Ethiop. J. Biol. Sci., **10(1): 19-38, 2011**

ISSN: 1819-8678

VEGETATION STRUCTURE AND REGENERATION STATUS OF ANBESA CHAKA LOWLAND BAMBOO FOREST, WESTERN ETHIOPIA

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ABSTRACT: This study was conducted in Anbesa Chaka Lowland Bamboo Forest with the aim of determining forest sturcture, population structure and regeneration status of some selected species. A total of 70 sample plots, measuring 400 m^2 each and 300 m apart, were established within eight transect lines to study the structure and regeneration status of the forest in the study area. Height and diameter at breast height of all tree species (DBH above 2.5 cm) in each sample plot were recorded. Regeneration status of tree species was also assessed in 5 m x 5 m of sub-plots at the four corners and the center of each main sample plot. Importance Value Index (IVI) was calculated for all tree and bamboo species. The structural analysis of the forest showed that the density distribution of individual tree species were comparable with distribution in the lower and higher diameter classes for some species individuals and a large number of small-sized individuals distribution for other tree species in the forest. Height class distribution of the tree species revealed a high proportion of individuals in the lowest height class. Tree species density was 281 per hectare and the density of lowland bamboo was about 8650 culms ha^{-1}. The total tree basal area was 12.4 m^2/ha and the mean basal area of lowland bamboo was 9.5 m^2/ha. Importance Value Index (IVI) was calculated for all tree and bamboo species. Six general patterns of species were recognized from the analysis of population structure. Important value index, population structure and regeneration status could serve as criteria for species prioritization in order to maintain the biodiversity, cultural and economic value of the forest.

Key words/phrases: Anbesa Chaka, Lowland bamboo forest, Regeneration status, Species density, Vegetation structure.

INTRODUCTION

Despite their potential economic and ecological uses, the bamboo forests, like other forests of Ethiopia, are now being destroyed due to high population pressure. In the 1960s, the total area of natural bamboo forest was estimated to be 1.5 million hectares, including 1 million hectares of lowland bamboo forest (FAO, 2005; Kasahun Embaye, 2003). However, a study by private consultants mentioned in Kassahun Embaye (2003) significantly reduced this estimate to 1 million hectares which included

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800, 000 ha of lowland bamboo forests (Kassahun Embaye, 2003) showing that the Ethiopian bamboo area has been shrinking since 1997.

Detailed ecological investigations on vegetation have been undertaken to suggest various solutions for ecological problems. The suggestions may be used as a tool for biological conservation and management purposes; as an input to environmental impact assessments; or to provide the basis for prediction of possible future changes (Kent and Coker, 1992). In these directions, various studies have been made recently and contributed towards the understanding of the vegetation of the country. (Zerihun Woldu and Backeus, 1991; Tamrat Bekele, 1994; Sebsebe Demissew, 1998; Tesfaye Awas et al., 2001; Kumelachew Yeshitela and Tamrat Bekele, 2002; Kassahun Embaye, 2003; Simon Shibru and Girma Balcha, 2004; Teshome Soromessa et al., 2004; Abate Ayalew et al.,2006; Dereje Denu, 2006; Getaneh Balachew, 2006 and Abate Zewdie, 2007).

Therefore, the study of the vegetation at which bamboo species grow in combination with other species and the potential of *Combretum-Terminalia* or broad-leaved deciduous woodland is important in relation to development, sustainable resources management, biodiversity conservation and environmental protection (Kassahun Embaye, 2003). According to Kassahun Embaye (2003), however, there has beenlittle study performed on the lowland bamboo forest of Anbesa Chaka so far. Therefore the objectives of this study were to: (a) investigate the vegetation structure, tree species population structure and regeneration status of some selected species of the forest, and (b) provide information for further ecological studies that would contribute for conservation and sustainable utilization of the forest and its resources.

MATERIALS AND METHODS

Study area

The study area is located in Bambasi District, Assosa Zone, of Benishngul-Gumuz National Regional State (BGNRS). It is located at 665 km west of Addis Ababa; 17 km from Bambasi. The study area lies at the range of 09º 53' 45"- 09º 55'50" N and 34º 39'10" - 34º40'42" E (Fig.1). Bambasi district is one of the 7 districts of Assosa Zone with an area of about 2,210 square kilometer (CSA, 2007).

