Vegetation Composition in Hugumbirda-Gratkhassu National Forest Priority Area, South Tigray

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ABSTRACT

The floristic composition and structure of the vegetation of Hugumbirda-Grat-Khassu forest, South Tigray, Northern Ethiopia is described and related to environmental factors. To analyze the vegetation and environmental data seventy-four relevè (20m x 20m) were used. For each species the cover/abundance value was estimated. Height and diameter at breast height (DBH) of all woody individuals taller than 2 m and thicker than 2 cm were measured. Importance Value Index was calculated for 24 tree/shrub species and the result helped to identify the five dominant tree/shrub species and to show the overall forest situation. The species and relevès were classified with the two-way indicator species analysis program TWINSPAN.

We recorded 102 species belonging to 83 genera and 50 families. Five community types are described: *Allophylus macrobotrys-Ficus sur, Nuxia congesta-Podocarpus falcatus*, *Acacia abyssinica-Olea europaea*, *Myrica salicifolia-Erica arborea-Maesa lanceolata* and *Acacia etbaica- Dichrostachys cinerea-Acacia tortilis* type. Of these, community type 2 has high species richness while community type 3 is poor in species richness. The general arrangement of all species was found to show high density at lower height and DBH classes. Based on the cumulative results of Importance Value Index, *Juniperus procera, Olea europaea subsp. cuspidata, Nuxia congesta, Cassipourea mallosana* and *Olinia rochetiana* were identified to be the most dominant tree species of the forest and they contributed 71.43% of the basal area. Analysis of community-environment relationships didn't show significant differences except for altitude and slope.

Key words: Community, DBH, Floristic composition, Forest structure, Releve, Vegetation classification.

1. INTRODUCTION

It is to be noted that Ethiopia is one of the centres of plant genetic diversity, and that its indigenous forests have been repositories of biodiversity including microorganisms, fungi, soil fauna and flora, medicinal plants, wild animals, birds, insects, as well as human beings (Tewolde Berhane Gebre Egziabher, 1990; Legesse Negash, 2002). According to Zerihun Woldu et al. (2002) and Zewge Teklehaimanot and Healey (2001), Ethiopia is endowed with rich fauna and flora because of its diverse ecological features, which make the country an important centre of diversity and endemism. World Conservation Monitoring Centre (WCMC) (1992) has pointed out that the flora of Ethiopia is very heterogeneous and has a rich endemic element. It is estimated to contain around 6500 to 7000 species of higher plants, of which about 12 percent are endemic (WCMC, 1992). Nevertheless, Zewge Teklehaimanot and Healey (2001) have noted that continued exploitation of natural forests without giving due consideration to their propagation, domestication and cultivation has resulted in a vicious cycle where increased forest destruction has led to increased scarcity and/or rarity of resources which in turn have resulted in increased demand and subsequent further destruction.

Tigray is one of the most environmentally degraded regions in Ethiopia, with very scanty vegetation. At present the original vegetation is found around churches where it is forbidden to cut trees and in other isolated and protected areas (Feoli, 1996). Mitiku Haile and Kindeya Gebremedhin (2000) stated that, misuse of natural resources has resulted in very serious land degradation in most places. The present arable land can no longer support the ever-increasing human population. Generally, it can be said that environmental degradation, drought and socio-economic instability are common in contemporary Tigray.

To conserve the remaining natural forests of Ethiopia and the environment for the genetic resources and raw material for the industries, 58 National Forest Priority Areas (NFPA's) covering an area of 3.6 million hectares have been selected (SFCDD, 1990). However, various studies indicate that protection of these NFPA's has not been effective. The NFPA's failed to fully recognize the historical and customary rights and interests of local communities in forest products and forestlands. Local communities have frequently disregarded the boundaries established by the forestry sector on the notion that boundaries have violated their traditional access to and dependence on the forest resources.

According to Zerihun Woldu et al. (2002) improving the management of the natural resources while providing ecological services and immediate economic needs is the major research and development challenges for the degraded areas of northern Ethiopia in particular and drylands of east Africa in general. Thus, accommodating new conservation approaches such as participatory forest management can contribute significantly to mitigate the problem of forest destruction. The Hugumbirda-Grat-Khassu forest is one of the National Forest Priority Areas (NFPA's), which was identified with the aim to introduce improved management system. However, as the socio-economic study of the area by Zenebe GebreEgziabher et al. (1998) have noted, with high population pressure and the increasing demand for agricultural land, the forest resource is on the verge of complete depletion. Encroachment of forestland and illegal cutting of trees are rampant and consequently the most valuable indigenous tree species as well as wild animals are becoming severely affected in the area. Therefore, in view of the need to develop more effective approaches to conservation and sustainable utilization of the forest resources, an investigation of the floristic composition and the relation to environmental factors was conducted.

1.1. Description of the Study Area

1.1.1. Location

Hugumbirda-Grat-Khassu National Forest Priority Area is located in the southern zone of Tigray at about 600 km north of Addis Ababa or some 160 km south of Mekele, the capital of Tigray Regional State. It is located between 12^0 22' and 12^0 42'N latitude, 39^0 28' and 39^0 40' E longitude (Fig. 1) at an altitudinal distributions from 1560 m to 2688 m.

