Vegetative structure, floristic composition and natural regeneration of a species in Ylat Forest, Meket Woreda, Northeastern Ethiopia

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Manuscript received: 3 March 2017. Revision accepted: 29 June 2017.

Abstract. Tegegne S, Workineh B. 2017. Vegetative structure, floristic composition and natural regeneration of a species in Ylat Forest in Meket Woreda, Northeastern Ethiopia. Asian J For 1: 40-53. The natural forest of Ylat in Meket Woreda, Northeastern Ethiopia was examined to decide the vegetative structure, floristic formation and natural regeneration of woodland species and to supply data on sustainable administration of the woody plants in specific and the woodland founts in common. Systematic sampling design was used in this study to gather vegetation information. For each of the sampling sites, five transect lines having fifty-four primary plots with 400 m² (20m × 20m) each were laid out to gather the information on woody species along 200 m line transects. A total of 60 vascular plant species having a place to 41 families and 56 genera were identified of which 13 (21.67%) were trees, 31 (51.67%) bushes, 6 (10%) climbers and 10 species (16.66) of herbs. Of the families, Lamiaceae (8.33%) and Fabaceae, Rosaceae, Solanaceae and Euphorbiaceae 3 species (5%) were the most overwhelming woody plant species and followed by Sapindaceae, Aloaceae, Ranunculaceae, Poaceae, Oleaceae, Polygonaceae and Cucurbitaceae contains 2 species each (3.33%). A total of 2652 woody plant species individuals (1227.77 individual/ha) were found of which 405 individuals were Myrsine africana and 19 individuals were Millettia ferruginea and 20 individuals were Dombeya torrida. This data showed the highest and the lowest number of woody plant species. The thickness of woody species with DBH ≥ 2.5cm was 1227.77 individual/ha, basal zone was 1 m² /ha, frequency of woody species was 258. The overall Shannon diversity and evenness of woody species was 2.94 and 0.84 respectively, demonstrating that the diversity and evenness of woody species within the timberland is moderately high. The woody plant species having the highest importance value index (IVI) were Erica arborea (36.31) followed by Allophylus abyssinicus (28.65) whereas Hagenia abyssinica, Myrica salicifolia, Euphorbia tirucalli, Calpurnia auroa were the lowest IVI and should be given conservation priority. Finally, this study showed that the population structure of the most woody plant species in Ylat Timberland was in a great state of regeneration recruitment level.

Keywords: Floristic composition, vegetation structure, regeneration status, Ylat Forest

INTRODUCTION

Ethiopia is considered as one of the top twenty five richest countries in the world in terms of biodiversity (WCMC 1994). Around 6000 species of higher plants is the estimation, of which about 10% are endemic (Ensermu and Sebsebe 2014). And also as Anonymous (1997a, b) suggests that, Ethiopia has the fifth largest flora in Africa. A very heterogeneous flora and a rich endemic element are considered to be caused by the diversity in climate, vegetation and terrain. A report from Kelbessa et al. (1992), indicated that six endangered endemic plant species are found in Ethiopia especially in the Ogaden region of the ecosystem only, which is floristically the richest in endemism in Ethiopia.

Vegetation is defined as an assemblage of plants growing together in a particular location and characterized either by its component species or by the combination of structural and functional characters that determine the appearance or physiognomy of vegetation (Goldsmith et al. 1986). A system of largely spontaneously growing plants is called vegetation. Not all growing plants form vegetation; for instance, a sown corn field or flower beds in a garden forms no vegetation. But the weeds surrounding such plants do form vegetation. A pine plantation will turn into vegetation after a few years of spontaneous growth of the pine trees. The vegetation of Ethiopia is complicated. There is a variation from region to region; some regions of the countries (Southern and South Western parts of the countries) are relatively richer in biodiversity than the other parts of the countries. The complexities of vegetation arise from the great variation in altitude employing equally great spatial difference in moisture regime as well as temperature and also depend on rainfall and altitude variation (Woldu 1999).

Vegetation types in Ethiopia are also highly diverse, varying from Afroalpine and Sub Afroalpine to Riparian and swamp vegetation.Those includes Afroalpine and Sub Afroalpine vegetation, Dry evergreen montane forest and grassland, Moist evergreen montane forest, Evergreen scrub, Combretum Terminalia (broad-leaved) deciduous woodland, Acacia-Commiphora (small- leaved) deciduous woodland, Lowland semi-ever green forest, The desert and semi-desert scrubland, and Riparian and swamp vegetation (Friis and Demissew 2001).

Ethiopia is also a very important centre of crop genetic diversity and for this reason; it is one of the twelve Vavilovian centers (Vavilov 1951; Harlan 1969). It has a very high genetic diversity in four of the world’s widely grown food crops (wheat, barley, sorghum, peas), in three
of the world's most important industrial crops (linseed, cotton, castor bean), in the world's most important cash crop (coffee), and in food crops of regional and local importance (teff, finger millet, nug, sesame, enset) (EPA 1997).

However, the vegetation resources, including forests are being devastated at an alarming rate, due to a number of causes. The predominant causes for the devastation of natural forests are agriculture (the expansion and the conversion of natural vegetation to farmland) and overexploitation for various purposes such as fuel wood, cultivation purpose, charcoal production, construction material and timber, uncontrolled utilization of natural founts (over-consumption), deforestation. Additionally, forest fires, land degradation, habitat loss, drying of water bodies, soil erosion and fragmentation, invasive species, and wetland destruction (drying of water bodies) leads to the decline of forest and forest resource. All are accelerated by rapid human population growth. The growing of population is at a rate of about 3%/y. Bad management of stake holders such as Zone, Woreda and Kebele rural and agricultural organizations also leads to the decline of natural high forest. One of the biggest challenges for the country is deforestation. The natural high forest will be gone in a few decade time due to deforestation (accelerated decline of vegetation). Deforestation and land degradation lead to ecological and socio-economic crises in Ethiopia (Lisanework 1987). The current rate of deforestation is 15000-20000 hectare per year (EFAP 1994).

In case of the above factors, Ethiopia’s forest area reduced from 16% in the 1950s and to 3.1% by 1982 (UNEP 1992). According to Yirdaw (1996), the annual loss of the high land montane forest areas of Ethiopia has been estimated at between 160,000 and 200,000 ha. Because of the rapid decrease of forests plant and animal species that are important both at national and global levels, they are in the state of endangered now. This is mainly attributed to lack of proper conservation strategies and practices of forest and forest resources (Kelbessa et al. 1992). As the plant and animal species are lost from the area, the indigenous knowledge and associated practices will also be obscured and finally will be gone forever. Consequently, the danger certainly poses a major threat to the well being of the population that depends on the biological resources of this ecosystem (Beyene 2010).