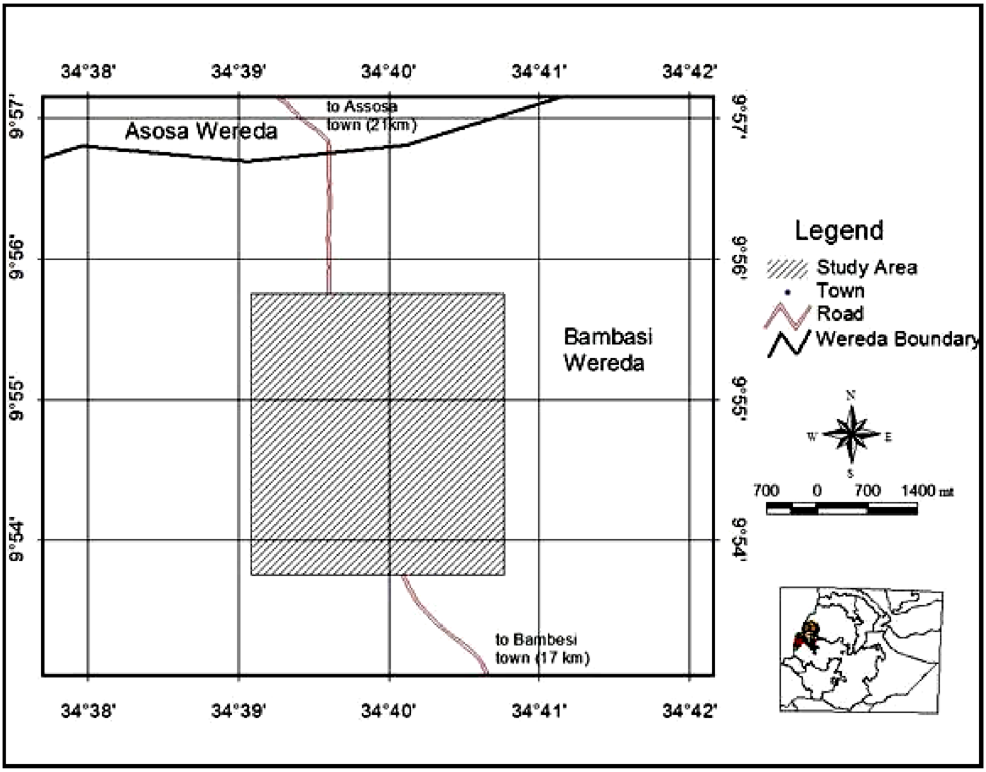

Fig.1. Location of the study area.

The study area is topographically described by diversified landforms: extensive mountain ranges, dissected plateaus, hills, undulating and rolling plains, deep gorges and valleys, most of the area can be classified as lowlands, below 1,500 m a.s.l (BGNRS, 1995). The altitude covers from 1425-1605 m a.s.l. The geology of the study area is characterized by extensive Late Tertiary that covers the Pre-Cambrian rocks (Mohr, 1971). Pre-Cambrian rocks underlie all other recently formed rocks in most part of Ethiopia. However, they are exposed to the surface in some areas where the younger cover rocks have been eroded away or not deposited at all (Mohr, 1971; Mesfin Wolde Mariam, 1972). The general characteristics of the soil are 60% sandy and 30% clay soil (EIAR, 2006).

Since the climatic data at Bambasi metreological station has been recorded for only 2006 and 2007, the climatic data were taken from Assosa station, which is about 21 km away from Anbesa Chaka lowland bamboo forest.

The rainfall and temperature data at that site were collected by National Meteorological Service Agency (NMSA, 2008) from the year 2002-2007. The distribution of rainfall in the study area is characterized by a single maximum rainfall pattern under wet season from May to October. The average annual rainfall at Assosa station for six consecutive years was 1052 mm and the mean annual temperature was about 21.6 ºC (Fig. 2). Maximum temperature was recorded in March (32.4°C) while the minimum temperature was in December (12.4°C).

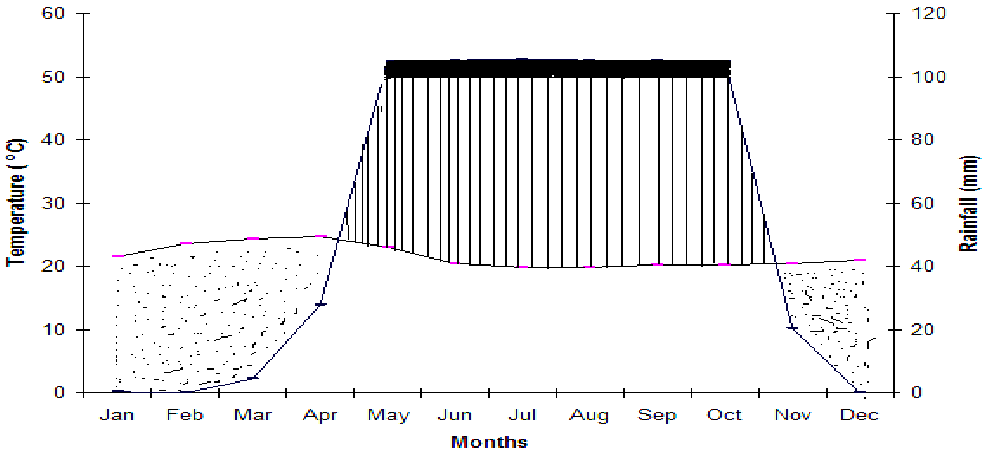

Fig. 2. Climadiagram showing rainfall distribution and temperature variation from 2002-2007 at Assosa. Data source: National Metrological Service Agency.

Sampling design

A reconnaissance survey was made across the study area from November 28-30, 2007 in order to obtain an impression of the site conditions, the forest vegetation and to determine the number of transect lines to be laid. Actual field data were collected from November 1-31, 2007.

Data on vegetation distribution were collected using systematic sampling technique following the Braun- Blanquet approach as outlined by Mueller-Dombois and Ellenberg (1974). Systematic plot sampling was selected because of the need to ensure that sufficient representative samples of vegetation from all altitudinal zones were included. Eight transect lines were systematically positioned/laid. Along each transect, sample plots of 20 m x

20 m (400 m^2) were taken at a distance of 300 m from each other. The distance between each transect line was 1 km. A total of 70 quadrats were used to collect data on the vegetation of the area. The number of quadrats in each transect was limited by the size of the forest. For the collection of herbaceous species, subplots of 5 m x 5 m at the four corners and the center of the large plot were laid. These subplots were also used for seedling and sapling count. Plant specimens were collected from each quadrat and were taken to Addis Ababa University Herbarium for identification. Identification of plant speciemens were done using the published Flora of Ethiopia and Eritrea.