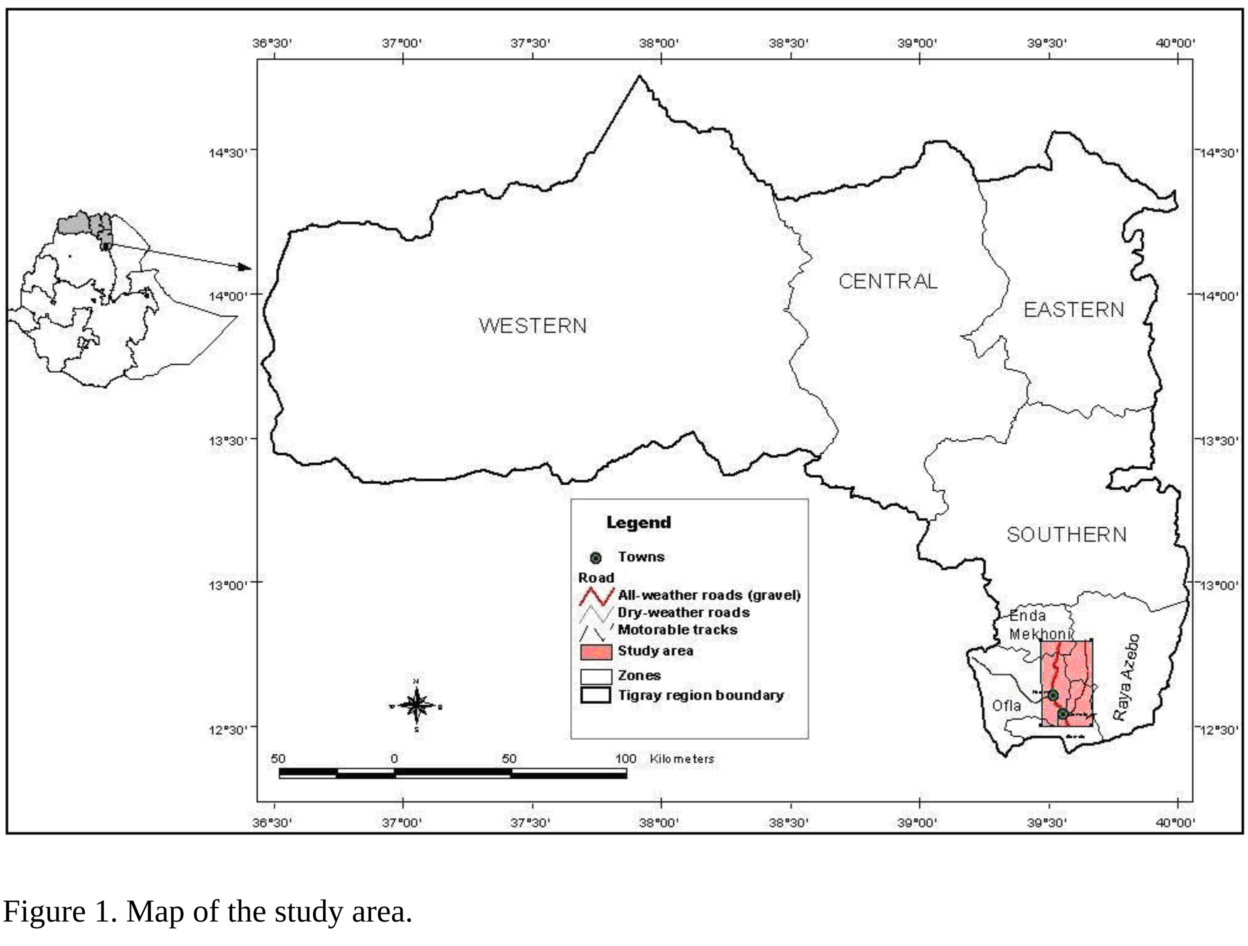

Figure 1. Map of the study area.

1.1.2. Climate

Metrological data of monthly maximum and minimum temperature and monthly rainfall were taken from two stations (Alamata and Korem) for the period 1978 to 2001.One of the nearest metrological station is located in Alamata town at a distance of 5 km from Grat-Khassu. Here the mean annual minimum temperature is 14°C and the mean annual maximum temperature is 29.8°C. The hottest month is June with a mean maximum temperature of 34.3°C, and the coldest is October with a mean minimum temperature of 10.7°C. The mean annual precipitation is 750.9 mm.

The other nearest metrological station is in Korem town. Here the mean annual minimum temperature is 8.8°C and the mean annual maximum is 22.1°C. The hottest month is June with a mean maximum temperature of 24.3°C, and the coldest is December with a mean temperature of 6.1°C. The mean annual precipitation is 998.9mm.

1.1.3. Vegetation

Formerly, the area was covered with dense forest composed of different indigenous species. According to Zenebe Gebre-Egziabher et al. (1998) and information obtained from local informants, the natural forest was exploited by Italian concessionary named Montu Doro who installed sawmills at Hugumbirda in 1950 with the permission of the then governor of Welo province.

The forest was officially put under the auspices of State Forestry Agency in 1965 (SFCDD, 1997). Then in 1981 the area was identified as one of the National Forest Priority Areas (NFPAs). Boundary demarcation, which is the basis for the current management of the forest, was undertaken in 1993. Based on this demarcation, the project covers a total area of 21, 654.24ha. Out of this about 532.75 ha is plantation forest whereas the rest contains disturbed natural high forest, bushes, shrubs, agricultural plots and settlement area.

2. METHODOLOGY

2.1. Botanical composition survey

Vegetation data was collected from 74 sample plots (relevè), size 20mx20m (400m^2) following Kumlachew Yeshitla and Tamrat Bekele (2002) and Tesfaye Awas et al. (2001*)*. During sampling, visually checked homogeneous, representative stands (Werger, 1974; Andreucci et al., 2000) were selected and delimited for sampling.

Plant species found within each relevè were recorded by their vernacular name and their cover/abundance (ground cover) percentage was estimated following the procedure of Braun-Blanquet (Braun-Blanquet, 1965; Muller-Dombois and Ellenberg, 1974). The percent cover values, which are visually estimated in the field, were later converted into 1-9 modified Braun-Blanquet scale (van der Maarel, 1979):

1. Rare-generally only one individual
2. Sporadic (few) –less than 5% cover of the total area
3. Abundant with less than 5% cover of the total area
4. Very abundant and less than 5% cover of the total area
5. 5-12% cover of the total area
6. 12.5-25% cover of the total area
7. 25-50% cover of the total area
8. 50-75% cover of the total area
9. 75-100% cover of the total area

DBH (diameter at breast height) was measured at 1.3m using callipers for shrubs and trees that had a DBH equal or greater to 2cm (Martin, 1995; Tuxill and Nabhan, 2001). Height of trees and shrubs greater or equal to 2m was measured using hypsometer for taller trees and shrubs and measured pole marked at 0.5m intervals and 4m long (Tuxill and Nabhan, 2001;Bongers et al., 1988). The pole is held vertically at the base of the tree/shrub, enabling the observer standing far enough away from it to see the base and the top of the stem. The number of pole length was then counted to estimate the height of the plant. Those plant species having height and DBH less than two are counted by species.

