



# Floristic Composition and Diversity of Woody Plant Species of Wotagisho Forest, Boloso Sore Woreda, Wolaita Zone, Southwest, Ethiopia

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## To cite this article:

Dikaso Unbushe Gojamme, Tesema Tekle Tanto. Floristic Composition and Diversity of Woody Plant Species of Wotagisho Forest, Boloso Sore Woreda, Wolaita Zone, Southwest, Ethiopia. *International Journal of Natural Resource Ecology and Management*. Vol. 1, No. 3, 2016, pp. 63-70. doi: 10.11648/j.ijnrem.20160103.11

**Received:** June 4, 2016; **Accepted:** June 16, 2016; **Published:** August 2, 2016

**Abstract:** The study was conducted on Wotagisho forest in Boloso Sore Woreda, Wolaita Zone, and Southwest, Ethiopia, to determine the floristic composition, vegetation structure, community type, and regeneration and conservation status of woody species. Systematic sampling method was used to collect data from 50 quadrats (20m x 20m) established along transects. Analysis on the structure of the forest indicated that the forest was not under good regeneration status. Anthropogenic activities carried out in the area such as cattle overgrazing, cutting of tree for fire wood, charcoal and house construction were the major threats to the forest. Therefore, it is recommended that timely measures should be taken by all stakeholders to sustain utilization of vegetation of the study area.

**Keywords:** Plant Community, Species Diversity, Vegetation Composition

## 1. Introduction

Ethiopia has the fifth largest flora in Africa and the flora is heterogeneous and has rich endemic elements owing to the diversity in climate. It has estimated to contain between 6,500-700 species of higher plants, of which about 12% are endemic [1]. Due to the wide variation in climate, Geology and terrain working on different time scale [2].

The Ethiopian vegetations, particularly the forest resources are under severe pressure as a consequence of inhabitants, the need for more farmlands and grazing lands. There is a severe and increasing fuel wood gap in the country which leads to depletion of the standing stock and hence, further degradation of the remaining forest stands [3]. The major threats to the conservation of the Ethiopian vegetation are intensive use of forest lands for agriculture and livestock, need of fuel wood and construction materials, forest fires and human settlement [4]. These major causes of forest destruction are very much interrelated and most are ultimately initiated by the rapid population growth in the country. Ethiopian has rapidly growing human population of about 86 million [5] which largely dependent on low-productivities and rain-fed agriculture and over 105.92

million livestock population computing for land and forest resources [5]. This created high rate of deforestation and forest degradation as important problem in the country [6]. Today the forest coverage of Ethiopia is less than 3% compared with an average of 20% for sub-Saharan African [7]. Reduction in forest cover has number of consequences including soil erosion and reduced capacity for watershed protection with possible flooding, reduced capacity and loss of biodiversity [8]. This leads to instability of ecosystem and reduced availability of various forest products and services [6].

The depreciation of the natural vegetation in many parts of the country has also led to the threat and decline in number and distribution of many plant species [9]. The important influential environmental factors affecting vegetation distribution and patterning in Ethiopia include altitude, climate (precipitation and temperature), land degradation due to unsustainable land use practices [10] soil type and the interaction of all these factors [11]. Soil water availability is also considered key factor for the generation, survival and growth of seedling community [12]. Many scholars also agree that the forest of Ethiopia become decreasing from time to time due to anthropogenic activities [13, 14].

Botanical assessment such as floristic composition and

structure studies are essential in view of their value in understanding the extent of plant diversity in forest ecosystem [15]. Knowledge of Floristic composition and structure of forest reserves is also useful in identifying important elements of plant diversity, protecting threatened and economic species, and monitoring the status of the forest [16, 17]. Thus, the study of floristic composition and structures of tropical forest became more imperative in the face of the increasing threat to the forest ecosystem. Even though Wotagisho forest provide ecological services and socioeconomic value to local community, awareness and knowledge on sustainable use and management of the forest recognized to be very less. Therefore, the accurate data on the forest resource is essential requirement for forest

management and planning with the context of sustainable development [18]. No such study has been conducted on the floristic composition and diversity of woody plant species of Wotagisho forest. Currently, intensive use of land for agriculture and high demand of wood for different purpose are leading factors to loss of the plant species [19]. Therefore, this study is initiated to provide primary information on floristic composition and species diversity so as to generate data that would be used in the future management of the forest.