Most of the remaining natural forests in Ethiopia are found in the southern and South- Western parts of the country, and the forests have virtually disappeared from the rest of the country except a few scattered and relatively small areas of forest cover that remained in the northern, central and eastern parts of the country (Gebre Egziabher 1986). Generally, the remaining forests are only small remnant patches mostly confined to inaccessible areas (mountain tops and steep slopes) and sacred places (churches, monasteries and mosques) (Wassie et al. 2002). With the prevailing alarming rate of deforestation and other factors described above, the remaining natural forests could disappear within a few decades, unless appropriate and immediate measures are taken (Zegeye et al. 2010).

As described above, according to the report of WCMC (1994), Ethiopia is considered as one of the top twenty five richest countries in the world in terms of biodiversity. Most of the ecosystems or habitats are important for biodiversity conservation and excluded from the country’s system of protected areas. In order to conserve the wildlife genetic resources, Hillman (1993), described that, some protected areas at different levels has been built by the government and 193,600 Km² of land has been dedicated for wild life protection area. The Wild life Conservation Areas are divided into two main categories, namely, Principal Wildlife Conservation Areas, which include nine National Parks and four Wildlife Sanctuaries, and Secondary Wildlife Conservation Areas (WCA) comprising eight Wildlife Reserves and eighteen Controlled Hunting Areas (CHA). But up to now, there is no formal protected area which has been built to conserve an ecosystem or habitat important for plant species although Ethiopia’s biodiversity is mainly due to the high diversity of the plant species (Tadesse 1991).

Various studies have been conducted in different parts of our country Ethiopia on population dynamics and regeneration ecology of forests (Demissew 1988; Alelign et al. 2007; Beyene 2010; Getaneh 2012). The outcomes of these works give relevant information on the rejuvenation status of numerous trees and bush species, which are very important to perform suitable conservation and management measures. But up to now, there is no study carried out on the floristic composition and vegetative structure of Ylat Forest found in Amhara region North Wollo Zone Meket Woreda.

The objectives of this research were (i) to document the floristic composition of woody plant species of Ylat Forest, Meket Woreda, Northeastern Ethiopia (ii) to describe the vegetative structure of the forest, (iii) to evaluate the natural regeneration status of woody plant species of the forest.

MATERIALS AND METHODS

Description of the study area

Location and geographical features of the district

The study was carried out in the month of October 2008 in the Ylat Forest in Meket Woreda, border of Boya and Kolla Boya Kebele. Meket Woreda is one of the twelve districts of North Wollo Zone Amhara regional state located at a distance about 657 km from Addis Ababa, North East Ethiopia (Meket Woreda Communication Office) (Figure 1).

As the information gained from Meket Woreda Agricultural and Rural Office, the capital of the district is Filakit (found at 11° 35' 55" -12° 2' 30" N and 38° 32' 35" - 39°16'40" E) located on the main highway about 137 km west from Woldiya, the capital of North Wollo zone. The district is bordered on the North by Bugna, on the East by Gubalafto and Gidan, on the West by Gaynt and on the South by Wadla Woreda. The ranges altitude of the study area are 1699 – 3502 meters above sea level having 47 kebeles in which out of those 6 are urban kebeles.
Climate

The data from the head of the Meket Woreda Agricultural Office Ato Anteneh Alemie show that the study area is generally characterized by diverse agroclimatic zones; most of which are the “Kolla” and “Woyna dega” climates that are comparable to cold arid and warm to cool Sub-humid (semi cold, semi hot-arid) climatic types respectively. There are also various climatic and other environmental conditions.

The area is often characterized by the mean minimum and maximum temperature of 18 and 27.8°C. In the district area, low temperature is recorded during the month of July to October 15, but sometimes in January, low temperature is recorded when rain fall during autumn season. And also high temperature is recorded from the month of February 15 to June 15. The mean annual rain fall ranges from 900mm-1400mm. High rainfall are during the month of June to August and low rainfall is during autumn season from March to May.

Topography and soil

The study area is generally characterized by rough topography. It consists of mountains and gorges. The district falls an altitudinal range of 1699-3502 m.a.s.l. The major soil type and their spatial coverage in the district is Camisol 58.03%. Other soil types are also found in the study area (Litosol 12%, Roaksol 15.47%, Ntosol 6.12% and Vertisol 15.47%). The livelihood of the local people is predominantly based on subsistence agriculture. Agriculture activity is characterized by mixed cropping practices with the main principal crops of bean, pea, maize, teff, sorghum, barely, wheat and nug etc. and the cash crops including lentil and garlic (Meket Woreda Agricultural and Rural Development Office).

Vegetation

The vegetation type of the Ylat Forest is indicated by patches of scattered plants like Acacia albida, Dodonaea angustifolia, Bersama abyssinica, Maytenus arbustifolia, Croton macrostachyus, Olea europaea, Myrsine africana, Juniperus procera and Myrica salicifolia etc. The forest covers large area about 102 km² a few times later. But the forest is declining due to various reasons such as agriculture expansion and cultivation, fuel wood, timber production etc. One of the many serious problems in Ethiopia is deforestation. Vegetations have been cleared for the various purposes as described above. Now, the Ylat Forest is protected and it is the only forest conserved in the Meket Woreda.

Human population and social condition

According to the data obtained from the study Woreda information office, the total population of the observed district Meket Woreda was 273,000, among those 137,256 were males and 134,744 were females. All people in this area speak Amharic language (100%) and they belong to Amhara ethnic group. The two common religions embraced by these people are Orthodox (94.35%), Islam (4.95), and 0.7% people embrace other types of religion.

Wild Life

The information from kebele agricultural officer describe that the study area is generally poor in wildlife due to deforestation and high human interference. However, different kinds of wild animals are also found, such
as mammals like apes, monkeys, antelopes, common fox, leopards, rabbit, Ethiopian tiger, and hyena and birds including jигра etc. are found.

Methodology for data collection

**Reconnaissance survey**

To obtain vegetation patterns of the study area and to identify representative sampling sites about the forest, reconnaissance survey of Ylat Forest was conducted in the month of October 2008 E.C.. According to Panwar and Bhardwaji (2005), it is important to know the size of the vegetation as well as the number of plots to be laid out per hectare before data collection. In this case 20 m x 20 m (400 m²) plots were laid on the study area to collect the vegetation data. The data was collected from November to December 2008 E.C..

**Sampling design (vegetation data collection)**

Systematic sampling design was employed for this study to collect vegetation data, and it followed the line transect method described by Bullock (1996). In this method, parallel line transects were laid across the forests in west-east direction determined using compass. For each of the sampling sites, five transect lines each having 54 main plots was used to sample vegetation data. The first sampling point was established systematically which is 200 m away from each other. Plots having equal size of 20 m x 20 m (400 m²) was laid out to collect the data on woody species. The distance between main plots was 200 m along each of the transect lines. The latitude, longitude and altitude were taken from the center of each main plot and a GPS (Global Positioning System) was used to do the measurement. In each quadrant, all woody plant species with a DBH of ≥ 2.5 cm was measured and recorded.