2.2. Environmental data

The environmental variables measured for every stand (relevè) selected include altitude, slope, aspect (exposure), soil depth and estimate of grazing intensity and human impact.

Altitude was measured using an Everest Altimeter, slope was measured using clinometers, and Aspect was determined using Suunnto compass. As a possible indicator of total solar energy, aspect was codified according to Zerihun Woldu et al. (1989). Thus N=0; E=2; S=4; W=2.5; NE=1; SE=3; SW=3.3 and NW=1.3

From the corners and centre of each stand, soil depth was measured using a measured long metal marked at 10cm interval and 1.25m long. Average depth of these measurements was then taken for the stand soil depth. Then nature of the measured depth was determined following Parent (2000). The details are described below.

-<20cm = very shallow

-21-50cm = shallow

-51-100cm =moderate deep

->100cm =deep

Grazing intensity was estimated following Kebrom Tekle et al. (1997) and Zerihun Woldu and Backeus (1991): 0= nil; 1= slight; 2= moderate and 3= heavy.

The state of human interference at each relevè was estimated following Gebremedhen Hadera (2000) and Kumlachew Yeshitla and Tamrat Bekele (2002) and with modifications. A 0-3 subjective scale was taken into consideration to record the presence or absence of stumps, logs and signs of fuelwood collection. Therefore, the magnitude of the impact was quantified as follows

0=nil; 1= low; 2= moderate; and 3=heavy

2.3. Data analysis

2.3.1. Vegetation data

Two-way indicator species analysis, which is a recommended technique for its robustness and effectiveness (Gauch and Whittaker, 1981), was used to classify the vegetation data. TWINSPAN is a divisive polythetic method of vegetation classification; it classifies both relevès and species. The computer program used was the TWINSPAN program (Hill, 1979). The groups obtained were characterized as local plant community types, and described as “type”, which were provisionally characterized by dominating and/or characteristic species, mainly trees and shrubs. A dominating species in this case is a species having a synoptic cover-abundance value (mean frequency x mean cover-abundance) (van der Maarel et al., 1978) of at least five, and a characteristic species having a high frequency in the type and a lower frequency in most other types. The community types identified were further characterized by means of environmental factors, which appeared to be correlated to the floristic composition of the type.

2.3.2. Structural data

The structure of the plants was described in terms of tree density, diameter and height. Tree density was computed by converting the count from the sample plot to a hectare basis. The diameter at breast height (DBH) was classified into 14 DBH classes and the percentage distribution of trees and shrubs in each class were computed. Height was classified into 9 height classes and the percentage distribution of the plants in each class was calculated.

The following parameters and index were calculated to determine the vegetation structure and the dominant species of the forest: for those individual species having DBH greater than 10cm and relative frequency greater than 0.60 %, relative density, relative frequency, relative dominance and importance value index (IVI) (Muller-Dombois and Ellenberg, 1974; Misra, 1974) were calculated using the following formulae:

Relative density = Number of individuals of a species/ Total number of individuals of all species x 100

Relative frequency =Frequency of a species/ Sum frequency of all species x 100

Relative dominance=Basal area of a single species/Total basal area of all species x 100

Importance Value Index (IVI) = Relative density + Relative frequency + Relative dominance.

2.3.3. Environmental data

To get a mean value for the various environmental parameters of each distinct plant community type, the values for all the relevè that make up the particular community type were added and averaged. One-way analysis of variance (ANOVA) was performed to detect variation among the community types with respect to any one environmental parameter. Tukey’s tests were performed to detect significant differences among the different means of the environmental parameters of each community types. The correlation of the various environmental parameters among each other was evaluated by calculating Pearson’s product moment correlation coefficient.

Meteorological data obtained from two stations of the study area were analyzed for mean monthly maximum and minimum temperature and mean monthly rainfall registered for 20 years. Clima diagram was produced from these results.

2.3.4. Voucher Plant Specimen Collection and Identification

Every time a new species was encountered in the relevè, a specimen was collected in duplicate, numbered, dried and placed in a reference collection following standard Herbarium procedures (Bridson and Forman, 1992). The specimens were then identified by comparing them with already identified specimens in the National Herbarium of Ethiopia (ETH) and by referring to Hedberg and Edwards (1989), Edwards et al. (1995), Edwards et al. (1997), Edwards et al. (2000), and Hedberg et al. (2003).

3. RESULTS

3.1. Floristics

A total of 102 species of plants representing 83 genera and 50 families were recorded from the study area (Appendix 1). Of these 24 (23.52%) were trees, 18 (17.64 %) tree/shrub, 47 (46.06 %) shrubs, 2 (1.96 %) shruby herb, 9 (8.82 %) woody climbers (lianas) and 2 (1.96 %) herbs. The comparative distribution of species within the families is given in Table 1.

3.2. Vegetation Classification

Five community types were obtained from the classification out put. Their description based on the dominant and characteristic species having synoptic cover-abundance values greater than one in at least one community type and their altitudinal distribution is as follows.

3.2.1. Allophylus macrobotrys –Ficus sur type

This community is found at altitude from 2215-2246. *Allophylus macrobotrys* is a dominant species and *Ficus sur* is characteristic species of the type. Associated species in the type include *Ekebergia capensis, Teclea simplicifolia, Cassipourea malosana and Nuxia congesta*. Regenerating species of *Grewia mollis, Maytenus undata, Pavetta oliveriana, Vernonia rueppelli* and *Buddleja polystachya* are abundant under the canopy layer. Woody climbers such as

Clematis hirsuta, Cynanchum abyssinicum, Jasminum grandiflorum and *Rhoicissus tridentate* are common in the type.

Table 1. Family-wise percentage distribution of species.

