *Olea europeae L.* subsp. *cuspidata (Wall. ex G.Don)* 22 (2.43%) individuals, *Rhus natalensis* Krauss with 7 (0.77%) individuals, *Olea capensis L. subsp. macrocarpa (C.H. Wright) Verdc* with 6 (0.66%) individuals, *Ficus sur* Forssk, *Myrica salicifolia A.Rich and Maesa lanceolata Forssk each with 5 (0.55%)individuals, Juniperus procera Hocket.ex Endl and Celtis africana Burm. f. each with 3 (0.33%)* individuals constitutes the upper story in present study sites. The tallest tree was an individual of *Podocarpus falcatus* (Thunb.) R.B. ex. Mirb and *Olea europeae* L.sub sp. cuspidat a (Wall.exG.Don) each with H = 46m.

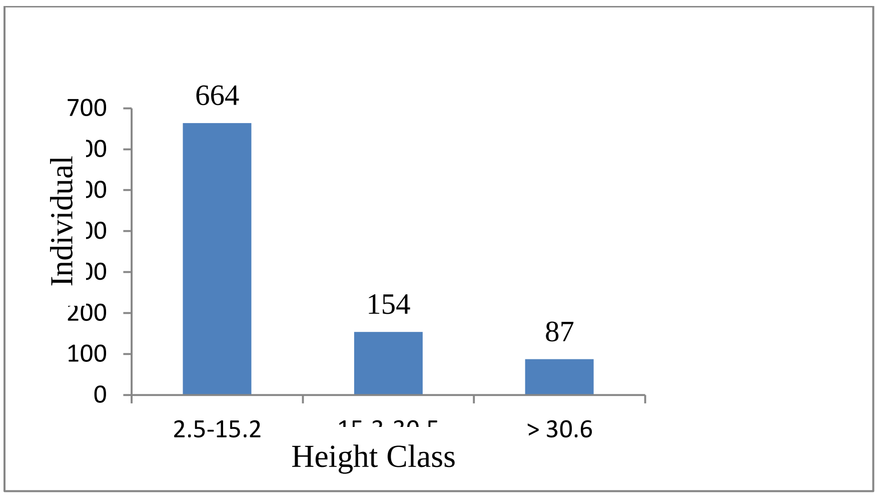

Figure 6: Density of tree and shrub in the lower, middle, and upper story of the study area**.**

3.2.5. Frequency

Based on the percentage frequency values, the tree/shrub species were classified into five frequency classes: A = 0-20, B = 21-40, C = 41-60, D = 61-80, and E = 81 – 100. The frequency and % frequency values of species are given in Figure 7. Accordingly, the frequency distribution of species showed that *Podocarpus falcatus* (Thunb.) R. B. ex. Mirb (83.58%) and *Maesa lanceolata* Forssk (74.63%) were the two most frequently observed tree species (in 56 and 50 quadrats out of 67 quadrants, respectively).

Bersama abyssinica, Discopodium penninervium, Olea europeae subsp.cuspidata, Rhus natalensis and *Olea capensis* subsp. *macrocarpa* were 56.7%, 34.3%, 34.3, 34.3 and 22.4% distribution, respectively. The other species with the least occurrence in the study site are *Acokanthera schimperi, Cupressus lusitanica, Hagenia abyssinica, Ilex mitis, Myrsine melanophloeos, Polyscias fulva, Premna schimperii* and *Prunus africana.*

The distributions of trees and shrubs are classified into five frequency classes. As shown in figure 7 there are a large number of species in lower frequency classes than that in the middle and higher frequency classes, indicating the heterogeneity of the forests.

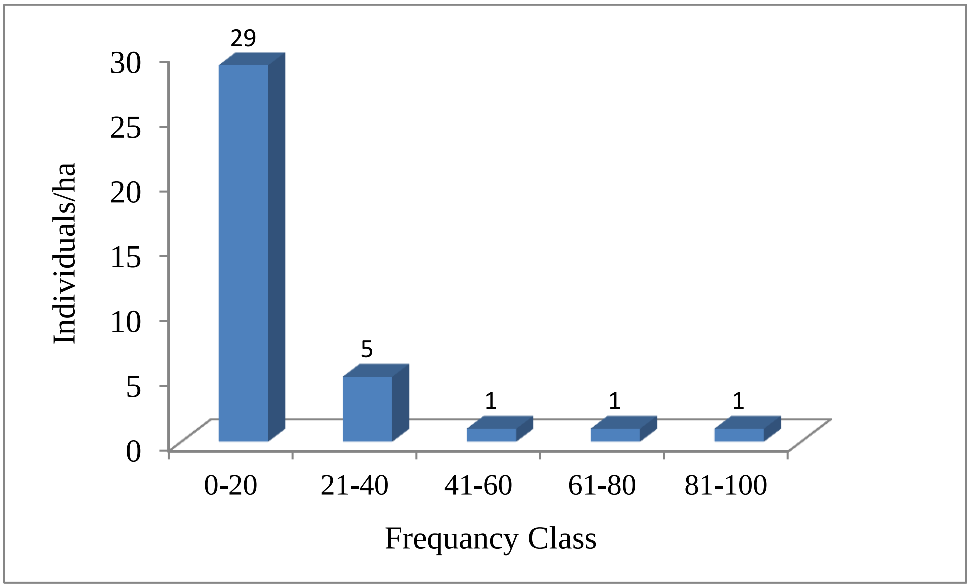

Figure 7: Frequency class distribution of trees and shrubs in the study area**.**

3.2.6. Basal Area

The total basal area of the studied forests was 67.96 m^2 ha^{-1}. *Podocarpus falcatus* (Thunb.) R. B. ex. Mirb, *Maesa lanceolata* Forssk, *Bersama abyssinica* Fresen, *Olea europeae* L. subsp. *cuspidata* (Wall.exG.Don and *Discopodium penninervium Hochst.* covers the largest portion of the total BA in the studied forests. *Podocarpus falcatus* (Thunb.) R. B. ex. Mirb has the biggest share of the total basal area (31.73m2/ha) from the other four species. The total basal area calculated for the study area was about 67.96 m2/ha for woody plants ≥ 2.5 cm in DBH. As indicated in Table 3. *Podocarpus falcatus (Thunb.) R. B. ex. Mirb* has the biggest share of the total BA 31.73 m2/ha (46.69%).

