Woody Plant Species Diversity, Structure and Regeneration Status of Woynwuha Natural Forest, North West Ethiopia

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Abstract: *A study was conducted in Woynwuha natural forest, North West Ethiopia to investigate woody plant species diversity, structure, and regeneration status of the forest. A total of 50 square quadrats each having an area of 625m^2 were used for vegetation data collection. Vegetation data were collected through field observation, species counting, speciemen collection and height and DBH measurements. Data was analysed using Shannon Weiner diversity index, Simpson's index, important value index and height and diameter distribution graphs. A total of 69 woody plant species belonging to 41 families and 59 genera were recorded. Fabaceae was the most species-rich family in the area. The overall average Shannon-Wiener Diversity Index (H`) was 3.24 and the average evenness values (E') was 0.76 indicating high diversity with more or less even distribution. The computational result of the important value index indicated that Carissa edulis was ecologically most important species. The tree cumulative diameter class frequency distribution in general resembles interrupted inverted-J- shape pattern indicating the existence of much seedling than big sized trees. The same pattern was also observed with regard to height class distribution indicating the selective removal of higher trees by the local communities.*

Key words: Species Diversity, Population Structure, Regeneration Status, Important Value Index, and Woynwuha Natural Forest.

1. Introduction

The conservation and sustainable use of biological diversity and the eradication of extreme poverty are two of the main global challenges of our time. It has been recognized by the international community that these two challenges are intimately connected, and require a coordinated response. The protection of biodiversity is essential in the fight to reduce poverty and achieve sustainable development. Seventy percent of the world`s poor lives in rural areas depend directly on biodiversity for their survival and well-being. The impact of environmental degradation is most severe for people living in poverty, because they have few livelihood options on which to fall back (IUCN's, 2010).

Most of the natural forests in Africa face pressure from communities who derive their basic livelihood from forests, or the land on which they grow crops, and even greater pressure come from commercial plantation companies and extractors of timber and other products. Conflicts often occur because of competition for forest resources from local people's livelihoods, commerce, wildlife and forestry, and the alarming rate of biodiversity loss in African forests poses an international concern (Bennun *et al.*, 2004).

Ethiopia is one of the few countries in the world that possesses a unique characteristic flora and fauna with a high level of endemism (WCMC, 1991). It is estimated that between 6,500 and 7,000 species of higher plants occur in Ethiopia, of which about 15% are endemic (WCMC, 1992). Ethiopia is the fifth largest floral country in tropical Africa (WCMC, 1991). The remnant natural forests in the central and northern highlands are found only as isolated small patches at inaccessible locations and around the numerous churches and burial grounds (Alemnew Alelign, Demel Teketay,Yonas Yemshaw & Sue Edwards,Tropical ecology 48(1): 37-49, 2007).

The natural conditions on the study area have been changed from this it can be predicted that until acceptable alternatives can be found, deforestation will be undoubtedly continue and the natural forest resource will be exhausted in the coming few years. This intern may lead to loss of flora and fauna. Information on the composition, structure and regeneration status of woody plant species is lacking for the study area.Therefore, the present study was initiated to investigate woody plant species diversity, vegetation structure, and regeneration status of Woynwuha natural forest in Goncha Siso Enesie district, North West Ethiopia. The specific objectives of the study were to provide a species list of the study area, to investigate woody plant species diversity of the forest, to assess the structure and regeneration of woody plant species in the forest.

2. Materials and Methods

2.1 Description of the Study Area

2.1.1 Location

Woynwuha natural forest is located in Debreyakob kebele, Goncha Siso Enesie district, East Gojjam Zone, Amhara National Regional State (Fig 1). The district is located about 338 km north-west of Addis Ababa, the capital city of Ethiopia. The study site is located between 10^0 $52^’$ North latitude and 38^0 $14^’$ East longitudes. The study natural forest has an area of 162.057 ha.

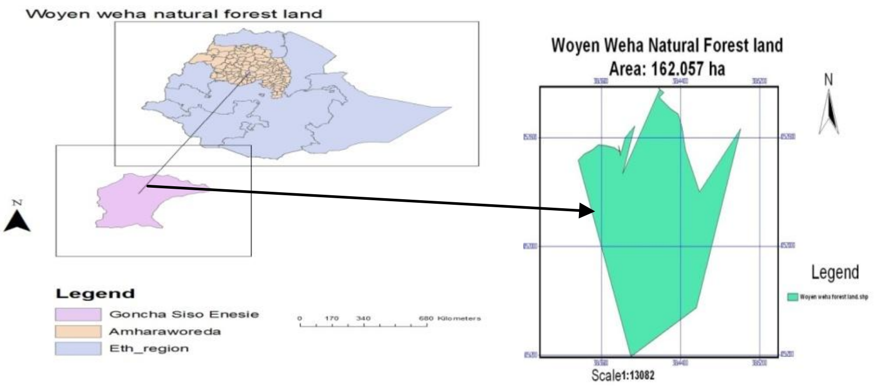


Figure 1. Map of the study area and forest

2.1.2 Topography, soil and Climate

Topography of the study area is generally characterized by undulated hill and the total area of the district is 98383 ha. The soils are mostly acidic with pH values ranging from 4.2-7.3 (Debre Markos Soil Labratory, 2007). The elevation of the study forest ranges from 2009-2733m.a.s.l and boarded by two Kebeles and four Gotts namely Tach Dinjet in the north, Gufu Giorgis in the east, Debreyakob kola in the west and Jibra Kola in the south. It is under communities' forest. Traditionally the districts have three major types of agro-climatic zones: '*Dega*' (12%), '*Weina-Dega'* (48%) and *'Kolla'* (40%). the natural under study lies in sub-humid climate. The mean annual rainfall is in the range of 1100-1800mm and monomodal rainfall pattern of distribution, which occurs in the months of June to September. The monthly mean temperature is $19.5^0{}_C$ the annual average maximum and minimum temperature of the study area is 24^oc and 15^oc, respectively (WAO, 2011/12). Based on the data from Motta (58 kilometres from the study forest) and Bahir Dar (180 kilometres from the study forest) meteorological stations, the five years (1987-1991) average rainfall and temperature pattern of Goncha Siso Enesie *District* are presented in (Fig 2.)

