SPECIES DIVERSITY, POPULATION STRUCTURE AND REGENERATION STATUS OF WOODY PLANTS IN YEGOF DRY AFROMONTANE FOREST, NORTH EASTERN ETHIOPIA

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ABSTRACT

The study was conducted in Yegof forest, northeastern Ethiopia to investigate the floristic diversity, population structure and regeneration status of woody species. Systematic random sampling method was employed to collect the vegetation data. A total of 40 plots, measuring 20m x 20m, were sampled along line transects following the altitudinal gradient. In each plot, all woody species were identified, counted, and height and diameter at breast height (DBH) were measured and recorded. A total of 76 species of plants belonging to 66 genera and 43 families were recorded in the study area. Out of these plant species, 10 (13.2%) were trees, 15 (19.7%) tree/shrub, 39 (51.3%) shrubs, 8 (10.5%) climbers and 4 (5.3%) herbs. Fabaceae was the dominant family represented by 9 species (11.84%) followed by Rhamnaceae and Oleaceae 4 species each (5.26%) and Anacardiaceae and Lamiaceae 3 species each (3.95%). 15 families were represented by 2 species each (2.63%) and 23 families were represented by 1 species each (1.32%). The diversity and evenness of woody species in Yegof forest were 2.26 and 0.57, respectively. The total density and basal area of woody species in Yegof forest were 1768.13 individuals ha^{-1} and 15.85 m^2 ha^{-1}, respectively. The results on DBH class distribution and important value index (IVI) suggest that species with poor reproduction and recruitment status as well as low IVI values need to be prioritized for conservation activities.

Keywords: Conservation, Floristic composition, Plant diversity, Regeneration, Yegof forest.

INTRODUCTION

Tropical forests are the most diverse ecosystems and are often considered as the reservoirs of biodiversity (Fangliang *et al*. 1996). Ethiopia, located in the tropics, has a wide range of ecological settings that has created environments conducive for the development of various forms of life. Thus, the country is endowed with a rich fauna and flora that makes it an important regional center of biological diversity and endemism (Woldu 1999). The flora of Ethiopia is very heterogeneous and has a rich endemic element. It is estimated to contain around 6,000 species of higher plants, of which about 10 % are endemic (Kelbessa &

Demissew 2014). Many of the genetic resources of the country are still unexplored. However, these large biodiversity resources are under continuous threats of destruction mainly due to habitat loss and fragmentation, unsustainable utilization of biological resources, invasive species and climate change (Limeneh & Teketay 2004, EBI 2014).

Although deforestation has a long history in Ethiopia, accelerated deforestation particularly in northern parts of the country began in the early parts of the 20thcentury. The forest cover of Ethiopia was about 16% of the land area in the early 1950s and rapidly declined to 3.6% in the early 1980s and 2.7% in 1989 (EFAP 1994). FAO (2010) estimated the rate of deforestation in Ethiopia as 141,0000 ha yr^{-1}. The highlands of Ethiopia, which are defined as land areas above 1500 m, are very suitable for human inhabitation (Yirdaw 2002). As a result, humans and livestock settlements have concentrated in the highland areas, especially in the 2300 – 3200 m a.s.l. range because of the relatively good rainfall reliability, cool temperatures and the absence of diseases such as malaria and trypanosomiasis common in the lowland areas surrounding the highlands.

This population pressure on the highlands accompanied by sedentary rainfed agriculture, extensive cattle herding activities and socio-political instability has resulted in heavy deforestation, habitat fragmentation and over exploitation of species (Yirdaw 2002). Thus, most of the highlands in northern Ethiopia are severely degraded and requires urgent conservation activities. A few scattered and small patches of natural forests are found at inaccessible areas and scared places in the northern highlands of the country (Yirdaw 2002, Wassie *et al*. 2005). These remnant forests in the degraded landscapes might contribute to restoration, biodiversity conservation and provide many other environmental, ecological and socio-economic benefits. In addition, Dry Afromontane Forests (DAF) are rich in tree/shrub endemicity compared to the southwest Moist Afromontane Forests (MAF) in Ethiopia (Yeshitila & Shibru 2002).

Yegof forest is one of the remnant forest patches and National Forest Priority Area (NFPA) identified for conservation and production functions in northern Ethiopia. However, human encroachment is still a major threat of the forest due to illegal cutting of trees for timber, construction materials, farm implements, firewood collection and livestock grazing. As a result, the most valuable indigenous tree species are destroyed and wild animals living in the forest are becoming severely affected (Zewde 1989).

Very few studies have been carried out in the forest which focuses on historical perspective of forest management in Wello (Zewde 1989), deforestation (Crummey 1988) and natural resource management (Punkhurst 2001). Thus, there is a need to generate relevant information in order to develop efficient management plan for the forest to ensure biodiversity conservation, sustainable utilization of forest resources and restoration of indigenous vegetation in the degraded areas, as the forest will serve as a seed source. The objectives of the present study were to: a) assess the diversity of woody plants in the forest b) identify the population structure of woody plants and c) assess the natural regeneration status of woody plants in the forest.

