academicJournals

Vol. 6(5), pp. 382-391, May 2014
DOI: 10.5897/IJBC2014.0703
Article Number: B467A9A44257
ISSN 2141-243X

http://www.academicjournals.org/IJBC

International Journal of Biodiversity and Conservation

*Full Length Research Paper*

# Floristic composition, diversity and vegetation structure of woody plant communities in Boda dry evergreen Montane Forest, West Showa, Ethiopia

**Fikadu Erenso*, Melesse Maryo and Wendawek Abebe**

Department of Biology, Dilla University, P.O Box 419, Ethiopia.

Receive 07 March, 2014; Accepted 15 April, 2014

**This study was conducted on Boda Forest in West Showa Zone, Oromia National Regional State, west Ethiopia with the objective of determining the floristic composition, species diversity and the vegetation structure of the woody plant communities in Boda natural forest. Systematic sampling method was used to collect the vegetation data. Accordingly, 60 plots of 20 x 20 m (400 m$^2$) quadrats were laid at every 50 m along five transect lines from south to north direction using compass. Vegetation parameters such as diameter at breast height (DBH), height and density of the study woody species were recorded, and all the collected vascular plant species were brought to National Herbarium of Ethiopia for identification. Vegetation classification was performed using R program Version 2.15.2 software vegan and labdsv packages. The Sorensens's similarity coefficient and Shannon-Wiener diversity index were also used to detect similarities among communities and to compute species diversity and evenness between the plant communities, respectively. A total of 95 species belonging to 76 genera and 58 families were identified from the forest. The collected species were composed of 34.7% trees, 45.2% shrubs, 13.6% liana, 3% epiphyte, 1% trees/shrubs and 1% tree/liana. Five community types, *Galiniera saxifrage-Maesa lanceolata, Juniperus procera-Myrsine Africana, Carissa spinarum-Helichrysum citrispinum*, *Osyris quadripartite-Rhus ruspolii* and *Acacia abyssinica-Gomphocarpus fruticosus* were recognized from the hierarchical cluster analysis. Generally, the forest was dominated by the small sized trees and shrubs indicating that it is in the stage of secondary regeneration. The presence of strong anthropogenic disturbance in the area necessitates the need for an immediate conservation action in order to ensure the sustainable utilization and management of the forest.**

**Key words:** Anthropogenic disturbance, diversity, floristic composition, plant community, population structure.

## INTRODUCTION

Ethiopia is one of the countries in the world endowed with rich biological resources. One of these resources is natural vegetation where floristic and faunistic life forms dynamic ecosystems (Balcha, 2002). The major ecological systems in the country support large and highly varied genetic resources along with its extremely

*Corresponding author. E-mail: fikaduerenso@gmail.com.

variable agro-climatic conditions and the altitudinal ranges (-110 to 4,620 m a.s.l at Ras Dejen) (FAO, 1996). The varied topography, the rift valley and the surrounding lowlands have given Ethiopia a wide spectrum of habitats and a large number of endemic plants and animals (Teketay, 1999; Woldu, 1999).The size of Ethiopian flora is estimated to be over 6500-7000 species of vascular plants, of which about 12% are considered endemic (Tewolde, 1991).

According to Kelbessa et al. (1992), 120 threatened endemic plant species are known from Ethiopia. Thirty five of these species were from the dry afromontane forests of the country. Dry evergreen montane forest has a very complex type of vegetation, roughly above 1500 m a.s.l. and below 3200 m a.s.l., with an average annual temperature and rainfall of 14-25°C and 700-1100 mm, respectively (Friis, 1992; Woldu, 1999). The Boda dry evergreen montane forest is one of the remnant dry afromontane forests that are found in the high lands of West Showa next to Chilimo National forest. Settlements, illegal cutting, small patches of farmland, substitution by the exotic species and open pasture fields are challenges that are facing this forest. Overgrazing and continuous human interference are believed to lead to an irreversible change in the function of forests (Bishaw, 2001). It also frequently leadto loss of forest cover and biodiversity, erosion, desertification and reduced water resources (Kelbessa and Soromessa, 2008). Indigenous knowledge on medicinal and other useful plants is also eroded with destruction of these forests (Hundera and Gadissa, 2008).

However, forest resources are the fruits of evolution that are developed through the combined influence of physical environment and people, and play important economic, social and cultural roles, particularly in the lives of many local communities. For instance, the multitude of uses, which could be obtained for trees and shrubs have been categorized as timber, fuelwood and charcoal, food, forage, medicine, raw materials as well as protection and soil improvement (Teketay and Bekele, 2005).

In order to maintain ecological equilibrium and to meet the forest product requirements, of the species diversity, floristic composition and vegetation structure are important to judge the success of the conservation efforts of the natural forests for their sustainability. No such study was done on Boda natural forest. There is a lack of knowledge on the sustainable forest management in the local community. Currently, intensive use of land for agriculture, and the high demand of wood for different purposes are leading to the loss of plant species. People were attracted only to temporary yields obtained at the initial stage without realizing the outcome they would be facing in the long term (Abebe, 2007). The present trend of forest management needs a step forward progress that depends on scientific data or information to minimize uncontrolled exploitation and restrict the conversion of forest into agricultural land, and the substitution by the exotic species. Otherwise, the small remnants of natural forest left will be gone in the very near future. Based on this background and baseline, this study was undertaken aiming at describing and providing available floristic information of Boda natural forest, including some impacts on the vegetation of the study area.