In each quadrat, all the plant species were recorded. Data on Diameter at Breast Height (DBH) / Diameter at Shrub Height (DSH) of the trees or shrubs, number of stems, coverage of each of trees/shrubs and coverage of herbaceous composition of collection were totalled from collection of 54 quadrats of 20 x 20m (400m²). Specimens of all plant species were collected, pressed and identified at the National Herbarium using Flora of Ethiopia and Eritrea. Diameters at Breast Height (DBH) ≥ 2.5 cm of trees and shrubs were measured by using diameter tape following the methods described by Cunningham (2001). Individuals of trees and shrubs with DBH < 2.5cm was counted as seedlings. New woody plant species occurring outside the sampling plots (quadrats) were also recorded to prepare a complete checklist of plants in the area. Diameter was measured for each individual trees and shrubs having DBH (Diameter at Breast Height) using a conventional tape-meter. Diameter of small and big trees was measured by using a caliper and diameter tape, respectively.

The plot was made by using two measuring tapes bisecting at right angles in each center locating the four corners of the plot, and the square plot was fenced with a rope made from sack.

**Methods of data analysis**

**Structural data analysis**

Density, frequency, diameter at breast height (DBH), dominance, importance value index (IVI) and basal area were used in the analysis of quantitative structure data to describe vegetation structure in all 54 sample plots.

**Density of the plant species.** Density is defined as the number of plants of a certain species per unit area. It is closely related to abundance but more useful in estimating the importance of a species. The counting is usually done in small plots placed several times into vegetation communities under study and the sum of individuals per species is calculated in terms of species density per convenient area unit such as a hectare (Mueller-Dombois and Ellenberg 1974).

\[
D = \frac{\text{Number of above ground stems of a species counted}}{\text{Sampled area in hectare(he)}}
\]

The relative density of the species is calculated by using the following formula.

\[
RD = \frac{\text{Number of individual tree species}}{\text{Total number of individuals} \times 100}
\]

**Frequency of the plant species.** Frequency is defined as the chance of finding a species in a particular study sample. According to Goldsmith et al.(1986), frequency is obtained by using quadrants and expressed as the number of quadrants occupied by a given species per number thrown or more often, as percentage. Higher frequency means higher importance of the plant in the community.

\[
F = \frac{\text{Number of plant in which species occur}}{\text{Total number of plots} \times 100}
\]

The importance of a species within the frequency can be obtained by comparing the frequency of occurrences to the entire tree species present, and it is called the relative frequency and the formula is as follows:

\[
RF = \frac{\text{Frequency of one species}}{\text{Total frequency} \times 100}
\]

**Relative dominance of plant species.** Relative dominance is the ratio of dominance of individual tree species per dominance of all tree species. It will be calculated by the following formula:

\[
RDO = \frac{\text{Dominance of individual tree species}}{\text{Dominance of all species} \times 100}
\]

Dominance is the degree of coverage of species as an expression of the space at ground level (Mueller-Dombois and Ellenberg 1974). Dominance is measured in terms of cover or basal area. It is the mean basal area per tree times the number of tree species.

**Diameter at Breast Height (DBH) plant species.** This measurement technique is carried out at about 1.3m height
from the ground using a measuring tape. It is easy, quick, inexpensive and relatively accurate. There is direct relationship between DBH and basal area (Beyene 2010). Basal area is the area outline of a plant near ground surface. It is the cross-sectional area of tree stems at DBH.

\[ \text{Basal area} = \sum \pi \left( \frac{d}{2} \right)^2 \]

Where:
- \( d \) is diameter at breast-height and \( \pi = 3.14 \)

**Importance Value Index of the species.** It is used to calculate woody plant species. In calculating this index, the percentage values of the relative frequency, relative density and relative dominance are summed up together and this value is designated as the Importance Value Index or IVI of the species (Kent and Coker 1992). As Lamprecht (1989) indicates that, it is useful to compare the ecological significance of species.

IVI = Relative density + Relative frequency + Relative dominance

**Plant diversity analysis of plant species**

The diversity of woody species (species richness and evenness) will be determined using the Shannon-Wiener Diversity Index (H’) and Evenness or Equitability Index (E) (Krebs 1999 and Barnes et al. 1998). Especially for Shannon-Wiener Diversity Index (H’), in addition to counting for species richness and evenness, it is not affected by sample size and it used to measure the degree of uncertainty namely, if the diversity is high in a given habitat, the certainty of observing a particular species is low (Kent and Coker 1992; Krebs 1999). While Shannon-Wiener Equitability index (H’) (the relative equitability or evenness) of the species in each cluster was also calculated using Microsoft Excel. The species evenness that measures the equity of species in a samples area is represented by 0 and 1, are equally abundant (Whittaker 1972). As Molles (2007) described that, it can be zero which is the value for a community with a single species and takes a maximum value of lnS for a given number of species (S), when the same number of individuals represents all species also increases as species richness and evenness increases.

Both the Shannon-Wiener Diversity Index (H’) and Evenness or Equitability Index (E) expressed as follows,

\[ H’ = \sum_{i=1}^{S} P_i \ln P_i \]

Where,
- \( H’ \) is the Shannon-Wiener Diversity Index,
- \( \sum P_i \) is sum of species from species 1 to species \( S \),
- \( P_i \) is the proportion of individual’s abundance of the \( i^{th} \) species,
- \( S \) is number of species encountered,
- \( \ln \) is natural logarithm in base e.

\[ J = \frac{H’}{H_{\text{max}}} \times 100 \]

Where:

\( H’ \) max = ln S

\( H’ \) is Shannon diversity index

lnS is the natural logarithm of the total number of species in each community

\( S \) is number of species in each community

**RESULTS AND DISCUSSION**

**Floristic composition**

In this study, 60 species of vascular plants representing 41 families and 36 genera were identified and recorded (Table S1). Out of the 60 identified plant species, 51.67% (31 in numbers) were shrubs, 21.67% (13 in numbers) were trees, 10% (6 in numbers) were lianas and 16.66% (10 in numbers) were herbs (Figure 2).

Out of the total families, 8.33% were Lamiaceae, 5% were Fabaceae, Rosaceae, Solanaceae, and Euphorbiaceae and 3.33% were Sapindaceae, Aloeaceae, Ranunculaceae, Poaceae, Oleaceae, Polygonaceae and Cucurbitaceae (Table 1).

**Woody species**

A total of 31 species belonging to 23 families and 31 genera with \( \geq 2.5 \text{cm} \) DBH of woody species individuals were recorded from 54 sample plots (2.16). The highest number of species were Rosaceae, Solanaceae, Lamiaceae and Fabaceae, followed by Euphorbiaceae and Sapindaceae. 1227.77 were the total woody plant species individuals recorded with \( M. \) africana as the highest of all woody species with 15.27% (Table S2).