Those of the four species *Maesa lanceolata* Forssk (9.90m2/ha (14.57%), *Bersama abyssinica* Fresen (5.52m2/ha(8.12%), *Olea europeae* L. subsp. *cuspidata* (Wall.exG.Don (4.19m2/ha(6.17%) and *Discopodium penninervium* Hochst 3.73m2/ha (5.49%) together covered 23.34m2/ha (34.34%) of the total BA. 55.07m2/ha (81.03%) of the total basal area was shared by these five species as shown in Table 3. The normal basal area value for tropical forest in Africa is 23–37 m2 /ha (Zelalem Teshager *et al.*, 2018). Thus, the basal area of the study area (67.96 m2 /ha) is within a high range.

Table 3: Basal area, density and their percent contribution of selected five tree species in the study Sites.

Tree Species	BA (m2 /ha)	% BA	Density	% Density
Podocarpus falcatus (Thunb.) R. B. ex. Mirb	**31.73**	**57.62**	**267**	**39.73**
Maesa lanceolata Forssk	**9.90**	**17.98**	**207**	**30.8**
Bersama abyssinica Fresen.	**5.52**	**10.02**	**86**	**12.8**
Olea europea L.subsp.cuspidata(Wall.exG.Don)	**4.19**	**7.61**	**37**	**5.51**
Discopodium penninervium Hochst.	**3.73**	**6.77**	**75**	**11.16**

3.2.7. Importance Value Index

The Importance Value Index (IVI) of 55 species was also calculated. Accordingly, species that had higher IVI values were *Podocarpus falcatus* (Thunb.) R. B. ex. Mirb, *Maesa lanceolata* Forssk, and *Bersama abyssinica* Fresen constitute 58.30% of the total 300 IVI values in the studied Forests. Whereas species having low IVI values were *Cupressus lusitanica* Miller, *Ilex mitis* (L.) Radlk, *Premna schimperii* Engl, *Polyscias fulva* (Hiem) Harms, *Acokanthera schimperi* (A. DC.) Schweinf etc. constitute 41.70%. The Importance Value Index (IVI) of the study area was calculated and based on the result *Podocarpus* *falcatus* (Thunb.) R. B. ex. Mirb is the highest one occupying (31%) followed by *Maesa lanceolata* (17.56%), *Bersama abyssinica* (9.74%), *Discopodium penninervium* (6.93%), and *Olea europeae* L. subsp. *cuspidat*a (Wall.exG.Don) (5.76%) respectively.

Table 4: The importance value index (IVI) and priority class for conservation of tree species in study sites (D = Density, F= Frequency, RD = Relative density, RDO = Relative Dominance, RF = Relative frequency**).**

Species Name	**Individuals no**	**BA(m2/ ha)**	**RD**	**RDO**	**RF**	**IVI**	**%IVI**	**Priority**
Acokanthera schimperi (A. DC.) Schweinf.	1	0.06	0.11	0.08	0.30	0.50	0.17	1
Allophylus abyssinicus (Hochst.)	5	0.19	0.55	0.28	0.91	1.74	0.58	1
Bersama abyssinica Fresen.	86	5.52	9.50	8.12	11.59	29.21	9.74	4
Calpurnia aurea (Ait.) Benth	10	0.05	1.10	0.07	1.22	2.39	0.80	1
Celtis africana Burm. f.	5	0.16	0.55	0.23	0.91	1.70	0.57	1
Croton macrostachyus Del.	11	0.06	1.22	0.09	2.13	3.44	1.15	2
Cupressus lusitanica Miller	1	0.00	0.11	0.00	0.30	0.42	0.14	1
Discopodium penninervium Hochst.	75	3.73	8.29	5.49	7.01	20.79	6.93	4
Dovyalis abyssinica (A. Rich.)	5	0.29	0.55	0.43	1.52	2.51	0.84	1
Dracaena steudneri Engl	8	0.30	0.88	0.44	2.13	3.46	1.15	2
Ekebergia capensis Spamn.	8	0.63	0.88	0.93	1.83	3.64	1.21	2
Ficus sur Forssk.	13	0.12	1.44	0.17	1.22	2.83	0.94	1
Hagenia abyssinica (Broce) I.F	1	0.04	0.11	0.05	0.30	0.47	0.16	1
Halleria lucida L.	9	0.03	0.99	0.04	2.13	3.17	1.06	2
Hypericum revolutum Vahl	4	0.01	0.44	0.01	0.91	1.37	0.46	1
Ilex mitis (L.) Radlk.	1	0.00	0.11	0.00	0.30	0.42	0.14	1
Juniperus procera Hocket.ex Endl	11	0.66	1.22	0.97	1.52	3.71	1.24	2
Maesa lanceolata Forssk	207	9.90	22.87	14.56	15.24	52.68	17.57	4