## MATERIALS AND METHODS

### The study area

The study area, Dendi district, is one of the eighteen districts of the West Showa zone of Oromia Regional State. The district capital city, Ginchi, is located 77 km west of Addis Ababa, on the Addis Ababa-Naqamte Road. Geographically, the district lies within the coordinates of 8°43'N-9°17' N and 37°47'E-38°20' E. The district covers about a total area of 104,680 ha. Of which 72, 836 ha is covered by farm land, 19,080 ha grazing-land, 9,685 ha forest and shrubs and others 3,079 ha with the population of 192,784 (99,475 males and 93309 females). The district has 48 farmers associations and five urban, out of which Ghinchi and Olankomi have municipal governments (Dendi District Report, 2011).

Boda natural forest at Boda Bosoka has Farmers associations, 22 km away from the district’s capital city, along Ginchi- Busa Road Figure 1. It covers around 20 ha.

The physiographic region of the district is characterized by one major escarpment running from east to west direction. The steepness of the escarpment varies from place to place being generally steeper at the central part of the district. Both on the top and bottom, the escarpment merges with flat lands largely used for farming. The altitudinal range of the district is between 2,000 to 3,288 m a.s.l. Besides, the relief feature of the area is characterized by rugged topography, which provides a variety of hills having interesting scenes. The district is an important watershed area for Awash and Nile river basin (Bekele, 1994).

### Climate

The district has three traditional agro-climatic regions namely: Dega (10%), Woina-Dega (60%) and Kolla (30%). The annual average temperature of the study area is 17.5°C. The mean minimum and maximum temperature of the district is 9.3 and 23.8°C respectively. The study area has two rainy seasons with an average annual precipitation of 1,225 mm where the minor rainy season extend from March to May, and the major rainy season from June to September (Dendi District Report, 2011).

### Soil

The majority of the soil of the district range from sandy to sandy-loams and clay-loams. Generally, the soils are reddish brown and shallow at higher altitudes, while at lower altitudes they tend to become dark-gray and deep-gray. The soils in the surrounding low plains are vertisols black soils with characteristics of high clay content (CNRASD, 1999; cited in Tamrat, 1993).

### Vegetation and wildlife

Dendi District is covered with ever green forests with various types of vegetation. The entire high land of the district is believed to have been covered once with dense forest. According to Friis (1992) the

