FULL-LENGTH ARTICLE

Floristic composition, diversity and richness of selected Forest patches in Wombera district, Benshangul Gumuz Regional State, Ethiopia

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ABSTRACT

Floristic composition, diversity and community types of six forest patches in three agro-ecologies (higher, middle and lower) were studied in Wombera district, Benishangul Gumuz Regional State. Transect lines were laid 300m apart along altitudinal gradients; and plots were laid every 150m along the transect lines. Cover-abundance, height, DBH of woody plant species, and landscape variables were recorded in 142 (20× 20m) main plots. Seedlings and saplings were collected from five 5 × 5 m plots nested inside 20 × 20 m plots: four at corners and one in the center. Herbs and grass were collected from 1 × 1 m plots that were nested inside of 5 × 5 m plots, four at corners and one in center. Shannon diversity and Evenness indices were used to compute Floristic diversity and evenness. The Multivariate tool of R package (ver. 3.4.3) was used for community analysis. A total of 375 species representing 90 families and 70 genera were recorded from 142 plots in six forest patches within three agro-ecologies, of which 144 species were identified in higher altitudes, representing 52 families dominated by Asteraceae, Poaceae, Fabaceae, and Polygonaceae. In middle attitude, 115 species representing 49 families dominated by Fabaceae, Asteraceae, Poaceae, and Moraceae were identified. A total of 123 species were identified at lower altitudes, which represented 45 families, dominated by Fabaceae, Poaceae, and Combretaceae. The hierarchical classification analysis identified six communities, named after two or more indicator species. The plant communities are assembled by altitudinal gradients.

Key words: Agro-Ecology; Community; Diversity; Forest patches; Vegetation

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INTRODUCTION

Ethiopian owns extreme altitudinal ranges from lowland below sea level (Danakil Depression, 110 mbsl) to top mountains [Ras Dashen (4532masl) (Teketay, 1999; Woldu, 1999)]. The Great Rift Valley is also the other landscape that runs from northeast to southwest of the country and separates the country into Northwestern and Southeastern highlands enabling the country owning semi-arid lowlands to the east, south, and west of the country (Friis, 1986; Bekele, 1993). Such diversified landscapes and altitudinal ranges have given rise to diversified agro-ecological zones, temperature, rainfall patterns, soil texture, and wind patterns in Africa (Friis *et al*., 2010). The diversified environmental conditions and landscapes also resulted in diversified flora and fauna (Bekele *et al*., 1999; Woldu, 1999).

Ethiopia is home to about 6027 species of higher plants with approximately10% endemism, and hence one of the six plant biodiversity-rich countries in Africa (Kelbessa ans Demissew, 2014). Ethiopia also has two of the 34 global biodiversity hotspots, namely the Eastern Afromontane and Horn of Africa biodiversity hotspots (Myer *et al*., 2000). The country is a regional center for biological diversity due to its wide range of altitude, its high geographical diversity with high and rugged mountains, flat-topped plateaus and deep gorges, incised river valleys and rolling plains (Kelbessa *et al.*, 1992; Woldu, 1999).

In contrast, many studies have shown that most of the vegetation covers of the country have been deforested, and few remnant high land forests remain in southwestern and western parts and as patches in conservation areas, churches (Bekele, 1993) and sacred sites in the country (Friis, 1992; Wassie *et al*., 2005; Senbeta, 2006; Demissew and Friis, 2009; Friis *et al*., 2010). Environmental variables determine vegetation Structure and composition. Altitude is the most determinant factor that influences the occurrence and distribution of the plant communities (Schmitt, *et al*., 2010). Species richness tends to peak at intermediate elevations (Didita *et al*., 2010). The main objective of the study was to assess vegetation diversity, composition, community type along altitudinal and disturbance gradients (highly disturbed, intermediate, low disturbance level and intact). Current and historic understanding of vegetation ecology in Benshangul Gumuz particularly, in Wombera district was not adequate. Awas (2007) had made a study of the floristic composition and the ethnobotany in the lowland areas of Benshangul. However, no research has been conducted in Wombera district. Thus, this study filled the gap which addressed vegetation ecology status of the district with high significance to the scientific community, policy makers and other stake holders to conserve, study, rehabilitate, and utilize the vegetation.

MATERIALS AND METHODS

Descriptions of the study Area

Wombera ditrict is located 658km from Addis Ababa, capital city of the country. It is found in the Metekel administrative zone of Benishangul Gumuz Regional State in the northwestern part of Ethiopia. The district is one of the largest districts in Metekel administrative zone. It is bounded by the districts of Guba and Dangur in the north, Bullen in the east, Agallometi, and Yaso in the south, and Serba Abbay and Sherkole in the west. The latitudinal and longitudinal position of the district range between 90 57' 30$^{''}$ to 11^{0} 08' 45$^{''}$ N and 35^{0} 09$^{'}$ 09” to 35^{0} 50' 25" E, respectively (Fig. 1).

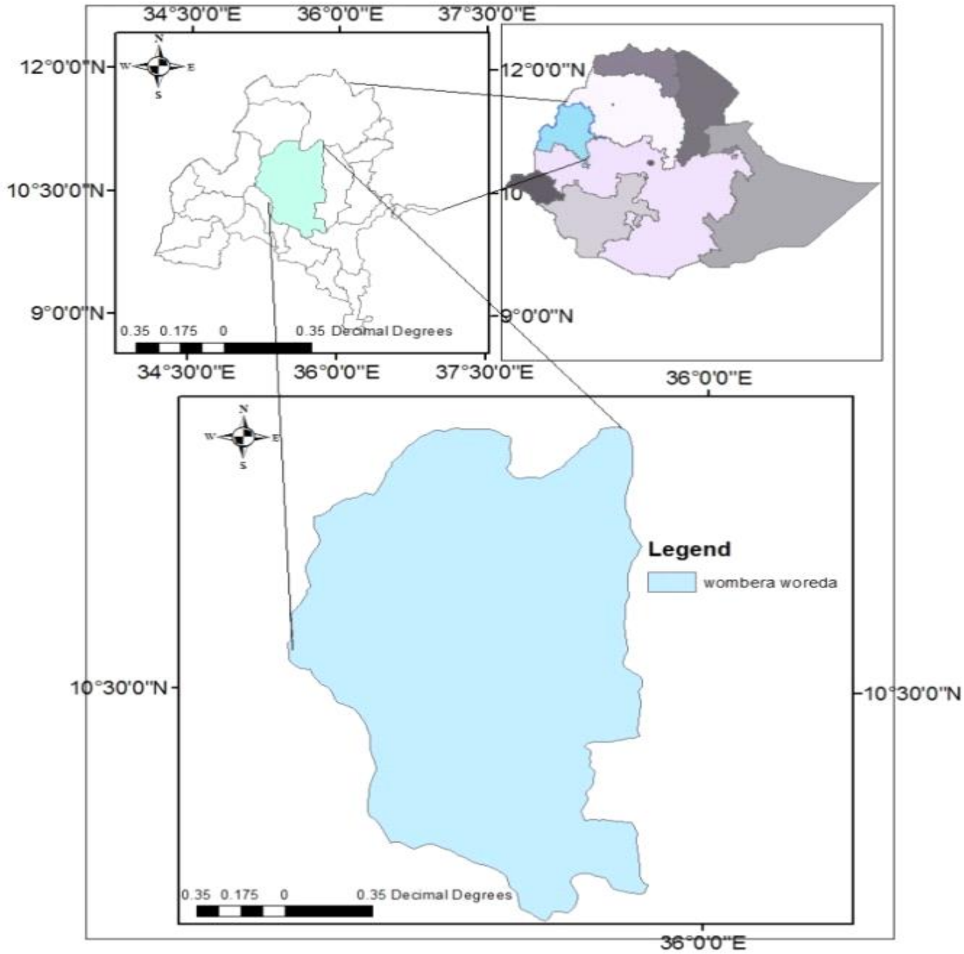

Fig.1. Map of the study area

Climate and Temperature

Twenty years of climate data (1999-2016) were taken from the Ethiopian metrological agency. Climate data were drawn using the Walter climadiagram program of R software version 3.4.2 (R Software Developing Team 2017) and library climatol (Woldu, 2017).The altitude of the study area ranges between 600-2615 masl. The average annual temperatures for the high altitude, middle and lower altitude were 15.9^{o}C (7.2^{o}C - 26^{o}C), 20.7^{o}C (11.9^{o}C - 30.6^{o}C), 25.7^{o}C (18.8^{o}C-37.2^{o}C), respectively. Likewise, the average annual rainfalls for the three altitudes were 1942mm, 1560 mm, and 1210mm, respectively (Fig. 2).

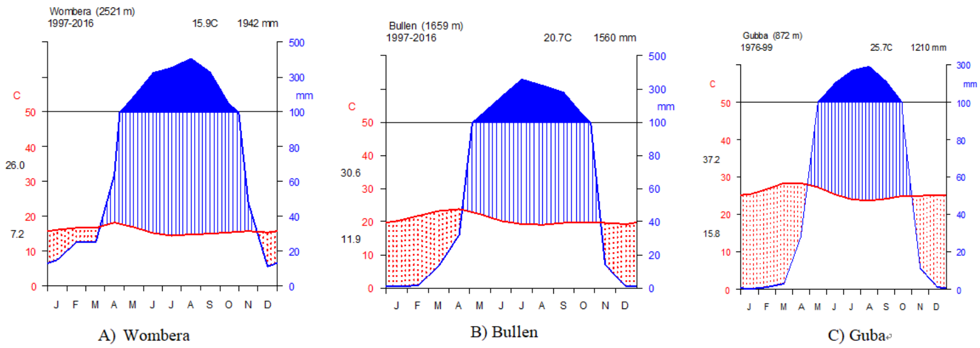

Fig. 2. Climate diagram of meteorological stations located in the three altitudinal categories of the study area

Reconnaissance Survey

During the reconnaissance survey, general prerequisite works were carried out: A reconnaissance survey of the study area was made from June to November, 2018 to obtain an impression of the study site condition and physiognomy of the vegetation. Sampling sites were selected and determined based on the accessibility of forest patches.

Vegetation data collection

A series of nested plots were established following previous study (Stohlgren *et al.,* 1995) at 300 m intervals along attitudinal gradients. The plots were laid 150m apart along parallel transect lines. Data were collected from 142 Plots. In 20 × 20 m plots, trees with stem diameter at breast height (DBH) >2.5 cm and shrubs at diameter stump height (DSH) were collected. Canopy cover of each tree species was estimated and computed to the total area of the plot. Seedlings and saplings were collected in five 5 × 5 m plots nested inside 20 × 20 m plots with four at corners and one in center. Herbs and grass were collected in 1 × 1 m plots that were nested inside of 5 × 5 m plots with four at corners and one in center.

All plant specimens were collected, temporarily tagged with plot numbers and temporary labels were assigned to species (fast method), pressed and brought to the National Herbarium (ETH) for identification and storage. The species were identified at the National Herbarium (ETH) of Addis Ababa University by using the taxonomic keys in the various volumes of the Flora of Ethiopia and Eritrea (Hedberg & Edwards, 1989; Edwards *et al*., 1995; Phillips, 1995; Edwards *et al*., 1997; Hedberg *et al*., 2003; Tadesse, 2004; Hedberg *et* *al*., 2006, 2009a, 2009b). The species were confirmed with authenticated specimens published in the flora of Ethiopia and Eritrea. Botanical names and authorities were verified using the species and family lists in Volume 8 of the Flora of Ethiopia and Eritrea (Hedberg *et al*., 2009).

Data Analysis

Cover/abundance (ground cover) for each plant species was estimated following the procedure of Braun-Blanquet (1965) and Kent and Coker (1992) to determine different vegetation parameters. The percent canopy/foliage cover was transformed to ordinal scales and assigned value one to nine cover-abundance classes according to the modified 1-9 Braun-Blanquet scale (Van der Maarel, 1979). The scales are 1 ≤ 0.1%, 2 = 0.1 to 1%, 3 = 1 to 2%, 4 = 2 to 5%, 5 = 5 to 10%, 6 = 10 to 25%, 7 = 25 to 50%, 8 = 50 to 75%, and 9 >75%. The three-column data, abundance or cover, were imported to R Package 3.4.3 (R Core Team, 2017) and modified to carry out the analysis for various vegetation parameters.

Floristic Composition and Diversity analysis

The Floristic richness, diversity and evenness indices of plant communities were analyzed by using R Package 3.4.3 (Woldu, 2017). Among the various coefficients widely used to compute the diversity of a community, species diversity and turnover (β diversity) are the most commonly used (Krebs, 1999). It is sometimes used for identifying areas of High natural or human disturbances. The value usually falls between 1.5 and 3.5, rarely exceeding 4.5 (Maguran, 1988; Økland, 1990; Krebs, 1999). A high Shannon index indicates high diversity and often low disturbance whereas; a low Shannon index shows low diversity and often high disturbance.

Species turnover (β diversity) measures the change in species compositions from patches to patches along Environmental gradients (vertical height, soil depth etc) (Whittaker, 1972). Thus, in this altitude (low, middle and high) and disturbance (low, intermediate and high) gradient were used. In other words, β–diversity measures the changes in species diversity among sets of habitats. A high β–diversity index indicates a low level of similarity among areas or communities, while a low beta diversity index shows a high level of similarity (Økland, 1990). The Values of ß-diversity less than one are lower and, greater than five can be considered as higher (Woldu, 2017).

Vegetation Classification (plant communities)

Cluster analysis is a multivariate technique widely used to group a set of observations (plots or vegetation samples) based on their attributes or floristic composition (Kent and Coker, 1992; McCune and Grace, 2002).In this study, hierarchical (agglomerative) cluster analysis was executed using the free statistical software R version 3.4.3 (R Development Core Team, 2017) to classify the vegetation into plant community types. The cover-abundance of the species was used for analysis. Plant communities were classified using the Hierarchical clustering method using similarity ratio, ward clustering algorithms. To determine the optimal number of groups in the cluster analysis, different classification methods were carried out. Ward produces a nicely compact community (Woldu, 2017). Validation of the community was analyzed using the package called "clv" in R software. The intra-cluster and inter-community distances were also performed. This function helps to deduce the cohesiveness or dispersion as well as the relative proximity of the community to each other. All analyses were carried out using R programs updated in Woldu (2017).

RESULTS

Floristic Composition

A total of 375 species representing 90 families and 70 genera were recorded from 142 sampling plots within three agro-ecologies (lower, middle and higher altitude).

Angiosperms, gymnosperms, and Pteridophytes were represented by 363, 1, and 7 species, respectively. Among the angiosperm families, Fabaceae (36 species) were the richest, followed by Asteraceae (species 35); and Poaceae (33 species). Pteridophytes were represented by four families and seven species, namely Aspleniaceae (two species), Polypodiaceae (two species), Pteridaceae (one species) and Selaginellaceae (two species). *Juniperus procera* (Cupressaceae) was the only species of Gymnosperms that was recorded in a few plots.

One hundred forty four species were identified in higher altitude: 37 woody, 30 shrub, 15 liana and 62 herbs. They were categorized under 52 families among which Asteraceae, Poaceae, Fabaceae, and Polygonaceae are the dominant family. From 115 species recorded in middle altitude, 46 trees, 23 shrubs, 41 herbs, and five lianas were identified. These species represent 49 families dominated by Fabaceae, Asteraceae, Poaceae, and Moraceae.

In lower ago-ecology forest patches, a total of 123 species: 40 Trees, 27 shrubs, 45 Herbs, and nine lianas representing 45 families were recorded dominated by family Fabaceae, Poaceae and Combretaceae (Fig. 3).

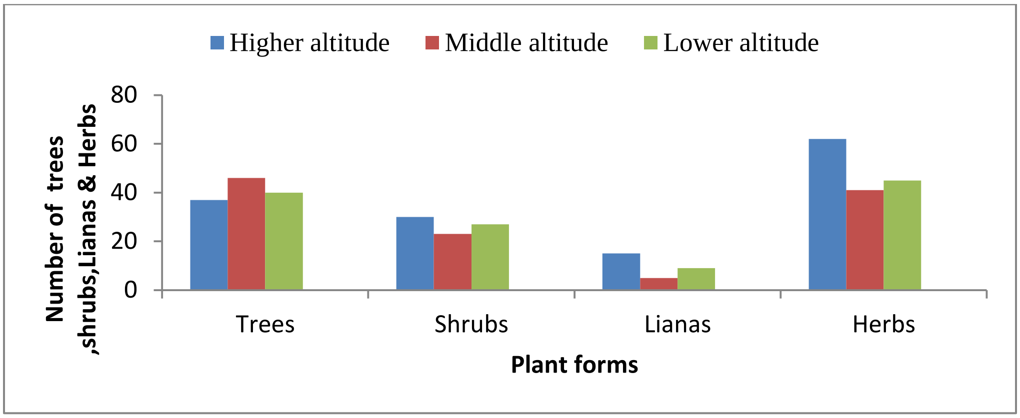

Fig. 3. Plant forms: number of trees shrubs, Lianas and Herbs along altitudinal gradients

Families in six Forest Patches

In higher altitude forest patches, Asteraceae (22 species, 15.83 %) was the dominant families followed by Poaceae (12 species, 8.63%) and Fabaceae, Polygonaceae, and Solanaceae had an equal number of species (6 each, 4.32%). In middle altitudes, Fabaceae (15 species, 13.27%) was the dominant, followed by Poaceae and Asteraceae (8 species, 7%). In the lower altitudes, Fabaceae (15 species, 12.20%) followed by Poaceae (13 species, 10.57%) and Combretaceae (7, 5.69%) (Fig. 4).

Vegetation Classification (Plant Communities)

The hierarchical classification analysis resulted in six plant community types in the study area (Fig. 5). They were named after two or more indicator species (Table1). Community I, Community II and Community III are closely related; Community IV and community V are more similar than other communities. The detailed description of each community type and their altitudinal ranges, indicator species, dominant species and examples of other species in different vegetation layers (tree, shrub, grasses and herb); the similarity between the six communities: richness, diversity, and evenness are described within the following subsections.

Community I: *Nuxia congeta- Maesa lanceolata* Community type: This community is in the dry Afromontane forests occurring in altitudes range of 2000-2600. Indicator species include *Nuxia congeta*, *Maesa lanceolata, and Accacia abyssinica* were significantly varied (P < 0.001).

Community II: *Allophyllus abyssinicus-Hagenia abyssinica* community type. This community type is in the same altitudinal range with community I and community III. They are older than community I and younger than community III. Indicator species are *Allophyllus abyssinicus-Hagenia abyssinica* which, were significantly varied at (P<0.001).

Community III: *Apodytes dimidiata- Prunus africana community type.* Indicator species were *Prunus africana* and *Apodytes dimidiata* and significantly varied (P < 0.001). This community was dominated by: the most upper canopy tree such as *Syzygium guineense*, *Ficus sur*, *Olea europaea* near the river border and *Prunus africana*, *Apodytes dimidita*, and *Ekebergia capensis* away from the river.

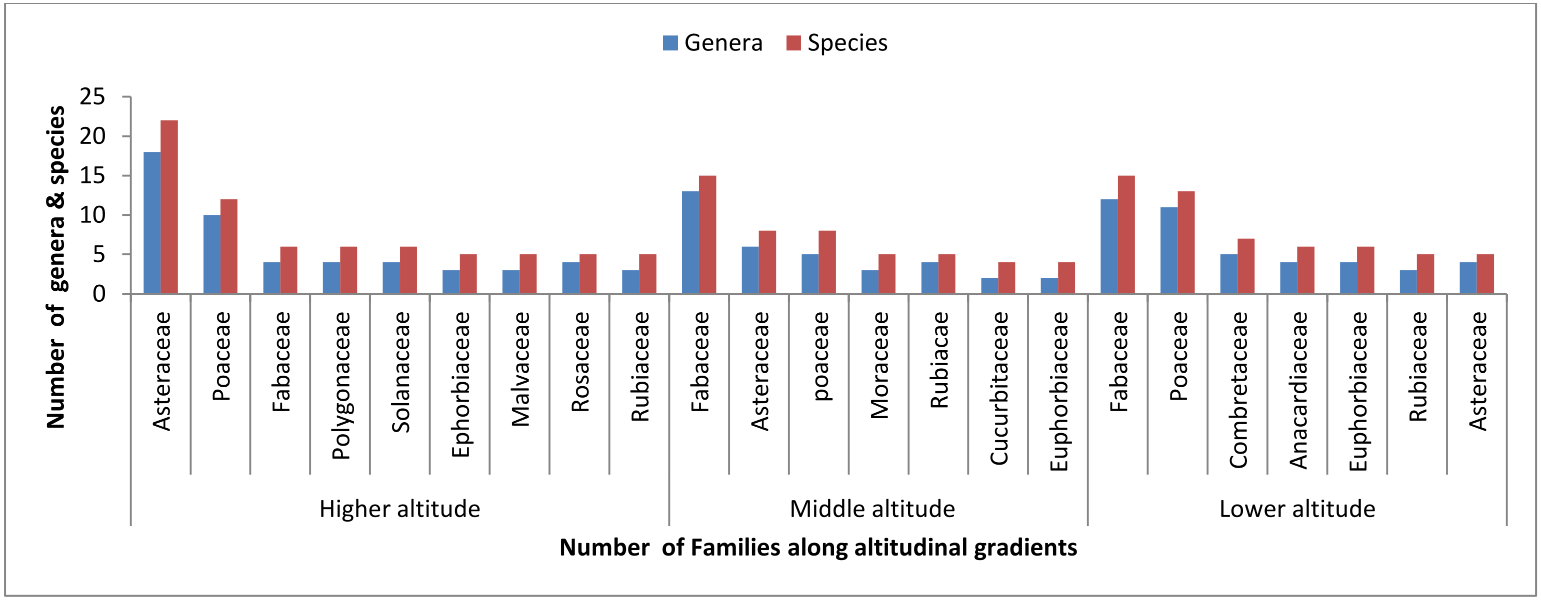

Fig. 4. Families and species distribution along altitudinal gradients

Community IV: *Combretum collinum-Pterocarpus lucens* community type. Pterocarpus lucens, *Sterculia africana* and *Boswellia papyrifera* significantly varied (P < 0.01). They are the lower altitude plant assemblages ranging from 600m-1000masl. They are within the *combretum-Terminalia* woodland vegetation types. The upper canopy trees species are *Combretum collinum*, *Combretum molle, Pterocarpus lucens, Sterculia africana* and *Boswellia papyrifera*. The middle layer is *Ziziphus abyssinica* and others.

Community **V**: *Ficus sycomorus-Acacia hecatophylla* and *Syzygium guineense community type.* They are significantly varied P<0.001). They occupy at an altitudinal range of 1000-1200 masl. The dominant woody species of these communities were: *Terminalia macroptera, Acacia hecatophylla, Stereospermum kunthianum, Ficus sycomorus, Cordia africana and Piliostigma thonningii.* The middle layers are covered by woody shrubs *Grewia mollis, Ziziphus abyssinica, Grewia mollis and Vernonia hochstetteri.*

Community VI: *Albiza schimperiana- Millettia ferruginea* community type. The Indicator species are Albiza *schimperiana- Militia ferruginea* which were significantly varied at P < 0.001. *This community extends from 1600-1800 altitudinal ranges. The upper canopies: Albiza schimperiana, Millettia ferruginea, Albiza gummifera, Fagaropsis angolensis, Ficus sycomorus, Cordia africana, Croton macrostachyus, Stereospermum kunthianum,* and *Sapium ellipticum.* The middle layer is consists of *Vernonia amygdalina*, *Vernonia thomsoniana*, *Clausena anisata*, and *Dodonaea angustifolia*. The ground layer of these community covered by grasses and herbs such as: *Rubia cordifolia*, *Zehneria scabra*, and *Datura stramonium*.

Fig. 5. Dendrogram showing plant communities

Table 1. Synoptic and indicator values of species in each community type (CI – CVI)

	Synoptic value*						Indicator value %**						
Species	**CI**	**C II**	**CIII**	**CIV**	**CV**	**CVI**	**CI**	**C II**	**CIII**	**CIV**	**CV**	**CVI**	**P value**
Nuxia congeta	5.33	0.78	0	0	0.3	0	76.8	2.6	0	0	0	8	0.001
Maesa lanceolata	5.22	1.11	0	0	0.4	1.3	65.3	57	0	0	0	6.3	0.001
Allophyllus abyssinicus	0.83	5.44	1.67	0	0	0	0	73.7	9.3	0	0	0	0.001
Dombeya torrida	1	4.83	0	0	0	0	5.7	68.5	0	0	0	0	0.001
Hagenia abyssinica	1	3.33	0	0	0	0	5.8	57	0	0	0	0	0.001
Apodytes dimidiate	1.44	1.39	4.83	0	0	0	10.5	70	54.7	0	0	0	0.001
Prunus africana	1	1.44	4.67	0	0	0	5.5	7.9	52.5	0	0	0	0.001
Pterocarpus lucens	0	0	0	3.92	0.6	0	0	0	0	58.1	0	0	0.001
Sterculia Africana	0	0	0	2.96	0.6	0	0	0	0	56	34	0	0.001
Combretum collinum	0	0	0	2.44	0	0	0	0	0	48	0	0	0.001
Syzygium guineense	1.28	1.28	3.56	0	3.2	0.2	3.8	3.8	19.6	0	19.6	4.8	0.001
Ficus sycomorus	0	0	0	0	3	0	0	0	0	0	29.7	22	0.001
Albizia schimperiana	0	0.67	0.94	0	0	5.8	0	25	35	0	0	61.1	0.001
Millettia ferruginea	0	0	0	0	0.1	4.7	0	0	0	0	0	50	0.001
Albizia gummifera	0	0	0	0	0.3	4.4	0	0	0	0	0	50	0.001

CI=community one, CII= community two, CIII= community three, CIV= community four, CV= Community five and CVI= community six

* The mean values of the species cover-abundance in each community.

** The product of the relative frequency and relative cover-abundance values in each Community.

Diversity and Evenness of Plant Communities

Community VI was the richest, followed by community II and Community V. Community II was the highest in evenness, followed by Community VI, community V and community II. Community VI highest in diversity followed by community II and community V (Table 2).

Table 2. Species diversity richness in communities

Community	Richness	Sh.H	Evenness
I	96.00	4.20	0.92
II	113.00	4.41	0.95
III	61.00	3.67	0.89
IV	89.00	3.88	0.91
V	103.00	3.95	0.92
VI	138.00	4.43	0.93

SH. H Shannon diversity

DISCUSSION

Floristic Composition and Diversity

The 375 species representing 90 families and 70 genera recorded from the Wombera district are under the two general categories of broad vegetation types. They are the Dry evergreen Afromontane forest and grassland complex, and the Combretum-Terminalia woodland and wooded grassland among twelve vegetation types of Ethiopia classified by Friis *et al.* (2011) to be precise The general vegetation richness of the district is mainly related to an altitudinal range which resulted in diversified agro-ecology. The topographic heterogeneity: undulating landscape, deep gorges, mountain peaks, plains, river and river gorges created sort microclimates which harbour different species.

The total woody species (145) recorded from four forest patches at higher and middle altitudes were similar to Berhanu *et al*. (2017) from dry Afromontane Forest Patches in Awi Zone. Wombera district and Awi zone share boundaries. The altitudinal range of wombera dry Afromontane forest patches ranges from 1765-2650 (current study) masl and Awi zone altitudes also range from 1830-2660. The altitudinal range may contribute to the similarity of woody vegetation in the two study areas. On the other hand, wombera district dry Afromontane has a significant difference of woody vegetation composition than similar agro-ecology: Zege Peninsula forest (Aleign *et al*., 2007), Adelle and Boditi forests (Yineger *et al*., 2008), Amba Mariam forest (Tilahun *et al*., 2011), Tara Gedam and Abebaye forests (Zegeye *et al*., 2011), Zengena forest (Tadele *et al*., 2013), and Kuandisha forest (Berhanu *et al*., 2017). In addition, 77 woody species identified from Lower altitudes in *Combretum–Terminalia* woodland and wooded grassland vegetation are similar to the study by Awas (2007) in western Ethiopia. The difference in species richness among these patches could be mainly related to the dissimilarities of the sites in terms of location, altitudes, human impact, rainfall, and other biotic and abiotic factors, as discussed by Kidane (2005).

The highest proportion of Asteraceae family, Poaceae, and Fabaceae in dry Afromontane higher altitude forest; Fabaceae, Asteraceae and Poaceae, in middle latitudes, and Fabaceae, Poaceae and Combretacea in the lower altitudes respectively (Fig. 4)were in line with families recorded in the flora of Ethiopia and Eritrea Volumes. The result is similar to other studies (Kidane, 2005; Tadesse, 2004; Gurmessa *et al.*, 2012; Yineger *et al*., 2008). The Combretaceae family had a higher proportion (Awas, 2007) in Beshangul gumuz western Ethiopia that is also in line with the family recorded in the flora of Ethiopia and Eritrea Volumes.

Plant communities

Measures of community diversity play a role in ecology and conservation biology (Magurran, 2004). It is an important parameter of a plant community that is related to ecosystem dynamics and environmental quality (Liu and Brakenhielm, 1996). The hierarchical classification analysis resulted in Six plant community types in Wombera district Forest patches (Fig. 5). They were named based on synoptic and indicator values (Table 2). The Six plant community types of wombera district forest patches showed variation in their species richness, diversity, and evenness (Table 3). Variations among the plant communities' types are the direct reflection of the effects of the environmental variables and geographic locations (Suratman, 2012; Parthasarathy, 2001). However, in the Wombera district, higher altitude forest patches, community I, community II and, community III are found on similar geographic locations and environmental conditions (altitude, aspect, slope, moisture and soil type) (mixed forest). They are in higher altitude study sites that have a similar ecosystem. The variation among the three communities is mainly age gradient (succession).

Community I: mainly dominated by shrubs and lower layer canopy trees: *Nuxia congeta*, *Maesa lanceolata, and Accacia abyssinica.* These species can invade virgin grasslands; abandon farmland and any bare land under poor soil conditions. The lower layer canopy trees are well-known soil layer builders for the succeeding species of middle and upper canopy trees. The lower layer canopy trees and shrubs form pioneer forests or primary plant communities. It is partly in line with the definition of Facilitation definition, "when later species can become established and grow only; after earlier species have suitably modified the environment (Connell and Slatyer 1977). The lower canopy tree species grow faster than upper canopy and middle canopy trees. They produce seed in mass and dispersed at faster rate than other tree species. With respect to pioneer and climax tree species, Whitmore (1989) observed that climax species typically have bigger seeds while seeds of herbs, grasses and sedges have small seeds.Thus small seeded tree species especially pioneer trees produce relatively large quantity of seeds and increase their survival on bare lands.

Community II is on a similar altitudinal range with community I and community III. They are grown on the ecology of community I. In intact forests of community II, the middle layer canopy trees dominate the forest p with a few or absent lower layer canopy trees. Grasses and herbs are rare on the ground layer in intact forests. However, the herbs and grasses cover the disturbing parts of the forest patches.

Community III: These communities are the successor of community I and community II. Community II (middle layer canopy trees) built-in community I, Community III (upper canopy trees) built-in Community II. It is similar to the finding of Muller-Dombois & Ellenberg (1974), plant species that are dependent on their environment and influence one another and modify their environment. These communities are dominated by the most upper canopy tree such as *Syzygium guineense, Ficus sur,* and *Olea europaea* nearer to the river border; *Prunus africana and Apodytes dimidiate,* and *Ekebergia capensis* away from the river. This is similar to the finding of Gebre Egziabher (1988) who stated that the vegetation of dry Afromontane are dominated by *Juniperus procera, Olea europaea* subsp. *cuspidata, Podocarpus falcatus,* and *Prunus africana.* Thus upper canopy trees are the dominant in climax forest patches due their long life span. Their canopies also protrude above lower and middle canopy trees and suppress their growth pattern and dominate the climax forests. In intact climax forests, there are no middle layer and lower layer canopy tree species.

However, in disturbed parts of the forest patches, the Lower layer strata are dominated by *Maytenus arbutifola, Teclea nobilis, Brucea antidysenterica, Bersama abyssinica,* and sapling of upper canopy trees. It is partly in line with the definition of inhibition by Connell and Slatyer (1977), i.e. togetherness completely eliminates the role of tolerance. In highly disturbed climax forests, the *Schefflera abyssinica* and *Croton macrostachyus united upper canopy trees. The ground layer of intact climax forests had no vegetation except a few shade-tolerant herbs. However, in highly disturbing climax forests, the ground layer is dominated by Solanecio gigas, Echinops ellenbeckii, Solaneciomannii, Solaneciotuberosus, Solanumanguivi, Echinops giganteusEriosema scioanum, Cyathula uncinulata, Impatiens aethiopica, Nicandraphysaloides,Pavonia procumbens, and Urtica simensis.*

The assemblage difference among Community I, Community II and Community III are due to disturbance and age gradients. Community I is the youngest, and Community III is the oldest in the forest patches. The similarity in species composition in lower, middle and upper layer canopy trees in the three communities are in line with the Community-unit theory. It stated that they are highly structured, repeatable, and identifiable associations of species controlled by environmental gradients (Clements, 1936). On the other hand, the association and replacement of lower, middle, and upper layer canopy trees along age gradients in pioneer, intermediate, and climax forests correspondingly support continuum theory. It stated that plant communities change gradually along complex environmental gradients, such that no distinct associations of species can be identified (Whittaker, 1953; Curtis, 1959).

Community IV: the communities are the lower altitude plant assemblages ranging from 600-1200 masl. They are within the *Combretum-Terminalia* woodland vegetation types. This community is the largest in area coverage. The dominancy of upper canopy trees: *Combretum collinum*, *Combretum molle*, *Pterocarpus lucens*, *Sterculia africana* and *Boswellia papyrifera*; middle layer canopy trees: *Ziziphus mauritiana, Grewia velutina, Commiphora pedunculata, Grewia mollis,* and *Grewia velutina* were related to fire adaptation.

Community V: is also in *Combretum-Terminalia* woodland and grassland. *Terminalia macroptera-Acacia hecatophylla* were the indicator species of these communities. They assembled at an altitudinal range of 1000-1200. The dominancy woody tree species: *Terminalia macroptera, Acacia hecatophylla, Stereospermum kunthianum, Ficus* *sycomorus, Cordia africana and Piliostigma thinning;* the middle layers of woody shrubs: *Grewia mollis, Ziziphus abyssinica, Grewia mollis and Vernonia hochstetteri* were also an indication of their association or adapted to the high frequency and intensity of the fire.

Community VI: *Albiza schimperiana- Millettia ferruginea* community types. *These communities extend from 1200-1800 altitude rage.* The dominant upper canopy trees: *Albizia schimperiana, Millettia ferruginea, Albiza gummifera, Fagaropsis angolensis, Ficus sycomorus, Cordia africana, Croton macrostachyus, Stereospermum kunthianum,* and *Sapium ellipticum.;* The middle layer canopy trees: *Vernonia amygdalina, Vernonia thomsoniana, Clausena anisata, Dodonaea angustifolia,* and the ground layer grasses and herbs such as *Rubia cordifolia, Zehneria scabra, and Datura stramonium* were dominant to middle altitude adaptation. Community IV and community V exist in the lower altitude. They mainly adapted to high intensity and frequency of fire, high temperature, low rainfall and shallow soil layer. Community VI is in steep slope landscape, intermediate moisture, and temperature and soil layer. In Community VI the dominate species particularly, *Albizia schimperiana*, *Albizia gummifera*, *Sapium ellipticum*, and *Millettia ferruginea* had the highest regeneration potential; The seed bank germinates massively, and the root proliferates when the steam part of the plant is damaged or slashed. The edible seeds of these species are widely dispersed by wild animals. The adaptation mechanism of the species helps them to dominate the middle altitude.

Community species diversity

The diversity and equitability of species in given plant communities are used to interpret the relative variation between and within the communities. These help to explain the underlying reason for such a difference (Kent and Coker, 1992). