

**AN ECOLOGICAL STUDY OF BITEYU FOREST, GURAGE
ZONE, SOUTHERN NATIONS, NATIONALITIES PEOPLES
REGION**

**A THESIS SUBMITTED TO THE SCHOOL OF GRADUATE
STUDIES, ADDIS ABABA UNIVERSITY**

**IN PARTIAL FULFILMENT FOR THE REQUIREMENTS OF
THE DEGREE OF MASTER OF SCIENCE IN BIOLOGY**

**BY
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JUNE 2003

ADDIS ABABA

ADDIS ABABA UNIVERSITY
SCHOOL OF GRADUATE STUDIES

**AN ECOLOGICAL STUDY OF BITEYU FOREST, ALONG THE WESTERN
ESCARPMENT OF THE GURAGE MOUNTAIN CHAIN, ETHIOPIA**

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*A Thesis Presented to the School of Graduate Studies, Addis Ababa University in
Partial Fulfillment for the Requirements of the Degree of Master of Science in*

BIOLOGY

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June 2003

Acknowledgements

I am very much indebted to my advisor Dr. Zerihun Woldu for his reliable advice during the field work, consistent and industrious help at times of data analysis which require computer soft wares, borrowing GPS and compass, as well as for reading the manuscript. In general it was not possible to complete this work without his valuable support in every aspect of the study.

My sincere thanks also goes to my advisor Prof. Sebsebe Demissew for suggesting the specific study area, arranging the facilities during my stay in the field, providing an altimeter, for his help in identification and confirmation of identified specimens, reading the manuscript, for his regular follow up and his brotherly assistance. His support was very crucial in the completion of this study.

I would like to thank Dr. Nigist Asfaw for her material support. I am also thankful to Dr. Ensermu Kelbessa for his encouragement and help in identifications of some of the specimens.

I have no words to express my heartfelt gratitude to my brother Lemma Biru who devoted his resources to see the successful completion of this study. My sincere thanks also go to Dr. Shiferaw, Almaz, Misrak, Betelihem, Mesfin, Tesfa and Ephrem for their financial and moral support while doing this study.

I am thankful to my wife W/o Genet Woldearegay for her everlasting help and encouragement

and very much indebted for the material assistance received from Ato Shimekt Woldearegay.

I am very much thankful to Ato Negash Balcha for the good deeds that he made in arranging logging during my stay in the field. Likewise, I also thank Ato Wolde Kere and his family for providing me all the necessities during my stay in the field. I also appreciate the material and moral support from my friends Ato Tolcha Regassa and Ato Desalegn Wanna.

I would like to thank the National Herbarium of Ethiopia for allowing me to use the facilities available during the fieldwork and staff members Ato Melaku Wondafrash for his help in identification of specimens, Ato Solomon Kasse, W/t Shewangziw Lemma and W/t Sosina Ketema for their kind assistance. I am also thankful to the National Soil Research Center and staff members for allowing me to use the facilities to measure soil electrical conductivity. My sincere thanks also go to GIS lab of Ethiopian Agricultural Research Organization for the map of the study area and National Meteorology Service Agency for the climatic data.

Finally, I would like to thank the School of Graduate Studies for the financial support for the research from the fund obtained from SAREC and the Department of Biology for all assistances while doing this study.

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Abstract

Biteyu Forest is located at the edge of the western escarpment of the Gurage mountain chain. This forest is probably one of the forest patches that were once widespread on the central plateaux of Shewa. In this study vegetation composition of the forest following altitudinal gradients was performed. Sixty, 20 m x 20 m quadrats were selected and all the plants in the quadrats were recorded. Cover abundance value of all the species was estimated. The vegetation data was analyzed using the program SYNTAX (Podani, 1998) to identify the community types. Six community types were identified and named after two or three dominant species. Shannon-Wiener diversity index were computed to measure species diversity in a community. One-way analysis of Variance (ANOVA) was used to test the difference in communities in relation to environmental parameters along the altitudinal gradient including soil properties (pH, texture and electrical conductivity), altitude, slope and aspect. Height and DBH of the woody species in all the quadrats were taken.

177 species belonging to 143 genera and 68 families were identified. Shannon-Wiener diversity index revealed that species diversity is high in communities 1, 4 and 2 respectively. This is probably due to high rate of disturbance in the communities. Statistical analysis (ANOVA) have shown that the difference in communities might partly be explained by the variation in altitude, slope and soil properties at $p < 0.05$ level of significance with the exception of aspect and silt. Height and DBH class measurement indicated that most of the woody species in the forest are confined in the lowest class distribution. Sørensen's similarity coefficient showed the similarity of the forest with Menagesha-Suba forest in floristic composition.

1. INTRODUCTION

1.1. Background

Mountain ecosystems are known for their high biological diversity. The topographic relief on mountains tends to produce different local climate (Misra, 1974; Avila, 1992), which may differ considerably from the regional climate (Walter, 1973; Stoutjesdisk and Barkman, 1992). The change in climate which results from differences in altitude considerably affects the vegetation of a mountain (Ewusie, 1980), making altitude an important factor that influences the growth and development of plants and vegetation distribution and composition.

Distinct vegetation zones usually occur on mountains (Longman and Jenik, 1987; Begon *et al.*, 1996). On mountains climatic variations become more and more extreme and rapid with increase in altitude due to the variations in environmental conditions, which cause due changes in altitude over short vertical distance, as a result of the abrupt changes in microclimate (Lovett, 1993, Fernandez-Palecius and de Nicolas, 1995). Due to biotic factors such as the competitive ability of species (Walter, 1973; Rickleftis and Schuluter, 1993) and the change in climatic factors such as temperature, light, potential evapotranspiration, relative humidity and rainfall etc. plant distribution and community transition could be affected (Walter, 1973; Misra, 1974; Burbour *et al.*, 1987; Demel Teketay, 1994; Zerihun Woldu, 1999).

Mountain regions usually have rocky and shallow soils. The abrupt changes on mountains accompanied by changes in the characteristics of soils and microclimatic factors also result in the variation in the distribution and structural composition of vegetation (Lind and Marrison, 1974). Moreover, maximum plant growth depends on the soils having the biological,

chemical and physical conditions necessary for the root system to maximize the absorption of nutrients and water required by the plants to enable the biochemical reactions that occur in the root (Barber, 1984).

Microflora, microfauna and larger animals contribute to the maintenance and development of the soil, which in turn can affect the growth and development of vegetation. In addition, vegetation types are influenced by soil texture, aeration, chemical composition and other soil properties (Young and Giese, 1990).

Soil pH is one of the soil properties that determines the growth and development of plants of an area. Soil pH provides useful information of a given soil. Pearcy *et al.* (1994) describe pH as an index of cation saturation. Etherington (1975) indicated lower pH in soils as an indicator to the presence of divalent cations like Mg and Ca. Climate and parent materials are known to cause alkalinity or acidity of soils (Fitzpatrick, 1986). Besides, the variation in soil pH could result from the differences in mineral nutrient and microflora (Russell, 1961). Leaching due to high rainfall also leads to acidic soil, which in turn retards, the decomposition of organic matter as a result of the intolerance of soil animals like earthworm to acidic soils (Lewis and Taylor, 1979).

The amount and type of soluble salts in the soil may vary depending on the texture of the soil, drainage, species type climate etc. (Landon, 1996). Valuable information on the total amount of soluble salts in soils could be obtained more directly by electrical conductivity than pH (Thompson and Troech, 1978; Landon, 1996).

As one goes from the lower to higher altitudes, the amount of rainfall increases to a certain point on the mountain beyond which it decreases, although this may not be in a linear fashion. In addition, an increase in altitude tends to decrease air and soil temperature, and hence increase in humidity, which is unfavorable to the growth of most plant (Hedberg, 1964; Daniel Gamechu, 1986; Stiling, 1996). At higher altitudes, the atmospheric pressure tends to reduce (Daniel Gamechu, 1986). Thus, the decrease in atmospheric pressure is known to have some direct effect on plants by causing a decrease in CO₂ availability (Lundgren, 1971). Consequently, the vegetation at higher altitude could become more sparse and stunted (Ewuisie, 1980; Kumar, 1981).

Moisture gradient, light, temperature, air pressure and other related climatic factors of environment are influenced not only by altitude but also by slope direction and slope degree (Mira, 1974; Burbour *et al.*, 1987). On mountains the slope on the windward side receives more rainfall when compared with the leeward slope, which is relatively drier (Misra, 1974; Stiling, 1996). Thus, the direction of existing winds could be considered as an important factor (McLean and Ivimer-Cook, 1973). Additionally, steep slopes may constantly and continually expose new surfaces to weathering and erosion (Burbour *et al.*, 1987). Steep slopes experience faster movement of water and minerals (Morgan, 1980). The marked effect of slope is its influence on the run-off and drainage and consequently upon the depth as well as nutrient and water content of the soil (Russell 1961; Thompson and Troech, 1978). Moreover, the steepness of a slope largely determines the stability of the surface retention of water and has an effect on aspect (Burbour *et al.*, 1987). Areas that have steep slopes are liable to soil erosion and increased surface run-off, which will remove nutrients from the surface during

high rainfall (Thompson and Troech, 1978). Hence nutrient availability will be reduced in such slopes. As a result of the slope of the ground, the composition and structure of vegetation may be altered (McLean and Ivimer-Cook, 1973). Thus, slope together with other environmental factors will determine the type of vegetation of an area.

Goodall (1973) explained that the presence of species on mountains or on any other types of ecosystem is a positive evidence for adaptation of species to the existing environmental conditions. Nevertheless, the following two ideas seem to provide possible explanation for the absence of species from a stand (Goodall, 1973). These are:

1. Absence of the species from the population in which the sample is taken and/or,
2. Absence of species due to improper sampling when a sample is taken.

Seasonal distribution and amount of rainfall are crucial factors to vegetation development (Young and Giese, 1990). The most abundant species in an area therefore, are those of greatest physiological tolerance of the given range of conditions. Thus, richest stand could well reflect regions of more fertile soil, or operations of some factors such as grazing which improve the presence of additional herbs (Williams and Lambert, 1961). Therefore, the expected abundance of a given species in a given stand depends on the local climatic factors and other related factors in the stand (Palmer and Dixon, 1990; Lovett, 1993).

1.2. Status of Forests and Trend in Vegetation Loss

So far, forests have received a very little protection and conservation efforts through out the world. During the past ten thousand years, global forest cover has been reduced by about one third from an estimate 6.3×10^9 ha to 2.2×10^9 ha (Maini and Ullsten, 1993). Recent reports by Myer (1989) cited in Hughton (1993) indicated that the annual loss of closed forests in the world increased from $7,340 \times 10^3$ ha in 1979 to $13,860 \times 10^3$ ha in 1989. In tropical forests alone, due to human activities between 0.1 to 0.3 % of species become extinct annually (Balmford *et al.*, 1998). FAO (1986) estimated that some 45 million ha high forestland and woodlands would be converted into arable land up to the year 2010 to satisfy the food demand of the world. Despite this depressing trend, these days, forests are becoming one of the main concerns on the international policy agenda. Most concerned individuals and governments are trying to implement international and local policies developed to protect the forests. Nevertheless, the objectives to protect the forests could not be realized due to a host of problems attached with the failure to use forests and their products in a sustainable way (Wilson, 1991; Woodwell, 1993).

The landscapes together with ecological features in Ethiopia are responsible for its richness in both fauna and flora. This is due to great variety in topography and environmental conditions (Demel Teketay, 1994; Zerihun Woldu, 1999), making the country an important center of diversity and endemism. Although the various vegetation types of Ethiopia are under considerable pressure from the rapidly expanding population (Zerihun Woldu *et al.*, 1989; MacLacham, 2001) the number of higher plants is estimated to be more than 6500 species of which about 10.5-12% probably are endemic (World Conservation Monitoring Center, 1992;

Ethiopian Forestry Action Program, 1994). Further estimate on the total number of woody plants made by Haase and Janben (1995) indicate that out of the 1000 woody plants about 300 are tree species.

Ethiopia's natural vegetation has also been severely affected by agricultural activities for at least 5000 years and wide spread deforestation has probably taken place around at 2500 ago (World Conservation Monitoring Center, 1992). In the past most of Ethiopia's highlands were believed to have been covered with dense forests. The extent to which the highlands of Ethiopia were once forested is evidently indicated by the numerous isolated mature forest trees or patches of forests or woodlands of approximately the same species composition as in the remaining areas with closed forest (Friis, 1986; Friis and Mesfin Tadesse, 1990) as well as old trees found in many churchyards. These remaining patches of forests are found in inaccessible and remote parts of the country.

The forest cover of the country has been on decline in the last decades. According, to Hedberg (1979) the reduction was estimated to be 16% in 1950s and to 4% in 1970s. Reports by the Government of the Peoples Democratic Republic of Ethiopia (1990); Ethiopian Forestry Action Program (1994) indicate that the forest cover was reduced to 2.7% in 1989 and less than 2.3% in 1990. One reason for the decline of the forest is attributed to energy requirement. About 94% of the energy requirement of the country relies on biomass alone (Haile Leul Tebicke, 2002) of which, trees and shrubs contribute the largest proportion. It is also stated that most of the existing forest patches in Ethiopia are in a secondary state of development (Friis and Mesfin Tadesse, 1990; Tamrat Bekele, 1993).

According to Lanly (1981) the area of closed forest cleared annually in Ethiopia was about 10,000 ha. But recent estimate showed that between 160,000 and 200,000 ha natural vegetation is cleared annually (Konemund *et al.*, 2002). If this trend continues over the next few years, the only remaining high forests would be found scattered in inaccessible areas (Ethiopian Forestry Action Program, 1994). Michelsen *et al.* (1993), Tamrat Bekele (1993), Yonas Yemshaw (2002) also indicated that these small patches of forests in the country are the most endangered of the forests which could be wiped out in the near future if the deforestation trend remains unabated.

Compilation of information on species composition on the different forests and description of the vegetation types are vital steps in the conservation process. With this regard, attempts have been made to describe the vegetation types in the country. Some authors such as Logan (1946), Pichi-Sermolli (1957), von Breitenbach (1963), Beals (1969), Wilson (1977), Friis *et al.* (1982), White (1983), Friis (1992), Bonnefille *et al.* (1993), Zerihun Woldu (1999); Friis and Sebesebe Demissew (2001) have attempted to describe vegetation types of the country. Sebesebe Demissew (1980), Hailu Sharew (1982), Lisanework Nigatu (1987), Tamrat Bekele (1993), Teshome Sormesa (1997), Kumilachew Yeshitla (1997), Sebesebe Demissew (1998) Simon Shibru (1999), Yosef Assefa (2001), Tesfaye Awas *et al.* (2001), Desalegn Wana (2002) have tried to study some of the forest patches found in different parts of the country. This study is also an attempt to provide information on the vegetation of one of the remnant forests in the central part of the country and contribute to the knowledge base of Ethiopian forests.

2. OBJECTIVES

2.1. General objective

The main objective of the present study is to investigate plant communities of Biteyu Forest in relation to some environmental variables.

2.2. Specific objectives

1. To study the effects some of the environmental factors on plant communities along altitudinal gradient.
2. To study the relationship between environmental gradients, species diversity and species richness of the study area.
3. To collect basic vegetation data of the study area.
4. To determine the type of the forest of the study area.
5. To make recommendation on the use of the forest on sustainable basis.

3. LITERATURE REVIEW

3.1. Community Theories

A plant community denotes associations of plants occurring in particular locality and dominated by one or more prominent species in a given time and space (Begon *et al.*, 1996; Ricklefs, 1997). It can also be viewed in terms of the interactions of associated populations (Pahl-Wostl, 1995). Andreucci *et al.* (2000) explained plant communities as combination of species that can vary more or less gradually along gradients or discontinuously across ecotones (distinct boundaries).

