



**Floristic Composition, Species Diversity and Vegetation
Structure of Gera Moist Montane Forest, Jimma Zone of
Oromia National Regional State, Southwest Ethiopia**

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ABSTRACT

Floristic composition, Species diversity and Vegetation structure of Gera Moist Montane Forest was conducted in Jimma Zone of Oromia National Regional State, South west Ethiopia, with the objective to study the floristic composition and structure of the Forest. A total of 132 plant species in 112 genera and 59 families were identified from this Forest. Fabaceae was the most dominant family with ten species (7.57%) and nine genera. Seven endemic species were recorded from the study area. Systematic sampling method was used to collect vegetation data. Accordingly, 50 quadrats each with 900 m² (30 m X 30 m) for woody species and subplots of 1 m X 1 m within the main plots for herbaceous plants were laid along three line transects. All plots were laid at a distance of 200 m along transect lines. Shannon-Wiener diversity index were used to compute species richness and evenness between the plant communities. DBH, basal area, height and frequency were computed and compared to describe the structure of the Forest. The regeneration status of some woody species of the Forest was evaluated based on the number of seedlings and saplings per hectare. For seedlings, the main quadrats were divided into subplots of 5 m X 5 m (25 m²). Vegetation classification was performed using R-2.11.1 software packages. Five clusters were recognized and designated as local plant community types. Plant communities were named after two of the dominant woody species occurring in each group using the relative magnitude of the highest mean cover abundance within the cluster. The total seedlings and saplings of 20 selected woody species of Gera Forest were about 4,838 and 1,331 individuals per hectare respectively. Future research directions and recommendations are suggested for the sustainable utilization of the vegetation.

Key words/Phrases: Gera Forest, Floristic composition, plant community, species diversity, vegetation structure.

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LIST OF ACRONYMS

AAU	Addis Ababa University
BA	Basal Area
CR	Critically endangered
DBH	Diameter at Breast Height
EFAP	Ethiopian Forestry Action Plan
EN	Endangered
ENMSA	Ethiopian National Meteorological Station Agency
EPA	Environmental Protection Authority
ETH	National Herbarium
EWNHS	Ethiopian Wildlife and Natural History Society
FAO	Food and Agriculture Organization
FEE	Flora of Ethiopia and Eritrea
G.D.A.R.D.O	Gera District Agriculture and Rural Development Office
GPS	Geographical Position System
IBC	Institute of Biodiversity Conservation
IUCN	International Union for Conservation of Nature and Natural Resources
IUFRO	International Union for Forestry Research Organizations
IVI	Importance Value Index
LC	Least concern
MRPP	Multi-Response Permutation Procedure
NBSAP	National Biodiversity Strategy and Action Plan
NFPA	National Forest Priority Area

NMSA	National Meteorological Service Agency
NT	Near threatened
PCC	Population Census Commission
RD	Relative Density
RDO	Relative Dominance
RED	Relative Euclidean Distance
RF	Relative Frequency
TWINSpan	Two Way Indicator Species Analysis
USAID	United States of America International Development
VU	Vulnerable
WBISPP	Woody Biomass Inventory and Strategic Planning Project
WRI	World Resource Institute

CHAPTER ONE

1. INTRODUCTION

Ethiopia is an important regional center for biological diversity due to its wide ranges of altitude, great geographical diversity with high and rugged mountains, flat-topped plateaus and deep gorges, incised river valleys and rolling plains (Ensermu Kelbessa *et al.* 1992; Zerihun Woldu, 1999). These helped the emergence of wide ranges of habitats that are suitable for the evolution and survival of various plant and animal species. As a result, the country is regarded as one of the most important countries in Africa with respect to endemism of plant and animal species in tropical Africa (EFAP, 1994; EWNHS, 1996). The Flora of Ethiopia contains about 6000 species of vascular plants, of which about 10% are endemic (Ensermu Kelbessa, pers.comm.).

A substantial proportion of the Ethiopian highlands were once believed to have been covered by forests having wide coverage but had gradually been cleared (Friis, 1992). Tamrat Bekele (1993) remarked that the occurrence of isolated mature trees in farmlands and the patches of forests that are seen around church-yards and religious burial grounds indicate the historical presence of vast expanse of forests in the past. Historical documents indicated that Ethiopia had experienced substantial deforestation, soil degradation and an increase in the area of bare land over the years. The need for fuel-wood, arable land and grazing areas have been indicated as the main causes of forest degradation; frequently leading to loss of forest cover and biodiversity, erosion, desertification and reduced water resources (Ensermu Kelbessa and Teshome Soromessa, 2008). Deliberate fire and non-integrated investment activities are also reasons for the reduction of forests in Ethiopia.

The high level of dependency of the local community on agriculture (more than 90%) and high rate of population growth (EFAP, 1994; Tadesse Woldemariam, 2003; Simon Shibru and Girma Balcha, 2004; Feyera Senbeta, 2006) have also accelerated the problems. On the other hand, lack of integration of the local people living around the conservation areas into the conservation efforts, is the major constraint to the overall conservation effort in Ethiopia (Feyera Senbeta and Demel Teketay, 2003). Because of this, it had been realized that unless the local community was involved in the conservation effort, the sustainability of forest resources will always be uncertain (Aklilu Ameha, 2002).

Southwestern Ethiopia was rich in remnants of natural forests, but they were disappearing at an alarming rate because of encroachment by agricultural activities and the pressure from investors (Taye Bekele *et al.* 2001). The new investment opportunities being undertaken in southwest Ethiopia are converting the few remaining moist montane forests into other land use systems such as coffee and tea plantations (Taye Bekele *et al.* 2001). Loss of forest cover and biodiversity due to human-induced activities was a growing concern in many parts of the world (Feyera Senbeta and Demel Teketay, 2003). In addition, generation of scientific knowledge through the studies of floristic composition and structural analysis could be one of the intervention mechanisms to contribute towards the conservation of vegetation resources and the associated biodiversity. It is, thus, equally important to study and document the remaining vegetation resources for conservation and sustainable utilization based on scientific knowledge. Hence, this study was conducted with the main objective of investigating floristic composition, plant diversity, community types and vegetation structure in Gera Forest.

1.1. Statement of the Problem

Gera Forest has been continuously exploited through agricultural land expansion, timber logging, firewood collection, wood cutting for construction and other purposes. Based on studies conducted during 1996-1998, the annual rate of deforestation of Gera forest was 4.7% (Bezuayehu Tefera *et al.* 2000; cited in Kitessa Hundera and Tsegaye Gadissa, 2008).

Part of Gera Forest has been used for coffee plantation and there is still a growing interest to invest on the remaining part of this Forest. In addition, firewood supply for Chira town is mainly obtained from this Forest area. This uncontrolled exploitation of the Forest and its conversion in to other land uses would inevitably lead to changes in the floristic composition and structure of the Forest and brings loss of biological diversity.

Moreover, little is known about the Forest as no floristic and structural study of the Forest was made before. In order to maintain the ecological equilibrium and to meet the Forest products requirement of the population, scientific information is required. Thus, the present study was initiated to generate basic scientific information on the biodiversity and structure of the Forest.

1.2. Objectives of the Study

1.2.1. General Objective

- To study the floristic composition, species diversity and vegetation structure of Gera Moist Montane Forest.

1.2.2. Specific Objectives

- ❖ To document the floristic composition of the Forest vegetation,
- ❖ To document the endemic plants of Gera Forest,
- ❖ To document commercially important tree species of Gera Forest,
- ❖ To analyze the structure of the Forest vegetation,
- ❖ To identify the plant community types of the Forest vegetation,
- ❖ To provide baseline information on the Forest vegetation that would help for future management, and
- ❖ To make recommendations on the future management and conservation of the Forest.

CHAPTER TWO

2. LITERATURE REVIEW

2.1. Floristic diversity of Ethiopia

Ethiopia is one of the centers of plant genetic diversity, and that its indigenous forests have been repositories of biodiversity including microorganisms, fungi, soil fauna and flora, medicinal plants, wild animals, birds, insects, as well as human beings (Tewolde Berhane Gebre Egziabher, 1990; Legesse Negash, 2002).

The variations in latitude have resulted in a wide variation in rainfall, humidity, temperature and exposure to wind. These differences along with edaphic variations form the basis for the wide biodiversity of the country. This geographical and ecological diversity of Ethiopia, with extraordinary range of terrestrial and aquatic ecosystems, contributed to the high rate of endemism and diversity (Demel Teketay *et al.* 2004). There are about 6000 vascular plant species in Ethiopia of which about 10 percent are endemic (Ensermu Kelbessa, pers.commun.). The Forest and woody vegetation resources of Ethiopia were estimated to cover greater than 11.7 percent of the land, of this the woodlands cover about 4.5 percent of the total land of Ethiopia (EPA, 1998).

2.2. Vegetation Types of Ethiopia

Vegetation refers to an assemblage of plants growing together in a particular location, or the collective plant cover of an area (Jennings *et al.* 2003). The vegetation resources of Ethiopia, including forests, woodlands and bushlands have been studied by several scholars (EFPA, 1994).

Attempts to describe the vegetation were also conducted by many Ethiopian scholars of which Hailu Sharew (1982), Lissanework Nigatu (1987), Tamrat Bekele (1994), Sebsebe Demissew *et al.* (1996), Kumilachew Yeshitela (1997), Teshome Soromessa (1997), Sebsebe Demissew (1998) and Zerihun Woldu (1999) were a few. Friis *et al.* (2010) indicated that there are twelve major vegetation types in Ethiopia. These major vegetation types include Desert, Semi-desert scrubland forest; *Acacia-Commiphora* woodland and bushland; Wooded grassland of the Western Gambela Region; *Combretum-Terminalia* woodland and wooded grassland; Dry Evergreen Afromontane forest and grassland complex; Moist Evergreen Afromontane forest and bushland; Transitional rain Forest; Ericaceous belt; Afro-alpine belt; Riverine vegetation; Fresh - water lakes; and Salt Lakes vegetation.

2.3. Moist Montane Forest of Ethiopia

This vegetation type is in most cases characterized by one or more closed strata of evergreen trees that may reach a height of 30 to 40 m. Sometimes only the lower stratum remains, due to the removal of the tallest trees. The Moist Afromontane forest, according to Friis (1992) occurs mainly in the south-western part of the Ethiopian Highlands between (1500-) 1800 and 2600 (- 3000) m, with an annual rainfall between 700 and 2000 mm (or more).

The Haremma Forest on the southern slopes of the Bale Mountains is the easternmost example of this forest. These forests predominantly contain broad-leaved evergreen species in the multilayered canopy. The most characteristic type of this forest type occurs widely in the upland parts of Welega, Ilubabor and Kefa floristic regions (Sebsebe Demissew and Nordal, 2010).

The characteristic emergent species of this vegetation type that form the 20-30 m high canopy is *Pouteria adolfi-friederici*. Other characteristic species include *Albizia gummifera*, *Albizia schimperiana*, *Sapium ellipticum*, *Euphorbia ampliphylla*, *Ekebergia capensis*, *Ficus sur*, *Hallea rubrostipulata*, *Olea welwitschii*, *Polyscias fulva* and *Schefflera abyssinica* (Sebsebe Demissew and Nordal, 2010).

2.4. Threats to Biodiversity in Ethiopia

A loss in biodiversity due to degradation of environment and other threats to components of ecological systems was the most serious environmental problems Ethiopia was facing (FAO, 1996; NBSAP, 2005). This loss in biological diversity ultimately implies economic losses to a country and the world as a whole. The removal of vegetation cover also reduces the quantity of carbon that can be sequestered from the atmosphere (EFAP, 1994) and contribute to the global warming. The extent of past forest cover on the Ethiopian high lands is evident from the numerous isolated mature forest trees or small patches of forests or woodlands that make conspicuous landmarks on the plateau (Friis, 1992). Large areas with evergreen bushland or farmland mixed with bushland represent formerly forested areas (Friis, 1992). There was a decline in forest cover from the original 35% to 16% by the early 1950's. By the early 1980's, it has been estimated that the land area covered by forest had declined to 3.6% and by 1989 to 2.7% and estimated to be 2.4% in 1992 (Million Bekele and Leykun Berhanu, 2001).

The rich biodiversity of the country was under serious threat from deforestation, land degradation, overexploitation, overgrazing and habitat loss (De Vletter, 1991; EPA, 1998; Demel Teketay, 2001). In most cases, the major destructive factor of plant diversity was deforestation caused by agricultural expansion and fuel- wood scavenging (Ababu Anage, 2009).

In current situations, Ethiopia is in the track of high investment rate, agro-industry expansion and population migration to a fragile ecosystem like forests and related resources. However, almost all of these huge activities were done without prior environmental impact assessment. As a result, many virgin and irreplaceable forests are cleared for different activities like livestock ranches, coffee and tea plantations (Kumilachew Yeshitela, 2001; Yonas Yemishaw, 2001; Getachew Tesfaye and Demel Teketay, 2005).

The other threats to the plant biodiversity of the country are unsustainable utilization of natural resources, forest fires, land degradation, habitat loss and fragmentation, extensive replacement of farmer's local varieties or breeds by improved ones, invasive species, wetland destruction and climate change. But all these are related to the root causes of poverty, which are lack of alternative viable livelihoods, increasing population pressure and inadequate awareness of the threats (De Vletter, 1991; EPA, 1998).

These different threats are in rapid progress to decline the trend in the conservation status of Ethiopia's plant diversity. The challenges to conservation and sustainable use of Ethiopia's biodiversity are very complicated and interlinked (Ababu Anage, 2009). Some reports indicated that there are still high rate of deforestation in Ethiopia beyond any expectations (De Vletter, 1991; EPA, 1997; EPA, 1998; Demel Teketay, 2001; Yonas Yemishaw, 2001; FAO, 2007). So, the plant biodiversity of Ethiopia need better attention to conserve and protect from these losses.

2.5. Vegetation Structure and Plant Community

Vegetation structure is the organization in space of the individuals that form a community and by extension a vegetation type or plant association (Muller-Dombois and Ellenberg, 1974). It is the spatial pattern of growth forms in a plant community, especially with regard to their height, abundance or coverage within the individual layer (Jennings *et al.* 2003).

2.6. Species diversity, richness and similarity

Species diversity can be viewed from different perspectives: alpha, beta and gamma diversity. Alpha diversity refers to the diversity of species within a particular habitat or community. Beta diversity is a measure of the rate and extent of change in species along a gradient from one habitat to another. It is between habitat diversity that measures turnover rates. Beta diversity is sometimes called habitat diversity (Kent and Coker, 1992). Gamma diversity is the diversity of species in comparable habitats along geographical transect and it depends on the alpha and beta diversity (Kent and Coker, 1992).

Species diversity indices provide information about community composition. Measures of species diversity are usually seen to be key indicators for the wellbeing of ecological systems. Among many of the species diversity indices, diversity and evenness are often calculated using Shannon diversity index (Kent and Coker, 1992). It is the most widely used index that combines species richness with evenness.

Species richness refers to the total number of species in a community while evenness is the relative abundance of species within the sample or community (Kent and Coker, 1992). Diversity is, thus, measured by recording the number of species and their relative abundances.

The two components may be examined separately or combined in some form of index like the Shannon diversity index. Patterns of plant species diversity have often been noted for prioritizing conservation activities because they reflect the underlying ecological processes that are important for management (Lovett *et al.* 2000).

Similarity indices measure the degree to which the species composition of quadrats or samples is alike. Sorenson's coefficient which is expressed as $S_s = 2a / (2a+b+c)$ is the most common binary similarity coefficients because it relies on presence or absence data (Kent and Coker, 1992).

2.7. Species abundance and frequency

Abundance is the number of individual plants of a given species per unit area. It can be used to show spatial distribution and ranges over time. Frequency is the proportion of plots in which a species occurs. It is a measure of the occurrence of a given species in a given area. It indicates how the species are dispersed and is an ecologically meaningful parameter. In other words, it gives an approximate indication of the homogeneity of the stand under consideration (Kent and Coker, 1992).

2.8. Species importance value index (SIV) and dominance

Species importance value index permits a comparison of species in a given location and reflects the dominance, occurrence and abundance of a given species in relation to other associated species in an area (Kent and Coker, 1992). Therefore, for setting conservation priority, it is a good index for summarizing vegetation characteristics and ranking species for management and conservation practices.

CHAPTER THREE

3. 1. DESCRIPTION OF THE STUDY AREA

3.1.1. Location

The study was conducted in Gera District, Jimma Zone of Oromia National Regional State, Southwest Ethiopia (Figure 1). The study Forest is located at about 380 km south west of Addis Ababa and has a total area of 80,830.4 ha. The altitudinal range of the study Forest varies from 1600 to 2400 m a.s.l. Gera District has an area of 1,330.1 Km² and one urban center, Chira town. It is bordered on the south by Gojeb River which separates it from the Southern Nations, Nationalities and Peoples Region, on the northwest by Sigmo, on the north by Setema, on the northeast by Gomma, and on the east by Seka Chekorsa Districts (Figure 1).



Figure 1: Map of Ethiopia and Jimma Zone showing the location of Gera Forest.

[Source: Kitessa Hundera, 2010.]

3.1.2. Topography

Gera District is characterized by mountains (Waka, Kimbibit and Timba), plateaus (Chewra and Kella), plains (Walla, Kecho, Tuta and Tuam Mayi,) and valleys (Naso and Gojeb). The District extends between 1390 and 2980 m a.s.l. Gera Forest, however, is situated in the intermediate altitudinal range between 1600 to 2400 m a.s.l. (GPS reading during field work).

3.1.3. Demographics

The 2007 national census reported a total population for this District of 112,395, of whom 56,488 were men and 55,907 females; 4,746 or 4.22% of the population were urban dwellers. The three largest ethnic groups reported in Gera District were Oromo (86.08%), Amhara (8.27%), and Kafficho (4.16%); all other ethnic groups made up 1.49% of the population.

3.1.4. Soil

The study area has a dystric nitosol soil type, which is deep, clay red soil. The soil is porous and has good potential for agriculture, good physical properties, stable structure, deep rooting volume, and high moisture storage volume. Orthic Acrisol and dystric nitosol are the major soil types found in Gera District (G.D.A.R.D.O., 2012).

3.1.5. Climate and agroclimatic zones

The rainfall and temperature data for the study area were collected from National Meteorological Service Agency (NMSA, 2013). The mean annual temperature is about 18.4 °C and the mean minimum and maximum temperatures are 11.7 °C and 26.5 °C respectively. The mean annual rainfall of the study area is 1805 mm (Figure 2). Gera is classified into dega (5%), woinadega (75%) and kolla (20%) agroclimatic zones (G.D.A.R.D.O, 2012).

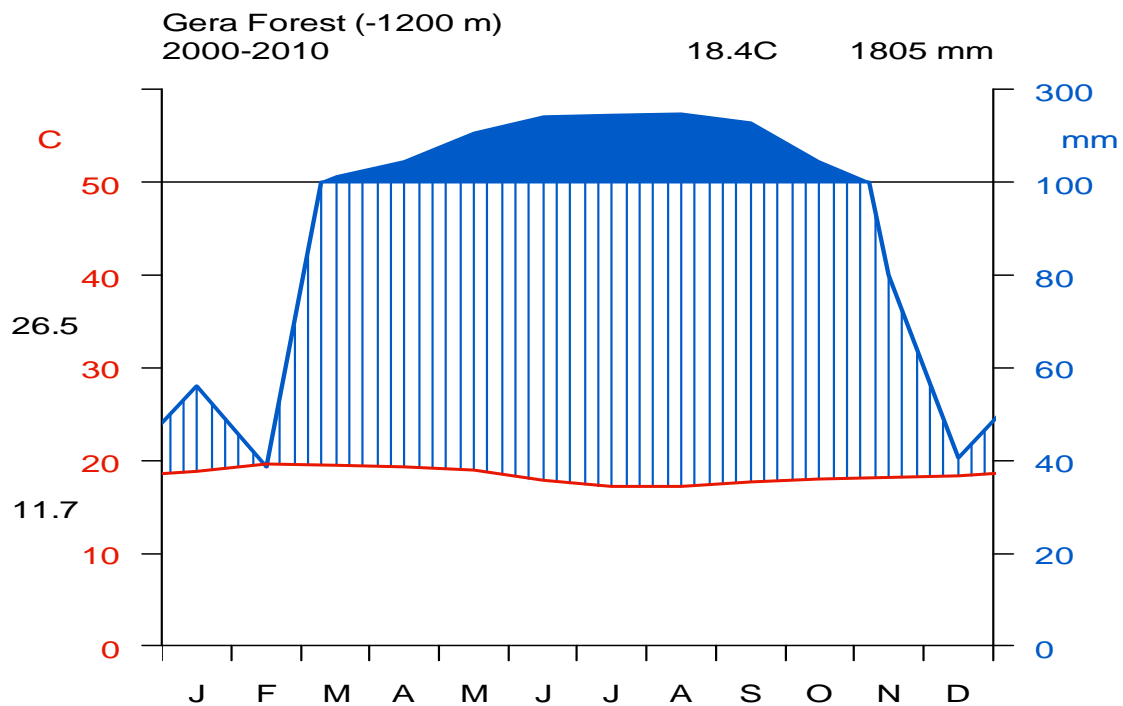


Figure 2. Climadiagram of the study area showing rainfall distribution and temperature variation from 2000 to 2010. [Data source: National Meteorological Service Agency (NMSA, 2013)].

3.1.6. Land use, Agriculture, Trade and Tourism

The proportion of arable, grazing and forest lands in Gera District is 15.47%, 5.6% and 56% respectively (G.D.A.R.D.O., 2012). The remaining land area is either degraded, houses built-up or serves for other purpose (Table 1). High forest, woodland and plantation forests are available in the District.

The majority of the natural Forest patches are under the government protection. Gera District has 226,754 cattle, 54,801 sheep, 14,473 goats, 7,041 mules, 30,532 horses, 1934 donkeys and 21,205 poultry (G.D.A.R.D.O., 2012).

There are some retail traders, small shops, and open markets, in the District. Teff, maize, wheat, sorghum, barely, horse bean, field pea, peppers, fruits, spices, and coffee are important cash crops in the District. Honey production is also practiced in the Forest area. Regarding tourism, water fall on the Naso River, hot springs at Walla and Timba Chele and largely available wild animals are some of the major potentials of the development of tourist industry in the District. Moreover, historically, the District is one of the five Gibe States, created by Guunji, around 1835 (G.D.A.R.D.O., 2012).

Table 1: Land use pattern of Gera District

No.	Land use Type	Area in hectare	%
1	Potential arable land	22,323	15.47
2	Grazing land	8089.22	5.6
3	Forest	80,830.4	56
4	Cultivable land	3,148	2.18
5	Uncultivable land	5,901.76	4.09
6	Construction	9002.62	6.24
7	Others	15,045	10.42
	Total	144,340	100

Source: G.D.A.R.D.O. (2012)

3.1.7. Wildlife

The Forest vegetation of Gera District hosts various species of wild animals including mammals, birds, reptiles and amphibians. Some of the common mammals like buffalo, lion, colobus monkey, gelada baboon, vervet monkey, leopard, warthog, pig, civet cat and antelope are found in the Forest. However, the wildlife populations of these animals are under severe threat due to deforestation and habitat fragmentation mainly because of human encroachment. There is no wildlife conservation area in the District.

3.1.8. Drainage

Gera District, with an altitudinal range between 1390 and 2980 m a.s.l. and wide topographic land forms, is endowed with numerous streams and rivers. Several perennial rivers such as Naso and Gojeb, and intermittent streams (Atta, Naniya, Sisay, Koka, Dacho, etc) are flowing through the district. Locally protected springs, rivers, developed springs and wells are the major sources of drinking water in Gera.

3.1.9. Vegetation

The vegetation type of the study area is broad-leaved and moist montane forest with important species in the Forest including *Olea capensis*, *Schefflera abyssinica*, *Prunus africana*, *Albizia gummifera*, *Syzygium guineense*, *Bersama abyssinica*, *Pouteria adolfi-friedericii*, *Apodytes dimidiata*, *Cassipourea malosana*, *Celtis africana*, *Croton macrostachyus*, *Ekebergia capensis* and *Ficus sur* (IBC, 2005). Some areas of Gera Forest have been cleared for coffee plantation, road construction, timber harvesting, and agricultural intensification which resulted in bushland and farmland formation.



Plate 1: Part of Gera Forest near Naso River



Plate 2: Impact of road construction on the Forest

3.2. MATERIALS AND METHODS

3.2.1. Required materials

The materials that used during the actual plant data collection in the field were plant press, pole cutter, secateurs, plastic bags, flimsies, rolling meter, GPS and digital camera.

3.2.2. Methods

3.2.2.1. Reconnaissance survey

Reconnaissance survey was conducted in October, 2012 to get an impression of the site conditions and identify the possible sampling sites and number of transect lines to be laid across the Forest.

3.2.2.2. Sampling design

Systematic sampling following Kent and Coker (1992) and Muller-Dombois and Ellenberg (1974) were used in this study. Sampling sites were arranged along transects in three directions. The first transect was laid from Chira town to Anfallo area where Naso River is found. The second transect was laid from Chira town to non- coffee part of Gera Forest. The third transect was laid from Chira town to Beshasha town, on the way to Agaro. Each of the three transects contain 16, 21 and 13 plots respectively with 30 m x 30 m (900 m²) for woody species. The plots were arranged at a distance of 200 m from each other depending on the length of the transect. In addition, five sub plots each with 1 m x 1 m, one at each corner and one at the center of the main plot were laid to sample herbaceous plants.