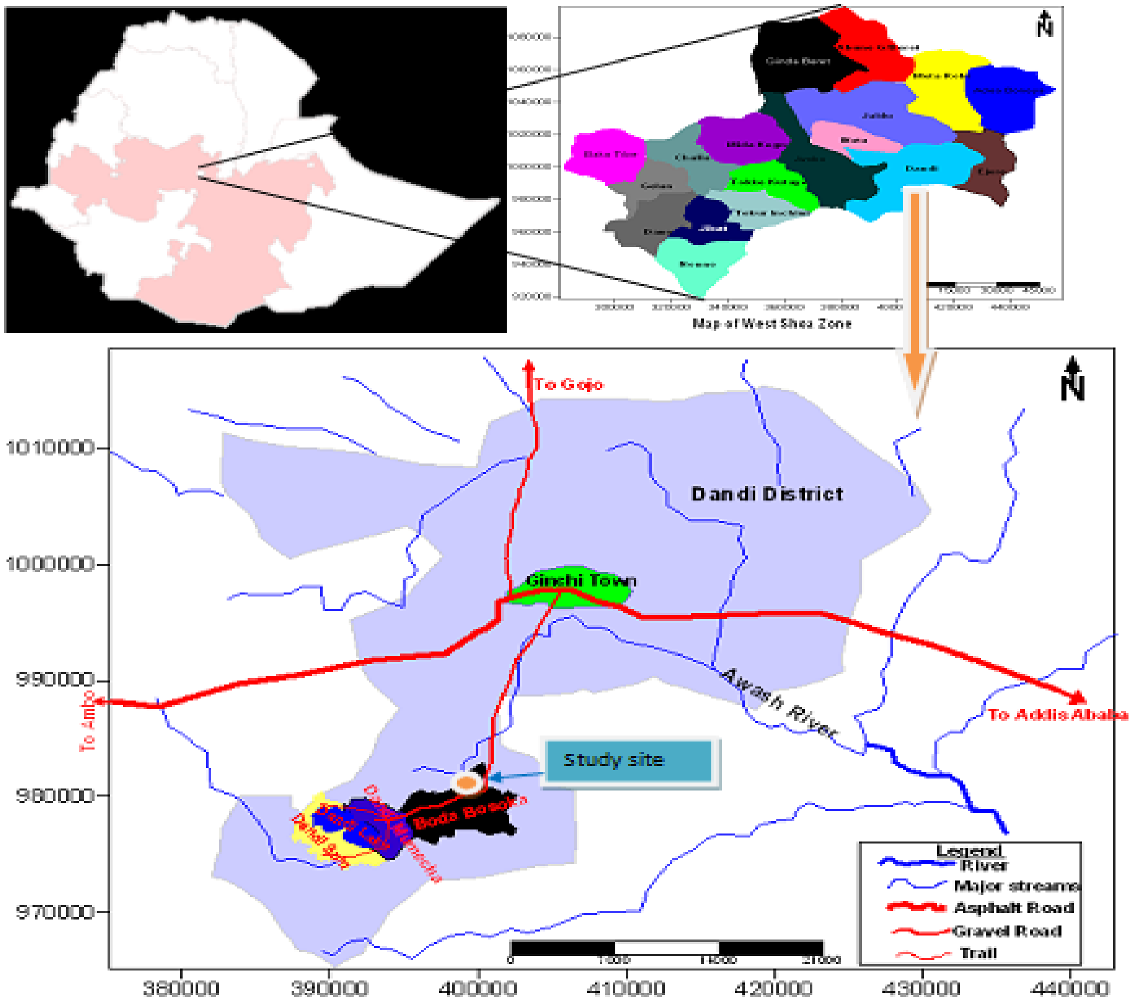


**Figure 1.** Location map of Dendi District and study site (ODA, 2011).

forest in the study area is considered as one of the remnant dry evergreen Afro-mountane forests of Ethiopia. The major tree species in the canopy are *Junipers procera, Podocarpus falcatus, Prunus africana*, *Olea europaea* subsp*. cuspiaata, Hagenia abssinica, Ficus* spp*., Croton macrostachyus* and *Eucalyptus globulus*. Besides, in the study area small indigenous flowering grasses, herbs as well as bushes such as *Carissa edulis* and *Rosa abyssinica* are very common.

Wildlife species *Phacochoerus africanus, Redunca redunca, Cercopithecus aethiops, Sylvicapra grimmia*, *Crocuta crocuta* and various types of bird species including *Bostrychia carunculata*, *Cyanochen* cyanoptera, *Serinus nigriceps*, *Poicephalus flavifrons*, *Agapornis taranta*, *Tauraco leucotis*, *Alcedo semitorquata* are common.

## Sampling design

The vegetation data were collected systematically from 60 plots of 20 x 20 m (400 m$^2$) quadrats laid at every 50 m along 5 transect lines from south-north direction using compass following the Braun-Blanquet approach of phytosociology as modified by vander Maarel (1979). The distance between each transect line was 100 m in a zigzag form of starting point of laying plot. This is to include as much vegetation as possible that can represent the vegetation of the study area. Plant species in each plot was counted and recorded at individual level, and voucher specimens was also collected, numbered, pressed and taken to the National Herbarium of Ethiopia (ETH), Addis Ababa University, for identification and storage following standard taxonomic method (Bridson and Forman, 1992).

## Floristic data collection and identification

Additional plant species occurring outside the quadrats, but inside the forest within 10 m distance was also recorded only as 'present' for floristic composition, but they were not used in the subsequent vegetation data analysis (Bekele, 1994). The vernacular (local) names were used when available. The altitude of each quadrat was recorded by using global Positioning System (Garmin 12 channel GPS). Specimens with height >2 m were identified, counted and measured using a clinometers and mater tape. Where topographic features make it difficult to measure their height were estimated visually. All individuals of the trees with a circumference > 7 cm at breast height (DBH 2.50 m) were also measured and recorded. The reported specimens of the woody species were collected, identified and deposited at the National Herbarium, Addis Ababa University.

### Plant diversity and population structure data analysis

Biological diversity could be quantified in different ways. Shannon-Wiener diversity index and species richness were computed to describe species diversity, and the population size of each of the species present (Mueller-Dombis and Ellennberg, 1974). Shannon - Wiener diversity index is the most popular measure of species diversity because it accounts both for species richness and evenness, and it is not affected by sample size (Kent and Coker, 1992; Krebs, 1999). Shannon-Wiener diversity index is calculated as follows:

$$H' = \sum_{i=1}^{s} pi \ln pi$$

Where, H' = Shannon diversity index; S = the number of species; Pi = the proportion of individuals or the abundance of the $i^{th}$ species expressed as a proportion of total cover; ln = $\log base_n$.

The minimum value of H' is 0, which is the value for a community with a single species, and increases as species richness and evenness increases (Manuel and Molles, 2007).

Evenness (Equitability) is measured as the relative abundance of the different species making up the richness of an area and when compared the similarity of the population size of each of the species present. The species evenness that measures the equity of species in a given sample area is represented by 0 and 1, where 0 indicates the abundance of few species and 1 indicates the condition where all species are equally abundant (Whittaker, 1975). Shannon's equitability (J) or Evenness is calculated as follows:

J = H/Hmax = H/*l*ns

Where, J = Evenness, H' = Shannon-Wiener diversity index and H'max = ln s, where s is the number of species.

Sorensen's similarity index is used to evaluate woody species composition (tree/shrubs) and species distribution among the plant communities. It was described using the following formula (Kent and Coker, 1992):

Ss = 2a/(2a+b+c),

Where: Ss = Sorensen's similarity coefficient; a = number of species common to both communities; b = number of species in community 1; c = number of species in community 2.

The diameter at breast height (DBH), basal area, tree density, height, frequency and importance value index were used for description of vegetation structure. These vegetation data were computed and summarized using Microsoft Office Excel (2007) spread sheet using the following formulae (Mueller-Dombois and Ellenberg, 1974; Kent and Coker, 1992). The frequency distribution of tree species was calculated as:

Frequency (F): The probability or chance of finding a species in a given sample area or quadrat. It is dependent on quadrat size, plant size and patterning in the vegetation (Kent and Coker, 1992). It is calculated with this formula:

$$F = \frac{\text{Number of plots in which a species occur}}{\text{total number of plots laid out in the study site}} \times 100$$

Relative Frequency (RF): It is the frequency of species A/sum of frequencies of all species x100.