Plant association is characterized by combinations of different characteristic species, having a defined floristic composition in that association than the other association (Andreucci *et al.*, 2000). It is also a fundamental level in the hierarchical classification (Mueller-Dombois and Ellenberg, 1974). Species belonging to a community are closely associated with one another implying, the ecological limits of distribution of each species will coincide with the distribution of the community as a whole (Ricklefs, 1997). According to Kershaw (1973) a community cannot be described simply by listing all the species present, rather it is characterized by detailed studies of those species which most contribute to its unique structure and composition.

Regarding the structure of communities' two different views have been presented in the past. These are the Clementesian view, which consider plant communities as discrete units and Gleasonian view that regarded plant communities as continuous entities (Lewis and Taylor, 1979). But recently, Collins *et al.* (1993) proposed a hierarchical continuum concept of plant

community, which reconcile the two views. These community concepts are briefly summarized below.

3.1.1. The Discrete Community Concept (Community Unit Theory)

The discrete community unit theory implies the existence of distinct communities (Walter, 1971). In the discrete community concept (community unit theory), the distinctive vegetation of each area represents a distinct community, which is separated by sharp vegetational transition from other communities (Ricklefs, 1997). Therefore, such communities are considered as closed communities and they are known by rapid replacement of species along gradients. Discontinuities over the continuous environment pattern are an important feature of discrete communities (Roberts, 1987).

Within this community unit concept, the plant community is the basic unit, and may be represented by a group of relatively homogenous samples, classified based on floristic similarity into a hierarchical table (Palmer and Van Staden, 1992). Moreover, this view regards communities as having a degree of internal organizations, which jointly modifies the environment with sharp delimitation from other environments. Therefore, the existence of such communities could be attributed to the competition and exclusion of other less competitive ones by the few dominant species (Roberts, 1987; Paul, 1993).

Species belonging to a community are closely associated with one another implying, the ecological limits of distribution of each species will coincide with the distribution of the

community as a whole (Barbour *et al.*, 1987). The community unit theory (discrete concept) attempts to establish a classification (cluster analysis) of plant associations.

3.1.2. Community Continuity (Continuum Concept)

The continuum concept implies the gradual distribution pattern in plant communities. This may be due to many environmental factors like moisture, temperature, light, soil conditions (Ricklefs, 1990) showing gradual variation over space and time. In continuum concept, communities replace one another (Claessen *et al.*, 1994) and distribution of one species within each group has similarity and the end of one group becomes the beginning of another. The view of the community unit theory (continuum concept) paved the way to the new ordination technique (Kumar, 1981).

According to Roberts (1987) both concepts (discrete concept and continuum concept) emphasize on environmental factors giving very little attention to the modification effect of the vegetation and their subsequent influence on the pattern of community. Therefore, the need for a hypothesis that incorporate the two different views with regard to the existence natural patterns of a community became crucial. Accordingly, Collins *et al.* (1993) developed the so-called hierarchical continuum concept. With regard to the distribution patterns of plant communities, Collins *et al.* (1993) indicated that, species change their distribution and abundance patterns along the gradients in response to environmental fluctuations. Thus, the hierarchical continuum concept assumes that some species will have a wider distribution, others localized, and still some others will have a much-restricted distribution across the

sample area. Thus, the distribution pattern and abundance of species assumes a hierarchical structure where species with wider, intermediate and restricted distribution ranges show some kind of hierarchies than a continuum or discrete.

3.2. Species Diversity

According to Mclean and Ivimer-cook (1973); Kumar (1981); Paul (1993) species diversity can be viewed in terms of species richness (total number of species in a given area), species endemism (total number of species confined to that specific area), evenness (distribution or the relative abundance of the individuals within each species) and taxonomic diversity (measurements of magnitude of differences between species as seen by their taxonomic distribution in genera, orders, classes and Phyla) Diversity depends on such processes like ecological, evolutionary, geological, and biogeochemical and the interactions between them (Huston, 1994). In view of this geologically older areas like the tropics would have high species diversity (Ewuisie, 1980). Species diversity tends to increase also with time following an environmental disturbance. During the progress of succession, species diversity first increases and then declines as the climax is approached (Ewuisie, 1980).

In mountainous ecosystems if there are abrupt changes in altitudes, slope, moisture gradients, temperature, rainfall and drainage, diversity also may change abruptly with a shorter distance (Lovett, 1990; Begon *et al.*, 1996).

3.3. Techniques in Vegetation Classification

Multivariate techniques are used to study the complex nature of plant communities the objective being to summarize large and complex data sets obtained from community samples and to help in the interpretation and generation of hypotheses about community structure and variation (Lambert and Williams, 1966). Among the many multivariate techniques developed in the past three decades classification and ordination are the two main and basic techniques, which are employed to study the complex nature of communities (Ricklefs and Schuluter, 1993).

3.3.1. Classification

The availability of vast amount of ecological data and the observations and experiences in ecosystems have necessitated the integration of the diverse knowledge of classification processes. Classification relies on defining a set of classes in which members of the same class 'shall be as like as possible' and members of different classes 'as unlike as possible', with the intention that similarity is a matter of degree. Thus, similar properties shared by different classes and other properties that are not shared commonly serve to identify that particular class. Accordingly, classification begins with the assumption that communities consist of discrete entities.

Various techniques of vegetation classification have been discussed by several authors like Gauch (1962), Whittaker (1962), Shimwell (1971), Mueller-Dombois and Ellenberg (1974), Westhoff and Maarel (1978), Greig-Smith (1980, 1983), Gold-Smith and Harrison (1976) and

Dingby and Kempton (1994). Gauch (1962) subdivided classification techniques into a table arrangement; non-hierarchical and hierarchical which are briefly described below.

Table arrangement: The objectives of table arrangements are to bring together the species with similar distribution and samples that are similar in composition. However, critics of this technique point out the fact that the results are subjective (Kershaw, 1973) and the application to unknown and odd species is not easy (Westhoff and Maarel, 1978).

Non-hierarchical method: When there is no particular advantage in the groups or species or samples being arranged in a hierarchy, a non-hierarchical method of classification, where groups have no joint structure, may then be chosen (Gauch 1962; Dingby and Kempton, 1994). In this case species or samples are arranged in clusters, bringing similar species or samples together (Pielou, 1969) to optimize structure of individual groups. The aim of such techniques is in producing the most efficient groups regardless of the route by which they are derived (Greig-Smith, 1983). If homogeneity of group is of a prime importance in the application process, the non-hierarchical techniques are best fit. However, this method runs into computational difficulties (Dingby and Kempton, 1994).

Hierarchical classification technique: In such classification technique, samples having the same properties are arranged into classes and the classes at any level are subclasses of classes at higher level (Pielou, 1969). Therefore, the groups themselves are arranged into a hierarchy (Dingby and Kempton, 1994).

Hierarchical classification technique is further divided into

- i. Monothetic divisive,
- ii. Polythetic divisive and
- iii. Polythetic agglomerative.

Monothetic divisive classification technique: Such technique begins with all the samples in a single group and then divides them hierarchically into progressively smaller groups on the basis of the presence and absence of a single species (Williams and Lambert, 1964).

Polythetic divisive classification technique: In this case information on all species is used. It begins with all samples together in a single cluster and successively divides the samples into a hierarchy of smaller and smaller clusters until finally, each cluster contains only one sample or some specified small number of samples (Dingby and Kempton, 1994).

Polythetic agglomerative classification technique: This type of technique also use information on all species. However, these begin with each sample prearranged to a cluster with a single number and agglomerate these in a hierarchy of larger and larger cluster until finally a single cluster contains all the samples (Dingby and Kempton, 1994).

3.3.2. Ordination

Ordination does not produce distinct groups, which can be classified; instead it shows the interrelationship among species that are believed to be controlled by environmental gradient (Kershaw, 1973). In ordination communities with most similar attributes for instance species

composition and relative abundance will appear close together. Where as, communities that differ greatly in the relative importance of similarity sets of species, or that possess quite different species appear far apart (Begon *et al.*, 1996). Regarding its final output ordination allow community to be arrange on graph (Lambert and Dale, 1964).

Ordination aims at representing the individuality of each stand. As opposed to the use of classification in describing discrete plant communities, ordination techniques have evolved for relating continuously variable communities. Ordination enables to obtain information on both continuity and discontinuity of the data studied as well as to recognize the number of possible clusters and their shapes (Goodall, 1973; Kershaw, 1973).

However both ordination and classification can be applied to get complete description of given a vegetation (Goodall, 1973; Mueller-Dombois and Ellenberg, 1974). Whittaker (1967; 1973) elaborated this technique in his gradient analysis. According to Lambert and Dale (1964) ordination is used as alternative to classification but the choice lies on the ecologist for categories of vegetation or ordination scatter gram.

The success of ordination method depends on the use of appropriate variety of environmental variables (Begon *et al.*, 1996). It provided some hypothesis to be tested about the relationships between community composition and environmental factors (Chapman and Reiss, 1992). Results obtained by ordination emphasize the occurrence of predictable association of species under particular set of environmental variables and their common trend, which are most important in sorting out a group (Begon *et al.*, 1996).

4. MATERIALS AND METHODS

4.1. Description of the study area

4.1.1. Location

The study area is located in Beteyu Forest $8^{\circ} 13' N$ and $38^{\circ} 21' E$ at the edge of the western escarpment of the Garage mountain chain in the Southern Nations, Nationalities Peoples Region, 17 km NW of Butajira town (Figure 1). Bityeu Forest is one of the relict patches of forests, which is probably a remnant forest that was once widespread on the Central plateaux of Shewa. This forest covers four mountain chains. Three of the mountains (Kechemochi, Gerodeaebi and Beiri) were chosen for this study. The topography of the mountains is steep slope with an elevation ranging from 2590 m to 2890 m. The forest is estimated to cover an area of 4 to 6 Km². The mountain chain is drained by small streams like Godede, Kelekele and Kugnet, which merge together and form Wegeram River that eventually forms the Meki River.

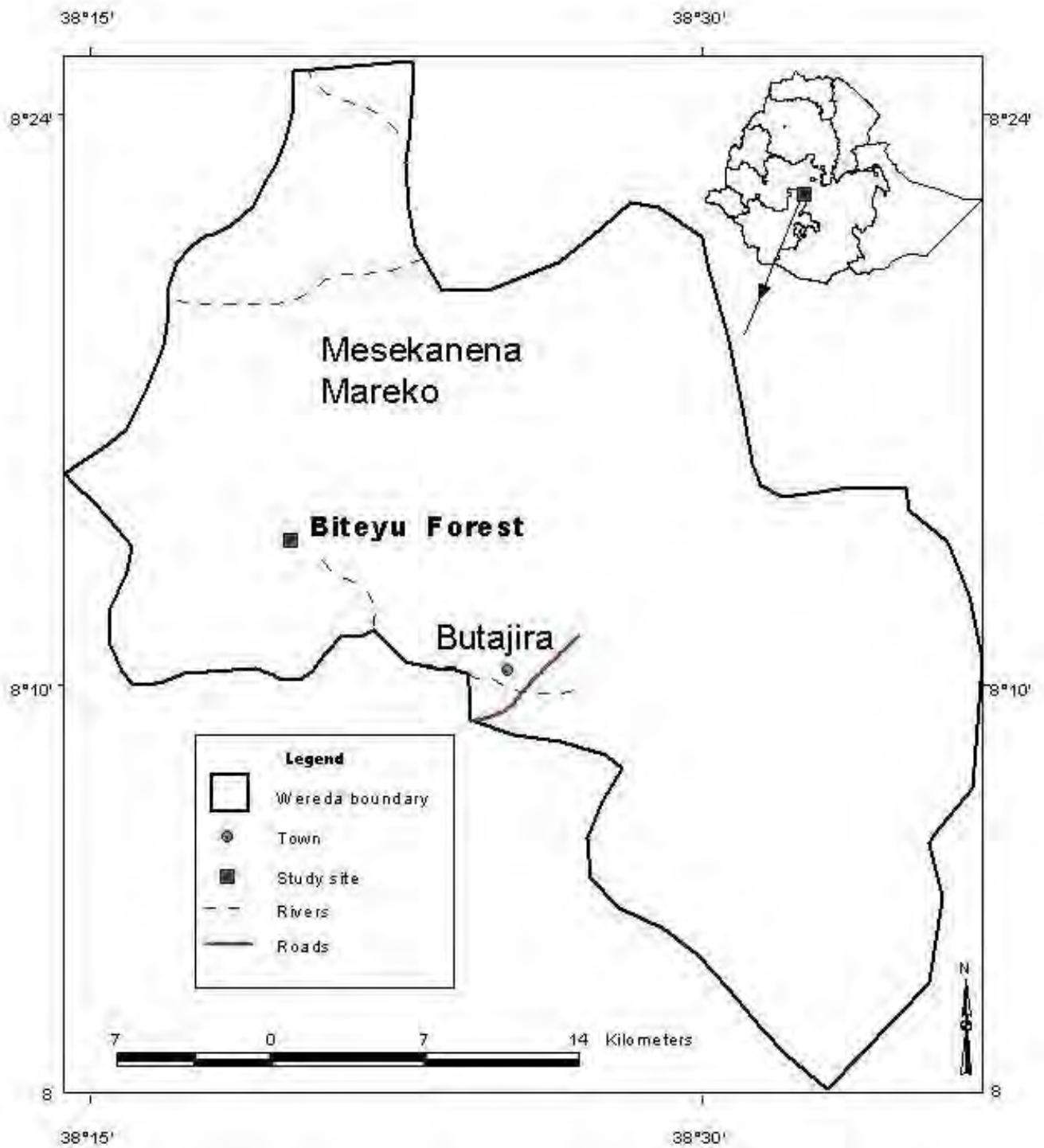


Figure 1. Location Map of the Study Area

4.1.2. Climate

The position of ITCZ (INTERTROPICAL CONVERGENT CONVERGENCE ZONE), that divides the humid tropical air mass to the south from the dry northeast, highly determine the climate of Ethiopia (Daniel Gamechu, 1977). As part of the land escape of Ethiopia, the study area is also expected to be influenced by ITCZ. According to Daniel Gamechu (1977) the highlands of western and central Shewa are characterized by seven rainy months between March and September, the small rains begins March to May and the big rains during June to September with higher concentrations of the rain observed in July and August. Based on the climatic data of Butajira town, which was recorded by the National Meteorology Services Agency since 1970, the study area receives rain in seven months from March to September (Figure 2) and the big rains with a similar trend as indicated by Daniel Gamechu (1977) the higher concentrations of the rain observed in July and August. The Climatic record near the study area shows the average annual rainfall 1081mm and mean monthly maximum temperature 22.7°C and mean monthly minimum temperature 8.9°C .

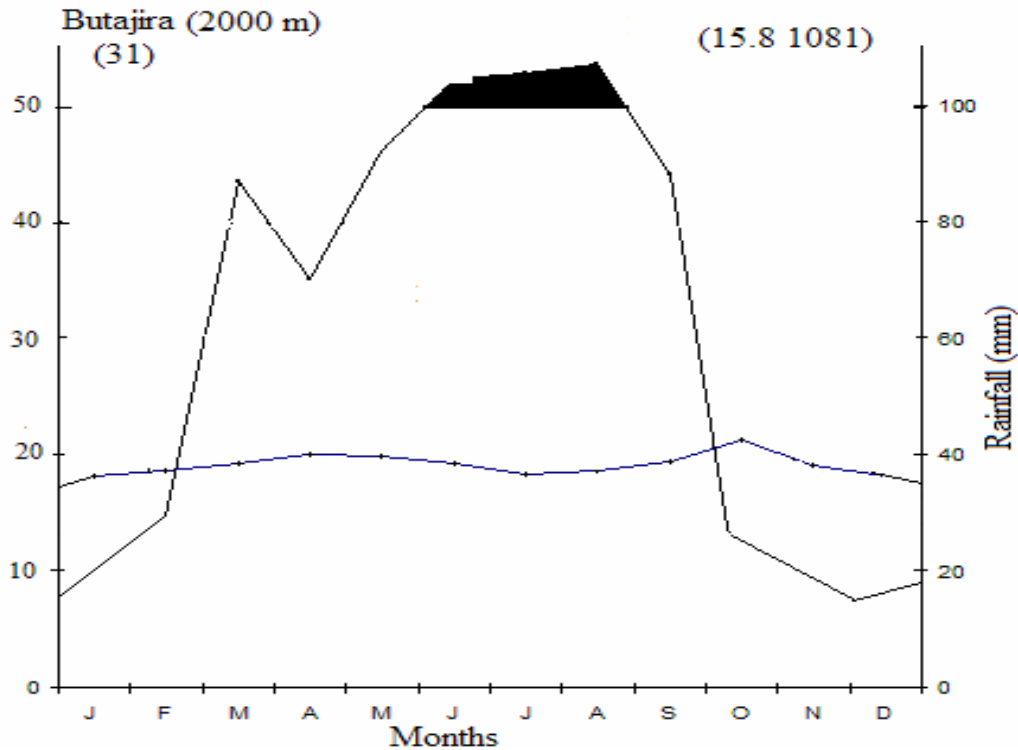


Figure 2. Climate Diagram for Butajira town
 Source: National Meteorological Services Agency

4.1.3. Population and Land Use

According to the population census 1984 made by Central Statistics Office (CSA, 1985) the total population of Meskanena Mareko woreda was 182,076 (CSA, 1985) and after 10 years, the 1994 population census has showed the growth of the population of the woreda to 227,135 (CSA, 1996). This shows an increment by 24.6% in 10 years. Further more CSA (1996) indicated that 197,695 of the people live in rural areas.

In most rural areas of this woreda especially in almost all the mountain areas Enset (*Ensete ventricosum*) is the staple food. Cultivation of enset is the main occupation of the people. The

available farmland is limited. The continued divisions of Enset land from generation to generation have gone to such extent that most of the holdings are less than half hectare. People do not have enough land to cultivate other food crops except few villagers living at the upper most edge of the mountains that practice barely cultivation to some extent. Despite the shortage of farmland, due to the ease to grow Enset densely populated villages exist all round the forest.

Due to the lack of cash crops in the area some members of the community are involved in illegal tree cutting to generate income, which led to a serious deforestation. People living around the forest extensively cut Junipers, Podocarpus, Olive and Hagenia trees to produce timber for sale (Personal communication and observation).

4.2. Methods

4.2.1. Vegetation Data

A reconnaissance survey was made from March 7 to 9, 2002 and actual data collection was conducted between June 2, 2002 and June 22, 2002. Six transects were made starting from the lowest altitude to the ridge top from an altitude of 2590 m to 2830 m on the northern side and from an altitude of 2650 m to 2840 m on the southern side of Kechemochi mountain, on Gerodeabi mountain from an altitude of 2640 m to 2890 m on the northern and from an altitude of 2610 m to 2835 m on the southern part and on Beiri mountain from an altitude of 2590 m to 2830 m on southeast and from an altitude of 2650 m to 2840 m on the northwest side (Appendix 1). A total of sixty (20 x 20 m) releve's, 21 from Kechemochi, 20 from Gerodeabi and 19 from Beiri were established at every 20 m altitudinal gradient between the quadrats.

All plant specimens in the quadrats were recorded and voucher specimens were pressed and brought to the National Herbarium (ETH) Addis Ababa University for identification.

Cover abundance values of trees, shrubs, herbs and grasses were estimated following modified 1-9 Braun-Blanquette scale and converted into van deer Maarel (1979) as follows,

1=rare, generally one individual.

2=occasional, with less than 5% cover

3=abundant, with less than 5% cover

4=very abundant, with less than 5% cover

5=5-12% cover

6=2.5-25% cover

7=25.5-50% cover

8=50.5-75% cover

9=above75% cover

The specimens collected were identified by comparing them with the specimens already identified in the National Herbarium in Addis Ababa University and using published accounts of the Flora of Ethiopia and other taxonomic works of neighboring countries (Hedberg and Edwards, 1989, Hedberg and Edwards, 1995; Edwards *et al.*, 1995; Edwards *et al.*, 1997, Edwards *et al.*, 2000).

Height and DBH (diameter at breast height) of woody species and height of each woody species higher than 2 m was recorded. Species composition and size class indicate the likely state of the vegetation of a site (Enright, 1982). Accordingly, Diameter at Breast Height (DBH), which was measured using ordinary measuring tape and calculated by dividing the circumference of the woody species, measured at about 1.3 m heights by π (Martin, 1997). For woody species having more than one branch DBH was measured separately for each branch.

4.2.2. Environmental data

Environmental factors (altitude, slope and aspect) were recorded. Altitude was measured using Everest altimeter. Slope and aspect were measured using Compass and GPS (Global positioning system) was used to locate the study area. Aspect was indicated with the modified scale (Zerihun Woldu *et al.*, 1989), referring to the total amount of solar energy received as follows, N=0, NE=1, E=2, SE=3, S=4, SW=3.3, W=2.5, NW=1.3 and Ridge top=4.

4.2.2.1. Soil pH

Soil samples to the depth of 20 cm depth were collected from the four corners and one from the center of each stand and mixed and brought to the soil laboratory Addis Ababa University for texture and pH and National Soil Research Center for Electrical conductivity measurements. The soil samples after being air dried and passed through a 2 mm sieve were analyzed for soil pH, soil texture and electrical conductivity measurements following (Juo, 1978; National Soil Research Center, 2001). For soil pH determination, soil suspension at 1:1 soil to distilled water ratio was made by dissolving 20 g of soil in 20 ml distilled water. The contents were stirred with glass rod and allowed to settle for 30 minutes. Then pH was measured using Beckman Chemmate pH meter.

4.2.2.2. Soil Particle Size

One of the widely used approaches in soil particle size analysis is the Hydrometer method. This method is preferable due to its inexpensiveness, ease and rapidity to use (National Soil Research Center, 2001). The principle behind the use of the hydrometer method of soil particle size analysis is that the density of soil suspension at a given depth becomes less as the particle settle. Consequently, the values obtained at the two readings are related empirically to the particle size.

In hydrometer method 40 g of sodium hexametaphosphate and 10 g of sodium carbonate were dissolved to make a volume of 1 liter by adding distilled water to be used as a dispersing agent. 51 grams of air-dried soil sample was added to 50 ml of dispersing agent and 100 ml of distilled water. The contents were stirred with glass rod and allowed to stand for 30 minutes. The contents were stirred again for 15 minutes with multi-mix machine. Then these are transferred to a 1liter glass cylinder and diluted with distilled water up to 1 liter mark. The suspension was mixed by covering the top of the cylinder with a palm till the materials deposited at the bottom disperse in the suspension. Hydrometer and temperature readings were taken after 40 seconds and 3 hours.

From the hydrometer and temperature reading obtained, particle size was then calculated as follows,

1. %Sand = $100[H_1 - 0.2(T_1 - 68) - 2]$ 2
2. %Clay = $H_2 - [0.2(T_2 - 68) - 2]$ 2
3. %Silt = $100 - (\%Sand - \%Clay)$

Where

H_1 = the first hydrometer reading after 40 seconds

H_2 = the second hydrometer reading after 3 hours

T_1 = Temperature reading after 40 seconds

T_2 = Temperature reading after 3 hours

4.2.2.3. Soil Electrical Conductivity

To measure soil electrical conductivity a soil water suspension in a ratio of 1:2.5 was prepared following (National Soil Research Center, 2001). In this case soil water suspension was made by dissolving 10 gm of soil by 25 ml of distilled water and stirred for 30 minutes with automatic stirrer. Then electrical conductivity and temperature was recorded. Electrical conductivity in aqueous solution increases with increase in temperature about 2% per °C (Nycle, 1986).

Electrical Conductivity is then calculated as follows:

$$EC = S.C/T_f$$

Where

C = Constant (1.06)

EC = Electrical Conductivity

S = Reading obtained for the sample at Temperature T

T_f = Conversion factor of the Temperature T

4.3. Data Analysis

The vegetation data, which was converted into van der Maarel scale (1979), was subjected to the so-called Multivariate Package SYNTAX (Podani, 1998) to classify the vegetation. A hierarchical clustering technique is used to classify vegetation data on the basis of group average linkage, which is a hierarchical polythetic agglomerative classification technique. Similarity ratio was used as a resemblance index to classify to releves.

The mean values of environmental variables for communities were computed and one-way analysis of Variance (ANOVA) has been performed to find if there is a significant variance among communities and environmental factors. The program SPSS 10 was used to perform the ANOVA.

Shanon-Wiener (1949) Diversity index was applied to measure species diversity.

Shannon and Wiener (1949) species diversity index expressed as;

$$H' = -\sum(p_i \ln p_i)$$

Where p_i = the proportion of the total number of individuals in the i^{th} sp.

$$H' = \text{Species diversity}$$

The similarity of the forest with 4 other forests found in the country was compared using Sørensen's similarity coefficient $2c/(a+b)$, Where c is the number of tree and shrub species shared by the forests compared and a is the number of tree and shrub species in Biteyu forest and b is the number of tree and shrub species of the forest compared.

5. RESULT S AND DISCUSSION

5.1. Description of Plant Communities

A total of 177 species belonging to 143 genera and 68 families were identified (Appendix 2).

The number of species in each family is summarized in Table 1.

Table 1. Family and Number of Species.

Family	Number of Species
Asteraceae	33
Lamiaceae	9
Rubiaceae	8
Fabaceae	6
Rosaceae	5
Solanaceae	5
Apiaceae	4
Aspleniaceae	4
Myrsinaceae	4
Ranunculaceae	4
Polypodiaceae	4
Caryophyllaceae	3
Urticaceae	3
Hypericaceae	3
Oleaceae	3
Euphorbiaceae	3
Pteridiaceae	3
Scrophulariaceae	3
Gentianaceae	3
Boraginaceae	3
Campanulaceae	3
Crassulaceae	3
Primulaceae	3
Anacardiaceae	2
Flacourtiaceae	2
Orchidaceae	2

Rhamnaceae	2
Polygonaceae	2
Commelinaceae	2
Acanthaceae	2
Araliaceae	2
Lobeliaceae	2
Poaceae	2
Others	1

With regard to habit, trees were represented by 14.7% species; shrub by 22% species; perennials by 40.7% species; annuals by 6.2% species; climbers by 5.6% species; epiphytes by 2.8% species; ferns by 6.8% species and grasses by 1%. The vernacular names of 79 species were recorded for the first time (Appendix 2).

The result obtained from SYNTAX showed six main clusters that are represented by numbers 1, 2, 3, 4, 5 and 6. The relevés were grouped on the basis of grouped average linkage. The main clusters were determined at dissimilarity level between 0.75 to 0.85 (Figure 3). The six community types and their altitudinal ranges of distribution are summarized (in Table 2). In classification of vegetation, classifying communities by considering the dominant species as representative species of that particular community is one of the widely used approaches (Odum, 1971; Ricklefs, 1990; Andreucci *et al.*, 2000).

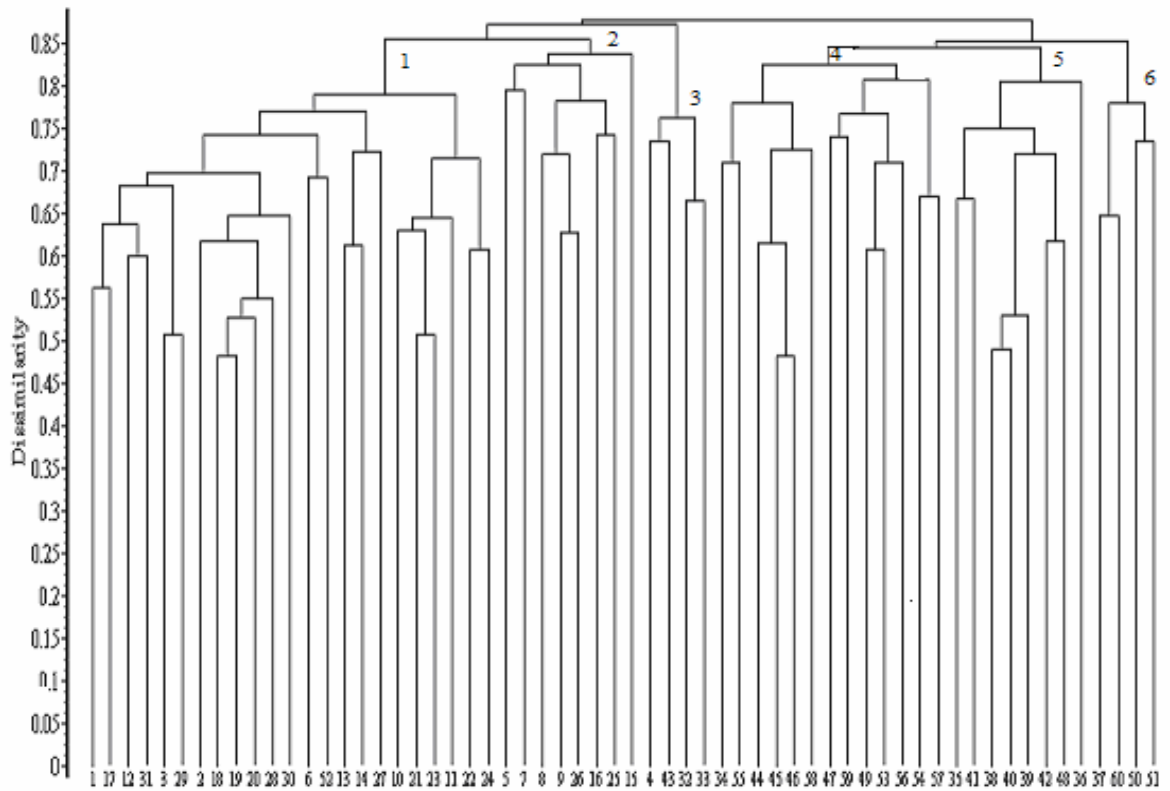


Figure 3. Dendrogram of relevés of vegetation composition in Biteyu Forest (X-axis showing the relevés and Y-axis showing the dissimilarity level).

Naming of the communities follows the names of species having high mean cover abundance value (dominant species). Lists of species of the six community types (Table 3) and their dominant species whose mean values are shown in **bold** (Shown in Table 3). The clusture numbers (Figure 3) corespondes to the community types discussion below.

Table 2. The Distribution of Community Types and their Altitudinal Range.

NO	Community Types	Altitudinal range (m)
1	<i>Olinia rochetiana-Olea europaea ssp. cuspidata-Maesa lanceolata</i>	2590-2840
2	<i>Schefflera volkensii-Rhus retinorrhoea</i>	2715-2800
3	<i>Podocarpus falcatus-Myrsine africana-Juniperus procera</i>	2610-2710
4	<i>Schefflera abyssinica-Olea europaea ssp. cuspidata-Discopodium penninervium</i>	2665-2815
5	<i>Olea europaea ssp.cuspidata-Ilex mitis</i>	2790-2835
	<i>Discopodium penninervium-Mikanopsis clematoides-Erica arborea</i>	2750-2890

5.1.1. Community Types

1. *Olinia rochetiana-Olea europaea ssp. cuspidata-Maesa lanceolata* Community Type.

The altitudinal range where this community type found ranges from 2590 m to 2840 m. The dominant tree species in this community type are *Olinia rochetiana*, *Olea europaea ssp. cuspidata*, *Maesa lanceolata*, *Juniperus procera*, *Ilex mitis* and *Hagenia abyssinica*. In the shrub layer *Buddleja polystachya*, *Osyris quadripartita*, *Canthium oligocarpum* were recorded. The herb layer includes the species *Cynoglossum coeruleum*, *Satureja simensis* and *Alchemilla abyssinica*. The grass species *Hyparrhenia* sp. and *Oplismenus* sp. were recorded. The climber *Asparagus africanus* is constituent parts of this community type.

2. *Schefflera volkensii*-*Rhus retinorrhoea* Community Type.