Maytenus obscura (A. Ric.).	35	2.74	3.87	4.03	4.88	12.77	4.26	3
Myrica salicifolia.A.Rich.	4	0.07	0.44	0.11	0.91	1.46	0.49	1
Myrsine melanophloeos (L.) R.Br.	1	0.01	0.11	0.01	0.30	0.43	0.14	1
Nuxia congesta KBr. ex Fresen	2	0.04	0.22	0.07	0.61	0.90	0.30	1
Olea capensis L. subsp. macrocarpa (C.H. Wright)	28	2.40	3.09	3.54	4.57	11.21	3.74	3
Olea europeae L.subsp.cuspidata(Wall.exG. Don	37	4.19	4.09	6.17	7.01	17.27	5.76	3
Olea welwitschii (Knobl.) Gilg & Schellenb.	3	0.15	0.33	0.22	0.91	1.46	0.49	1
Olinia rochetiana A. Juss	7	0.53	0.77	0.78	1.52	3.08	1.03	2
Osyris quadripartita Dec.	2	0.13	0.22	0.19	0.30	0.72	0.24	1
Podocarpus falcatus (Thunb.) R. B. ex. Mirb	267	31.73	29.50	46.70	17.07	93.27	31.10	4
Polyscias fulva (Hiem) Harms	1	0.01	0.11	0.02	0.30	0.44	0.15	1
Premna schimperii Engl.	1	0.01	0.11	0.01	0.30	0.43	0.14	1
Prunus africana (Hook. f.) kalkm.	1	0.04	0.11	0.05	0.30	0.47	0.16	1
Psydrax schimperiana subsp. Schimperiana	9	0.23	0.99	0.34	0.61	1.94	0.65	1
Rhus natalensis Krauss.	31	2.93	3.43	4.31	7.01	14.75	4.92	3
Salix subserrata Willd.	2	0.11	0.22	0.16	0.61	0.99	0.33	1
Trichocladus ellipticus Eckl. & Zeyh.	11	0.78	1.22	1.15	0.91	3.28	1.10	2
Vernonia auriculifera Hiern.	1	0.04	0.11	0.06	0.30	0.48	0.16	1
Vernonia rueppellii Sch. Bip. ex Walp.	1	0.04	0.11	0.05	0.30	0.47	0.16	1
Total	905	100	100	100	100	300	100	

3.2.8. Conservation Priority

Priority class based on Importance Value Index (IVI) values for the conservation of woody species in the study site was computed. Accordingly, species which has lower IVI values need higher prioritization (needs urgent conservation) and are grouped under priority class 1 as shown in table 5.

Table 5: Species conservation priority classes in the present study.

Priority class 1	**Priority class 2**	**Priority class 3**
Acokanthera schimperi (A. DC.) Schweinf.	*Croton macrostachyus Del.*	*Maytenus obscura (A. Ric.).*
Allophylus abyssinicus (Hochst.)	*Dracaena steudneri Engl*	*Olea capensis L. subsp. macrocarpa (C.H. Wright*
Calpurnia aurea (Ait.) Benth	*Ekebergia capensis Spamn*	*Olea europeae L.subsp.cuspidata(Wall.exG.Don*
Celtis africana Burm. f.	*Halleria lucida L.*	*Rhus natalensis Krauss.*
Cupressus lusitanica Miller	*Juniperus procera Hocket.ex Endl*	
Dovyalis abyssinica (A. Rich.)	*Olinia rochetiana A. Juss*	
Ficus sur Forssk	*Trichocladus ellipticus Eckl. & Zeyh.*	
Hagenia abyssinica (Broce) I.F		
Hypericum revolutum Vahl		
Ilex mitis (L.) Radlk. Etc.		

3.2.9. Population Structure of Selected Tree Species

The analysis of the population structure of Mehalwonz-Zego forest individual tree species in ten diameters at breast height (DBH) classes dominantly showed eight patterns of population structure.

(1) The first pattern was formed by the species having high number of individuals in the tenth class Individual species are concentrated only in the last diameter at breast height (DBH) class (>90 cm) and relatively few individuals in fourth, fifth, seventh, eighth and ninth class (Fig. 8a). Species like *Olea welwitschii* (Knobl.) Gilg & Schellenb, *Myrsine melanophloess*(L. R. Br.) and *Myrsine africana* L. had this structure.

(2) The second pattern contains a high number of individuals in the first and second DBH classes, medium in the third class, then decreases with increasing DBH towards the higher classes (Fig. 8b), the

distribution showed an Inverted J-shaped structure in which the highest proportion of individuals was present in lower diameter at breast height classes. These species contain good regeneration status but less recruitment. *Discopodium penninervium Hochst*. had inverted J-curve structure.

(3) The third pattern contains a high number of individuals in the first and second class then decrease with increasing DBH towards the ninth class and gradually increasing in the tenth class (Fig. 8c) in this pattern there were species like *Halleria lucida* L., *Hypericum revolutum* Vahl and *Juniperus procera* Hocket.ex Endl.

(4) The species in the fourth pattern contains a high number of individuals in the tenth class which is followed by the fifth, fourth and eighth classes respectively, and contains a low number of individuals in other remaining classes when we compare them with this four class (fig. 8d).Example: *Calpurnia aurea* (Ait.) Benth

(5) The fifth pattern shows down and up (increase to some extent with increasing DBH class then decrease in the next class and continue like this covering the whole DBH classes). There may be selective cutting of the trees in the different DBH classes for domestic use (Fig. 8e). *Dovyalis abyssinica* (A. Rich.) shows this type of pattern.