## 2. Materials and Methods

### 2.1. Description of Study Area

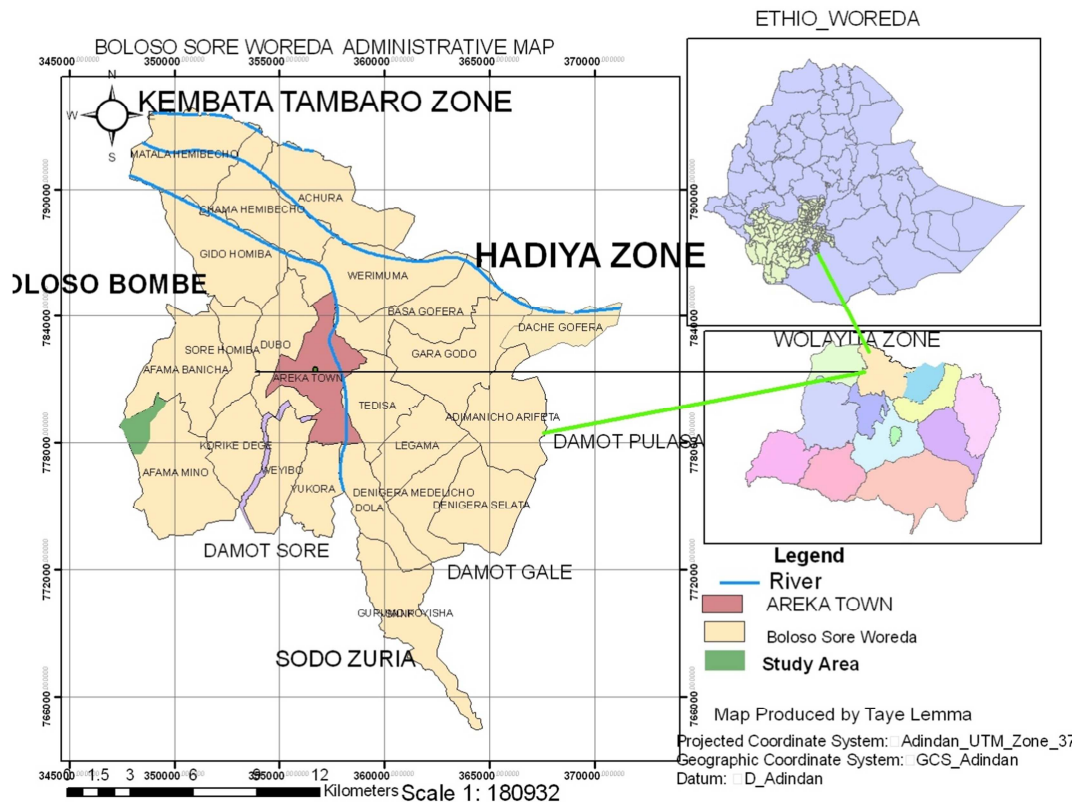


Figure 1. Map of study area [20].

The study area (Figure 1) is located in Wolaita zone, Southern Nation Nationalities People Region. It is about 439 km away from capital city of Ethiopia. Geographical location of the study area is 3507'N longitudinal and 7780'E latitude and at elevation of 2463 m.a.s.l [20]. There are three agro climatic regions in the area namely Dega, Woinadega and Kola. The study area has two rainy seasons with average annual Rain fall of 533.6mm and the major rain season is from July to September. The annual average temperature of the study area is 22°C and the minimal and maximal temperature is 8°C and 14.9°C respectively [20]. The study area is mainly predominated by clay soil types.

### 2.2. Sampling Design

Systematic sampling technique was used to collect vegetation data [21, 22]. Sampling sites were arranged along

transects which were laid at a distance of 1000 m from each other. Along each transect, sample plots of 20 m x 20 m were taken at distance of 200 m from each other. A total of 50 quadrats were laid for vegetation data collection. Five 2 m x 2 m sub plots, one at each corner and one at the centre of the main plot were laid to collect seedling and sapling data.

