



VEGETATIVE STRUCTURE, FLORISTIC COMPOSITION AND NATURAL
REGENERATION OF A SPECIES IN YLAT FOREST IN MEKET WOREDA,
NORTH EASTERN ETHIOPIA

BY
SISAY TEGEGNE

A THESIS SUBMITTED TO THE SCHOOL OF GRADUATE STUDIES OF ADDIS ABABA
UNIVERSITY IN PARTIAL FULFILLMENT OF THE REQUIREMENT FOR THE DEGREE OF
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ABSTRACT

The natural forest of Ylat in Meket Woreda, North Eastern Ethiopia was studied to determine the vegetative structure, floristic composition and natural regeneration of forest species and provide information on sustainable management of the woody plants in particular and the forest resources in general. Systematic sampling design was employed for this study to collect vegetation data. For each of the sampling sites, five transect lines each having fifty-four main plots with 400 m² (20m × 20m) were laid out to collect the data on woody species along 200m line transects.

A total of 60 vascular plant species belonging to 41 families and 56 genera were identified of which 13 (21.67%) were trees, 31 (51.67%) shrubs, 6 (10%) climbers 10 species (16.66) and herbs each. Of all the families, Lamiaceae (8.33%) and Fabaceae, Rosaceae, Solanaceae and Euphorbiaceae 3 species (5%) were the most dominant woody plant species 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 encountered of which 405 in number were *Myrsine africana* and *Millettia ferruoginea* 19 in number of individuals and *Dombeya torrida* 20 in number of individuals were the highest the lowest woody plant species respectively. The Density of woody species with DBH ≥ 2.5cm (1227.77 individual/ha), basal area (1 m² /ha), frequency of woody species (258) the overall Shannon diversity and evenness of woody species was 2.94 and 0.84 respectively, indicating that the diversity and evenness of woody species in the forest is relatively high. The woody plant species that have the highest importance value index (IVI) were *Erica arborea* (36.31) followed by *Allophylus abyssinicus* (28.65) while *Hagenia abyssinica*, *Myrica salicifolia*, *Euphorbia tirucalli*, *Calpurnia aurea* were the lowest IVI should be given conservation priority. Finally, this study indicated that the population structure of the most woody plant species in Ylat forest is in a good state of regeneration recruitment level.

Key words: Floristic composition, vegetation structure, regeneration status, Ylat forest

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Acronyms

BA	Basal Area
CSA	Central Statistical Agency
DBH	Diameters at Breast Height
EBI	Ethiopian Biodiversity Institute
EFAP	Ethiopian Forestry Action Program
EPA	Environmental Protection Program
FAO	Food and Agricultural Organization
GPS	Global Positioning System
IUCN	International for the Conservation of nature
IVI	Important Value Index
RD	Relative Density
RDO	Relative Dominance
RF	Relative Frequency
UNEP	United Nation Environmental Program
UNRISD	United Nations Research Institute for Social Development
WCMC	World Conservation Monitoring Center

CHAPTER ONE

1. INTRODUCTION

Ethiopia is considered as one of the top twenty five richest countries in the world in terms of biodiversity (WCMC, 1994). It is estimated to around 6000 species of higher plants, of which about 10% are endemic (Ensermu and Sebsebe, 2014). And also as Anonymous (1997a, b) indicates that, Ethiopia has the fifth largest flora in Africa. The flora is very heterogeneous and has a rich endemic element owing to the diversity in climate, vegetation and terrain. Ensermu Kelbessa *et al.* (1992), report 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). Vegetation is a system of largely spontaneously growing plants. Not all growing plants form vegetation; for instance, a sown corn field or flower beds in a garden do not. But the weeds surrounding such plants do form vegetation. A pine plantation will become vegetation after some years of spontaneous growth of the pine trees. The vegetation of Ethiopia is complex. 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 as compared to 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 (Zerihun Woldu, 1999).

Vegetation types in Ethiopia also highly diverse, varying from Afroalpine and Sub Afroalpine to Riparian and swamp vegetation (Friis and Sebsebe Demissew, 2001). 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 Sebsebe 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, 1998).

However, the vegetation resources, including forests are being destroyed at an alarming rate, because of a number of factors. The major factors for the destruction of natural forests are agricultural (expansion conversion of natural vegetation to farmland) and overexploitation for various purposes such as fuel wood, cultivation purpose, charcoal production, construction material and timber, unsustainable utilization of natural resources (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 spurred by rapid human population growth. Population is growing at a rate of about 3% yr⁻¹ (Anonymous 1988). Poor management of stake holders such as Zone, Woreda and Kebele rural and agricultural organizations also leads to the decline of natural high forest.

Deforestation is one of the biggest challenges for the country. The natural high forest will be gone in a few decade time due to deforestation (accelerated the decline of vegetation). Deforestation and land degradation lead to ecological and socio-economic crises in Ethiopia (Gebre Egziabher, 1986 and Nigatu, 1987). The current rate of deforestation is (i.e. 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, 1983). According to Eshetu 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. Due to the high decline of forests plant and animal species that are important both at national and global levels are becoming endangered, this is mainly attributed to lack of proper conservation strategies and practices of forest and forest resources (Ensermu 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 become lost 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 (Semere 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) (Alemayehu Wassie *et al.*, 2005). 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 (Haileab Zegeye *et al.*, 2010).

As described above, according to WCMC (1994) report, Ethiopia is considered as one of the top twenty five richest countries in the world in terms of biodiversity. The most of the ecosystems or habitats important for biodiversity conservation are not included in the country's system of protected areas. In order to conserve the wildlife genetic resources, Hillman (1993), described that, Ethiopia has established protected areas at different levels and dedicated 193,600Km² of land to 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, no area has been formally protected in the country 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 (Mesfin Tadesse, 1991).

Various studies have been conducted in different parts of our country Ethiopia on population dynamics and regeneration ecology of forests (Aleling *et al.*, 2007; Friis *et al.*, 1982; Getaneh, 2006; Gilbert, 1970; Habtam, 2012; Haileab *et al.*, 2010; Hailu, 1982; Haugen, 1992; Kumelachew and Tamrat, 2002; Lisanework and Mesfin, 1989; Sebsebe, 1988; Semere, 2010; Tamrat, 1993a,b, 1994; Tesfaye *et al.*, 2001; Zerihun, 1985; Zerihun *et al.*, 1989; Zerihun and Mesfin, 1990). The results of these works provide relevant information on the regeneration status of many tree and shrub species, which is of paramount importance to undertake appropriate conservation and management measures. But up to now there is no study carried out on the floristic composition and vegetative structure of Yilat forest found in Amhara region North Wollo Zone Meket Woreda.

The study was conducted, to document the diversity of woody plant species so as to improve information and to recommend for the management sustainable utilization and conservation of the forest resource at Yilat forest. Yilat forest is one of the ruminant forests found in Amhara region, North wollo zone, Meket woreda. Now a day due to the loss of endemic species and the spread of exotic species in Ethiopia this study used to identify the vegetative composition and to recommend better conservation of the forest.

1.2. OBJECTIVES OF THE STUDY

1.2.1. General objectives

To determine the species composition, vegetative structure and status of natural regeneration of woody species that can form the basis for the sustainable management of woody plants in particular and the forest resources in general.

1. 2.2. Specific objectives

- To document the floristic composition of woody plant species of Yilat forest
- To describe the vegetative structure of the forest
- To evaluate the natural regeneration status of woody plant species of the forest

CHAPTER TWO

2. LITERATURE REVIEW

2.1. Dry Evergreen Afromontane forests and Grassland Complex Vegetation Type

The Ethiopian highlands contribute large coverage of land area with Afromontane vegetation, of which Dry Evergreen Afromontane Forests form the largest part. Dry Evergreen Afromontane forest and Grassland complex vegetation type is a complex system of succession with grassland rich in legume shrub and small to large trees of closed forest with a canopy of several strata. It occurs in an altitudinal range of 1800-3000 m, with average annual temperature and rainfall of 14-25⁰c and 700-1100 (rarely up to 1700 mm), respectively (Friis, 1992; Friis et al., 2010).

About 40 species, subspecies and varieties of woody plants occur in this vegetation type, from these 128 (27.83%) are reported only from this vegetation type. This indicates that this vegetation type is rich with species composition (Friis et al., 2010).

According to Friis et al., (2010), there are four subtypes recognized. Undifferentiated Afromontane Forest; Dry single-Dominant Afromontane forest of the Ethiopian highlands; Afromontane woodland, wooded grassland and grassland Transition between Afromontane vegetation and Acacia-Commiphora Bushland on the Eastern escarpments. Some of the common Dry Evergreen Afromontane forest studied from highlands and mountain chains of Ethiopia include: Anabe and Denkoro Forest in Wollo (Mesfin Tadesse, 1993), Chilimo Forest and Wof- Washa Forest, Menagesha Suba Forest (Sebsebe Demissew, 1988).

2.2. Deforestation in Ethiopia

Tilahun Bayou (2010) cited the United Nations Research Institute for Social development (UNRISD) defines deforestation is the loss or continual degradation of forest habitat primarily due to human related causes. Agricultural, urban sprawl, unsustainable forestry practices and mining all contribute to human caused deforestation. In this case the term deforestation used to refer to activities that use the forest, such as fuel wood cutting, commercial logging, as well as activities that cause temporary removal of forest cover such as the slash and burn technique, a component of some shifting cultivation agricultural system or clear cutting (Tilahun Bayou, 2010).

Deforestation can include not only conversion to non-forest, but also degradation that reduces forest quality, density and structure of the trees, the ecological services supplied, the biomass of plants and animals, the species diversity and the genetic diversity (FAO, 2005). It also used to describe forest clearing for annual crops and forest loss from over grazing. According to Williams (2006), the causes of deforestation are complex and often differ in each forest and country. The main causes of deforestation in Ethiopia are shifting agriculture, livestock production and fuel wood in drier areas.

Ethiopia is a country in Eastern Africa; it has the second largest population in Africa and has been hit by famine many times because there was a shortage of rain, and a depletion of natural resources (Haileselassie, 2004). Growing populations are increasing forest degradation which is leading the country to famine. As the population continue to grow the need of the people increase. And the country has lost 98% of its forested regions in the last 50 years (parry, 2003).

Forests in Ethiopia play a big role in protecting erosion, because if there are more trees the water wouldn't be able to wash away the soil. Trees also help to keep water in the soil and reduce global warming by uptake of carbon dioxide. Because there are not enough trees, the Blue Nile is carrying all the soil and other nutrients in the water to the neighboring countries of the Sudan and Egypt, where their land is very fertile (Tilahun

Bayou, 2010). Historically forests have been any important for the people of Ethiopia for their livelihood even more than now. People used trees to cook their food, to build their traditional homes. They also made traditional medicines from trees and other forests plants (Tilahun Bayou, 2010). Forests were also important in Ethiopia religious beliefs, believed in holy spirits in the forest that they treat the same as human beings (Alemayehu Wassie, 2002).