This community type exists at altitudes from 2715 m to 2800 m. *Schefflera volkensii* is the dominant species in the upper canopy. The less abundant but important species in the tree layer include *Rhus retinorrhoea*, *Juniperus procera*, *Domebya torrida*, *Prunus africana* and *Ekebergia capensis*. The shrub layer includes *Conyza hypoleuca*, *Buddleja polystachya* and *Rhamnus staddo*. The herb layer is well represented by *Plantago palmata*, *Plecteranthus assurgens* and *Satureja simensis*. The climbers *Mikaniopsis clematoides*, *Jasminum abyssinicum*, *Stephania abyssinica* and *Urera hypselodendron* are common in this community type.

3. *Podocarpus falcatus*-*Myrsine africana*-*Juniperus procera* Community Type.

This community type occurs at altitudes from 2610 m to 2710 m. *Podocarpus falcatus*, *Myrsine africana* and *Juniperus procera* are the dominant species in the tree layer. *Olinia rochetiana*, *Rhus retinorrhoea* and *Dovyalis abyssinica* are also found in the upper canopy. The shrub layer consists of *Myrsine africana*, *Osyris quadripartita*, *Brucea antidysentrica*, *Smilax aspera* and *Pentas schimperiana*. In the herb layer *Agrocharis melantha* and *Satureja biflora* are most common.

4. *Schefflera abyssinica*-*Olea europaea* ssp. *cuspidata*-*Discopodium penninervium* Community Type.

This community occurs at altitude between 2665 m to 2815 m mainly dominated by the trees *Schefflera abyssinica* and *Olea europaea* ssp. *cuspidata*. *Juniperus procera* and *Dombya torrida* are common species in the tree layer. The shrub layer is dominated by *Myrsine africana* and *Discopodium penninervium*. The herbs *Hypoestes triflora*, *Satureja paradoxa* and *Salvia nilotica* the grass *Oplismenus* sp. are important species of the community

5. *Olea europaea* ssp. *cuspidata*-*Ilex mitis* Community Type.

This community type is found at altitudinal range between 2790 m to 2835 m. The tree layer of this community type is predominantly dominated by *Olea europaea* ssp *cuspidata*, *Ilex mitis*, *Maesa lanceolata*, *Schefflera volkensii* and *Juniperus procera*. The dominant species of the shrub layer in this community type includes *Bersama abyssynica*, *Rhamnus staddo* and. Herbs such as *Agrocharis melantha*, *Plantago palmata* and *Alchemilla abyssinica* the climber *Mikaniopsis clematoides* are some of the important species in this community type.

6. *Discopodium penninervium*-*Mikanopsis clematoides*-*Erica arborea* Community Type.

This community type exists at altitude between 2750 m to 2830 m. *Erica arborea* is the dominant tree in the tree layer. Additionally, *Olea europaea* ssp. *cuspidata* and *Maesa lanceolata* are also found to be the component part of the tree layer in this community type. The shrub layer is mainly dominated by *Dsicopodium penninervium*, *Dovyalis abyssinica* and *Buddleja polystachya*. *Satureja paradoxa*, *Satureja biflora* and *Pilea rivularis* cover the herb layer. Climbers including *Mikaniopsis clematoides*, *Aspragus africanus* and *Clematis simensis*, are important species in this community type.

Table 3. Species list showing mean values of species, Communities and Communities' Dominant species.

Species	Communities					
	1	2	3	4	5	6
<i>Acalypha psilostachya</i>	0	0	0.5	0.14	0.57	0
<i>Silene macrosolen</i>	0	0	0	0	0.14	0
<i>Mikaniopsis clematoides</i>	1.96	0	1.5	1.86	2.29	3.05
<i>Plantago palmata</i>	0.52	1.75	0.5	1	1.43	1
<i>Cerastium octandrum</i>	0.13	0.13	0	0.07	0	0
<i>Chiliocephalem tegetum</i>	0	0	0	0.07	0	0

<i>Lobelia holstii</i>	0	0.25	0.5	0.07	0	0
<i>Helychrysum sp</i>	0.35	0	0	0.29	0	0
<i>Commelina benghalensis</i>	0.13	0.5	0.25	0.36	0	0
<i>Erica arborea</i>	0.35	0.75	0	0	0	3
<i>Conyza pyrrophappa</i>	0.22	0.5	1	0	0.29	0.5
<i>Euphorbia obovalifolia</i>	0	0	0	0.64	0	0
<i>Cynoglossum amplifolium</i>	0.61	0.75	0	0.86	0.86	0
<i>Rubus steudnerii</i>	0.3	0.38	0	0.21	0	0
<i>Achyranthes aspera</i>	0.48	0.5	0	0.43	0.29	0.5
<i>Lithospermum afromontanum</i>	0.17	0.75	0.5	0	0.29	0
<i>Crotolaria sp.</i>	0.09	0	0	0.14	0.29	0.5
<i>Conyza steudellii</i>	0.3	0	0	0.14	0.57	0
<i>Ilex mitis</i>	1.96	0	0	0.86	3.71	0.5
<i>Olea europaea ssp. cuspidata</i>	4.26	0	0.5	3.25	5.14	2.25
<i>Jasminum stans</i>	0.35	0	0	0.29	2.29	0.5
<i>Rhus ruspolii</i>	0.48	0	0	0.14	2	0.5
<i>Agrocharis melantha</i>	0.48	0.5	1	1.29	1.71	1
<i>Sebaea brachyphylla</i>	0.17	0	0	0.86	1.43	1
<i>Conyza sp.</i>	0	0	0.5	0	0.57	0
<i>Cynoglossum coeruleum</i>	0.96	0.5	0	0	0.29	0
<i>Monopsis stellarioides</i>	0.48	1.25	0.5	0	0	0
<i>Schefflera volkensii</i>	0.61	4	0	0	2.99	0.5
<i>Haplocarpha schimperi</i>	0.26	0.63	0	0	0.29	0
<i>Oplismenus sp.</i>	0.91	0.5	0	1.36	1	0.5
<i>Podocarpus falcatus</i>	2.17	0	6.14	0	0	0
<i>Nuxia congesta</i>	0.83	0.5	1.25	0.64	0.29	0.5
<i>Rhamnus staddo</i>	0.26	0.75	0	0	0	1.5
<i>Hypericum peplidifolium</i>	0.44	0.75	0.5	0.29	1.29	0
<i>Nepeta azurea</i>	0.09	0.25	0	0	0.86	0.5
<i>Ranunculus multifidus</i>	0	0	0	0.14	0.43	0
<i>Dovyalis abyssinica</i>	0.09	0	1	0.14	0.57	1.75
<i>Scabiosa columbaria</i>	0.17	0	0	0.36	0.29	0
<i>Helichrysum odoratissium</i>	0.09	0.5	0	0.14	0	0.5
<i>Cirsium dender</i>	0.61	0	0.5	0.29	0.29	0.5
<i>Anagallis arvensis</i>	0	1	0	0	0.29	0
<i>Primula verticillata</i>	0.17	0.25	0	0	0.43	0
<i>Australina flaccida</i>	0.35	0	0	0	0.57	0
<i>Dichrocephala chrysanthemifolia</i>	0.35	0.5	0	0.29	0.29	1
<i>Pluchea discoridis</i>	0.17	0.5	0	0	0	0
<i>Juniperus procera</i>	2.26	2	3	1.71	2.29	0
<i>Kalanchoe petitiiana</i>	1.5	1.38	1.5	1.07	1.07	1
<i>Anthospermum herbaceum</i>	0	0.25	0	0.14	0.29	0
<i>Solanum benderianum</i>	0	0	0	0.43	0	0
<i>Solanum indicum</i>	0	0.25	0	0.29	0	0.5

<i>Trifolium burchellianum</i>	0.09	0.25	0	0.14	0	0
<i>Clematis simensis</i>	0.39	0.25	0	0.64	0.29	0.75
<i>Pilea rivularis</i>	0.09	0	0	1.07	0.86	1.5
<i>Galinsoga quadriradiata</i>	0.09	0	0	1.29	0.29	0.5
<i>Myrica salicifolia</i>	0.17	0	0	1.93	2.43	1.25
<i>Trifolium semipilosum</i>	0.09	0	0	1.64	0.71	1
<i>Echinops macrochaetus</i>	0.44	0.25	0.5	0.43	0	0
<i>Hypericum quartinianum</i>	0	0	0	1	0	0
<i>Kalanchoe densiflora</i>	0.78	0.75	0.5	1.86	0.5	0
<i>Brucea antidysentrica</i>	0.83	0.5	2.25	0.86	0.71	0.75
<i>Dombya torrida</i>	0.74	1.75	0.5	1.71	0.43	0
<i>Solanecio manni</i>	0	0	0	0.14	0	0
<i>Crassocephalum macropappum</i>	0.17	0	0	0.43	0.29	0.5
<i>Helichrysum sp.</i>	0.26	1	0	0.14	0	0.5
<i>Dichrocephala integrifolia</i>	0.65	0.25	0.5	0.86	0	1.5
<i>Commelina africana</i>	0.3	0.25	0	0.14	0.29	1.25
<i>Gomphocarpus fruticosus</i>	0	0	0.5	0.14	0	1
<i>Phytolacca dodecandra</i>	0.17	0.38	0	0.93	0	1.25
<i>Veronica abyssinica</i>	0	0	0	0.43	0	1
<i>Discopodium penninervium</i>	0.83	0.88	1.25	3	1.86	3.25
<i>Schefflera abyssinica</i>	0.3	0	0	4	1.71	0
<i>Rumex nervosus</i>	0	0.38	0	1.29	0	1
<i>Stellaria sennii</i>	0.17	0.25	0.75	0.25	0.86	1
<i>Satureja biflora</i>	0.17	0.38	0.75	1.71	0.86	1.5
<i>Salvia nilotica</i>	0.26	1	0.5	1.29	1.14	1
<i>Pavetta sp.</i>	0	0	0	0.29	0.29	1
<i>Vernonia reuppellii</i>	0.09	0.25	0.5	1.64	0.43	1.5
<i>Viola abyssinica</i>	0	0.25	0	0.43	0	0.5
<i>Galium thunbergianum</i>	0.17	0.75	0	0.14	0	0
<i>Jasminum abyssinicum</i>	0.96	1.88	2	0	0.29	0
<i>Acemella caulirhiza</i>	0.26	0.25	0	0.43	0.29	0.5
<i>Helichrysum foetidum</i>	0	0	0.25	0.07	0	0
<i>Conyza vernonioides</i>	0.48	0.25	0.5	0.57	0	0.5
<i>Hyparrhenia sp.</i>	0.57	1.25	1.75	0.57	0	0
<i>Osyris quadripartita</i>	0.91	0.25	2.5	0.14	0	0
<i>Myrsine africana</i>	1.22	0	5.75	2.14	1.71	0.5
<i>Rosa abyssinica</i>	0.57	0	2.25	0.64	0	1.5
<i>Pentas schimperiana</i>	0.44	0.5	1.5	0.86	1.43	1.5
<i>Ajuga integrifolia</i>	0.17	0	0.5	0.14	0	0
<i>Phagnalon abyssinicum</i>	0.13	0	0.25	0	0	0
<i>Vigna oblongifolia</i>	0	0.25	0	0	0.29	0.5
<i>Aspragus africanus</i>	0.61	0.5	0.5	0.79	0	1.5
<i>Colutea abyssinica</i>	0.87	0.5	1.5	1	0.29	0.5
<i>Crassula alsinoides</i>	0.09	0	0	0.29	0.57	0

<i>Hypoestes triflora</i>	0.35	1	0.5	2.21	0.29	0.25
<i>Laggera crispate</i>	0	0.25	0	0.29	0	0
<i>Laggera tomentosa</i>	0.09	0.25	0	0.29	0.29	0
<i>Lysimachia ruhmeriana</i>	0.26	0.5	0	0.93	0	0
<i>Hypericum revolutum</i>	0.48	1.38	0.5	0.43	0.29	0.5
<i>Alchemilla abyssinica</i>	0.83	1.63	0	0.5	0.86	1
<i>Geranium arabicum</i>	0.26	0.75	0.5	0	0	0
<i>Canthium oligocarpum</i>	0.78	1	1.5	0	0	0
<i>Clematis hirsute</i>	0.09	0.25	0	0	0	0
<i>Embelia schimperi</i>	0.09	0.75	0	0	0	0
<i>Halleria lucida</i>	0.28	0	0	0	0	0
<i>Olinia rochetiana</i>	5.09	0.75	1.75	1	0.29	1.5
<i>Stachys aculeolata</i>	0.96	0.25	0.5	0	0	0
<i>Peperomia fernandopoiana</i>	0.52	0.5	0	0.14	0	0.5
<i>Senecio ragazzii</i>	0.96	0.25	0	0	0	0
<i>Swertia kilimandscharica</i>	0.7	0.25	0.5	0.29	0.29	0
<i>Urera hypselodendron</i>	0.39	0.38	0	0	0	0
<i>Verbascum sinaticum</i>	0.28	0	0	0.29	0.57	0
<i>Apodytes dimidiata</i>	0.17	0.25	0	0.14	0	0
<i>Ekebergia capensis</i>	0.52	0.88	0	0.14	0	0
<i>Impatiens tinctoria</i>	0.26	0	0	0.29	0.57	0.75
<i>Rhus retinorrhoea</i>	1.65	3.15	1.5	0	1.86	0.75
<i>Campanula edulis</i>	0.44	1	0.5	0	0	0
<i>Maytenus addat</i>	0.7	0	0	0	0	0
<i>Kniphofia foliosa</i>	0.78	0.25	0	0.21	0.57	0
<i>Plectranthus assurgens</i>	1.04	1.75	0.5	0	0	0.5
<i>Satureja simensis</i>	0.96	1.75	0	0	0	0
<i>Stephania abyssinica</i>	0.91	1	0	0	0	0
<i>Selaginella abyssinica</i>	0	1.5	0.5	0.29	0	0.5
<i>Bersama abyssinica</i>	1.22	0.63	1	0.86	2.71	0.5
<i>Maesa lanceolata</i>	3.56	1.13	1	0.57	2.71	1.25
<i>Sanicula elata</i>	0.96	1.25	1	0.29	0.71	0
<i>Galinieria saxifraga</i>	0.52	0.88	0.5	0.29	0	2
<i>Solanum nigrum</i>	0.26	0	0	0	0	0
<i>Galium simensis</i>	0.96	0.5	0.5	0.57	0.29	0.5
<i>Myrsine melanophloeos</i>	0.78	0.25	0.5	0.71	1	0
<i>Smilax aspera</i>	1.04	0	1.5	0.36	0	0
<i>Crepis carbonaria</i>	0.52	0.75	0	0.14	0.29	0.5
<i>Hagenia abyssinica</i>	1.74	0.25	0	0.29	0	0.5
<i>Minulopsis solmisii</i>	1	0.5	0	0.14	0.29	0
<i>Peucedanum mattirolii</i>	0.17	0	0.25	0	0	0
<i>Bidens prestinaria</i>	0	0	0	0.29	0	0
<i>Oldenlandia monantus`</i>	0	0.25	0	0.29	0	0
<i>Conyza hypoleuca</i>	0.65	1.75	0	0.29	0	0.5

<i>Launea rueppellii</i>	0.09	0	0	0.14	0	1
<i>Prunus africana</i>	0.17	1.38	0	0.43	0	0.5
<i>Swertia abyssinica</i>	0.26	0.5	0	0.14	0	0.5
<i>Pittosporum viridiflorum</i>	0.78	0.5	0.5	1.07	0	0
<i>Sparmannia ricinocarpa</i>	0.17	0	0	0.14	0	0.5
<i>Buddleja polystachya</i>	0.96	0.75	1.25	0.36	1.29	1.75
<i>Habenaria petitiiana</i>	0	0	0	0.14	0.29	0.5
<i>Gerbera piloselloides</i>	0.09	0.38	0.25	0	0	0
<i>Scolopia theifolia</i>	0.87	0.88	0	0	0	0
<i>Lobelia giberoa</i>	0.43	0	0	0	0	0
<i>Conyza tigreensis</i>	0.61	0.5	0	0	0	1
<i>Rhamnus prinoides</i>	0.17	0.38	0	0	0.29	0
<i>Sonchus bipontini</i>	0	0.25	0	0	0	0
<i>Thymus schimperii</i>	0	0.38	0	0.14	0	0
<i>Rumex nepalensis</i>	0	0.25	0	0	0	0
<i>Zehneria scabra</i>	0	0.25	0	0	0	0
<i>Satureja paradoxa</i>	0.91	0.91	0	1.29	0.57	1.5
<i>Oxalis corniculata</i>	0.26	0	0	0.29	0	0
<i>Lotus corniculatus</i>	0.09	0	0	0.07	0	0
<i>Solanum vilosum</i>	0.09	0.5	0	0	0	0

5.1.2. Endemic Species

Based on the information available on the published Floras of Ethiopia among the species collected from the study area, the following species (Table 4) have been recorded to be endemic to Ethiopia. The presence of these endemic species in the forest shows the importance of the in the conservation process.