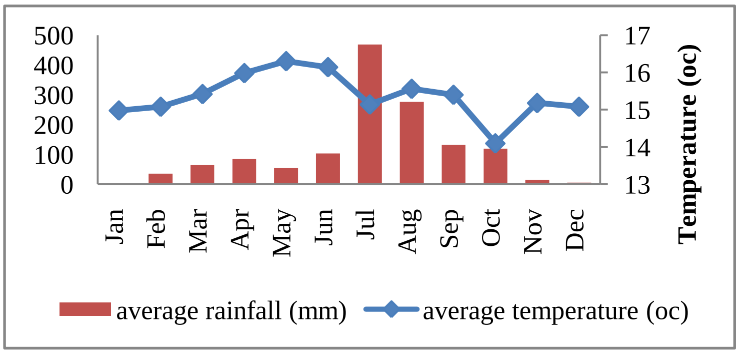


Figure 2. Average rainfall and temperature data for five years (1987-1991) of Goncha siso Enesie *District* (Source: National meteorological data, Motta and Bahir Dar stations, 2012)

2.2 Methods of Data Collection

2.2.1 Sampling Design

In this study, a systematic sampling method was employed to collect data. by laying 11 transect lines each spaced 150m apart following the homogeneity of the vegetation and elevation gradient of the forest following (Blanquet, 1932; Zerihun Woldu, 1980 and 1985;Tamrat Bekele, 1994 and Scholder, 1999). The first transect line was laid out randomly at one side of the forest along the gradient, with the help of a Silva explorer compass (type 3NL). A total of 50 rectangular sampling plots (quadrats) each having an area of 625m^2 (25m X 25m) were laid on the transect lines. The spacing between sampling plots were a distance of 100m using measuring tape. The altitude and position of each plot were measured with Garmin etrex10 GPS. Within each major sampling plots, three sub-plots each having an area of 20m^2 (2m X 10m) two at the end of the main quadrants and one at the center were laid for the purpose of saplings and seedlings inventory following Haile Adamu (2012). At all major sampling plots, all woody plant species were identified, counted, and recorded.

Diversity data were collected by summing up the number of species identified directly in the field. For the sake of species identification, local names of all woody species were listed and then scientific names were identified following colored plant identification guides such as flora of useful trees and shrubs in Ethiopia Azene Bekele (2007) and referring to the published volumes of Flora of Ethiopia and Eritrea (1994) were used. In case identification was not possible tree species specimens were taken to the National Herbarium at the Department of Biology in the Addis Ababa University and identification was made latter.

Tree height and diameter at breast height (DBH) were measured using clinomeater and caliper/measuring tap, respectively. DBH of all trees above 1.3m from the ground were measured. In cases where a tree bole branched at breast height or below, the diameter were measured separately for the branches and averaged as one DBH and in cases where tree boles buttressed, DBH measurement were undertake from the point just above the buttresses. Apart from DBH data, data on number of saplings and seedling for all plants were collected each sub-plots.

The height (m) and collar diameter (diameter at the ground level) of seedlings and saplings within each main quadrats (plot) were measured using a meter marked stick and a verner caliper, respectively. Within each main quadrats, data on number of sapling and number of seedling for all plant species and regeneration status of woody species were assessed by counting seedling (woody species of height ≤50cm and DBH ≤2.5cm) and sapling (woody species of height ≥50cm and DBH ≤ 2.5 cm).

2.3 Data Analysis

2.3.1 Composition and vegetation structure analysis

The number of species (species richness) was determined by summing up the number of species identified directly in the field from each plot and then relative abundance, frequency, the Shannon-wiener index were calculated.

Two sets of abundance (number of individuals of a species in the area) were calculated in this study. These were (1) Average abundance per quadrant, calculated as the sum of the number of stems of species from all quadrants divided by the total number of quadrants, and (2) Relative abundance, calculated as the percentage of the abundance of each species divided by the total stem number of all species per hectare following Kindeya Gebrehiwot (2003).

2.3.2 Plant diversity and equitability analysis

The species diversity is the combination of the species richness (the number of species in the sample plots) and evenness of species (abundance distribution among species). Based on these results, the Shannon wiener diversity index (H`), evenness and richness were summarized with respect to the identified species through the analysis of two components of species diversity.

- Shannon diversity index is calculated as follows (krebs, 1999, Kent and Coker, 1992 and Jayarman, 2000)

$$H' = \sum_{i=1}^{s} p_i \ln p_i \text{ -------------------------------- } (1)$$

Where; H' = the Shannon-Weiner Diversity Index, Pi = the proportion/probability of individuals found in the i^th species, s = total number of species (1, 2, 3…..s), Ln = natural logarithm. Species richness was taken from all species encountered in each plot

$$S = \text{number of species/plot area} \text{ --------------------------- } (2)$$

- The Shannon's evenness index (E) was calculated from the ratio of observed diversity to maximum diversity using the equation.

$$EH = \frac{\sum_{i=1}^{s} p_i \ln p_i}{\ln s} \text{ ----------------------- } (3)$$

Where, EH= Equitability (evenness) index which has values between 0 (a situation in which the abundance of all species are completely disproportional) and 1 (all species are equally abundant).