At the beginning of the 20thc around 42 million hectares or 35% of Ethiopia's land was covered by trees, but recent research indicates that forest cover is not less than 3 percent because the number of the population growth fast and the need is growing plus people don't have enough knowledge about the benefits of trees (Parry, 2003). Ethiopia which is a country badly affected by deforestation and forest degradation loses 141,000 hectares of natural forest each year for many reasons (Tilahun Bayou, 2010). If the number continues to grow the future of the country will be very bad.

Currently, the total number of the country land covered by forest is 13,000,000 ha of land (Tilahun Bayou, 2010 cited Mongabay, 2002). Between 1990 and 2005 the country actually lost 14% of its forest or 2.1 million hectare, and that indicate us deforestation increased by 10.4% from 1990-2005, therefore because of deforestation the number of wild animals of the country has becoming less and less overtime. Previously the country has around 6,603 species of plants, 839 birds, 205 mammals 288 reptiles and 76 amphibians as well (Tilahun Bayou, 2010 cited Mongabay, 2002).

2.3. Regeneration of vegetation

Plants maintain and expand their populations in time and space by the process of regeneration (Habtam, 2012). Regeneration is a complex ecosystem process involving asexual and sexual reproduction, dispersal and establishment in relation to environmental factors (Barnes *et al.*, 1998). It is an ecological process that ensures the development of successive generations of plants. The strategies by which plants

regenerate are soil seed banks, seedling banks and vegetative parts (Grime, 1979; Garwood, 1989). According to Petrie (1999), natural regeneration refers to the natural process by which plants replace or reestablish themselves by means of self-sown seed or vegetative recovery (sprouting from stumps, rhizomes or roots).

As Grime (1979) and Garwood (1989), described, tropical forest plants regenerate from one or more pathways, i.e.

1. Seed rain: recently dispersed seeds
2. Soil seed bank: dormant seeds in the soil
3. Seedling bank or advance regeneration: established, suppressed seedlings in the understory and
4. Coppice: root or shoot sprouts of damaged individuals.

Many plant species possess combinations of regenerative strategies. The existence of multiple forms of regeneration has important roles in the evolutionary and ecological potential of the plant and depends on environmental factors such as physical factors (for example light, temperature, moisture, nutrients and wind), biotic factors (for example competition, herbivore and disease) and disturbance regimes strongly influence regeneration processes, and thereby, determine the abundance and status of the plant species (Habtam, 2012).

In addition, vegetative regeneration can be affected by size, shape and orientation of gap to the sun, soil type, and topography and soil seed bank (Habtam, 2012). Topography affects the soil characteristics and plays a critical role in the variation of stand structure and floristic composition of the forests by causing vegetation, extent of damage to vegetation upon formation of the gap, temperature drainage, moisture, and nutrients to vary from ridge top to valley bottom (Enoki and Abe, 2004). Demel Teketay (2005) report indicated that height and species composition of the surrounding aspects and its spatial disturbances can also affect vegetation regeneration.

Understanding the dynamics of soil seed banks and seedling banks of forest vegetation helps to assess the natural regeneration potential of plants (Teketay, 1996). As Haileab Zegeye *et al.* (2010), indicates that assessment of soil seed banks, seedling banks and population structure has some practical importance in forest conservation and management.

Generally According to Taye Bekele *et al.* (2002), a tree species with no seedling and sapling in a forest is under risky condition and it is suggested that these species are under threat of local extinction. Hence, for a successful regeneration and establishment of seedlings, a sufficient volume of viable seeds, appropriate climatic and edaphic conditions are indispensable. Therefore, the study of regeneration of forest trees and Knowledge of the regeneration status of the plant species is important for developing management strategies of natural forests and setting priorities (Haileab Zegeye *et al.*, 2010).

2.4. Sampling of vegetation characteristics (vegetative structure)

Vegetation structure and floristic composition are usually measured or estimated on a plant community basis. Barkman (1979) distinguished between texture, the composition of morphological elements and structure. Vegetation structure is the organization in space of individuals that form a vegetation type of plant association. It can be investigated at the level of physiognomic, life form, floristic, biomass and stand vegetation structures, which are hierarchically integrated. In the analysis of vegetation structure, the growth stages of trees as seedlings, saplings and mature trees and distribution of size classes within a population can be one of the elements of diversity that allows or denies the chance of rapid recovery after disturbances (Harper, 1982).

According to Van der Maarel (2005), among the four overall measurements vegetative structure and floristic composition, the more widely used than others, may be mentioned here under:

1. Stratification: the arrangement of phytomass in layers. Usually a tall tree, low tree, tall shrub, low shrub, dwarf-shrub, tall herb, low herb and moss layer are distinguished if separated from each other (Mueller-Dombois and Ellenberg, 1974).

2. Cover- percentage cover is the relative area occupied by the vertical projection of all aerial parts of plants, as a percentage of the surface area of the sample plot. This can be determined for the vegetation as a whole or for separate layers (Eddy van der Maarel, 2005). Also Eddy van der Maarel (2005) describes that cover is usually estimated by eye, but can also be determined more accurately through the line-intercept method in sparse vegetation where contacts between the line and plant parts are counted or the point-intercept method in dense short vegetation where contacts with a cross-wire grid are counted.

3. Phytomass: total phytomass (plant biomass) in the plant community, is expressed as dry-weight $\text{g}\cdot\text{m}^2$, $\text{kg}\cdot\text{m}^2$ or $\text{t}\cdot\text{ha}$. ($\text{t}\cdot\text{ha}^{-1} = 10 \text{ kg}\cdot\text{m}^2$) (Barkman, J.J, 1988). According to Barkman, J.J. (1988), phytomass is usually determined by removing the standing crop, the above-ground phytomass during the period of maximal development. The standing crop is related to, but by no means identical to, what is produced during the growing season which varies from weeks in arctic to twelve months in moist tropical environments (Eddy van der Marel, 2005). Plant production, i.e. production by autotrophic plants, also called primary production to distinguish it from secondary production, which is the transformation of phytomass by heterotrophic organisms, animals and saprobes is usually expressed in terms of productivity, production per time unit, usually $\text{g}\cdot\text{m}^2\cdot\text{yr}$ (Barkman,J.J, 1988). The destructive sampling necessary for phytomass measurements usually requires an adapted sampling scheme so that a sufficient area of the same vegetation remains undisturbed (Eddy van der Marel, 2005).

Phytomass can be determined per layer so that a vertical phytomass profile can be obtained and interpreted in terms of species interactions and light climate (Fliervoet, 1985). Barkman (1988) developed a method and apparatus to determine phytomass denseness, and its horizontal and vertical distribution. This method is also destructive,

but only small sections of plant mass are cut. Such profiles can be fruitfully linked to measurements of microclimate (Stoutjesdijk and Barkman, 1992).

4. Leaf area index- the total area of leaf surface (actually photosynthetic surface) expressed in m^2 per m^2 surface area is known as leaf area index, LAI; it can be determined per layer and can thus also be used for a refined description of the architecture of vegetation (Eddy van der Maarel, 2005). A derivative characteristic is specific leaf area, SLA = leaf (lamina) area vegetation ecology an overview 15 per unit leaf (lamina) dry mass (Eddy van der Maarel, 2005). According to Eddy van der Maarel, (2005), LAI and cover are related, but no studies of the correlation between the two characteristics for individual species are known to the author.

2.5. Sampling of species characteristics

The species composition of a plant community, the key element in its definition, is described in its simplest form by a list of species occurring in the sample plot (Van der Maarel, 2005). The list is mostly restricted to vascular plants, and almost always to their above-ground parts; often easily recognizable mosses, liverworts and lichens are included. According to Van der Maarel (2005), the quantity of a species attains can be called its performance, but often the term abundance is used, even if this is only one of the following quantitative measures:

1. Abundance: the number of individuals on the sample plot. Because individuality in many (clonally) plant species is difficult to determine the concept of plant unit, a plant or part of a plant (notably a shoot) behaving like an individual, is needed, if only for a quantitative approach of species diversity based on the distribution of plant units over species (Williams, 1964).
2. Cover-abundance: is a combined parameter of cover in case the cover exceeds a certain level, for example 5% and abundance. This 'total estimate' (Braun-Blanquet,

1932) has been both criticized as a wrong combination of two independently varying parameters and praised as a brilliant integrative approach.

Table 1. Abundance of each species in a given unit of area of the sample is made using 1-9 modified (Braun-Blanquet, 1932) scale and Vad der Maarel, 1979).

Braun-Blanquet scale of abundance	Description of cover
1	Rare, generally one individual
2	Sporadic with less than 5% cover of the total area
3	Abundant with less than 5% cover of the total area
4	Very abundant & less than 5% cover of the total area
5	5-12% cover of the total area
6	12.5-25% cover of the total area
7	26-50% cover of the total area
8	51-75% cover of the total area
9	76-100% cover of the total area

3. Basal area: the area outline of a plant near the surface is of particular interest for trees and can be used for tree volume estimations (Mueller-Dombois and Ellenberg, 1974). A related measure is tree diameter at breast height (DBH at 1.37 m or 4.5 feet), which is more often used in standard forest descriptions (Eddy van der Maarel, 2005).

4. Important value index (IVI): the important value index (IVI) permits a comparison of species in a given forest type and depict the sociological structure of a population in its totality in the community (Habtam, 2012). 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). Curtis and McIntosh (1951) pointed out that important value index gives a more realistic figure of dominance from the structural point of view. It is also important to compare the ecological significance of a given species. Therefore, it is a good index for summarizing vegetation characteristics and ranking species for management and conservation practices.

2.6. Diversity

Species diversity has been identified as one of the key indices of sustainable land use practices and considerable resources are expended to identify and implement strategies that will reverse the current decline in biodiversity at local, regional and international scales (Shackelton, 2000). According to Groombridge (1999), biodiversity is the number, variety and variability of living organisms.

Rosenzweig (1995) pointed out that diversity could be viewed in terms of alpha, beta and gamma diversity. Rosenzweig (1995) define both Alpha and Beta diversity i.e. Alpha diversity refers the diversity or number of species within a particular habitat or community. Beta diversity is the rate and extent of change in species richness between communities across an environmental gradient over a relatively small distance. It is often estimated by calculating species turn over. Gamma diversity is the total number of unique species recorded in the population of interest, or number of species across a very large area such as a biome or continent and is dependent on the alpha and beta diversities (Bethany K, 2009).

2.6.1. Species richness and evenness

The two main techniques of measuring diversity are richness and evenness, or the different coefficient widely used to compute diversity of a community is species richness, evenness and sometimes heterogeneity. Krebs (1989); Hurlbert (1978) defined the following terms:

Species richness is the simplest concept of species diversity implying the number of species in a community where as evenness is a measure of equitability and it attempts to quantify the unequal representation of species in a community against a hypothetical community in which all species are equally common (Eddy van der Maarel, 2005). Heterogeneity is the measure of the probability of which, two individuals randomly picked from a community belong to different species (Habitam, 2012).

Methods for measuring diversity actually consist of two components. The first is species richness, and the second is the relative abundance (evenness or unevenness) of the species within the sample or community difference (Kent and Coker, 1992). These two components of species diversity may be examined separately or combined into some forms of indices. As Kent and Coker (1992), describes that species richness index has a great importance in assessing taxonomic, structural and ecological values of a given habitat, where as evenness is a measure of abundance of the different species that make up the richness of the area. Species diversity is the product of species evenness and richness. Species diversity indices provide information about species endemism rarity and commonness (Mueller Dombois and Ellenberg, 1974).