(6) The distribution showed an Inverted J-shaped structure in which the highest proportions of individuals were present in lower diameter classes. This pattern shows a high number of individuals in the first class then a decrease with increasing DBH towards the fourth class and there were no individuals in the higher DBH classes this can be due to the nature of the species (they do not grow to higher DBH class and some of them due to removal of the plant for different activities at this stage (in higher DBH class) (Fig. 8f).Species like *Vernonia amygdalina* Del.

(7) The distribution showed a J-shaped structure in which a higher proportion of individuals were present in higher diameter classes and the trend decreased towards the lower diameter classes (Fig. 8g), and there were no individuals from the first up to the seventh DBH class; this may be due to low regeneration status of the species and removal of the young individuals of the species for construction materials and other uses. It has some representative individuals in higher DBH classes that are class eight up to ten which increase towards the higher DBH class. *Dodonaea angustifolia* L.f and *Jasminum abyssinicum* Hochst. ex DC.were the best example for this pattern.

(8) Irregular distribution over diameter classes. Some of the diameter classes had a small number of individuals while other diameter classes had a large number of individuals and even some of them were

missed (Fig.8h), there were no individuals in the first class (this can be due to removal of the plant at this stage by humans or livestock's), third, sixth and eighth classes were also do not have individuals this can be due to selective cutting of plants at this stage for a different purpose. Individual species are concentrated only in the second; fourth, fifth, and tenth DBH classes, DBH class ten contains a higher number of individuals than those of the four DBH classes.

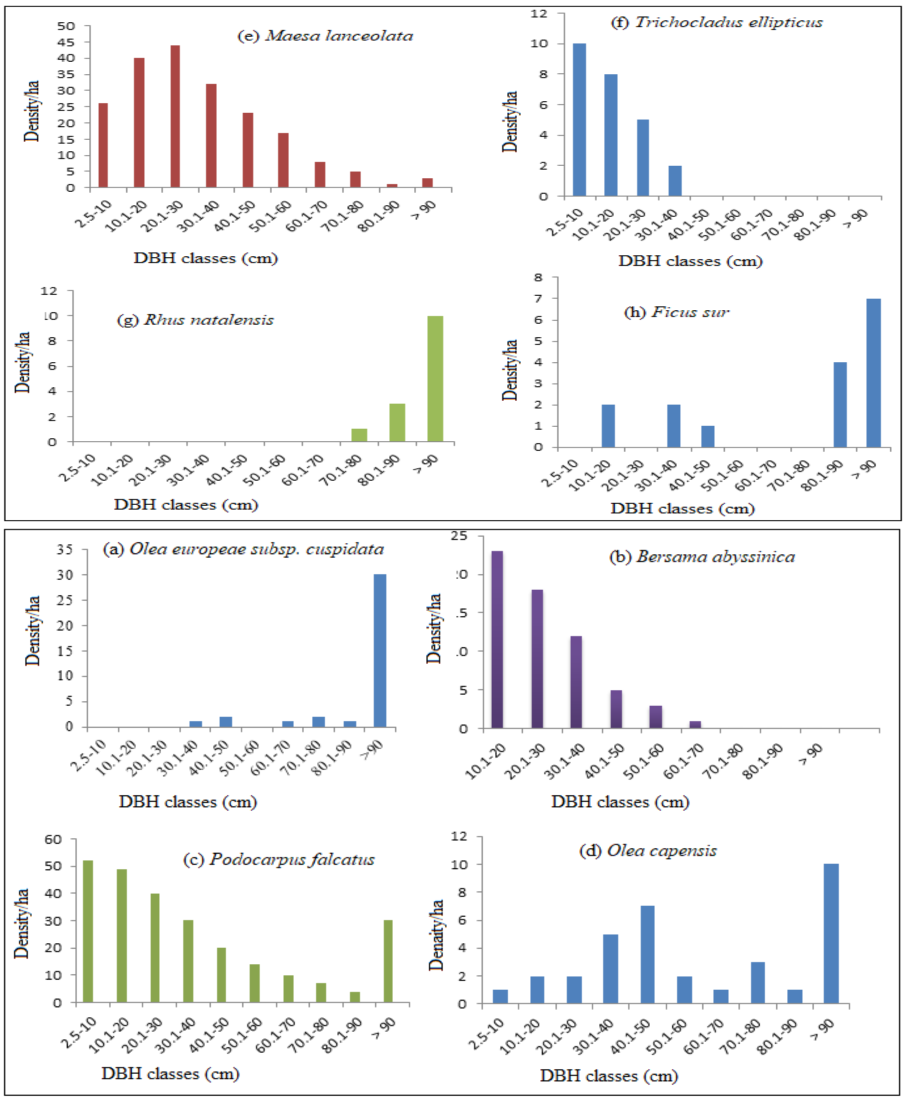

Figure 8: Representative population structure patterns of each tree species in Mehalwonze -Zego Forest. (a), *Olea europeae* L.subsp.cuspidata(Wall.exG.Don) (b) *Bersama abyssinica* Fresen., (c) *Podocarpus falcatus* (Thunb.) R. B. ex. Mirb, (d) *Olea capensis* L. subsp. macrocarpa (C.H. Wright) (e) *Maesa lanceolata* Forssk (f) *Trichocladus ellipticus* Eckl. & Zeyh., (g), *Rhus natalensis* Krauss. and (h) *Ficus sur* Forssk.

3.3. Regeneration status

From the 55 representative woody species, a total of 1302 (35%) Seedlings/ha, 1517 (41%) Saplings, and 905 (24%) mature individuals/ha were recorded (Figure 9). Accordingly, Sapling and seedling populations were greater than matured individuals. The ratio of seedling and sapling to the parent plant was 1:1.44 and 1:1.68 respectively. This shows that the distribution of saplings as a whole is greater than that of seedling and mature trees and that of the seedling is greater than mature trees. It indicates that the forest has a “good” regeneration status.