### 2.3. Data Collection

#### 2.3.1. Floristic Data Collection

Every plant species encountered in each quadrat was recorded using local name (vernacular names). For those species difficult to identify and give scientific name in the field, plant specimen were collected, pressed and brought to the national herbarium of Ethiopian, Addis Ababa University for taxonomic identification using published volume of the flora of Ethiopia and Eritrea [23, 24, 25]. The cover abundance data

for all species was visually estimated and later converted to the modified 1- 9 Braun-Blanquette scale [26].

### 2.3.2. Structural Data Collection

The tree density, diameter at breast height (DBH), frequency, dominance, basal area and IVI were measured, recorded and used for description of vegetative structure. Trees with eight >2 m and diameter at Brest Height (DBH) >2 cm were measured for tree and shrubs and. DBH measurement was taken at about 1.3m from the ground using measuring tape. Seedling and saplings of trees and shrubs were counted to estimate the regeneration status of the forest.

### 2.3.3. Environmental Data Collection

The altitude of each quadrates was recorded by using global position system (GPS) (Garmin 12 Chanel GPS) and geographical coordinates were measured using (Magellan GPS315) and slope degree (using Suunto clinometers), in the middle of the main plots. Engineering compass was used to measure direction and aspect of plots. The type of disturbance were also visually evaluated and recorded for each plot. Disturbance could be grazing, fire wood collection, charcoal making.

## 2.4. Data Analysis

### 2.4.1. Floristic Data Analysis

The covered abundance data defined as the proportion of an area quadrat covered by every species was estimated from each quadrat was converted to Modified 1-9 Braun-Blanquette scale [26]: 1=rare, generally one individual; 2=Occasional with less than 5%; 3=abundance with less than 5%; 4=very abundance with less than 5%; 5=5-12%cover; 6=12.5-25%cover; 7=25.5-50%cover; 8=50.5-75% cover and 9=above 75%.

### 2.4.2. Plant Community Classification

Hierarchical cluster analysis was conducted to identify vegetation samples that are similar in terms of their woody species composition. The cover abundance data of species were used for the analysis. The plant community types were named after two or three dominant species selected using the relative magnitude of their mean cover abundance values.

### 2.4.3. Plant Diversity

Shannon Wiener diversity index and species richness were computed using mean cover abundance value of species [22]. Shannon Wiener diversity index is calculated as followed as

$$H' = - \sum_{i=1}^S P_i \ln P_i \quad (1)$$

Where H=Shannon Wiener diversity index, S=the number of species,  $P_i$ =the proportion of individuals or the abundance of  $i^{th}$  specie and  $\ln$ =log base

Shannon equitability (J) or evenness is calculated as follow as

$$J = H/H_{MAX} = H/\ln S \quad (2)$$

Where, J=evenness, H=Shannon-wiener diversity index and  $H_{max} = \ln S$ =the natural logarithm of the total number of species and S=total number of species in the sample.

Sorensen's similarity ( $S_s$ ) coefficient was used to compare similarities among plant community types.

$$S_s = 2a/(2a+b+c) \quad (3)$$

Where:  $S_s$ =Sorensen's similarity coefficient, a=Number of species common to both samples, b=Number of species present in sample one and absent in sample two, c=Number of species present in sample two and absent in sample one.

### 2.4.4. Plant Population Structure Data Analysis

The tree density, diameter at breast height (DBH), frequency and dominance were analyzed using grouped classes as used by [27]. Relative density, relative frequency, relative dominance, important value index (IVI) and basal area were calculated to determine the vegetation structure and the dominant species of the forest using formulas deployed by [22].

## 3. Results and Discussion

### 3.1. Species Composition

Fifty one species of plants belonging to 47 genera and 31 families were recorded from the study area. The floristic composition contributed by shrubs and trees was 65% and 35% respectively (Figure 2). The most dominant families were Solanaceae, Euphorbiaceae, Moraceae, Vitaceae, Rubiaceae, Asteraceae, Fabaceae, Apocynaceae and Rutaceae. Myrtaceae, Moraceae, Fabaceae and Combretaceae were the families with higher economic values such as charcoal and timbers production.

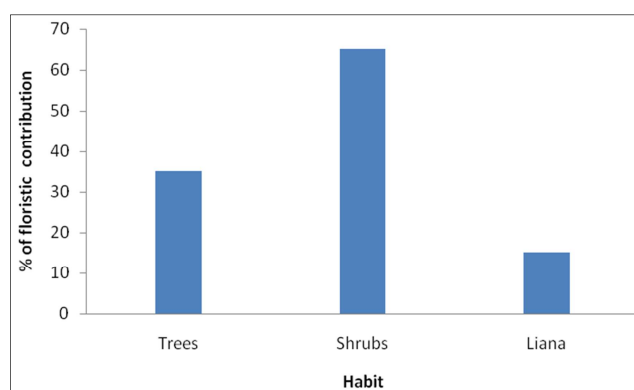


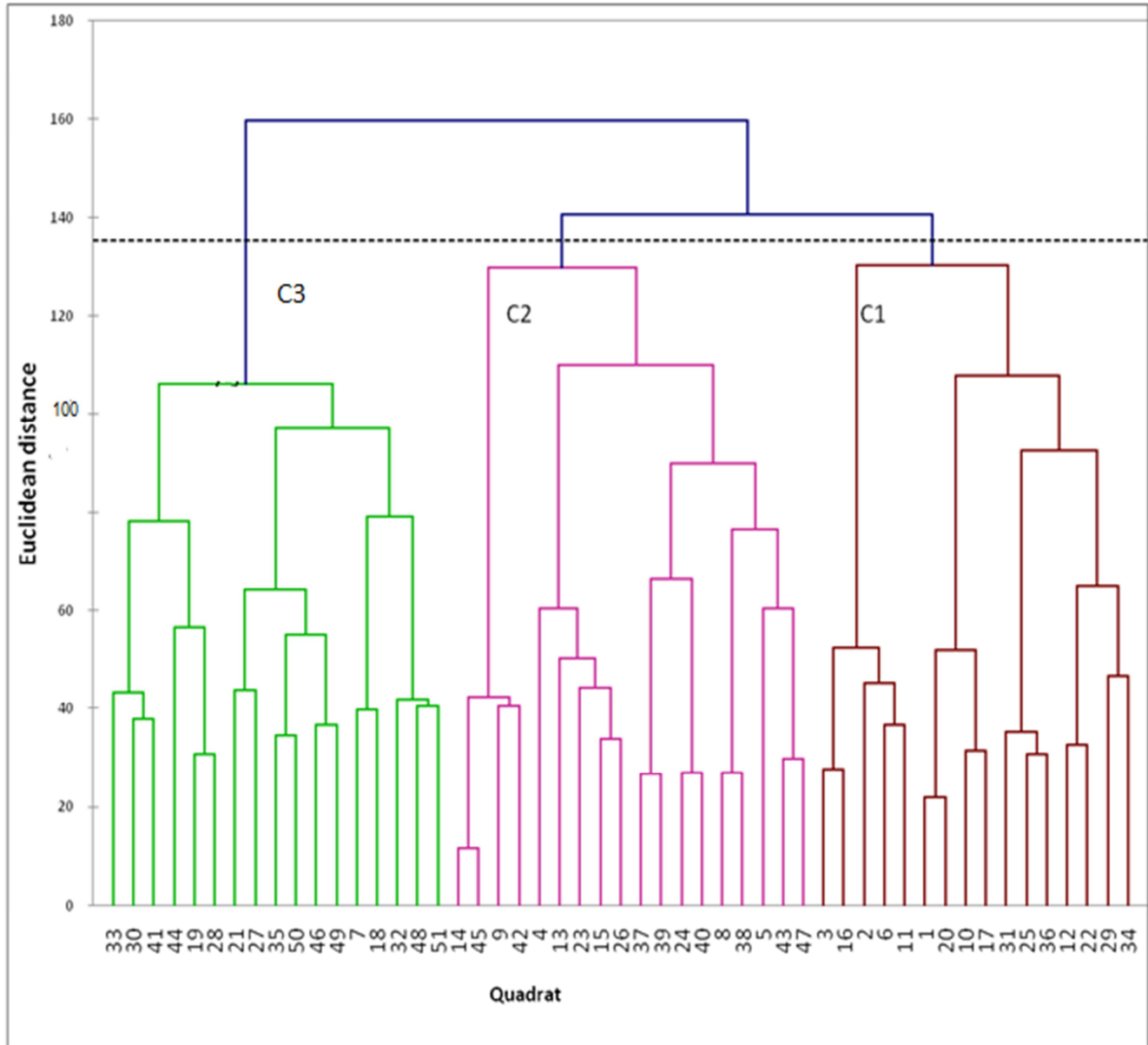
Figure 2. Habit of plant species in the forest.