Kent and Coker (1992), described that both Species diversity and species evenness are often calculated using the Shannon diversity index (H'), which naturally varies between 1.5 and 3.5 and rarely, exceeds 4.5. Shannon diversity index is the most appropriate and the most widely used index for combining species richness and evenness (Krebs, 1999).

CHAPTER THREE

3. MATERIALS AND METHODS

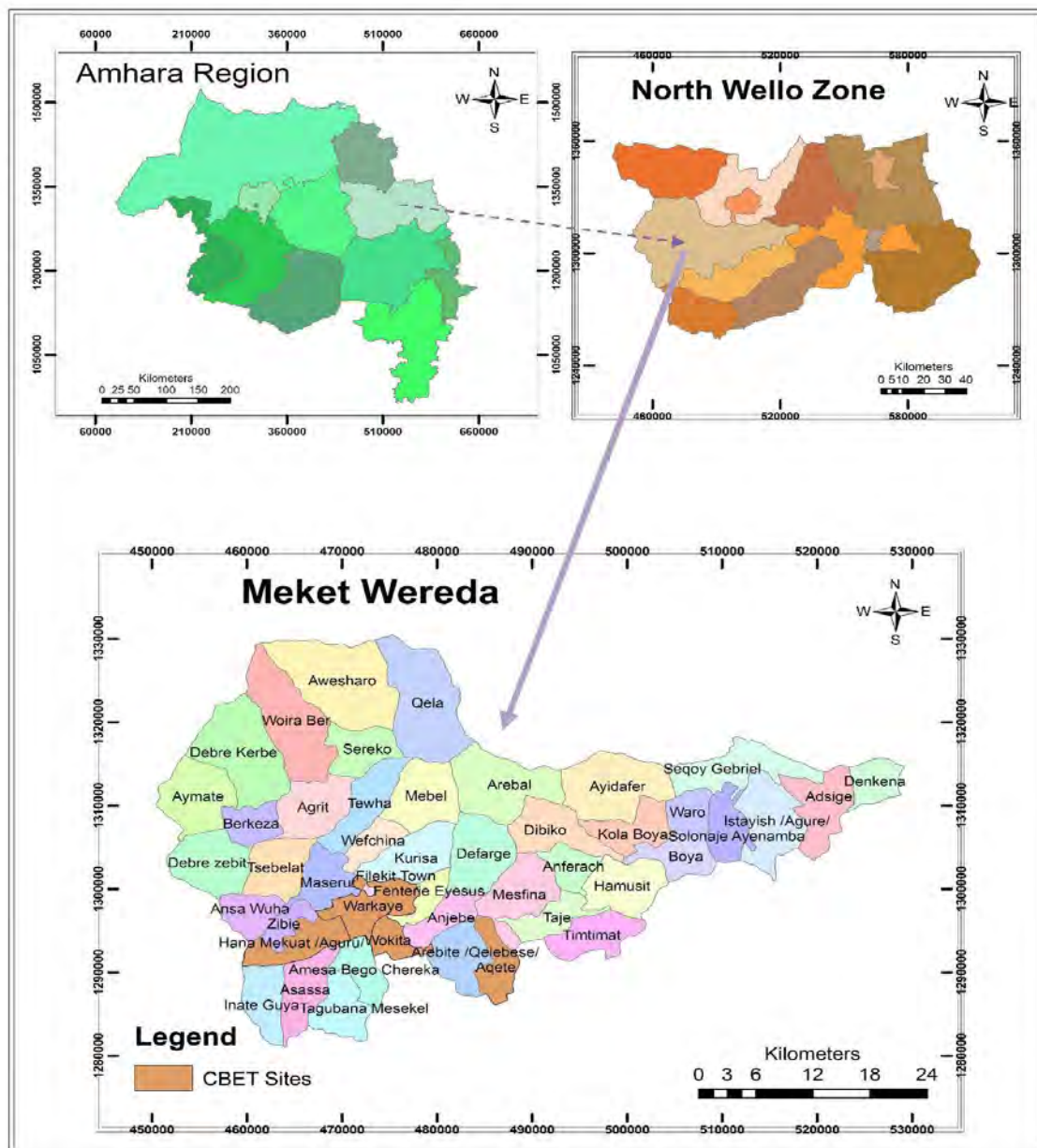
3.1. Description of the study area

3.1.1. Location and geographical features of the district

The study was conducted in the month of October 2008 E.C. in the Ylat forest found 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).

As the information gained from Meket Woreda Agricultural and Rural Office, the capital of the district is Filakit (found at $11^{\circ} 35' 55''$ - $12^{\circ} 2' 30''$ N and $38^{\circ} 32' 35''$ - $39^{\circ} 16' 40''$ 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 altitude of the study area ranges from 1699-3502 meters above sea level having 47 kebeles out of those 6 are urban kebeles.

Figure .1. Map of the study area



Source: Gebeyaw Ambelu, 2011

3.1.2. Climate

As the data gained from the head of the Meket Woreda Agricultural Office Ato Anteneh Alemie, the proposed study area is generally characterized by diverse agro climatic 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 variable climatic and other environmental conditions.

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

3.1.3. Topography and soil

The study 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 types and their spatial coverage in the district are Camisol 58.03%, also other soil types are found in the study area (Litosol 12%, Roaksol 15.47%, Ntosol 6.12% and Vertisol 15.47%). The economy of the local people is predominantly based on subsistence agriculture. Agriculture is characterized by mixed cropping practices mainly the principal crops including 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).

3.1.4. Vegetation

The vegetation type of the Ylat forest is characterized 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 in decline due different reasons like agriculture expansion and cultivation, fuel wood, timber production etc. It is true that most areas of Ethiopia deforestation have been one of the serious problems. Vegetations have been cleared for the various purposes as described above. Now a time the Ylat forest is protected and it is the only forest conserved in the Meket Woreda.

3.1.5. Human population and social condition

According to the data obtained from the study Woreda information office the total population of the proposed study district Meket Woreda was 273,000, among those 137,256 were males and 134,744 were females. All peoples found in this area spoken Amharic language (100%) and they are Amhara ethnic group. The two common religions that the people follow are Orthodox (94.35%) and Muslim (4.95) but 0.7% peoples follow other types of religion.

3.1.6. Wild Life

As the information gained from the study area kebele agricultural officer, the proposed study area is generally poor in wildlife due to pronounced deforestation and high human interference. But different kinds of wild animals are found. For example mammals like apes, monkeys, antelopes, common fox, leopards, rabbit, Ethiopian tiger, and hyena and birds including jigma etc. are found.

3.2. Methodology for data collection

3.2.1. Reconnaissance survey

Reconnaissance survey of Ylat forest was conducted in the month of October 2008 E.C. in order to obtain vegetation patterns of the study area and identify representative sampling sites about the forest. 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 collection was conducted from November to December 2008 E.C.

3.2.2. Sampling design (vegetation data collection)

Systematic sampling design was employed for this study to collect vegetation data. Following the line transect method described by Bullock (1996), 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 measured using GPS (Global Positioning System). In each quadrat, 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/ shrubs, number of stems, coverage of each trees/shrubs and coverage of herbaceous composition was collected from total 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 by species as seedlings. New woody plant species occurring outside the sampling plots (quadrates) were also recorded to prepare a complete checklist of plants in the area. Diameter was measured for all 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 by using rope made from sack.

3.3. Methods of data analysis

3.3.1. Structural data analysis

The quantitative structure data analysis was made using density, frequency, diameter at breast height (DBH), dominance, importance value index (IVI) and basal area for description of 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. 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).

$$D = \frac{\text{Number of aboveground stems of a species counted}}{\text{Sample area in hectare (ha)}}$$

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

$$RD = \frac{\text{Number of individual tree species}}{\text{total number of individual}} \times 100$$

Frequency of the plant Species

Frequency is the chance of finding a species in a particular trial 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. The higher the frequency, the more important the plant is in the community.

$$Frequency = \frac{\text{Number of plant in which species occur}}{\text{total number of plots}} \times 100$$

The importance of a species within the frequency can be obtained by comparing the frequency of occurrences of the entire tree species present is called the relative frequency and is given by the formula:

$$RF = \frac{\text{frequency of one species}}{\text{total frequency}} \times 100$$

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 taken at about 1.3m from the ground using a measuring tape. It is easy, quick, inexpensive and relatively accurate. There is direct relationship between DBH and basal area (Semere 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.

$$\text{Basal area} = \sum \pi (d/2)^2$$

Where "d" is diameter at breast-height and $\pi = 3.14$

Importance Value Index of the Species

It is used to calculate plant woody 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.

$$\text{IVI} = \text{Relative density} + \text{Relative frequency} + \text{Relative dominance}$$

3.3.2 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, 1989 and Barnes *et al.* (1998). Especially, Shannon-Wiener Diversity Index (H'), in addition to counting for both species richness and evenness, it is not also affected by sample size and it used to measure the degree of uncertainty that is, if the diversity is high in a given habitat, the certainty of observing a particular species is low (Kent and Coker, 1992 and 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 given sample area is represented by 0 and 1, are equally abundant (Whittaker, 1972). As Manuel and 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 $\ln S$ 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,

$\sum$ 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 numbers of species encountered

$\ln$ is natural logarithm in base e .

$$J = \frac{H'}{H'_{\max}} \times 100$$

Where

$H'_{\max} = \ln S$

H' is Shannon diversity index

$\ln S$ is the natural logarithm of the total number of species in each community

S is number of species in each community

CHAPTER FOUR

4. Results and discussion

4.1. Floristic composition

In this study, 60 species of vascular plants representing 41 families and 56 genera were identified and recorded (see Appendix one). 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.

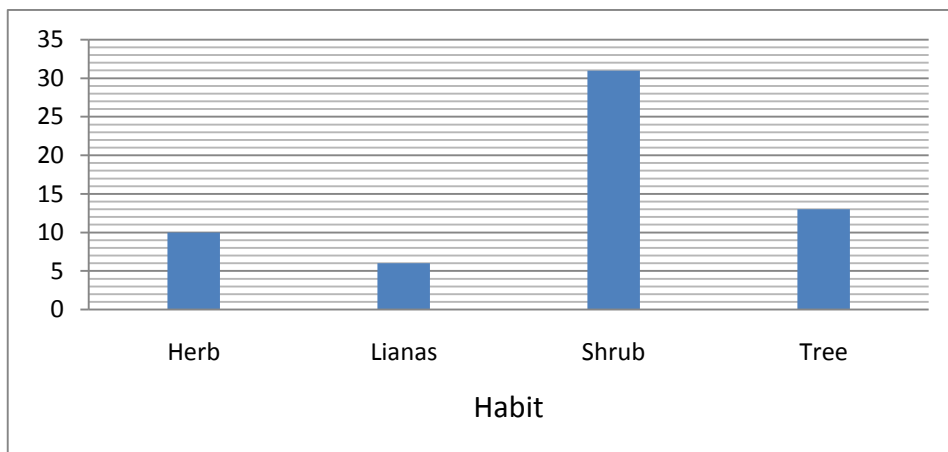


Figure 2. Growth forms by habit types

N.B. Herbaceous includes herbs and grasses and woody species includes lianas, shrubs and trees.