Density of a species = is a count of the numbers of individuals of a species within the quadrat (Kent and Coker, 1992). It is closely related to abundance but more useful in estimating the importance of a species. Counting is usually done in quadrats placed several times in the plant communities under study. Afterwards, the sum of individuals per species is calculated in terms of species density per convenient area unit such as a hectare (Mueller-Dombois and Ellenberg, 1974).

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

Relative density = Density of species A/total density of all species x 100.

Basal area (BA): Basal area is the area outline of a plant near ground surface. It is expressed in square m/hectare (Mueller-Dombois and Ellenberg, 1974). It is measured through diameter, usually at breast height (DBH) that is 1.3 m above ground level. It is also used to calculate the species dominance. DBH values were calculated from circumference measurements and used in the formula for the estimation of basal area as follows:

$$BA = \pi d^2/4$$

Where, BA = Basal Area in $m^2$ per hectare; d = diameter at breast height in meter. d = C/π, where c = circumference, π= 3.14.

Dominance: It is the mean basal area per species time's abundance of the species.

Relative dominance (RDO): It is basal area of a species /total basal area of all species x 100

Importance values index (IVI) was analyzed for woody species. IVI of a species was calculated from the sum of relative dominance (RDO), relative density (RD) and relative frequency (RF) (Kent and Coker, 1992).

IVI = RDO + RD + RF

### Plant community determination

The vegetation data analysis was made based on presence absence data. The R program Version 2.15.2 software vegan and labdsv packages (The R Core Team, 2012) was used to classify the vegetation into communities. The community name was derived based on the tree and/or shrub with high synoptic value.

## RESULTS AND DISCUSSIONS

### Floristic plant species composition

A total of 95 specimens of woody plants (shrubs, trees, and lianas) were identified from the forest. The identified species belong to 76 genera and 58 families. Two species were observed outside the sampling plots in the study area within the ranges of ten meters distance from the plot boundary. These were *Geranium arabicum* and *Opuntia ficus indica.* The collected species were composed of 34.7% trees, 45.2% shrubs, 13.6% liana, 3% epiphyte, 1% trees/shrubs and 1% tree/liana.

### Plant community classification

Cluster analysis was used to identify groups of sites (vegetation samples) that are similar in terms of their

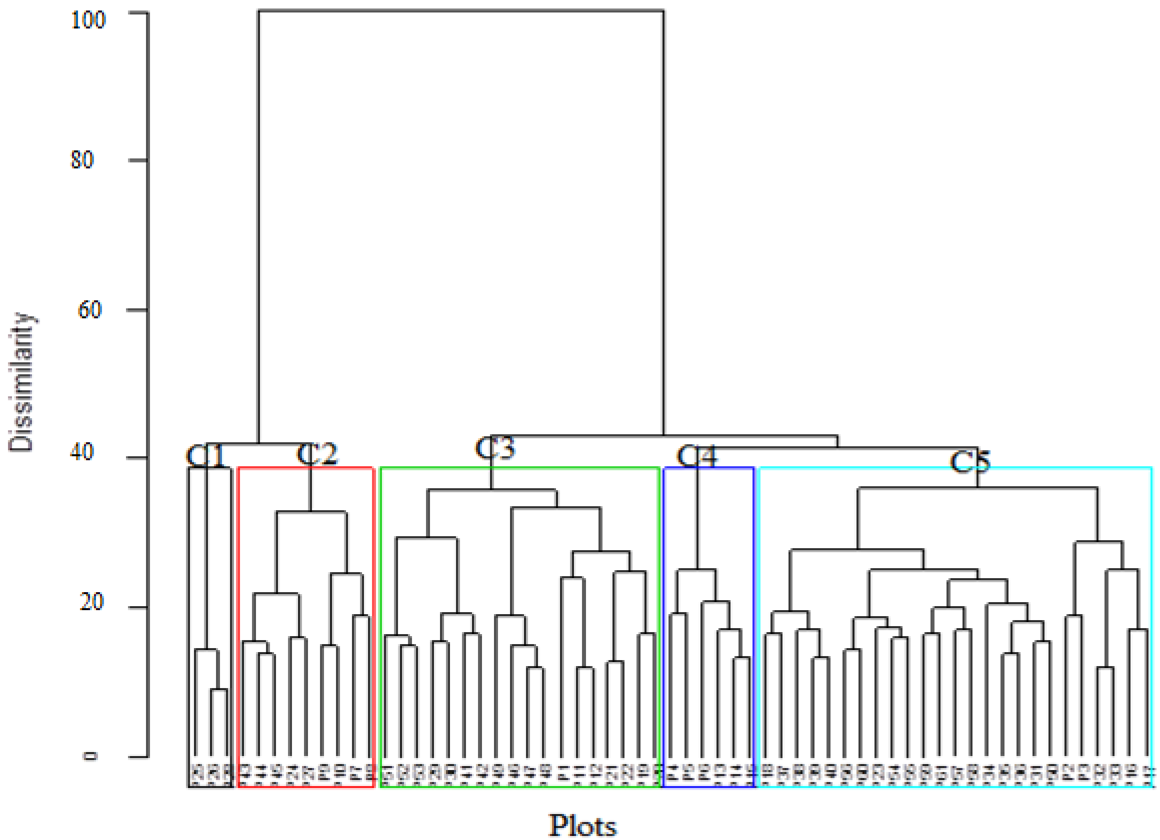


**Figure 2.** Dendrogram showing plant community types of the study area.

woody species composition. The abundance data of a species were used for the analysis. R program Version 2.15.2 software (The R Core Team, 2012) was used to perform a hierarchical cluster dendrogram, which depic-ted the vegetation community of woody species. The five plant community types (clusters) at Boda natural forest (Figure 2) and the five communities and distri-butions of the sample plots in the communities were identified (Table 1).