MATERIALS AND METHODS
STUDY AREA

The study was conducted in Yegof forest, located between 11^0 06'N and 39^0 45'E in South Wello zone of Amhara National Regional State, northeastern Ethiopia (Figure 1). Yegof Mountain is situated about 380 km north of Addis Ababa, the capital of Ethiopia, on the main road from Addis Ababa to Dessie. Altitude of the study area ranges from 1896 to 2235 m a.s.l. at the southern part of the mountain.

The study area has a unimodal rainfall distribution where there are five rainy months from May to September and there are no small rains. Very high concentration of rain fall occurs in July and August. The dry season extends from October to April (Gamachu 1977). Meteorological data from the nearest town, Kombolcha, indicated that the mean annual minimum and maximum temperature are 12 ^{0}C and 27 ^{0}C, respectively, and the mean annual rainfall is from 800 to 950 mm. The forest is composed of indigenous trees and plantations of fast-growing exotic species and it harbors a small population of Menelik's Bushbuck, Common Bushbuck, Klipspringer, Spotted Hyaena, Vervet Monkey, Porcupine and Rock Hyrax (EWNHS 2011). Sixty-two species of birds have been recorded in a survey conducted in April 1996 indicating that the place is one of the important bird areas of the country (BLI 2009). The soil P^H ranges from slightly acidic (6.0) to neutral (7.26) and the soil texture varies from loam to clay loam with a textural composition of 19-28% clay, 32-41% silt and 27-46 % sand (Eshetu 2002).

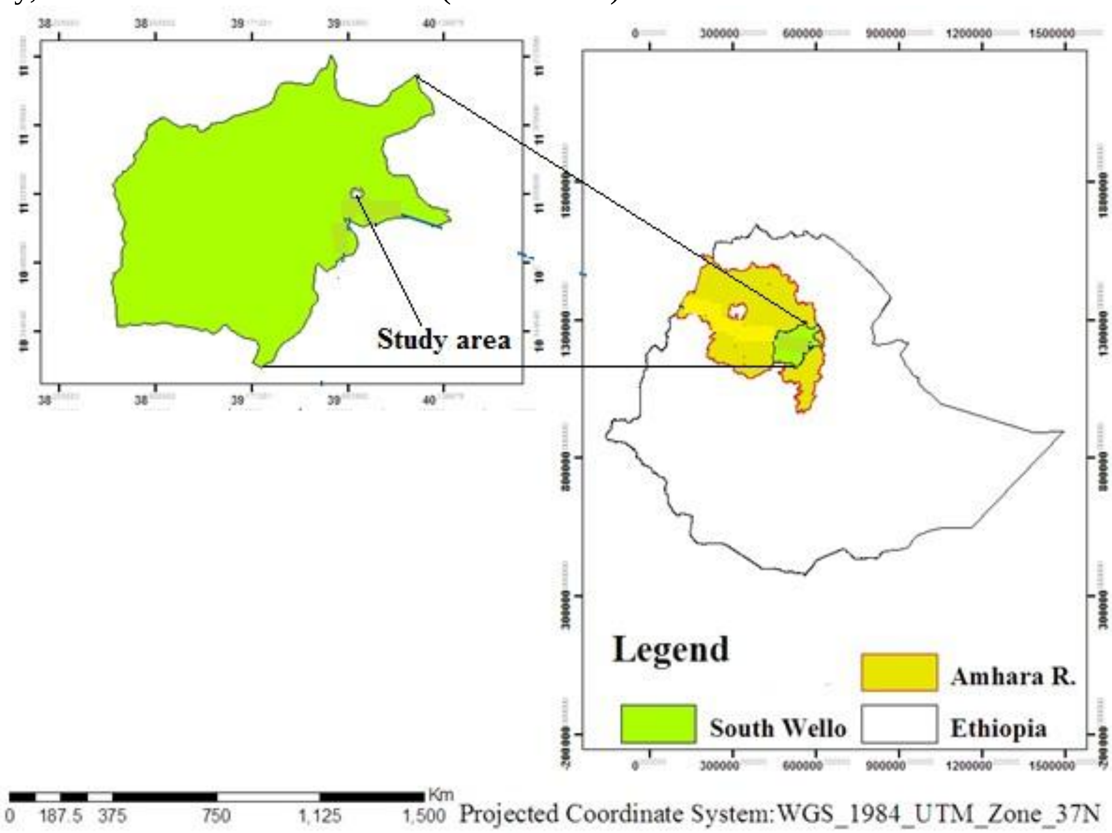

Figure 1: Location map of the study area

VEGETATION DATA COLLECTION

Reconnaissance survey was made in the forest to collect information on site conditions and determine sampling sites. Systematic sampling method (Mueller-Dombois & Ellenberg 1974, Kent & Coker 1992) was employed for inventory of woody species in the study area. Seven line transects 500 m apart were laid down following the altitudinal gradient. A total of 40 plots of 20 m x 20 m were established along line transects at 25 m altitudinal intervals. In each plot, all woody species ≥ 2 cm were identified and counted. Height and diameter at breast height (DBH) were measured by using a meter-marked stick and diameter tape, respectively. Trees/shrubs that branches at breast height or below, diameter of each branch was measured separately and the average was recorded. Individuals of woody species with DBH < 2 cm were counted and recorded as seedlings and considered in the regeneration assessment. In addition, elevation, longitude and latitude of each sampling plot were measured using Garmen 60 GPS. Identification of plant specimens was performed both in the field, and later at the National Herbarium (ETH), Addis Ababa University, using taxonomic keys and the flora of Ethiopia and Eritrea and by comparison with herbarium specimens. Nomenclature of plant specimens in this study follows the Flora of Ethiopia and Eritrea.