Out of the total families, 8.33% were *Lamiaceae*, 5% were *Fabaceae*, *Rosaceae*, *Solanaceae*, and *Euphorbiaceae* and 3.33% were *Sapindaceae*, *Aloaceae*, *Ranunculaceae*, *Poaceae*, *Oleaceae*, *Polygonaceae* and *Cucurbitaceae*.

Table 2. Plant families with their genera and species distribution in Yilat forest.

No.	Family	No. of Genera	% of Genera	No. of Species	% of Species
1	Lamiaceae	2	3.57	5	8.33
2	Fabaceae	3	5.36	3	5
3	Rosaceae	3	5.36	3	5
4	Euphorbiaceae	3	5.36	3	5
5	Solanaceae	3	5.36	3	5
6	Aloaceae	1	1.79	2	3.33
7	Ranunculaceae	2	3.57	2	3.33
8	Sapindaceae	2	3.57	2	3.33
9	Poaceae	2	3.57	2	3.33
10	Cucurbitaceae	2	3.57	2	3.33
11	Polygonaceae	2	3.57	2	3.33
12	Oleaceae	2	3.57	2	3.33
13	Acanthaceae	1	1.79	1	1.67

14	Loganiaceae	1	1.79	1	1.67
15	Capparidaceae	1	1.79	1	1.67
16	Apocynaceae	1	1.79	1	1.67
17	Sterculiaceae	1	1.79	1	1.67
18	Flacourtiaceae	1	1.79	1	1.67
19	Ericaceae	1	1.79	1	1.67
20	Myricaceae	1	1.79	1	1.67
21	Eubenaceae	1	1.79	1	1.67
22	Melianthaceae	1	1.79	1	1.67
23	Apiaceae	1	1.79	1	1.67
24	Balsamaminaceae	1	1.79	1	1.67
25	Cupressaceae	1	1.79	1	1.67
26	Malvaceae	1	1.79	1	1.67
27	Celasteraceae	1	1.79	1	1.67
28	Myrsinaceae	1	1.79	1	1.67
29	Asparagaceae	1	1.79	1	1.67
30	Convolvulaceae	1	1.79	1	1.67
31	Cactaceae	1	1.79	1	1.67
32	Santalaceae	1	1.79	1	1.67

33	Phytolaccaceae	1	1.79	1	1.67
34	Anacardiaceae	1	1.79	1	1.67
35	Salicaceae	1	1.79	1	1.67
36	Urticaceae	1	1.79	1	1.67
37	Scophulariaceae	1	1.79	1	1.67
38	Asteraceae	1	1.79	1	1.67
39	Guttiferaceae	1	1.79	1	1.67
40	Geraniaceae	1	1.79	1	1.67
41	Myrtaceae	1	1.79	1	1.67
Total		56	100	60	100

4.2. 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). Rosaceae, Solanaceae, Lamiaceae and Fabaceae were the highest number of species followed by Euphorbiaceae and Sapindaceae. 1227.77 total woody plant species individuals were encountered of which *Myrsine africana* were 15.27%, with the highest of all woody species (see Appendix 2).

Myrsine africana, *Erica arborea* and *Dodonaea angustifolia* were the dominant species consecutively. *Myrica salicifolia*, *Dombeya torrida*, *Capparis tomentosa*, *Millettia ferruginea* and *Euphorbia tirucalli* were some of the rare species within the plot. *Erica*

arborea and *Allophyllus abyssinicus* were the most common (frequent) species in the sample plots in Yilat forest.

4.2.1. Vegetation structure

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

The numbers of individuals which have DBH ≥ 2.5 cm were 1227.77. *Myrsine aficana* occupied 15.27% of the total density followed by *Erica arborea* (14.4%) and *Dodonaea angustifolia* (6.79%) (see Appendix 2). These woody species were the most dominant species. The least abundant species recorded were *Myrica salicifolia* (0.72%), *Dombeya torrida* (0.75%), *Capparis tomentosa* and *Euphorboa trucalli* (0.9%) and *Millettia ferruginea* (1.02%). The mean density of woody species of the study vegetation was higher than Achera forest (1034.17 individuals per hectare) (Habtam Getaneh, 2012).

Table 3. 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. Above shows that 97.15% of woody species individuals were in ≤ 10 cm DBH classes and about 2.85% was within 10 < 20cm DBH classes. There is a considerable decrease in number of individuals with increasing DBH. The Yilat forest is composed of

high proportion of small sized woody species. *Opuntia ficus-indica* was the maximum of all woody species that have an average DBH 65.08cm (see Appendix 4).

4.2.1.2. Basal area

The total basal area of woody species was 1 m²/ha (see Appendix 5). *Opuntia ficus-indica* (15.465%), *Acacia albida* (14.98%) and *Juniperus procera* (14.14%) were among 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 Yilat forest is low indicating the woody species are thin and scattered.

Table 4. Dominant woody species with their percentage basal area of Yilat forest

Species	Density	Average DBH (cm)	BA/ha	Percentage
<i>Opuntia ficus-indica</i>	16.2	65.08	0.154	15.465
<i>Acacia albida</i>	60.65	64.09	0.149	14.98
<i>Juniperus procera</i>	59.26	62.23	0.141	14.14
<i>Allophylus abyssincus</i>	69.44	55.11	0.11	11
<i>Erica arborea</i>	176.39	49.97	0.091	9.12

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

4.2.1.3. Frequency

The most frequent woody species in Ylat forest were *Erica arborea* (12.79%), *Allophylus abyssinicus* (12.02%) and *Myrsine africana* (10.857%). The less frequent woody species were *Euphorbia tirucalli*, *Opuntia ficus-indica*, *Hagenia abyssinica*, *Myrica salicifolia* and *Withania semnifera*.

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 Yilat forest woody species had been classified into four frequency classes (see Table 5).

	A	B	C	D
Frequency class	31-40	21-30	11-20	1-10
Species frequency	2	3	6	22

From the above table, the result showed there was high value in lower frequency classes and low values in higher frequency. This indicates that Yilat forest had heterogeneous species composition. The same result is also obtained in South Wollo zone, Yogof forest (Sultan Mohammed and Berhanu Abraha, 2013).

4.3. Importance value index

Curtis and McIntosh (1951) 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 *Erica arborea* (12.09%), *Allophylus abyssinicus* (9.59%), *Myrsine africana* (9.2%), *Juniperus procera* (9.17%) and *Acacia albida* (8.19) were plant species with highest importance value index. *Myrica salicifolia* (0.43%), *Euphorbia tirucalli* (0.5%), *Hagenia abyssinica* (0.58%), *Calpurnia aurea* (0.9%) and *Millettia ferruginea* (0.96%) were species with lowest importance value index.

The five most dominant woody species of Ylat forest occupied 48.24% of the total importance value index (see Appendix 7 and Table 6). Those dominant species were *Erica arborea*, *Allophylus abyssinicus*, *Juniperus procera*, *Myrsine africana* and *Acacia 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 indicates that the requirement of conservation management.

Table 6. IVI of woody species of Yilat forest

No.	Scientific name	IVI
1	<i>Erica arborea</i>	36.31
2	<i>Allophylus abyssinicus</i>	28.65
3	<i>Myrsine africana</i>	27.61
4	<i>Juniperus procera</i>	27.49
5	<i>Acacia albida</i>	24.57
6	<i>Euclaptus globulus</i>	20.02

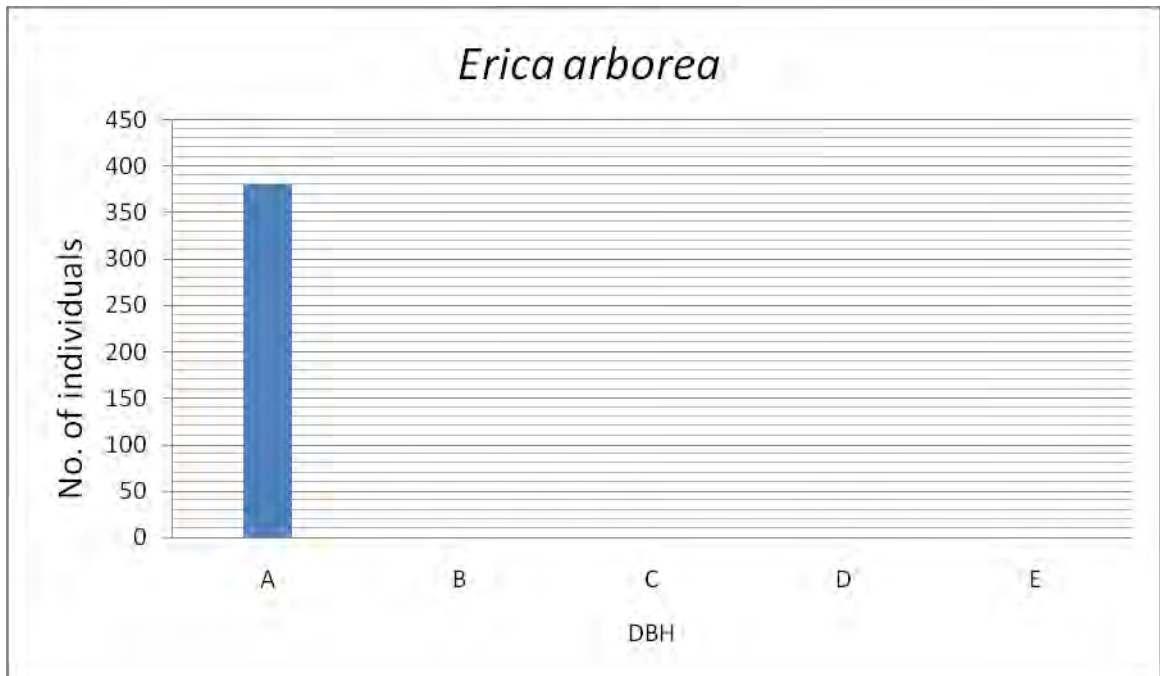
16	<i>Euclea racemosa</i> subsp. <i>schimperi</i>	20.02
7	<i>Opuntia ficus- indica</i>	17.175
9	<i>Dodonaea angustifolia</i>	13.05
8	<i>Hypericum revolutum</i>	13.02
10	<i>Discopodium penninervium</i>	12.69
12	<i>Otostegia tomentosa</i>	7.14
11	<i>Olea europaea</i> subsp. <i>cuspidata</i>	6.82
13	<i>Rhus retinorrhoea</i>	6.19
20	<i>Prunus Africana</i>	4.71
15	<i>Croton macrostachyus</i>	4.23
17	<i>Clerodendrum alatum</i>	4.07
18	<i>Salix subserrata</i>	4.04
19	<i>Capparis tomentosa</i>	3.87
21	<i>Carissa spinarum</i>	3.52
22	<i>Rosa abyssinica</i>	3.52
23	<i>Dombeya torrida</i>	3.5
26	<i>Withania somnifera</i>	3.49
25	<i>Clerodendrum myricoides</i>	3.27
14	<i>Dovyalis abyssinica</i>	3.06