The indicator values for each species in each group and tests for statistical significance ($P<0.05$) were analyzed to name the vegetation community (Table 2). The values are based only on the species abundance and frequency comparisons. In order to obtain an effective description of community types and their environmental relations, both classificatory and ordination techniques were employed.

### *Galiniera saxifrage-Maesa lanceolata community type*

This community was represented by three plots and 53 woody plant species. *Rhamnus staddo, Premna schimpehi, Juniperus procera, Maytenus heterophylla* and *Hypericum quartineanum* were the importance species in the tree layer of the community. *Canthium oligocarpum, Abrus schimperi, Sparmanna ricinocarpa* and *Myrsine africana* were important species in the shrub layer. The common Lianas in this community include *Toddalia asiatica* and *Gladiolus dalenii*. *Salvia nilotica, Pentas lanceola* and *Peperomia abyssinica* were also importance herb species in this community.

### *Juniperus procera-Myrsine africana community type*

This community was represented by nine plots and 61 plant species. *Maytenus addat, Hagenia abyssinica* and *Rhus vulgaris* were the importance species of the tree layer of the community.

In the shrub layer *Hibiscus panduliformis, Myrsine africana* and *Carissa spinarum* were the importance species.

### *Carissa spinarum-Helichrysum citrispinum community type*

This community was represented by 18 plots and 46 plant species. *Acanthus polystachius, Sida schimperiana,*

**Table 1.** The communities and distributions of the sample plots in the communities.

| Community | Number of plots | Plots in the community |
|---|---|---|
| I | 3 | 25, 26, 33 |
| II | 9 | 43, 44, 45, 24, 27, 9, 10, 7, 2 |
| III | 18 | 51, 52, 53, 29, 30, 41, 42, 49, 45, 47, 43, 1, 11, 12, 21, 22, 19, 20 |
| IV | 6 | 4, 5, 6, 13, 14, 15 |
| V | 24 | 18, 37, 38, 39, 40, 56, 60, 23, 54, 55, 59, 57, 53, 34, 35, 31, 50, 2, 3, 32, 33, 16, 17 |

**Table 2.** Indicator plant species for each community and the test of significance (P*value) observed for each indicator species.

| Indicator species | Local name | Communities | | | | | P*value |
|---|---|---|---|---|---|---|---|
| | | I | II | III | IV | V | |
| *Galiniera saxifraga* | Mixoo | **0.49** | 0.00 | 0.00 | 0.06 | 0.08 | 0.00 |
| *Maesa lanceolata* | Abayyii | **0.42** | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 |
| *Juniperus procera* | Gaatiraa | 0.21 | **0.41** | 0.10 | 0.21 | 0.00 | 0.21 |
| *Myrsine africana* | Qacama | 0.16 | **0.37** | 0.02 | 0.14 | 0.00 | 0.00 |
| *Carissa spinarum* | Agamsa | 0.20 | 0.20 | **0.36** | 0.20 | 0.20 | 0.90 |
| *Helichrysum citrispinum* | Mukaa gaguraa | 0.00 | 0.00 | **0.65** | 0.02 | 0.00 | 0.00 |
| *Osyris quadripartita* | Waatoo | 0.03 | 0.00 | 0.00 | **0.59** | 0.00 | 0.00 |
| *Rhus rus polii* | Daboobesaa | 0.00 | 0.02 | 0.00 | **0.50** | 0.00 | 0.00 |
| *Acacia abyssinica* | Laafto | 0.00 | 0.04 | 0.10 | 0.00 | **0.60** | 0.03 |
| *Gomphocarpus fluticosus* | Aanannoo | 0.00 | 0.00 | 0.00 | 0.00 | **0.67** | 0.00 |

**Table 3.** Sorensen's similarity coefficient among the plant communities.

| Community | I | II | III | IV | V |
|---|---|---|---|---|---|
| I | | | | | |
| II | **0.43** | | | | |
| III | 0.22 | 0.35 | | | |
| IV | 0.37 | 0.38 | 0.31 | | |
| V | 0.23 | 0.23 | 0.21 | 0.24 | |

and *Solanum marginatum* were the importance species of the shrub layer of the community. The common Lianas in this community include *Lagenaria abyssinica, Senna septemtrionalis* and *Clematis longicauda*.

### *Osyris quadripartite- Rhus ruspolii community type*

This community was represented by six plots and 38 plant species. *Mimusops kummel, Clerodendrum mylicoides, Juniperus procera, Maytenus addat* and *Maytenus heterophylla* were the importance species of the tree layer of the community. The shrub layer is dominated by *Solanum anguivi* and *Lippia adoensis*. The common climbers in this community include *Clematis longicauda* and *Dregea abyssinica.*

### *Acacia abyssinica-Gomphocarpus fruticosus community type*

This community was represented by 25 plots and 31 plant species. *Juniperus procera*, *Dovyalis abyssinica, Cupressus lusitanica* and *Eucalyptus globulus* were the importance species of the tree layer of the community. The shrub layer is dominated by *Canthium oligocarpum, Euphorbia schimperiana*, *Carissa spinarum*, *Ocimum lamiifolium* and *Solanum giganteum*.