DATA ANALYSIS

The diversity of woody species was determined using the Shannon-Wiener Diversity Index (*H'*) and Equitability/evenness index (J) (Kent & Coker 1992, Barnes *et al*. 1998). The Shannon-Wiener diversity index is the most widely used measure of species diversity because it combines species richness with species evenness (relative abundance) (Kent & Coker 1992). The Shannon diversity index (H') was calculated using the following equation:

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

Where, H' = Shannon diversity index, **s** = the number of species, Pi = the proportion of individuals of the i^{th} species expressed as a proportion of total cover in the sample, and ln = the natural logarithm. The Shannon evenness index (J) was also calculated using the following equation:

$$J = \frac{H'}{H'max} = \frac{H'}{\ln s} \ldots\ldots\ldots (2)$$

Where J = Shannon equitability or evenness index, H' = Shannon-Wiener diversity index, H' max = the maximum level of diversity possible within a given population, which equals In s, and s = the number of species, In = the natural logarithm.

Frequency of a species was computed as the proportion of samples within which a species is found. Density was then computed by converting the count from all plots into a hectare basis as indicated in Kent & Coker (1992). The density of individuals with DBH >10 cm to DBH > 20 cm was computed to measure the size class distribution of species in the forest

(Grubb *et al*. 1963). The patterns of species population structure were established based on density of species in different DBH classes and interpreted as indication of variation in population dynamics. Importance Value Index (IVI) of each tree species was computed as indicated in Mueller-Dombois and Ellenberg (1974) using a composite equation (3).
IVI = Relative density (RD) + Relative frequency (RF) + Relative dominance (RDO) -- (3)
where,

$$\text{Relative density (RD)} = \left(\frac{\text{Number of individuals of a tree species}}{\text{Total number of all tree species}}\right) \times 100 \ldots (4)$$

$$\text{Relative frequency (RF)} = \left(\frac{\text{Frequency of a tree species}}{\text{Total frequency of all tree species}}\right) \times 100 \ldots (5)$$

$$\text{Relative dominance (RDO)} = \left(\frac{\text{Dominance of a tree species}}{\text{Dominance of all tree species}}\right) \times 100 \ldots (6)$$

The individuals of a species with higher IVI value are dominant over individuals of species with relatively lower IVI values. The maximum IVI value of a species is 300.

The basal area (m^2 ha^{-1}) of trees and shrubs with DBH ≥ 2 cm was calculated by using the formula

$$\mathbf{BA} = \left(\frac{\mathbf{d}}{\mathbf{200}}\right)^{\mathbf{2}} \times \boldsymbol{\pi} \ldots\ldots\ldots\ldots (7)$$

where, BA = basal area in m^2 ha^{-1}; d = diameter of tree stem at breast height and π = 3.14 (Mueller-Dombois & Ellenberg 1974, Kent & Coker 1992). Phytogeographic comparison of Yegof forest with other montane forests of Ethiopia was computed using Sorensen's similarity coefficient (Ss),

$$\boldsymbol{Ss} = \frac{\boldsymbol{2a}}{\boldsymbol{2a+b+c}} \ldots\ldots\ldots\ldots \mathbf{(8)}$$

where, a = number of species common to both forests compared; b = number of species in one forest; and c = number of species in the other forest (Kent & Coker 1992).

RESULTS AND DISCUSSION

Floristic composition and diversity of woody species

A total of 76 species of plants belonging to 66 genera and 43 families were recorded in the study area. Out of these plant species, 10 (13.2%) were trees, 15 (19.7%) tree/shrub, 39 (51.3%) shrubs, 8 (10.5%) climbers and 4 (5.3%) herbs. Shrubs had the largest proportion of the life forms. Yegof forest is floristically poor compared with many other DAFs like Dodola (Hundera *et al*. 2007), Adelle and Boditi (Yineger *et al*. 2008), Tara Gedam and Abebaye (Zegeye *et al*. 2011) and woodlands (Adamu *et al*. 2012). However, it is more or less comparable with Hugumburda (Aynekulu 2011) and better than Wof Washa (Fisaha *et al*. 2013) and Zengena (Tadele *et al*. 2014) forests. Variation in species composition over different forests could be attributed to topographic differences among the forests and woodlands compared, as well as the degree of availability of suitable environmental conditions in the respective forests (Chen *et al*. 2003). Moreover, forests with a high degree of human interference and disturbance due to livestock grazing for prolonged periods show relatively lower species richness than others (Urban *et al*. 2000).