2.3.3 Structural Data Analysis

To analyze the vegetative structure of woody species, all individuals of each species encountered in the quadrat were grouped into diameter and height classes (Kershaw, 1973, Shimwell, 1984). Then table and histograms frequency were developed using the diameter and height classes versus the number of individuals categorized in each of the classes using Microsoft Excel Computer Software. To see the regeneration status of the woody plants or to evaluate the level of disturbance in the forest, all types of disturbances were record. Furthermore, checklist of plant species record in each plot, including their local uses and parts use were prepared.

2.3.4 Importance value index

The importance value index (IVI) indicates the importance of individual tree/shrub species in the land use systems. It is a composite index based on the relative measures of species frequency, abundance and dominance (Kent and Coker, 1992; Jose and Shanmugaratnam, 1994). This index is used to determine the overall importance of each species in the community structure (Relative Density, Relative Dominance and Relative Frequency) which describes the structural role of a species in a stand.

- Importance Value Index was calculated with the following formula.

$$\text{Importance value index} = \text{Relative Density} + \text{Relative frequency} + \text{Relative Dominance} \quad (4)$$

$$Relative\ density = \frac{\text{Density of species A}}{\text{Total density of all species}} * 100 \quad (5)$$

$$Relative\ frequency = \frac{\text{Frequency of speciese A}}{\text{Total frequency of all species}} * 100 \quad (6)$$

$$Relative\ Dominance = \frac{Basal\ area\ of\ speciies\ A}{\text{Total Basal area of all species}} * 100 \quad (7)$$

- To compare the diversity between plot and with another forest, Sorenson Similarity index was used (Lamprecht 1989; Kent and Coker, 1992).

$$S_s = \frac{2C}{(2C+A+B)} \quad (8)$$

Where, Ss = Sorensen's similarity index, A = number of species forest in natural forest A, B = number of species in natural forest B, C = number of species common to both forests.

3. Results and Discussion

3.1 Floristic Composition

Floristic composition of the vegetation was described in terms of its richness in species, abundance, dominance, and frequency (Lamprecht, 1989). In the studied forest, a total of 67 native woody species and 2 exotic tree species were recorded belonging to 41 families and 59 genera (Appendix 1) in the altitudinal range between 2009–2626m.a.s.l. The trees had the largest proportion of the life forms. Of these species, 34 (49%) were trees, 25(36%) were tree/shrubs, 7(10%) were shrubs and 3(4%) were climbers (Fig. 3). About 67(97%) of the woody species were endemic to Ethiopia.

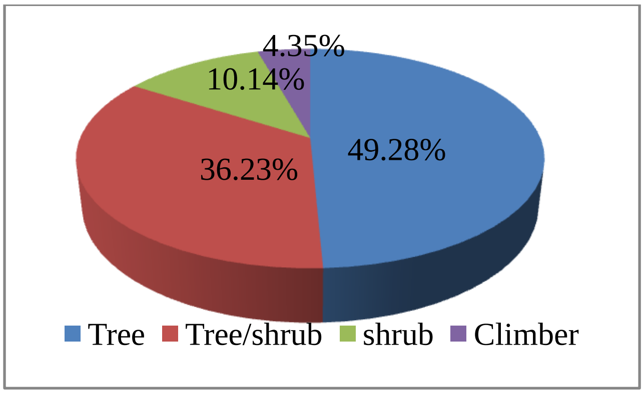


Figure 3. Life form percentage of the vegetation of the studied forest

Fabaceae was the most species-rich family comprising 9 (13.04%) species from the total plant species identified followed by *Euphorbiaceae* and *Moracea* each represented by four species. *Euphorbiaceae* and *Moracea* together comprised 11.59% of the total species. The next dominant families were *Anacardiaceae, Asteraceae, Oleaceae, Sapindaceae, and Sapotaceae* with 15 species together (21.72%) each represented by three species. The fourth dominant families were *Apocynaceae, Myrtaceae, Rosacea and Rubiaceae* each represented by 2 species and together accounted 11.59% of the total identified species. The remaining species belong to 29 families (42.03%) and each represented by a single species.This indicating the dominance of fabaceae family, which might be due the adaptation potential of Fabaceae families to wider agro-ecologies.

The overall average Shannon-Wiener Diversity (H`) Index and the average evenness values for the entire forest were 3.24 and 0.765, respectively (Appendix 2). According to Kent and Coker (1992), the Shannon-Weiner diversity index normally varies between 1.5 and 3.5 and rarely exceeds 4.5. Shannon diversity index is high when it is above 3.0, medium when it is between 2.0 and 3.0, low when between 1.0 and 2.0 and very low when it is smaller than 1.0 (Cavalcanti and Larrazabal, 2004). From this study, it can be concluded that the study forest is with high diversity and more or less even representation of individuals of all species encountered in the studied quadrants except a few species are dominant.

Species area curves were drawn to judge the adequacy of sampled areas to represent the species diversity and related vegetation qualities. The leveling out of the species area curve is used to determine whether adequate samples were taken. The species area curve is a cumulative curve that relates the occurrence of species with the area sampled. When the curves grew up and flattened at the end, this indicates that the number of plots taken is sufficient (Lamprecht, 1989, Gotelli and Colwell, 2001).