24	<i>Osyris quadripartita</i>	2.96
27	<i>Millettia ferruginea</i>	2.82
28	<i>Calpurnia aurea</i>	2.69
31	<i>Hagenia abyssinica</i>	1.74
29	<i>Euphorbia tirucalli</i>	1.5
30	<i>Myrica salicifolia</i>	1.285

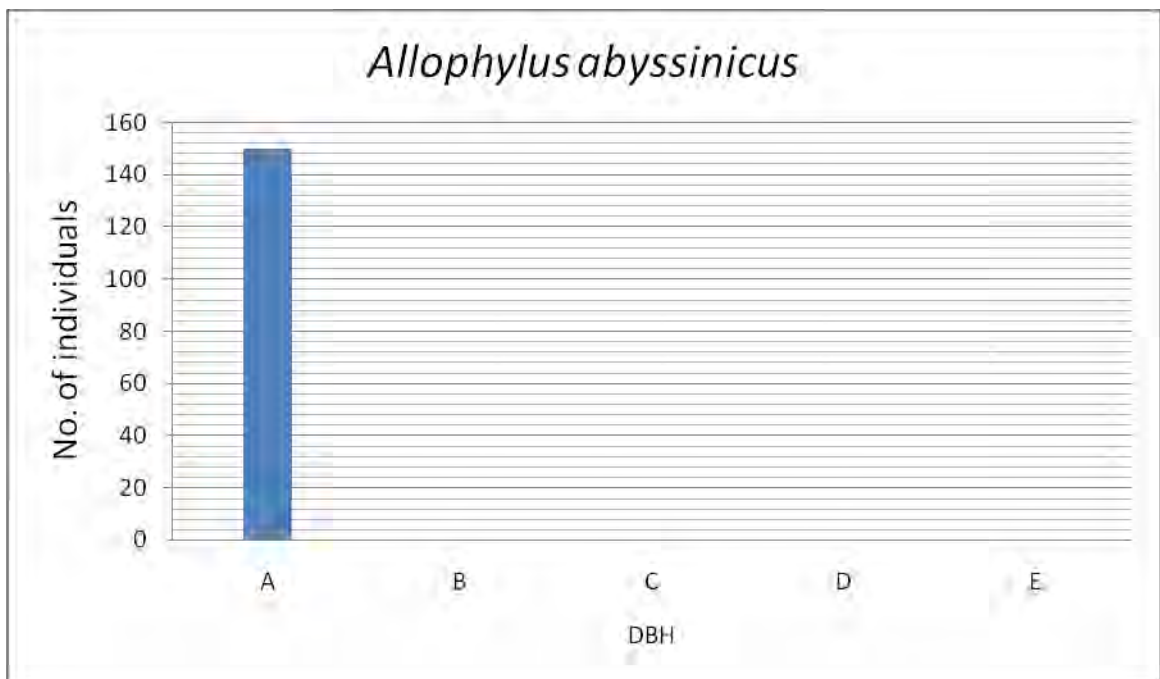
4. 4. Species population structure

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

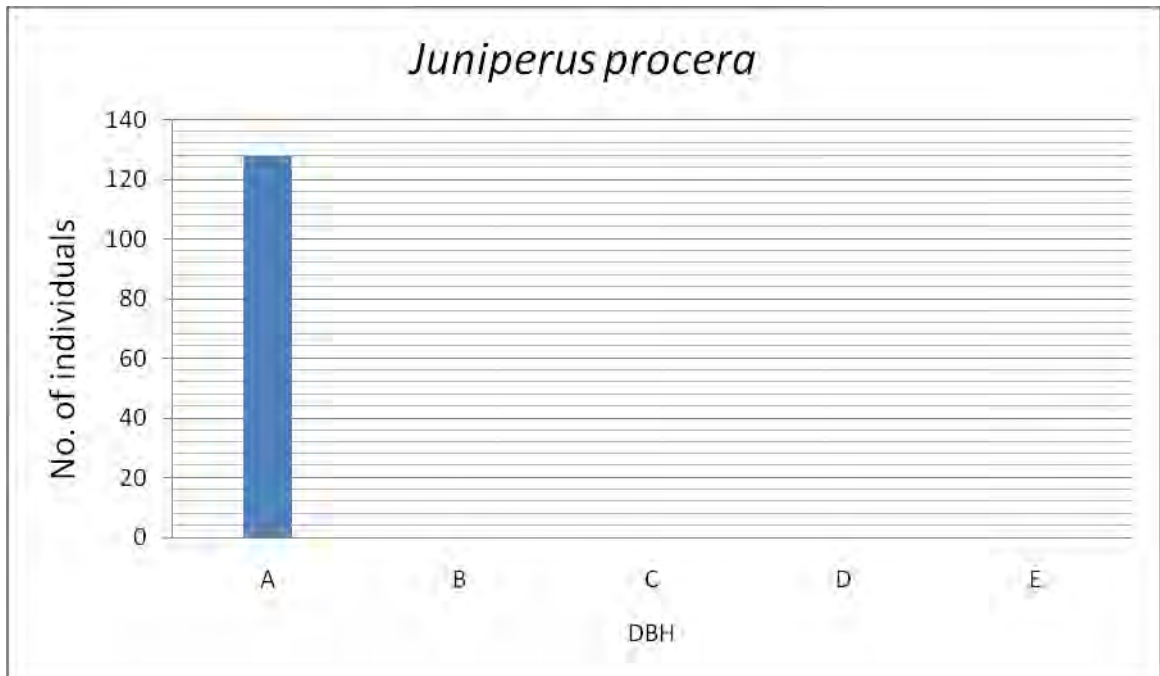
The six most important values of woody species representing 33 species in Yilat forest whose IVI value > 18 are illustrated in figure 2. The population structure of *Erica arborea*, *Allophylus abyssinicus*, *Juniperus procera*, *Myrsine africana*, *Acacia albida* and *Euclaptus globulus* shows inverted J curve population high number of individuals in the first DBH class by a progressive decline in the number of individuals with increasing DBH. This pattern suggests good regeneration and recruitment. This successful regeneration might be associated with its environmental adaptation. The density of this species increases with increasing diameter.



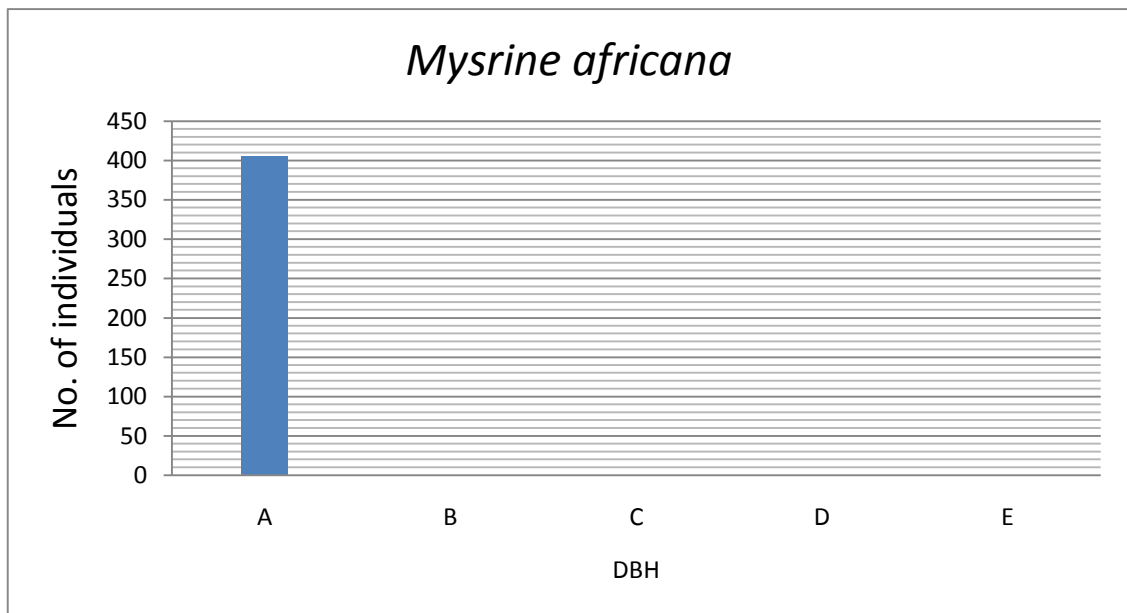
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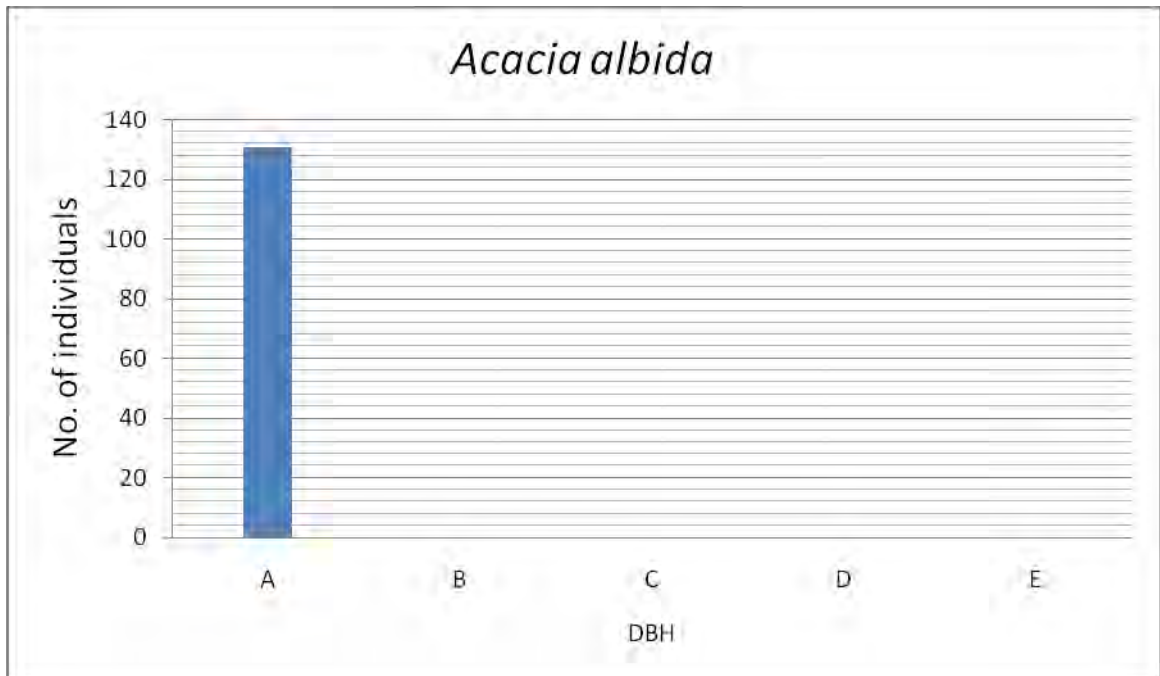
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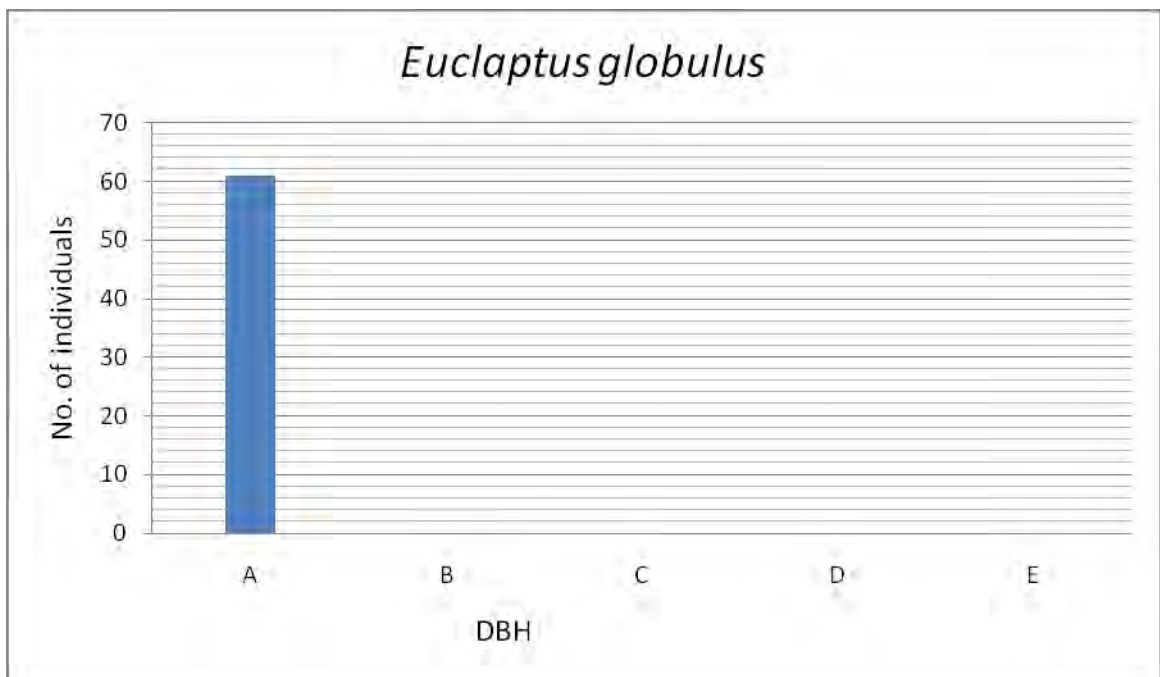
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d