\( M. \) africana, \( E. \) arborea and \( D. \) angustifolia were the dominant species consecutively. \( M. \) salicifolia, \( D. \) torrida, \( C. \) tomentosa, \( M. \) ferruginea and \( E. \) tirucalli were some of the rare species within the plot. \( E. \) arborea and \( A. \) abyssinicus were the most common (most frequent) species in the sample plots in Ylat Forest.

**Vegetation structure**

**Woody species density and DBH (Diameter at Breast Height)**

The numbers of individuals which have DBH \( \geq 2.5 \text{cm} \) were 1227.77. \( M. \) africana had 15.27% of the total density followed by \( E. \) arborea (14.4%) and \( D. \) angustifolia (6.79%) (Table S2). These 3 woody species were the most dominant species. The least abundant species recorded were \( M. \) salicifolia (0.72%), \( D. \) torrida (0.75%), \( C. \) tomentosa and \( E. \) tirucalli (0.9%) and \( M. \) ferruginea (1.02%). The mean density of woody species of the study vegetation was higher than Acheria forest (1034.17 individuals per hectare) (Getaneh 2012).

The following Table 2 shows that 97.15% of woody species individuals were in \( \leq 10 \text{cm} \) DBH classes and about 2.85% was within 10 < 20 cm DBH classes. An increase in DBH causes significant decrease on number of individuals. The Ylat Forest is composed of high proportion of small sized woody species. \( O. \) ficus-indica was the maximum of all woody species that have an average DBH 65.08 cm (Table 3 and Table S3).
Figure 2. Plant growth forms habit types in Ylat Forest, Meket Woreda, Northeastern Ethiopia. Note: Herbaceous includes herbs and grasses while woody species includes lianas, shrubs and trees

Table 1. Plant families with their genera and species distribution in Ylat Forest, Meket Woreda, Northeastern Ethiopia

| Family         | No. of Genera | % of Genera | No. of Species | % of Species |
|----------------|---------------|-------------|----------------|--------------|
| Lamiaceae      | 2             | 3.57%       | 5              | 8.33%        |
| Fabaceae       | 3             | 5.36%       | 3              | 5            |
| Rosaceae       | 3             | 5.36%       | 3              | 5            |
| Euphorbiaceae  | 3             | 5.36%       | 3              | 5            |
| Solanaceae     | 3             | 5.36%       | 3              | 5            |
| Aloeaceae      | 1             | 1.79%       | 2              | 3.33%        |
| Ranunculaceae  | 2             | 3.57%       | 2              | 3.33%        |
| Sapindaceae    | 2             | 3.57%       | 2              | 3.33%        |
| Poaceae        | 2             | 3.57%       | 2              | 3.33%        |
| Cucurbitaceae  | 2             | 3.57%       | 2              | 3.33%        |
| Polygonaceae   | 2             | 3.57%       | 2              | 3.33%        |
| Oleaceae       | 2             | 3.57%       | 2              | 3.33%        |
| Acanthaceae    | 1             | 1.79%       | 1              | 1.67%        |
| Loganiaceae    | 1             | 1.79%       | 1              | 1.67%        |
| Capparidaceae  | 1             | 1.79%       | 1              | 1.67%        |
| Apocynaceae    | 1             | 1.79%       | 1              | 1.67%        |
| Sterculiaceae  | 1             | 1.79%       | 1              | 1.67%        |
| Flacourtia     | 1             | 1.79%       | 1              | 1.67%        |
| Ericaceae      | 1             | 1.79%       | 1              | 1.67%        |
| Myricaceae     | 1             | 1.79%       | 1              | 1.67%        |
| Ebenaceae      | 1             | 1.79%       | 1              | 1.67%        |
| Meliaceae      | 1             | 1.79%       | 1              | 1.67%        |
| Apiaceae       | 1             | 1.79%       | 1              | 1.67%        |
| Balsaminaceae  | 1             | 1.79%       | 1              | 1.67%        |
| Cupressaceae   | 1             | 1.79%       | 1              | 1.67%        |
| Malvaceae      | 1             | 1.79%       | 1              | 1.67%        |
| Celasteraceae  | 1             | 1.79%       | 1              | 1.67%        |
| Myrsinaceae    | 1             | 1.79%       | 1              | 1.67%        |
| Asparagaceae   | 1             | 1.79%       | 1              | 1.67%        |
| Convolvulaceae | 1             | 1.79%       | 1              | 1.67%        |
| Cactaceae      | 1             | 1.79%       | 1              | 1.67%        |
| Santalaceae    | 1             | 1.79%       | 1              | 1.67%        |
| Phytolaccaceae | 1             | 1.79%       | 1              | 1.67%        |
| Anacardiaceae  | 1             | 1.79%       | 1              | 1.67%        |
| Salicaceae     | 1             | 1.79%       | 1              | 1.67%        |
| Urticaceae     | 1             | 1.79%       | 1              | 1.67%        |
| Scrophulariaceae| 1             | 1.79%       | 1              | 1.67%        |
| Asteraceae     | 1             | 1.79%       | 1              | 1.67%        |
| Gutierrezaceae | 1             | 1.79%       | 1              | 1.67%        |
| Geraniaceae    | 1             | 1.79%       | 1              | 1.67%        |
| Myrtaceae      | 1             | 1.79%       | 1              | 1.67%        |
| Total          | 56            | 100%        | 60             | 100%         |

Table 2. Distribution of woody species in DBH classes

| DBH (cm) | Density/ha | % |
|----------|------------|---|
| ≤10      | 1192.77    | 97.15 |
| 10<20    | 35         | 2.85  |
| 20<30    | 0          | 0     |
| 30<40    | 0          | 0     |
| ≥40      | 0          | 0     |

Table 3. Dominant woody species with their percentage basal area of Ylat Forest, Meket Woreda, Northeastern Ethiopia

| Species                  | Density/ha | Average BA/ha (cm) | BA/ha | Percentage |
|--------------------------|------------|--------------------|-------|------------|
| Opuntia ficus-indica     | 65.08      | 0.154              | 15.465|
| Acacia albida            | 64.09      | 0.149              | 14.98 |
| Juniperus procera        | 62.23      | 0.141              | 14.14 |
| Allophyles abyssinicus   | 55.11      | 0.11               | 11    |
| Erica arborea            | 49.97      | 0.091              | 9.12  |

Basal area

The total basal area of woody species was 1 m²/ha (Table S4). *Opuntia ficus-indica* (15.465%), *Acacia albida* (14.98%) and *J. procera* (14.14%) were some of the highest basal area woody species. According to Dawins (1959; cited in Lamprecht 1989) the normal area of virgin tropical forest in Africa is 23-37m²/ha. Based on the report, the basal area of Ylat Forest is low indicating the woody species are thin and scattered.

*Opuntia ficus-indica* has low density but highest basal area because of its high value of DBH while *E. arborea* has high density but low value of basal area because of its low value of DBH.

Frequency

The most frequent woody species in Ylat Forest were *E. arborea* (12.79%), *Allophyles abyssinicus* (12.02%) and *M. africana* (10.85%). The less frequent woody species were *E. tirucalli, Opuntia ficus-indica, Hagenia abyssinica, M. salicifolia* and *Withania seminifera* (Table S2).

Frequency indicates an approximate homogeneity and heterogeneity of species. Lamprecht (1989) pointed out that the high value in higher frequency and low value in lower frequency classes indicate constant or similar species composition where as high value in lower frequency classes and low values in higher frequency indicate high degree of floristic heterogeneity. For convenience, the Ylat Forest woody species had been classified into four frequency classes (Table 4).

In the table, the result showed that there was high value in lower frequency classes and low values in higher frequency. This indicated that Ylat Forest had heterogeneous species composition. The similar result was also gotten from South Wollo zone, Yogof forest (Mohammed and Abraha 2013).
The five most dominant woody species of Ylat Forest had 48.24% of the total importance value index (Table S5 and Table 5). Those dominant species were *E. arborea*, *A. abyssinicus*, *J. procera*, *M. africana* and *A. albida*. This result shows that much of IVI was attributed by few species. About 57.57% of woody species had IVI value less than 5 indicating the requirement for conservation management.

### Species population structure

Dissimilar scheme of species population structure can indicate variation in population dynamics. The schemes are based on various size classes (DBH) and density. On the other hand, the variation could arise from inherent characters, interventions of human and livestock.

The six most significant values of woody species representing 33 species in Ylat Forest whose IVI value > 18 are illustrated in Figure 3. The population structure of *E. arborea*, *A. abyssinicus*, *J. procera*, *M. africana*, *A. albida* and *E. globulus* shows inverted J curve population high number of individuals in the first DBH class by a progressive decrease in the number of individuals with increasing DBH. This scheme indicates good rejuvenation and recruitment. This successful regeneration might be associated with its environmental adaptation. As diameter increase, the density of this species also increases.

### Regeneration status of the Ylat Forest

The counting of the composition and the density of seedlings and saplings of woody species were done in Ylat Forest. Since, the number and type of seedlings and saplings in any vegetation cover shows the regeneration status of that vegetation cover. Accordingly, a total of 1339.83 seedlings/ha, 1319.45 saplings/ha and 122.77 mature individuals/ha were recorded. From the analysis of seedlings and saplings data, the density of tree was 604.74/ha and shrub seedlings was 735.09/ha. Similarly, the densities of trees and shrub species saplings were 627.32/ha and 692.13/ha respectively (Figure 4).

The ratio of seedlings to mature individuals of woody species in Ylat Forest was 1.09:1, the ratio of seedlings to saplings was 1.02:1 and sapling to mature individuals was 1.07:1. This result shows the presence of more seedlings than saplings and saplings than mature woody species, which indicates successful regeneration of forest species.

The woody species in the study area were categorized into two groups based on the number of seedlings and saplings encountered during the study (Table 6).

From this study, *E. arborea*, *J. procera*, *M. africana* and *A. albida* had highest number of saplings/ha. *E. arborea*, *M. africana*, *D. angustifolia* and *D. penninervium* had the highest number of seedlings/ha in the study area (Table S6).

The composition, distribution and density of seedlings and saplings indicate the future status of the vegetation cover. Woody species in category “B” needs priority of conservation.

### Importance value index

Mcintosh (1967) pointed out Important Value Index gives a more realistic figure of dominance from the structure standpoints. Lamprecht (1989) also noted that the IVI is useful to compare the ecological significance of species.

The result of IVI showed that *E. arborea* (12.09%), *A. abyssinicus* (9.59%), *M. africana* (9.2%), *J. procera* (9.17%) and *A. albida* (8.19) were plant species with highest importance value index, while *M. salicifolia* (0.43%), *E. tirucalli* (0.5%), *H. abyssinica* (0.58%), *Calpurnia aurea* (0.9%) and *F. ferruginea* (0.96%) were species with lowest importance value index.
Figure 3. Population structure of six important woody species in Ylat Forest, Meket Woreda, Northeastern Ethiopia. DBH A: 2.5-10cm, B: 10.1-20cm, C: 20.1-30cm, D: 30.1-40cm, E: > 40cm

Figure 4. Seedling and sapling distribution of woody species of Ylat Forest, Meket Woreda, Northeastern Ethiopia

Species diversity and evenness
The diversity and evenness of woody species in Ylat Forest is relatively high. It is indicated by 2.94 of diversity value and 0.84 of evenness value. According to Kent and Coker (1992), Shannon-Wiener index value varies between 1.5 and 3.5 and to exceed 4 is rare. Thus, the result of the present study showed that the Ylat Forest has an balanced species distribution. It is showed by the relatively high value of Shannon-Wiener diversity index (H’=2.94) of Ylat Forest which is more diverse that of Menagesha Suba State forest (H’=2.57) (Beche 2011).
The regeneration status of different woody plant species in Ylat Forest, Meket Woreda, Northeastern Ethiopia

| Group | Species |
|-------|---------|
| A     | Acacia albida  
Allophylus abyssinicus  
Calpurnia aurea  
Capparis tomentosa  
Carissa spinarum  
Clerodendrum alatum  
Clerodendrum myricoides  
Croton macrostachus  
Discopodium penminivervum  
Dodonaea angustifolia  
Doyyalis abyssinica  
Erica arborea  
Euclaptus globulus  
Euclea racemosa subsp. schimperi  
Euphorbia tirucalli  
Hagenia abyssinica  
Hypericum revolutum  
Juniperus procera  
Millletia ferruginea  
Myrica salicifolia  
Myrsine africana  
Olea europaea subsp. cuspidata  
Opuntia ficus-indica  
Oxysir quadrripartita  
Prunus africana  
Rhus retinorrhoea  
Rosa abyssinica  
Salix subserata  
Withania somnifera |
| B     | Dombeya torrida  
Otostegia tomentosa |

Note: Group "A" = species with ≥ 1 seedlings and saplings and Group “B”=species no seedlings and saplings at all.