Structural data collection

DBH (Diameter at Breast Height) more than 2.5 cm of tree individuals in the plots were measured for height and DBH. Measurement of the diameter of the trunk with a diameter tape at height of 1.3 m above ground level was the criterion used to select the tree individuals. Seedlings and saplings of each tree species with DBH less than 2.5 cm, and height less than 2 m were counted to estimate the regeneration status of the forest. Tree species with DBH below 2.5 cm and height more than 1 m and seedling with DBH below 2.5 cm and height less than or equal to 1 m were counted. With in the main sample plots, the number of culms of bamboo, their height and diameter at breast height were measured at the middle of the internodes nearest 1.3 m above the ground following Franklin (2003) and Vazquez-Lopez, *et al*. (2004) data collection methods.

Environmental parameters including elevation and slope were recorded for each quadrat. A Garmin e Trex Global Positioning System (GPS) receiver was used to estimate geographic coordinates. Elevation was estimated using altimeter and Garmin GPS. Slope was measured using Clinometer. For the climatic characterization of the sites, meteorological data (2002-2007) were obtained from the nearest meteorological stations according to the database provided by the NMSA (2008).

Structural data analysis

From the woody species (tree and shrubs) identified, the entire tree species recorded in the sample plots were used for the analysis of structural features including density, height, diameter at breast height (DBH), basal area and important value index. The vertical structure of the forest was described using the International Union for Forestry Research Organization (IUFRO) classification scheme following (Lamprecht, 1989). The scheme classifies the storey into three simplified vertical structures: upper storey (trees with more than 2/3 height of the top); middle storey (trees with height between 1/3 and 2/3 of the top height) and lower storey (trees with height less than 1/3 of the top height). Density and basal area values were calculated for all tree species and described on hectare basis. The diameter at breast height (DBH) was classified into five classes and the percentage distribution of individuals in each class was calculated. Tree height was also classified into eight classes and percentage distribution of individuals in each class was computed.

The analysis of population structure of all tree species was expressed in density of individuals per hectare against the already established DBH classes. The results of population structure of the tree species were then interpreted as an indication of variations in population dynamics. The regeneration status of the tree species were grouped and summarized based on their seedling density ha^{-1} of species across all quadrats.

RESULTS AND DISCUSSION

Vertical structure

Anbesa Chaka lowland bamboo forest was covered by the most dominant bamboo species called *Oxytenanthera abyssincia* in lower storey and the middle stratum under scattered trees. Underneath the bamboo there was a layer of herbs mostly consisting of *Guizotia scabra* and *Desmodium gangeticum* and grasses which included *Hyparrhenia cymbaria, Hyparrhenia dissoluta* and *Loudetia arundinacea*, with a ground layer of bamboo leaf litter. The mean height of lowland bamboo species was about 9 m and it was accompanied by small trees such as *Albizia malacophylla, Syzygium guineense, Terminalia laxiflora*, *Combretum molle* and shrubs largely dominated by *Acanthus pubescens*. Large individual trees included *Ozoroa insignis* and *Olea welwitschii* protruding from the dense bamboo layer and constituting the upper layer of the forest.

The result of the study indicated that the highest tree species density (63.4%) was found in the lower storey (Table 1). The trees found in this layer and absent in the middle as well as the upper storey, contributed about 10% of the tree species in the height class. These species included *Boswellia papyrifera, Combretum collinum, Dombeya quinqueseta, Pterocarpus lucens, Ziziphus mucronata* and *Maytenus senegalensis* and occupied only the lower storey in the forest. The restriction of these species distribution within this storey class may be due to the inherent habit of the species, anthropogenic activities or the bamboo lower storey favored these shade-tolerance tree species able to respond to gaps in the canopy.

The middle layer (storey) accounted for 35% of the tree species in the height class. It was only 1.6% of the individuals which were found in upper layer. These were *Syzygium guineense, Ozoroa insignis* and *Olea welwitschii*.

The lower and the middle storeys attained highest number of species compared to the upper storey (Table 1). Similarly, the ratios of individual trees to species of the lower and the middle storeys was greater than the ratio obtained for the upper storey, i.e., those species in the lower and middle storeys, on average, were represented by many individuals whereas those in the upper storey was represented by one or two individuals.

Table 1. Density, species number and ratio of individual trees by storey.

Storey	Density No of stem/ha	%	Species number	%	Ratio of individuals to species
Upper	4.60	1.60	3	6.10	1.7:1
Middle	98.2	35.0	18	36.7	5.5:1
Lower	177.9	63.4	28	57.2	6:4

Tree density

A total of 786 individuals of tree species with a corresponding density of all tree species whose DBH more than 2.5 cm in Anbessa Chaka lowland bamboo forest was about 281 stems hectare. The density of the lowland bamboo (*Oxytenanthera abyssinica*) was ca. 8650 culms ha^{-1}. A few species of trees were found to dominate the density of the vegetation of the study area. The ratio of density of individuals with DBH more than 10 cm to density above 20 cm DBH showed size class distribution (Grubb *et al.*, 1963). The densities of tree species with DBH above 10 cm were found to be 120.3 and those with DBH above 20 cm were 115.6 individuals ha^{-1} .The ratio of tree densities with DBH more than 10 cm to DBH above 20 cm was 1.04. The ratio indicated comparable tree density distribution in the lower and higher DBH classes for some species and the larger number of small sized tree individuals for other species in Anbesa Chaka lowland bamboo forest.

Tree height and diameter

The density distribution of individual tree species in different height classes showed a uniform pattern of decreasing number of species with increasing height (Fig. 3). This pattern of height class distribution of the tree species revealed a high proportion of individuals in the lowest height class and few individuals in the largest height class. Generally, density distribution of the tree individuals was found to be inversely proportional to the increasing height classes which show more or less a uniform trend of declining with increasing height. In other words, the population structure was inverted J-shape distribution. This type of distribution showed that the forest was dominated by low-stature individuals.