Species diversity curve rises relatively rapidly at first, and then much more slowly in later samples as increasingly rare taxa are added (Gotelli and Colwell, 2001; Rosenzweig, 1995). In agreement with above statements, ten sample plot was taken randomly, the species diversity curves of the vegetation of the study Forest showed that species richness across quadrants was good and pattern of diversity curve owing to the fairly enough number of quadrats observed (Fig 4).

Figure 4. Species richness curve of the whole vegetation

The number of species (69) recorded in the study area was found to be also higher than the number of species recorded in other Ethiopian Afromontane forests like Dilfaqar Regional Park forest (51) (Dereje Mekonnen, 2006), Bonga forest (51) (Abayneh Derero *et al*., 2003) and Jibat (54) (Tamrat Bekele, 1994). However, the total number of species in the study area was lower than that of reported for Hugumburda forest (79) (Ermias Aynekulu, 2011), Belete forest (79) (Kitessa Hundera and Tsegaye Gadissa, 2008), Abebayen and Tara gedam forest (143) (Haileab Zegeye, 2005), Afer-Shala Luqa (216) species (Teshome Soromessa *et al*., 2004), Chilimo (90) (Tadesse W.mariam *et al*., 2000) and Wof-Washa forest (252) (Demel Teketay and Tamrat Bekele, 1995).

Generally, factors like social and environmental influences might have impacted the forest composition and species richness (Espinosa and Cabrera, 2011) though it depends on intensity and persistency of influences (Kuffer and Senn-irlet, 2004). Possible reasons for these diversity differences may be also forest size. This means as the forest area is getting wider, the probability of getting new species increases contributing to higher divesrsity value.

3.2 Abundance and Population Structure of Woody Plant Species

Species-abundance measures are ways of expressing not only the relative richness but also evenness and there by assessing diversity (Barnes *et al*., 1998). A total of 8698 individuals of woody plants (2783 individuals per ha) were encountered from 50 studied quadrats. The ten most abundant woody species in their order of highest density were: *Carissa edulis, Maytenus arbutifolia, Calpurnia aurea, Croton macrostachyus, Acacia abyssinica, Mimusops kummel, Allophylus abyssinicus, Otostegia integrifolia, Bersema abyssinica* and *Rosa abyssinica*.

Generally speaking, only few species were dominating the vegetation of the study area in their abundance while many of the species were very rare or low in their abundance. Such a result reflects either adverse environmental situations or random distribution of available resource in the study area (Feyera Senbeta, 2005, Tatek Dejene, 2008). It can be further inferred about this study result from the above authors point of views in that the woody plants were distributed in uneven manner may be due to inability of individuals to cope up harsh environmental condition, human disturbance, livestock trampling and grazing, and other biotic and abiotic impairments in the area.

In this study both diameter and height class distribution of the population structure of the study area reflected an interrupted reversed J-shape (L-shape), which seemed to show a pattern where species frequency distribution had the highest frequency in the lower diameter and height classes and a gradual decrease towards the higher classes. Eighty one percent of the total density lies between the first, second, third and fourth diameter classes, whereas, about 15.5% and 4 % of the density were found to be in the middle diameter classes (16-36 cm) and in the higher diameter classes (36-44cm), respectively (Fig 5). This indicated that there was drawing out of middle and high diameter class trees for various purposes by local dwellers like for fencing, construction and fuel wood.Similarly, the density distribution of woody individuals in different height classes also showed a similar pattern with diameter classes although there were a very high decrease in density of class three, four, five and six. Generally, it showed a decrease in density with increasing height classes (Fig 6).

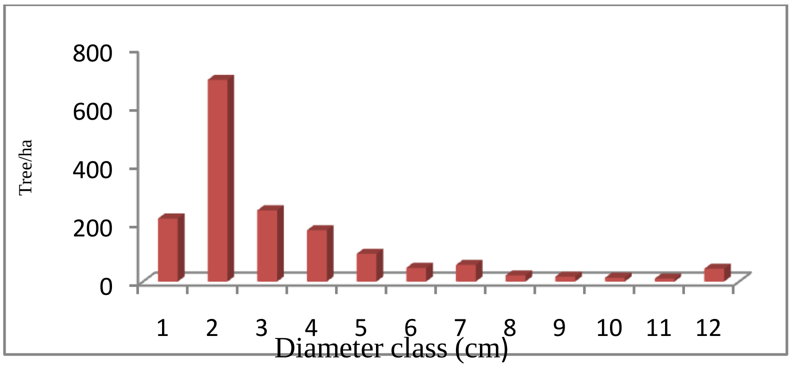


Figure 5. Diameter class frequency distribution of selected tree species
DBH class: (1=<4 cm; 2=4-8 cm; 3=8-12 cm; 4=12-16 cm; 5=16-20 cm; 6=20-24 cm; 7=24-28 cm; 8=28-32 cm; 9=32-36 cm, 10=36-40 cm, 11=40-44 cm, 12=>44 cm