The analysis of floristic composition, vegetative structure and regeneration data on Ylat Forest between altitudinal gradients of 1699-3502 m. The counting activity found a total of 60 species belonging to 41 families and 56 genera. The collection activity in Ylat Forest yielded 1227.77 individual hec⁻¹ woody plant species. And it is also found that there were high value of woody plant species in first frequency classes, low value in the next frequency classes, a simple decline in the last frequency class. Therefore, this indicated that the Ylat Forest had heterogeneous species composition. From the overall distribution DBH classes, in Ylat Forest, high contribution of woody plant species in the lower Diameter Basal Height classes and lower plant contribution in the higher classes or as the DBH class size increases, the number of individuals gradually decrease which stimulates an ordinary inverted J-shaped distribution. It brings to an indication that the dominance of small sized individuals dominate the forest and allegedly due to selective cutting of large tree individuals for agriculture (farm implements), charcoal production and building houses (construction purpose) the forest remains in the status of good regeneration high recruitment potential. The data analysis of Ylat Forest revealed that the density value of seedling (1339.83 individual hec⁻¹) and sapling (1319.45 individual hec⁻¹) of the population structure were relatively higher than the value on the mature (1227.77 individual hec⁻¹) woody plant species, although, there was a fact that, due to the different factors, before reaching the maturity, the seedling and sapling individuals died, but this still brought up a good status of the vegetation cover in the future and a priority for conservation should be given.

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Table S1. Plant species, family and growth habit recorded from Ylat Forest, Meket Woreda, Northeastern Ethiopia

| Scientific name       | Family          | Habit  |
|-----------------------|-----------------|--------|
| Acacia albida Del.    | Fabaceae        | Tree   |
| Acanthus senii Chiov. | Acanthaceae     | Shrub  |
| Allophylus abysinicus (Hochst.) Radlk. | Sapindaceae | Tree   |
| Aloe rehmannii         | Aloeaceae       | Herb   |
| Aloe pulcherrima Gilbert and Sebsehe | Aloeaceae | Shrub  |
| Anthoxanthum aethopicum I. Hedberg | Poaceae | Herb   |
| Asparagus africanus Lam. | Asparagaceae | Shrub  |
| Bersama abyssinica Fresen. | Melianthaceae | Shrub  |
| Buddleja polyphylla Schott | Loganiaceae | Shrub  |
| Calpurnia aurea (Ait.) Benth. | Fabaceae | Shrub  |
| Capparis tomentosum Lam. | Capparidaceae | Shrub  |
| Carissa spinarum       | Apocynaceae     | Shrub  |
| Clematis sintenis Fresen. | Ranunculaceae | Liana  |
| Clerodendrum alatum Güere | Lamiastraceae | Shrub  |
| Clerodendrum myricoides (Hochst.) Vatke | Lamiaceae | Shrub  |
| Clusia abyssinica Jaub. & Spach. | Euphorbiaceae | Shrub  |
| Croton macrostachyus Del. | Euphorbiaceae | Tree   |
| Cucumis ficifolius A.Rich. | Cucurbitaceae | Shrub  |
| Discopodium penninitum Hochst. | Solanaceae | Shrub  |
| Dodonaea angustifolia L.f. | Sapindaceae | Shrub  |
| Dombeya torrida (J.F.Gmel.) P. Bamps | Sterculiaceae | Shrub  |
| Dovyalis abyssinica (A.Rich.) Warb. | Flacourtiaeeae | Shrub  |
| Erica arborea L. | Ericaceae | Shrub  |
| Eucliptus globulus Labill | Myrtaceae | Shrub  |
| Euclea racemosa Murr. Subsp. shumperi (A.DC.). White | Ebenaceae | Shrub  |
| Euphorbia tirucalli L. | Euphorbiaceae | Tree   |
| Fendia comminns L. | Apiceae | Herb   |
| Geranium arabicum Forssk. | Geraniaceae | Shrub  |
| Hagenia abyssinica (Brace) J.F. Gmel. | Rosaceae | Tree   |
| Hibiscus crassinervius Hochst. ex A. Rich. | Malvaceae | Shrub  |
| Hypericum revolutum Vahl | Guttiferaeae | Tree   |
| Hypparrhenia variabilis Stapf | Poaceae | Herb   |
| Impatiens rothii Hook.f. | Balsaminaceae | Herb   |
| Inula confertiflora A. Rich. | Asteraceae | Shrub  |
| Ipomeova tenuirostris Choisy | Convolvulaceae | Liana  |
| Jasminum grandiflorum L. | Oleaceae | Liana  |
| Juniperus procera Hochst.ex Endl. | Cupressaceae | Tree   |
| Maytenus arbutifolia (A. Rich) Vilczek | Celastraceae | Shrub  |
| Millettia ferruginea (Hochst.) Bak. | Fabaceae | Shrub  |
| Myrica salicifolia A. Rich. | Myricaceae | Shrub  |
| Myrsine africana L. | Myrsinaceae | Tree   |
| Olea europaea L. subsp. cuspidata (Wall. ex G.Don) Cif. | Oleaceae | Tree   |
| Opuntia ficus-indica (L) Miller | Cactaceae | Shrub  |
| Osyris quadriparritita Decn. | Santalaceae | Tree   |
| Otostegia integrifolia Bentham. | Lamiastraceae | Shrub  |
| Otostegia tomentosa A. Rich. | Lamiastraceae | Shrub  |
| Otostegia tomentosa A. Rich subsp ambigens (Chiov.) Sebald | Lamiastraceae | Shrub  |
| Phytolacca dodendron L. He rit. | Phytolaccaeae | Liana  |
| Prunus africana (Hook. f) Kalkm. | Rosaceae | Tree   |
| Rhaz retinorhorea Oliv. | Anacardiaceae | Shrub  |
| Rosa abyssinica Lindley | Rosaceae | Shrub  |
| Rumex nepalesis Spreng. | Polygonaceae | Herb   |
| Rumex nervosus Vahl | Polygonaceae | Shrub  |
| Salix subserrata Willd. | Salicaceae | Shrub  |
| Solanum marginatum L.f. | Solanaceae | Shrub  |
| Thalictrum rhynchocarpum Dill. & A. Rich. | Ranunculaceae | Herb   |
| Ureca hypselodendron (A. Rich) Wedd. | Urticaceae | Liana  |
| Verbascum sinaicum Bent. | Scrophulariaceae | Herb   |
| Withania somnifera (L.) Dunal | Solanaceae | Shrub  |
| Zehnera scabra (Linn. f) Sond. | Cucurbitaceae | Liana  |

