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Woody Species Composition, Diversity and Structure of Kumuli Dry Evergreen Afromontane Forest in Yem District, Southern Ethiopia

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Abstract
This study was conducted in Kumuli forest to investigate woody species diversity and structure of the forest. Woody vegetation data were taken from 32 (20 m x 20 m) systematically laid quadrats in three transects. Shannon-Wiener diversity and evenness index was applied to quantify species diversity and richness. MS excel spreadsheet was used for the data analysis. About 133 woody plant species representing 107 genera and 53 families were recorded in this study. Shrubs have the highest proportion (44.3%) followed by trees (26.3%), trees/shrubs (19%), woody climbers (6%) and lianas (3%). Asteraceae was the dominant family comprising 10% of the total woody species followed by Fabaceae (6%) and Celastraceae, Rosaceae and Rubiaceae (each 5%). The density of the woody species was 7791 stems ha^{-1}. The total basal area of the forest was found to be 30.16 m^2 ha^{-1}. The trends in dbh structure showed an inverted J-type with highest densities falling in the lower dbh classes indicating good structure. Most tree species had low IVIs that is attributed to density-dependent and density-independent factors. Height structure analysis also showed a similar pattern with highest densities falling in lower classes, except that less density was observed in the 1st height class. *Acanthus eminens*, *Myrsine africana*, *Olea capensis*, *Podocarpus falcatus* and *Syzigium guineense* were species which showed good reproduction and good recruitment while *Prunus africana* showed both bad reproduction and bad recruitment.
Keywords: woody species, dbh classes, Importance Value Index, *Olea capensis, Myrsine africana*

Introduction
The forest biodiversity is an important renewable natural resource serving tremendous values of scientific, agricultural, medical, pharmaceutical, educational, cultural and ecological importance. Of course, they are repositories of plant genetic resources which serve as home of other biodiversity. Moreover, in the recent global environmental crisis, they act as important carbon sink. In Ethiopia, about 40% of the land area was covered with forests at the turn of the 19th century (EFAP, 1994) in the country declined rapidly to about 2.4% in 1992 with annual forest clearance of about 150,000 to 200,000 ha (Sayer *et al.,* 1992; EFAP, 1994; FAO, 2007) The direct and indirect economic dependence of the fast growing rural population on agriculture and absence of alternative economic activities resulted in conversion of forests into agricultural and other land use systems (von Breitenbach, 1963; EMA, 1988; EFAP, 1994; Reusing, 1998; Zerihun Woldu, 1999; Demel Teketay, 2001; Friis *et al*., 2001). Consequently, environmental crises such as soil erosion, fragmentation of habitats, loss of biodiversity, loss of the role of carbon sequestration and the regulation of global warming coupled with subsequent climate change that could worsen the livelihood of the people and the loss of local traditional knowledge systems concerning wise use of forests (Hegazy, 1999; Taye Bekele *et al*., 1999; Sala *et al.*, 2000; Demel Teketay, 2001; Thomas *et al.,* 2004). Kumuli natural forest is a dry evergreen afromontane forest that is located in Yem District in the Southern Ethiopia. This forest is one of the repository genepools for the indigenous plant species that has not been investigated so far. Hence, this study was conducted with the objectives of describing the woody species composition and structure and investigating the woody species diversity and richness of the forest.

Materials and Methods
Description of the Study Area
Kumuli government owned natural forest is located in Yem District whose administrative center is at Saja (Fig. 1) in the Southern Ethiopia between coordinates . The District is at 297 km southwest of the capital city, Addis Ababa (Livelihood Wereda Reports, 2009). The forest size of the study forest is a 155 ha natural forest that contains only indigenous woody species. There are few small villages few in close proximity of it.

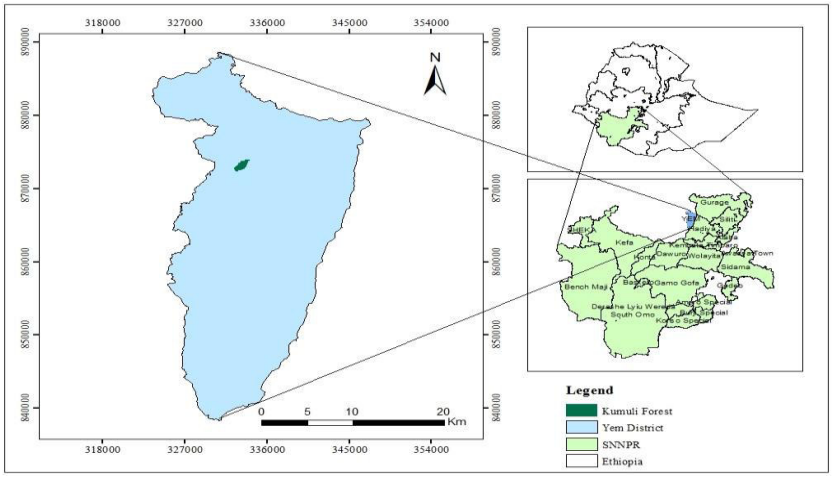


Fig. 1. Map showing of Yem District and the study forest

The altitudinal ranges of the sample quadrats of this study were between 2206 - 2783 m a.s.l. The mean annual rainfall of the study area is between 1184 mm to 2300 mm with maximum rainfall between the months of June and September. The annual mean temperature of the area is between 15^{O}C and 22^{O}C while the mean highest temperature being 21.1^{o}C (in January) and lowest temperature being 7.0 ^{o}C (in December) (EMA, 1988).

Data Collection

Systematic sampling method was used to collect data of woody species from a total of 32 (20 m by 20 m) sample quadrats. The quadrats were laid in three transects that follow altitudinal gradient from north to south direction using maritime compass and polyethene string. The transects were 200 m apart from each other. The quadrats were laid at 20 m regular interval from each other and at the left and right sides of the transect lines to maintain diversity of species sampled.

In each quadrat, all the woody species and their seedlings when encountered were counted, the circumference of each species ≥7.85 cm at breast height (i.e. 1.3 m) was measured using tape measure and these values were converted into diameter at breast height (dbh), the heights of the woody species were estimated visually. Plant specimens were collected, pressed, dried and identified at the National Herbarium (ETH), at the Addis Ababa University.

Analysis of Data

The woody species diversity and evenness in the forest were calculated using Shannon-Wiener diversity index (Krebs, 1989). The index considers the species richness and proportion of each species in all sampled quadrats in the study area. The formula of the index is;

$H' = -(\sum_{i=1}^{s} pi\ lnpi)$, where pi is the proportion of individuals or the abundance of the ith species expressed as a proportion of total number of individuals encountered during the inventory.

The relative abundance with which each species is represented in an area was calculated using Shannon's species evenness (equitability) index (Krebs, 1989). Equitability assumes a value between 0 and 1 with 1 being complete evenness. The formula of this index is; $J' = \frac{H'}{lnS}$, where $H' = \text{diversity index}$; S = the total number of species sampled.

Frequency, density, diameter at breast height (dbh), area (BA) and height structure were analysed following Kent and Cocker (1992). Frequency = number of quadrats the species encountered divided by total number of quadrats sampled. Density = total number of stems of a species/total number of area sampled.

Diameter at breast height (dbh) = $\frac{\text{circumference}}{\Pi}$, where $\Pi = 3.14$.

Basal area (BA) = the cross-section area of a tree at breast height was calculated from dbh as, $BA = (\frac{dbh}{200})^2$,

where BA = basal area (m^2), dbh = diameter at breast height.

Importance value index (IVI) was computed and used for selected individual woody species.