No	***Family***	***Number of species***	***%***	***No***	***Family***	***Number of species***	***%***
1	Acanthaceae	1	0.98	26	Moraceae	2	1.96
2	Anacardiaceae	3	2.94	27	Myricaceae	1	0.98
3	Apiaceae	2	1.96	28	Myrsinaceae	2	1.96
4	Apocynaceae	2	1.96	29	Oleaceae	2	1.96
5	Asclepiadaceae	3	2.94	30	Oliniaceae	1	0.98
6	Asparagaceae	1	0.98	31	Phytolaccaceae	1	0.98
7	Asteraceae	7	6.86	32	Pinaceae	1	0.98
8	Balanitaceae	1	0.98	33	Pittosporaceae	1	0.98
9	Berberidaceae	1	0.98	34	Podocarpaceae	1	0.98
10	Boraginaceae	3	2.94	35	Polygonaceae	1	0.98
11	Cactaceae	1	0.98	36	Ranunculaceae	2	1.96
12	Capparidiaceae	1	0.98	37	Rhamnaceaae	4	3.92
13	Celastraceae	2	1.96	38	Rhizophoraceae	1	0.98
14	Cupressaceae	2	1.96	39	Rosaceae	3	2.94
15	Ebenaceae	1	0.98	40	Rubiaceae	3	2.94
16	Ericaceae	1	0.98	41	Rutaceae	2	1.96
17	Euphorbiaceae	2	1.96	42	Santalaceae	1	0.98
18	Fabaceae	12	11.76	43	Sapindaceae	2	1.96
19	Flacourtiaceae	2	1.96	44	Solanaceae	3	2.94
20	Hypericaceae	1	0.98	45	Sterculiaceae	1	0.98
21	Labiatae	5	3.92	46	Tiliaceae	3	2.94
22	Loganiaceae	2	1.96	47	Ulmaceae	1	0.98
23	Malvaceae	2	1.96	48	Urticaceae	1	0.98
24	Meliaceae	1	0.98	49	Verbanaceae	2	1.96
25	Melianthaceae	1	0.98	50	Vitaceae	1	0.98

3.2.2. Nuxia congesta-Podocarpus falcatus type

Juniperus procera, Nuxia congesta and *Maytenus undata* are among the dominant tree species. *Podocarpus* (*Afrocarpus) falcatus* is characteristic species of the type. *Pittosporum viridiflorum, Maytenus undata* and *Myrsine africana* are among the associated species of the community. *Berberis holstii, Abutilon longicuspe, Heliotropium cinerascens, Buddleja polystachya* and *Barleria ventricosa* are common in the shrub layer. Climbers such as *Asparagus racemosus,* *Solanum benderianum, Clematis hirsuta and Cynanchum abyssinicum* are abundant. Altitudinal distribution of the type is 2200-2390 m a.s.l.

3.2.3. Acacia abyssinica - Olea europaea type

The community type is distributed between 2000 and 2566 m. *Olea europaea* is a dominant species in the tree layer and *Carissa edulis* in the shrub layer. *Acacia abyssinica* is a characteristic species of the type. Associated species include *Rhus natalensis, Juniperus procera, Cadia purpurea, Dovyalis abyssinica, and Olinia rochetiana. Sarcostema vimnale* and *Lipia adoensis* are from the shrub layer. *Heracleum abyssinicum* and *Laggera pterodonta* from the herb layer are those species recorded only in this community. *Pinus patula* and *Cuppresus luscitanica* are common exotic species of the community. *Cynanchum abyssinicum, Toddalea asiatica, Solanum benderianum, Clematis simensis, Rhoicissus tridentat, Asparagus racemosus and Helinus mystacinus* are climber species recorded in the community.

3.2.4. Myrica salicifolia-Erica arborea-Maesa lanceolata type

Myrica salicifolia is among the dominant species and *Erica arborea* and *Measa lanceolata* as characteristic species of the community. *Astragalus atropilosulus, Hypericum revolutum* and *Clutia abyssinica* are associated species of the type. Other species mainly in the shrub layer include *Conyza hypoleuca* and *Vernonia bipontinnii*. The type is found at altitude from 2650-2700 m a.s.l.

3.2.5. Acacia etabaica-Dichrostachys cinerea-A. tortilis type

This community type is found at an altitudinal distribution of 1780-1935 m a.s.l. i.e., at the lower altitude of the sampling site (Grat-Khassu). Other associated species to the dominant and character species mentioned in the type include *Acacia tortilis, A. asak, A. seyal, Ziziphus spina-christi, Rhus natalensis, Carissa edulis, Canthium setiflorum, Ziziphus mucronata, Sageretia thea, Flueggea virosa and Maera angolensis. Grewia tembensis and Rhus retinorroea* were the species with few frequencies in the community.

3.3 Plant Community-Environment Relationship

An analysis of variance (ANOVA) of the environmental variables with plant community types is shown in Table 2. The community types don't show significant differences with respect to the environmental variables except for altitude, slope and human impact.

Table 2. Tukey's multiple range test between environmental variables and community types.

Variables	Communities				
	1	2	3	4	5
Altitude (m)	2250 b	2310 b	2379 b	2674 c	1898 a
Slope (%)	22.14 a	23.90 ab	23.08 a	31.00 b	18.00 a
Aspect	2.70 ns	2.22 ns	2.62 ns	2.77 ns	2.42 ns
Soil depth (cm)	90.13 ab	90.24 ab	87.09 ab	97.13 b	79.14 a
Grazing	0.29 ns	0.55 ns	1.10 ns	1.00 ns	1.20 ns
Human impact	0.86 a	1.05 a	1.59 ab	1.00 a	2.80 b
No of species	21.57 ns	22.55 ns	16.00 ns	18.00 ns	18.00 ns

The results of Pearson's product-moment correlation of the environmental parameters show that some of the environmental parameters are correlated (Table 3). Altitude is positively correlated to soil depth and slope, and negatively correlated to human impact, species richness and aspect. Species richness decreases with increase in altitude. Slope is negatively correlated to both grazing and human impact. Grazing and human impact are positively correlated to each other and are negatively correlated to soil depth.