Table S2. Woody species, number of stems, density and frequency of Ylat Forest, Meket Woreda, Northeastern Ethiopia

| Scientific name        | No. of stems | Density | Density/r. ha (%) | Freq. freq (%) |
|------------------------|--------------|---------|-------------------|---------------|
| Acacia albida           | 131          | 60.65   | 4.94             | 12            | 4.65 |
| Allophylus abyssinicus  | 150          | 69.44   | 5.65             | 31            | 12   |
| Calpurnia aurea         | 35           | 16.2    | 1.32             | 3.2           | 1.16 |
| Capparis tomentosa      | 24           | 11.11   | 0.9              | 2             | 0.78 |
| Carissa spinarum        | 48           | 22.22   | 1.81             | 3             | 1.16 |
| Clerodendrum alatum     | 66           | 30.56   | 2.49             | 2             | 0.78 |
| Clerodendrum myricoides | 45           | 20.83   | 1.69             | 2             | 0.78 |
| Croton macrostachyus    | 30           | 13.89   | 1.13             | 3             | 0.78 |
| Discopodium penniniervium | 144     | 66.67   | 5.43             | 12            | 4.65 |
| Dendronaea angustifolia | 180          | 83.33   | 6.79             | 7             | 10   |
| Dovyalis abyssinica     | 34           | 15.74   | 1.28             | 3             | 1.16 |
| Erica arborea           | 381          | 176.39  | 14.4             | 33            | 12.79|
| Eucliptus globulus      | 61           | 28.24   | 2.3              | 2             | 5.7  |
| Euclea racemosa         | 51           | 23.61   | 1.92             | 2             | 0.78 |
| Olae europaea subsp. cuspidata | 44     | 20.37   | 1.66             | 3             | 1.04 |

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### Table S3. DBH range of woody species of Ylat Forest, Meket Woreda, Northeastern Ethiopia

| Scientific name               | Diameter at Breast Height (cm) |
|-------------------------------|--------------------------------|
|                              | 1-10  | 11-20 | 21-30 | >40  |
| Acacia albida                 | 131    | 0     | 0     | 0    |
| Allophylus abyssinicus        | 150    | 0     | 0     | 0    |
| Calophrinia aurea             | 35     | 0     | 0     | 0    |
| Capparis tomentosa            | 24     | 0     | 0     | 0    |
| Carissa spinarum              | 48     | 0     | 0     | 0    |
| Clerodendrum alatum           | 66     | 0     | 0     | 0    |
| Clerodendrum myricoides       | 45     | 0     | 0     | 0    |
| Croton macrostachyus          | 30     | 0     | 0     | 0    |
| Discopodium penninervium      | 144    | 0     | 0     | 0    |
| Dodonaea angustifolia         | 180    | 0     | 0     | 0    |
| Dombeya torrida               | 20     | 0     | 0     | 0    |
| Duvialis abyssinica           | 34     | 0     | 0     | 0    |
| Erica arborea                 | 381    | 0     | 0     | 0    |
| Euclaptus globulus            | 61     | 0     | 0     | 0    |
| Euclea racemosa subsp. schimperi | 51    | 0     | 0     | 0    |
| Euphorbia tirucalli           | 24     | 0     | 0     | 0    |
| Hagenia abyssinica            | 28     | 0     | 0     | 0    |
| Hypericum revolutum           | 141    | 0     | 0     | 0    |
| Juniperus procera             | 128    | 0     | 0     | 0    |
| Millettia ferruginea          | 27     | 0     | 0     | 0    |
| Myrica salicifolia            | 19     | 0     | 0     | 0    |
| Myrsine africana              | 405    | 0     | 0     | 0    |
| Olea europaea subsp. cuspidata | 44    | 0     | 0     | 0    |
| Opuntia ficus-indica          | 0      | 35    | 0     | 0    |
| Osyris quadripartita          | 47     | 0     | 0     | 0    |
| Ootogea tomentosa             | 96     | 0     | 0     | 0    |
| Prunus africana               | 37     | 0     | 0     | 0    |
| Rhus retinorhoea              | 89     | 0     | 0     | 0    |
| Rosa abyssinica               | 42     | 0     | 0     | 0    |
| Salix subserata               | 57     | 0     | 0     | 0    |
| Withania somnifera            | 33     | 0     | 0     | 0    |
| Total                         | 2617   | 35    | 0     | 0    |

### Table S5. Importance Value Index (IVI) of each woody species of Ylat Forest, Meket Woreda, Northeastern Ethiopia resulted from the sum of relative density, relative frequency and relative dominance

| Scientific name               | r. density | r. freq  | r. dom  | IVI    |
|-------------------------------|------------|----------|---------|-------|
| Acacia albida                 | 4.94       | 4.65     | 14.98   | 24.57 |
| Allophylus abyssinicus        | 5.65       | 12       | 11      | 28.65 |
| Calophrinia aurea             | 1.32       | 1.16     | 0.21    | 2.69  |
| Capparis tomentosa            | 0.9        | 0.78     | 2.19    | 3.87  |
| Carissa spinarum              | 1.81       | 1.16     | 0.55    | 3.52  |
| Clerodendrum alatum           | 2.49       | 0.78     | 0.8     | 4.07  |
| Clerodendrum myricoides       | 1.69       | 0.78     | 0.42    | 3.27  |
| Croton macrostachya           | 1.13       | 0.78     | 2.32    | 4.23  |
| Discopodium penninervium      | 5.43       | 4.65     | 2.61    | 12.69 |
| Dodonaea angustifolia         | 6.79       | 3.89     | 2.37    | 13.05 |
| Dombeya torrida               | 0.75       | 2.33     | 0.41    | 3.5   |
| Duvialis abyssinica           | 1.28       | 1.16     | 0.61    | 3.06  |
| Erica arborea                 | 14.4       | 12.79    | 9.12    | 36.31 |
| Euclaptus globulus            | 2.3        | 9.7      | 8.02    | 20.02 |
| Euclea racemosa subsp. schimperi | 1.92       | 0.78     | 1.53    | 4.23  |
| Euphorbia tirucalli           | 0.9        | 0.39     | 0.21    | 1.5   |
| Hagenia abyssinica            | 1.06       | 0.39     | 0.29    | 1.74  |
| Hypericum revolutum           | 5.32       | 3.49     | 4.21    | 13.02 |
| Juniperus procera             | 4.83       | 8.52     | 14.14   | 27.49 |
| Millettia ferruginea          | 1.02       | 1.55     | 0.25    | 2.82  |
| Myrica salicifolia            | 0.72       | 0.39     | 0.17    | 1.285 |
| Myrsine africana              | 15.27      | 10.85    | 1.49    | 27.61 |
| Olea europaea subsp. cuspidata | 1.66       | 4.04     | 1.12    | 6.82  |
| Ootogea tomentosa             | 1.32       | 0.39     | 15.46   | 17.175 |
| Osyris quadripartita          | 1.77       | 0.78     | 0.41    | 2.96  |
| Prunus africana               | 3.62       | 3.1      | 0.42    | 7.14  |
| Rhus retinorhoea              | 1.41       | 1.93     | 1.37    | 4.71  |
| Rosa abyssinica               | 3.36       | 2.3      | 0.53    | 6.19  |
| Salix subserata               | 1.58       | 1.55     | 0.39    | 3.52  |
| Withania somnifera            | 2.15       | 1.55     | 0.34    | 4.04  |
| Total                         | 100        | 100      | 100     | 300   |
Table S4. Basal Area (BA) and dominance of woody species in Ylat Forest, Meket Woreda, Northeastern Ethiopia