A total of 50 plots were laid for vegetation data collection. Geographical coordinates of the plots were recorded using Magellan NAV5000 Pro GPS navigation system. The number of plots in each transects along with its location and altitude is given in Appendix 1.

3.2.2.3. Vegetation data collection

Vegetation data collection was conducted in November, 2012. A complete list of trees, shrubs, herbs, and climbers was made from the plots along each transect. Vernacular names of species were recorded during field work.

Plant specimens were collected, pressed, and brought to the National Herbarium (ETH), Addis Ababa University for identification and storage. The nomenclature of the taxa follows Flora of Ethiopia and Eritrea (FEE). In each plot, structural attributes such as diameter and height were recorded for some selected woody plants. Diameter was measured for all individual trees and shrubs having DBH greater than 2.5 cm using a diameter tape. Trees and shrubs with DBH less than 2.5 cm were counted. Height was measured for individual trees and shrubs with DBH greater than 2.5 cm.

Partition of the major quadrats was made into four, each 25 m² (5 m X 5 m), so as to make seedling count easier. In this study, seedling refers to young woody species with height \leq 2 m and DBH less than 2.5 cm, while sapling refers to woody plants with height greater than 2 m. The cover abundance of each species was first estimated visually, recorded and later converted to the Braun-Banquet 1-9 modified scale (Kent and Coker, 1992).

3.3. Data Analysis

3.3.1. Vegetation data analysis

Hierarchical cluster analysis is one of the most commonly used multivariate techniques to analyze community ecological data. It helps to group a set of observations (vegetation samples) together, based on their attributes or floristic similarities (Kent and Coker, 1992). For this study, agglomerative hierarchical classification using similarity ratio cluster analysis was performed using R for windows version 2.11.1 (Venables *et al.* 2010) to classify the vegetation into plant community types based on abundance data of the species in each plot.

Synoptic table of the results of the hierarchical agglomerative cluster analysis was produced using the cluster identifications to compute mean values of the cover abundance of the species in the respective clusters. A synoptic table is a table with the mean values of the species cover abundance of cluster groups. Synoptic values are the products of species' frequency and average cover abundance values (mean frequency x mean cover-abundance) (van der Maarel *et al.* 1987; cited in Abate Ayalew *et al.* 2006).

3.3.2. Diversity and similarity indices

The two main components of measuring diversity are species richness and evenness. Species richness is a measure of the number of different species in a given site. Species richness index has a great importance in assessing taxonomic, structural and ecological value of a given habitat. Evenness is a measure of abundance of the different species that make up the richness of the area. Species diversity shows the product of species richness and evenness.

Shannon-Wiener diversity index is the most popular measure of species diversity because it accounts both for species richness and evenness, and it is not affected by sample size (Kent and

Coker, 1992; Krebs, 1999). Thus, Shannon-Wiener diversity index, species richness and Shannon's evenness were computed to describe species diversity of the plant community types in the vegetation of Gera Forest. Shannon-Wiener diversity index was calculated as follows:-

$$H' = - \sum_{i=1}^S p_i \ln p_i$$

- H' = Shannon Diversity Index,
- S = the number of species,
- P_i = the proportion of individuals or the abundance of the i^{th} species expressed as a proportion of total cover and
- \ln = logbase _{n}

Evenness (Equitability) $J = H' / H' \text{ max}$, where;

- J = Evenness,
- H' = Shannon-Wiener diversity index and $H' \text{ max} = \ln s$ where s is the number of species.

Sorensen's similarity index was used to determine the pattern of species turnover among successive communities. It is described using the following formula (Kent and Coker, 1992).

$$S_s = 2a / (2a + b + c), \text{ Where;}$$

- S_s = Sorensen's similarity coefficient;
- a = Number of species common to both samples;
- b = Number of species found only in sample 1;
- c = Number of species found only in sample 2.

3.3.3. Structural data analysis

The structure of the vegetation was described using frequency distributions of DBH, height and Importance value index (IVI). Tree or shrub density and basal area values were computed on hectare basis. Importance value indices (IVI) were computed for dominant woody species based on their relative density (RD), relative dominance (RDO) and relative frequency (RF) to determine their dominance (Kent and Coker, 1992). The following structural parameters were calculated following Mueller-Dombois and Ellenberg (1974).

IVI = Relative Density (abundance) + Relative Dominance (basal area) + Relative Frequency,

Where: • Relative Density (RD) = the number of all individuals of a species/the total number of

all individuals (DBH > 2.5cm) X 100;

• Relative Frequency (RF) = Frequency of a species/total frequency of all species X100.

• Relative Dominance (RDO) = total basal area of all individuals of a species/total basal area of all species X 100 and Basal area (BA) was calculated using DBH as, $BA = \pi d^2/4$, where, $\pi = 3.14$; d is diameter at breast height.

CHAPTER FOUR

4. RESULTS

4.1. Plant Species Composition of Gera Forest

A total of 132 plant species belonging to 112 genera and 59 families were collected, and identified from Gera Forest (Appendix II). Fabaceae was the most dominant family with ten species (8.03%) and nine genera. Asteraceae was the second dominant family with nine species (6.81%) and five genera (Table 2).

The third species- rich family was Euphorbiaceae with eight species (6.06 %) and six genera followed by Malvaceae, Lamiaceae and Rubiaceae with six species (4.54%) each. The fifth species-rich family were Acanthaceae with five species (3.78%) followed by Boraginaceae with four species (3.03%) and three genera (Table 2).

The families, which contributed three species each, were Celastraceae, Moraceae, Oleaceae, Piperaceae, Poaceae, Polypodiaceae, and Rutaceae, while Araliaceae, Aspleniaceae, Dracaenaceae, Lycopodiaceae, Meliaceae, Rhamnaceae, Rosaceae, Sapindaceae, Tiliaceae, Ulmaceae, Urticaceae and Zingiberaceae contributed two species each and the rest 32 families contained only one species each. Fabaceae, Asteraceae, Euphorbiaceae, Malvaceae and Rubiaceae contributed 29.52 % of the total plant species and the remaining 54 families contributed 70.48 % of the total plant species.

Table 2: Families with their corresponding number of genera and species.

Family	Number of genera	%	Number of species	%
Fabaceae	9	8.03	10	7.57
Asteraceae	5	4.46	9	6.81
Euphorbiaceae	6	5.36	8	6.06
Malvaceae	3	2.68	6	4.54
Rubiaceae	6	5.36	6	4.54
Acanthaceae	4	3.57	5	3.78
Lamiaceae	6	5.36	6	4.54
Boraginaceae	3	2.68	4	3.03
Celastraceae	2	1.77	3	2.27
Moraceae	1	0.89	3	2.27
Oleaceae	2	1.77	3	2.27
Piperaceae	2	1.77	3	2.27
Poaceae	3	2.68	3	2.27
Polypodiaceae	3	2.68	3	2.27
Rutaceae	3	2.68	3	2.27
Araliaceae	2	1.77	2	1.51
Aspleniaceae	1	0.89	2	1.51
Dracaenaceae	1	0.89	2	1.51
Lycopodiaceae	2	1.77	2	1.51
Meliaceae	2	1.77	2	1.51
Rhamnaceae	2	1.77	2	1.51

Rosaceae	2	1.77	2	1.51
Sapindaceae	2	1.77	2	1.51
Tiliaceae	2	1.77	2	1.51
Ulmaceae	2	1.77	2	1.51
Urticaceae	2	1.77	2	1.51
Verbenaceae	1	0.89	1	0.75
Zingiberaceae	2	1.77	2	1.51
Others	31	27.6	32	24.24
Total	112	100	132	100

Among the total plant species, 51 (38.63 %) were herbs, 34 (25.75 %) trees, 31(23.48%) shrubs, 11 (8.33%) climbers, and 5 (3.78%) shrubs/trees. Herbs occupied the highest proportion followed by trees and shrubs (Figure 3).

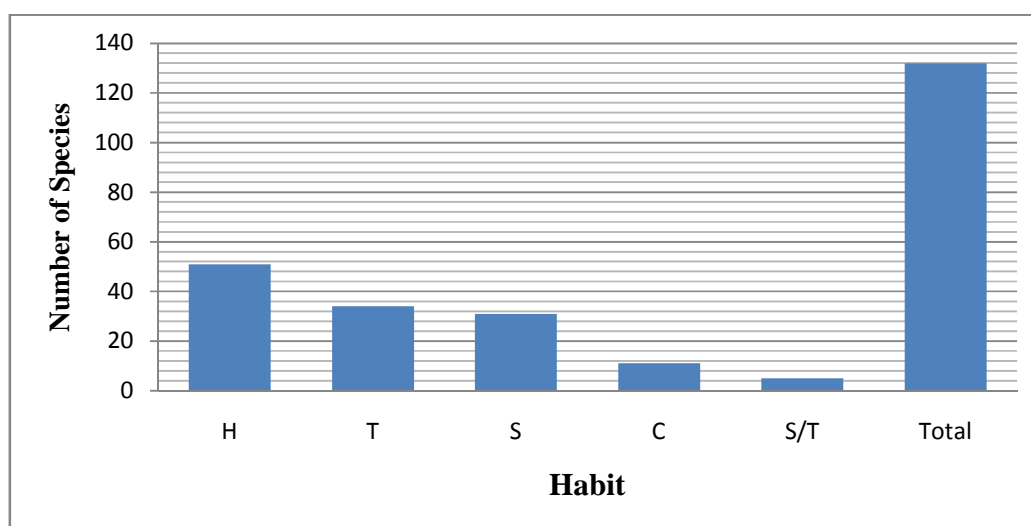


Figure 3: Habit of plant species collected from Gera Forest (H= Herbs, S= Shrubs, T= Trees, C= Climbers and S/T= Shrubs or Trees).

4.2. Endemism

Gera Forest contains a number of flowering plant species that are endemic to Ethiopia. Based on the published Flora volumes and list of species in Gera Forest, the endemic species and the levels of threat on each taxon are given in Table 3 below. Accordingly, 7 (5.30 %) endemic species have been recorded from Gera Forest.

Table 3. Endemic taxa recorded from Gera Forest and their respective family, habit and IUCN category: (T = Tree, S = Shrub, H = Herb, NT= Nearly Threatened, LC= Least Concern, VU= Vulnerable, CR= Critically Endangered).

No.	Scientific name	Family	Habit	IUCN category
1	<i>Aframomum corrorima</i>	Zingiberaceae	H	VU
2	<i>Erythrina brucei</i>	Fabaceae	T	LC
3	<i>Justicia diclipteroides</i> subsp. <i>aethiopica</i>	Acanthaceae	H	NT
4	<i>Millettia ferruginea</i>	Fabaceae	T	LC
5	<i>Satureja paradoxa</i>	Lamiaceae	H	NT
6	<i>Solanecio gigas</i>	Asteraceae	S	LC
7	<i>Vepris dainellii</i>	Rutaceae	T	LC

4.3. Commercially important tree species

Out of 23 major commercial indigenous tree species reported by Million Bekele and Leykun Berhanu (2001), nine species (39.13%) were recorded from the study area. These tree species are *Albizia gummifera*, *Apodytes dimidiata*, *Celtis africana*, *Cordia africana*, *Croton macrostachyus*, *Ekebergia capensis*, *Olea welwitschii*, *Syzygium guineense* and *Pouteria adolfi-friederici*.

4.4. Plant Community types in Gera Forest

All the one hundred thirty two plant species were used for vegetation classification. Cluster analysis of vegetation data in R-2.11.1, showed five different communities (clusters) for Gera Forest (Figure 4). The following five plant communities were named after two of the dominant woody species occurring in each group using the relative magnitude of the highest mean cover abundance within the cluster. A list of the community types along with the synoptic-cover abundance values of the species is given in Table 4.

4.4.1. *Vernonia auriculifera* - *Prunus africana* Community type

The altitudinal distribution of this community type extends from 1700 to 2950 m a.s.l. and it is represented by 113 species. The dominant species in the tree layer is *Prunus africana*. *Vernonia auriculifera* is the dominant species in the shrub layer of this community. *Millettia ferruginea*, *Pouteria adolfi-friederici*, *Dracaena steudneri*, *Cordia africana* and *Allophylus abyssinicus* are associated tree species in this type. *Tectaria gemmifera*, *Achyranthes aspera* and *Ageratum conyzoides* are the dominant species in the herb layer of this community.

4.4.2. *Schefflera abyssinica* - *Maytenus arbutifolia* Community type

This community type was distributed at altitudes between 1980 and 2160 m a.s.l. *Schefflera abyssinica* is the dominant species in the tree layer.

Maytenus arbutifolia is the dominant species in the shrub layer of this type. *Syzygium guineense* and *Lepidotrichila volkensii* are associated tree species. *Oplismenus hirtellus* and *Pycnstachys eminii* dominate the field layer of this community type.