3.4. Vegetation Structure

Height and DBH measurements were used to construct the density distribution for the various categories. The distribution of trees in different height classes is shown in Fig.2 A considerable proportion of the individuals (33.3%) belong to the lowest height classes i.e. (<2m). Only few individuals (4.2%) attain heights of more than 21 m.

Table 3. Pearson's product-moment correlation coefficient for correlations between environmental variables.

	altitude	slope	aspect	soil depth	grazing	human impact	Number of species
altitude	1.000						
slope	.035 .766	1.000					
aspect	-.025 .832	.176 .133	1.000				
soil depth	.244 .023	.042 .722	.010 .931	1.000			
grazing	.029 .808	-.007 .952	.086 .465	-.161 .172	1.000		
human impact	-.296* .010	.005 .964	.208 .075	-.354 .002	.704** .000	1.000	
Number of species	-.342** .000	.137 .142	.011 .925	-.128 .278	-.136 .249	-.018 .879	1.000

**. Correlation is significant at the 0.01 level

*. Correlation is significant at the 0.05 level

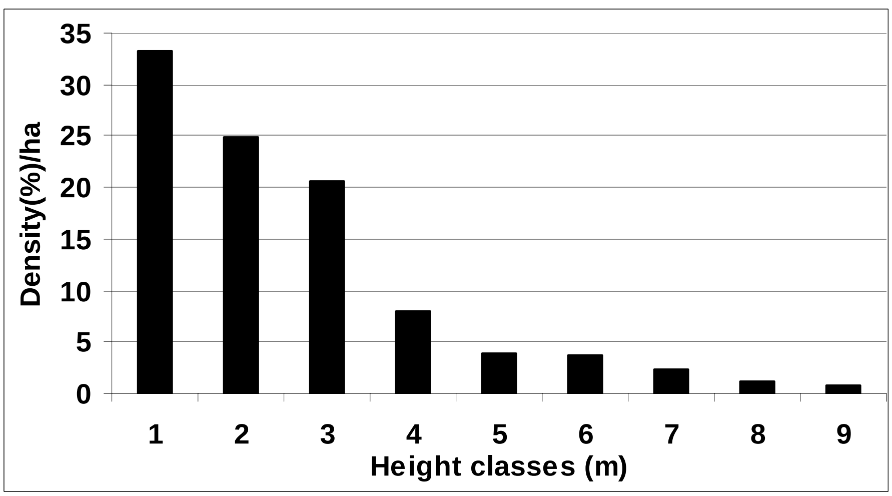

Figure 2. Density (%)/ha of tree/shrub in different height classes. Class1=<2m; 2=2-5; 3=6-9; 4=10-13; 5=14-17; 6=18-21; 7=22-25; 8=26-29; 9=>29.

DBH measurements reveal a trend similar to that of the height distribution (Fig.3). Most individuals have a diameter less than 20 cm (86%). About 36.4% belong to the lowest diameter class (<2 cm), and 19.1 % to the next higher class (2-5 cm). Only 0.4 % have DBH grater than 50 cm. The result confirms that the number of individuals decreases as the height and DBH of the individual's increase.

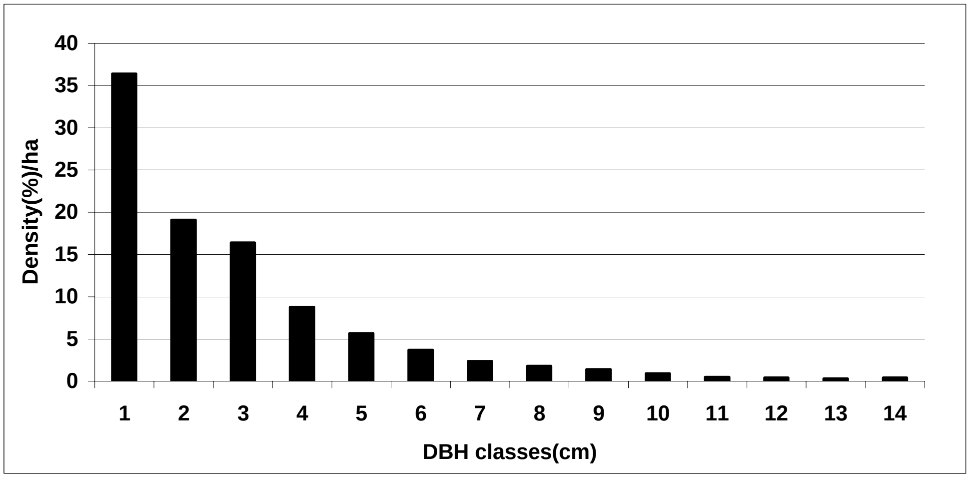

Figure 3. Density (%) of tree/shrub/ha at different DBH classes. Class1=<2cm; 2=2-5; 3=6-9; 4=10-13; 5=14-17; 6=18-21; 7=22-25; 8=26-29; 9=30-33; 10=34-37; 11=38-41; 12=42-45; 13=46-49; 14=>50.

Table 4. Importance Value Index of the most dominant tree/shrub species of the study area.