| Scientific name                  | BA   | BA/ha  | BA%  | Mean BA | total no. | Dominancy | r. dominancy |
|----------------------------------|------|--------|------|---------|-----------|-----------|--------------|
| Acacia albida                    | 0.322| 0.1491 | 14.98| 0.002458| 131       | 0.322     | 14.98        |
| Allophylus abyssinicus           | 0.2384| 0.1104 | 11   | 0.001589| 150       | 0.2384    | 11           |
| Calpurnia aurea                  | 0.0045| 0.002083| 0.21| 0.00012857| 35       | 0.0045    | 0.21         |
| Capparis tomentosa               | 0.04712| 0.0218 | 2.19 | 0.0001963| 24       | 0.04712   | 2.19         |
| Carissa spinarum                 | 0.011934| 0.005525| 0.55| 0.00024862| 48       | 0.011934  | 0.55         |
| Clerodendrum alatum              | 0.0172| 0.007963| 0.8  | 0.0002606| 66       | 0.0172    | 0.8          |
| Clerodendrum myricoides          | 0.00894| 0.0041375| 0.42| 0.000199| 45       | 0.00894   | 0.42         |
| Croton macrostachyus             | 0.0499| 0.0231 | 2.32 | 0.001663| 30       | 0.0499    | 2.32         |
| Discopodium penninervium         | 0.05621| 0.02602| 2.61 | 0.003903| 144      | 0.05621   | 2.61         |
| Dodonaea angustifolia            | 0.051| 0.02361| 2.37 | 0.000283| 180      | 0.051     | 2.37         |
| Dombeya torrida                  | 0.00897| 0.00415| 0.417| 0.00305| 20       | 0.00897   | 0.417        |
| Doryalis abyssinica              | 0.013267| 0.006142| 0.617| 0.0003902| 34       | 0.013267  | 0.617        |
| Erica arborea                    | 0.1961| 0.091 | 9.12 | 0.000515| 381      | 0.1961    | 9.12         |
| Euclaptus globulus               | 0.1724| 0.0798| 8.02 | 0.00283| 61       | 0.1724    | 8.02         |
| Euclea racemosa subsp. schimperi | 0.033| 0.01528| 1.53 | 0.00647| 51       | 0.033     | 1.53         |
| Euphorbia tirucalli              | 0.0046| 0.00212| 0.21 | 0.00019166| 24       | 0.0046    | 0.21         |
| Hagenia abyssinica               | 0.0062| 0.00285| 0.29 | 0.0002214| 28       | 0.0062    | 0.29         |
| Hypericum revolutum              | 0.09054| 0.042| 4.21 | 0.00642| 141      | 0.09054   | 4.21         |
| Juniperus procera                | 0.304| 0.141 | 14.14| 0.002375| 128      | 0.304     | 14.14        |
| Millettia ferroginia             | 0.0054| 0.002481| 0.25| 0.0002| 27       | 0.0054    | 0.25         |
| Myrica salicifolia               | 0.00377| 0.00175| 0.175| 0.001984| 19       | 0.00377   | 0.175        |
| Myrsine africana                 | 0.032| 0.0148| 1.49 | 0.000079| 405      | 0.032     | 1.49         |
| Olea europaea subsp. cuspidata   | 0.024| 0.012 | 1.12 | 0.00535| 44       | 0.024     | 1.12         |
| Opuntia ficus-indica             | 0.3325| 0.15394| 15.465| 0.0095| 35       | 0.3325    | 15.465       |
| Osyris quadripartita             | 0.0089| 0.004157| 0.41| 0.001911| 47       | 0.0089    | 0.41         |
| Otoxegia tomentosa               | 0.009122| 0.004223| 0.42| 0.000905| 96       | 0.009122  | 0.42         |
| Prunus africana                  | 0.0294| 0.0136| 1.37 | 0.000795| 37       | 0.0294    | 1.37         |
| Rhus retinorrhoea                 | 0.01145| 0.00535| 0.53| 0.0012865| 89       | 0.01145   | 0.53         |
| Rosa abyssinica                  | 0.00834| 0.00386| 0.39| 0.001985| 42       | 0.00834   | 0.39         |
| Salix subserrata                 | 0.00722| 0.003343| 0.34| 0.001027| 57       | 0.00722   | 0.34         |
| Withania somnifera               | 0.04| 0.02016| 1.86 | 0.00133| 33       | 0.04      | 1.86         |
| Total                           | 2.15| 1      | 100  | 0.0587| 2652     | 2.15      |              |
Table S6. The regeneration status of woody plant species in Ylat Forest, Meket Woreda, Northeastern Ethiopia

| Scientific name                          | Seedlings/ha | Saplings/ha |
|------------------------------------------|--------------|-------------|
| Acacia albida                            | 66.203       | 67.13       |
| Allophylus abyssinicus                   | 49.17        | 27.315      |
| Calpurnia aurea                          | 28.241       | 35.19       |
| Capparis tomentosa                       | 32.41        | 50.463      |
| Carissa spinarum                         | 17.593       | 58.33       |
| Clerodendrum alatum                      | 30.55        | 27.3        |
| Clerodendrum myricoides                  | 29.17        | 28.704      |
| Croton macrostachyus                     | 31.02        | 34.26       |
| Discopodium penninervium                 | 73.61        | 14.352      |
| Dodonaea angustifolia                    | 75.463       | 60.65       |
| Dombeya torrida                          | 0            | 0           |
| Dovyalis abyssinica                      | 45.83        | 43.52       |
| Erica arborea                            | 185.65       | 157.41      |
| Euclaptus globulus                       | 30.0926      | 25          |
| Euclea racemonsa subsp. schimperi        | 13.426       | 18.06       |
| Euphorbia tirucalli                      | 63.89        | 65.74       |
| Hagenia abyssinica                       | 30.093       | 31.944      |
| Hypericum revolutum                      | 47.69        | 57.87       |
| Juniperus procera                        | 53.24        | 75.93       |
| Millettia ferruginea                     | 12.5         | 9.722       |
| Myrica salicifolia                       | 43.43        | 61.574      |
| Myrsine africana                         | 79.17        | 71.2963     |
| Olea europaea subsp. cuspidata            | 43.06        | 42.13       |
| Opuntia ficus-indica                     | 68.06        | 61.57       |
| Osyris quadripartita                     | 34.26        | 37.5        |
| Otostegia tomentosa                      | 0            | 0           |
| Prunus africana                          | 44.44        | 40.741      |
| Rhus retinorhoea                         | 46.759       | 45.37       |
| Rosa abyssinica                          | 18.98        | 19.91       |
| Salix subserrata                         | 24.074       | 22.685      |
| Withania somnifera                       | 21.76        | 27.78       |
| Total                                    | 1339.83      | 1319.45     |