### 3.2. Plant Community Types

Three plant community types were produced from cluster analysis (Figure 3). Each community was named after two dominant species within the group [28]. The dominant species were those with highest mean cover- abundance value for a given community (Table 1). The first community type, *Maytenus gracilipes*-*Gnidia glauca*, was found at altitudinal gradient between 2077 m -2099 m. This

community types was rich in plants with woody habits. The dominant tree species include *Syzygium guineense*, *Ficus sur*, *Bersama abyssinica*, *Flacourtia indica*, and *Schrebera alata*. The second community type, *Schrebera alata*-*Syzygium guineense*, was found at altitudinal range of 2077m - 2137m. The dominant tree species in this community were *Schrebera*

*alata*, *Syzygium guineense*, *Acacia hockii*, *Albizia schimperiana* and *Croton macrostachyus*. The third community type, *Combretum aculeatum*-*Flacourtia indica*, was found at altitudinal range of 2002m – 2132m. The dominant tree species include *Myrsine africana*, *Combretum aculeatum* and *Syzygium guineense*.



Where C1=community 1, C2=community 2, C3=community 3)

**Figure 3.** Denderogram that represent plant Community types of Wotagisho forest.

### 3.3. Species Diversity and Richness

The least numbers of species were recorded in the community two (i.e. 16 species) and the highest numbers of species were recorded in community three (i.e. 26 species). On the other hand, community type three was the most diverse and had the highest number of individual with medium even distribution. Community type two had highest even distribution but with the least number of individual with least diversity value compared with the other

communities. Community type one had the medium number of individuals with least even distribution when compared with the other communities. Shannon-Wiener diversity, species richness, evenness of communities was given in Table 2. The possible reason for variability of each value between each community type could be difference in number of species, cover abundance values, degree of disturbance, the slope of the quadrats in the community and other related factors.

**Table 1.** Top five plant species with the highest mean cover abundance values for community types.

S/n	Community types					
	C1		C2		C3	
	Scientific name	Mean Cover	Scientific name	Mean Cover	Scientific name	Mean Cover
1	<i>Maytenus gracilipes</i>	2.8	<i>Schrebera alata</i>	2.8	<i>Combretum aculeatum</i>	1.5
2	<i>Gnidia glauca</i>	2.5	<i>Syzygium guineense</i>	2.3	<i>Flacourtia indica</i>	1.3
3	<i>Syzygium guineense</i>	1.9	<i>Bersama abyssinica</i>	1.2	<i>Cordia africana</i>	1.2
4	<i>Cordia africana</i>	1.8	<i>Combretum aculeatum</i>	1.2	<i>Rytigyni neglecta</i>	1.2
5	<i>Schrebera alata</i>	1.8	<i>Flacourtia indica</i>	1.2	<i>Carissa edulis</i>	1.2

**Table 2.** Shannon-Wiener diversity, species richness, evenness of plant communities and altitudinal ranges.

Community type	Species richness	Species evenness	Diversit (H)	Altitudinal range (m)
C1	18	0.93	2.70	2077-2099
C2	16	0.96	2.66	2077-2137
C3	26	0.95	3.10	2002-2132

### 3.4. Similarity Among the Plant Community Types

Community type 1 and 2 had the highest similarity ratio (Table 3). This was probably due to similarity in altitudinal range and the existence of most quadrats adjacent to each other that show similar adaptation mechanisms and requirements for species occurring in those communities. Hence, they may have more common species. The least similarity ratio was exhibited by community type 1 and 3. They may have few more common species because of variation in slope and other environmental factors such as soil type.