Scientific name	***Relative Density***	***Relative Frequency***	***Relative Dominance***	***Importance Value Index (IVI)***	***IVI Rank***
Juniperus procera	14.47	8.35	30.34	53.16	1
Olea europaea subsp. cuspidata	9.44	6.96	19.97	36.37	2
Nuxia cogesta	8.94	6.50	11.22	26.66	3
Cassipourea malosana	8.75	5.57	6.17	20.49	4
Olinia rochetaina	9.63	6.19	3.75	19.55	5
Rhus natalensis	6.23	7.58	1.26	15.07	6
Rhus glotinosa	4.59	6.50	2.04	13.13	7
Acacia abyssinica	3.02	5.26	2.09	10.37	8
Podocarpus falcatus	5.48	2.47	1.40	9.35	9
Ekebergia capensis	2.10	3.86	3.17	9.13	10
Allophylus macrobotrys	1.45	2.32	5.34	9.11	11
Pittosporum viridiflorum	2.39	5.10	1.26	8.75	12
Bersama abyssinica	2.51	4.95	0.62	8.08	13
Celtis africana	2.52	4.02	1.50	8.04	14
Calpurnia aurea	2.52	4.33	0.27	7.12	15
Osyris quadripartita	2.01	4.79	0.30	7.1	16
Ficus sur	1.20	1.85	3.81	6.86	17
Teclea simplicifolia	1.95	3.56	0.88	6.39	18
Dovyalis abyssinica	2.14	2.94	0.56	5.64	19
Dombeya torrida	0.94	4.31	0.05	5.3	20
Acacia etbaica	3.27	0.77	1.23	5.27	21
Myrica salicifolia	1.51	0.77	1.99	4.27	22
Acacia tortilis	1.95	0.77	0.75	3.47	23
Maytenus arbutifolia	1.01	1.39	0.08	2.48	24
Total	**100**	**100**	**100**	**300**	

Density distribution over DBH and height classes of the most dominant species follows the same trend as that of the relative basal area. *Juniperus procera* attain highest sizes and is the most dominant tree in the area.

The dominant tree species that represent the forest structure *Juniperus procera* and *Olea europaea subsp. cuspidata* have individuals distributed in all the height and DBH classes. While *Olinia rochetiana* and *Cassipourea malosana* have high number of individuals below 13 m in height and 21cm in DBH and no individuals above 21m in height and 45 cm in DBH.

Relative density, relative frequency, relative dominance and importance value index were computed for 24 tree/shrub species with DBH greater than 10 cm and relative frequency greater than 0.60 %. The results of the analysis are presented in Table 4.

4. DISCUSSION

Five community types were identified from the classification strategies. These include community types 1, 2, 3, 4, and 5.

Community type 1, which is dominated by *Allophylus macrobotrys* and characterized by *Ficus sur*, 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 *Hagenia abyssinica* and *Podocarpus (Afrocarpus) falcatus* are common here.

Community type 2 with good timber species: *Juniperus procera*, *Olea europaea sub*sp. *cuspidata* and *Podocarpus falcatus* has experienced human interference in the form of selective cutting. Cattle interferences were also observed in some of its stands.

Community type 3 is rich in shrub layer species and woody climbers. The stands sampled in this community are located in an area having shallow soils with medium human interference in the form of firewood collection and selective cutting. This might be due to being near to the farmers settlement area. Although most area of this stands was highly affected before about 20 years being used as farming land, by now it is in good regeneration status. In most of its stands introduced exotic species of *Cuppresus lusitanica* and *Pinus patula* have been observed.

Community type 4 *Myrica salicifolia-Erica arborea-Maesa lanceolata* distributed at higher altitudes of the sampling site is unique in its own type having species different from other types. This community is surrounded by upper slope and bare rock area, thus little disturbance by human and cattle is encountered. Even though lianas are not recorded in this type it is having good species richness.

Community type 5 is highly influenced by people collecting firewood, charcoal making and grazing animals. This is due to its being nearby to Alamata town and having species of plants suitable for charcoal making and firewood. The stands of this community are from an area, which is at lower altitudes, having shallow soil and that receives lower amount of annual rainfall with higher temperature.

The community types don't show significant difference ($P < 0.05$) with respect to the environmental variables except for altitude and slope. The major discriminate among the community types is due to altitude. This is in line with the result observed by Kumlachew Yeshitla and Tamrat Bekele (2002) and Zerihun Woldu *et al*. (1989). The community types could be grouped into three based on altitude: group 1 with altitude 2250-2379 m (types 1, 2 and 3), group 2 community number 4 and group 3 community number 5 (with P value of 0.124). On the other hand, the communities were grouped in one in respect to aspect, grazing and number of species. All communities were homogenous with a P value of 0.651 in respect to aspect.

Density distribution at different height classes in the study area showed that 33.3 % of the individuals have a height less than 2 meters and 24.9 % fall between 2-5 meters range. Figure 2 shows that 78.8 % of all individuals are 9 meter or shorter. Individuals greater than 29 meters in height are rare (0.7 %). Thus the study confirms that the number of individuals decreased as the height of the individuals increased indicating long time disturbance (thus less mother trees). Such result was also observed in Chilmo forest by Tamrat Bekele (1993).

Density distribution at different DBH classes also showed similar trend as that of height class distribution. It indicates dominance of small sized individuals. The pattern of such density can be an indicator for community dynamics in the forest. The total number of trees/shrubs in each DBH classes decreased with an increasing in DBH classes. This relationship also was observed in Dessa forest by Gebremedhin Hadera (2000); in Chilmo and Menagesha forests (Tamrat Bekele, 1993) and the tropical lowland rain forest of Los Tuxtlas, Mexico (Bongers et al., 1988). The forest pattern is formed by the species structure with reversed *J* shaped in DBH class distribution. 36.4 % of the individuals in the forest have DBH less than 2 cm (Fig. 3).

Relative density distribution of the species showed *Juniperus procera* (14.47 %) followed by *Olinia rochetania* (9.63 %) and *Olea europaea subsp. cuspidata* (9.44 %) to have the highest relative density compared to the others. About twenty-nine per cent of the tree/shrub species have a relative density greater than five, while 70 % of the species have a relative density of less than 5 %. Analysis of the frequency distribution indicated that *Juniperus procera, Rhus natalensis, Olea europaea subsp. cuspidata, Nuxia congesta, Rhus glutinosa and Olinia rochetania* were found to be with the highest relative frequency indicating their good distribution throughout the forest (Table 4). Relative dominance, which is the basal area of a single species, divided by total basal area of the species ranges from 0.05 % *(Dombeya torrida)* to 30.34 % (*Juniperus procera*). Thus the contribution of each species to the basal area differs from one another. Species such as *Juniperus procera, Olea europea* subsp.*cuspidata,* and *Nuxia congesta* have the highest basal area percentage ranging from 11.22 % to 30.34 % being *Juniperus procera* and *Olea europea* sharing high basal area 30.34 % and 19.97 % and importance value index 53.16 % and 36.37 % respectively.