Table 4. Endemic species collected from Biteyu Forest and their habit.

Species	Habit
<i>Cerastium octandrum</i>	Herb
<i>Chiliocephalem tegetum</i>	Herb
<i>Cirsium denderi</i>	Herb
<i>Crassocephalum macropappum</i>	Herb
<i>Cynoglossum coeruleum</i>	Herb
<i>Kalanchoe petitiana</i>	Succulent
<i>Laggera tomentosa</i>	Shrub
<i>Launea reupellii</i>	Herb
<i>Lotus corniculatus</i>	Herb
<i>Mikaniopsis clematoides</i>	Climber
<i>Maytenus addat</i>	Tree
<i>Peperomia fernandopoiana</i>	Herb
<i>Phagnalon abyssinicum</i>	Herb
<i>Satureja paradoxa</i>	Herb
<i>Thymus schimperi</i>	Herb
<i>Vernonia reupellii</i>	Shrub

5.3. Species Diversity

Among the six communities, the Shannon-Wiener diversity index result shows (Table 4), community 1 is the richest in number of species, whereas, community 3 has the lowest number of species.

Table 5. Shannon-Wiener Diversity index.

Communities	Richness	D. Index/H/	Evenness
1	146	4.547	0.912
4	132	4.427	0.907
2	120	4.507	0.914
5	98	4.049	0.898
6	83	4.156	0.914
3	72	4.017	0.939

The Shannon-Wiener diversity index shows, community 1 has the highest species diversity (4.547) followed by communities 2, 4, 6, 5. The greater diversity in any community can be attributed to the amount of disturbance in the quadrats. Like wise, community 1 has the highest number of species (146). Next to community 1, community 4 has been found to have the higher richness value followed by communities 2, 5, 6 and 3.

Species evenness shows the relative proportional abundance of a species in quadrats. Low evenness value implies the dominance of the environment by few species. Based on this, community 3 followed by communities 2 and 6 has the highest evenness value. Community 5 has the least evenness value.

5.4. Community-Environment Relationships

Soil chemical and physical properties are important factors in determining plant growth. Together with other factors, the results obtained from soil properties applying one-way analysis of Variance (ANOVA) shows the difference in the plant communities could be partially attributed to soils texture, soil electrical conductivity at level of significance (Appendix 3).

The mean value result for aspect (Table 5) reveals that it has no significance in determining the distribution of the communities at. Similarly, there is no significant difference in soil pH and silt except the slight variations obtained among the communities.

Table 6. Mean values of some environmental factors (soil texture, pH, EC, slope and aspect)

Environmental Factors	Community 1	Community 2	Community 3	Community 4	Community 5	Community 6
Aspect	2.19	1.25	1.65	2.41	2.45	1
Slope ($^{\circ}$)	29.13	21.86	40	38.4	35	36
pH	6.05	5.99	5.78	5.86	5.62	5.75
ECmmho/cm	277.5	237	140.5	228	206.75	235
% Sand	64.5	70.9	74.5	72.7	743	70.4
%Clay	21.5	11.25	8.75	11.15	10	11.74
%Silt	17.52	18	17	16.15	16.61	17.52
Texture	Sandy clay loam	Loamy sand	Loamy sand	Loamy sand	Loamy sand	Loamy sand

The pH values in the communities were between (5.62-6.05). On the other hand, slope has shown a significant difference in the distribution of the communities. Higher electrical conductivity value (277.5 mmhos/cm) in community 1 and lower (140.55 mmho/cm) in community 3 has been observed. Thus, there is a significant difference among communities at $P < 0.05$ level of significance (Appendix 3).

The proportion of sand in community 1 is lower (64.5%) and highest (74.5%) in community 3. Where as, the proportion of silt is higher (18%) in community 2. The silt particle has shown no significant variation at $P < 0.05$ level of significance. In terms of textural class only community 1 is found to be Sandy clay loam and the other communities belong to Loamy Sand (Table 5).

5.5. Density, Frequency and Distribution of Some Woody Species in Different DBH and Height-Classes

5.5.1. Density and Frequency

The total number of the woody species per hectare (density) is 930. The density of some of the representative species is given in Table 6. Among the woody species *Maesa lanceolata* has the largest number (85/ha). *Olinia rochetiana*, *Olea europaea* ssp. *cuspidata* and *Podocarpus falcatus* have density 81, 79 and 73 per hectare respectively. The species *Myrsine melanophloeos* and *Juniperus procera* observed to have a density of 58 and 52 respectively. The species *Hagenia abyssinica* was found in some stands at higher altitudes. The total count showed *H. abyssinica* to be 13/ha. In some of the upper part of the stands *Erica arborea* and

Discopodium penninervium were observed in a higher density. However, almost all *E. arborea* and *D. penninervium* were found in the smallest DBH-class (2-10 cm) and height-class (2-6 m). The reason for the occurrence of *E. arborea* having the same stage of development can be attributed to previous burning of the vegetation in the site. Tamrat Bekele (1993) also made the same observation. Besides, the density of woody species is observed declining as the altitude increases.

The species recorded in all communities include *Maesa lanceolata*, *Olinia rochetiana*, *Bersama abyssinica*, *Brucea antidysentrica* and *Discopodium penninervium*. The species *Juniperus procera* and *Myrsine melanophloeos* exist in all communities except community six.

Table 7. Density (number/hectare) of Some Woody Species.

Species	Density
<i>Ilex mitis</i>	34
<i>Maesa lanceolata</i>	85
<i>Juniperus procera</i>	52
<i>Dombeya torrida</i>	11
<i>Podocarpus falcatus</i>	73
<i>Myrsine africana</i>	52
<i>Olea europaea ssp. cuspidata</i>	79
<i>Olinia rochetiana</i>	81
<i>Pittosporum viridiflorum</i>	17
<i>Myrsine melanophloeos</i>	58
<i>Apodytes dimidiata</i>	16
<i>Dovyalis abyssinica</i>	11
<i>Brucea antidysentrica</i>	11
<i>Hagenia abyssinica</i>	13
<i>Schefflera volkensii</i>	73
<i>Ekebergia capensis</i>	6
<i>Galinieria saxifraga</i>	3
<i>Halleria lucida</i>	2
<i>Hypericum revolutum</i>	15
<i>Nuxia congesta</i>	3
<i>Osyris quadripartita</i>	25
<i>Discopodium penninervium</i>	34
<i>Erica arborea</i>	37
<i>Euphorbia obovalifolia</i>	8
<i>Rhus ruspolii</i>	9
<i>Myrica salicifolia</i>	5
<i>Schefflera abyssinica</i>	67
<i>Maytenus addat</i>	8
<i>Rhus retinorrhoea</i>	61
<i>Scolopia theifolia</i>	3

5.5.2. DBH-Class Distribution

Among the woody species recorded in the study area, the distribution of 15 representative woody species in different diameter class is shown in Table 7. Most of the woody species in the forest are confined in the low diameter class distribution.

Table 8. Percentage distribution of Woody Species of Biteyu Forest in DBH-class (cm).

DBH-class	2-10	10-20	20- 50	50- 80	80-110	>110
<i>Ilex mitis</i>	10.2	3.7	37.5	33.3	0	15.4
<i>Maesa lanceolata</i>	17.4	37.3	43.3	1.5	0	0
<i>Juniperus procera</i>	17.2	48.3	20.7	10.3	3.5	0
<i>Dombeya torrida</i>	42.2	10.5	29.8	18.2	0	0
<i>Podocarpus falcatus</i>	16.7	66.7	16.7	0	0	0
<i>Myrsine africana</i>	47.6	23.8	19.1	4.8	4.8	0
<i>Olea europaea ssp.cuspidata</i>	30.8	15.4	38.5	0	15.4	0
<i>Olinia rochetiana</i>	35.3	22.6	37.3	4.8	0	0
<i>Pittosporum viridiflorum</i>	36.4	9.1	36.4	18.2	0	0
<i>Myrsine melanophloeos</i>	26.3	57.9	10.5	5.3	0	0
<i>Apodytes dimidiata</i>	54.6	0	36.4	9.1	0	0
<i>Hagenia abyssinica</i>	0	0	0	10.3	48.3	41.4
<i>Dovyalis abyssinica</i>	38.5	30.8	30.8	0	0	0
<i>Schefflera volkensii</i>	24.1	10.3	24.1	41.1	0	0
<i>Brucea antidysentrica</i>	36.4	36.4	27.3	0	0	0
% Distribution of DBH-classes	32	21	27.2	10	6.5	3.7

The highest proportion (30%) of the tree species recorded was in lower DBH-class (2-10 cm) and 24.2% of the individuals are between (10-20 cm). The medium DBH-Class (20-50 cm) covers a proportion greater than 27% of the trees (Figure 4). The DBH-class 50-80 cm comprises 10.5%. Only 4.4% of the tree specie is in the diameter class (80-110 cm) largely due to the old *H. abyssinica* tree. Only 3.8% of the tree species have a diameter greater than 110 cm. This is also because of the few old *H. abyssinica* trees found in some of the quadrats.

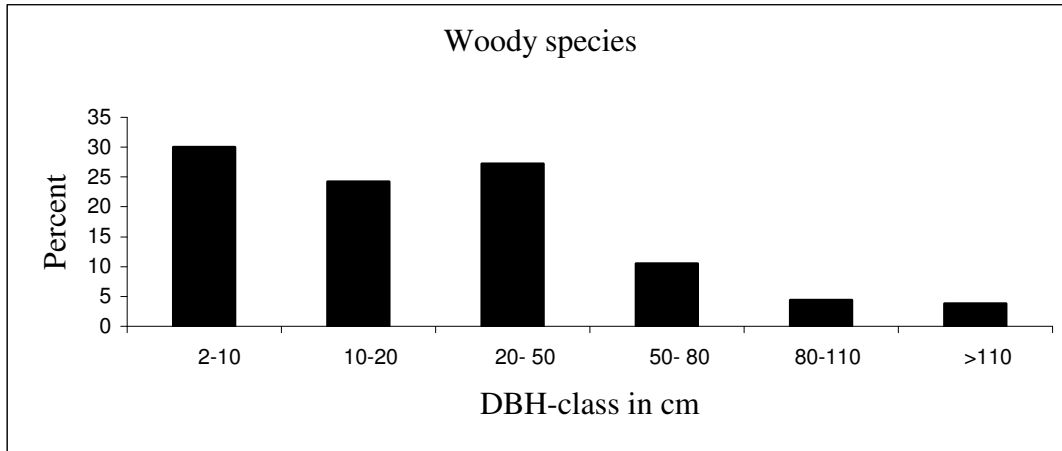


Figure 4. Percentage distribution of woody species in Biteyu Forest DBH-class (cm).

The DBH-class distribution of four-selected tree species (*J. procera*, *P. falcatus*, *O. europaea* ssp. *cuspidata* and *H. abyssinica*) are described below to see the likely future of these trees.

1. The DBH measurements show 17.2% of the tree *Juniperus procera* (Figure 5) is found in the lowest DBH-class (2-10 cm) and the largest proportion (48.3)% of this tree is found to be between 10-20 cm diameter class. The *J. procera* trees having a diameter between 20-50 cm constitute 20.7%. Individuals having a DBH between 50-80 cm are only 10.3%. Few trees of *J. procera* (3.5%) were found to be in the DBH-class between 80-110 cm. There was no *J. procera* tree in the study area having a DBH greater than 110 cm.

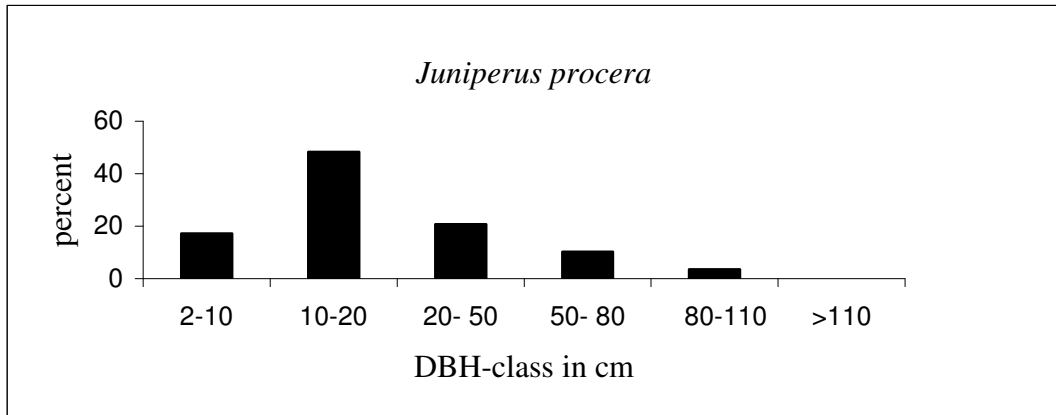


Figure 5. Percentage distribution *Juniperus procera* in Biteyu Forest in DBH-class (cm).

2. The distribution of *Podocarpus falcatus* in different DBH-class (Figure 6) indicates that the proportion (16.7%) of this species is between 2-10 cm. Most of the trees (66.7%) are in the DBH-class 10-20 cm. The remaining proportion (16.7%) of the *P. falcatus* trees in the study area has been observed to have a DBH between 20-50 cm. No *P. falcatus* trees having DBH greater 50 cm had been recorded. This could be due to selective removal.

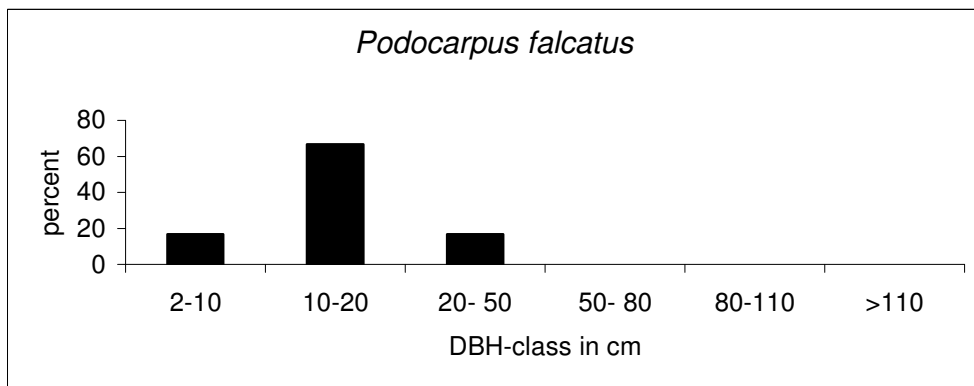


Figure 6. Percentage distribution of *Podocarpus falcatus* in Biteyu Forest in DBH-class (cm).

3. The DBH distribution of *Olea europaea* ssp. *cuspidata* (Figure 7) also indicate considerable proportion (30.8%) is between 2-10 cm. The largest proportion (38.5%) of *O. europaea* ssp. *cuspidata* is recorded in the lower DBH-class (20-50 cm). The individuals belonging to the DBH-class 10-20 cm were 15.4%. The same proportion 15.4% of the *O. europaea* ssp. *cuspidata* was in the DBH-class between 50-80 cm.