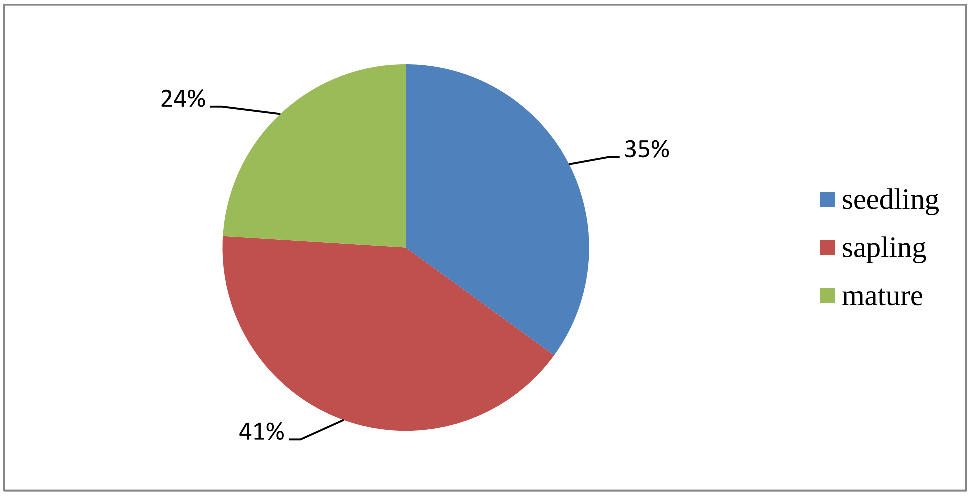

Figure 9: Percentage of seedling, sapling and mature tree species in the study area.

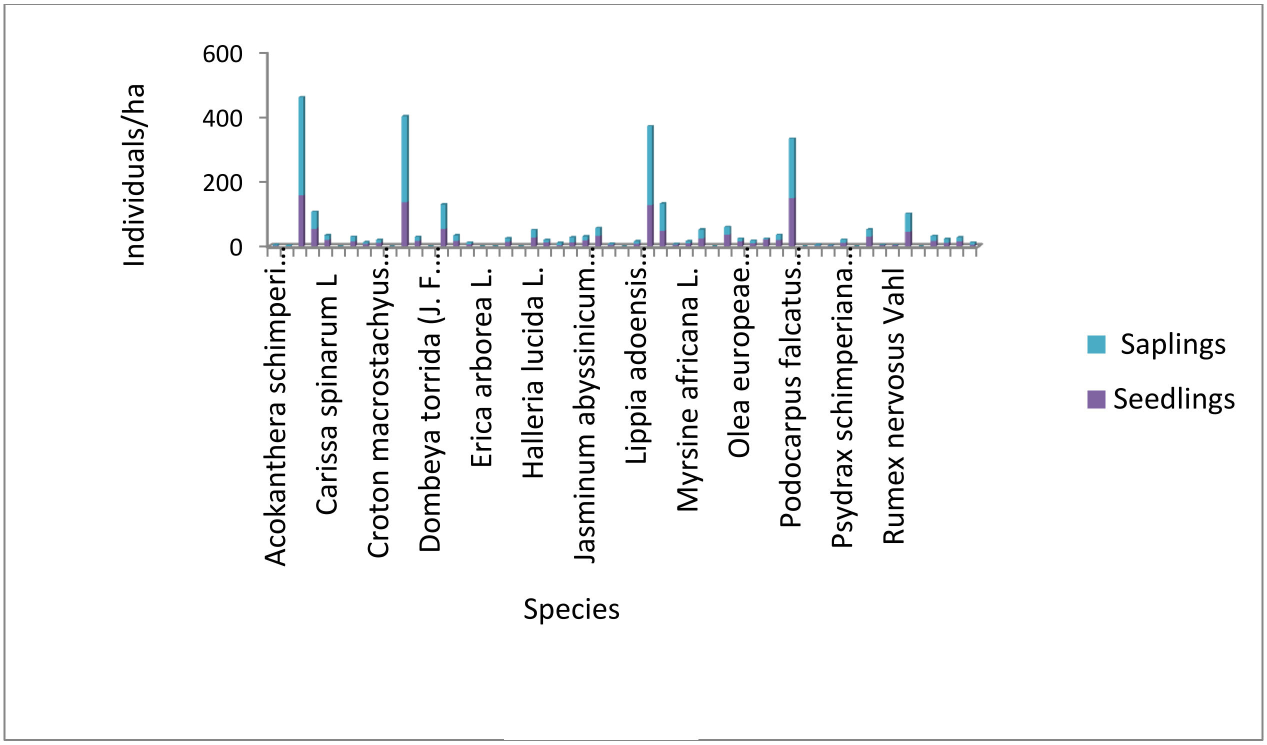

Figure 10: Seedling and sapling numbers of each species

The woody species in the area were different each other with their seedling and sapling densities /ha that is used to ensure conservation measures through prioritization to promote healthy regeneration and the sustainable use of these species. (Such species were with no seedling and sapling, species with no sapling but have seedlings/ha, species with no seedlings and few saplings in general) (Table: at appendix1).