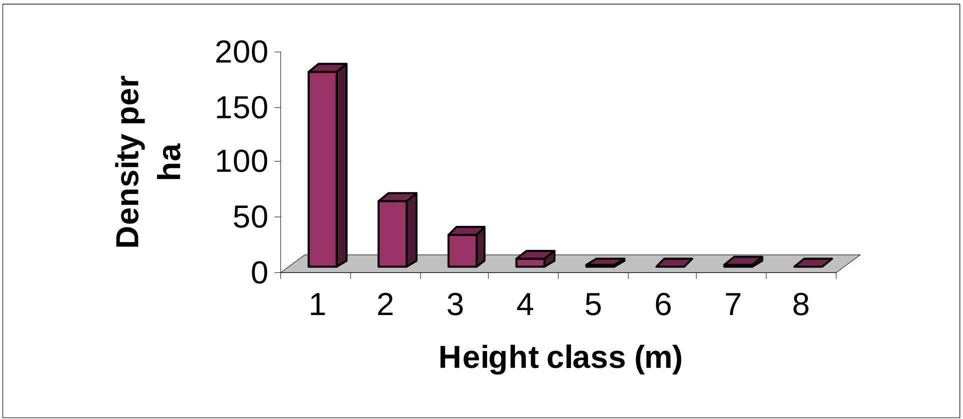

Fig. 3. Tree density distribution by height class; where (1) = 6-9 m, (2) = 9.1-12 m, (3) =12.1-15 m, (4) =15.1-18 m, (5) =18.1-21 m, (6) =21.1-24 m, (7) =24.1-27 m, (8) = > 27 m.

Unlike the density distribution of height classes, the density distribution of tree individuals in the various DBH classes was not uniform in Anbesa Chaka lowland bamboo forest (Fig. 4). The distribution of trees in DBH classes from the first to the second class significantly increased and slightly decreased with the third class and finally decreased in the last two upper DBH classes. This irregular distribution of individuals indicated that the population structure was a bell-shaped pattern which results from selective cutting of lower and higher sized individuals. Thus, the result indicated that the density distribution of individuals by DBH classes and height classes did not coincide in Anbesa Chaka lowland bamboo forest.

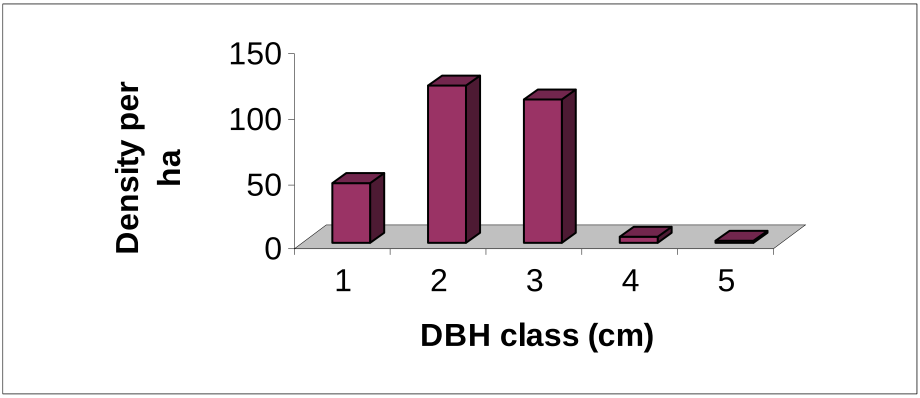

Fig. 4. Tree density distribution by DBH class; where (1) = 2.6-10 cm, (2) = 10.1-20 cm, (3) = 20.1-50 cm, (4) = 50.1-80 cm, (9) = >80 cm.

Frequency

Frequency demonstrates patterns of individuals of one species distribution in a plot. It gives an approximate indication of the homogeneity of the stand under consideration (Kent and Coker, 1992). The frequency of all the tree species in Anbesa Chaka lowland bamboo forest is given in Appendix 1. *Albizia malacophylla* displayed the most frequent tree species with (89%), followed by *Syzygium guineense* (64%), *Terminalia laxiflora* (53%), *Combretum molle* (46%) and *Lannea barteri* (43%). The tree species with the least occurrence were *Acacia sieberiana* (2.9%), *Entada abyssinica* (2.9%), *Securidaea longepedunculata* (2.9%), *Annona senegalensis* (1.4%) and *Sarcocephalus latifolius* (1.4%). The least occurrence of these tree species observed in the forest might indicate that these species were either habitat restricted or their population may be affected by human impact or the bamboo lower storey filtered out these species because of its rapid growth and high degree of dominance.

The frequency gives an idea of approximate indication of the homogeneity and heterogeneity of a stand, too. Lamprecht (1989) stated that high value in higher frequency classes and low value in lower frequency classes indicate constant or similar species composition whereas high value in lower frequency classes and low values in higher frequency indicate high degree of floristic heterogeneity. According to their total frequency expressed as percentage, the tree species of Anbesa Chaka lowland bamboo forest were grouped into five frequency classes. These were: A = 81-100, B = 61-80, C = 41-60, D = 21-40 and E = 0-20. The frequency and % frequency values of each tree species were given in Appendix 1. Only tree species *Albizia malacophylla* belonged to class A (81-100%) and tree species *Syzygium guineense* belonged to frequency class B (61-80%). *Combretum molle*, *Lannea barteri* and *Terminalia laxiflora* were the tree species belonged to frequency class C (41- 60 %) and only *Lonchocarpus laxiflorus* was found in frequency class D (21-40). The lower frequency class (0-20) comprised the remaining species. The frequency class distribution of the individuals showed that about 82.1% of tree species were obtained in the lower frequency class and only 3.6% were occupied by the higher frequency class (Fig. 5). Therefore, the distribution of individuals in different frequency classes revealed the existence of high degree of floristic heterogeneity in Anbesa Chaka lowland bamboo forest.