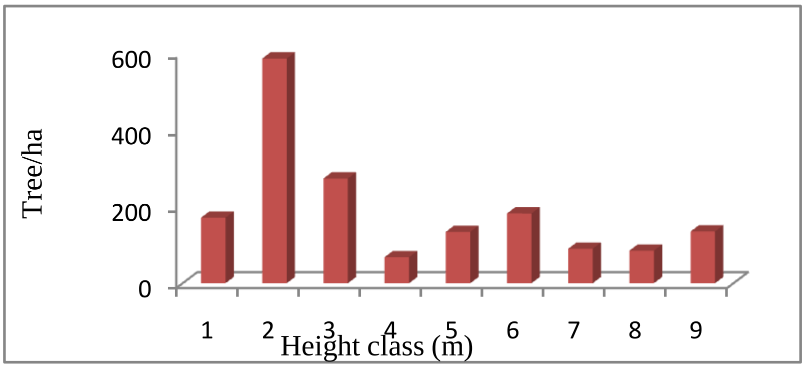


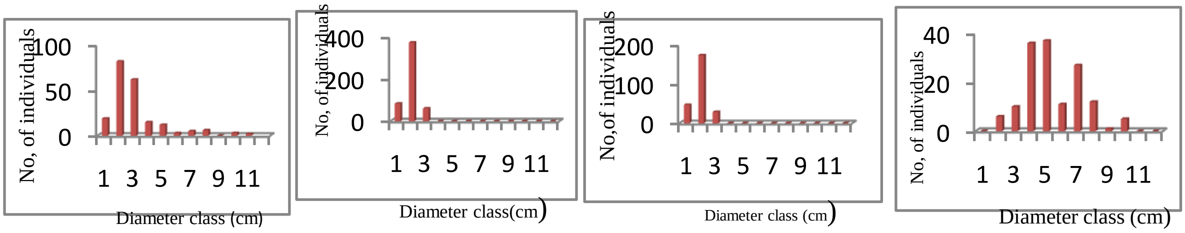
Figure 6. Height class frequency distribution of woody species

Height class (1=<2 m; 2=2-4 m; 3=4-6 m; 4=6-8 m; 5=8-10 m; 6=10-12 m; 7=12-14 m; 8=14-16 m, 9=>16 m**)**

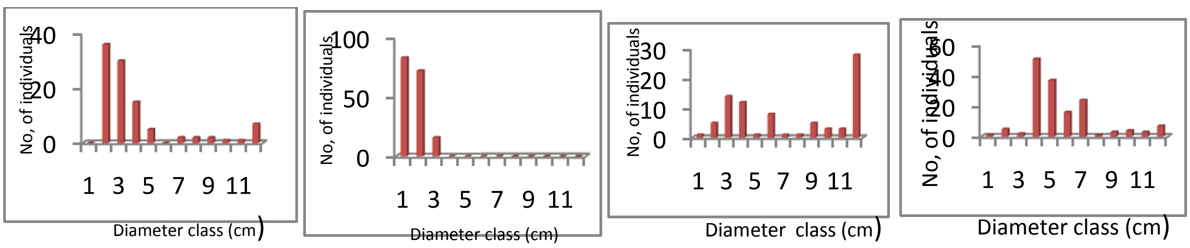
Information on population structure of a tree species indicates the history of the past disturbance to that species and the environment and hence, used to forecast the future trend of the population of that particular species (Demel Teketay, 1997; Tamrat Bekele, 1994). The population structure of selected species from the vegetation of the study area fell into one of the four general diameter class distributed patterns. These are: 1) interrupted reversed J-shape, which seemed to show a pattern where species frequency distribution had the highest frequency in the lower diameter classes and a gradual decrease towards the higher classes; but showing either a complete absent or a very high decrease in density somewhere in the lower classes or middle classes. 2) J-shape, which showed a type of frequency distribution in which there was a low number of individuals in the lower diameter classes but increased towards the higher diameter classes. 3) Bell-shape, which showed a type of frequency distribution in which a number of individuals in the middle classes were high, and decreased towards the lower and higher diameter classes and 4) Irregular-shape, which seemed a Bell-shape distribution pattern but a complete absent of individuals in some class and a fair representation of individuals in other class (Haile Adamu, 2012). These patterns were illustrated by the eight dominant species that had been selected based on their relative frequency distribution and importance value index.

Accordingly, diameter class of *Croton macrostachyus* (Fig 7a), *Carissa edulis* (Fig 7b), *Maytenus arbutifolia* (Fig 7c), *Allophylus abyssinicus* (Fig 7e) and *Calpurnia aurea* (Fig 7f) were depicted an interrupted Inverted-J-shape pattern *Olea europaea* (Fig 7g), *Albizia gummifera* (Fig 7h) were depicted in the Irregular-shape patern and *Acacia abyssinica* (Fig 7d), depicted in the Bell-shape pattern. This reflects a hampered regeneration status of the species due to possible reasons like human disturbance, livestock trampling or browsing in the area (impacts of domestic animals such as goat. sheep and caw).

The patterns of Diameter at Breast Height (DBH) class distributions indicated the general trends of population dynamics and recruitment processes of the species. From the DBH class distributions of the species, two types of regeneration status were determined, i.e. good and poor regeneration. Some species possessed high number of individuals in the lower DBH classes, particularly in the first class, which suggests that they have good regeneration potential. Other species possessed either no or few number of individuals in the lower DBH classes, particularly in the first class, which indicates that the species are in poor regeneration status.