4.4.3. *Coffea arabica* - *Olea capensis* Community type

This community type was distributed at altitudes between 1800 and 2050 m a.s.l. It consists of 58 species. *Coffea arabica* is the dominant species in the shrub layer and *Olea capensis* is the dominant species in the tree layer of this type. *Syzygium guineense*, *Schefflera abyssinica*, *Olea welwitschii* and *Albizia gummifera* are the associated tree species. *Olyra latifolia* is the dominant species in the herb layer of this community.

4.4.4. *Syzygium guineense* - *Galiniera saxifraga* Community type

The altitudinal distribution of this community type extends from 2140 to 2320 m a.s.l. The community consists of 65 species. *Syzygium guineense* and *Galiniera saxifraga* are the dominant species in the tree layer. *Olea welwitschii*, *Apodytes dimidiata* and *Maesa lanceolata* are the associated tree species in this community type. *Dracaena afromontana*, *Clausena anisata* and *Bersama abyssinica* are the dominant species in the shrub layer. *Piper capense* and *Medicago polymorpha* are the dominant species in the herb layer of this community.

4.4.5. *Croton macrostachyus* - *Albizia gummifera* Community type

This community type was distributed at the altitudes ranging from 1970 to 2200 m a.s.l. This community consists of 47 species. *Croton macrostachyus* and *Albizia gummifera* are the dominant species in the tree layer of this type. *Achyranthes aspera*, *Tectaria gemmifera* and *Pycnstachys eminii* are the associated species in the herb layer of this community.

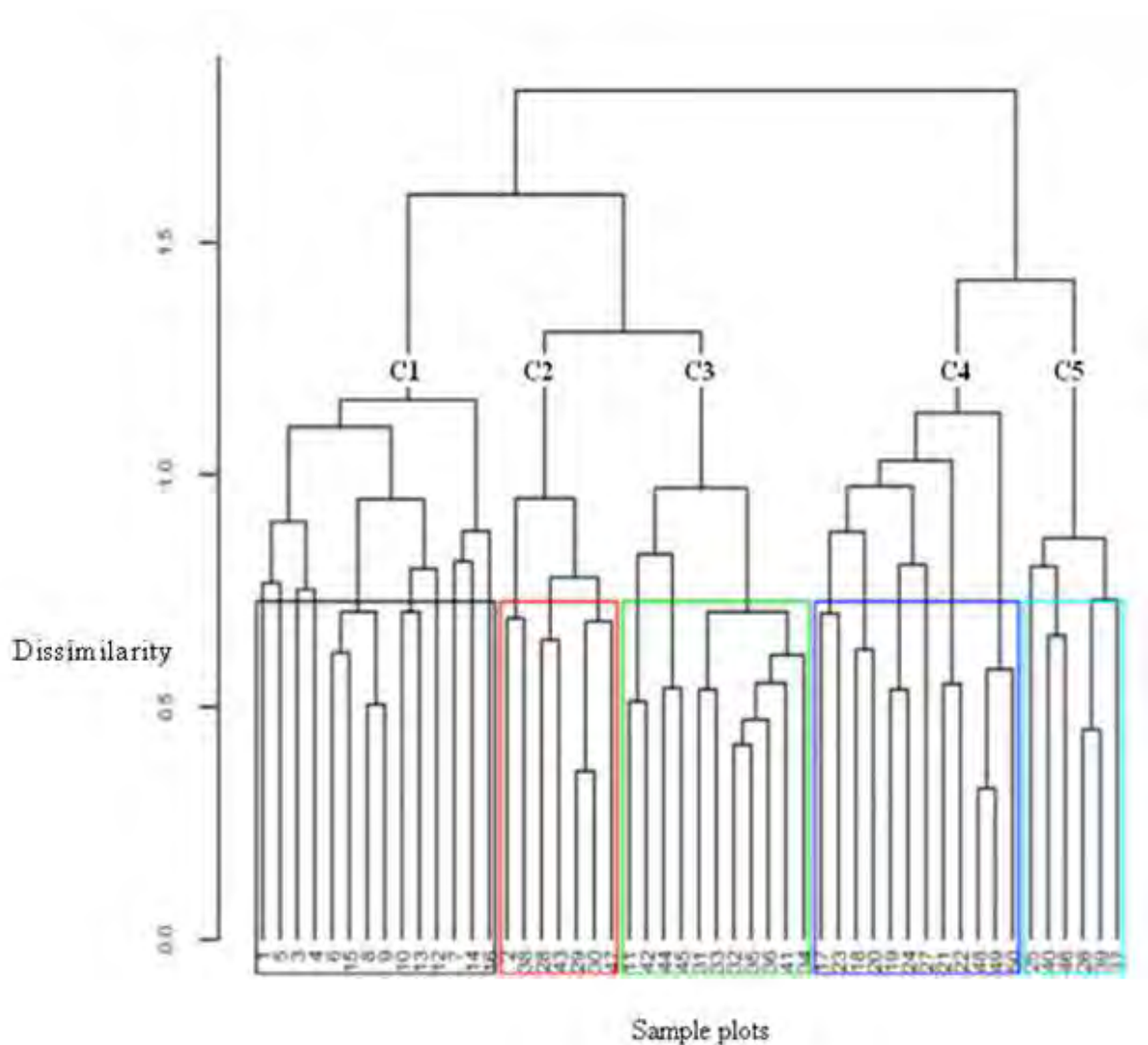


Figure 4: Dendrogram of the vegetation data obtained from hierarchical cluster analysis of Gera Forest. (C₁= Community type 1, C₂= Community type 2, C₃= Community type 3, C₄= Community type 4 and C₅= Community type 5).

Communities (clusters) contain the following plots:-

C₁: Plots 1, 3, 4, 5, 6, 7, 8, 9, 10, 12, 13, 14, 15 and 16

C₂: Plots 2, 28, 29, 30, 38, 43 and 47

C₃: Plots 11, 31, 32, 33, 34, 35, 36, 41, 42, 44 and 45

C₄: Plots 17, 18, 19, 20, 21, 22, 23, 24, 27, 48, 49 and 50

C₅: Plots 25, 26, 37, 39, 40, and 46

Table 4: Synoptic cover-abundance values for species having a value of > 1.0 in at least one community type. (Values in bold refer to occurrences as dominant species).

Species	Community 1	Community 2	Community 3	Community 4	Community 5
<i>Vernonia auriculifera</i>	32.5	0	0	6.7	8.3
<i>Prunus africana</i>	28.6	10	17.7	24.6	0
<i>Tectaria gemmifera</i>	27.5	0	8.2	15	2.5
<i>Millettia ferruginea</i>	23.6	15	5.5	0.8	14.2
<i>Dracaena steudneri</i>	18.9	0	0.9	0	0
<i>Pouteria adolfi-friederici</i>	17.1	0	0	0	0
<i>Achyranthes aspera</i>	16.4	2.1	7.7	3.3	5
<i>Ageratum conyzoides</i>	13.2	0	1.4	0	0
<i>Cordia africana</i>	12.1	2.9	3.6	2.9	5
<i>Allophylus abyssinicus</i>	11.8	5.7	0	0	0
<i>Calpurnia aurea</i>	11.8	11.4	0	0	0
<i>Phoenix reclinata</i>	10.4	0	0	0	0
<i>Schefflera abyssinica</i>	36.8	70	61.4	0	25
<i>Maytenus arbutifolia</i>	11.8	45.7	7.3	17.1	4.2
<i>Polyscias fulva</i>	3.6	45	15.9	15.4	30
<i>Oplismenus hirtellus</i>	15.7	32.1	29.1	26.3	0
<i>Lepidotrichila volkensii</i>	2.1	12.1	0	8.8	0
<i>Pycnstachys eminii</i>	0	10.7	3.6	2.5	4.2
<i>Coffea arabica</i>	43.9	1.4	61.8	0	6.7
<i>Olea capensis</i>	11.8	10	16.8	0	0

<i>Olyra latifolia</i>	13.2	10.7	14.1	0	3.3
<i>Syzygium guineense</i>	3.6	17.9	48.6	55	43.3
<i>Galiniera saxifraga</i>	11.4	6.4	9.1	37.5	6.7
<i>Piper capense</i>	9.6	11.4	8.6	29.2	0
<i>Dracaena afromontana</i>	10	0	0	19.6	0
<i>Medicago polymorpha</i>	0	0	0	17.9	0
<i>Olea welwitschii</i>	1.4	0	10.5	17.1	0
<i>Clausena anisata</i>	11.8	10.7	0	17.1	1.7
<i>Ficus sur</i>	12.9	2.1	3.6	16.3	0
<i>Bersama abyssinica</i>	6.1	9.3	11.4	16.3	6.7
<i>Maesa lanceolata</i>	12.1	8.6	0	15.4	5.8
<i>Apodytes dimidiata</i>	2.1	0	3.6	14.6	0
<i>Croton macrostachyus</i>	8.6	7.1	9.1	13.8	48.3
<i>Albizia gummifera</i>	7.1	7.1	10	12.1	46.7
<i>Vernonia amygdalina</i>	11.4	7.1	2.7	12.1	15
<i>Vepris dainellii</i>	7.1	6.4	12.3	7.1	13.3
<i>Rubus niveus</i>	6.1	1.4	0	0.8	7.5
<i>Flacourtia indica</i>	0	1.4	0.9	2.5	5.8

4.5. Species Diversity, Evenness and Richness of the Plant Communities

The highest species richness, evenness and diversity were observed in community 1 (Table 5). This community attained a species evenness index of 0.88 with average altitude of 2325 m a.s.l. showing the highest even distribution of species. Community type 4 exhibited a species evenness index of 0.85 showing the highest even distribution of species next to community 1 (Table 5). Community type 4 consists of plots 17, 18, 19, 20, 21, 22, 23, 24, 27, 48, 49 and 50 where no *Coffea arabica* was recorded. Community 2 has the least species evenness but greater than communities 3 and 5 in terms of species richness. Community type 5 exhibited the least species richness and diversity (Table 5). Community type 4 consists of plots 25, 26, 37, 39, 40, and 46. The average altitude of this community was 2085 m a.s.l. Generally, the mean evenness of the communities was more or less similar pattern (Table 5).

Table 5: Shannon - Wiener Diversity Index

Communities	Average altitude (m)	Richness	Diversity (H)	Evenness
1	2325	113	4.186782	0.885644
2	2070	62	3.377851	0.81845
3	2085	58	3.381597	0.832815
4	2230	65	3.553735	0.851319
5	2085	47	3.240746	0.84172

4.6. Similarity among plant communities

Sorenson's similarity coefficient was used to determine the similarities among plant communities (Table 6). Accordingly, communities 1 and 5 had the highest similarity ratio which is 0.77. Next to communities 1 and 5, communities 1 and 4 had higher similarity ratio which is 0.72. The least similarity ratio was exhibited by communities 1 and 3 which is 0.49 (Table 6).

Table 6: Sorensen similarity coefficient among community types.

	Community 1	Community 2	Community 3	Community 4
Community 2	0.65			
Community 3	0.493	0.495		
Community 4	0.72	0.71	0.67	
Community 5	0.77	0.66	0.64	0.65

4.7. Vegetation Structure

4.7.1. Tree and Shrub density

The ratio of density of individuals with DBH > 10 cm to density of individuals with DBH > 20 cm is taken as a measure of the size classes distribution (Grubb *et al.* 1963; cited in Shiferaw Belachew, 2010). Trees and shrubs density of Gera Forest, expressed as the number of individuals with DBH greater than 2.5 cm were 1778 individuals /ha. Individuals with DBH between 10 and 20 cm and with DBH greater than 20 cm were 516 /ha (29.02%) and 304 /ha (17.1%) respectively (Table 7). Accordingly, the ratio of individuals between 10 and 20 cm DBH to DBH > 20 cm was 1.69 for Gera Forest, indicating a prevalence of small sized individuals.

Comparisons of tree densities with DBH between 10 and 20 cm (a), DBH > 20 cm (b) and the ratio (a/b) for Gera Forest with other 10 forests in Ethiopia is given in Table 8.

Table 7: Distribution of individuals in different DBH classes.

DBH (cm)	No. of individuals /ha	%
2.6-10.0	958	53.88
10.1-20.0	516	29.02
>20.0	304	17.1
Total	1778	100

Table 8: Comparisons of tree densities with DBH between 10 and 20 cm (a) and tree densities with DBH > 20 cm (b) of Gera Forest with 10 other forests in Ethiopia

Forests	A	b	(a/b)	Sources
Alata-Bolale	365	219	1.67	Woldeyohannes Enkossa, 2008
Belete	613	323	1.90	Kitessa Hundera and Tsegaye Gadissa, 2008
Bibita (Gura Ferda)	500	263	1.90	Derje Denu, 2006
Dodola	521	351	1.48	Kitessa Hundera <i>et al.</i> 2007
Donkoro	526	285	1.90	Abate Ayalew <i>et al.</i> 2006
Jibat	565	287	1.96	Tamrat Bekele, 1993
Masha - Andaracha	384.7	160.5	2.40	Kumlachew Yeshtela and Taye Bekele, 2003
Menagesha Suba	484	208	2.33	Tamrat Bekele, 1993
Menna- Angetu	292	139	2.10	Ermias Lulekal <i>et al.</i> 2008
Sese	513.7	412.7	1.24	Shiferaw Belachew, 2010
Gera	516	304	1.69	Present study

4.7.2. Diameter at breast height (DBH)

The diameter at breast height (DBH) class distribution of woody species of Gera Forest is given in (Figure 5). A total of 1778 individuals/ha with DBH > 2.5 cm were counted within sampled plots. As the DBH class size increases, the number of individuals gradually decreases ranging from 958 stems/ha in the lowest class down to 20 stems/ha in the highest DBH class.