Different woody species encountered in the forest have different densities of seedlings and saplings. The highest numbers of saplings and seedlings were *Bersama abyssinica* Fresen with (304) saplings and (157) seedlings, *Podocarpus falcatus* (Thunb.) R. B. ex. Mirb(285) and (148), *Discopodium penninervium* Hochst (266) and (136), *Maesa lanceolata* Forssk (244) and (127), *Maytenus obscura* (A. Ric.) Cuf (83) and (49) and *Dovyalis abyssinica* (A. Rich.) (76) and (53) respectively. These species cover 1258 (82.93%) saplings and 670 (51.46%) seedlings from the total 1517 saplings and 1302 seedlings (Figure 10). The remaining 259 (17.03%) and 632 (48.54%) are covered by the other 49 Species.

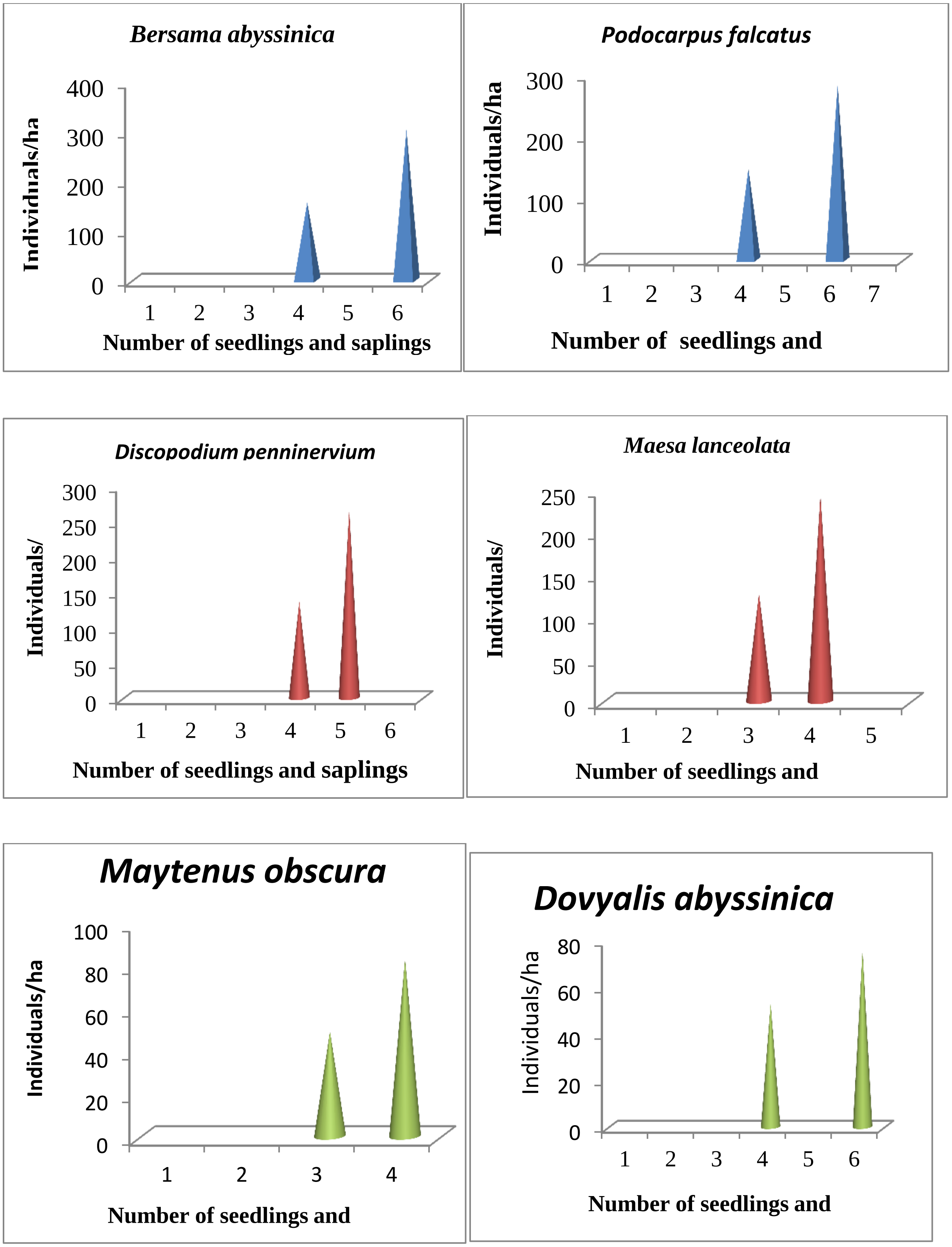

Figure 11: Seedling and sapling amount of 6 top dominant species in the study site.

3.4. Correlation with Environmental Variables

The five environmental variables grazing, disturbance, slope, altitude and aspect were correlated using Pearson correlation. Pearson's correlation analysis showed strong positive correlation between grazing and disturbance the second strong correlation was observed between altitudes and grazing whereas there was poor negative correlation between grazing and slope.

Table 6: Pearson's correlation coefficient.

	Altitude	Aspect	Grazing	Slope	Disturbance
Altitude	1.00	0.10	0.35**	0.05	0.30*
Aspect		1.00	0.06	0.12	0.24*
Grazing			1.00	-0.08	0.75***
Slope				1.00	0.06
Disturbance					1.00

5. Human Disturbances and Altitudinal Difference Impact on Trees Regeneration.

Regeneration analysis of the study revealed that the density of seedlings, saplings, and matures woody tree/shrub species was significantly correlated with altitude. Altitude was the most important factor shaping the species communities [12]. It is also among the strongest determinants of community composition and influencing the spatial distribution of species in Mehalwonze –Zego forest. According to the points of scale 0 = (No disturbance), 1= (1-20% of the quadrat disturbed), 2= (21-40%), 3= (41-60%), 4= (61- 80%), 5 = (81- 100% of the quadrat disturbed percent each numbers represent in the study site [25]. most of the plots or ¾ of the area shows 1 (1-20%) was disturbed which means that there is little disturbance but the forest is not that much disturbed whereas the other plots or ¼ of the area were under the value 2(21-40%) which shows that human interference and livestock grazing in the area was higher than that of ¾ of the study site at all.