**Table 3.** Sorenson's similarity among three plant communities.

Community type	C1	C2	C3
C1	1.00		
C2	0.862	1.00	
C3	0.573	0.621	1.00

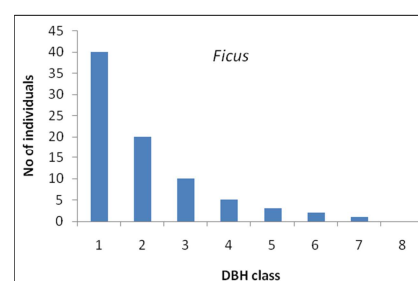
### 3.5. Vegetation Structure

#### 3.5.1. Density and Diameter at Breast Height (DBH)

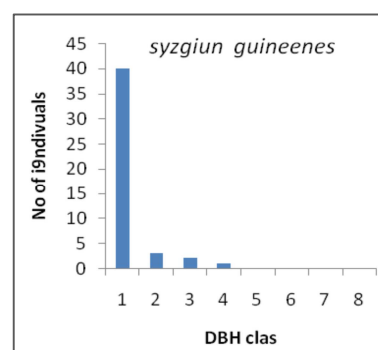
The highest density (210.792/ha) of woody plant species was observed for DBH class 26 to 50cm and the lowest density (76.208/ha) of woody species was observed in DBH class 51 to 60) which was considered as trees or shrubs. The density of plant species with DBH class as their contribution of the numbers of species were given in Table 4. The density of woody plant species increases with increasing number of species. So the general pattern of DBH class size distribution forms an irregular inverted J-shape (Figure 4) for the most selected dominant trees species. This might be associated with selective cutting of trees by people for construction and other house use.

**Table 4.** DBH class and the density of plant species in the forest.

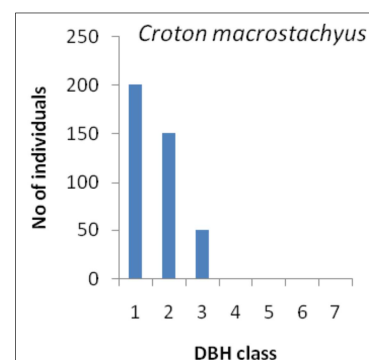
class	DBH incm	Density/ha	Total no of species	Percentage
1	1-15	160.76	8	19
2	16-25	166.5	9	19.7
3	26-50	210.792	20	35
4	51-60	76.208	3	5
5	61-80	170.52	11	21.5



(a)



(b)



(c)

**Figure 4.** The DBH class distribution of selected trees: *Ficus* (a), *Syzygium guineense* (b) and *Croton macrostachyus* (c).



### 3.5.2. Basal Area

Total basal area of all tree species distributions from Wotagisho forest was found to be 45.14 m ha<sup>1</sup>. The highest basal area value of the forest was contributed by *Syzygium guineense* (41%). Other large trees in this forest include *Teclea nobilis* which contributed (16%), *Hypericum revolutum* (5.5%) and *Croton macrostachyus* (5.6%).

### 3.5.3. Dominant Plant Species

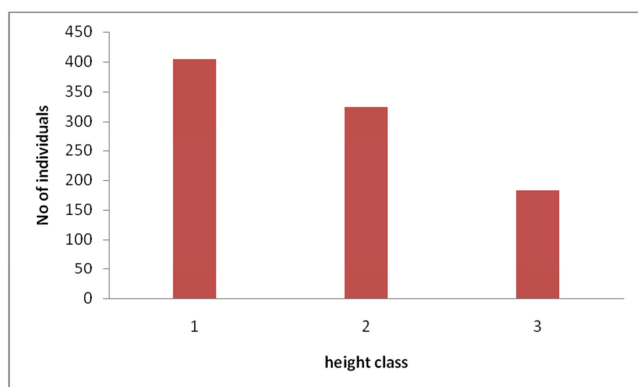
From 51 total plant species, the most relatively dominant species in Wotagisho forest was *Syzygium guineense* which contributed 75% followed by *Schrebera alata* which contributed 40% and *Maytenus gracilipes* which contributed 31% (Table 5). But the least dominant species was *Ficus sur* which contributed 5% followed by *Podocarpus falcatus* which contributed 2% the total species.

**Table 5.** The dominant plant species with their relative percentage contribution from Wotagisho forest.

Plant species	Total basal area	Dominance	Relative dominance	percentage
<i>Syzygium guineense</i>	63.59	54.6562	10.971	75
<i>Schrebera alata</i>	1.987	30.33	5.186	40
<i>Maytenus gracilipes</i>	31.17	28.15	5.6521	31

### 3.5.4. Height Class of Tree Species

The trees in study area were divided into three arbitrary height classes. The percentage of tree decrease with increase in height class (that is the highest percentage of tree was found in the height class 1, but, the least percentage of trees was found in height class 3). In other words, the numbers of individuals in height class decrease with increase in height range. The general height class distribution pattern (Figure 5) indicates a normal distribution of species and maximum values occurred in the first class and reduced gradually up to the third class. This pattern represents good reproduction status and regeneration potential.