This appears to be a regular distribution that resembles the inverted J-shaped distribution of individuals in the different DBH classes (Figure 5). About 53.88% of individuals have DBH between 2.6 cm and 10 cm. Few individuals of *Pouteria adolfi-friederici*, *Albizia gummifera*, *Olea welwitschii*, *Schefflera abyssinica* and *Prunus africana* were encountered in the higher DBH classes.

The middle DBH classes were also dominated by the above species and additionally few individuals of *Allophylus abyssinicus*, *Dracaena steudneri*, *Polyscias fulva*, *Syzygium guineense*, *Millettia ferruginea* and *Ficus sur*. High proportion of DBH density was contributed by *Coffea arabica*, *Olea capensis*, *Macaranga capensis*, *Cordia africana*, *Croton macrostachyus*, *Maesa lanceolata* and *Galiniera saxifraga*.

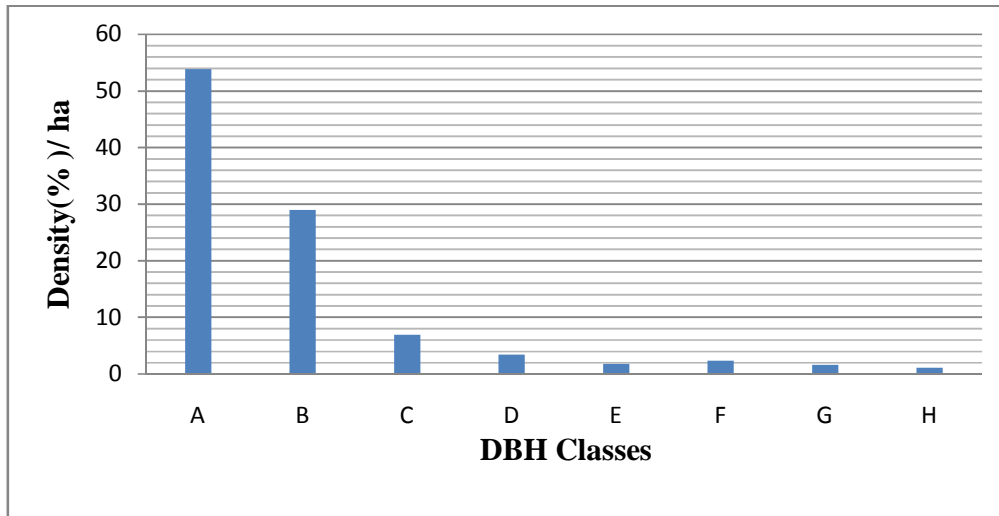


Figure 5: Density (%)/ha of individuals in DBH classes.

Legend: DBH class A = 2.6 -10.0 cm, B = 10.1-20.0 cm, C = 20.1- 30.0 cm, D =30.1-40.0 cm, E= 40.1-50.0 cm, F = 50.1- 60.0 cm, G = 60.1-70.0 cm and H >70.0 cm.

4.7.3. Height class distributions

The height class distribution of trees and shrubs in Gera Forest indicated that more than 38% of the individuals had heights less than 9 m (Figure 6). Species that contribute most to these values in the lower height classes were *Bersama abyssinica*, *Coffea arabica*, *Croton macrostachyus*, *Maesa lanceolata*, *Millettia ferruginea*, *Olea capensis*, *Maytenus arbutifolia*, *Rytigynia neglecta*, *Dracaena afromontana*, *Teclea nobilis* and *Vepris dainellii*.

Gera Forest is occupied by species like *Allophylus abyssinicus*, *Polyscias fulva* and *Syzygium guineense* which contribute most to medium height classes. Trees representing the highest height classes (11%) dominating the upper canopy are *Pouteria adolfi-friederici*, *Prunus africana*, *Olea welwitschii* and *Albizia gummifera*.

Pouteria adolfi-friederici is the emergent tree and grows above all the canopy trees in Gera Forest. Generally, the highest proportion of species is concentrated in the lower height class followed by the middle and upper height class of the vertical structure of Gera Forest.

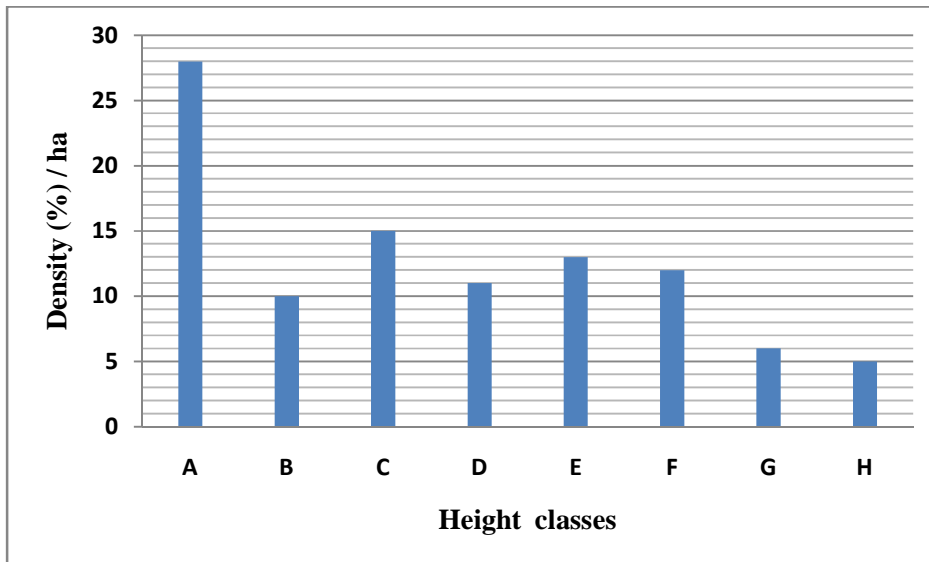


Figure 6: Distribution of individuals/ha among the height classes.

Legend: A= 2.6-6.0 m, B= 6.1- 9.0 m, C= 9.1-12.0 m, D= 12.1-15.0 m, E= 15.1-18.0 m, F= 18.1- 21.0 m, G= 21.1-24.0 m and H > 24.0 m.

4.7.4. Importance value index (IVI)

Analysis of importance value index (IVI) is used for setting conservation priority. Those species with lower IVI values need high conservation efforts while those with higher IVI values need monitoring management. The importance value index (IVI) of most dominant species of Gera Forest was calculated and presented in Table 9. The results of the analysis show that *Coffea arabica*, *Schefflera abyssinica*, *Syzygium guineense* and *Polyscias fulva* to be the first four most important species with higher IVI values (Table 9). Analysis of the relative density indicated that *Coffea arabica*, *Schefflera abyssinica*, *Polyscias fulva* and *Syzygium guineense* were the four most abundant species and constituting about 63.64% of the total density (Table 9).

4.7.5. Dominant Species of Gera Forest

Based on their IVI values, the most dominant and ecologically significant woody plants in Gera Forest were *Coffea arabica*, *Schefflera abyssinica*, *Syzygium guineense*, *Polyscias fulva*, *Croton macrostachyus*, *Millettia ferruginea*, *Vepris dainellii*, *Prunus africana*, *Galiniera saxifraga* and *Olea welwitschii*.

Table 9: Importance value index (IVI) values of dominant tree species in Gera Forest

(RF =Relative Frequency, RD = Relative Density, and RDO = Relative Dominance)

Species	RD %	RDO %	RF %	IVI %
<i>Coffea arabica</i>	23.12	7.92	48.89	79.93
<i>Croton macrostachyus</i>	6.49	4.01	7.19	17.69
<i>Galiniera saxifraga</i>	5.37	2.12	4.37	11.86
<i>Millettia ferruginea</i>	8.03	4.65	4.12	16.8
<i>Olea welwitschii</i>	2.53	5.32	3.98	11.83
<i>Polyscias fulva</i>	14.20	2.55	5.19	21.94
<i>Vepris dainellii</i>	9.2	1.76	4.69	15.65
<i>Prunus africana</i>	4.57	6.34	3.62	14.53
<i>Schefflera abyssinica</i>	15.25	34.17	9.97	59.39
<i>Syzygium guineense</i>	11.07	30.7	7.90	49.67
Total	99.83	99.54	99.92	299.29

4.7.6. Species Population Structure

Five generalized patterns of population structure emerge from the analysis of the population structure of 15 selected dominant species in Gera Forest (Figure 7). The first pattern was formed by species with positively skewed distribution (inverted J-curve). These species had the highest density in the lower DBH classes with gradual decrease in density towards the higher DBH classes, which suggested good reproduction and recruitment potential in the Forest. *Maesa lanceolata*, *Galiniera saxifraga*, *Podocarpus falcatus*, *Teclea nobilis* and *Vepris dainellii* had inverted J-curve structure. The second pattern was bell-shaped distribution formed by species with high number of individuals in the middle DBH classes. Species such as *Albizia gummifera*, *Dracaena steudneri*, *Polyscias fulva* and *Millettia ferruginea* were characterized by this distribution pattern.

The third pattern was formed by species having irregular distribution over diameter classes. Some diameter classes were poorly represented indicating selective removal of medium-sized individuals while other diameter classes are well represented. Species like *Prunus africana*, *Olea welwitschii* and *Macaranga capensis* had this type of population pattern. *Olea welwitschii* showed this pattern of distribution.

The fourth pattern was exhibited by species with individuals well represented in the lower DBH classes but absent in the higher DBH classes, representing species with good reproduction but bad recruitment. Species like *Croton macrostachyus* was characterized by this distribution pattern. The fifth pattern shows poor reproduction and complete absence of individuals in lower and intermediate DBH classes. Species like *Pouteria adolfi-friederici* and *Schefflera abyssinica* were characterized by this distribution pattern.

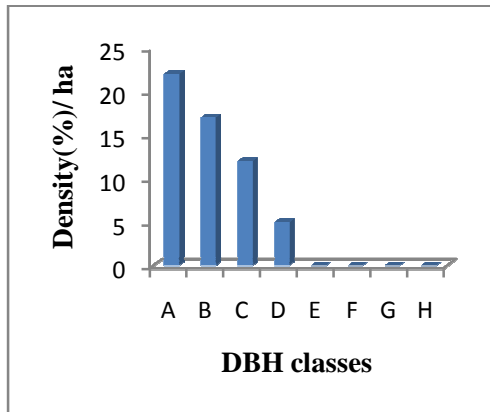


Figure 7 A- *Maesa lanceolata*

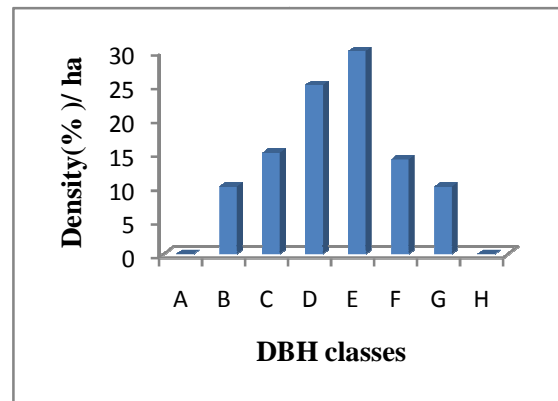


Figure 7 B- *Polyscias fulva*

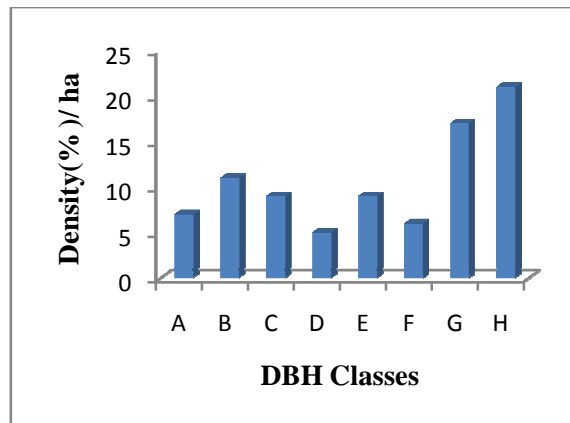


Figure 7 C- *Prunus africana*

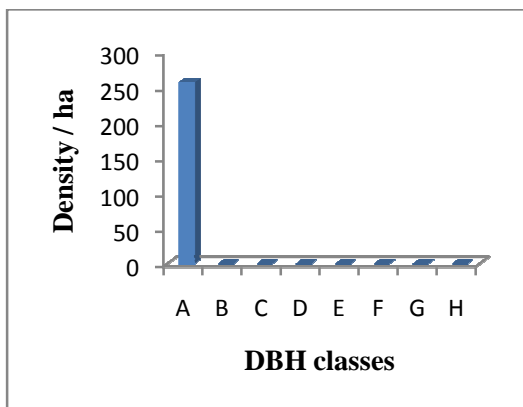


Figure 7 D- *Coffea arabica*

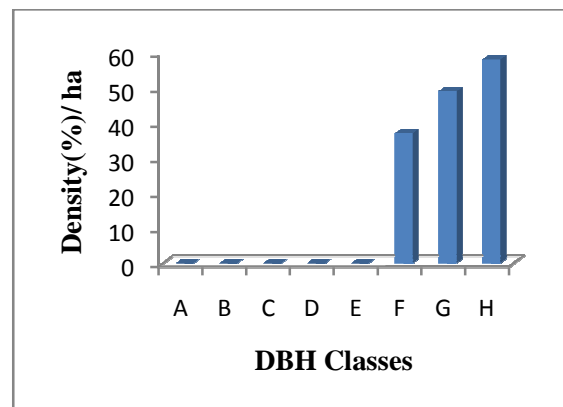


Figure 7 E- *Schefflera abyssinica*

Figure 7: Population structure of some selected tree species

Legend: DBH class A = 2.6-10.0 cm, B = 10.1-20.0 cm, C = 20.1- 30.0 cm, D=30.1-40.0 cm, E= 40.1- 50.0 cm, F = 50.1- 60.0 cm, G = 60.1-70.0 cm and H >70.0 cm.