e



f

Fig. 3. Population structure of six important woody species in Yilat forest

A=2.5-10cm, B=10.1-20cm, C=20.1-30cm, D=30.1- 40cm, E=> 40Cm

4.5. Regeneration status of the Yilat forest

The number and type of seedlings and saplings in any vegetation cover shows the regeneration status of that vegetation cover. The composition and density of seedlings and saplings of woody species in Yilat forest were counted. Accordingly, a total of 1339.83 seedlings/ha, 1319.45 saplings/ha and 1227.77 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 (Fig. 3.).

The ratio of seedlings to mature individuals of woody species in Yilat 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.

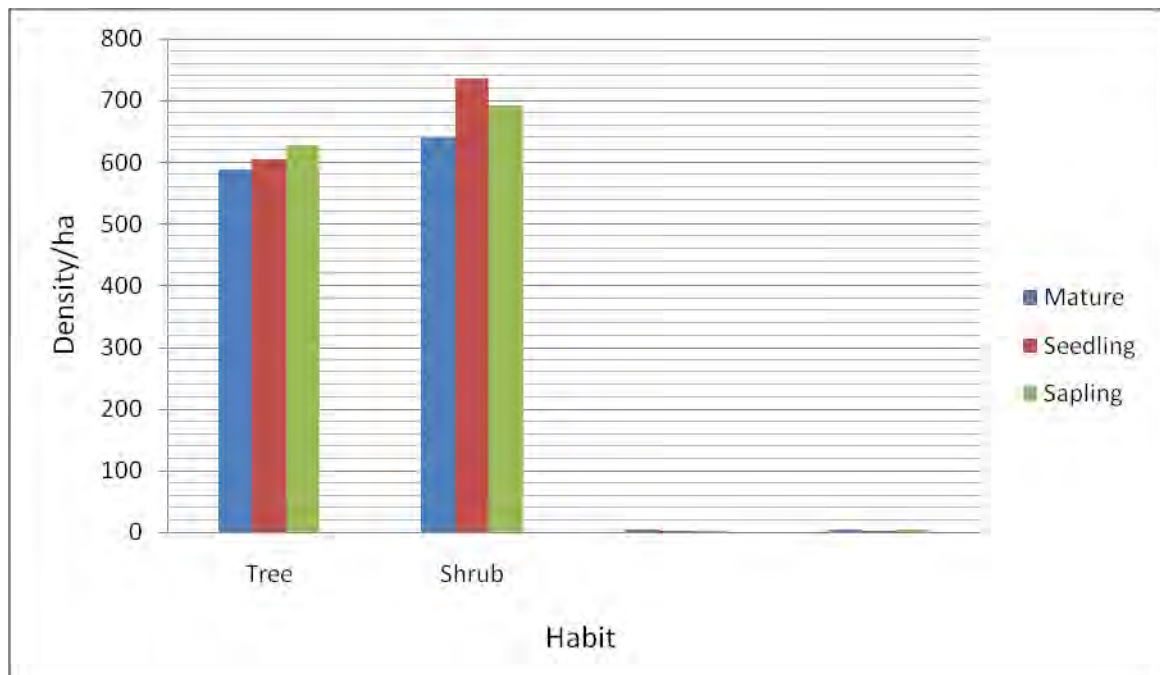


Fig.4. Seedling and sapling distribution of woody species of Ylat forest

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 7).

Table 7. The regeneration status of different woody plant species in Yilat forest

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

Group A	Group B
<i>Dodonaea angustifolia</i>	<i>Otostegia tomentosa</i>
<i>Clerodendrum alatum</i>	<i>Dombeya torrida</i>
<i>Juniperus procera</i>	
<i>Acacia albida</i>	
<i>Erica arborea</i>	
<i>Calpurnia aurea</i>	
<i>Capparis tomentosa</i>	
<i>Carrisa spinarum</i>	
<i>Clerodendrum myricoides</i>	
<i>Croton macrostachus</i>	
<i>Discopodium penninervium</i>	
<i>Euclea racemosa</i> subsp. <i>schimperi</i>	
<i>Euphorbia tirucalli</i>	
<i>Opuntia ficus-indica</i>	

<i>Hypericum revolutum</i>
<i>Millettia ferruginea</i>
<i>Osyris quadripartita</i>
<i>Prunus africana</i>
<i>Rhus retinorrhoea</i>
<i>Euclaptus globulus</i>
<i>Olea europaea</i> subsp. <i>cuspidata</i>
<i>Myrsine africana</i>
<i>Withania somnifera</i>
<i>Hagenia abyssinica</i>
<i>Rosa abyssinica</i>
<i>Salix subserata</i>
<i>Myrica salicifolia</i>
<i>Dovyalis abyssinica</i>
<i>Allophylus abyssinicus</i>

From this study *Erica arborea*, *Juniperus procera*, *Myrsine africana* and *Acacia albida* were with highest number of saplings/ha. *Erica arborea*, *Myrsine africana*, *Dodonaea angustifolia* and *Discopodium penninervium* were with the highest number of seedlings/ha in the study area (Appendix 8).

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

4.6. Species diversity and evenness

The diversity and evenness of woody species in Yilat forest was 2.94 and 0.84 respectively indicating that the diversity and evenness of woody species in the forest is relatively high. According to Kent Coker (1992), Shannon-Wiener index value varies between 1.5 and 3.5 and rarely exceeds 4. Thus, the result of the present study showed that the Yilat forest has an even species distribution. It is evident that the relatively high value of Shannon-Wiener diversity index ($H' = 2.94$ of Yilat forest is more diverse when compared with that of Menagesha Suba State forest ($H' = 2.57$) (Dinkissa Beche, 2011).

5. CONCLUSION AND RECOMMENDATIONS

The analysis of floristic composition, vegetative structure and regeneration data on Ylat forest between altitudinal gradients of 1699-3502 m indicated the presence of higher species diversity. A total of 60 species belonging to 41 families and 56 genera were recorded. In Ylat forest 1227.77 individual hec^{-1} woody plant species were collected. And also 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 indicates that the Yilat forest had heterogenous species composition. From the overall distribution DBH classes, In Yilat 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 fosters a regular inverted J-shaped distribution. This indicates that the dominance of small sized individuals in the forest and the forest is in the status of good regeneration high recruitment potential, which might have been due to selective cutting of large tree individuals for agriculture (farm implements), charcoal production and building houses

(construction purpose). The data analysis of Yilat forest relieved that the density value of seedling (1339.83 individual hec^{-1}) and sapling (1319.45 individual hec^{-1}) of the population structure relatively high compared to mature (1227.77 individual hec^{-1}) woody plant species, due to the different factors that before reaching the seedling and sapling individuals in to mature individuals (the death of seedling and sapling before reaching to mature individual), this the future status of the vegetation cover were in a good status and should be given priority for conservation.

Therefore, in order to ensure the conservation, management and sustainable utilization of the forest resources, the following recommendations are suggested.

- ❖ The most woody plant species of Yilat forest were found in a good regeneration status and recruitment. Therefore, these woody species should be given priority for conservation and be conserved in-situ.
- ❖ Detailed ethno botanical studies are also required to explore the wealth of indigenous knowledge on the diverse of plants and their implication in conservation.
- ❖ Further studies are required to fill the gap of this work such as analysis of soil sampling, and land use management system in the area. Because the present study was limited to document the floristic composition, structure and natural regeneration status of woody plants species.
- ❖ There is a need to create awareness in the local people and the government about the importance of conserving the forests.
- ❖ There is a need to minimize livestock grazing, tree cutting and other human disturbances in order to allow the natural regeneration of woody species in the forests.