5. CONCLUSION

The survey showed that the forest is 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 basic needs and traditional rights of the communities over the uses of forest resources should be recognized. The much-needed positive attitudes towards forest protection and development can only be obtained from the rural communities through the development of a genuine benefit sharing mechanism. Thus community participation is quite important.

6. ACKNOWLEDGMENT

We would like to thank Dr. Tesfaye Bekele, head of Forest Resources Conservation (MoA), who have provided us with a vehicle during reconnaissance survey. We are grateful to Ato Gebremedhin Hadera, head, and manager of woody biomass inventory and strategic planning project, and Ato G/Kidan Teklu, Natural Resources Conservation Department (MoA), for their material (Hypsometer, DBH caliper) and moral support. Thanks to National Metrological Service Agency for providing metrological data of the study area. We thank Swedish Agency for

Research with Developing Countries (SAREC/SIDA) and Research Programme on the Sustainable Utilization of Dryland Biodiversity (RPSUD) for covering the costs of the research.

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Appendix 1

List of plant Taxa collected in the study area with corresponding coll. no., family, vernacular name and habit

Col. No	SPECIES NAME	Family	Vernacular Name (Tigregna)	Habit
078	*Barleria ventricosa* Hochest.exNees	Acanthaceae		Shrub
007	*Rhus glutinosa* A.Rich.	Anacardiaceae	Tetaelo	Tree/Shrub
024	*R. natalensis* Krauss9	Anacardiaceae	Atam	Tree
053	*R. retinorrhoea* Oliv.	Anacardiaceae	Nefasito	Shrub
100	*Heracleum abyssinicum* (Boiss.) Norman	Apiaceae		Herb
034	*Heteromorpha trifoliata* (Wendel.) Eckl. and Zeyh.	Apiaceae	Mometse Akeytay	Shrub
039	*Acokanthera schimperi (*A.DC.) Benth.	Apocynaceae	Meroz	Tree/Shrub
028	*Carissa edulis* (Forssk.) Vahl	Apocynaceae	Egam	Shrub
077	*Cynanchum abyssinicum* Decn.	Asclepiadaceae	Hareg-gumgumo	Climber
093	*Gomphocarpus fruticosus* (L.) Ait.f.	Asclepiadaceae	Enchie	Shrub
094	*Sarcostemma viminale* (L.) R.Br.	Asclepiadaceae	Tsibtsibo	Shrub
047	*Asparagus racemosus* Willd.	Asparagaceae	Kestensto	ClimbIng shrub
019	*Conyza hypoleuca A.Rich.*	Asteraceae	Tsaeda-kotsilo	Shrub
099	*Laggera pterodonta* (DC.) Schulz. Bip.ex A.Rich.	Asteraceae		Herb
091	*Laggera tomentosa (*Sch.Bip.ex.A.Rich.) Oliv. & Hiern	Asteraceae	Kanskanso	Shrub
072	*Senecio hadiengis* Forssk.	Asteraceae	Suhumatali	Shrub
011	*Vernonia amygdalina* Del.	Asteraceae	Girawa	Tree
082	*V. rueppelli* Sch Bip.	Asteraceae	Tetaso	Tree
003	*V. bipontinnii* Vatke.	Asteraceae	Mechalo	Shrub
056	*Balanites aegyptiaca (L.) Del.*	Balanitaceae	Bedano	Tree
090	*Berberis holstii* Engl.	Berberidaceae	Mucha-eff	Shrub
076	*Cordia africana* Lam.	Boraginaceae	Awhi	Tree
037	*Ehretia cymosa Thonn.*	Boraginaceae	Tuwlaga	Tree/Shrub
079	*Heliotropium cinerascens* Steud.exDC.	Boraginaceae	Am-am-gimel	Shrub
096	*Opuntia ficus-indica* (L.) Mill	Cactaceae	Beles-kolkola	Shrub
061	*Maerua angolensis* DC.	Capparidiaceae	Kormediet	Shrub
075	*Maytenus arbutifolia* (A.Rich.) Wilczek	Celastraceae	Dawija	Tree/Shrub
009	*M. undata* (Thunb.) Blakelock	Celastraceae	Ats-ats	Tree/Shrub
022	*Cupressus lusitanica* Miller	Cupressaceae	Tsihdi-ferenji	Tree
002	*Juniperus procera Hochst.ex.Endl.*	Cupressaceae	Tsihdi-adi	Tree
029	*Euclea racemosa subsp. schimperi* (A.DC.) Dandly	Ebenaceae	Kuliow	Shrub
018	*Erica arborea L.*	Ericaceae	Hasta	Shrub
015	*Clutia abyssinica* Jaub. & Spach.	Euphorbiaceae	Hirtmtmo	Shrub
063	*Flueggea virosa* (Wild.) Voigt	Euphorbiaceae		Shrub
023	*Acacia abyssinica* Hochst.ex Benth.	Fabaceae	Chia	Tree
055	*A. asak* (Forssk.) Will.	Fabaceae	Sabansa	Tree/Shrub
050	*A. etbaica* Schweinf.	Fabaceae	Sraw	Tree
059	*A. seyal* Del.	Fabaceae	Wancho	Tree
051	*A. tortilis* (Forssk.) Hayne	Fabaceae	Karora	Tree
005	*Astragalus atropilosulus* (Hochst.) Bunge	Fabaceae	Tetem-agazen	Shrub
074	*Cadia purpurea* (Picc.) Ait.	Fabaceae	Shilaen	Shrub