The study sites were sensitive to excessive burning, agricultural expansion deforestation; overgrazing and a little bite introduction of exotic species that can alter natural communities. which means having, human impact in the form of intensive logging, livestock grazing and tree cutting have their own influence for abundance of species in the forest and also dominancy of some individuals. Only a few species were dominating the study forest in their abundance while many of the species were rare or low in their

Conclusions

In the present study, 55 species of woody plants which include (Trees, shrubs and wody climbers) were collected. The species identified belong to 53 genera and 38 families. Asteraceae was the most reach family that consists 6 (10.91%) species followed by Euphrbiaceae and Apocynaceae each with 3(5.45%) species. The forests have relatively rich diversity of woody species compared to some other forests of Ethiopia. DBH and height class distribution of the study site showed that the density of individuals decreases with increasing DBH and height class. The ratio of density of DBH > 10 cm to DBH > 20 cm showed the predominance of small sized individuals suggesting the forest is at the stage of secondary development.

DBH and height class distribution of woody species in the study area showed an inverted J-shaped distribution pattern indicating healthy population and good reproduction and recruitment potential of the forests. The most frequent tree species in the study sites were *Podocarpus falcatus* (Thunb.) R. B. ex. Mirb.The second and third frequent species were *Maesa lanceolata* Forssk and *Bersama abyssinica* Fresen.Whereas the least frequent species in the forests were *Acokanthera schimperi* (A. DC.) Schweinf, Ilex mitis (L.) Radlk, *Premna schimperii* Engl, *Prunus africana* (Hook. f.) kalkm , *Vernonia auriculifera* Hiern. *Vernonia rueppellii* Sch. Bip. ex Walp and *Polyscias fulva* (Hiem) Harms.The forests show high floristic heterogeneity. Importance Value Index (IVI) analysis indicated that *Podocarpus falcatus* (Thunb.) R. B. ex. Mirb *Maesa lanceolata* Forss and *Bersama abyssinica* Fresen were ecologically significant tree species in the study area.

Structural analysis and assessment of the regeneration status of woody species in the forests showed that generally the forests have good and healthy ecological conditions. However, some species need urgent conservation and management because they show abnormal population structure and pattern of regeneration such species were *Prunus africana* (Hook. f.) kalkm, *Premna schimperii* Engl, *Psydrax schimperiana* subsp. Schimperiana, *Myrsine melanophloeos* (L.) R.Br, *Dovyalis abyssinica* (A. Rich.) *Acokanthera schimperi* (A. DC.) Schweinf.etc.

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APPENDIX

Table A. 1**:** List of woody species collected from Mehalwonze-Zego Forest.

Scientific Name	Vernacular name	Family	Habit
Acokanthera schimperi (A. DC.) Schweinf.	Miranze	Apocynaceae	shrub
Allophylus abyssinicus (Hochst.)	Embus	Sapindaceae	Tree
Bersama abyssinica Fresen.	Azamir	Melianthaceae	Tree
Calpurnia aurea (Ait.) Benth	Degita	Fabaceae	shrub
Carissa spinarum L	Agam	Apocynaceae	shrub
Cassipourea malosana (Baker) Alston	Werer	Rhizophoraceae	Tree
Celtis africana Burm. f.	Kewoot	Ulmaceae	Tree
Clutia abyssinica Jaub. &Spach	Fiyelfej	Euphorbiaceae	shrub
Croton macrostachyus Del.	Bisana	Euphorbiaceae	Tree
Cupressus lusitanica Miller	yeferenjtside	Cupressaceae	tree/shrub
Discopodium penninervium Hochst.	Ameraro	Solanaceae	Tree
Dodonaea angustifolia L.f	Kitkita	Spindaceae	shrub
Dombeya torrida (J. F. Gmel.) P. Bamps	Welkifa	Sterculiaceae	Tree
Dovyalis abyssinica (A. Rich.)	Koshem	Flacoutrtiaceae	Tree
Dracaena steudneri Engl	Lankuso	Dracaenaceae	tree/shrub
Ekebergia capensis Spamn.	Lol	Meliaceae	Tree
Erica arborea L.	Asta	Ericaceae	Tree
Erythrococca trichogyne (Muell. Arg.) Prain	Sheroenchet	Euphorbiaceae	shrub
Ficus sur Forssk.	Shola	Moraceae	Tree
Hagenia abyssinica (Broce) I.F	Koso	Rosaceae	Tree
Halleria lucida L.	Mesenqero	Scrophulariaceae	Tree
Hypericum revolutum Vahl	Amja	Guttiferae	Tree
IIex mitis (L.) Radlk.	Misargmfo	Aquifoliaceae	Tree
Inula confertiflora A.Rich.,	Weynagift	Asteraceae	shrub
Jasminum abyssinicum Hochst. ex DC.	Abitahareg	Oleaceae	Woody climber
Juniperus procera Hocket.ex Endl	Habeshatside	Cupressaceae	Tree
Justicia schimperiana (Hochst. ex Nees) T. Anders	Sensel	Acanthaceae shrub	shrub
Laggera tomentosa (Sch.Bip.exA.Rich.)	Keskeso	Asteraceae	shrub
Lippia adoensis Hocmt.ex Walp.	Kesea	Verbenaceae	shrub
Maesa lanceolata Forssk	Qlewa	Myrsinaceae	shrub
Maytenus obscura	Atat	Celastraceae	Shrub
Myrica salicifolia.A.Rich.	Shinet	Myricaceae	Tree
Myrsine africana L.	Qchemo	Myrsinaceae	shrub/tree
Myrsine melanophloess(L. R. Br.	Weyil	Myrsinaceae	Tree
Nuxia congesta KBr. ex Fresen	Askuar	Loganiaceae	Tree
Olea capensis L. subsp. macrocarpa (C.H. Wright)	Wegeda	Oleaceae	Tree