Fabaceae was the dominant family represented by 9 species (11.84%) followed by Rhamnaceae and Oleaceae 4 species each (5.26%) and Anacardiaceae and Lamiaceae 3 species each (3.95%). Fifteen families were represented by 2 species each (2.63%) and 23 families were represented by 1 species each (1.32%). The highest representation of species from the family Fabaceae (9 species, 11.84%) in Yegof forest could be related to the fact that it is the second largest family in the flora of Ethiopia and Eritrea (Hedberg & Edwards 1989). This could also be attributed to its efficient and successful dispersal strategies as well as better adaptation to a wide range of ecological conditions. Fabaceae was also found to be dominant in other montane forests in Ethiopia like Belete (8 species, 10%) (Hundera & Gadissa 2008), Hugumburda (5 species, 6%) (Aynekulu 2011), Komoto (12 species, 11.65%) (Gurmessa *et al*. 2012), and Zengena (5 species, 10%) (Tadele *et al*. 2014).

A measure of species diversity is an important parameter of a plant community that plays a vital role in ecology and conservation biology. The overall Shannon–Wiener diversity (H') and evenness (J) of woody species in Yegof forest were 2.26 and 0.57, respectively. The species diversity of Yegof forest (H'=2.26) was lower than those reported from other DAFs in the country (e.g., Tara Gedam (H'=2.98) (Zegeye *et al*. 2011), Wof Washa (H'=3.25) (Fisaha *et al*. 2013) and Zengena (H'=2.74) (Tadele *et al*. 2014)). However, the overall diversity of the forest falls within the normal range of Shannon-Wiener diversity index, which lies between 1.5 and 3.5 and rarely exceeds 4.5 (Kent & Coker 1992). The evenness value (J=0.57) was more or less similar with those reported from other Afromontane forests like Sheko (J=0.54) (Senbeta *et al*. 2007) and Tara Gedam (J=0.65) (Zegeye *et al*. 2011), indicating a relatively equitable distribution of individuals among various species in the forest. Local climatic variations and high rate of forest disturbance due to human encroachment and livestock grazing, which are common in the study area, are among the factors most responsible for variations in species diversity and evenness in a given forest (Senbeta & Teketay 2003). Diversity and evenness indices imply the need to conserve the forest to restore its floristic diversity as well as to reduce and/or avoid human pressure.

DENSITY AND FREQUENCY OF WOODY SPECIES

The total density of woody species in Yegof forest was 1,768.13 individuals ha^{-1} (Appendix 1). It was higher than those reported from other DAFs like Dodola (761 individuals ha^{-1}) (Hundera *et al*. 2007), Adelle (898 individuals ha^{-1}) and Boditi (498 individuals ha^{-1}) (Yineger *et al*. 2008), Hugumburda (1,218 individuals ha^{-1}) (Aynekulu 2011), Wof Washa (698.8 individuals ha^{-1}) (Fisaha *et al*. 2013) and woodlands (376.86 individuals ha^{-1}) (Adamu *et al*. 2012) in Ethiopia. However, its density was found to be lower than Tara Gedam (3,001 individuals ha^{-1}), Abebaye (2,850 individuals ha^{-1}) (Zegeye *et al*. 2011) and Zengena (2,202 individuals ha^{-1}) (Tadele *et al*. 2014) forests. Variations in density distributions can be attributed to differences in topographic gradients and habitat preferences of different tree and shrub species forming the forest as well as the degree of anthropogenic influences (Whittaker *et al*. 2003).

The density of woody species with DBH > 2 cm was 1346.88 individuals ha^{-1}. The density of woody species with DBH > 10 cm was 338.75 individuals ha^{-1} whereas that of species with DBH > 20 cm was 82.5 individuals ha^{-1}. Thus, the ratio of density of woody species with DBH > 10 cm to DBH > 20 cm in Yegof forest was 4.1. This value was found to be much higher than other DAFs such as Dodola (1.5) (Hundera *et al*. 2007), Adelle (2.52) and Boditi (2.25) (Yineger *et al*. 2008) and Zengena (2.15) (Tadele *et al*. 2014), indicating a higher predominance of small-sized individuals in Yegof forest. The presence of higher proportion of small-sized individuals indicates that Yegof forest is in a stage of secondary regeneration. According to Grubb *et al*. (1963), higher values for the ratio of small-sized individuals to large-sized individuals indicate a predominance of small-sized individuals that start to grow following excessive cuttings or other anthropogenic disturbances. Similar results were reported by Hundera & Gadissa (2008) and Gurmessa *et al*. (2012). About 76.18% of the total density of woody species was contributed by species with DBH > 2 cm whereas those woody species with DBH > 10 cm and DBH > 20 cm contributed 19.16% and 4.67%, respectively, to the total density.