### Community similarity analysis

The Sorensen's similarity index measures the degree to which the species composition of forest or samples is alike, whereas dissimilarity coefficient assesses which two forest or samples differ in composition. Based on this, similarity in species composition slightly varied among communities Table 3.

The highest similarity was observed between communities I and II (43%). The least similarity was observed between community III and V (21%), followed by community I and III. Overall similarity coefficient ranges

**Table 4.** Species richness, evenness and Shannon-Wiener diversity index of the plant community types.

| Community | Species richness | Diversity index (H') | H'max | Species evenness (J) |
|---|---|---|---|---|
| I | 53 | 1.72 | 1.9 | 0.09 |
| II | 61 | 1.79 | 2.0 | 0.09 |
| III | 46 | 1.66 | 1.8 | 0.08 |
| IV | 38 | 1.58 | 1.8 | 0.08 |
| V | 31 | 1.49 | 1.4 | 0.08 |

from 21-43% among all the communities. Thus, species composition dissimilarities account for 57% of the most similar communities and 79% of those that share least similarity (community III and V)

### Species diversity

The five communities have almost the same species distribution (equitability or evenness) but comparatively community V has the least species evenness Table 4.

### Vegetation structure

#### *Frequency*

We recorded a total of 682 woody plants per ha- from all quadrats. The most frequent of the tree species in this forest found was *J. procera* (93.44%), occurring in almost all of the quadrats sampled, followed by *Maytenus heterophylla (*49.18%) and *Maytenus addat (*44.26%), while species like *Ficus vast, Euphorbia ampliphylla, Podocarpus falcatus*, *Erithrina brueci* and *Maesa lanceolata* were poorly represented.

#### *Basal area*

The total basal area of all tree species in Boda Forest was calculated from DBH data. It was found to be 114.64 $m^2$/ha. *J. procera* has the highest basal area (25.5%) followed by *Podocarpus falcatus* (24.64%). On the other hand the lowest (below 0.56 $m^2$/ha) was recorded for most species like *Rhamnus prinoides, Rhamnus staddo*, *Dovyalis abyssinica, Maesa lanceolata*. Thus, the species with the largest basal area could be considered the most important species in the forest.

With regard to basal area, the most important species of the study forest includes *Juniperus procera, Podocarpus falcatus, Ekebergia capensis, Olea europaea, Ficus vasta, Cupressus lusitanica* and *Eucalyptus globulus.*

### Importance value index (IVI)

The most leading dominant and ecologically significant trees in Boda Forest are *J. procera, Maytenus heterophylla, Ficus vast, Mayteus addat, Eucalyptus globulus, Rhamnus staddo, Ekebergia capensis* and *Premna schimpehi* on the basis of their IVI values relative to other species Table 5, but *Bersama abyssinica, Acacia abyssinica, Cordia africana, Rhus rus polii* and *Olea europaea* are species among the lowest relative IVI values.

## DISCUSSION

### Floristic composition

In this study, a total of 95 woody species, including shrubs, trees, shrubs/trees, epiphyte, liana and tree/-liana), were recorded. Overall diversity and evenness were 1.79 and 0.09, respectively. According to Kent and Coker (1992), the Shannon-Weiner diversity index normally varies between 1.5 and 3.5 and rarely exceeds 4.5. In our study area, however, there is high diversity and evenness showing more or less even representation of individuals of most woody species in the sampled quadrats.

### Vegetation structure

Vegetation classification is a powerful tool employed for several purposes, including: efficient communication, data reduction and synthesis, interpretation, and land management and planning. It also provides one way of summarizing our knowledge of vegetation patterns (Dalle et al., 2005). The study identified five plant community types (clusters) at Boda natural forest. Plant communities are conceived as types of vegetation recognized by their floristic composition. The species compositions of com-munities better express their relationships to one another and environment than any other characteristic.

Community types I and II, which is dominated by *G. saxifrage, M. lanceolata J. procera* and *M. africana*, is found in specialized habitats such as along river courses. The stands sampled in this type are located at the middle of the forest, which is less grazed by cattle and its human impact is found to be low. Regenerating species of *M. addat, H. abyssinica* and *R. vulgaris* are common here.