An inverted J- shaped distribution was exhibited by some tree species representing a healthy regeneration. On the other hand, bell-shaped and irregular distribution patterns were also observed. Most of the species with irregular distributions are tree species that are hunted by the local people selectively for house construction, firewood and timber production or over grazing which affects the seedlings under the mother tree. The complete absence of individuals in some diameter classes indicates that the regeneration of species was hampered during one or several phases of their life cycle.

4.7.7. Regeneration Status of Gera Forest

The composition, distribution and density of seedlings and saplings are indicators of the future regeneration status of any forest (Fekadu Gurmessa, 2010). The total seedlings and saplings of dominant woody species in the study area were about 4,838 and 1,331 individuals per hectare respectively. The ratio of seedlings to saplings was 3.63. In this study different species have different densities of seedlings and saplings.

The highest density of seedlings and saplings were recorded for *Millettia ferruginea*, *Croton macrostachyus*, *Cordia africana*, *Syzygium guineense*, *Vernonia amygdalina*, *V. auriculifera*, *Coffea arabica* and *Grewia ferruginea*. Species like *Podocarpus falcatus*, *Schefflera abyssinica*, *Teclea nobilis* and *Olea capensis* showed the lowest seedling and sapling densities. On the other hand, some woody species like *Polyscias fulva*, lacked both seedlings and saplings in Gera Forest.

Table 10: List of selected woody species with their seedlings and saplings/ha used to determine the regeneration status of Gera Forest.

No.	Name of the species	No. of Seedling	No. of Sapling
1	<i>Podocarpus falcatus</i>	97	32
2	<i>Maesa lanceolata</i>	108	54
3	<i>Dracaena afromontana</i>	145	45
4	<i>Syzygium guineense</i>	471	58
5	<i>Coffea arabica</i>	365	139
6	<i>Millettia ferruginea</i>	761	156
7	<i>Prunus africana</i>	145	59
8	<i>Croton macrostachyus</i>	508	154
9	<i>Bersama abyssinica</i>	140	53
10	<i>Justicia schimperiana</i>	132	26
12	<i>Grewia ferruginea</i>	760	41
13	<i>Vernonia amygdalina</i>	145	55
14	<i>Vernonia auriculifera</i>	456	216
15	<i>Dracaena steudenri</i>	193	44
16	<i>Cordia africana</i>	154	54
17	<i>Maytenus arbutifolia</i>	116	33
18	<i>Schefflera abyssinica</i>	3	12
19	<i>Teclea nobilis</i>	55	54
20	<i>Olea capensis</i>	87	46
	Total / ha	4,838	1,331

CHAPTER FIVE

5. DISCUSSION, CONCLUSION AND RECOMMENDATIONS

5.1. Discussion

5.1.1. Floristic description and Vegetation classification

Fabaceae and Asteraceae have been reported as dominant families in the Aframontane Flora of Ethiopia (Negusse Tadesse, 2006; Getachew Tena *et al.* 2008). The dominance of Fabaceae and Asteraceae could be attributed to their efficient and successful dispersal mechanisms and adaptation to a wide range of ecological conditions (Ensermu Kelbessa and Teshome Soromessa, 2008).

Fabaceae is the largest family in the Flora of Ethiopia and Eritrea while Asteraceae is third, following Poaceae. In Gera Forest, however, Poaceae was not recorded as a dominant family because it was represented only by three species (Table 2).

Dominance of families may vary in different forests of Ethiopia. For example, Kumelachew Yeshitela and Tamrat Bekele (2002) reported the dominance of Euphorbiaceae and Moraceae from Aframontane and transitional rainforest vegetation of southwestern Ethiopia.

Out of the 132 plant species identified in the present study, only seven (5.3%) are endemic to Ethiopia. Feyera Senbeta *et al.* (2007) also reported low number of endemic plants (only 3%) from Sheko Forest, southwest Ethiopia.

Information on endemic flowering plant species of Ethiopia and the levels of threat to them has been published by Ensermu Kelbessa *et al.* (1992) and Vivero *et al.* (2005). Coetzee (1978), White (1978) and Friis *et al.* (2001) reported low endemism in the Afromontane rainforests of Ethiopia. Endemism may arise due to geographical and ecological isolations (Kruckeberg and Rabinowitz, 1985).

5.1.2. Species Diversity of the Plant Communities

Community type 1 (*Vernonia auriculifera* - *Prunus africana* community) was found to be with the highest species richness, evenness and diversity (Table 5). This community is found in specialized habitats including river courses (Naso River). Wild population of *Coffea arabica* is found abundantly in this community. According to the local informants, coffee plantation is highly prohibited in this community type. This is a good practice for biodiversity conservation.

The presence of Naso River and less anthropogenic influences might have contributed to highest species richness, evenness and diversity of this community. High evenness in a community indicates little dominance by any single species but repeated coexistence of species over all plots of the community (Anteneh Belayneh *et al.* 2011).

The prevalence of abundant seedlings and saplings of *Coffea arabica*, *Millettia ferruginea* and *Vernonia auriculifera* in this community indicates, the community is regenerating and may persist in the future. Fekadu Gurmessa (2010) noted that the composition, distribution and density of seedlings and saplings are indicators of the regeneration status of any forest.

Community type 2 (*Schefflera abyssinica* - *Maytenus arbutifolia* community) was distributed at altitudes between 1980 and 2160 m a.s.l. This community is characterized by small and large sized trees with good canopy of *Schefflera abyssinica*.

Community type 3 (*Coffea arabica* - *Olea capensis* community) was highly dominated by *Coffea arabica* (Table 4). In this community, some trees, shrubs and herbs were cleared for coffee plantation. This community is less than communities 1, 2 and 4 in terms of its species richness. This could be due to expansion of coffee plantation by the local farmers and investors. Feyera Senbeta *et al.* (2007) pointed that high dominance of *Coffea arabica* in Sheko Forest was an indication of human influence through selective removal of other associated plant species in order to promote Coffee development.

More seedlings and saplings of *Coffea arabica* showed good regeneration potential of the future coffee Forest. Some plant species may have a wide range of dispersal mechanisms or rapid reproduction strategies. Species able to survive and flourish after disturbance tend to be those that reproduce rapidly and abundantly (McKinney, 1997).

Community type 4 (*Syzygium guineense* - *Galiniera saxifraga* community) was distributed at altitudes between 2140 to 2320 m a.s.l. *Syzygium guineense* and *Galiniera saxifraga* are the most dominant tree species in this type. Regenerating species of *Piper capense* and *Bersama abyssinica* are abundant under the canopy layer of this community. The dominance of *Syzygium guineense* in the community may be due to its low demand for timber and construction purposes

by the local people and also its seeds germinate rapidly and easily. Kitessa Hundera and Tsegaye Gadissa (2008) reported similar results from Belete Forest of southwest Ethiopia.

Community type 4 is greater than communities 2, 3 and 5 in terms of its species richness, diversity and evenness. But it is less than community type 1 in terms of species richness, diversity and evenness (Table 5). *Coffea arabica* was not recorded from this community type, indicating no coffee plantation and relatively low human interference.

According to the local informants, agricultural practice is done few kilometers away from the Forest area where this community was found. This practice might have contributed to high species richness, diversity and evenness of this community, as moderate disturbance is known to increase species diversity.

Community type 5 (*Croton macrostachyus* - *Albizia gummifera* community) is distributed at the altitudes ranging from 1970 to 2200 m a.s.l. This type is dominated by low sized *Croton macrostachyus* which has more seedlings and saplings and good regeneration potential.

This community exhibited the least species richness and diversity that are 47 and 3.2 respectively (Table 5). As this community was easily accessible, it experienced human interference in the form of selective cutting of economically important trees and firewood collection.

Cattle interferences were also observed in some of its stands. These factors could have contributed for low species richness and diversity of this community. Fekadu Gurmessa (2010) also reported similar results from Komto Forest.

The least similarity coefficient was exhibited by communities 1 and 3 which is 0.49 (Table 6). The average altitudes of these communities were 2325 m a.s.l. and 2085 m a.s.l. respectively. Wild population of *Coffea arabica* has been found abundantly in community 1. This community is relatively managed while some trees, shrubs and herbs were cleared for coffee plantation in community 3. Such kinds of anthropogenic factors in community 3 and difference in altitudes could be the reason for the least similarity between communities 1 and 3.

Coffee plantation in natural forest has reduced forest density and species diversity (Sheauchi *et al.* 1998; cited in Kitessa Hundera and Tsegaye Gadissa, 2008). The highest similarity coefficient was exhibited by communities 1 and 5 that is 0.77 (Table 6).

5.1.3. Structural Description

The total number of woody species in each DBH class decreased with increasing DBH classes. Small sized woody species predominate in the Forest. This indicates Gera Forest has been exposed to high rate of deforestation through selective cutting of large sized individuals and it is in the stage of secondary regeneration.

The Forest pattern was formed by the species structure with reversed J- shaped in DBH class distribution which suggested good reproduction and recruitment potential of the Forest.

This relationship was also observed in Sese Forest by Shiferaw Belachew (2010), Chilimo and Menagesha Forests (Tamrat Bekele, 1993), Masha- Andracha Forest (Kumlachew Yeshtela and Taye Bekele, 2003), and Alata-Bolale Forest (Woldeyohannes Enkossa, 2008) (Table 8).

High proportion of DBH density was contributed by *Olea capensis*, *Macaranga capensis*, *Cordia africana*, *Croton macrostachyus*, *Maesa lanceolata* and *Galiniera saxifraga*. This could be due to the use of plants by local people for different purposes like construction, timber, farm implements and firewood. For example, *Olea capensis* and *O. welwitschii* are widely used by the local people for farm implements and debarking of the medium sized individuals for beehive making and the use of bark for smoking houses. Kitessa Hundera and Tsegaye Gadissa (2008) reported similar results from Belete Forest of southwest Ethiopia. As the DBH of *Coffea arabica* falls between 2.6 to 10 cm range, it contributes most only for the first DBH class (Figure 7D).

Density distribution at different height classes in the study area showed that more than 53% of the individuals had heights less than 12 meter and 36 % of individuals fall between 12.1- 21.0 meters range. Individuals ≥ 21.1 meters in height are 11% (Figure 6). Density distribution at different height classes also showed similar trend as that of DBH classes. The highest proportion of species is concentrated in the lower height classes followed by the middle and upper height classes of the vertical structure of the Forest.

Thus, this study confirms that the number of individuals decreased as the height of the individuals increased suggesting the dominance of low stature individuals in the Forest.

This could be due to long time disturbance of the Forest. This result is in line with the results observed in Chilimo Forest by Tamrat Bekele (1993), Denkoro Forest by Abate Ayalew *et al.* (2006) and Bonga Forest by Ensermu Kelbessa and Teshome Soromessa (2008).

As the height of *Coffea arabica* falls between 2.6 - 9 m, it contributes most for the first and second height classes given in Figure 6. Trees representing the highest height classes (11%) dominating the upper canopy are *Pouteria adolfi-friederici*, *Prunus africana*, *Olea welwitschii* and *Albizia gummifera*.

Two major groups of woody species can be recognized based on the five patterns of species population structure. The first group consists of species that are capable of regenerating in the Forest under-story. These species are *Millettia ferruginea*, *Podocarpus falcatus*, *Maesa lanceolata*, *Grewia ferruginea*, *Cordia africana*, *Syzygium guineense*, *Vernonia amygdalina* and *V. auriculifera*.

The second group includes those species that are old and large sized but not well represented by their seedlings and saplings showing poor regeneration in the Forest. These species are *Polyscias fulva*, *Pouteria adolfi-friederici* and *Schefflera abyssinica*. This could be due to the inability of seeds to germinate readily under the parent plants. Such similar species population pattern depicting poor reproduction and complete absence of individuals in intermediate classes was also observed in Denkoro Forest by Abate Ayalew *et al.* (2006).

Nichols (2005) reported that the seeds of *Schefflera abyssinica* do not germinate readily. Birds and monkeys probably eat the seeds, performing the task of preparing the seeds for germination.

Schefflera abyssinica is also found as an epiphyte on other trees. The seeds are lodge in tree forks and other places that are rich in plant detritus and where water can reach to wash the seeds. Young species of *Schefflera abyssinica* prefers growth on other plants. As a result, the seedlings were not seen on the ground (Ensermu Kelbessa and Teshome Soromessa, 2008).

Most of the species with irregular distributions are tree species that are hunted by the local people selectively for house construction, firewood and timber production or overgrazing which affects the seedlings under the mother trees.

The complete absence of individuals in some diameter classes indicates that the regeneration of species was hampered during one or several phases of their life cycle. These might be caused by trampling by livestock, selective cutting for construction, timber or firewood purposes (Fekadu Gurmessa, 2010).

The Importance value index of most dominant species was calculated and presented in Table 9. This shows that *Coffea arabica*, *Schefflera abyssinica* and *Syzygium guineense* were the first three most important species with higher IVI values indicating their good distribution throughout the Forest (Table 9). High dominance and density of *Schefflera abyssinica* and *Syzygium guineense* might be due to their low demand by the local people for timber and other construction purposes.

The highest composition, distribution and density of seedlings and saplings of *Millettia ferruginea*, *Croton macrostachyus*, *Cordia africana*, *Syzygium guineense*, *Vernonia amygdalina*,

Vernonia auriculifera, *Coffea arabica* and *Grewia ferruginea* are the indicators of the regeneration status of Gera Forest. Generally, the presence of more seedlings and saplings indicate Gera Forest is under regeneration.

5.2. Conclusion and Recommendations

5.2.1. Conclusion

The study has resulted in the documentation of 132 vascular plant species representing 112 genera and 59 families. Fabaceae and Asteraceae were found to be the most dominant families followed by Euphorbiaceae, Malvaceae and Rubiaceae. Acanthaceae, Lamiaceae, Boraginaceae, Celastraceae, Moraceae, Oleaceae, and Piperaceae families had also significant contribution to the overall species composition of Gera Forest. This Forest was also an important reservoir of endemic plants.

About seven endemic plant taxa some of which are in the IUCN Red Data List were identified. Hence, Gera Forest could serve for the purpose of biodiversity conservation. It also has agronomical significance due to its high wild coffee (*Coffea arabica*) gene pool.

The vegetation of Gera Forest was grouped into five plant community types. The highest species richness and maximum diversity was observed in community one. Community type 5 exhibited the least species richness and diversity. The variation in species composition and diversity among communities could be associated with different factors, such as altitude, anthropogenic impacts and soil properties.

Analysis of the woody species composition of Gera Forest indicated that the composition was lower than that of Belete, Bibita, Donkoro, Jibat, Masha - Anderacha, Menagesha Suba and Menna-Angetu forests of Ethiopia but higher than that of Dodola and Sese forests.

The presence of relatively higher percentage of lower diameter size in the Forest indicated that Gera Forest is at stage of secondary regeneration. In addition, the density of woody species in Gera Forest decreases with increasing DBH and height classes implying good recruitment.

Analysis of population structure of most common species of trees and shrubs revealed different patterns of population structure, indicating a high variation among species population dynamics of Gera Forest. Accordingly, five population patterns have been observed in Gera Forest.

Analysis of regeneration of some selected woody species revealed that some tree species have lower seedling and sapling stages while others are represented by more seedling, sapling and mature stages in the Forest.

5.2.2. Recommendations

Gera Forest is one of the remaining forests harboring a unique gene reserve of wild coffee and several associated economic plant species. This Forest is ecologically, socially and economically very important for the inhabitants residing nearby who are mostly dependent on forest products to make their living. Loss of such a forest and the various threatened species would have great implications for the environment, biodiversity and socio-economic setup of the communities. The concerned bodies have to take due consideration for conservation and sustainable utilization of this Forest resource.

For effective management and monitoring of Gera Forest on a sustainable basis, the following points are forwarded as recommendations:

- ❖ The management strategy should focus on multiple-use conservation approach. For example, undisturbed areas of the Forest can be designated for strict conservation so that they may act as repositories of biodiversity and possibly as a source of forest genetic resources while the peripheral areas could be utilized on a sustainable basis,
- ❖ Assist in propagation and distribution of seedlings of *Schefflera abyssinica*, *Polyscias fulva*, *Olea capensis*, *O. welwitschii* and *Prunus africana* whose uses are already wide spread in the study area.
- ❖ Introduce modern beehive so as to reduce the pressure on selectively utilized species for the purposes of hive construction in particular, *Olea welwitschii*, *Polyscias fulva* and *Croton macrostachyus*.
- ❖ Initiate enrichment plantation of those species that have been over utilized for various purposes such as *Prunus africana*, *Olea capensis*, *O. welwitschii*, *Macaranga capensis*, *Podocarpus falcatus*, *Pouteria adolfi-friedrici* and *Polyscias fulva*,
- ❖ Natural regeneration of species in the Forest can be facilitated through reduced grazing pressure, and
- ❖ More basic and applied researches should be encouraged to assist the planning and management of the Forest.

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APPENDICES

Appendix 1: Sample Plots together with their corresponding altitude and location

Transect	Plot (Quadrat)	Altitude (m a.s.l)	Latitude	Longitude
1	1	2100	07 ⁰ 43.02' N	036 ⁰ 15.91' E
1	2	2050	07 ⁰ 43.152' N	036 ⁰ 16.045' E
1	3	1880	07 ⁰ 43.16' N	036 ⁰ 15.98' E
1	4	1920	07 ⁰ 41.28' N	036 ⁰ 15.21' E
1	5	2000	07 ⁰ 41.1' N	036 ⁰ 15.29' E
1	6	2030	07 ⁰ 42.7' N	036 ⁰ 15.3' E
1	7	2030	07 ⁰ 41.9' N	036 ⁰ 15.2' E
1	8	2950	07 ⁰ 42.73' N	036 ⁰ 15.30' E
1	9	2060	07 ⁰ 42.81' N	036 ⁰ 15.433' E
1	10	2040	07 ⁰ 42.998' N	036 ⁰ 15.480' E
1	11	2050	07 ⁰ 43.04' N	036 ⁰ 15.480' E
1	12	1650	07 ⁰ 36.79' N	036 ⁰ 12.18' E
1	13	1700	07 ⁰ 36.74' N	036 ⁰ 11.95' E

Transect	Plot (Quadrat)	Altitude (m a.s.l)	Latitude	Longitude
1	14	1700	07 ⁰ 36.79' N	036 ⁰ 12.05' E
1	15	1720	07 ⁰ 36.87' N	036 ⁰ 12.37' E
1	16	1700	07 ⁰ 36.92' N	036 ⁰ 12.95' E
2	17	2320	07 ⁰ 46.19' N	036 ⁰ 14.21' E
2	18	2320	07 ⁰ 46.10' N	036 ⁰ 14.21' E
2	19	2300	07 ⁰ 46.21' N	036 ⁰ 14.21' E
2	20	2315	07 ⁰ 45.93' N	036 ⁰ 14.21' E
2	21	2300	07 ⁰ 45.93' N	036 ⁰ 14.22' E
2	22	2290	07 ⁰ 45.96' N	036 ⁰ 14.26' E
2	23	2300	07 ⁰ 45.93' N	036 ⁰ 14.15' E
2	24	2300	07 ⁰ 45.86' N	036 ⁰ 14.24' E
2	25	2200	07 ⁰ 45.88' N	036 ⁰ 14.33' E
2	26	2200	07 ⁰ 45.663' N	036 ⁰ 14.35' E
2	27	2200	07 ⁰ 45.69' N	036 ⁰ 14.35' E
2	28	2150	07 ⁰ 45.50' N	036 ⁰ 14.38' E
2	29	2150	07 ⁰ 45.55' N	036 ⁰ 14.40' E

Transect	Plot (Quadrat)	Altitude (m a.s.l)	Latitude	Longitude
2	30	2150	07 ⁰ 45.37	036 ⁰ 14.44' E
2	31	1800	07 ⁰ 39.51	036 ⁰ 14.88' E
2	32	1800	07 ⁰ 39.51	036 ⁰ 14.88' E
2	33	1977	07 ⁰ 39.81' N	036 ⁰ 14.74' E
2	34	1977	07 ⁰ 39.81' N	036 ⁰ 14.74' E
2	35	1988	07 ⁰ 40.285' N	036 ⁰ 14.58' E
2	36	1988	07 ⁰ 40.285' N	036 ⁰ 14.58' E
2	37	1990	07 ⁰ 40.43' N	036 ⁰ 14.56' E
3	38	2030	07 ⁰ 40.81' N	036 ⁰ 14.450' E
3	39	2110	07 ⁰ 45.460' N	036 ⁰ 15.355' E
3	40	2160	07 ⁰ 45.82' N	036 ⁰ 15.23' E
3	41	2000	07 ⁰ 46.087' N	036 ⁰ 17.387' E
3	42	1970	07 ⁰ 46.232' N	036 ⁰ 17.381' E
3	43	1980	07 ⁰ 46 .381' N	036 ⁰ 17.299' E
3	44	1945	07 ⁰ 46.096' N	036 ⁰ 18.052' E
3	45	1945	07 ⁰ 46.096' N	036 ⁰ 18.044' E

Transect	Plot (Quadrat)	Altitude (m a.s.l)	Latitude	Longitude
3	46	1970	07 ⁰ 46.133' N	036 ⁰ 18.017' E
3	47	2160	07 ⁰ 45.545' N	036 ⁰ 14.422' E
3	48	2140	07 ⁰ 45.563' N	036 ⁰ 14.499' E
3	49	2200	07 ⁰ 45.605' N	036 ⁰ 14.464' E
3	50	2190	07 ⁰ 45.638' N	036 ⁰ 14.403' E

Appendix 2:- List of plant species collected from Gera Forest. Key: T=Tree, S=Shrub, H=Herb

and C= Climber.

No.	Scientific Name	Family	Vernacular Name (Afan Oromo)	Habit	Coll. No
1	<i>Acanthus eminens</i> C.B. Clarke	Acanthaceae	Balawarantii	S	YM 001
2	<i>Achyranthes aspera</i> L.	Amaranthaceae	Tebe dima	H	YM 035
3	<i>Achyrospermum schimperi</i> Hochst.ex Briq.	Lamiaceae	Bala dalecha	H	YM 038
4	<i>Adenostemma mauritianum</i> DC.	Asteraceae	Maxxanee	H	YM 099
5	<i>Adiantum incisum</i> Forssk.	Adiantaceae		H	YM 126
*6	<i>Aframomum corrorima</i> (Braun) Jansen	Zingiberaceae	Ogiyo	H	YM 090
7	<i>Aframomum zambesiacum</i> (Baker) K.Schum.	Zingiberaceae	Ogiyo-deljessa	H	YM 117
8	<i>Ageratum conyzoides</i> L.	Asteraceae		H	YM 047
**9	<i>Albizia gummifera</i> (J.F.Gmel.) C.A.Sim.	Fabaceae	Sasa	T	YM 014
10	<i>Allophylus abyssinicus</i> (Hochst.) Radlkofer	Sapindaceae	Se'o	T	YM 070
**11	<i>Apodytes dimidiata</i> E. Mey. ex Arm.	Icacinaceae	Wendebo	T	YM 089
12	<i>Arthropteris monocarpa</i> (Cordem.) C.Chr.	Oleandraceae		H	YM 131
13	<i>Asparagus racemosus</i> Willd.	Asparagaceae	Sariitii	S	YM 031

14	<i>Asplenium aethiopicum</i> (Burm.f.) Bech.	Aspleniaceae		H	YM 127
15	<i>Asplenium protensum</i> Schrad.	Aspleniaceae		H	YM 128
16	<i>Bersama abyssinica</i> Fresen.	Melianthaceae	Lolchiisaa	S	YM 015
17	<i>Brucea antidysenterica</i> J.F.Mill.	Simaroubaceae	Boqo/Qomonyo	S	YM 009
18	<i>Calpurnia aurea</i> (Ait.) Benth.	Fabaceae	Ceekaa	S	YM 005
19	<i>Canthium oligocarpum</i> Hiern	Rubiaceae	Barsadi	S/T	YM 048
**20	<i>Celtis africana</i> Burm.f.	Ulmaceae	Qawo	T	YM 054
21	<i>Chamaecrista mimosoides</i> (L.) Greene	Fabaceae	Harengema	S	YM 125
22	<i>Clausena anisata</i> (Willd.) Benth.	Rutaceae	Ulumaayyii	S	YM 012
23	<i>Clerodendrum myricoides</i> (Hochst.) Vatke	Lamiaceae	Marachissa	S	YM 121
24	<i>Coffea arabica</i> L.	Rubiaceae	Bunaa	S/T	YM 069
25	<i>Combretum paniculatum</i> Vent.	Combretaceae	Begge	C	YM 113
26	<i>Commelina benghalensis</i> L.	Commelinaceae	Laalunxyee	H	YM 091
27	<i>Coniogramme africana</i> Hieron.	Hemionitidaceae	Gitto	H	YM 096
**28	<i>Cordia africana</i> Lam.	Boraginaceae	Waddessaa	T	YM 067
29	<i>Crassocephalum crepidioides</i> (Benth.) S. Moore.	Asteraceae		H	YM 040
30	<i>Crotalaria incana</i> L.	Fabaceae	Atokemelle	H	YM 046

31	<i>Crotalaria mildbraedii</i> Bak.f.	Fabaceae		S	YM 092
**32	<i>Croton macrostachyus</i> Del.	Euphorbiaceae	Bakanisaa	T	YM 055
33	<i>Culcasia falcifolia</i> Engl.	Araceae	Emberiko	C	YM 080
34	<i>Cyathea manniana</i> Hook.	Cyatheaceae	Sesno	S/T	YM 085
35	<i>Cymbopogon caesius</i> (Hook, &Am.) Stapf.	Poaceae	Kello	H	YM 118
36	<i>Cynoglossum amplifolium</i> Hochst. ex A.DC.	Boraginaceae	Chaqo	H	YM 097
37	<i>Cynoglossum coeruleum</i> Hochst. ex A.DC.	Boraginaceae	Matane-chati	H	YM 115
38	<i>Deinbollia kilimandscharica</i> Taub	Sapindaceae	Qomenno	T	YM 075
39	<i>Desmodium repandum</i> (Vahl) DC.	Fabaceae	Matane	H	YM 036
40	<i>Dracaena afromontana</i> Mildbr.	Dracaenaceae	Algae	S	YM 002
41	<i>Dracaena steudneri</i> Engl.	Dracaenaceae	Lankuso/Yudo	T	YM 082
42	<i>Drynaria volkensii</i> (Hieron)	Polypodiaceae		H	YM 122
43	<i>Ehretia cymosa</i> Thonn.	Boraginaceae	Ulaagaa	S	YM 066
**44	<i>Ekebergia capensis</i> Sparrm.	Meliaceae	Sombo	T	YM 024
45	<i>Englerina woodfordioides</i> (Schweinf.) M. Gilbert	Loranthaceae	Harmuko	S	YM 119
*46	<i>Erythrina brucei</i> Schweinf.	Fabaceae		T	YM 109
47	<i>Euphorbia ampliphylla</i> Pax	Euphorbiaceae		T	YM 027

48	<i>Euphorbia schimperiana</i> Scheele	Euphorbiaceae	Anneno	H	YM 087
49	<i>Euphorbia</i> sp.	Euphorbiaceae		H	YM 119
50	<i>Ficus lutea</i> Vahl	Moraceae	Harbu	T	YM 059
51	<i>Ficus sur</i> Forssk.	Moraceae	Harbuu	T	YM 023
52	<i>Ficus thonningii</i> Blume	Moraceae	Dambii	S	YM 103
53	<i>Flacourtia indica</i> (Burm.f.) Merr.	Flacourtiaceae	Akuukkuu	T	YM 084
54	<i>Galineria saxifraga</i> (Hochst.) Bridson	Rubiaceae	Simararu	T	YM 063
55	<i>Geranium arabicum</i> Forssk.	Geraniaceae		H	YM 050
56	<i>Girardinia diversifolia</i> (Link) Friis	Urticaceae		H	YM 095
57	<i>Gouania longispicata</i> Engl.	Rhamnaceae	Homechesa	C	YM 007
58	<i>Grewia ferruginea</i> Hochst. ex A.Rich.	Tiliaceae	Bururi	S	YM 064
59	<i>Halleria lucida</i> L.	Scrophulariaceae	Mukafoni	S/T	YM 053
60	<i>Hibiscus cannabinus</i> L.	Malvaceae	Kunche gajo	H	YM 025
61	<i>Hibiscus macranthus</i> Hochst. ex A. Rich.	Malvaceae	Keraba	H	YM 073
62	<i>Hibiscus vitifolius</i> L.	Malvaceae		H	YM 037
63	<i>Hippocratea africana</i> (Willd.) Loes.	Celastraceae	Hida -galle	C	YM 116
64	<i>Huperzia ophioglossoides</i> (Lam.) Hayata	Lycopodiaceae		H	YM 123

65	<i>Hypoestes forskaolii</i> (Vahl) R.Br.	Acanthaceae	Togo	H	YM 003
66	<i>Ilex mitis</i> (L.) Radlk.	Aquifoliaceae	Qetto	T	YM 033
67	<i>Impatiens hochstetteri</i> Warb.	Balsaminaceae	Kichu	H	YM 044
68	<i>Jasminum abyssinicum</i> Hochst. ex DC.	Oleaceae	Elchime	C	YM 021
*69	<i>Justicia diclipteroides</i> Lindau subsp. <i>aethiopica</i> Hedrèn	Acanthaceae		H	YM 104
70	<i>Justicia schimperiana</i> (Hochst. ex Nees) T. Anders.	Acanthaceae	Dumuga	S	YM 071
71	<i>Landolphia buchananii</i> (Hall.f.) Stapf.	Apocynaceae	Qeyo	C	YM 106
72	<i>Lantana viburnoides</i> (Forssk.) Vahl.	Verbenaceae	Kusaye	S	YM 039
73	<i>Lepidotrichila volkensii</i> (Gurke) Leroy	Meliaceae	Sa'o/Hororo	T	YM 052
74	<i>Lepisorus excavatus</i> (Bory ex Willd.) Ching	Polypodiaceae		H	YM 132
75	<i>Loxogramme abyssinica</i> (Baker) M.G.Price	Polypodiaceae		H	YM 130
76	<i>Lycopodium clavatum</i> L.	Lycopodiaceae		H	YM 056
77	<i>Macaranga capensis</i> (Baill.) Sim.	Euphorbiaceae	Wongo	T	YM 004
78	<i>Maesa lanceolata</i> Forssk.	Myrsinaceae	Abbayyii	T	YM 018
79	<i>Margaritaria discoidea</i> (Baill.) Webster	Euphorbiaceae	Qetto	S	YM 114
80	<i>Mariscus sieberianus</i> Nees	Cypraceae		H	YM 124
81	<i>Maytenus arbutifolia</i> (A .Rich.) Wilczek	Celastraceae	Kombolcha	S	YM 022

82	<i>Maytenus undata</i> (Thunb.) Blakelock	Celastraceae	Kombolcha	S/T	YM 100
83	<i>Medicago polymorpha</i> L.	Fabaceae	Siddisa	H	YM 074
*84	<i>Millettia ferruginea</i> (Hochst.) Bak.	Fabaceae	Sotollo/Askra	T	YM 016
85	<i>Momordica foetida</i> Schumach.	Cucurbitaceae	Minan bofa	C	YM 028
86	<i>Olea capensis</i> L.	Oleaceae	Gaagama	T	YM 057
**87	<i>Olea welwitschii</i> (Knobl.) Gilg & Schellenb	Oleaceae	Baya	T	YM 058
88	<i>Olyra latifolia</i> L.	Poaceae	Gaawa	H	YM 030
89	<i>Oplismenus hirtellus</i> (L.) P. Beauv.	Poaceae	Salamey	H	YM 049
90	<i>Passiflora edulis</i> Sims	Passifloraceae		C	YM 013
91	<i>Pavonia schimperiana</i> Hochst. ex A. Rich.	Malvaceae		H	YM 021
92	<i>Pavonia urens</i> Cav.	Malvaceae	Hiniccinni	H	YM 101
93	<i>Pentas lanceolata</i> (Forssk.) Deflers	Rubiaceae		H	YM 053
94	<i>Peperomia molleri</i> C. DC.	Piperaceae		H	YM 129
95	<i>Peperomia tetraphylla</i> (Forster) Hook.	Piperaceae		H	YM 077
96	<i>Phoenix reclinata</i> Jacq.	Arecaceae	Mexxii	T	YM 065
97	<i>Physalis peruviana</i> L.	Solanaceae		H	YM 043
98	<i>Piper capense</i> L.f.	Piperaceae	Tunjo	H	YM 076

99	<i>Pittosporum viridiflorum</i> Sims.	Pittosporaceae	Sole	T	YM 006
100	<i>Plectranthus lanuginosus</i> Hochst. ex Bent.	Lamiaceae	Dama kesse	H	YM 062
101	<i>Podocarpus falcatus</i> (Thunb.) R. B. ex Mirb	Podocarpaceae	Birbirsaa	T	YM 020
102	<i>Polyscias fulva</i> (Hiern) Harms	Araliaceae	Kariyo	T	YM 008
**103	<i>Pouteria adolfi-friederici</i> Rob. & Gilg	Sapotaceae	Qararoo	T	YM 017
104	<i>Premna schimperi</i> Engl.	Lamiaceae	Urgessa	S	YM 032
105	<i>Prunus africana</i> (Hook.f.) Kalkm	Rosaceae	Oomoo	T	YM 107
106	<i>Psychotria orophila</i> Petit	Rubiaceae	Xumanee	S	YM 079
107	<i>Pycnostachys eminii</i> Gurke	Lamiaceae	Qoricha qemele	H	YM 026
108	<i>Rhamnus prinoides</i> L'Herit.	Rhamnaceae	Gesho	S	YM 110
109	<i>Ricinus communis</i> L.	Euphorbiaceae	Qobbo	S	YM 111
110	<i>Rubus niveus</i> Thunb.	Rosaceae		S	YM 045
111	<i>Rytigynia neglecta</i> (Heirn) Robyns.	Rubiaceae	Mixoo	S	YM 051
112	<i>Sapium ellipticum</i> (Krauss) Pax	Euphorbiaceae	Bosoqa	S	YM 086
*113	<i>Satureja paradoxa</i> (Vatke) Engl.	Lamiaceae	Nado	H	YM 093
114	<i>Schefflera abyssinica</i> (Hochst. ex A. Rich.) Harms	Araliaceae	Botto/Gatamaa	T	YM 010
115	<i>Senna septemtrionaiis</i> (Viv.) Irwin & Barney	Fabaceae		S	YM 041

116	<i>Sida rhombifolia</i> L.	Malvaceae	Karrabaa	H	YM 029
117	<i>Solanecio angulatus</i> (Vahl) C. Jeffrey	Asteraceae		H	YM 088
*118	<i>Solanecio gigas</i> (Vatke) C. Jeffrey	Asteraceae	Simbiriko	S	YM 034
119	<i>Sparmannia ricinocarpa</i> (Eckl. & Zeyh.) O. Ktze	Tiliaceae		S	YM 072
120	<i>Stephania abyssinica</i> (Dillon & A. Rich.) Walp.	Menispermaceae		C	YM 083
**121	<i>Syzygium guineense</i> (Willd.) DC. subsp. <i>afromontanum</i> F. White	Myrtaceae	Bedessa	T	YM 019
122	<i>Teclea nobilis</i> Del.	Rutaceae	Hadheessa	T	YM 011
123	<i>Tectaria gemmifera</i> (Fèe) Alston	Tectariaceae	Gitto	H	YM 098
124	<i>Thunbergia alata</i> Boj. ex Sims	Acanthaceae		C	YM 042
125	<i>Trema orientalis</i> (L) Bl.	Ulmaceae	Debbo	T	YM 060
126	<i>Tristemma mauritanum</i> J.F. Gmel.	Melastomataceae	Teyb	H	YM 110
127	<i>Urera hypselodendron</i> (A.Rich.) Wedd.	Urticaceae	Emo	C	YM 078
*128	<i>Vepris dainellii</i> (Pichi-serm.) Kokwaro.	Rutaceae	Hadheessa	T	YM 094
129	<i>Vernonia adoensis</i> Sch. Rip. ex Walp	Asteraceae	Solle	S	YM 102
130	<i>Vernonia amygdalina</i> Del.	Asteraceae	Ebbichaa	T	YM 061
131	<i>Vernonia auriculifera</i> Hiern	Asteraceae	Reejjii	S	YM 081
132	<i>Vernonia hochstetteri</i> Sch. Bip. ex Walp.	Asteraceae	Eilbu	S	YM 112

* Endemic species recorded from Gera Forest

** Commercially important tree species in Gera Forest