Dodonea angustifolia was found to be the most frequent species in Yegof forest occurring in 93% of all plots sampled. This might be attributed to its higher density and occurrence in a wide altitudinal range extending from 800 to 2650 m a.s.l. (Bekele 2000). Other species commonly occurring across the plots were *Euclea racemosa* (83%), *Maytenus arbutifolia*, *Osyris quadripartita* (78% each), *Rhus natalensis*, *Rhus retinorrhoea* (75% each), *Olea europaea sbusp. cuspidata* (73%), *Albizia gummifera* (70%), *Calpurnia aurea* (60%), *Pittosporum viridiflorum* (58%) and *Juniperus procera* (50%) (Appendix 1). The frequency distribution of woody species indicated that higher percentage of species were found at lower frequency classes with more than 76% of the species having a frequency value of less than 40%, indicating a relatively good floristic heterogeneity in the study area (Figure 2). Similar result was reported by Tadele *et al*. (2014) in Zengena forest. Variation in the frequency of species might be attributed to habitat preferences among species, species characteristic for adaptation, degree of disturbance and availability of suitable conditions for regeneration (Rey *et al*. 2000).

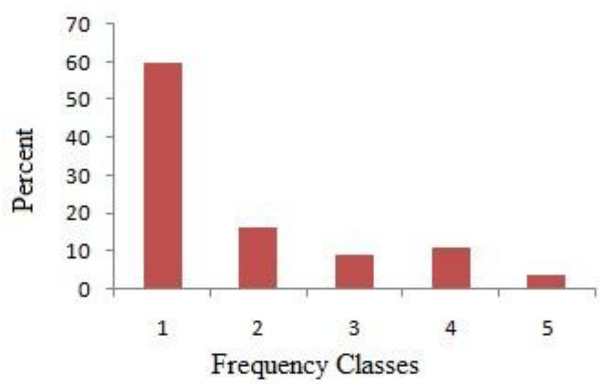

Figure 2: Frequency class distributions of woody species in Yegof forest
Frequency classes: 1 = ≤ 20%; 2 = 20 – 40%; 3 = 40 – 60%; 4 = 60 – 80%; 5 = 80 – 100%.

BASAL AREA AND IMPORTANT VALUE INDEX (IVI) OF WOODY SPECIES

The total basal area of woody species in Yegof forest was 15.85 m^2 ha^{-1}. The species with the highest basal area was *Albizia gummifera* (3.26 m^2 ha^{-1}), followed by *Myrica salicifolia* (1.78 m^2 ha^{-1}), *Juniperus procera* (1.47 m^2 ha^{-1}) and *Podocarpus falcatus* (1.41 m^2 ha^{-1}) (Appendix 1). These four large-sized tree species contributed about 50% of the total basal area. The total basal area of Yegof forest (15.85 m^2 ha^{-1}) is much less than reported for other DAFs such as Adelle (26 m^2 ha^{-1}) and Boditi (23 m^2 ha^{-1}) (Yineger *et al*. 2008), Tara Gedam (115.36 m^2 ha^{-1}) (Zegeye *et al*. 2011), Wof Washa (64.32 m^2 ha^{-1}) (Fisaha *et al*. 2013), Zengena (22.3 m^2 ha^{-1}) (Tadele *et al*. 2014) and woodlands (42.54 m^2 ha^{-1}) (Adamu *et al*. 2012) in Ethiopia. However, it is relatively much better than Hugumburda forest (9.23 m^2 ha^{-1}) (Aynekulu 2011) where most of large-sized tree species are over-exploited. The higher basal area value of *Albizia gummifera* could be attributed to its higher density and frequency than the other three species. According to Cain & Castro (1959), basal area measurements are used to indicate the relative ecological significance and/or dominance of woody species in a forest ecosystem. Thus, *Albizia gummifera* can be designated as the most ecologically significant species in Yegof forest. *Justicia schimperiana*, *Maesa lanceolata*, *Pterolobium stellatum* and *Vernonia amygdalina* had the least input (0.01%) to the total basal area due to their low density and small size.

Albizia gummifera exhibited the highest IVI value (37.28), followed by *Dodonea angustifolia* (24.46), *Juniperus procera* (16.98), *Rhus retinorrhoea* (16.52), *Olea europaea sbusp. cuspidata* (15.92), *Rhus natalensis* (15.26), *Myrica salicifolia* (14.5), *Euclea racemosa* (13.71), *Pittosporum viridiflorum* (12.53) and *Maytenus arbutifolia* (12.1). These top ten woody species contributed about 59.75% of the total IVI in the forest. Eighteen woody species had IVI values of less than 1 (Appendix 1). IVI values can also be used to set conservation priority among plant species in the study area (Shibru & Balcha 2004). Therefore, species with low IVI values such as *Dovyalis abyssinica*, *Combretum aculeatum*, *Dombeya torrida*, *Dichrostachys cinerea*, *Justicia schimperiana*, *Maesa lanceolata*, *Pavetta abyssinica*, *Schrebera alata*, *Vernonia amygdalina*, *Pterolobium stellatum*, *Ziziphus mucronata*, *Ziziphus spina-christi*, *Ficus thonningii* and *Jasminum abyssinicum* should be prioritized for conservation measures in the study area. *Albizia gummifera* has the highest IVI value that could be attributed to its higher basal area