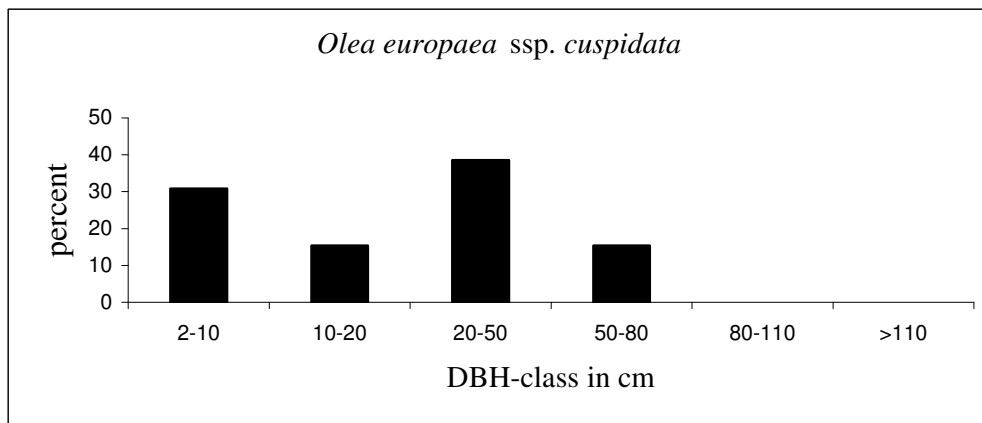


Figure 7. Percentage distribution of *Olea europaea* ssp. *cuspidata* in Biteyu Forest in DBH-class (cm).

4. In the study area no *Hagenia abyssinica* tree having a DBH less than 50 cm has been recorded. Smallest proportion (10.3%) of this species found in the DBH-class between 50-80 cm. It was found that 48.3% of *H. abyssinica* to be in the DBH-class between 80-110 cm. Old *H. abyssinica* trees having a DBH greater than 110 cm comprise the remaining 41.4%. The DBH-class distribution of *H. abyssinica* is given on Figure 8. DBH measurement of this species reveals all the trees in the study area are well above 50 cm. Among the few trees recorded only two individuals have a diameter less than 80 cm. More than 90% of this species are in the highest DBH-class (> 80 cm).

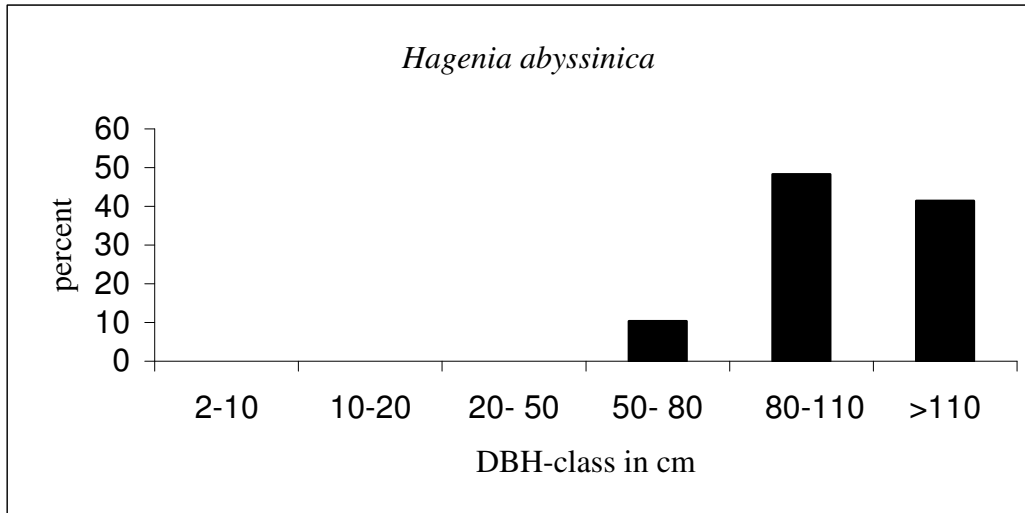


Figure 8. Percentage distribution of *Hagenia abyssinica* in Biteyu Forest in DBH-class (cm).

5.5.3. Height-class distribution

The percentage height class distribution of some of the representative species is presented in Table 8. The height class distribution follows similar trend with that of the DBH-class distribution. Most of the woody species in the study area are belong to the smallest height class group. The percentage of the woody species attaining a height up to 2-6 m comprises the greatest proportion (>19%). Woody species having heights between 6-9 m are 16% (Figure 9). (>16%) was found to be in the height-class 9-12 m. The height-class 12-15 m was found to comprise 11.4% of the tree species.

Table 9. Percentage distribution of Woody Species of Biteyu Forest in Height-class (m).

Height- class	2-6	6-9	9-12	12-15	15-18	18-21	21-24	24-27	>27
<i>Ilex mitis</i>	12.8	30.4	6.3	14.9	2.1	8.5	4.3	17	4.3
<i>Maesa lanceolata</i>	10.9	3.6	32.1	5.4	23.2	5.4	17.9	1.8	0
<i>Schefflera volkensii</i>	8.5	16.7	30	3.3	23.3	3.3	0	6.7	10
<i>Brucea antidysentrica</i>	10	30	10	29	0	0	10	0	10
<i>Dovyalis abyssinica</i>	28.6	14.3	11.5	10	21.5	7.1	0	0	7.1
<i>Juniperus procera</i>	35	12	12	8	8	6.9	6.9	5.1	5.1
<i>Apodytes dimidiata</i>	54.6	0	9.1	0	9.1	9.1	9.1	0	9.1
<i>Dombeya torrida</i>	5.3	21.1	26.3	10.5	21.1	5.3	5.3	0	5.3
<i>Podocarpus falcatus</i>	34.4	21.9	3.1	25	3.1	3.1	0	3.1	6.3
<i>Hagenia abyssinica</i>	0	0	0	0	5.8	88.4	5.8	0	0
<i>Myrsine africana</i>	28.6	19	9.5	14.3	4.8	0	14.3	10.3	0
<i>Olea europaea ssp.cuspidata</i>	3.1	18.8	25	18.8	12.5	9.4	3.1	3.1	6.3
<i>Olinia rochetiana</i>	3.6	16.7	27.4	13.1	14.3	4.8	8.3	4.8	3.6
<i>Pittosporum viridiflorum</i>	18.2	18.1	18.2	0	18.2	9.1	0	9.1	9.1
<i>Myrsine melanophloeos</i>	27.8	22.2	5.6	22.2	0	0	0	22.2	0
% Distribution of Height-classes	20.5	16.3	15	11.7	11	10.8	5.5	5.5	5

The tree species having a height between 15-18 m were 11%. Greater than 10% of trees has been observed to be in the height-class 18-21 m. Larger trees constitute the smallest proportions. Thus, each of the height-classes 21-24 m and 24-27 m comprise 5.5%. Only 5% of the trees attain a height greater than 27 m (Table 8).

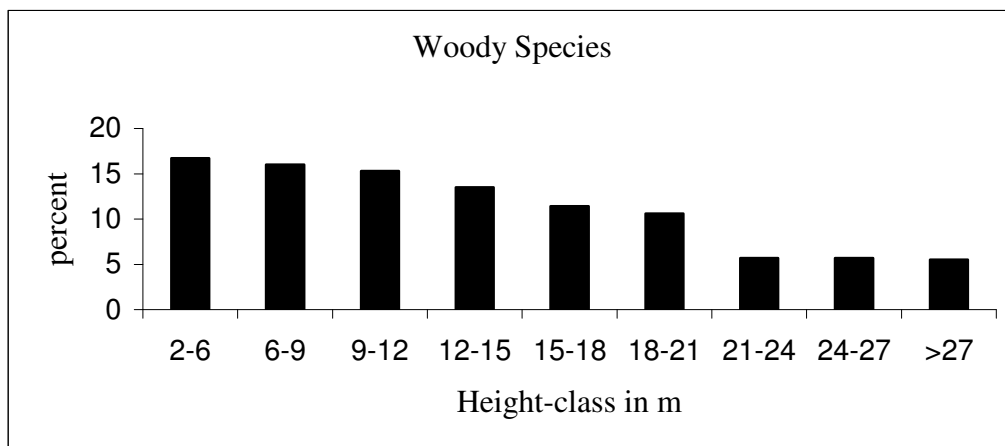


Figure 9. Percentage distributions of woody species in Biteyu Forest in height-class (m).

The distribution of four important timber trees (*Hagenia abyssinica*, *Podocarpus falcatus*, *Olea europaea* ssp. *cuspidata* and *Juniperus procera*) was observed and briefly discussed below to see the state of the forest.

1. The height-class distribution of *Hagenia abyssinica* is shown on (Figure 10). All the trees in the study area attain height greater than 15 m. *Hagenia abyssinica* having a smaller height are not common. The largest proportion (88.4%) of *Hagenia abyssinica* is found in the height-class 18-21 m. Lower and medium height-class of this species is not found in any of the quadrats. This might be due to selective cutting and/or isolation of the male and the female individuals, which can prevent pollination.

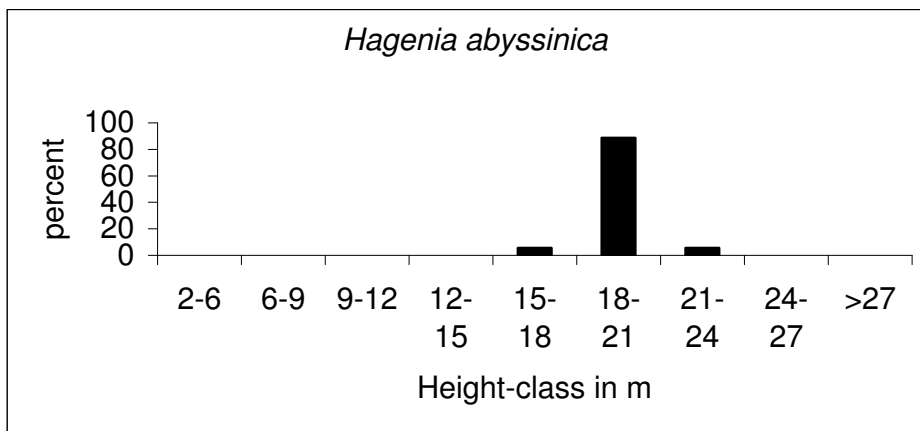


Figure 10. Percentage distribution of *Hagenia abyssinica* in Biteyu Forest in height-class (m).

2. Substantial proportion (34.4%) of *Podocarpus falcatus* is found in the lowest height-class (2-6 m) distribution. About 22% of the species also occur in the lowest height-class (6-9 m). The proportion of the species in the height-class between 12-15 m is 25%. Selective cutting of these trees has lowered the proportion of the highest height-classes (Figure 11). Only 6% are above 27 m.

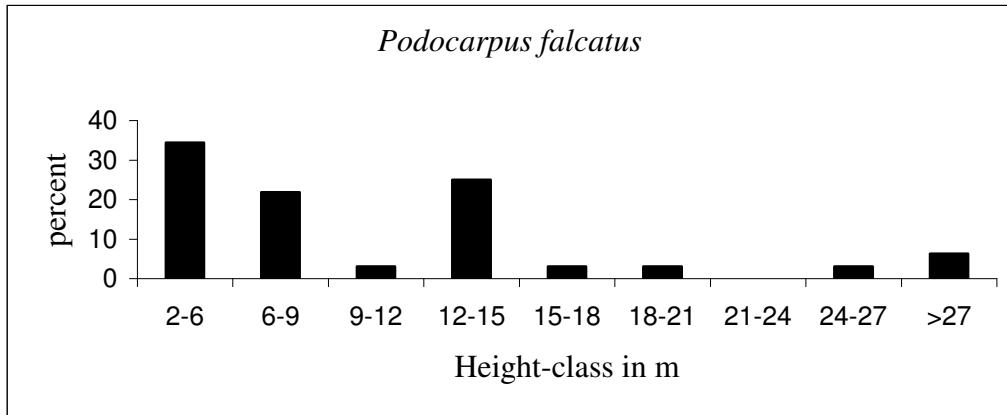


Figure 11. Percentage distributions of *Podocarpus falcatus* in Biteyu Forest in height-class (m).

3. The proportion of *Olea europaea* ssp. *cuspidata* that belongs to the lowest height-class distribution (2-6 m) is about 3%. Further more, 19% of the trees are also in the lower (6-9 m) height-class. The same proportion is found to be in the height-class 12-15 m. Like most other tree species the proportion of this tree decline (Figure12) as the height-class increases. However, 6.3% of the trees are in the height-class >27 m.

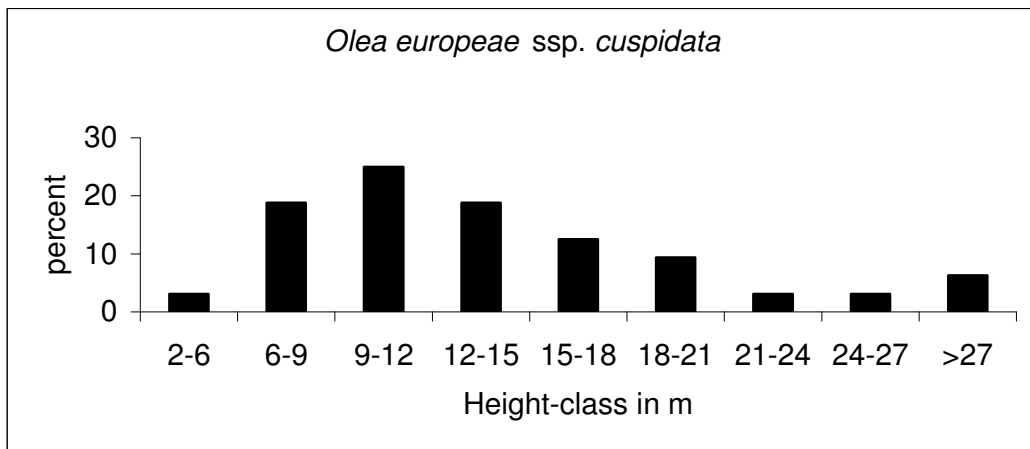


Figure 12. Percentage distribution of *Olea europaea* ssp. *cuspidata* in Biteyu Forest in height-class (m).

4. The highest proportion (>20%) of the species *Juniperus procera* was recorded in the lowest (2-6 m) height-class group. 16.3% also occurs in the lower height-class (6-9 m). Similar trend with most other trees has been observed in the height-class distribution.

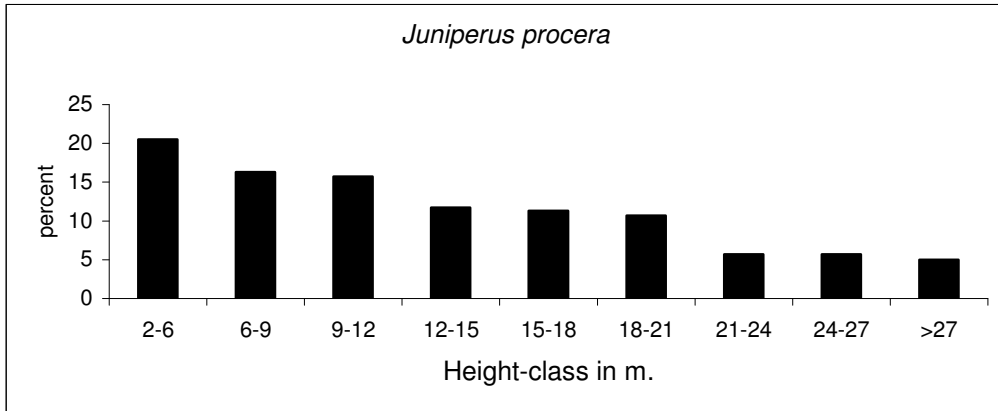


Figure 13. Percentage distribution of *Juniperus procera* in Biteyu Forest in height-class (m).

5.5.4. DBH and Height-Class Comparison with Other Forests of Ethiopia

In Biteyu forest most of the individuals (53%) are less than 20 cm in diameter. Similarly, most of the woody individuals (56.9%) in Menagesha forest and (49%) in Jibat forest have DBH less than 20 cm. Only 3.7% of the individuals in Biteyu forest are in the DBH-class >110 cm. Nearly equal proportion of the individuals in Menagesha forest (1.1%) and Jibat forests (<2%) of the trees have diameter greater than 110 cm (Table 10). On the other hand, in Wof-washa forest 9.5% of the individuals have diameter > 110 cm.