(a) *Croton macrostachyus* (b) *Carissa edulis* (c) *Maytenus arbutifolia* (d) *Acacia abyssinica*

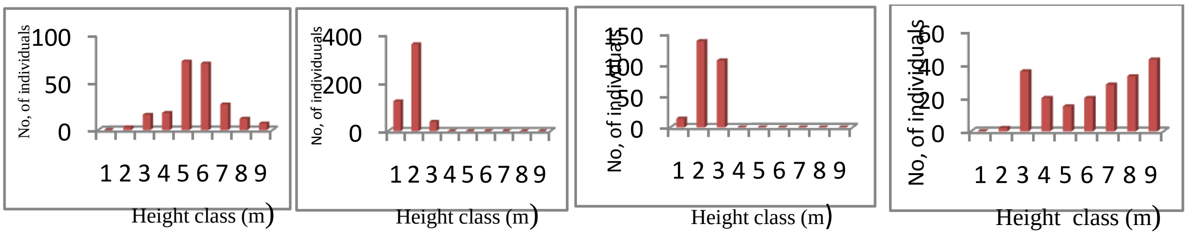


(e) *Allophylus abyssinicus* (f) *Calpurnia aurea* (g) *Olea europaea* (h) *Albizia gummifera*

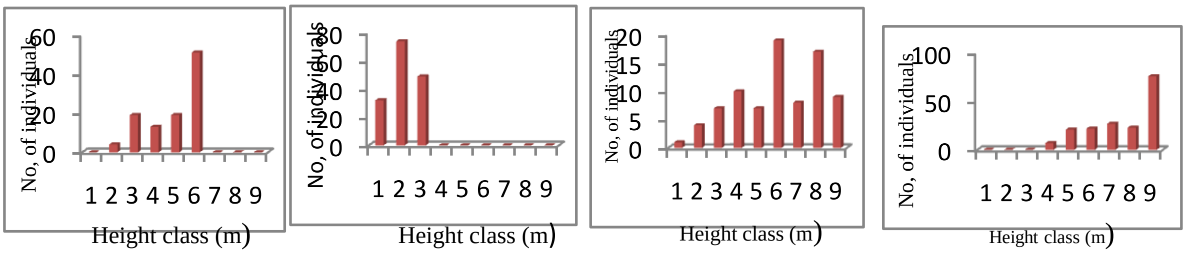
Figure 7. Diameter class frequency distribution of selected tree species

DBH class: (1=<4 cm; 2= 4-8 cm; 3= 8-12 cm; 4= 12-16 cm; 5= 16-20 cm; 6= 20-24 cm; 7= 24-28 cm; 8= 28-32 cm; 9=32-36 cm, 10=36-40 cm, 11=40-44 cm, 12=>44 cm).

On the other hand, the patterns of height class distribution fell into three categories (Fig 8). These were: 1) interrupted reversed J-shape, which seemed to show a pattern where species frequency distribution had the highest frequency in the lower height classes and a gradual decrease towards the higher classes. But showing either a complete absent or a very high decrease in density somewhere in the lower classes or middle classes. 2) J-shape, which showed a type of frequency distribution in which there was a low number of individuals in the lower height classes but increased towards the higher height classes, and 3) Irregular-shape, which generally seemed a Bell-shape distribution pattern but a complete absent of individuals in some class and a fair representation of individuals in other class. Accordingly, height class of *Allophylus abyssinicus* (Fig 8e), *Albizia gummifera* (Fig 8h) were J-shape pattern. *Carissa edulis* (Fig 8b), *Maytenus arbutifolia* (Fig 8c), *Calpurnia aurea* (Fig 8f) were depicted an interrupted Inverted-J-shape pattern, *Croton macrostachyus* (Fig 8a), *Acacia abyssinica* (Fig 8d), *Olea europaea* (Fig 8g) nearly irregular shape (Bell-shape).



(a) *Croton macrostachyus* (b) *Carissa edulis* (c) *Maytenus arbutifolia* (d) *Acacia abyssinica*



(e) *Allophylus abyssinicus* (f) *Calpurnia aurea* (g) *Olea europaea* (h) *Albizia gummifera*

Figure 8. Cumulative height class frequency distribution of woody species

Height class (1=< 2m; 2= 2-4m; 3= 4-6m; 4= 6-8m; 5= 8-10m; 6= 10-12m; 7= 12-14m; 8=14-16m, 9=>16m)

3.3. Basal Area, Frequency and Importance Value Index (IVI)

Basal area provides the measure of the relative importance of the species than simple stem count, (Lamprecht, 1989). Species with largest contribution in dominance value through higher basal area could be considered as the most important species in the study vegetation. Otherwise, in most cases shrubs could be the dominant species if only we consider density as a measure to indicate the overall dominance of the species (W.Adefires, 2006; S.Simon and B.Girma, 2004).

The average basal area of all woody species was 20.03 m^2/ha. The following species made the largest contribution to the basal area: *Albizia gummifera* (22.87%), *Olea europaea* (17.77%), *Croton macrostachyus* (15.76%), *Acacia abyssinica* (14.30%), *Carissa edulis* (10.95%), *Maytenus arbutifolia* (3.85%), *Allophylus abyssinicus* (3.79%) and *Juniperus procera* (3.75%). But the other remaining species contributed only 6.94 %. This implies that the above-mentioned eight species are the most ecologically important woody species in Woynwuha natural forests.

Important value index (IVI) is a good index for summarizing vegetation characteristics, ranking species management and conservation practices. It reflects the degree of dominancy and abundance of a given species in relation to the other species in the area (Kent and coker, 1992). The result of IVI which is calculated from relative density, relative basal area (relative dominance) and relative frequency, of woody species is shown in (Appendix 3). According to Lamprecht (1989), stands that yield more or less the same IVI for the characteristic species indicate the existence of the same or at least similar stand composition and structure, site requirements and comparable dynamics among species.

The result of the index showed that the ten most important woody species with the highest IVI in decreasing order were *Carissa edulis* (8.57%), *Maytenus arbutifolia* (6.44%), *Pittosporium viridiflorum* (5.52%), *Coffiee Arabica* (4.74%), *Myrsine africana* (4.08%), *Albizia gummifera* (3.25%), *Jasminum abyssinicum* (3.06%), *Calpurnia aurea* (2.99%), *Bersema abyssinica* (2.82%) and *Croton macrostachyus* (2.72%). These contributed to over 44.22% of the total importance value indices; this implies that these woody species are the most ecologically important woody species in the study area. Whereas, species with small contribution to the total IVI were like *Ficus vasta, Erica arborea, Cordia africana*, and others those woody species which have IVI rank less than ten are threaten and it needs of immediate conservation measure (Appendix 3).

Albizia gummifera (22.873), *Olea europaea* (17.774), *Croton macrostachyus* (15.759), *Acacia abyssinica* (14.3040, *Carissa edulis* (10.957) were species with the highest relative basal area, and *Carissa edulis* (15.624), *Maytenus arbutifolia* (10.692), *Calpurnia aurea*. (7.657), *Croton macrostachyus* (7.243) were species with the highest relative density, On the other hand *Croton macrostachyus* (7.579), *Carissa edulis* (7.024), *Maytenus arbutifolia* (6.47), *Acacia abyssinica* (5.545), *Allophylus abyssinicus* (5.36), *Calpurnia aurea* (5.176), *Olea europaea* (5.176), *Albizia gummifera* (4.621), *Rosa abyssinica* (3.327) were species with highest relative frequency in Woynwuha natural forests. The most abundant species in this study is *Carissa edulis* (434.88/ha) followed by *Maytenus arbutifolia* (297.6/ha).

Frequency reflects the pattern of distribution and gives an approximate indication of the heterogeneity of a stand (Z.Haileab, 2005; Lamprecht, 1989). The highest relative frequency was scored by *Croton macrostachyus* which has relatively highest relative density and the highest relative basal area. These may be due to the fact that these species might have a wide range of seed dispersal mechanisms like by wind, livestock, wild animal, birds and the like. Studies pointed out that high values in higher frequency classes (class A and B) and low values in lower frequency classes (classes C and E) indicated constant or similar species composition following S.Simon and B.Girma, (2004). High values in lower frequency classes and low values in higher frequency classes on the other hand indicate a high degree of floristic heterogeneity. In the present study, high values were obtained in lower frequency classes whereas low values were in higher frequency classes (Fig 9). This showed that floristic heterogeneity exists in Woynwuha natural forests.

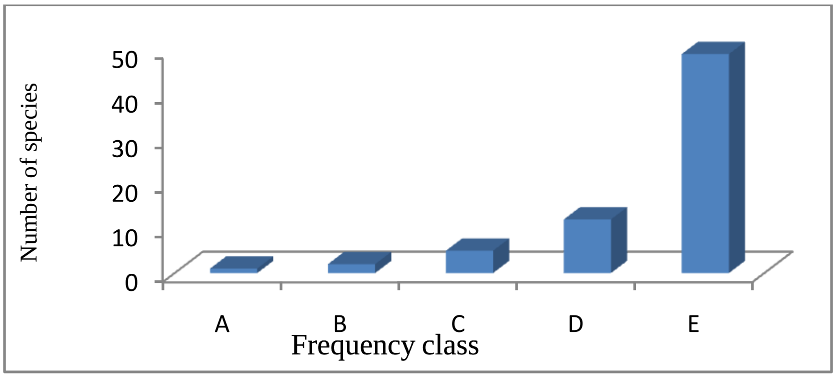


Figure 9. Frequency distribution of woody species of Woynwuha natural forests

Frequency class: (A= 81-100%; B= 61-80%; C= 41-60%; D= 21-40%; E= 0-20%

3.4 Regeneration Status

Composition and density of seedlings and saplings would indicate the status of regeneration in the study area. The population structure helps to study the regeneration pattern of a species (Swamy *et al*. 2000). The study forests had relatively high number of saplings 3274 (37.64%) followed by seedlings 2950 (33.92%) and mature trees 2474 (28.44%). A total of 6224 individual (1991.68 individuals/ha) seedlings and saplings belonged to 61 species were counted from all quadrants, while a total of 3274 individuals (1047.68 individuals/ha) saplings counted for 58 species, and a total of 2950 individuals (944 individuals/ha) seedling counted for 56 species.

Accordingly, the following species made the largest contribution to the seedling counts per hectare: *Maytenus arbutifolia* (267.2), *Carissa edulis* (214.72), *Calpurnia aurea* (163.52), *Croton macrostachyus* (129.6), *Acacia abyssinica* (108.16), *Otostegia integrifolia* (101.44), *Bersema abyssinica* (90.24), *Allophylus abyssinicus* (87.36), *Albizia gummifera* (77.76), *Rhus vulgaris* (72.64), *Rosa abyssinica* (76.8), *Cassipourea malosana* (52.16), *Dodonaea viscose* (48), *Olea europaea* (41.28), *Myrsine africana* (34.24), *Rhus retinorrhoea* (41.6) (Fig 10). In this seedling and sapling assessment, *Carissa edulis*, *Maytenus arbutifolia*, *Calpurnia aurea*, *Croton macrostachyus*, *Acacia abyssinica* and *Allophylus abyssinicus*, were with good recruitment status relative to other species. On the other hand, some species like *Pouteria altissima*, *Albizia lophantha*, *Crassocephalum sarcobasis* and *Cordia africana* showed less recruitment status of seedling and sapling. This may be due to the selective browsing effect of animals and ecological adaptation problem in the study area. Generally, good regeneration was observed for most bush/shrub species than trees which needs further study.