POPULATION STRUCTURE

Plant population structures help to understand the general trend of population dynamics and also provide valuable information about their regeneration, recruitment and viability status that could be used for developing evidence-based conservation and management strategies (Popma *et al*. 1988, Yineger *et al*. 2008). Analysis of the population structure of the top ten most abundant woody species revealed four representative patterns implying different population dynamics among species. The first pattern was represented by *Albizia gummifera* (Figure 3a). It shows lower number of individuals in the first diameter class followed by higher number of individuals in the second and third diameter classes and absence of individuals in the middle and higher diameter classes. This type of population structure suggests poor reproduction and recruitment status. This could be attributed to unfavorable environmental conditions such as rocky land and poorly developed soil, and human disturbance (Zegeye *et al*. 2011). In addition, free grazing and browsing of domestic animals, which is very common in the study area, could have a negative effect on seedling establishment and survival in these and other woody species in the montane forests (Bekele 2000). Similar distribution pattern was reported by (Senbeta *et al*. 2007) for *Celtis zenkeri* in Sheko forest. *Dodonea angustifolia* and *Rhus natalensis* are also characterized by this distribution pattern.

The second pattern was represented by *Euclea racemosa* (Figure 3b). It indicates higher number of individuals in first diameter class followed by very low number of individual in the second diameter class and absence of individuals in the other diameter classes. This type of population structure suggests good reproduction and bad recruitment status (Hundera & Gadissa 2008, Lulekal *et al*. 2008). Use-based exploitation of species in this category (e.g., *Maytenus arbutifolia* and *Calpurnia aurea* are widely used for house construction (huts) and fences in the study area) can be mentioned as a factor for absence of individuals after the middle diameter classes. *Maytenus arbutifolia* and *Calpurnia aurea* also show this type of population structure.

The third pattern was represented by *Pittosporum viridiflorum* (Figure 3c). It exhibits higher number of individuals in the first diameter class and gradually declining numbers with increasing diameter classes. It represents an inverted J-shape distribution although there are no individuals in the middle and higher diameter classes. This might be due to selective cutting of matured individuals for different purposes. This kind of population structure implies a good reproduction and recruitment status of the species in the forest (Zegeye *et al*. 2011, Gurmessa *et al*. 2012, Fisaha *et al*. 2013, Tadele *et al*. 2014). *Olea europaea subsp. cuspidata* and *Rhus retinorrhoea* are also characterized by this distribution pattern.

The fourth pattern was represented by *Juniperus procera* (Figure 3d). It shows higher number of individuals in the first diameter class and an irregular pattern in successive diameter classes. This type of population structure implies good reproduction but hampered recruitment and selective cutting of medium and large sized individuals for different purposes. Similar distribution pattern was reported by (Lulekal *et al*. 2008) for *Podocarpus falcatus* in Mana Angetu forest. Generally, the observed representative population structures of woody species in Yegof forest are indicators for the need to take appropriate conservation measures by the relevant authorities at various levels, giving due attention to those species with poor reproduction and recruitment status as well as reducing human pressure on medium and large sized individuals that would serve as seed sources for regeneration of woody species in the forest and restoration of the surrounding degraded areas.