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7. Appendices

Appendix 1. List of plant species, family and growth habit recorded from Ylat forest

No.	Scientific name	Family	Habit
1	<i>Acacia albida</i> Del.	Fabaceae	Tree
2	<i>Acanthus sennii</i> Chiov.	Acanthaceae	Shrub
3	<i>Allophylus abyssinicus</i> (Hochst.) Radlk.	Sapindaceae	Tree
4	<i>Aloe berhana</i> Reynolds	Aloaceae	Herb
5	<i>Aloe pulcherrima</i> Gilbret and Sebsebe	Aloaceae	Shrub
6	<i>Anthoxanthum aethopicum</i> L. Hedberg	Poaceae	Herb
7	<i>Asparagus africanus</i> Lam.	Asparagaceae	Shrub
8	<i>Bersama abyssinica</i> Fresen.	Melanthaceae	Shrub
9	<i>Buddleja polystachya</i> Fresen.	Loganiaceae	Shrub
10	<i>Calpurnia aurea</i> (Ait.) Benth.	Fabaceae	Shrub
11	<i>Capparis tomentosa</i> Lam	Capparidaceae	Shrub
12	<i>Carissa spinarum</i> L.	Apocynaceae	Shrub
13	<i>Clematis simensis</i> Fresen.	Ranunculaceae	Lianas

14	<i>Clerodendrum alatum</i> Gürke	Lamiaceae	Shrub
15	<i>Clerodendrum myricoides</i> (Hochst.) Vatke	Lamiaceae	Shrub
16	<i>Clusia abyssinica</i> Jaub. & Spach.	Euphorbiaceae	Shrub
17	<i>Croton macrostachyus</i> Del.	Euphorbiaceae	Tree
18	<i>Cucumis ficifolius</i> A.Rich.	Cucurbitaceae	Herb
19	<i>Discopodium penninervium</i> Hochst.	Solanaceae	Shrub
20	<i>Dodonaea angustifolia</i> L.f.	Sapindaceae	Shrub
21	<i>Dombeya torrida</i> (J.F.Gmel.) P. Bamps	Sterculiaceae	Tree
22	<i>Dovyalis abyssinica</i> (A.Rich.) Warb.	Flacourtiaceae	Shrub
23	<i>Erica arborea</i> L.	Ericaceae	Shrub
24	<i>Euclaptus globulus</i> Labill	Myrtaceae	Tree
25	<i>Euclea racemosa</i> Murr. Subsp. <i>schimperii</i> (A.DC.) White	Eubenaceae	Shrub
26	<i>Euphorbia tirucalli</i> L.	Euphorbiaceae	Tree
27	<i>Ferula comminus</i> L.	Apiaceae	Herb
28	<i>Geranium arabicum</i> Forssk.	Geraniaceae	Herb
29	<i>Hagenia abyssinica</i> (Brace) J.F. Gmel.	Rosaceae	Tree
30	<i>Hibiscus crassinervius</i> Hochst. ex A. Rich	Malvaceae	Shrub

31	<i>Hypericum revolutum</i> Vahl	Guttiferaceae	Tree
32	<i>Hyparrhenia variabilis</i> Stapf	Poaceae	Herb
33	<i>Impatiens rothii</i> Hook.f.	Balsaminaceae	Herb
34	<i>Inula confertiflora</i> A. Rich.	Asteraceae	Shrub
35	<i>Ipomoea tenuirostris</i> Choisy	Convolvulaceae	Lianas
36	<i>Jasminum grandiflorum</i> L.	Oleaceae	Lianas
37	<i>Juniperus procera</i> Hochst.ex Endl.	Cupressaceae	Tree
38	<i>Maytenus arbitufolia</i> (A. Rich) Wilczek	Celastraceae	Shrub
39	<i>Millettia ferruginea</i> (Hochst.) Bak.	Fabaceae	Shrub
40	<i>Myrica salicifolia</i> A. Rich.	Myricaceae	Shrub
41	<i>Myrsine africana</i> L.	Myrsinaceae	Tree
42	<i>Olea europaea</i> L. subsp. <i>cuspidata</i> (Wall. ex G.Don) Cif.	Oleaceae	Tree
43	<i>Opuntia ficus-indica</i> (L) Miller	Cactaceae	Shrub
44	<i>Osyris quadripartita</i> Decn.	Santalaceae	Tree`
45	<i>Otostegia integrifolia</i> Benth.	Lamiaceae	Shrub
46	<i>Otostegia tomentosa</i> A. Rich.	Lamiaceae	Shrub
47	<i>Otostegia tomentosa</i> A. Rich subsp ambigens (Chiov.) Sebald	Lamiaceae	Shrub

48	<i>Phytolacca dodecandra</i> L'Hérit.	Phytolaccaeae	Lianas
49	<i>Prunus africana</i> (Hook. f.) Kalkm.	Rosaceae	Tree
50	<i>Rhus retinorrhoea</i> Oliv.	Anacardiaceae	Shrub
51	<i>Rosa abyssinica</i> Lindley	Rosaceae	Shrub
52	<i>Rumex nepalensis</i> Spreng.	Polygonaceae	Herb
53	<i>Rumex nervosus</i> Vahl	Polygonaceae	Shrub
54	<i>Salix subserrata</i> Willd.	Salicaceae	Shrub
55	<i>Solanum marginatum</i> L.f.	Solanaceae	Shrub
56	<i>Thalictrum rhynchocarpum</i> Dill. & A. Rich.	Ranunculaceae	Herb
57	<i>Urera hypselodendron</i> (A. Rich) Wedd.	Urticaceae	Lianas
58	<i>Verbasicum sinaiticum</i> Benth.	Scrophulariaceae	Herb
59	<i>Withania somnifera</i> (L.) Dunal	Solanaceae	Shrub
60	<i>Zehnera scabra</i> (Linn. f.) Sond.	Cucurbitaceae	Lianas

Appendix 2. Woody species, number of stems and density of Ylat forest

	Scientific name	Number of stems	Density	Density/ha (%)

1	<i>Acacia albida</i>	131	60.65	4.94
2	<i>Allophylus abyssinicus</i>	150	69.44	5.65
3	<i>Calpurnia aurea</i>	35	16.2	1.32
4	<i>Capparis tomentosa</i>	24	11.11	0.9
5	<i>Carissa spinarum</i>	48	22.22	1.81
6	<i>Clerodendrum alatum</i>	66	30.56	2.49
7	<i>Clerodendrum myricoides</i>	45	20.83	1.69
8	<i>Croton macrostachyus</i>	30	13.89	1.13
9	<i>Discopodium penninervium</i>	144	66.67	5.43
10	<i>Dodonaea angustifolia</i>	180	83.33	6.79
11	<i>Dombeya torrida</i>	20	9.26	0.75
12	<i>Dovyalis abyssinica</i>	34	15.741	1.28
13	<i>Erica arborea</i>	381	176.39	14.4
14	<i>Euclaptus globulus</i>	61	28.24	2.3
15	<i>Euclea racemosa subsp. schimperi</i>	51	23.61	1.92
16	<i>Euphorbia tirucalli</i>	24	11.11	0.9
17	<i>Hagenia abyssinica</i>	28	12.963	1.06
18	<i>Hypericum revolutum</i>	141	65.28	5.32
19	<i>Juniperus procera</i>	128	59.26	4.83

20	<i>Milettia ferruginea</i>	27	12.5	1.02
21	<i>Myrica salicifolia</i>	19	8.796	0.72
22	<i>Myrsine africana</i>	405	187.5	15.27
23	<i>Olea europaea</i> subsp. <i>cuspidata</i>	44	20.37	1.66
24	<i>Opuntia ficus-indica</i>	35	16.2	1.32
25	<i>Osyris quadripartita</i>	47	21.76	1.77
26	<i>Otostegia tomentosa</i>	96	44.44	3.62
27	<i>Prunus africana</i>	37	17.3	1.41
28	<i>Rhus retinorrhoea</i>	89	41.204	3.36
29	<i>Rosa abyssinica</i>	42	19.44	1.58
30	<i>Salix subserrata</i>	57	26.39	2.15
31	<i>Withania somnifera</i>	33	15.28	1.24
Total		2652	1227.77	100

Appendix 3. Percentage, relative density frequency and relative frequency of woody species of Ylat forest

No.	Scientific name	r. density	Frequency	r. freq (%)
1	<i>Acacia albida</i>	4.94	12	4.65
2	<i>Allophylus abyssinicus</i>	5.65	31	12
3	<i>Calpurnia aurea</i>	1.32	3	1.16
4	<i>Capparis tomentosa</i>	0.9	2	0.78
5	<i>Carissa spinarum</i>	1.81	3	1.16
6	<i>Clerodendrum alatum</i>	2.49	2	0.78
7	<i>Clerodendrum myricoides</i>	1.69	2	0.78
8	<i>Croton macrostachyus</i>	1.13	2	0.78
9	<i>Discopodium penninervium</i>	5.43	12	4.65
10	<i>Dodonaea angustifolia</i>	6.79	10	3.89
11	<i>Dombeya torrida</i>	0.75	6	2.33
12	<i>Dovyalis abyssinica</i>	1.28	3	1.16
13	<i>Erica arborea</i>	14.4	33	12.79
14	<i>Euclaptus globulus</i>	2.3	25	9.7
15	<i>Euclea racemosa</i> subsp. <i>Schimperi</i>	1.92	2	0.78
16	<i>Euphorbia tirucalli</i>	0.9	1	0.39
17	<i>Hagenia abyssinica</i>	1.06	1	0.39

18	<i>Hypericum revolutum</i>	5.32	9	3.49
19	<i>Juniperus procera</i>	4.83	22	8.52
20	<i>Millettia ferruginea</i>	1.02	4	1.55
21	<i>Myrica salicifolia</i>	0.72	1	0.39
22	<i>Myrsine africana</i>	15.27	28	10.85
23	<i>Olea europaea</i> subsp. cuspidata	1.66	13	4.04
24	<i>Opuntia ficus-indica</i>	1.32	1	0.39
25	<i>Osyris quadripartita</i>	1.77	2	0.78
26	<i>Otostegia tomentosa</i>	3.62	8	3.1
27	<i>Prunus africana</i>	1.41	5	1.93
28	<i>Rhus retinorrhoea</i>	3.36	6	2.3
29	<i>Rosa abyssinica</i>	1.58	4	1.55
30	<i>Salix subserrata</i>	2.15	4	1.55
31	<i>Withania somnifera</i>	1.24	1	0.39
Total		100	258	100

Appendix 4. DBH range of woody species of Ylat forest

No.	Scientific name	Diameter at Breast Height			
		1-10 cm	11-20 cm	21-30cm	>40 cm
1	<i>Acacia albida</i>	131	0	0	0
2	<i>Allophylus abyssinicus</i>	150	0	0	0
3	<i>Calpurnia aurea</i>	35	0	0	0
4	<i>Capparis tomentosa</i>	24	0	0	0
5	<i>Carissa spinarum</i>	48	0	0	0
6	<i>Clerodendrum alatum</i>	66	0	0	0
7	<i>Clerodendrum myricoides</i>	45	0	0	0
8	<i>Croton macrostachyus</i>	30	0	0	0
9	<i>Discopodium penninervium</i>	144	0	0	0
10	<i>Dodonaea angustifolia</i>	180	0	0	0
11	<i>Dombeya torrida</i>	20	0	0	0
12	<i>Dovyalis abyssinica</i>	34	0	0	0
13	<i>Erica arborea</i>	381	0	0	0
14	<i>Euclaptus globulus</i>	61	0	0	0
15	<i>Euclea racemosa</i> subsp. <i>schimperi</i>	51	0	0	0
16	<i>Euphorbia tirucalli</i>	24	0	0	0