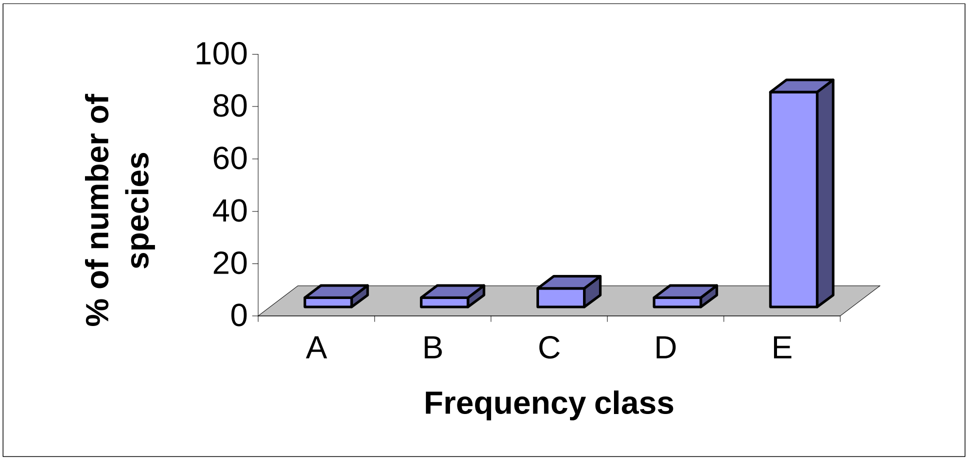

Fig. 5. Frequency distribution of tree species in Anbesa Chaka lowland bamboo forest.

Basal area

The total basal area of tree species for Anbesa Chaka lowland bamboo forest was 12.4 m^2/ha. The total basal area of the lowland bamboo was about 9.5 m^2/ha. The basal area distributions of tree individual species in Anbesa Chaka lowland bamboo forest were analyzed with regard to their DBH classes (Fig. 6). About 58% of the total basal area was distributed in 3^{rd} diameter class (20.1-50 cm). This was due to the abundance of tree species such as *Syzygium guineense*, *Albizia malacophylla* and *Combretum molle*. These individuals accounted for 46.3% of the basal area of the third DBH class. The second highest basal area (17.6%) was contributed by the second diameter class (10.1-20 cm) and the third (15.8%) by the fourth DBH class. The lower and higher diameter classes occupied the least total basal area coverage of the forest i.e., about 9%. The highest DBH class (above 80 cm) possessed few individuals but they accounted for much of the basal area of the forest. One of such trees was *Olea welwitschii* which was represented by few individuals but its contribution to the basal area was high.

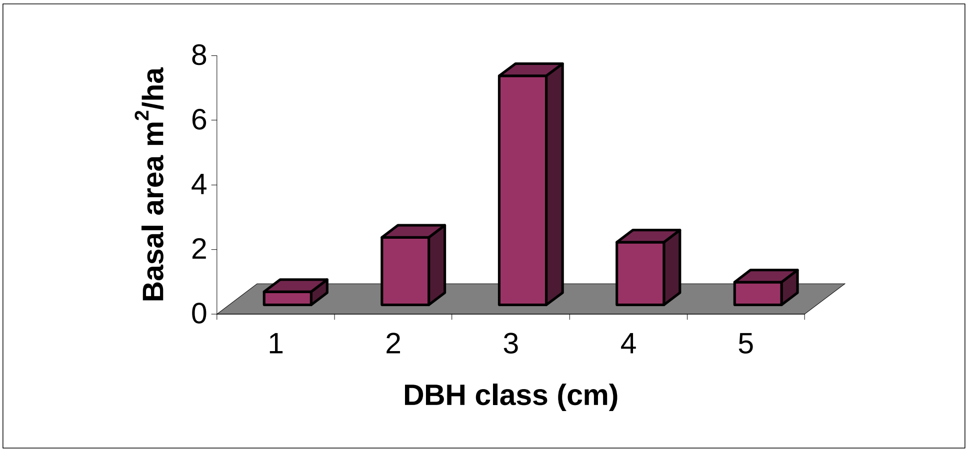

Fig. 6. Basal area distribution of tree individuals over DBH classes in Anbessa Chakalowland bamboo forest; where (1) = 1-10 cm, (2) = 10.1-20 cm, (3) = 20.1-50 cm, (4) = 50.1-80cm, (5) = >80cm.

The normal value of basal area (BA) for virgin tropical rain forest in Africa is 23 - 37 m^2/ha (Lamprecht, 1989). Although bamboo dominated forest is different from virgin tropical rain forest, one could expect less basal area coverage of tree species due to the wide occurrence of lowland bamboo in the study area. Griscom and Ashton (2003) also reported that the average tree basal area was 4.6 m^2/ha in a plot with high bamboo density as compared with 387 m^2/ha in adjacent plots without bamboo in southeastern Peru. The low tree basal area in Anbesa Chaka lowland bamboo forest could be a possible evidence for the dominance of lowland bamboo, the occurrence of relatively few, dispersed and smaller sized trees, shrubs and herbs in the forest or a high disturbance degree of the forest.