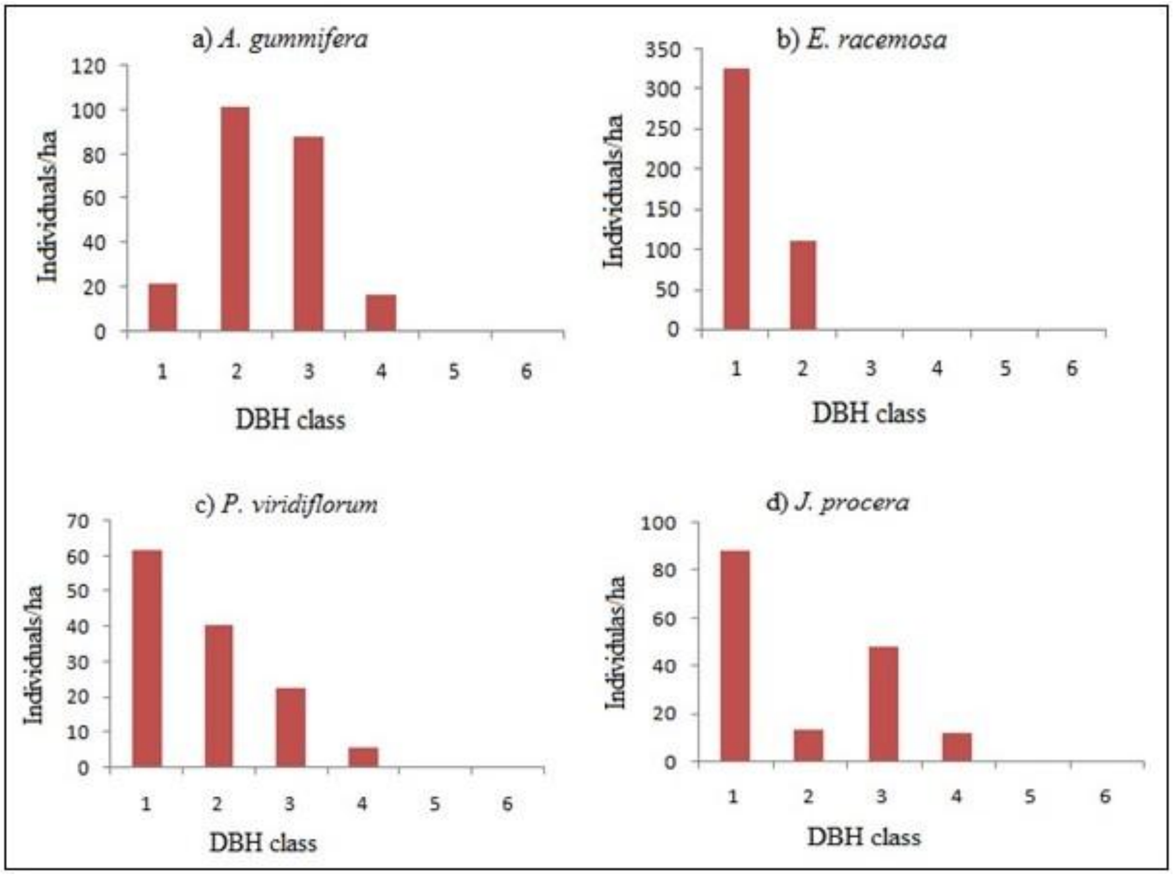

Figure 3(a-d): Population structures of representative woody species in Yegof forest. Diameter classes: 1= 0-2 cm; 2= 2-10 cm; 3= 10-20 cm; 4= 20-40 cm; 5= 40-60 cm; 6= > 60 cm.

PHYTOGEOGRAPHIC COMPARISON

Floristic similarity analysis between Yegof and three DAF and two MAFs in Ethiopia indicated that Yegof forest is floristically more related to the DAFs than the MAFs (Table 1). Yegof forest shows high floristic similarity with Hugumburda (0.42) and Abebaye (0.41) forests that could be attributed to the relative similarities in elevation and climatic factors. The elevation ranges from 1860 to 2700 m a.s.l. in Hugumburda forest (Aynekulu 2011) and from 1921 to 2072 m a.s.l. in Abebaye forest (Zegeye *et al*. 2011). In addition, Yegof and Hugumburda forests receive almost comparable annual rainfall, i.e., the mean annual rainfall in Yegof reaches to 950 mm and that of Hugumburda is 981 mm (Aynekulu 2011). Yegof and Abebaye forest areas also share relatively similar rainy seasons with unimodal rainfall distribution. Therefore, the overlap in elevational ranges coupled with exposure to relatively similar climatic conditions may have resulted in a similarity in the species composition (Urban *et al*. 2000) between these forests.

Conversely, the two MAFs, Masha and Mana Angetu, are floristically dissimilar from Yegof forest. The elevation of Masha forest ranges from 1700 to 3000 m a.s.l. (Abrham Assefa et al., 2013) and the elevation of Mana Angetu forest ranges from 1533 to 2431 m a.s.l. (Ermias Lulekal et al., 2008). Thus, elevational variation could be the factor responsible for the floristic dissimilarities observed between these forests. According to Demel Teketay & Tamrat Bekele (1995), elevational variation is one of the major environmental gradients that could shape the species composition and distribution of plant communities in forest ecosystems.

CONCLUSION

Yegof forest is one of the remnant forest patches and National Forest Priority Areas identified for conservation and production function in the highlands of northeastern Ethiopia. It contains 76 woody species dominated by highest proportion of shrubs indicating that the forest is in a stage of secondary regeneration. Tree species like *Juniperus procera*, *Albizia gummifera*, *Olea europaea subsp. cuspidata*, *Pittosporum viridiflorum* and *Myrica salicifolia* are also found scattered in the adjacent land areas currently used for agriculture, grazing, and settlement suggesting that the area was once covered with similar vegetation types. Habitat fragmentation due to human encroachment is a major threat that will affect successional processes in this remnant forest patch by reducing the regeneration and recruitment potential of several woody species. Sustainability of remnant forest patches like Yegof forest should be given due attention for the existence of many woody plant species, particularly in the highlands of northern Ethiopia where most of the original forest cover have almost disappeared. Species with poor reproduction and hampered/poor recruitment such as *Albizia gummifera, Dodonea angustifolia, Rhus natalensis, Calpurnia aurea*, *Maytenus arbutifolia* and *Euclea racemosa* should be given the first priority for conservation measures.

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Appendix 1. Density (D) in ind. ha^{-1}, Frequency (F), Basal Area (BA) in m^2 ha^{-1}, Relative Density (RD), Relative Frequency (RF), Relative Dominance (RDom.) and Important Value Index (IVI) of woody species in Yegof forest.