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

The population structure of woody plants was determined from the dbh measures and height estimation data. The dbh and height class distribution of the forest species was categorised into 11 diameter classes (1 = <5 cm, 2 = 5-10 cm, 3 = 10-15 cm, 4 = 15-20 cm, 5 = 20-25 cm, 6 = 25-30 cm, 7 = 30-35 cm, 8 = 35-40 cm, 9 = 40-45 cm, 10

= 45-50 cm, 11 ≥ 50 cm and 5 height classes (1 = 0-1 m, 2 = 1-5 m, 3 = 5-10 m, 4 = 10-20 m, 5 ≥ 20 m) following Tadesse Woldemariam *et al*. (2000).

Results

Species Composition and Diversity

A total of 133 woody plant species representing 107 genera and 53 families were recorded in the forest (Table 1). The data on habit from 32 quadrats each 400 m² showed that shrubs have the highest proportion (45.1%) followed by trees (26.3%), shub/tree (19.5%), woody climbers (6%) and lianas (3%). About 7% of the woody spcies are endemic to the Ethiopian flora (Table 2).

Table 1. List of woody species sampled from Kumuli forest [C= Climber, L = Liana, S = shrub, T/S = Tree/Shrub, T = Tree]

Species	Habit	Family	Local/Yem name	Collection Code
***Abutilon figurianum* Webb**	S	Malvaceae	Kesa	GK132
***Acacia brevispica* Harms**	C	Fabaceae	Not known	GK75
***Acacia negrii* Pic.-Serm.**	T	Fabaceae	Ezu	GK95
***Acalypha fruiticosa* Forssk.**	S	Euphorbiaceae	Not known	GK102
***Acanthus eminens* C.B.Clarke**	S	Acanthaceae	Zarquwa	GK09
***Agarista salicifolia* (Comm. ex Lam.) Hook. F.**	T/S	Sapindaceae	Totu	GK92
***Albizia gummifera* (J. G. Gmel.) C. A. Sm.**	T	Fabaceae	Siso	GK87
***Allophyllus abyssinicus* (Hochst.) Radlk.**	T	Sapindaceae	Toshu	GK150
***Apodytes dimidiata* E. Mey. ex Arn.**	T	Icacinaceae	Kereworma	GK111
***Asparagus racemosus* Willd.**	S	Asparagaceae	Keshelzona	GK149
***Bersama abyssinica* Fresen.**	T/S	Melianthaceae	Boa	GK16
***Botriocline schimperi* Oliv. & Hiern. ex Benth.**	S	Asteraceae	Not known	GK41
***Bridelia scleroneura* Muell. Arg.**	T/S	Euphorbiaceae	Not known	GK51
***Brucea antidysenterica* J. F. Mill.**	S	Simaroubaceae	Tolo	GK128
***Buddleja polystachya* Fresen.**	T	Buddlejaceae	Festu	GK108
***Calpurnia aurea* (Ait.) Benth.**	T/S	Fabaceae	Zimsa	GK03
Canthium oligocarpum* Hiern ssp. *oligocarpum	T/S	Rubiaceae	Not known	GK86
***Carissa spinarum* L.**	S	Apocynaceae	Alelu	GK15
***Catha edulis* (Vahl) Forssk. ex Endl.**	T/S	Celastraceae	Jima	GK71
***Celtis africana* Burm. f.**	T	Ulmaceae	Waeya	GK74
***Chionanthus mildbraedii* (Gilg & Schellenb.) Stearn**	T/S	Oleaceae	Jigiwa	GK79
***Clausena anisata* (Willd.) Benth.**	S	Rutaceae	Kemekesa	GK152
***Clematics longicauda* Steud A.Rich.**	L	Ranunculaceae	Segu	GK83
***Clerodendron myricoides* Vatke**	S	Verbenaceae	Mignmignu	GK120
***Clutia abyssinica* Jaub. & Spach.**	S	Euphorbiaceae	Nagina	GK93
***Combretum collinum* Fresen.**	T/S	Combretaceae	Keso	GK52
***Conyza aegyptiaca* (L.) Ait.**	S	Asteraceae	Not known	GK116
***Conyza parhopappa* A.Rich.**	S	Asteraceae	Not known	GK32
***Croton macrostachyus* Del.**	T	Euphorbiaceae	Woshkela	GK153
***Dalbergia lactea* Vatke**	S	Fabaceae	Not known	GK30
***Dodonaea angustifolia* L.f.**	T/S	Sapindaceae	Titira	GK35
***Dovyalis abyssinica* (A.Rich.) Warb.**	T	Flacourticeace	Maara (Glotal)	GK42
***Dracaena steudneri* Engler**	T	Dracaenaceae	Teso	GK100b
***Ehretia cymosa* Thonn.**	T/S	Boraginaceae	Kerewaza	GK68
***Ekebergia capensis* Sparrm.**	T	Meliaceae	Oroma	GK61
***Elaeodendron buchananii* (Loes.) Loes.**	T	Celastraceae	Qopheru	GK14
***Embelia schimperi* Vatke**	S	Myrsinaceae	Tomoqo	GK97
***Englerina woodfordioides* (Schwfth.) M.Gilbert**	S	Loranthaceae	Tigna	GK53
***Erica arborea* L.**	T/S	Ericaceae	Heyeyu	GK130
***Euclea racemosa* Murr. ssp. *schimperi* (A. DC.) White**	S	Myrsinaceae	Megaru	GK65
***Ficus sur* Forssk.**	T	Moraceae	Teya	GK125
***Ficus* sp. (Unknown)**	T	Moraceae	Not known	GK45
***Euphorbia ampliphylla* Pax**	T	Euphorbiaceae	Akma	GK95b
***Flacourtia indica* (Barm. f.) Merr.**	T	Flacourticeace	Not known	GK127