042	*Calpurnia aurea* (Ait) Benth.	Fabaceae	Hitsawits	Tree/Shrub
066	*Senna sinqueana (*Del.)Lock	Fabaceae	Hambahambo	Shrub
098	*Colutea abyssinica* Kunth and Bouche	Fabaceae	Que-queta	Shrub
058	*Dichrostachys cinerea* (L.) Wight and Arn.	Fabaceae	Harshmersha	Shrub
033	*Pterollobium stellatum* (Forssk.) Brenan	Fabaceae	Konteftefe	Shrub
012	*Dovyalis abyssinica (*A.Rich.) Warb.	Flacourtiaceae	Mengolhats	Tree/Shrub
032	*D. verrucosa (*Hochst.) Warb.	Flacourtiaceae	Tuemtenay	Shrub
004	*Hypericum revolutum* Vahl.	Hypericaceae	Abedi	Tree/Shrub
073	*Becium grandiflorum* (Lam.) Pichi-serm.	Lamiaceae	Tebeb	Shrub
025	*Clerodendron myricoides* (Hochst.) Vatke	Lamiaceae	Shewha	Shrub
102	*Meriandra bengalensis* (Konig ex. Roxb.) Benth.	Lamiaceae	Mesaguh	Shrub
036	*Otostegia fruticosa* (Forssk.) Schweif.ex Penzing	Lamiaceae	Chamo	Shrub
095	*O. integrifolia* Benth	Lamiaceae	Chi-endog	Shrub
092	*Buddleja polystachya* Fresen	Loganiaceae	Metere	Shrub
016	*Nuxia congesta* R.Br.ex.Fresen	Loganiaceae	Tekarie	Tree
086	*Abutilon hirtum* (Lam.) Sweet	Malvaceae	Necha	Shruby herb
081	*A. longicuspe* Hochest.exA.Rich.	Malvaceae	Thaeda-necha	Shruby herb
043	*Ekebergia capensis* Sparrm.	Meliaceae	Kot	Tree
010	*Bersama abyssinica* Fresen.	Melianthaceae	Mirkuz-zibe	Tree/Shrub
083	*Ficus palmata* Forssk.	Moraceae	Beles	Tree/Shrub
069	*F. sur* Forssk.	Moraceae	Shanfa	Tree
001	*Myrica salicifolia* A.Rich.	Myricaceae	Shihnet	Tree/Shrub
014	*Myrsine africana* L.	Myricinaceae	Kechemo	Shrub
008	*Maesa lanceolata* Forssk.	Myrsinaceae	Saweria	Tree
080	*Jasminum grandiflorum* (R.Br.ex.Fresen.) P.S.Green	Oleaceae	Tselim-habi	Climber
027	*Olea europaea* subsp *cuspidate (*Wall. ex DC.) Cifferri	Oleaceae	Awlie	Tree
006	*Olinia rochetania* A.Juss.	Oliniaceae	Ale-ale	Tree
085	*Phytolacca dodecandra* LHerit.	Phytolaccaceae	Shimti	Shrub
089	*Pinus patula* L.	Pinaceae	Bush	Tree
026	*Pittosporum viridiflorum* Sims	Pittosporaceae	Mayliho	Tree/Shrub
087	*Podocarpus (Afrocarpus) falcatus (Thun) Mirb.*	Podocarpaceae	Zigba	Tree
030	*Rumex nervosus* Vahl	Polygonaceae	Enbacho	Shrub
067	*Clematis hirsuta* Perr and Guill	Ranunculaceae	Hareg-hazo	ClimbIng shrub
048	*Clematis simensis* Fresen.	Ranunculaceae	Hareg-thirae	Woody climber
064	*Helinus mystacinus* (Ait.) E.Mey.ex Steud.	Rhamnaceaae		Woody climber
045	*Sageretia thea* (Osbeck) M.C.Johnston	Rhamnaceae	Kenchelchele	Shrub
057	*Ziziphus mucronata* Willd.	Rhamnaceae	Kunkura-hido	Shrub
052	*Z. spina-christi* (L.) Desf.	Rhamnaceae	KunkuraGeba)	Shrub
054	*Cassipourea malosana* (Baker) Alston	Rhizophoracea	Keyh-om	Tree
101	*Hagenia abyssinica* (Bruce) J.F.Gmel.	Rosaceae	Habi	Tree
017	*Rosa abyssinica* Lindely	Rosaceae	Kaga	Shrub
065	*Rubus steudneri* Schweinf.	Rosaceae	Mengolel	Shrub
060	*Canthum setiflorum* Hiern.	Rubiaceae		Shrub
070	*Pavetta oliveriana* Hiern	Rubiaceae	Shumeja	Shrub
035	*Psydrax schimperiana* (A.Rich.) Bridson	Rubiaceae	Tsehag	Shrub
038	*Teclea simplicifolia* (Engl.) Verdoorn	Rutaceae	Salih	Tree/Shrub

049	*Toddalia asiatica* (L.) Lam.	Rutaceae	Hareg	Woody climber
013	*Osyris quadripartite* Decn.	Santalaceae	Kerets	Tree
068	*Allophylus macrobotrys* Gilg	Sapindaceae	Meara	Tree/Shrub
020	*Dodonaoea angustifolia* L.f.	Sapindaceae	Tahsos	Shrub
021	*Discopodium penninervium* Hochst.	Solanaceae	Alhim	Tree
088	*Solanum benderianum* Schimper ex Engl.	Solanaceae		Climber
071	*S. schimperianum* Hochst. ex A.Rich.	Solanaceae	Berbereawald	Shrub
031	*Dombeya torrida* (J.F.Gmel.) P. Bamps	Sterculiaceae	Buyak	Tree/Shrub
046	*Grewia ferruginea* Hochst.exA.Rich.	Tiliaceae	Meleglega	Tree/Shrub
041	*G. mollis* Juss.	Tiliaceae	Reway	Tree/Shrub
062	*G. tembensis* Fresen.	Tiliaceae	Chaka	Shrub
040	*Celtis africana* Burm.f.	Ulmaceae	Moto-koma	Tree
084	*Debregeasia bicolar* (Roxb.) Wedd.	Urticaceae	May-awalie	Shrub
097	*Lippia adoensis* Hochst.ex Walp.	Verbanaceae	Kusihe	Shrub
044	*Rhoicissus tridentata* (L.f.) Wild and Drummond	Vitaceae	Keyh-hareg	Woody climber