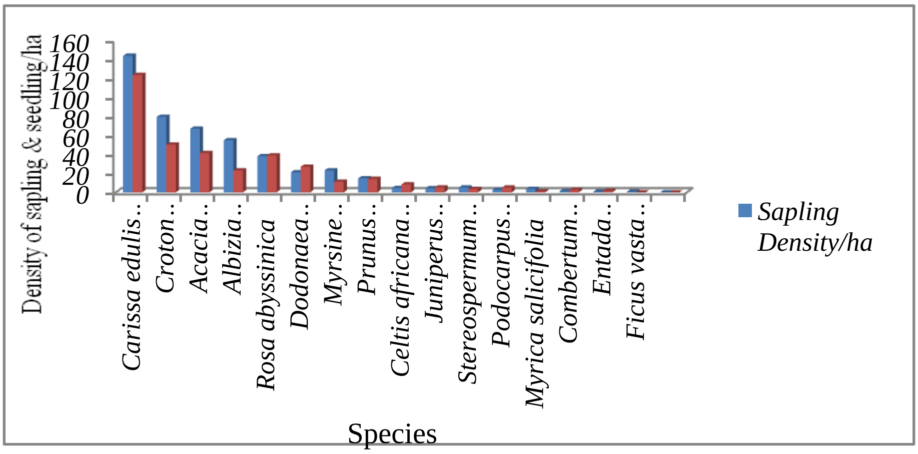


Figure 10. Regeneration status (seedling and sapling) of woody tree species

3.5 Similarity in Woody Species Composition

The trend of species composition varied from one forest to another. From the total species identified in the study forests 36 (44.44%) species, 22 (21.78%) species, 8 (7.34%) species were found in Tara Gedam forests, Debrelibanos forests, Metema forests respectively. 34 (20.98%) species, 47 (46.53%) species, 61 (55.96%) species in the study forests only when we compare with the selective above site 56 species (34.56%) in Tara Gedam forest, 32 species (31.68%) in Debrelibanos forest, 40 species (36.69%) in Metema forests only.

The similarity in species composition between the study forests and Tara Gedam forests was 0.44, the study forests and Debrelibanos forests was 0.36, the study forests and Metema forests was 0.14. The similarity coefficient was below 0.5 (maximum is 1.0), indicating that there is low similarity among the forests and each forest has its own characteristic species under uniform climatic conditions.

Hence, it seems likely that other factors such as the type of plantation species, edaphic conditions of the stands, management practices, age, and altitudinal difference between the selective sites etc. may have contributed to the differences in the similarity of species composition among the selective sites. Other authors (S.Feyera 1998; S.Feyera *et al.,* 2001; Pande *et al*., 1988) have reported similar results. Thus, the study forests, Tara Gedam forests, Debrelibanos forest and Metema forests are important in terms of floristic diversity and sensitive from a conservation point of view.

Tabel 1. Similarity coefficient between Woynwuha natural forest and selective site
W= Woynwuha forest, Tg= Tara gedam forest, Dl= Debrelibanos forest, M=Metema forest

	Wv_sTg		Wv_sDl		Wv_sM	
	Spp type	%	Spp type	%	Spp type	%
Both	36	44.44	22	21.78	8	7.34
other site	56	34.56	32	31.68	40	36.69
Woynwuha	34	20.98	47	46.53	61	55.96
Total	126	100	101	100	109	100

4. Conclusions and Recommendations

Woynwuha natural forest has high floristic composition and diversity with good distribution. Fabaceae was the dominant vegetation family. The Shannon winner diversity index also showed higher diversity value as compared to other forests. Moreover, the forest has more or less even species distribution. However, the results of woody species revealed that only few species were scored high density and basal area. Both the cumulative diameter and height class frequency distribution patterns of woody individuals resulted in an interrupted inverted-J shape, which is the reflection of a more or less good regeneration profile in the area. Similarly, the population structure of the eight selected important species resulted as all of them were in good regeneration status though the degree of the problems varies from species to species. *Cordia africana* was the most critically hampered species followed by *Crassocephalum sarcobasis, Albizia lophantha and Pouteria altissima.*

In general, the results of this study showd that high IVI. If appropriate management activities are applied, the nature of the population structure of most of the tree species will be improved. The study forests possess high species richness and evenness, including endemics plant species. The similarity in species composition between woynwuha and other selected the forests were low, indicating that each forest has its own characteristic species. The diversity and evenness indices indicate the need to conserve the forests from floristic diversity points of view.

In order to ensure the conservation of the Woynwuha Natural forest, the following recommendations were forwarded for effective use in the study area:

- Make use of knowledgeable community members in the awareness creation campaigns, considering the fact that people have great tendency to listen seriously whatever is told to them by their own community members and elders than any outsider and assigning qualified person for conserving and rehabilitation of woynwuha natural forests.
- The most important option to save the remaining forest urgently is to solve the key problem of the community. The government and its institutions should play roles and responsibilities for solving the problem. This option also needs to be linked with strong extension services to build awareness of the community about sustainable conservation and utilisation of woody species.
- The legal protection of the forest should be strengthened to make more effective protection mechanisms of the natural forest.
- In-situ and ex-situ conservation methods have to be employed for the conservation of indigenous species having low IVI values and poor regeneration status.

- Integrated research and development interventions have to be carried out for further studies on patterns of the composition, structure and regeneration states of the forest through effective management in the area.

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