Important Value Index

Important Value Index (IVI) reflects the degree of dominance and abundance of a given species in relation to the other species in the area (Kent and Coker, 1992). Thus, species with the greatest importance value can be considered as the most dominant tree species of the forest. Accordingly, *Oxytenanthera abyssincia* was identified as the most dominant species with an important value of 156.22 (Table 2). This species occurred in every plots surveyed. Its dominance was clearly reflected by the highest relative frequency, relative density and relative dominance values of the species. The ranking in dominance was followed by *Albizia malacophylla* (29.19*), Syzygium guineense* (24.78), *Combretum molle* (13.76), *Terminalia laxiflora* (13.30) and *Lannea barteri* (10. 05).

Table 2. The importance value index (IVI) for the 6 ecologically most important species in Anbesa Chaka lowland bamboo forest. (RF = Relative frequency, RD = Relative density, RDom = Relative dominance, IVI = Importance value index).

Botanical name	RD	RF	RDom	IVI
Oxytenanthera abyssincia	96.60	16.24	43.38	156.22
Albizia malacophylla	2.15	14.39	12.65	29.19
Syzygium guineense	1.60	10.44	12.74	24.78
Combretum molle	0.86	7.42	5.48	13.76
Terminalia laxiflora	0.88	8.58	3.84	13.30
Lannea barteri	0.53	6.96	2.56	10.05

Species population structure

The species population structures of the tree individuals in Anbesa Chaka lowland bamboo forest were separately analyzed and presented in Fig. 7. Based on the analyses of density distribution by diameter classes of 18 selected tree species, six generalized patterns of population structures were recognized.

The first pattern (Fig. 7a) showed a J-shaped pattern, a type of density distribution in which there was low number of individuals in the lower diameter classes but increased towards the middle classes as observed in *Combretum molle.* Low stem numbers in smaller size-classes indicate poor recruitment in a given forest site and regeneration does not proceed. Most species under this pattern are less competent to reproduce and hence show poor reproduction and hampered regeneration. The species with this pattern were *Syzygium guineense, Ozoroa insignis, Polyscias farinosa, Anogeissus leiocarpa, Erythrina abyssinica* and *Ziziphus abyssinica.*

The second type (Fig. 7b) revealed bell-shaped, in which the lowest DBH classes have low frequency followed by increase in the number of individuals towards the medium classes, and then a subsequent decrease towards the higher DBH classes. The tree species in this group were *Albizia* *malacophylla, Ficus lutea, Lannea barteri, Terminalia laxiflora, Allophylus rubifolius, Lonchocarpus laxiflorus* and *Pterocarpus lucens.* This pattern showed poor reproduction and recruitment of species, which could be associated with selective cutting and removal of large-sized trees probably for house construction or farm tools, for firewood and household utensils.

The third pattern (Fig. 7c) was one where individuals were represented in the higher DBH classes but were absent in the lower and middle classes. The population structure of *Olea welwitschii* showed this pattern. The pattern indicates poor regeneration due to the prescence of big individuals that have no potential to reproduce. Only *Olea welwitschii* belonged to this type and it inhabited the river side of the study area.

The fourth pattern (Fig. 7d) was one where a species showed diameter class distribution with a progressive increase in the lower DBH classes and then slightly decreased in the middle classes and finally increased towards the higher DBH classes, as represented by *Stereospermum kunthianum.*

The fifth pattern was represented by *Combretum collinum* (Fig. 7e). This group was present only in the first and second DBH classes (2.6–10 and 10.1–20 cm). The species included in this group were *Boswellia papyrifera* and *Dombeya quinqueseta*. There may be selective cutting of the trees in the middle and higher DBH classes for domestic use.

The sixth type (Fig. 7f) was a pattern where few individuals occurred in the lower DBH class 2.6-10 cm and 20.1-50 cm, but were absent in the other classes. The only representative species of this type was *Entada abyssinica.*

Regeneration status of Anbesa Chaka lowland bamboo forest

A total of 28 tree species belonging to 15 families were recorded in the seedling class. The total seedling density was 519 individuals per hectare. These tree species contributed to 18.6% of the total floristic composition of the study area. The understory seedling composition was dominated by *Dombeya quinqueseta*, *Gardenia ternifola*, *Combretum molle*, *Syzygium guineense* and *Boswellia papyrifera* which accounted for 71.2% of the total seedling count. Six tree species were not represented by seedling stage. These were *Entada abyssinica, Ziziphus mucronata, Erythrina abyssinica, Ficus lutea*, *Olea welwitschii* and *Pterocarpus lucens*.