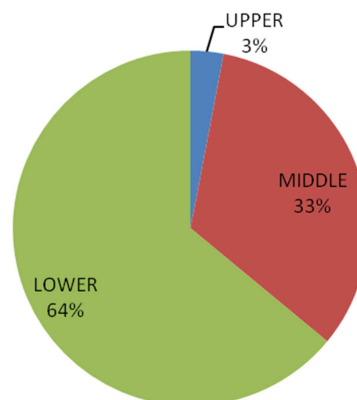


**Figure 5.** Height class distribution and number of individuals/ha of woody species in the forest.

### 3.5.5. Vertical Structure of Wotagisho Forest

The vertical stratification of the tree in the study area was examined using IUFRO classification scheme [30]. According to this scheme, tree with height above 2/3m top height represent upper story, tree with height between 1/3 and

2/3 represent middle story and tree with height <1/3 represent lower story. Therefore, vertical stratification of the tree in the study area represent mainly lower story which is 64% of the individuals (Figure 6).



**Figure 6.** Percentage of trees in lower, middle and upper story.

### 3.5.6. Important Index Value (IVI)

The highest IVI value was contributed by *Syzygium guineense* and the lowest IVI value by *Maytenus gracilipes* (Table 6). As indicated in IUFRO classification scheme [29], IVI value is used for comparison of ecological significant of species in which high IVI values indicate that the species structure in the community is high

**Table 6.** IVI value of plant species in Wotagisho forest (RD: relative density, RF: relative frequency, RD: relative Dominance; IVI: important index value).

Species name	RD	RF	RD	IVI
<i>Maytenus gracilipes</i>	5.7035	3.065	5.6521	14.4205
<i>Syzygium guineense</i>	11.0812	2.6656	10.971	24.7187
<i>Rhoicissus revoli</i>	4.7683	8.889	4.720	18.3773
<i>Gnidiaglauca</i>	8.3277	5.1086	8.2455	21.6818

### 3.5.7. Regeneration Status of Vegetation

From 5 woody species recorded in the area, seedling covered about 25% and sapling covered about 15%. However, 45% of the species have neither seedling nor saplings. Therefore, management and conservation priority should be given for the species with no seedling and sapling in the forest [12].

## 4. Conclusion and Recommendation

The major families identified in the study area include Solanaceae, Euphorbiaceae, Moraceae, Vitaceae, Rubiaceae, Asteraceae, Fabaceae, Apocynaceae, Rutaceae and Fabaceae. The families with highest floristic composition contribution were made by Myrtaceae followed by Flacourtiaceae. Three plant community types were distinguished from Wotagisho forest.

The highest IVI value was contributed by *Syzygium guineense* and the lowest IVI value by *Maytenus gracilipes*. *Syzygium guineense* also contributed the highest basal area of the forest. Almost all density of stems was found in the lower

and middle storey (97%) but the upper storey was represented by the lowest density of stems. Based on structural description of DBH and Height class distribution in the forest, similar trends have been shown in both diameter and height. The density of woody species decreases with increasing DBH and height indicating the predominance of small-sized individuals in the forest. This implies that larger trees in the forest were under pressure due to overexploitation for different purposes. The major anthropogenic activities observed in the area include cattle overgrazing, cutting of tree for fire wood and house construction and cutting of tree for production of charcoal all of which have negatively influenced the vegetation dynamic and tree density of the forest. Therefore, it needs effective management intervention to sustain products and services from the forest. Therefore, based on this gap the following recommendations were forwarded.

1. Raising awareness of local communities on the value of forest resources and ecological consequences of deforestation
2. Creating participatory forest management by which human impacts can be minimized through discussion and consultation with the local communities
3. Sustainable protection and management of the forests needed through the collaborative effort of the government, NGO and the local community for reduction of tree cutting and production of charcoal.
4. Detail ecological studies are very important concerning the distribution of the possible plant community type in relation to edaphic factors, which were not the subject of this study.

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