Species	Habit	Family	Local/Yem name	Collection Code
***Galiniera saxifraga (*Hochst.) Bridson**	S	Rubiaceae	Burenu	GK36b
***Gnidia glauca* (Fresen.) Gilg.**	T	Thymeliaceae	Aluwo	GK66
***Gounia longispicata* Engl.**	C	Rhamnaceae	Not known	GK73
***Hagenia abyssinica* (Bruce) Gmel.**	T	Rosaceae	Ofa	GK121
***Helichrysum schimperi* (Sch. Bip.) Moesner**	S	Asteraceae	Apso	GK76
***Helichrysum sp.* (Unidentified)**	S	Asteraceae	Hapso	GK27
***Helichrysum traversii* Chiov.**	S	Asteraceae	Not known	GK36
***Hippocratea africana* (Willd.) Loes.**	L	Celastraceae	Keregemdu	GK12
***Hibiscus diversifolius* Jacq.**	S	Malvaceae	Kesa	GK69
***Hypericum quartinianum* A. Rich.**	T/S	Hypericaceae	Arinshesho	GK124
***Hypericum revolutum* Vahl**	T/S	Hypericaceae	Faeya	GK142
***Ilex mitis* (L.) Radlk.**	T	Icacinaceae	Botewa	GK67
***Jasminum abyssinicum* Hochst. ex DC.**	C	Oleaceae	Foregemdu	GK13
***Juniperus procera* Hochst. ex Endl.**	T	Curessacezae	Arkewa	GK37
***Justicia schimperiana* (Hochst. ex Nees) T. Anders**	S	Acanthaceae	Atebiyo	GK55
***Landolphia buchananii* (Hall.f.) Stapf**	L	Apocynaceae	Agega	GK04
***Lantana viburnoides* (Forssk.) Vahl**	S	Verbenaceae	Not known	GK38
***Leptadenia hastata* (Pers.) Decne**	C	Asclepediaceae	Tubu	GK79b
***Leucas argentea* Gurke**	S	Lamiaceae	Debase	GK25
Lippia adöensis* Hochst. ex Walp. var. *adöensis	S	Verbenaceae	Shasha	GK109
***Malva* sp. (Unidentified)**	S	Malvaceae	Not known	GK84
***Malva verticillata* L.**	S	Malvaceae	Kesa	GK23
***Maytenus addat* (Loes.) Sebsebe**	T	Celastraceae	Korma	GK26
Maytenus gracilipes* (Welw. ex Oliv.) Exell. ssp. *gracilipes	S	Celastraceae	Tuluma	GK17
***Maytenus senegalensis* (Lam.) Exell**	T/S	Celastraceae	Sona	GK54
Maytenus arbutifolia* (A. Rich.) Wilczek var. *arbutifolia	S	Celastraceae	Sona	GK85
***Millettia ferruginea* (Hochst.) Bak.**	T	Fabaceae	Zagu	GK18
***Myrica salicifolia* A. Rich.**	T/S	Myricaceae	Muneta	GK20
***Myrsine africana* L.**	T/S	Myrsinaceae	Futuwa	GK10
***Nuxia congesta* R. Br.**	T/S	Loganiaceae	Shigna (Nasal)	GK62
***Ocimum gratissimum* L.**	S	Lamiaceae	Not known	GK114
***Olea europaea* L. ssp. *cuspidata* (Wall. ex G. Don) Cif.**	T	Oleaceae	Buna	GK29
***Olea capensis* L. sbsp. *macrocarpa* (C. H. Wright) Verdc.**	T	Oleaceae	Zigja	GK42
***Olinia rochetiana* A. Juss.**	T	Oliniaceae	Fegegu	GK07
***Osteotega tomentosa* A.Rich.**	S	Lamiaceae	Not known	GK43b
***Osyris quadripartita* Decn.**	T/S	Santalaceae	Mekekuma	GK22
***Oxyanthus speciosus* DC.**	S	Rubiaceae	Wetekibo	GK118
***Pavetta abyssinica* Fresen.**	S	Rubiaceae	Not known	GK59
***Pentas lanceolata* (Forssk.) Deflers**	S	Rubiaceae	Otomiya	GK90
***Pentas schimperiana* (A.Rich.) Vatke**	S	Rubiaceae	Otomiya	GK21
***Periploca linearifolia* Quart.-Dill.& A. Rich.**	C	Asclepediaceae	Tubu	GK94
***Phoenix reclinata* Jacq.**	T	Arecaceae	Deya	GK78
***Phragmanthera regularis* (Sprague) Ined.**	S	Loranthaceae	Tigna	GK53c
***Phytolacca dodecandra* L 'Hérit.**	S	Phytolaccaceae	Andode/lght,drk	GK43a, b
***Pittosporum viridiflorum* Sims**	T/S	Pittosporaceae	Toshu	GK96
***Podocarpus falcatus* (Thanb.) R. B. ex Mirb.**	T	Podocarpaceae	Gedewa	GK34
***Polyscias farinosa* (Del.) Harms**	T	Araliaceae	Tognu	GK40
***Premna schimperi* Engl.**	T/S	Lamiaceae	Wagnara	GK63
***Protea gaguedi* J. F. Gmel.**	T	Proteaceae	Burbuke	GK65
***Prunus africana* (Hook. F.) Kalkm.**	T	Rosaceae	Ona	GK113
***Pterollobium stellantum* (Forssk.) Brenan**	S	Fabaceae	Not known	GK69
***Pycnostachyus abyssinica* Fresen.**	S	Lamiaceae	Zero	GK115

Species	Habit	Family	Local/Yem name	Collection Code
***Rhamnus prinoides* L 'Hérit.**	S	Rhamnaceae	Gesho	GK103
***Rhamnus staddo* A. Rich.**	T/S	Rhamnaceae	Wacha	GK31
***Rhus natalensis* Bernh. ex Krauss.**	T/S	Anacardiaceae	Kamo	GK104
***Rosa abyssinica* Lindl.**	S	Rosaceae	Garona	GK33
***Rubus apetalus* Poir.**	S	Rosaceae	Keu	GK81
***Rubus nuveus* Thunb.**	S	Rosaceae	Keu	GK44
***Rubus rosifolius* Sm.**	S	Rosaceae	Keu	GK105
***Rubus steudneri* Schweinf.**	S	Rosaceae	Keu	GK88
***Rytigynia neglecta* (Hiern.) Robyns**	S	Rubiaceae	Keumbuna	GK08,
***Schefflera abyssinica* (A. Rich.) Harms**	T	Araliaceae	Dega	GK126
***Schrebera alata* (Hochst.) Welw.**	T	Oleaceae	Orewa	GK57
***Senna petersiana* (Bolle) Lock**	S	Fabaceae	Not known	GK23
***Sida rhombifolia* L.**	S	Malvaceae	Not known	GK47
***Smilax anceps* Willd.**	C	Smilacaceae	Koma	GK112
***Smilax aspera* L.**	C	Smilacaceae	Koma	GK143
***Solanum incanum* L.**	S	Solanaceae	Amemu	GK145
***Solanum indicus* L.**	S	Solanaceae	Gemekewa	GK131
***Solenacio gigas* (Vatke) C. Jeffrey**	S	Asteraceae	Domorisa	GK80
Sp.(Unidentified)	T	Sapotaceae	Not known	GK91
***Syzigium guineense* (Willd.) DC.**	T	Myrtaceae	Shewu/Darker	GK46
***Syzigium guineense* ssp. *afromontanum* F. White**	T	Myrtaceae	Etni Shewu	GK110
***Tacazzea apiculata* Oliv.**	L	Apocynaceae	Tubu	GK01
***Teclea nobilis* Del.**	T/S	Rutaceae	Meku	GK19
***Toddalia asiatica* (L.) Lam.**	S	Rutaceae	Keregora	GK129
***Trichilia volkensii* (Gurke) Leroy**	T	Meliaceae	Not known	GK11
***Triumfetta brachyceras* K. Schum.**	S	Tiliaceae	Kesa	GK123
***Urena* sp.(Unidentified)**	S	Malvaceae	Kesa	GK64
***Urera hypselodendron* Wedd.**	C	Urticaceae	Halu	GK100
***Vepris dainellii* (Pic. Serm.) Kokwaro**	T/S	Rutaceae	Wichkeba	GK06
***Vernonia amygdalina* Del.**	T/S	Asteraceae	Suqeru	GK149
***Vernonia auriculifera* Hiern.**	T/S	Asteraceae	Buzo	GK131
***Vernonia biafrae* Oliv. & Hiern.**	S	Asteraceae	Etni Suqeru	GK147
***Vernonia filigera* Oliv. & Hiern.**	S	Asteraceae	Soyema	GK28
***Vernonia hochstetteri* Sch. Bip. ex Walp.**	S	Asteraceae	Soyema	GK05
***Vernonia schimperi* DC.**	S	Asteraceae	Soyema	GK60
***Vernonia wollastonii* S. Moore**	S	Asteraceae	Not known	GK76
***Viscum triflorum* DC.**	S	Viscaceae	Tigna	GK49

Table 2. List of endemic woody species encountered in Kumuli forest and their status in IUCN threat category [C = climber, S = shrub, T = tree, VU = vulnerable, NT = near threat, LC = least concern, NA = Threat not applicable]

Species	Family	Habit	Yem name	IUCN category
Acacia negrii	Fabaceae	T	Ezu	**V[**
Botriocline schimperi	Asteraceae	S	Etni Suqeru	**NA**
Clematis longicauda	Ranunculaceae	C	Segu	**NA**
Maytenus addat	Celastraceae	T	Korma	**NT**
Millettia ferruginea	Fabaceae	T	Zagu	**LC**
Otostegia tomentosa* ssp. *tomentosa	Lamiaceae	S	-	**VU**
Polyscias farinosa	Araliaceae	T	Tognu	**VU**
Pycnostachys abyssinica	Lamiaceae	C	Zero	**NA**
Solanecio gigas	Asteraceae	S	Domorisa	**NA**
Vepris dainellii	Rutaceae	S	Wichkeba	**LC**

Regarding species proportion of families, Asteraceae comprised of 14 species (10%) followed by Fabaceae 8 species (6%), Celastraceae, Rosaceae and Rubiaceae 7 species each with (5%), Malvaceae 6 species (4.5%), Euphorbiaceae, Lamiaceae and Oleaceae 5 species each with (4%), and the remaining proportion by

other families (Fig. 2). Of the total of 53 families, 10 families comprised 45% of the species while the remaining 43 families comprised 55% of the total species.