Table 10. Comparison of forests based on DBH-class distribution Menagesha, Jibat and Wof-Washa Forests (Tamrat Bekele, 1993).

DBH-class (cm)	Biteyu	Menagesha	Jibat	Wof-washa
<20	53	56.9	48.9	32.6
20- 50	27.2	32.8	39.5	31.7
50- 80	10.5	6.5	9.8	14.6
80-110	6.5	2.5	1.4	11.7
>110	3.7	1.1	<2	9.5

Similarly, woody species belonging to the lowest height-class (<9 m) were greater than 36% in Biteyu forest, 38.5% in Menagesha forest and 25.5% in Jibat forest. In these forests the greatest percentage of the woody species belongs to the lowest height-class (< 9 cm). On the other hand; only small proportions of the trees (5%) in Biteyu forest, (6.8%) in Jibat forest and (<3%) in Menagesha forest attain heights greater than 27 m. Where as, 13% of the trees in Wof-washa forest were found to have height >27 m (Table 11).

Table 11. Comparison of Biteyu Forest based on Height-class distribution with Menagesha, Jibat and Wof-Washa Forests (Tamrat Bekele, 1993).

Height-class (m)	Biteyu	Jibat	Menagesha	Wof-washa
<9	36.5	25.5	38.5	23.3
9-12	15	24	32	21.3
12-15	11.7	15.2	10.8	13.7
15-18	11	14	11	13.1
18-21	10.8	7.2	2.2	6.1
21-24	5.5	3.7	2.2	1.6
24-27	5.5	3.5	1	8
>27	5	6.8	<3	12.8

The existence of different DBH and height distribution in the forest can be due to the lack of organized communal ownership of the forest since the fall of the imperial government in 1974. After the fall of the imperial regime individuals started to involve in selective cutting of trees for timber as well as extensive exploitation of fuel woods.

The DBH and height-class distribution shows the stage of development of Biteyu forest could be nearly similar to those of Menagesha and Jibat forest. Further more, The DBH and height-class distribution revealed that the forest at present is in its different stages of secondary development. In addition, the invasion of *Euphorbia* thicket in community 4 could be evidence (Iversen, 1991 in Tamrat Bekele, 1993) to that the forest is in its secondary state of development.

5.6. Determination of Forest Type of the Study Area

Some authors such as Pichi- Sermolli (1957), White (1983), Friis (1992), Sebsebe Demissew *et al.* (1996), Zerihun Woldu (1999), Friis and Sebsebe Demissew (2001) have attempted to summarize the vegetations of Ethiopia.

According to Friis (1992) dry evergreen montane forests develop on altitudes between 1500-2700 m with annual rainfall between 700 and 1100 mm. In such type of forests the canopy is usually dominated by *Podocarpus falcatus*, *Juniperus procera*, *Croton macrostachys*, *Olea europaea* ssp. *cuspidata*, true lianas, epiphytes including *Peperomia*, ferns and orchids are common. The ground cover is rich in ferns, grasses, Sedges and small herbeouceous cotyledons. At the upper limits *Erica arborea*, *Hagenia abyssinica*, *Hypericum revolutum*, *Myrsine africana*, *Myrsine (Rapanea) melanophloeos*, *Rosa abyssinica*, and *Nuxia congesta* and clumps of *Arundenaria alpina* are also common (Friis, 1992). Sebsebe Demissew *et al.* (1996); Zerihun Woldu (1999) also included *Juniperus procera*, *Olea europaea* ssp. *cuspidata*, *Celts africana* *Euphorbia obovalifolia* and *Ekebergia capensis* as the common tree species in Dry evergreen montane forests. Based on the definition as well as the composition of the species indicated above Biteyu Forest appears to be Dry evergreen montane forest.

The species recorded from the present study site have similarity with other forests else where in the country. Menagesha-Suba Forest (Sebsebe Demissew, 1980; Tamrat Bekele, 1993), Jemjem Forest (Hailu Sharew, 1982) Jibat, Chilimo and Wof-Washa Forest (Tamrat Bekele, 1993), Harena Forest (Lisanework Nigatu, 1987) and Dodola Forest (kitessa Hundera 2003). Based on tree and shrub species list available (Appendix 4), the similarity analysis using Sørensen's similarity coefficient results are show in Table 11.

Table 12. Floristic similarity Between Biteyu Forest with other forests. Jibat, Chilimo Forest (Tamrat Bekele, 1993) Menagesha-Suba Forest (Sebsebe Demessew, 1980; Tamrat Bekele, 1993) Jemjem Forest (Hailu Sharew, 1982), Harena Forest (Lisanework Nigatu, 1987) and Dodila Forest (Kitessa Hundera, 2003).

Forest	Altitude (m)	Number of species used for comparison	Sørensen's Similarity Coefficient
Biteyu	2590 - 2890	47	1
Menagesha-Suba	2400-3000	48	0.67
Dodola	2400-3300	34	0.59
Jibat	2200- 2900	50	0.53
Chilimo	2400 - 2800	50	0.47
Jemjem	1570-1940	65	0.32
Harena	Ca.2200-3300	80	0.41

Among the forests in comparison, Biteyu forest has the highest similarity with Menagesha-Suba forest in floristic composition. The possible reason for this can be the geographical proximity of the two forests. Next to Menagesha-Suba forest, Dodola and Jibat forest were found to share more number of woody species with Biteyu forest than Chilimo, Jemjem and Harena forests.

6. CONCLUSIONS AND RECOMMENDATIONS

Six community types have been identified using the computer program SYNTAX. These are Community type 1. *Olinia rochetiana-Olea europaea* ssp. *cuspidata*-*Maesa lanceolata* community at altitude between 2590 m and 2840 m. Community type 2. *Schefflera volkensii-Rhus retinorrhoea* community at altitude between 2715 m and 2800 m. Community 3. *Podocarpus falcatus-Myrsine africana-Juniperus procera* community at altitude between 2610 m and 2710 m. Community type 4. *Schefflera abyssinica-Olea europaea* ssp. *cuspidata-Discopodium penninervium* community at altitude between 2665 m and 2815 m. Community type 5. *Olea europaea* ssp. *cuspidata-Ilex mitis* community at altitude between 2790 m and 2835 m. and Community type 6. *Discopodium penninervium-Mikanopsis clematoides-Erica arborea* community at altitude between 2750 m and 2890 m.

There is no clear boundary of species distribution in the forest. This can be attached to the high human interference because of the proximity of the forest to human habitations. However species diversity was found to decrease as altitude increases. Shanon-Wiener diversity index (Table 4) shows that there is high species diversity in community 1. The reason for this can be high state of disturbance in the quadrats.

The DBH and Height-Class distribution analyses have shown that there are similar trends in both diameter and height. The proportion of trees having higher diameter as well as height decreases as the distribution class increased (Tables 7& 8). Such trends have been observed in other forests in the country (Tables 9 & 10). From the DBH and Height-class distribution

analyses it is clear that the forest is in its secondary state of development. Sørensen similarity coefficient (Table 11) has also revealed that Biteyu Forest has similarity in floristic composition with Menagesha-Suba and Dodola Forest than Jibat, Chilimo, Harena and Jemjem Forests.

In the area where this study has been conducted cattle are putting heavy pressure on the vegetation. Bushes as well as trees are cut for fuel and timber frequently. These activities result in almost total destruction in vegetation of the forest (personal observation). Consequently, rivers, springs and streams that used to have water the whole year round are observed drying up soon after the rainy seasons (observation and personal communication). Since mountains are devoid of vegetation cover they cannot retain enough water. This in turn will reduce potable water supply and interrupt the irrigation farms, lower down following Meki River, which is supplied by the Wegeram River that develop from Godede, Kugnet and others streams around the forest.

The system implemented so far to manage the forest had had a strong consequence on the protection activities. People living around the forest were aware of the importance of the forest in keeping their environment in its natural state (personal communication with elderly persons). Before the fall of the Hailesilase regime the forest was a communal forest and it was administered by member of the community. The Shengo (local administrators elected by the community) was fully responsible in assigning individuals that patrol and control as well as to punish any individual found guilty of cutting trees or even collecting fallen trees without the prior permission of the Shengo. The punishment was so series that, the person found guilty

would totally be excluded from any kind of social life (edir, ekub and talak). In this case the permission to use naturally fallen trees was given to newly married couples or to individuals who lost their house due to fire, lightning etc. People were encouraged to plant trees like Eucalyptus for fuel and construction. The protection of the forest is still supposed to be in the hands of the Kebele leaders. However, the system has totally failed (personal observation).

Therefore, it would be very important to avoid human interference as was done in the past. If this is done the forest will recover and return to the original state. Additionally, as it was done before the fall of the Hailesilase regime it would be advisable to encourage people living around to plant trees, which can be used, for fuel as well as for construction purposes. Elderly persons know very well about the value of the forest in balancing nature (personal communication). Such elderly persons found to have a keen interest to involve in the process of acquainting the people living around the forest about the aesthetic as well as natural value of the forest. Therefore, it would be advisable to involve these elderly individuals in the process of managing as well as acquainting the young generation about the previous ways used in managing the forest so that the present and next generations also able to learn the importance of the forest and how to protect it.

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Appendix 1: Types of species recorded, face, number of quadrats and altitudinal range of the mountains.

Mountains	Altitude range (m)	Aspect	Number of quadrats	Number of species
Kechemochi	2590-2830	North	11	123
Kechemochi	2650-2840	South	10	104
Gerodeabi	2640-2890	North	10	107
Gerodeabi	2610-2835	South	10	97
Beiri	2590-3830	Southeast	10	103
Beiri	2650-2840	Northwest	9	92

Appendix 2. Species List of Biteyu Forest (with Family, Vernacular names and Habit).

No	Species	Family	Vernacular (Guragigna)	Habit
1	<i>Acalypha psilostachya</i> Hochst.	Euphorbiaceae		Low shrub
2	<i>Acmella caulirhiza</i> Del.	Asteraceae	Guticha	Per herb
3	<i>Achyranthes aspera</i> L.	Amaranthaceae	Sidibo	Per herb
4	<i>Adiantum thalictroides</i> Wild ex Ktze.	Adiantaceae		Fern
5	<i>Agrocharis melantha</i> Hochst.	Apiaceae		Per herb
6	<i>Ajuga integrifolia</i> Ham.-Buch.	Lamiaceae	Ematelit	Per herb
7	<i>Alchemilla abyssinica</i> Fresen.	Rosaceae	Yefur enzin	Ann herb
8	<i>Anagallis arvensis</i> L.	Primulaceae		Ann herb
9	<i>Anthospermum herbaceum</i> L. f.	Rubiaceae		Per herb
10	<i>Apodytes dimidiata</i> E. Mey. ex Arn.	Icacinaceae	Wondimu	Tree
11	<i>Asplenium abyssinicum</i> Fe'e	Aspleniaceae		Fern
12	<i>Asplenium aethiopicum</i> (Burm. f.) Becherer	Aspleniaceae		Epiphyte
13	<i>Asplenium protensum</i> Schard.	Aspleniaceae		Fern
14	<i>Asplenium monanthes</i> L.	Polypodiaceae		Fern
15	<i>Asparagus africanus</i> Lam.	Aspragaceae		Climber
16	<i>Australina flaccida</i> Wedd.	Urticaceae		Per herb
17	<i>Bersama abyssinica</i> Fresen.	Melanthaceae	Kureta/Sebatala	High shrub
18	<i>Bidens prestinaria</i> (Sch. Bip.) Cuofd.	Asteraceae	Adeye	Ann herb
19	<i>Brucea antidysenterica</i> J. F. Mill.	Simaroubaceae	Abay	High shrub
20	<i>Buddleja polystachya</i> Fresen.	Loganiaceae	Abre	High shrub
21	<i>Campanula edulis</i> Forssk.	Lobeliaceae		Per herb
22	<i>Canthium oligocarpum</i> Hiern.	Rubiaceae	Chirye	High shrub
23	<i>Carania eminii</i> Schweinf.	Campanulaceae		Epiphyte
24	<i>Cerastium octandrum</i> A. Rich.	Caryophyllaceae		Ann herb
25	<i>Chiliocephalem tegetum</i> Mesfin	Asteraceae		Per herb
26	<i>Cirsium dender</i> I. Friis	Asteraceae	Dendere	Per herb
27	<i>Clematis hirsuta</i> Perr. & Guill.	Ranunculaceae		Climber
28	<i>Clematis simensis</i> Fresen.	Ranunculaceae	Yedibir hareg	Climber
29	<i>Crotolaria sp.</i>	Fabaceae		Low shrub
30	<i>Clutia abyssinica</i> Jaub. & Spach.	Euphorbiaceae		Low shrub
31	<i>Colutea abyssinica</i> Kunth. & Bouche	Fabaceae	Yefiyel kole	Low shrub
32	<i>Commelina africana</i> L.	Commelinaceae		Per herb
33	<i>Commelina benghalensis</i> L.	Commelinaceae		Per herb
34	<i>Conyza hypoleuca</i> A. Rich.	Asteraceae	Nechache	High shrub
35	<i>Conyza pyrhopappa</i> Sch. Bip. ex A. Rich.	Asteraceae		Per herb
36	<i>Conyza sp.</i>	Asteraceae		Low shrub
37	<i>Conyza steudelii</i> Sch. Bip. ex A. Rich.	Asteraceae		Per herb
38	<i>Conyza tigrensensis</i> Oliv. & Hiern	Asteraceae		Per herb
39	<i>Conyza vernonioides</i> Sch. Bip. ex A. Rich.	Asteraceae		Low shrub
40	<i>Crassocephalum macropappum</i> (Sch. Bip. ex A. Rich.) S. Moore	Asteraceae		Per herb
41	<i>Crassula alsinoides</i> (Hook. f.) Engl.	Crassulaceae		Per herb
42	<i>Crepis carbonaria</i> Sch. Bip.	Asteraceae		Per herb
43	<i>Cynoglossum amplifolium</i> Hochst ex DC.	Boraginaceae		Per herb
44	<i>Cynoglossum coeruleum</i> A. DC.	Boraginaceae	Tibikit	Per herb

45	<i>Diaphanathe schimperiana</i> (A. Rich.) Summerh.	Orchidaceae		Epiphyte
46	<i>Dichrocephala chrysanthemifolia</i> DC.	Asteraceae		Per herb
47	<i>Dichrocephala integrifolia</i> (L. f.) O. Kuntze	Asteraceae		Per herb
48	<i>Discopodium penninervium</i> Hochst.	Solanaceae	Enchochika	High shrub
49	<i>Dombeya torrida</i> (J. F. Gmel.) P. Bamps	Stereuliaceae	Daya	Tree
50	<i>Dovyalis abyssinica</i> (A. Rich.) Warb.	Flacourtiaceae	Simaytero	Tree
51	<i>Drynaria volkensii</i> Hieron.	Polypodiaceae		Fern
52	<i>Dryopteris inaequalis</i> (Schlechtend.) Kuntze	Aspidiaceae		Fern
53	<i>Echinops macrochaetus</i> Fresen.	Asteraceae	Yemardendere	Per herb
54	<i>Ekebergia capensis</i> Sparrm.	Meliaceae	Wulel	Tree
55	<i>Embelia schimperii</i> Vatke	Myrsinaceae	Enkoko	High shrub
56	<i>Englerina woodfordioides</i> (Schweinf.) M.G. Gibert	Loranthaceae		Parasite on <i>V. rueppellii</i>
57	<i>Erica arborea</i> L.	Ericaceae		Tree
58	<i>Euphorbia obovalifolia</i> A. Rich.	Euphorbiaceae	Kelekel	Tree
59	<i>Galinieria saxifraga</i> (Hochst.) Bridson	Rubiaceae	Anzolila	Tree
60	<i>Galinsoga quadriradiata</i> Ruiz & Pavon	Asteraceae		Ann herb
61	<i>Galium simensis</i> Fresen.	Rubiaceae	Ashehet	Per herb
62	<i>Galium thunbergianum</i> Eckl. & Zeyh.	Rubiaceae		Per herb
63	<i>Gomphocarpus fruticosus</i> (L.) Ait.	Asclepiadaceae		High Shrub
64	<i>Geranium arabicum</i> Forssk.	Geraniaceae		Per herb
65	<i>Gerbera piloselloides</i> (L.) Cass.	Asteraceae		Per herb
66	<i>Habenaria petitiiana</i> (A. Rich.) Th. Dur. & Schinz.	Orchidaceae		Per herb
67	<i>Halleria lucida</i> L.	Scrophulariaceae		High shrub
68	<i>Haplocarpha schimperii</i> (Sch. Bip.) Beauv.	Asteraceae		Per herb
69	<i>Helichrysum foetidum</i> (L.) Moench.	Asteraceae		Ann herb
70	<i>Helichrysum odoratissimum</i> (L.) Less	Asteraceae		Low shrub
71	<i>Helichrysum sp.</i>	Asteraceae		Low shrub
72	<i>Heracleum abyssinicum</i> (Boiss.) Norman	Apiaceae		Low shrub
73	<i>Hagenia abyssinica</i> (Bruce) J. F. Gmel.	Rosaceae	Kebse	Tree
74	<i>Hyparrhenia sp.</i>	Poaceae	Senbelet	Per Grass
75	<i>Hypericum peplidifolium</i> A. Rich.	Hypericaceae		Per herb
76	<i>Hypericum quartianum</i> A. Rich.	Hypericaceae		High shrub
77	<i>Hypericum revolutum</i> Forssk.	Hypericaceae	Abeje	Tree
78	<i>Hypoestes triflora</i> (Forssk.) Roem. & Schult.	Acanthaceae		Per herb
79	<i>Ilex mitis</i> (L.) Radlk.	Aquifoliaceae	Kecheche	Tree
80	<i>Impatiens tinctoria</i> A. Rich.	Balsaminaceae	Enshoshila	Per herb
81	<i>Jasminum abyssinicum</i> Hochst. ex DC.	Oleaceae		Climber
82	<i>Jasminum stans</i> Pax.	Oleaceae	Mito	High shrub
83	<i>Juniperus procera</i> Hochst. ex Endl.	Cupressaceae	Tede	Tree
84	<i>Kalanchoe densiflora</i> Rolfe	Crassulaceae	Yegecheandaa	Per herb
85	<i>Kalanchoe petitiiana</i> A. Rich.	Crassulaceae	Andawula	Per herb
86	<i>Kniphofia foliosa</i> Hochst.	Asphodelaceae	Ambare	Per herb
87	<i>Laggera crispata</i> (Vahl) Hepper & Wood	Asteraceae	Yoyo boshia	Per herb
88	<i>Laggera tomentosa</i> (Sch. Bip. ex A. Rich.) Oliv. & Hiern	Asteraceae	Yerte boshia	Low shrub
89	<i>Launea rueppellii</i> (Sch. Bip. ex Oliv. & Hiern) L. Boulos	Asteraceae		Per herb

90	<i>Laxogramme lanceolata</i> (Sw.) A. Presl.	Polypodiaceae		Fern
91	<i>Lithospermum afromontanum</i> H. Weim.	Boraginaceae		Per herb
92	<i>Lobelia giberroa</i> Hemsl.	Campanulaceae	Yegechebetir	Tree
93	<i>Lobelia holstii</i> Engl.	Campanulaceae		Per herb
94	<i>Lotus corniculatus</i> L.	Fabaceae		Per herb
95	<i>Loxoscaphe theciferum</i> (H. B.) Moore	Aspleniaceae		Fern
96	<i>Lysimachia ruhmeriana</i> Vatke	Primulaceae		Per herb
97	<i>Maesa lanceolata</i> Forssk.	Myrsinaceae	Kelebuye	Tree
98	<i>Mikaniopsis clematoides</i> (Sch. Bip. ex A. Rich.) Milne-Redh.	Asteraceae		Climber
99	<i>Mimulopsis solmsii</i> Schweinf.	Acanthaceae	Deremo	Per herb
100	<i>Monopsis stellarioides</i> (Pres.) Urb.	Lobeliaceae		Ann herb
101	<i>Myrsine africana</i> L.	Myrsinaceae	Kechemo	Tree
102	<i>Myrsine melanphloeos</i> (L.) R. Br.	Myrsinaceae	Gomra	Tree
103	<i>Maytenus addat</i> (Loes.) Sebsebe	Celastraceae	Atat	Tree
104	<i>Myrica salicifolia</i> A. Rich.	Myricaceae	Telota	Tree
105	<i>Nepeta azurea</i> R. Br.	Lamiaceae		Per herb
106	<i>Nuxia congesta</i> R. Br. ex Fresen.	Loganiaceae		High shrub
107	<i>Oldenlandia monathes</i> (A. Rich.) Hiern	Rubiaceae		Per herb
108	<i>Olea europaea</i> L. ssp. <i>cuspidata</i> (Wall. ex DC.) Cifferi	Oleaceae	Buna	Tree
109	<i>Olinia rochetiana</i> A. Juss.	Olinaceae	Tifiya	Tree
110	<i>Oplismenus</i> sp.	Poaceae	Sotir	Per grass
111	<i>Osyris quadripartita</i> Decne	Santalaceae	Karo	High shrub
112	<i>Oxalis corniculata</i> L.	Oxalidaceae		Per herb
113	<i>Pavetta</i> sp.	Rubiaceae		Low shrub
114	<i>Pentas schimperiana</i> (A. Rich.) Vatke	Rubiaceae	Musabir	Low shrub
115	<i>Peperomia fernandopoiana</i> DC.	Piperaceae		Per herb
116	<i>Peucedanum mattirolii</i> Chiov.	Apiaceae		Per herb
117	<i>Phagnalon abyssinicum</i> Sch. Bip. ex A. Rich.	Asteraceae		Per herb
118	<i>Phytolacca dodecandra</i> L' Herit	Phytolaccaceae	Endod	High shrub
119	<i>Pilea rivularis</i> Wedd.	Urticaceae		Per herb
120	<i>Pittosporum viridiflorum</i> Sims	Pittosporaceae	Ambilbaye	Tree
121	<i>Plantago palmata</i> Hook. f.	Plantaginaceae		Per herb
122	<i>Plectranthus assurgens</i> (Baker.) J.K. Morton	Lamiaceae	Yeroratebusil	Per herb
123	<i>Pleiopeltis excavata</i> (Willd.) Sledge	Polypodiaceae		Epiphyte
124	<i>Pluchea discoridis</i> DC.	Asteraceae		Per herb
125	<i>Podocarpus falcatus</i> (Thunb.) Mirb.	Podocarpaceae	Zigba	Tree
126	<i>Primula verticillata</i> Forssk.	Primulaceae		Ann herb
127	<i>Prunus africana</i> (Hook. f.) Kalkm.	Rosaceae	Geribe	Tree
128	<i>Pteridium aquilinum</i> L.	Pteridaceae		Fern
129	<i>Pteris cretica</i> L.	Pteridaceae		Fern
130	<i>Pteris quadriaurita</i> Retz.	Pteridaceae		Fern
131	<i>Ranunculus multifidus</i> Forssk.	Ranunculaceae		Per herb
132	<i>Rhamnus prinoides</i> L' Herit	Rhamnaceae	Gesho	High shrub
133	<i>Rhamnus staddo</i> A. Rich.	Rhamnaceae	Jeje	High shrub
134	<i>Rhus retinorrhoea</i> Steud. ex Oliv.	Anacardiaceae	Sheshamega	High shrub
135	<i>Rhus ruspolii</i> Engl.	Anacardiaceae	Tala	High shrub
136	<i>Rosa abyssinica</i> Lindley	Rosaceae	Engoche	Climber

137	<i>Rubus steudneri</i> Schweinf.	Rosaceae	Enjere	High shrub
138	<i>Rumex nepalensis</i> Spreng.	Polygonaceae	Tumiye	Per herb
139	<i>Rumex nervosus</i> Vahl	Polygonaceae	Habeshawua	Low shrub
140	<i>Salvia nilotica</i> Juss ex Jacq.	Lamiaceae	Hamam	Per herb
141	<i>Sanicula elata</i> Ham. ex D. Don	Apiaceae		Per herb
142	<i>Satureja biflora</i> (Ham ex Don) Briq.	Lamiaceae	Yedibir tosign	Low shrub
143	<i>Satureja paradoxa</i> (Vatke) Engl.	Lamiaceae	Beher	Per herb
144	<i>Satureja simensis</i> (Benth.) Briq.	Lamiaceae		Ann herb
145	<i>Scabiosa columbaria</i> L.	Dipsacaceae		Per herb
146	<i>Schefflera abyssinica</i> (Hochst. ex A. Rich.) Harms.	Araliaceae	Gitem	Tree
147	<i>Schefflera volkensii</i> (Engl.) Harms	Araliaceae	Angibo	Tree
148	<i>Scolopia theifolia</i> Gilg	Flacourtiaceae	Hamota	Tree
149	<i>Sebaea brachyphylla</i> Griseb.	Gentianaceae		Ann herb
150	<i>Selaginella abyssinica</i> Spreng.	Sellaginaceae		Fern
151	<i>Senecio ragazzii</i> Chiov.	Asteraceae		Per herb
152	<i>Silene macrosolen</i> Steud. ex A. Rich.	Caryophyllaceae	Wigirtu	Per herb
153	<i>Smilax aspera</i> L.	Smilacaceae	Abita	Shrub
154	<i>Solanecio mannii</i> (Hook. f.) C. Jeffery	Asteraceae		High shrub
155	<i>Solanum benderianum</i> Dammer	Solanaceae	Afechoma	Low shrub
156	<i>Solanum indicum</i> L.	Solanaceae	Kishishe	Low shrub
157	<i>Solanum nigrum</i> L.	Solanaceae	Awtiye	Low shrub
158	<i>Solanum vilosum</i> Willd.	Solanaceae	Yedibirawtiye	Per herb
159	<i>Sonchus bipontini</i> Asch.	Asteraceae		Per herb
160	<i>Sparmannia ricinocarpa</i> (Eckl. & Zehy.) O. Ktze.	Tiliaceae		Low shrub
161	<i>Stachys aculeolata</i> Hook. f.	Lamiaceae		Per herb
162	<i>Stellaria sennii</i> Chiov.	Caryophyllaceae		Ann herb
163	<i>Stephania abyssinica</i> (Quartin-Dillon & A. Rich.) Walp.	Menispermaceae	Kelala	Climber
164	<i>Swertia abyssinica</i> Hochst.	Gentianaceae		Ann herb
165	<i>Swertia kilimandscharica</i> Engl.	Gentianaceae		Per herb
166	<i>Tagetes minuta</i> L.	Asteraceae		Per herb
167	<i>Thalictrum rynchocarpum</i> Dill. & A. Rich.	Ranunculaceae		Per herb
168	<i>Thymus schimperi</i> Ronn.	Lamiaceae	Tosign	Per herb
169	<i>Trifolium burchellianum</i> Ser.	Fabaceae		Per herb
170	<i>Trifolium semipilosum</i> Fresen.	Fabaceae		Per herb
171	<i>Urera hypselodendron</i> (A.Rich.) Wedd.	Urticaceae	Zotir	Climber
172	<i>Verbascum sinaticum</i> Benth.	Scrophulariaceae	Yemar enzin	Per herb
173	<i>Vernonia rueppellii</i> Sch. Bip. ex Walp.	Asteraceae	Dingrita	High shrub
174	<i>Veronica abyssinica</i> Fresen.	Scrophulariaceae		Per herb
175	<i>Vigna oblongifolia</i> A. Rich.	Fabaceae		Climber
176	<i>Viola abyssinica</i> Steud ex Oliv.	Violaceae		Per herb
177	<i>Zehneria scabra</i> (L.f.) Sond.	Curcubitaceae	Arart	Climber

Appendix 3. ANOVA (Environmental Data).

		Sum Square	df	Mean	F	Sig.
ALTITUDE	Between Group	78697.25	5	15739.45	3.840	.005
	Within	221317.	54	4098.47		
	Total	300015.	59			
ASPECT	Between Group	15.25	5	3.051	.956	.453
	Within	172.30	54	3.191		
	Total	187.56	59			
SLOPE	Between Group	2518.36	5	503.67	4.913	.001
	Within	5536.21	54	102.52		
	Total	8054.58	59			
PH	Between Group	1.060	5	.212	2.121	.077
	Within	5.400	54	9.999E-		
	Total	6.460	59			
EC	Between Group	45582.68	5	9116.53	4.254	.002
	Within	115715.	54	2142.88		
	Total	161298.	59			
SAND	Between Group	301.56	5	60.31	6.069	.000
	Within	536.62	54	9.937		
	Total	838.18	59			
CLAY	Between Group	391.05	5	78.21	20.58	.000
	Within	205.12	54	3.799		
	Total	596.18	59			
SILT	Between Group	44.79	5	8.959	1.457	.219
	Within	332.05	54	6.149		
	Total	376.85	59			

Appendix 4. Woody Species of Biteyu Forest shared with some other forests in Ethiopia.

Species	Menagesha-						
	Biteyu	Jibat	Chilimo	Suba	Harena	Jemjem	Dodola
<i>Apodytes dimidiata</i>	X	X	X			X	
<i>Bersama abyssinica</i>	X	X	X	X	X	X	X
<i>Brucea antidysentrica</i>	X	X		X	X		
<i>Buddleja polystachya</i>	X	X					X
<i>Canthium oligocarpum</i>	X	X			X	X	
<i>Clutia abyssinica</i>	X						
<i>Conyza hypoleuca</i>	X						X
<i>Discopodium penninervium</i>	X			X			X
<i>Dombeya torrida</i>	X				X		X
<i>Dovyalis abyssinica</i>	X	X	X	X			X
<i>Ekebergia capensis</i>	X	X	X	X	X	X	
<i>Embelia schimperii</i>	X	X		X	X	X	
<i>Erica arborea</i>	X	X	X	X	X		X
<i>Euphorbia obovalifolia</i>	X			X			
<i>Galinieria saxifraga</i>	X	X		X	X		X
<i>Hagenia abyssinica</i>	X	X	X	X	X		X
<i>Halleria lucida</i>	X	X		X			X
<i>Hypericum revolutum</i>	X	X	X	X	X		X
<i>Ilex mitis</i>	X	X	X	X	X		X
<i>Jasminum abyssinicum</i>	X	X		X			X
<i>Jasminum stans</i>	X			X			
<i>Juniperus procera</i>	X		X	X			X
<i>Lobelia giberoa</i>	X			X	X		
<i>Maesa lanceolata</i>	X			X		X	X
<i>Myrica salicifolia</i>	X	X	X	X			
<i>Myrsine africana</i>	X	X	X	X		X	
<i>Myrsine melanophloeos</i>	X	X	X	X	X		
<i>Maytenus addat</i>	X	X					X
<i>Nuxia congesta</i>	X	X	X	X	X	X	X
<i>Olea europaea ssp. cuspidata</i>	X	X		X		X	X
<i>Olinia rochetiana</i>	X			X		X	X
<i>Osyris quadripartita</i>	X			X		X	
<i>Pentas schimperiana</i>	X						
<i>Pittosporum viridiflorum</i>	X	X	X	X		X	X
<i>Podocarpus falcatus</i>	X	X	X	X	X	X	
<i>Prunus africana</i>	X	X	X	X	X	X	
<i>Rhamnus prinoides</i>	X	X		X	X	X	X
<i>Rhamnus staddo</i>	X						X

<i>Rhus retinorrhoea</i>	X						
<i>Rhus ruspolii</i>	X					X	
<i>Rosa abyssinica</i>	X		X	X			
<i>Rubus steudneri</i>	X				X	X	X
<i>Schefflera abyssinica</i>	X			X	X	X	
<i>Schefflera volkensii</i>	X	X	X	X	X		X
<i>Scolopia theifolia</i>	X		X	X			