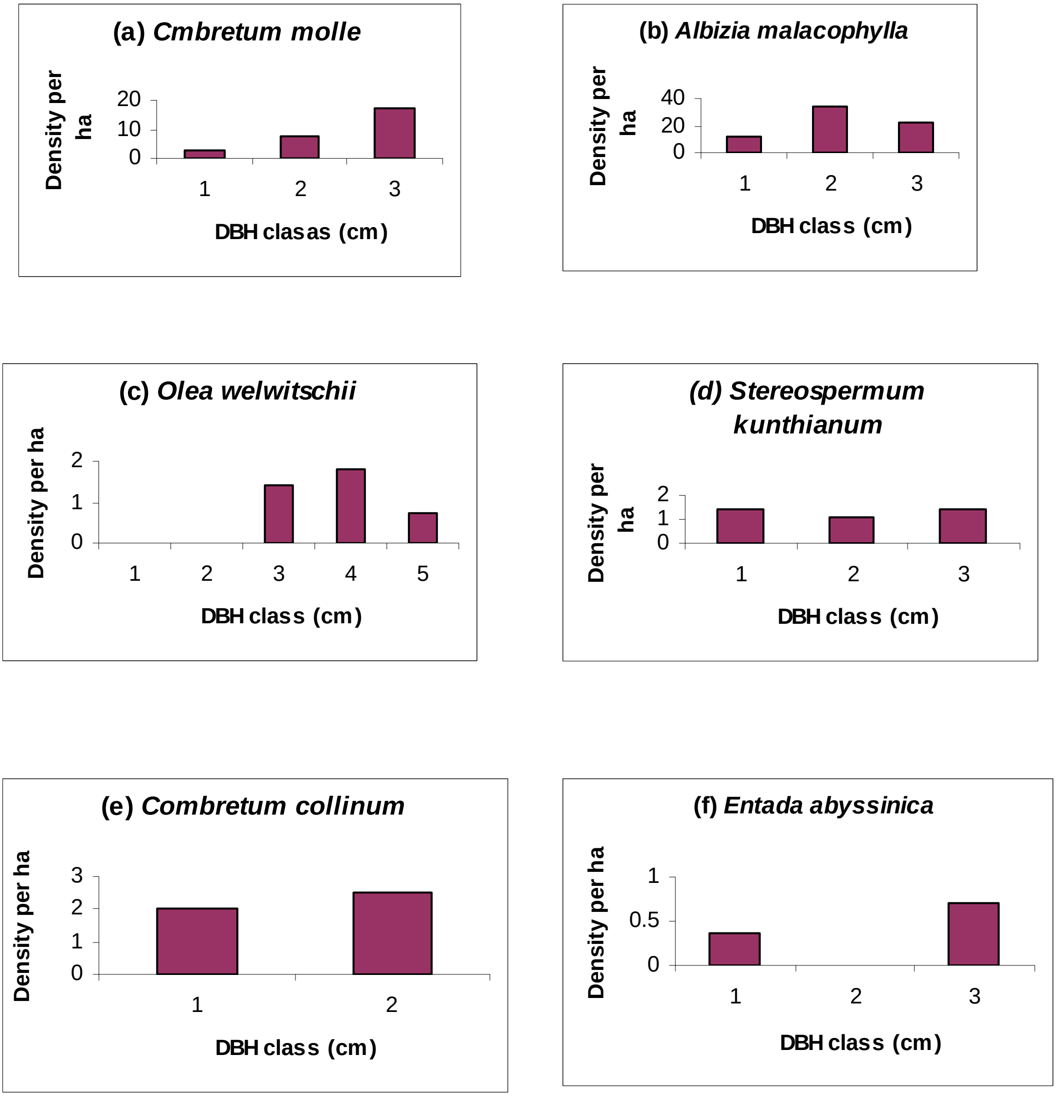

Fig. 7. Representative patterns of species population structure in Anbesa Chaka lowland bamboo forest; where 1 = 2.6-10 cm, 2 = 10.1-20 cm, 3 = 20.1-50 cm, 4 = 50.1-80 cm, 5= >80 cm.

The sapling density of the study area was 550 individuals per hectare. These tree species contributed to 21.2% of the total floristic composition of the forest. The highest sapling density (75%) of the total sapling count was displayed by *Boswellia papyrifera*, *Dombeya quinqueseta*, *Combretum molle*, *Gardenia ternifolia*, *Annona senegalensis* and *Terminalia laxiflora*.

Four species, *Entada abyssinica, Ziziphus mucronata, Sarcocephalus latifolius* and *Acacia sieberiana* were not represented by sapling stage in the forest. *Entada abyssinica* and *Ziziphus mucronata* were absent in the regeneration strata. *Dombeya quinqueseta, Gardenia ternifolia, Combretum molle, Boswellia papyrifera* and *Syzygium guineense* were the most successful in their regeneration systems and this may indicate the greater shade-tolerance ability of these tree species whereas *Entada abyssinica*, *Erythrina abyssinica*, *Ficus lutea*, *Olea welwitschii*, *Pterocarpus lucens* and *Ziziphus mucronata* showed the least.

The ratio of tree species seedlings to mature individuals was (1.82:1); saplings to mature individuals (1.96:1) and seedlings to saplings (0.94:1). The ratios revealed that the distribution of sapling and seedling population was slightly equal and higher than that of mature tree individuals which may be attributed to low disturbance effect and mortality rate on the established sapling and seedling stage. The main subcanopy component in Anbesa Chaka lowland bamboo forest is *Oxytenanthera abyssincia* and its influence on the regeneration status of seedling and sapling of tree individuals was observed during the field study. The density and diversity of tree seedling appeared lowest in dense bamboo plots of the study area and high tree seedling observed on plots which had low bamboo culms density and in open canopy.

The inhibitory effects of bamboos on tree regeneration have been reported in other forests for example, in a mixed hardwood-conifer forests in the Qinling Mountains, China (Wang *et al*., 2006), in lowland terra-firma forests of southwestern Peru (Griscom *et al*., 2007), in a Sub-boreal Forest in Northern Japan (Kubota and Hara, 1996), and in an *Abies faxoniana* forest Wang Lang Natural Reserve, China (Taylor *et al*., 1995). Limited study has been reported regarding inhibitory effects of bamboos on the establishment and development of tree seedling in Ethiopia. Thus, further research is needed to determine whether the presence of bamboo species in bamboo-dominated forest inhibit tree regeneration or not. To apply the regeneration analysis for the conservation priorities, the tree species in the study area were categorized into three classes based on their seedling density ha^{-1} (Table 3). The species under group 1 should get the first priority as they are found without seedlings or possess the least count and those species that fall under the second class need a management consideration for conservation priority.

Table 3. List of tree species under regeneration status classes in Anbesa Chaka lowland bamboo forest, where Class 1 = species without or with 1.0 seedling individuals ha^{-1}; Class 2 = species with seedling density was greater than 1.0 but less than 50 individuals ha^{-1}; Class 3 = species with seedling density was greater than 50 individuals ha^{-1}.

Regeneration status		
Class 1	Class 2	Class 3
Entada abyssinica	*Acacia sieberiana*	*Dombeya quinqueseta*
Combretum collinum	*Albizia malacophylla*	*Gardenia ternifolia*
Erythrina abyssinica	*Allophylus rubifolius*	*Syzygium guineense*
Ficus lutea	*Annona senegalensis*	
Lannea barteri	*Boswellia papyrifera*	
Anogeissus leiocarpa	*Combretum molle*	
Olea welwitschii	*Lonchocarpus laxiflorus*	
Polyscias farinosa	*Maytenus senegalensis*	
Pterocarpus lucens	*Ozoroa insignis*	
Ziziphus abyssinica	*Piliostigma thonningii*	
Ziziphus mucronata	*Sarcocephalus latifolius*	
	Securidaea longepedunculata	
	Stereospermum kunthianum	
	Terminalia laxiflora	

CONCLUSION AND RECOMMENDATIONS

The density and basal area of all tree species whose DBH above 2.5 cm in Anbesa Chaka lowland bamboo forest was about 281 stems ha-^{1} and 12.4 m^{2}/ha, respectively, which implied the occurrence of small and scattered tree individuals that were dominated by the existence of large number of small shrubs and lowland bamboo in the lower canopy of the forest.

The importance value index of species indicated that *Oxytenanthera abyssincia* was the most dominant and ecologically significant species of the study area. *Albizia malacophylla, Syzygium guineense, Combretum molle, Terminalia laxiflora* and *Lannea barteri* were the other dominant tree species of the forest. Such occurrence of a dominant tree species was an indication to the existence of good regeneration condition of the tree species in the forest. The analysis of the regeneration of tree species showed some of the individual species were in poor regeneration condition, while others were relatively in good condition. Accordingly, those species whose regeneration status falls under class 1 need conservation measures.

Size class description of the forest indicated that the density distribution of individual tree species were of comparable distribution in the lower and higher diameter classes for some species individuals and preponderance of small-sized individuals distribution for others in the forest.. Height class distribution of the tree species revealed a high proportion of individuals in the lowest height class. This could be attributed to a good stage of regeneration and recruitment of the forest. The tree species population structure revealed variability in population structure, which implied vegetation dynamics within the forest.

The activity needed to promote the conservation and sustainable use of lowland bamboo forest will depend on the status of bamboo resources and the nature of the threat. Hence, arrangement of options needs to be considered to address their potential to contribute in ecology and biodiversity conservation; their potential to improve the livelihood of forest-dwelling peoples and their potential for participatory forest management.

The following actions should be taken to address the problems of Anbesa Chaka lowland bamboo forest.

- Establish protected areas devoted to the conservation of lowland bamboo and the species dependent on it.
- Steps should be taken to develop appropriate methods for assessing bamboo resources and to develop an effective management information system on bamboo resources.
- Build up intensive educational programs to create awareness of the local community on the need to conserve, and sustainable use of bamboo forest.

ACKNOWLEDGEMENTS

Funding support from Department of Biology, the School of Graduate Studies of Addis Ababa University and Institute of Biodiversity Conservation (IBC) is gratefully acknowledged.

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Appendix 1. Frequency distribution of tree species in Anbesa Chaka lowland bamboo forest

No	Tree Species	Freq	% Freq	RFR
1	*Acacia sieberiana*	2	2.85714	0.55402
2	*Albizia malacophylla*	62	88.5714	17.1745
3	*Allophylus rubifolius*	10	14.2857	2.77008
4	*Annona senegalensis*	1	1.42857	0.27700
5	*Anogeissus leiocarpa*	13	18.5714	3.60110
6	*Boswellia papyrifera*	8	11.4285	2.21606
7	*Combretum collinum*	12	17.1428	3.32409
8	*Combretum molle*	32	45.7142	8.86426
9	*Dombeya quinqueseta*	9	12.8571	2.49307
10	*Entada abyssinica*	2	2.85714	0.55401
11	*Erythrina abyssinica*	10	14.2857	2.77008
12	*Ficus lutea*	8	11.4285	2.21606
13	*Gardenia ternifolia*	3	4.28571	0.83102
14	*Lannea barteri*	30	42.8571	8.31024
15	*Lonchocarpus laxiflorus*	15	21.4285	4.15512
16	*Maytenus senegalensis*	3	4.28571	0.83102
17	*Olea welwitschii*	4	5.71428	1.10803
18	*Ozoroa insignis*	9	12.8571	2.49307
19	*Piliostigma thonningii*	9	12.8571	2.49307
20	*Polyscias farinosa*	13	18.5714	3.60110
21	*Pterocarpus lucens*	7	10.0000	1.93905
22	*Sarcocephalus latifolius*	1	1.42857	0.27700
23	*Securidaea longepedunculata*	2	2.85714	0.55401
24	*Stereospermum kunthianum*	7	10.0000	1.93905
25	*Syzygium guineense*	45	64.2856	12.4653
26	*Terminalia laxiflora*	37	52.8571	10.2493
27	*Ziziphus abyssinica*	3	4.28571	0.83102
28	*Ziziphus mucronata*	4	5.71428	1.10803
	Total	361		100

(Freq= frequency, %Freq = % frequency, RFR= relative frequency)