Species name	D	F	BA	RD	RF	RDom.	IVI
Abutilon figarianum	1.26	5	0.008	0.071	0.350	0.051	0.471
Acacia lahai	31.88	28	0.808	1.806	1.923	5.096	8.825
Acacia polyacantha	20.63	30	0.404	1.169	2.098	2.551	5.817
Acokanthera schimperi	20.63	23	0.098	1.169	1.573	0.620	3.362
Albizia gummifera	208.76	70	3.259	11.827	4.895	20.559	37.281
Allophylus abyssinicus	45.63	58	0.163	2.585	4.021	1.030	7.636
Bersama abyssinica	11.88	20	0.100	0.673	1.399	0.634	2.705
Calpurnia aurea	61.25	60	0.113	3.470	4.196	0.712	8.378
Canthium lactescens	25.63	23	0.176	1.452	1.573	1.113	4.139
Carissa spinarum	30.01	55	0.057	1.700	3.846	0.357	5.903
Celtis africana	20	28	0.184	1.133	1.923	1.163	4.220
Combretum aculeatum	1.88	5	0.005	0.106	0.350	0.028	0.484
Combretum molle	5.63	10	0.089	0.319	0.699	0.560	1.578
Cordia africana	1.88	8	0.475	0.106	0.524	2.996	3.627
Croton macrostachyus	18.14	35	0.418	1.027	2.448	2.635	6.110
Dichrostachys cinerea	3.13	5	0.009	0.177	0.350	0.055	0.582
Dodonea angustifolia	236.88	93	0.730	13.385	6.469	4.606	24.460
Dombeya torrida	5.63	5	0.012	0.319	0.350	0.074	0.742
Dovyalis abyssinica	3.13	3	0.003	0.177	0.175	0.018	0.370
Dovyalis verrucosa	3.75	15	0.004	0.212	1.049	0.023	1.285
Ehretia cymosa	6.25	8	0.030	0.354	0.524	0.190	1.068

Ekebergia capensis	10.63	13	0.150	0.602	0.874	0.949	2.425
Euclea racemosa	111.26	83	0.259	6.303	5.769	1.634	13.707
Ficus sur Forssk.	5.01	8	0.076	0.283	0.524	0.478	1.286
Ficus thonningii	3.76	3	0.056	0.212	0.175	0.353	0.740
Grewia arborea	6.89	8	0.060	0.390	0.524	0.381	1.295
Grewia ferruginea	10	23	0.023	0.567	1.573	0.143	2.283
Heteromorpha arborescens	1.88	5	0.002	0.106	0.350	0.014	0.470
Jasminum abyssinicum	4.38	8	0.008	0.248	0.524	0.048	0.820
Juniperus procera	74.38	50	1.470	4.214	3.497	9.274	16.984
Justicia schimperiana	0.63	3	0.001	0.035	0.175	0.006	0.216
Maesa lanceolata	1.25	5	0.001	0.071	0.350	0.008	0.428
Maytenus arbutifolia	89.38	78	0.256	5.064	5.420	1.618	12.102
Myrica salicifolia	35.63	18	1.784	2.018	1.224	11.253	14.496
Myrsine Africana	28.13	23	0.033	1.593	1.573	0.211	3.378
Nuxia congesta	5.63	10	0.095	0.283	0.699	0.601	1.583
Olea europaea sbusp. cuspidata	105.64	73	0.770	5.984	5.070	4.861	15.915
Olinia rochetiana	16.88	10	0.038	0.956	0.699	0.237	1.893
Osyris quadripartita	60.63	78	0.169	3.435	5.420	1.068	9.922
Ozoroa insignis	1.88	3	0.008	0.106	0.175	0.049	0.331
Pavetta abyssinica	1.88	8	0.004	0.106	0.524	0.025	0.655
Phytolaca dodecandra	1.25	5	0.003	0.071	0.350	0.018	0.439
Pittosporum viridiflorum	68.76	58	0.732	3.895	4.021	4.615	12.531
Podocarpus falcatus	32.5	15	1.410	1.841	1.049	8.896	11.786
Premna oligotricha	24.38	38	0.077	1.310	2.622	0.483	4.416
Pterolobium stellatum	1.25	5	0.001	0.071	0.350	0.009	0.430
Rhus natalensis	133.13	75	0.398	7.507	5.245	2.512	15.264
Rhus retinorrhoea	127.51	75	0.637	7.259	5.245	4.017	16.521
Rosa abyssinica	13.13	20	0.019	0.744	1.399	0.121	2.263
Schrebera alata	2.5	8	0.011	0.142	0.524	0.067	0.734
Teclea simplicifolia	9.39	18	0.051	0.531	1.224	0.319	2.074
Toddalia asiatica	11.88	20	0.023	0.673	1.399	0.142	2.214
Vernonia amygdalina	0.63	3	0.001	0.035	0.175	0.007	0.217
Ziziphus mucronata	0.63	3	0.003	0.035	0.175	0.017	0.227
Ziziphus spina-christi	1.89	5	0.075	0.106	0.350	0.472	0.928
Total	1768.13	1430	15.85	100	100	100	300