Verdc.			
Olea europeae L.subsp.cuspidata(Wall.exG.Don)	Weyra	Oleaceae	Tree
Olea welwitschii (Knobl.) Gilg & Schellenb.	Damotweyra	Oleaceae	Tree
Olinia rochetiana A. Juss	Tifea	OIiniaceae	tree/shrub
Osyris quadripartita Decn.	Qeret	Santalaceae	Tree
Podocarpus falcatus (Thunb.) R. B. ex. Mirb	Zigba	Podocapaceae	Tree
Polyscias fulva (Hiem) Harms	Yeznjerowember	Araliaceae	Tree
Premna schimperii Engl.	Chocho	Lamiaceae	shrub
Prunus africana (Hook. f.) kalkm.	Tikurenchet	Rosaceae	Tree
Psydrax schimperiana (A. Rich.) Bridson, subsp. schimperiana;	Seged	Rubiaceae	Shrub/small tree
Rhamnus prinoides L'Herit.	Gesho	Rhamnaceae	shrub
Rhus natalensis Krauss.	Buse	Anacardiaceae	Tree
Rosa abyssinica R.Br	Qega	Rosaceae	shrub
Rumex nervosus Vahl	Embuacho	Polygonaceae	shrub
Salix subserrata Willd.	Nechelo	Salicaceae	shrub
Toddalia asiatica (L) Lam.,	Qonter	Capparidaceae	shrub /tree
Trichocladus ellipticus Eckl. & Zeyh.	Abeloha	Hamamelidaceae	Tree
Vernonia amygdalina Del.	Grawa	Asteraceae	tree
Vernonia auriculifera Hiern.	Guzho	Asteraceae	Tree

Table B.2**:** Tree species Name, number of individuals, quadrants w/r Spec occurs, percentage frequency, frequency and density/ha of the species.

Species Name	No.of individuals	Quadrants. No.Spp.Occures	Frequancy (%)	D/ha	F
Acokanthera schimperi (A. DC.) Schweinf.	1	1	1.5	0.37	1.49
Allophylus abyssinicus (Hochst.)	5	3	4.5	1.87	4.48
Bersama abyssinica fresen.	86	38	56.7	32.09	56.72
Calpurnia aurea (Ait.) Benth	10	4	6.0	3.73	5.97
Celtis africana Burm. f.	5	3	4.5	1.87	4.48
Croton macrostachyus Del.	11	7	10.4	4.10	10.45
Cupressus lusitanica Miller	1	1	1.5	0.37	1.49
Discopodium penninervium Hochst.	75	23	34.3	27.99	34.33
Dovyalis abyssinica (A. Rich.)	5	5	7.5	1.87	7.46
Dracaena steudneri Engl	8	7	10.4	2.99	10.45
Ekebergia capensis Spamn.	8	6	9.0	2.99	8.96
Ficus sur Forssk.	13	4	6.0	4.85	5.97
Hagenia abyssinica (Broce) I.F	1	1	1.5	0.37	1.49

Halleria lucida L.	9	7	10.4	3.36	10.45
Hypericum revolutum Vahl	4	3	4.5	1.49	4.48
Ilex mitis (L.) Radlk.	1	1	1.5	0.37	1.49
Juniperus procera Hocket.ex Endl	11	5	7.5	4.10	7.46
Maesa lanceolata Forssk	207	50	74.6	77.24	74.63
Maytenus obscura (A. Ric.).	35	16	23.9	13.06	23.88
Myrica salicifolia.A.Rich.	4	3	4.5	1.49	4.48
Myrsine melanophloeos (L.) R.Br.	1	1	1.5	0.37	1.49
Nuxia congesta KBr. ex Fresen	2	2	3.0	0.75	2.99
Olea capensis L. subsp. macrocarpa (C.H. Wright)	28	15	22.4	10.45	22.39
Oleaeuropeae L.subsp.cuspidata (Wall.exG.Don)	37	23	34.3	13.81	34.33
Olea welwitschii (Knobl.) Gilg & Schellenb.	3	3	4.5	1.12	4.48
Olinia rochetiana A. Juss	7	5	7.5	2.61	7.46
Osyris quadripartita Dec.	2	1	1.5	0.75	1.49
Podocarpus falcatus (Thunb.) R. B. ex. Mirb	267	56	83.6	99.63	83.58
Polyscias fulva (Hiem) Harms	1	1	1.5	0.37	1.49
Premna schimperii Engl.	1	1	1.5	0.37	1.49
Prunus africana (Hook. f.) kalkm.	1	1	1.5	0.37	1.49
Psydrax schimperiana subsp. Schimperiana	9	2	3.0	3.36	2.99
Rhus natalensis Krauss.	31	23	34.3	11.57	34.33
Salix subserrata Willd.	2	2	3.0	0.75	2.99
Trichocladus ellipticus Eckl. & Zeyh.	11	3	4.5	4.10	4.48
Vernonia auriculifera Hiern.	1	1	1.5	0.37	1.49
Vernonia rueppellii Sch. Bip. ex Walp.	1	1	1.5	0.37	1.49