Similarly, Shannon's diversity index (H') gave the value of 2.97 and Shannon's evenness index (J') was 0.60.

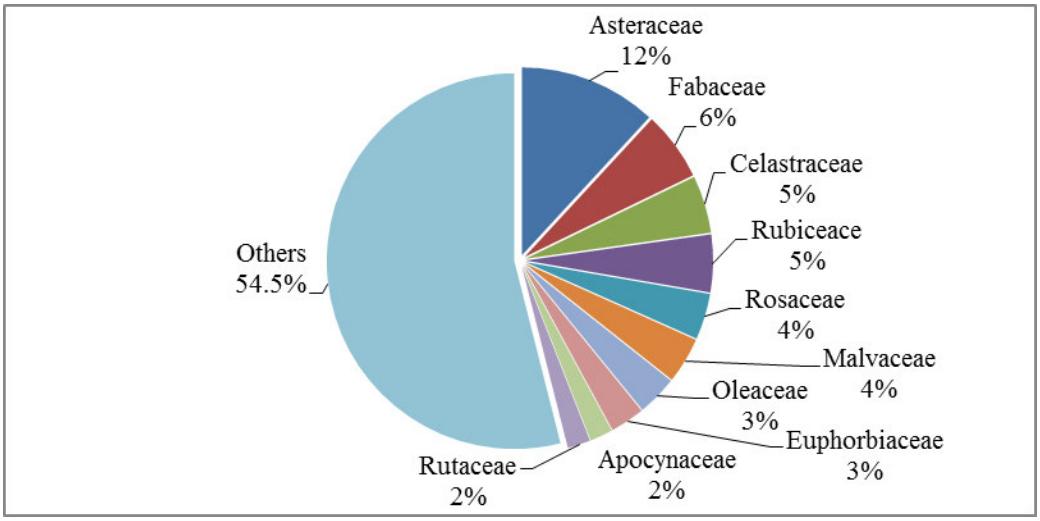


Fig. 2. Species proportion of families

Density

The density of the woody species varied considerably among species (Table 3). The total density of woody species in the forest was found to be 7791 stems ha^{-1}. Five woody species with highest density values that make the shrub layer of the forest in a rank order were *Myrsine africana* (1480 stems ha^{-1}), *Acanthus eminens* (1074 stems ha^{-1}), *Carissa spinarum* (944 stems ha^{-1}) and *Maytenus gracilipes* (814 stems ha^{-1}) and *Vernonia hochstetteri* (228 stems ha^{-1}). Similarly, three woody climbers that make both the tree/canopy layer and shrub layers with high densities in a rank order were, *Smilax aspera* (297 stems ha^{-1}), *Landolphia buchananii* (145 stems ha^{-1}) and *Jasminum abyssinicum* (129 stems ha^{-1}).

On the other hand, in the tree layer, species that showed highest density values in a rank order include *Olea capensis* (209 stems ha^{-1}), *Olinia rochetiana* (153 stems ha^{-1}), *Podocarpus falcatus* (52 stems ha^{-1}) and *Juniperus procera* (35.71 stems ha^{-1}).

Table 3. Frequency, Density and Importance Value Indices (IVIs) of woody species in Kumuli forest [D = Density, R.D = Relative density, F= Frequency, R.F = Relative frequency, TL Dbh = Total Dbh, BA = Basal Area, RDom = Relative dominance, IVI = Importance Value Index]

Species	D	R.D	F	R.F	TL Dbh	BA	BA/ha	Rdom	IVI
Myrsine africana	1480	19	25	78.13	120.6	1.14	0.89	2.96	**100.09**
Carisa spinarum	944	12.12	27	84.38	190.2	2.84	2.22	7.37	**103.87**
Olea capensis	263	3.38	27	84.38	280.5	6.18	4.83	16.02	**103.78**
Olinia rochetiana	192	2.47	27	84.38	214.7	3.62	2.83	9.39	**96.24**
Maytenus gracilipes	814	10.44	25	78.13	66.9	0.35	0.27	0.91	**89.48**
Syzigium guineense	136	1.75	23	71.88	155.4	1.9	1.48	4.92	**78.55**
Podocarpus falcatus	66	0.85	20	62.5	230.3	4.17	3.26	10.8	**74.15**
Acanthus eminens	1074	13.78	19	59.38	68.27	0.37	0.29	0.95	**74.11**
Bersama abyssinica	77	0.98	23	71.88	31.36	0.08	0.06	0.2	**73.06**
Teclea nobilis	207	2.66	20	62.5	98.14	0.76	0.59	1.96	**67.12**
Phoenix reclinata	61	0.78	18	56.25	74.23	0.43	0.34	1.12	**58.15**
Elaeodendron buchananii	69	0.88	18	56.25	46.39	0.17	0.13	0.44	**57.57**
Chionanthus mildbraedii	124	1.59	16	50	80.04	0.5	0.39	1.3	**52.89**
Juniperus procera	45	0.58	14	43.75	204.6	3.29	2.57	8.53	**52.86**
Landolphia buchananii	145	1.86	16	50	66.64	0.35	0.27	0.9	**52.76**
Rytigynia neglecta	65	0.84	15	46.88	30.12	0.07	0.05	0.18	**47.9**
Apodytes dimidiata	38	0.49	14	43.75	111.3	0.97	0.76	2.52	**46.76**
Calpurnia aurea	86	1.1	14	43.75	57.09	0.26	0.2	0.66	**45.51**
Osyris quadripartita	30	0.39	13	40.63	36.28	0.1	0.08	0.27	**41.29**
Vernonia hochstetteri	228	2.93	12	37.5	11.46	0.01	0.01	0.03	**40.46**
Jasminum abyssinicum	129	1.66	12	37.5	48.33	0.18	0.14	0.48	**39.64**
Schrebera alata	35	0.45	12	37.5	51.5	0.21	0.16	0.54	**38.49**

Species	D	R.D	F	R.F	TL Dbh	BA	BA/ha	Rdom	IVI
Rhus natalensis	25	0.32	12	37.5	55.67	0.24	0.19	0.63	**38.45**
Vepris dainellii	38	0.49	11	34.38	30.42	0.07	0.05	0.19	**35.06**
Dalbergia lactea	29	0.38	11	34.38	18.2	0.03	0.02	0.07	**34.83**
Albizia gummifera	9	0.12	11	34.38	18.75	0.03	0.02	0.07	**34.57**
Oxyanthus speciosus	38	0.49	9	28.13	87.11	0.6	0.47	1.54	**30.16**
Toddalia asiatica	32	0.4	9	28.13	62.32	0.31	0.24	0.79	**29.32**
Millettia ferruginea	30	0.39	9	28.13	54.21	0.23	0.18	0.6	**29.12**
Nuxia congesta	19	0.25	9	28.13	37.29	0.11	0.09	0.28	**28.66**
Celtis africana	44	0.56	8	25	114.9	1.04	0.81	2.69	**28.25**
Galiniera saxifraga	21	0.27	8	25	31.26	0.08	0.06	0.2	**25.47**
Erica arborea	219	2.82	7	21.88	59.46	0.28	0.22	0.72	**25.42**
Rosa abyssinica	16	0.2	8	25	21.6	0.04	0.03	0.1	**25.3**
Rhamnus staddo	30	0.39	7	21.88	54.07	0.23	0.18	0.6	**22.87**
Pittosporium viridiflorum	33	0.42	7	21.88	36.28	0.1	0.08	0.27	**22.57**
Olea europea	11	0.14	7	21.88	49.15	0.19	0.15	0.49	**22.51**
Ilex mitis	15	0.19	7	21.88	44.92	0.16	0.13	0.41	**22.48**
Dodonaea angustifolia	35	0.45	7	21.88	24.64	0.05	0.04	0.12	**22.45**
Prunus africana	19	0.25	5	15.63	149	1.74	1.36	4.52	**20.4**
Protea gaguedi	14	0.17	6	18.75	55.74	0.24	0.19	0.63	**19.55**
Maytenus senegalensis	20	0.26	6	18.75	43.96	0.15	0.12	0.39	**19.4**
Gnidia glauca	18	0.23	6	18.75	11.45	0.01	0.01	0.03	**19.01**
Euphorbia ampliphylla	7	0.09	5	15.63	114.8	1.04	0.81	2.68	**18.4**
Premna schimperi	11	0.14	5	15.63	103	0.83	0.65	2.16	**17.93**
Urera hypselodendron	59	0.75	5	15.63	34.24	0.09	0.07	0.24	**16.62**
Maytenus arbutifolia	14	0.17	5	15.63	33.19	0.09	0.07	0.22	**16.02**
Hippocratia africana	25	0.32	4	12.5	11.24	0.01	0.01	0.03	**12.85**
Rubus apetalus	14	0.17	4	12.5	26.08	0.05	0.04	0.14	**12.81**
Ehretia cymosa	9	0.12	4	12.5	9.22	0.01	0.01	0.02	**12.64**
Syzigium guineense* ssp. *afromontanum	5	0.06	3	9.38	51.03	0.2	0.16	0.53	**9.97**
Acacia brevispica	5	0.06	3	9.38	21.13	0.04	0.03	0.09	**9.53**
Vernonia amydalina	3	0.04	3	9.38	12.12	0.01	0.01	0.03	**9.45**
Dovyalis abyssinica	1	0.01	2	6.25	13.07	0	0	0.15	**6.41**
Allophylus abysinicus	3	0.04	2	6.25	21.49	0.04	0.03	0.09	**6.38**
Agarista salicifolia	9	0.12	1	3.13	54.01	0.23	0.18	0.59	**3.84**
Schefflera abyssinica	1	0.01	1	3.13	52	0.22	0.17	0.62	**3.76**
Hypericum quartinianum	5	0.06	1	3.13	51.03	0.2	0.16	0.53	**3.72**
Polyscias farinosa	1	0.01	1	3.13	46	0.17	0.13	0.43	**3.57**
Hypericum quartinianum	10	0.13	1	3.13	17.44	0.02	0.02	0.06	**3.32**
Flacoutia indica	6	0.07	1	3.13	22.21	0.04	0.03	0.1	**3.3**
Ficus sp.	3	0.04	1	3.13	23.19	0.04	0.03	0.11	**3.28**
Clausena anisata	5	0.06	1	3.13	5.72	0	0	0.01	**3.2**
Solanecio gigas	3	0.04	1	3.13	12.12	0.01	0.01	0.03	**3.2**
Catha edulis	2	0.03	1	3.13	12.12	0.01	0.01	0.03	**3.19**
Croton macrostachyus	2	0.03	1	3.13	12.12	0.01	0.01	0.03	**3.19**
Hypericum revolutum	3	0.04	1	3.13	7.07	0	0	0.01	**3.18**
Bridelia scleroneura	2	0.03	1	3.13	7.07	0	0	0.01	**3.17**
Combretum collinum	1	0.01	1	3.13	7.07	0	0	0.01	**3.15**

Frequency

The frequency of the woody species also varied considerably among species (Table 3). Accordingly, species with the highest relative frequency in a rank order were *Carissa spinarum, Olea capensis* and *Olinia rochetiana* (each 84.38%), *Myrsine africana* and *Maytenus gracilipes* (each 78.13%), *Bersama abyssinica* and *Syzigium guineense* (each 71.88%), *Podocarpus falcatus* and *Teclea nobilis* (each 62.50%), *Acanthus eminens* (59.38%), *Elaeodendron buchananii*, *Phoenix reclinata* and *Smilax aspera* (each 56.25%).

Importance Value Index

According to analysis of Importance Value Index /IVIs/ (Table 3), three shrubs namely *Carissa spinarum Myrsine africana* and *Maytenus gracilipes* in the shrub layer had highest IVIs of (in a rank order) 103.86, 100.08 and 89.48, respectively. Similarly, three tree species in the tree layer that had showed highest IVIs were *Olea capensis, Olinia rochetiana* and *Syzigium guineense* ssp. *guineense* with the values of (in a rank order) 103.78, 96.24 and 78.54, respectively.

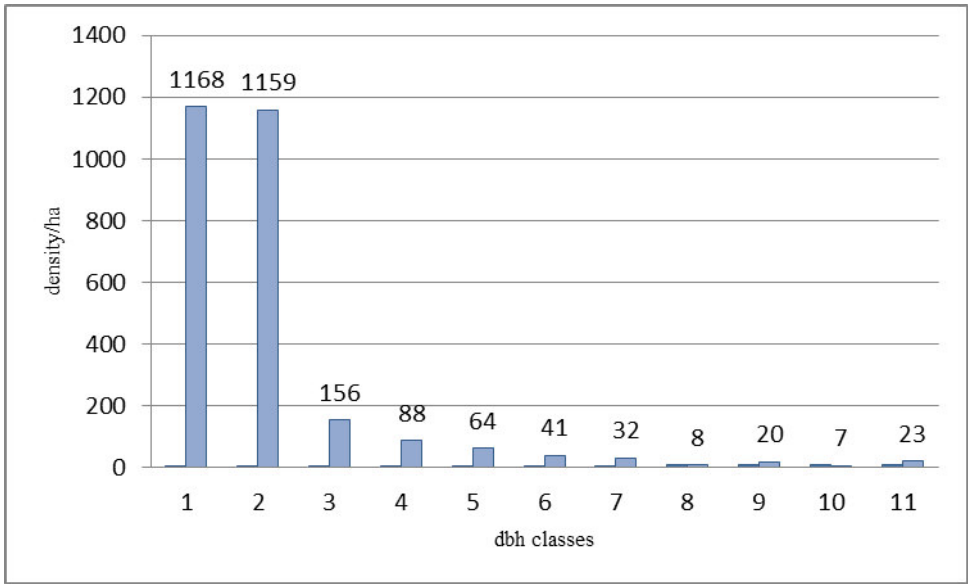
Basal Area

The total basal area (BA m^2) of the forest was also calculated from the values of dbh cm ha^{-1} . The total basal

area of the forest calculated was found to be 30.16 m^2 ha^{-1}. The BA was further determined for individual woody species and varied from 4.83 to 0.01 m^2 ha^{-1} (Table 3).

Dbh class distribution

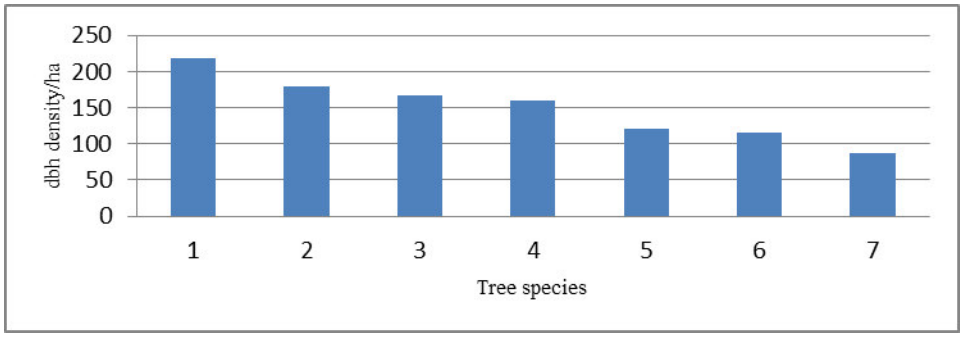
The dbh class distribution of the woody species in the forest followed an inverted J - type (Fig. 3). The dbh analysis showed that the overall sum total of densities of the dbh classes of the forest was 7067.19 ha^{-1}. The dbh class distribution revealed that the first lower two dbh classes, dbh class 1 (2.5-5 cm) and dbh class 2 (5-10 cm) comprised of about 89.4% of the dbh class distribution (Fig. 3) each contributing to 55.9% and 33.6% of the total density, respectively. Upper dbh classes i.e. dbh classes 3 and above constitute only small proportions to the size class distribution.



(1 = <5 cm, 2 = 5-10 cm, 3 = 10-15 cm, 4 = 15-20 cm, 5 = 20-25 cm, 6 = 25-30 cm, 7 = 30-35 cm, 8 = 35-40 cm, 9 = 40-45 cm, 10 = 45-50 cm, 11 ≥ 50 cm)

Fig. 3. The total dbh class distribution of woody species ha $^{-1}$

The dbh analysis was also done for dominant tree species in the forest. Seven dominant tree species with highest total dbh ha^{-1} in a rank order were *Olea capensis* (219 cm ha $^{-1}$), *Podocarpus falcatus* (180 cm ha $^{-1}$), *Olinia rochetiana* (168 cm ha $^{-1}$), *Juniperus procera* (160 cm ha $^{-1}$), *Syzigium guineese* (120 cm ha $^{-1}$), *Prunus africana* (110 cm ha $^{-1}$) and *Apodytes dimidiata* (96 cm ha $^{-1}$) (Fig. 4).



(1 = *Olea capensis*, 2 = *Podocarpus falcatus*,3 = *Olinia rochetiana*, 4 = *Juniperus procera*, 5 = *Syzigium guineese*, 6 = *Prunus africana*, 7 = *Apodytes dimidiata*

Fig. 4. Tree species with their total dbh cm ha^{-1}

The trends in the dbh class distribution was determined for the dominant tree and shrub species (Fig. 5). Regarding tree species, *Podocarpus falcatus* and *Olea capensis* were the two species which showed good trend of size structure being represented in lower, middle and upper dbh classes. *Prunus africana* is a species which showed bad trend being not represented in the lower dbh, but only in the upper classes. The tree species such as *Olinia rochetiana, Juniperus procera, Syzigium guineese* and *Apodytes dimidiata* showed irregular trends in the dbh class distribution (Fig. 5).

Height class distribution

Analysis of height class distribution of the forest is given in Fig. 6. The highest proportion of the total density of height classes was contributed by height class 2 (1-5 m) which is 62% (4775 ha^{-1}) followed by height class 3 (5-10 m) which contributed to 20% (1548 ha^{-1}) of the total sum of height classes. Height class 1 (0-1 m) constituted 13% (1047 ha^{-1}). Taller trees with height between 10-20 m (height class 4) made 5% (398 ha^{-1}) and those above 20 m tall (height class 5) contributed only to 1.06% (53 ha^{-1}).

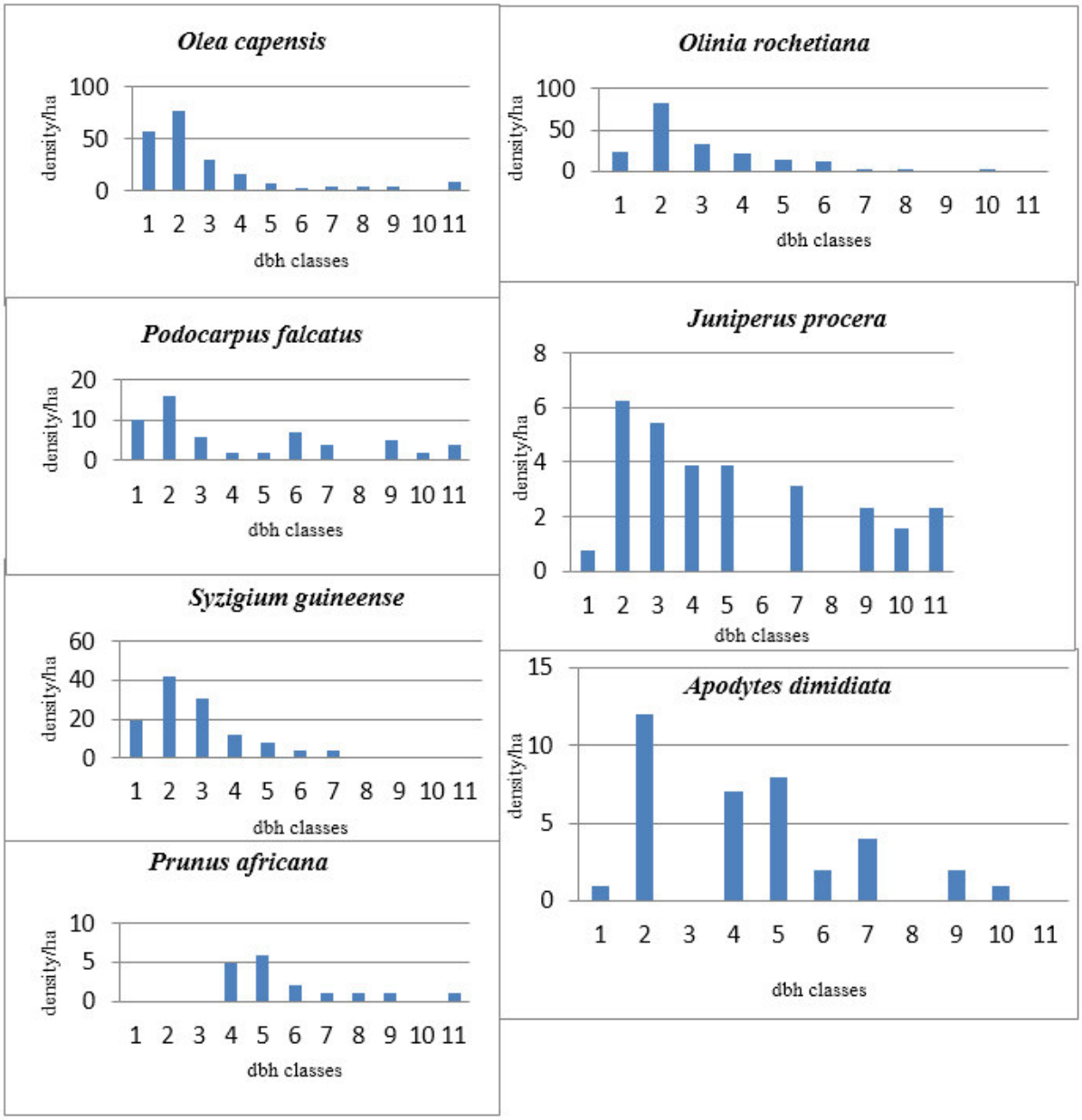
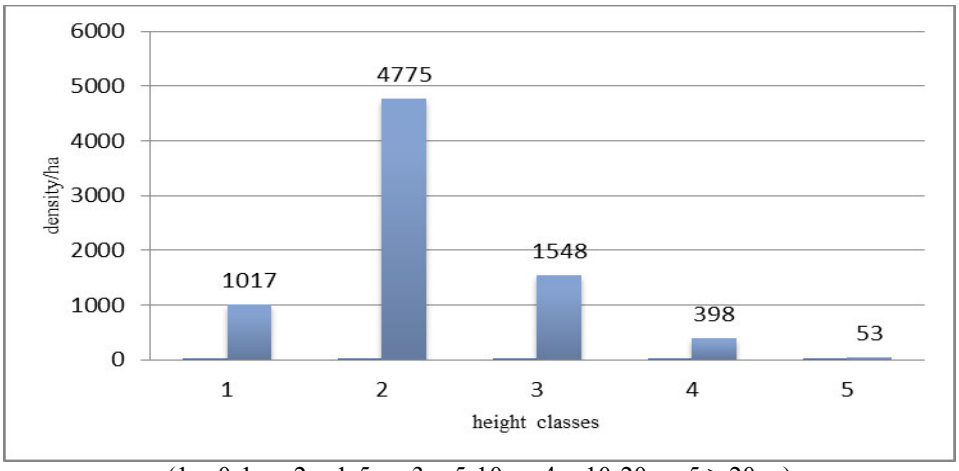


Fig. 5 Trends of dbh (cm) class distribution of seven dominant trees



(1 = 0-1 m, 2 = 1-5 m, 3 = 5-10 m, 4 = 10-20 m, 5 ≥ 20 m)
Fig. 6. Height (m) class distribution of Kumuli forest

Discussion

Information of species composition, diversity, and structure is important tool in assessing sustainability of any forest, conservation of species, and management of the ecosystems. About 133 woody plant species representing 107 genera and 53 families were recorded in this study. Shrubs had the highest proportion (44.3%) followed by trees (26.3%), trees/shrubs (19%), woody climbers (6%) and lianas (3%). The forest has close similarity in species composition with a dry evergreen Afromontane forest of TaraGedam which had 143 woody species in 30 quadrats 114 genera and 57 families of which comprised of trees (30.8%), trees/shrubs (39.9%), shrubs (23.1%) and lianas (6.3%) (Haileab Zegeye *et al*., 2011). While the angiosperms obviously comprised the biggest proportion of the woody species, gymnosperms were represented by only two indigenous species namely, *Juniperus procera* and *Podocarpus falcatus*. Mature individuals of the former had no seedlings in their own shade. This is from the fact that it is light demanding for seedling germination and regeneration is largely dependant on fire disturbance (Wimbush, 1937 cited in Friis, 1992). On the other hand, the latter had abundant seedlings indicating good regeneration and distribution in the forest. Generally, the analysis of habit of the woody species showed that the forest is dominated by shrubs.

Kumuli forest is clearly one the existing few natural forest patches that is repository for the genetic resources and home of biodiversity of the country. On top of this, it has species that are endemic to the country's Flora. About 11 species (7%) of the species sampled are endemic. The number of endemic woody species agrees with that of Gedo dry evergreen Afromontane forest (12 endemic woody species) (Berhanu Kebede, 2010). It is also important to identify the status the woody species if some of them are under threat so that suggest conservation priority. Regarding IUCN threat category, species such as *Hagenia abyssinica*, *Maytenus addat* and *Podocarpus falcatus* are under near threatened (NT), *Acacia negrii*, *Maytenus serrata, Otostegia tomentosa* subsp. *tomentosa,* and *Polyscias farinosa* are under vulnerable category (VU) while *Lippia adöensis*, *Millettia ferruginea* and *Vepris dainellii* are under least concern category (LC) of IUCN Red List (Vivero *et al.*, 2005).

Phytogeographically, most of the woody species found in Kumuli forest are ones that are characteristic to and commonly found in the dry evergreen Afromontane forests of central plateau (Friis *et al*., 2011). The altitudinal ranges of the forest is between 2200 and 2875 m a.s.l. The overall diversity indices ($H' = 2.97$) and evenness ($J' = 0.60$) of Kumuli forest are similar to that of woody species diversity of TaraGedam in northern Ethiopia ($H' = 2.98$ and $J' = 0.65$) (Haileab Zegeye *et al*., 2011).

The dbh class distribution of Kumuli forest followed reverse J-shaped trend with highest number of individuals being in the lower classes with subsequent decrease in the middle and upper dbh classes. This is due to big number of stems of shrubs, small-sized tree species and younger individuals of big-sized tree species, too. Similar trends were reported from studies in dry evergreen forests of Gedo of West Shewa Zone (Berhanu Kebede, 2010) and TaraGedam forest at South Gonder (Haileab Zegeye *et al*., 2011). The ratio of dbh trees >10 cm dbh to those >20 cm in Kumuli forest showed highest value of 2.99 than any other similar dry evergreen Afromontane forests in comparison (Table 4) indicating that the forest is dominated by shrubs (small-sized woody species).

Table 4. Comparison of woody species density ha $^{-1}$ in two dbh classes and total basal areas /BAs/ of Kumuli and that of four other dry afromontane forests

Forest	DBh>10	Dbh>20	Ratio >10:>20	Total Basal Area /BA/ m^2ha^{-1}
Chilimo*	639	250	2.60	30.18
Menagesha*	484	208	2.30	36.10
Wofwasha*	309	215	1.50	101.80
Gedo**	832	464	1.79	35.45
Kumuli	553	185	2.99	30.16

Sources: *Tamrat Bekele 1993, **Berhanu Kebede 2010

The finding in this study showed that many tree species had lower IVI values (Table 3) indicating that the majority of species are rare in the forest. This could also be supported by density and the frequency computed for most species indicates that the forest holds more rare species. The rarity may attributed to different density-dependent and density-independent factors such as completion for nutrients poor seed dispersal and germination, access of solar radiation, suitability of microclimate and past history disturbances in the forest. The IVI can be used for prioritizing species conservation whereby species with low IVI value need high conservation priority compared to the ones with high IVI.

Regarding the forest profiles, few tree species in the tree layer have contributed most to the total dbh of of Kumuli forest. These are; *Olea capensis* (219 cm ha^{-1}) followed by *Podocarpus falcatus* (180 cm ha^{-1}), *Olinia rochetiana* (168 cm ha^{-1}) and *Juniperus procera* (160 cm ha^{-1}). From the trends in the dbh class distribution of individual woody species, it can be seen that *Olea capaensis, Podocarpus falcatus* and *Syzigium guineense* had individuals in most of the dbh classes (i.e. the lower, middle and upper dbh classes) indicating both good regeneration and good recruitment. Species such as *Apodytes dimidiata, J. procera* and *O. rochetiana* had few individuals in the lower dbh class but had good number of individuals in the subsequent upper dbh classes indicating bad regeneration and good recruitment of the species. *Prunus africana* didn't have individuals in the lower dbh classes and still had few individuals in the upper dbh classes indicating both bad regeneration and bad recruitment. It is a highly threatened species listed under vulnerable (V) in the IUCN Red List category (WCMC, 1998). Its threat in the case of Ethiopian flora may be due to its being hunted for firewood, timber, construction and expansion of farmland. Else where in east Africa, the collection of mature bark for its use in traditional medicine and other uses has resulted in the species becoming endangered.

In the shrub layer of the forest, *Acanthus eminens*, *Carissa spinarum*, *Maytenus gracilipes* and *Myrsine africana* showed both good regeneration and good recruitment. In particular, *A. eminens* propagates both by seeds and vegetatively. This gave it advantage of invasive distribution in the forest (Gideon Woldemariam, Personal Observation). Such an invasive abundance of this species in the forest might suppress establishment seedlings of other woody species blocking reaching solar radiation to the forest floor so that it might impede regeneration of other shade intolerant species. It is regarded as a species of a late climax succession stage in less disturbed Afromontane forests (Althof, 2005).

The trends in the height class distribution of Kumuli forest also could show regular pattern after the 1st height class (0-1 m). The 2nd height class (1-5 m) consists the biggest proportion (62%) of the height class density. This might indicate that the forest is dominated by short height woody shrubs than saying it has not reached climax stage of tree species because there are only small proportion of trees at the last height classes (5% and 1% only). Comparison of the height class distributions of five other dry afromontane forests (Table 4) indicates that about 74% the forest height class distribution fall below 5 m. Here, height classes greater than 5 m could constitute only 6%.

The trend of height class distribution of Kumuli forest was compared with other dry evergreen Afromontane forests (Table 5). About 74% of the total density height class distribution fell in in height class 1 and 2 (i.e. 0-1 m and 1-5 m, respectively). On the other hand, height classes 3 and 4 (i.e individuals of species between 6 - 20 m comprised of 5% while those >20 m comprised of only 1%. This indicates that Kumuli forest of shorter stature that the rest of forests in comparison that may be linked to some disturbance history in the past.

Table 5. Comparison of Height class percentage of Kumuli forest with other dry evergreen afromontane forests

Height class	Chilimo[a]	Menagesha[a]	Wofwasha[a]	Gedo[b]	Denkoro[c]	Kumuli
<=5 m	No data	No data	No data	No data	No data	74
6-20 m	92.8	89.1	77.5	98.13	94.5	5
>20 m	<1	6	22.4	2	3.4	1

Sources: [a]Tamrat Bekele (1993), [b]Berhanu Kebede (2010), [c]Abate Ayalew *et al.* (2006)

The total basal area of Kumuli forest was also compared to other forests of dry evergreen afromontane forests. Total basal area of Wofwasha, Jibat, Menagesha, Chilimo and Kumuli forest are in a rank order 101.8

m^2ha^{-1}, 49.8 8 m^2ha^{-1}, 36.1 8 m^2ha^{-1}, 30.1 8 m^2ha^{-1} and 30.1 6 m^2ha^{-1}, respectively. This indicates that Kumuli forest is dominated by small sized shrubs than other dry evergreen Afromontane forests in comparison. Basal area is used to see the relative importance of the species in the formation of the horizontal structure of the forest.

Conclusion

From analysis of species composition, it can be said that Kumuli forest has similar woody species with that of dry evergreen afromontane forest patches of the central plateau. Generally, the diversity of the woody species indicates that the forest is obviously repository for the *in situ* genepools of some endemic as well as indigenous species of the nation.

The big ratio of size class distribution shows that the forest is dominated by small-sized woody species. The forest is also inferior to other dry evergreen afromontane forests in comparison in its total basal area, but relatively similar to some. The forest also is dominated by low height individuals, only few individuals had height > 5 m. Few woody species that could contribute to the densities of both the dbh and height class distribution.

It was also observed that the landscapes in the vicinity of the study forest have individuals of luxuriant and mature individuals of *Juniperus procera*, *Podocarpus falcatus*, *Prunus africana*, *Apodytes dimidiata*, *Syzigium guineense* and *Ficus sur* (most commonly around home gardens) in the cultivation fields and around homesteads. This indicates that Yem people have good indigenous practice of sustainable conservation of useful tree species which inturn guarantees regeneration of the species by seeds whose dispersal effected by different agents.

Recommendations

We suggest further ethnoanthropological investigations of Yem people on the legacy of protecting and conserving of natural vegetation, the tradition of keeping of indigenous tree species on farm lands as agroforestry species and planting or allowing growth of indigenous tree species around homesteads.

We suggest phonological studies on those indigenous woody species with low importance value indices (IVIs) and bad regeneration status thereby implement *in situ* and *ex situ* conservation efforts for preserving them. There are more forest remnants in the study district which need further investigations. From point of view of conservation of biodiversity, the presence of such forest vegetation around the landscape in the study forest clearly indicates it is home for considerable bird diversity and other diurnal mammalian diversity that includes primate species such as baboons and colobus monkeys needs call further studies.

References

Althof, A. (2005). Human impact on floara and begetation of Kakamega forest, Kenya. PhD Thesis, Universität Koblenz-Landau.

Birhanu Kebede (2010). Floristic Composition and Structural Analysis of Gedo Dry Evergreen Montane Forest, West Shewa Zone of Oromia National Regional State. Master's Thesis. Addis Ababa University.

Demel Teketay (2001). Deforestation, wood famine, and environmental degradation in Ethiopia's highland Ecosystems: urgent need for action. *Northeast African Studies,* 8(1): 53-76.

EFAP (1994). *Ethiopian Forestry Action Program*, Volume III. The Challenge for Development. Ministry of Natural Resources, Addis Ababa.

EMA (1988). National Atlas of Ethiopia. Ethiopian Mapping Authority. Addis Ababa.

Friis, Ib., Edwards, S. and Ensermu Kelbessa *et al*. (2001). Diversity and endemism in the flora of Ethiopia and Eritrea – what do the published Flora volumes tell us? *Biol. Skr*., 54:173-193.

Friis, Ib., Sebsebe Demissew and van Breugel, P. (2011). Atlas of Potential Vegetation of Ethiopia. Addis Ababa University Press and Shama Books.

Haileab Zegeye, Demel Teketay and Ensermu Kelbessa (2011). Diversity and regeneration status of woody species in Tara Gedam and Abebaye forests, northwestern Ethiopia. *Journal of Forestry*

Hegazy, A.K. (1999). The United Nations conservation on biological diversity: From adoption to implementation. In: *Environment 2000 and beyond*, (Hegazy, A.K). UNESCO, ICED. Cairo, Egypt. Pp 442.

Kent, M. and Coker, P. (1992). Vegetation description and analysis. Belhaven Press. London. Pp. 363.

Krebs, C.J. (1989). Ecological Methodology. Harper and Collins, New York.

Livelihood Woreda Reports (2009). SNNPR - Yem: Key Parameters for Monitoring Livelihoods at Woreda Level". [Online].

Reusing, M. (1998). *Monitoring the natural high forests in Ethiopia*. GTZ, Ministry of Agriculture. Addis Ababa, Ethiopia.

Sala, O.E., Chapin, F.S., Armesto, J.J., *et al*. (2000). Biodiversity - Global biodiversity scenarios for the year 2100. *Science*, 287: 1770-1774.

Sayer, J.A., Harcourt, C.S. and Collins, N.M. (eds.) (1992). The Conservation atlas of Tropical Forests, Africa. Macmillan Publishers, Great Britain.

Tadesse Woldemariam, Demel Teketay, Edwards, S. and Olsson, M. (2000). Woody plant and avian species diversity in a dry Afromontane forest on the Central Plateau on Ethiopia: Biological indicators for conservation. *Ethiopian Journal of Natural Resources,* 2: 255-293.

Tamrat Bekele (1993). Vegetation ecology of remnant Afromontane forests in the central Plateau of Shewa, Ethiopia. *Acta Phytogeographica Suecica*, 79. Opulus Press AB. Uppsala.

Taye Bekele, Hasse, G. and Teshome Soromsa (1999). Forest Genetic Resources of Ethiopia: Status and proposed actions. In: *Forest genetic resources conservation: Principles strategies and actions*. Proceeding of the national forest genetic resources conservation strategy development workshop, June 21-22, Addis Ababa.

Thomas, C.D., Cameron, A., Green, R. E., *et al*. (2004). Extinction risk from climate change. *Nature*, 427: 145-148.

Vivero, J.L., Ensermu Kelbessa and Sebsebe Demissew (2005). The Red List of Endemic Trees & Shrubs of Ethiopia and Eritrea. Fauna & Flora International, Cambridge, UK.

WCMC (1998). World Conservation Monitoring Centre. *Prunus africana*. The IUCN Red List of Threatened Species 1998: e.T33631A9799059. http://dx.doi.org/10.2305/IUCN.UK.1998.RLTS.T33631A9799059.en Downloaded on 29 October 2015.

Zerihun Woldu (1999). Forests in the vegetation types of Ethiopia and their status in the geographical context. In: *Forest Genetic Resources Conservation: Principles, Strategies and Actions*, (Edwards, S., Abebe Demissie, Taye Bekele and Haase, G., eds.). Workshop Proceedings. Institute of Biodiversity Conservation and Research, and GTZ. Addis Ababa. Pp. 1-38.