17	<i>Hagenia abyssinica</i>	28	0	0	0
18	<i>Hypericum revolutum</i>	141	0	0	0
19	<i>Juniperus procera</i>	128	0	0	0
20	<i>Millettia ferrogina</i>	27	0	0	0
21	<i>Myrica salicifolia</i>	19	0	0	0
22	<i>Myrsine africana</i>	405	0	0	0
23	<i>Olea europaea</i> subsp. cuspidata	44	0	0	0
24	<i>Opuntia ficus-indica</i>	0	35	0	0
25	<i>Osyris quadripartita</i>	47	0	0	0
26	<i>Otostegia tomentosa</i>	96	0	0	0
27	<i>Prunus africana</i>	37	0	0	0
28	<i>Rhus retinorrhoea</i>	89	0	0	0
29	<i>Rosa abyssinica</i>	42	0	0	0
30	<i>Salix subserrata</i>	57	0	0	0
31	<i>Withania somnifera</i>	33	0	0	0
Total		2617	35	0	0

Appendix 5. Basal Area (BA), BA/ha and percentage of BA of woody individuals of Ylat forest

No.	Scientific name	BA	BA/ha	BA%
1	<i>Acacia albida</i>	0.322	0.1491	14.98
2	<i>Allophylus abyssinicus</i>	0.2384	0.1104	11
3	<i>Calpurnia aurea</i>	0.0045	0.002083	0.21
4	<i>Capparis tomentosa</i>	0.04712	0.0218	2.19
5	<i>Carissa spinarum</i>	0.011934	0.005525	0.55
6	<i>Clerodendrum alatum</i>	0.0172	0.007963	0.8
7	<i>Clerodendrum myricoides</i>	0.00894	0.0041375	0.42
8	<i>Croton macrostachyus</i>	0.0499	0.0231	2.32
9	<i>Discopodium penninervium</i>	0.05621	0.02602	2.61
10	<i>Dodonaea angustifolia</i>	0.051	0.02361	2.37
11	<i>Dombeya torrida</i>	0.00897	0.00415	0.417
12	<i>Dovyalis abyssinica</i>	0.013267	0.006142	0.617
13	<i>Erica arborea</i>	0.1961	0.091	9.12
14	<i>Euclaptus globulus</i>	0.1724	0.0798	8.02
15	<i>Euclea racemosa</i> subsp. <i>schimperi</i>	0.033	0.01528	1.53
16	<i>Euphorbia tirucalli</i>	0.0046	0.00212	0.21
17	<i>Hagenia abyssinica</i>	0.0062	0.00285	0.29

18	<i>Hypericum revolutum</i>	0.09054	0.042	4.21
19	<i>Juniperus procera</i>	0.304	0.141	14.14
20	<i>Millettia ferrogina</i>	0.0054	0.002481	0.25
21	<i>Myrica salicifolia</i>	0.00377	0.00175	0.175
22	<i>Myrsine africana</i>	0.032	0.0148	1.49
23	<i>Olea europaea</i> subsp. <i>cuspidata</i>	0.024	0.012	1.12
24	<i>Opuntia ficus-indica</i>	0.3325	0.15394	15.465
25	<i>Osyris quadripartita</i>	0.0089	0.004157	0.41
26	<i>Otostegia tomentosa</i>	0.009122	0.004223	0.42
27	<i>Prunus africana</i>	0.0294	0.0136	1.37
28	<i>Rhus retinorrhoea</i>	0.01145	0.0053	0.53
29	<i>Rosa abyssinica</i>	0.00834	0.00386	0.39
30	<i>Salix suberrata</i>	0.00722	0.003343	0.34
31	<i>Withania somnifera</i>	0.04	0.02016	1.86
Total		2.15	1	100

Appendix 6. Mean basal area, dominance and relative dominance of woody species in Ylat forest

No.	Scientific name	Mean basal area	total no.	Dominancy	r. dominancy
1	<i>Acacia albida</i>	0.002458	131	0.322	14.98
2	<i>Allophylus abyssinicus</i>	0.001589	150	0.2384	11
3	<i>Calpurnia aurea</i>	0.00012857	35	0.0045	0.21
4	<i>Capparis tomentosa</i>	0.0001963	24	0.04712	2.19
5	<i>Carissa spinarum</i>	0.00024862	48	0.011934	0.55
6	<i>Clerodendrum alatum</i>	0.0002606	66	0.0172	0.8
7	<i>Clerodendrum myricoides</i>	0.000199	45	0.00894	0.42
8	<i>Croton macrostachyus</i>	0.001663	30	0.0499	2.32
9	<i>Discopodium penninervium</i>	0.0003903	144	0.05621	2.61
10	<i>Dodonaea angutifolia</i>	0.000283	180	0.051	2.37
11	<i>Dombeya torrida</i>	0.0305	20	0.00897	0.417
12	<i>Dovyalis abyssinica</i>	0.0003902	34	0.013267	0.617
13	<i>Erica arborea</i>	0.000515	381	0.1961	9.12
14	<i>Euclaptus globulus</i>	0.00283	61	0.1724	8.02
15	<i>Euclea racemosa</i> subsp. <i>schimperi</i>	0.000647	51	0.033	1.53

16	<i>Euphorbia tirucalli</i>	0.00019166	24	0.0046	0.21
17	<i>Hagenia abyssinica</i>	0.0002214	28	0.0062	0.29
18	<i>Hypericum revolutum</i>	0.000642	141	0.09054	4.21
19	<i>Juniperus procera</i>	0.002375	128	0.304	14.14
20	<i>Millettia ferruginea</i>	0.0002	27	0.0054	0.25
21	<i>Myrica salicifolia</i>	0.0001984	19	0.00377	0.175
22	<i>Myrsine africana</i>	0.000079	405	0.032	1.49
23	<i>Olea europaea subsp. cuspidata</i>	0.000535	44	0.024	1.12
24	<i>Opuntia ficus-indica</i>	0.0095	35	0.3325	15.465
25	<i>Osyris quadripartita</i>	0.0001911	47	0.0089	0.41
26	<i>Otostegia tomentosa</i>	0.000095	96	0.009122	0.42
27	<i>Prunus africana</i>	0.000795	37	0.0294	1.37
28	<i>Rhus retinorrhoea</i>	0.00012865	89	0.01145	0.53
29	<i>Rosa abyssinica</i>	0.0001985	42	0.00834	0.39
30	<i>Salix subserrata</i>	0.000127	57	0.00722	0.34
31	<i>Withania somnifera</i>	0.00133	33	0.04	1.86
Total		0.0587	2652	2.15	100

Appendix 7. Importance Value Index (IVI) of each woody species of Ylat forest resulted from the sum of relative density, relative frequency and relative dominance

No.	Scientific name	r. density	r. freq	r. dom	IVI
1	<i>Acacia albida</i>	4.94	4.65	14.98	24.57
2	<i>Allophylus abyssinicus</i>	5.65	12	11	28.65
3	<i>Calpurnia aurea</i>	1.32	1.16	0.21	2.69
4	<i>Capparis tomentosa</i>	0.9	0.78	2.19	3.87
5	<i>Carissa spinarum</i>	1.81	1.16	0.55	3.52
6	<i>Clerodendrum alatum</i>	2.49	0.78	0.8	4.07
7	<i>Clerodendrum myricoides</i>	1.69	0.78	0.42	3.27
8	<i>Croton macrostachyus</i>	1.13	0.78	2.32	4.23
9	<i>Discopodium penninervium</i>	5.43	4.65	2.61	12.69
10	<i>Dodonaea angustifolia</i>	6.79	3.89	2.37	13.05
11	<i>Dombeya torrida</i>	0.75	2.33	0.417	3.5
12	<i>Dovyalis abyssinica</i>	1.28	1.16	0.617	3.06
13	<i>Erica arborea</i>	14.4	12.79	9.12	36.31
14	<i>Euclaptus globulus</i>	2.3	9.7	8.02	20.02
15	<i>Euclea racemosa</i> subsp .schimperi	1.92	0.78	1.53	4.23
16	<i>Euphorbia tirucalli</i>	0.9	0.39	0.21	1.5

17	<i>Hagenia abyssinica</i>	1.06	0.39	0.29	1.74
18	<i>Hypericum revolutum</i>	5.32	3.49	4.21	13.02
19	<i>Juniperus procera</i>	4.83	8.52	14.14	27.49
20	<i>Milltetia ferruginea</i>	1.02	1.55	0.25	2.82
21	<i>Myrica salicifolia</i>	0.72	0.39	0.175	1.285
22	<i>Myrsine africana</i>	15.27	10.85	1.49	27.61
23	<i>Olea europaea subsp. cuspidata</i>	1.66	4.04	1.12	6.82
24	<i>Opuntia ficus-indica</i>	1.32	0.39	15.465	17.175
25	<i>Osyris quadripartita</i>	1.77	0.78	0.41	2.96
26	<i>Otostegia tomentosa</i>	3.62	3.1	0.42	7.14
27	<i>Prunus africana</i>	1.41	1.93	1.37	4.71
28	<i>Rhus retinorrhoea</i>	3.36	2.3	0.53	6.19
29	<i>Rosa abyssinica</i>	1.58	1.55	0.39	3.52
30	<i>Salix subserrata</i>	2.15	1.55	0.34	4.04
31	<i>Withania somnifera</i>	1.24	0.39	1.86	3.49
Total		100	100	100	300

Appendix 8. The regeneration status of woody plant species in Ylat forest

No.	Scientific name	Seedlings/ha	Saplings/ ha
1	<i>Acacia albida</i>	66.203	67.13
2	<i>Allophylus abyssinicus</i>	49.17	27.315
3	<i>Calpurnia aurea</i>	28.241	35.19
4	<i>Capparis tomentosa</i>	32.41	50.463
5	<i>Carissa spinarum</i>	17.593	58.33
6	<i>Clerodendrum alatum</i>	30.55	27.3
7	<i>Clerodendrum myricoides</i>	29.17	28.704
8	<i>Croton macrostachyus</i>	31.02	34.26
9	<i>Discopodium penninervium</i>	73.61	14.352
10	<i>Dodonaea angustifolia</i>	75.463	60.65
11	<i>Dombeya torrida</i>	0	0
12	<i>Dovyalis abyssinica</i>	45.83	43.52
13	<i>Erica arborea</i>	185.65	157.41
14	<i>Euclaptus globulus</i>	30.0926	25
15	<i>Euclea racemosa</i> subsp. <i>schimperi</i>	13.426	18.06
16	<i>Euphorbia tirucalli</i>	63.89	65.74
17	<i>Hagenia abyssinica</i>	30.093	31.944

18	<i>Hypericum revolutum</i>	47.69	57.87
19	<i>Juniperus procera</i>	53.24	75.93
20	<i>Millettia ferruginea</i>	12.5	9.722
21	<i>Myrica salicifolia</i>	43.43	61.574
22	<i>Myrsine africana</i>	79.17	71.2963
23	<i>Olea europaea subsp. cuspidata</i>	43.06	42.13
24	<i>Opuntia ficus-indica</i>	68.06	61.57
25	<i>Osyris quadripartita</i>	34.26	37.5
26	<i>Otostegia tomentosa</i>	0	0
27	<i>Prunus africana</i>	44.44	40.741
28	<i>Rhus retinorrhoea</i>	46.759	45.37
29	<i>Rosa abyssinica</i>	18.98	19.91
30	<i>Salix subserrata</i>	24.074	22.685
31	<i>Withania somnifera</i>	21.76	27.78
Total		1339.83	1319.45