Community types III, is rich in shrub layer species and

**Table 5.** The high importance value index (IVI) of tree species in Boda Forest.

| Botanical name | RDO | RD | RF | IVI | IVI% |
|---|---|---|---|---|---|
| *Juniperus procera* | 10.96 | 41.76 | 15.7 | 68.42 | 22.81 |
| *Maytenus heterophylla* | 1.22 | 9.16 | 8.26 | 18.64 | 6.21 |
| *Ficus vasta* | 16.37 | 0.18 | 0.83 | 17.38 | 5.79 |
| *Mayteus addat* | 0.96 | 7.33 | 7.44 | 15.72 | 5.24 |
| *Eucalyptus globulus* | 11.78 | 2.81 | 1.1 | 15.69 | 5.23 |
| *Ekebergia capensis* | 7.27 | 1.95 | 3.03 | 12.25 | 4.08 |
| *Rhamnus staddo* | 1.22 | 4.33 | 6.61 | 12.17 | 4.05 |
| *Cordia africana* | 7.95 | 0.85 | 2.75 | 11.56 | 3.85 |
| *Cupressus lusitanica* | 8.66 | 2.08 | 0.83 | 11.56 | 3.85 |
| *Premna schimpehi* | 1.22 | 3 | 7.16 | 11.37 | 3.79 |
| *Olea europaea* | 2.54 | 1.95 | 4.96 | 9.45 | 3.15 |
| *Acacia abyssinica* | 2.95 | 2.81 | 3.03 | 8.79 | 2.93 |
| *Bersama abyssinica* | 1.82 | 2.75 | 1.38 | 5.94 | 1.98 |
| *Rhus ruspolii* | 1.22 | 1.1 | 2.2 | 4.52 | 1.51 |
| Others | 23.86 | 17.94 | 34.72 | 76.54 | 25.53 |
| Total | 100 | 100 | 100 | 300 | 100 |

RDO, Relative dominance; RD, relative density; RF, relative frequency; IVI, Importance values index.

woody climbers. The stands sampled in this community are located in an area having shallow soils with medium human interference. In few of its stands introduced exotic species of *C. lusitanica* have been observed.

Community types V, is highly influenced by people collecting firewood, charcoal making and grazing animals. During the survey of this study, in this community, illegal cutting by local people and introduced exotic species of *C. lusitanica* and *E. globules* have been observed Plate 1. This is due to its being nearby to Boda town and having species of plants suitable for charcoal making and firewood.

Low species evenness can be attributed to excessive environmental disturbances, variable conditions for regeneration and selective exploitation of some species (Wassie and Teketay, 2006). Kidane (2003) also explained that the highest species numbers are found at low disturbance intensities while there is a drastic decrease at high disturbance intensity. The result of the present study agrees with this regarding species evenness. The five communities have almost the same species distribution (equitability or evenness) but comparatively community V has the least species evenness.

The patterns of plant species diversity have often been noted for prioritizing conservation activities because they reflect the underlying ecological processes that are important for management (Lovett et al., 2000; Senbeta et al., 2007). Based on similarity index measures, similarity in species composition slightly varied among communities. The highest similarity was observed between communities I and II (43%) due to the communities having close altitudinal similarity and adaptation. The least similarity was observed between community III and V (21%), followed by community I and III. This may be due to conservational variation and variation in disturbance due to anthropogenic activities. that is, one area which is better protected varies from the one which is highly exposed to deforestation resulting in communities' variation. As it was reported by Denu (2007), in addition to altitudinal gradient, other environmental factors such as aspect, slope, and soil physical and chemical properties have sound effects on patterns of vegetation in communities. The present study agreed that high dissimilarity between species to communities may arise from the altitudinal differences, degree of human impact (anthropogenic) action, over grazing and climatic conditions. For all communities, the Sorensen's similarity coefficient values were below 0.5, indicating the existence of low similarities among the recognized communities which implies that all the communities are important in terms of floristic diversity and needs attention from a conservation point of view.

According to Lamprecht (1989), species with the same importance value index (IVI) have the same or at least similar population structure. The result indicates that high IVI was attributed to few species. These species are those which are well adapted to the high pressure of disturbance, natural and environmental factors, and the effect of local communities. In contrast to this idea, almost all species in this study showed variation in terms of their IVI, showing different ecological importance of each species in the forest. In our study, basal area analysis across individual species revealed that very few species had high dominance. *J. procera* was the leading dominant and other dominant species in terms of basal

**Plate 1.** Some areas of Boda natural forest (Photo by Fikadu, September, 2013G .C).

area were *M. heterophylla, F. vast, M. addat, E. globulus, R. staddo, E. capensis* and *P. schimpehi*on. This implies that these eight species are the most ecologically important woody species at Boda forest.

## Conclusions

The results of the study indicated that the study forest had relatively high woody species diversity, that is, 95 specimens of plants (shrubs, trees, shrubs/trees, epiphyte, liana and tree/liana) and dominated by small sized tree and shrub species in secondary stage of development, indicating that the forest was heavily exploited and affected in the previous periods, but good regeneration is in process at the present time. Therefore, to improve the natural diversity and structure of the forest, to minimize the influence of the surrounding communities and utilize the forest resources sustainably for present and future generation, the following points were made as recommendations:

1. Initiate enrichment plantation program of those most leading dominant and ecologically significant trees, because of the use of selective cutting by local peoples (e.g. *P. falcatus, E. capensis* and *R. staddo*).
2. Raising awareness of local communities on the value of forest resources and ecological consequences of deforestation and device mechanisms by which human impacts can be minimized through discussion and consultation with the local communities with emphasis on returning the benefits of the protected areas to those communities.
3. Use the cut and carry method for feeding domestic animals than using free grazing method in the forest to enhance the germination capacity of the seeds in the soil and seedling development of woody species.

Finally, further studies on soil properties, land use management system and detailed ethno-botanical studies are also required to explore the wealth of indigenous knowledge on the diversity of plants and their implications in conservation are also recommended

## Conflict of Interests

The author(s) have not declared any conflict of interests.

## ACKNOWLEDGEMENTS

We would like to gratefully acknowledge Dilla University for financial support. Ginchi District, Agriculture and Rural Development Offices for providing necessary information and to the communities that were helpful during the field work and were kind enough to share their knowledge and experiences without reservations are highly acknowledged.

## REFERENCES


Abebe A (2007). Floristic Diversity and Regeneration Structure of some National priority species in Sigmo - Setema forest, Southwest

Bakele T (1993). Vegetation and Ecology of Afromontane forests on the central plateau of shewa, Ethiopia, *Acta phytogeorgr. Suec*. p.79.

Balcha G (2008). Biological diversity and current *ex situ* conservation practices in Ethiopia. Institute of Biodiversity Conservation and Research, Addis Ababa.

Bekele T (1994). Phytosociology and ecology of a humid Afromontane forest on the central plateau of Ethiopia. J. Vegetation Sci. 5:87-98.

Bishaw B (2001). Deforestation and land degradations in the Ethiopian Highlands: strategy for physical recovery. J. North East Afr. Stud. 8:7-26.

Bridson D, Froman L (1992). The Herbarium hand book. Royal Botanical Gardens Kew. Whit stable Litho Printers Ltd. (Great Britan eds). p. 303.

Dalle G, Brigitte LM, Johannes I (2005). Plant community and their speciesdiversity in the semi-arid rangelands of Borana lowlands, southern Oromia, Ethiop. Comm. Ecol. 6(2):167-176.

Denu D (2007). Floristic Compositioand Ecological Study of Bibita Forest (Gura Farda), Southwest Ethiopia, M.Sc. Thesis, Addis Ababa University, Addis Ababa.

Ethiopia. Unpublished M.Sc. Thesis, Addis Ababa University, Addis Ababa.

FAO (1996). Ethiopia: Country Report to the FAO International Technical Conference on Plant Genetic Resources. Leipzig, Germany.

Friis I (1992). Forests and Forest Trees of Northeast Tropical Africa: Their Natural Habitats and Distribution patterns in Ethiopia, Djibouti and Somalia. Kew Bulletin Additional Series XV, Her Majesty's Stationary Office (HMSO), London.

Hundera K, Gadissa T (2008). Vegetation composition and structure of Belete Forest, Jimma Zone, South western Ethiopia. Ethiop. J. Biol. Sci. 7(1):1-15.

Kelbessa E, Demmissew S, Woldu Z, Edwards S (1992). Some threatened Endemic plants of Ethiopia. NAPRECA Monograph, Series 2:35-55.

Kelbessa E, Soromessa T (2008). Interfaces of regeneration, structure, diversity and use of some plant species in Bonga forest: A reservoir for wild coffee gene pool. *SINET:* Ethiop. J. Sci. 31(2):121-134.

Kent M, Coker P (1992). Vegetation Description and Analysis. A practical approach. John Wiley and Sons, New York. p. 363.

Kidane L (2003). Floristic composition and human interaction in the Hugumburda Gratkassu forest. Msc.Thesis, Addis Ababa University.

Kotwal CP, Kandari SL, Dugar D (2008). Bioindicators in sustainable management of tropical forests in India. Afri. J. Plant Sci. 2:99-104.

Krebs CJ (1999). Ecological Methodology. 2nd ed. Addison Welsey Educational Publishers, USA. 620 p.

Lamprecht H (1989). Silverculture in the Tropics. Tropical forest ecosystems and their tree species-possibilities and methods for their long-term utilization. T2 Verlagsgesells chaft GmbH, RoBdort, Germany.

Manuel C, Molles JR (2007). Ecology concepts and applications. McGraw-Hill, Inc., New York.

McCune B, Grace JB (2002). *Analysis of Ecological Communities*. Version 5.0 MjM Software design, USA, p.304.

Muller-Dombois D, Ellenberg H (1974). Aims and Methods of Vegetation Ecology. Wiley and Sons, New York. 547 pp.

Senbeta F, Woldemariam T, Demissew S, Denich M (2007). Floristic Diversity and composition of Sheko Forest, Southwest Ethiopia. Ethiop. J. Biol. Sci. 6(1):11 - 42.

Teketay D (1999). Past and present activities, achievement and constraints in forest genetic resources conservation in Ethiopia. In: Proceedings of the national forest genetic resources conservation strategy workshop, 21-22 June 1999, Addis Ababa.

Teketay D, Bekele T (2005). Indicators and Tools for restoration and Sustainable management of forests in East Africa. Ethiopian Agricultural Research Center, Addis Ababa.

Tewolde BGE (1991). Diversity of the Ethiopia flora. *In* "Plant genetic Resources of Ethiopia" (J. M. M. Engels, J. G. Hawkes, and Melaku Worede, Eds.), Cambridge University Press, Cambridge. pp. 75-81.

The R Core Team (2012). A Language and Environment for Statistical Computing, Version 2.15.2. R Foundation for Statistical Computing.

Van der Maarel (1979). Transformation of cover abundance values in phytosociology and its effect on Community. *Vegetatio.* 39: 47-114.

Wassie A, Teketay D (2006). Soil seed banks in church forests of northern Ethiopia: Implications for the conservation of woody plants. FLORA 201:32-43.

Whittaker HG (1975). Communities and Ecosystem. 2nd edition, Macmillan Publishing Co. Willey and Sons, New York, USA, 547 p.

Woldu Z (1999). Forest in the vegetation types of Ethiopia and their status in the geographical context. In: Forest genetic resource conservation: Principles, strategies and actions. (Edwards, Sebsebe Demissew, Taye Bekele and Haase, G. eds). Workshop proceeding. Institute of Biodiversity Conservation and Research, and GTZ, Addis Ababa.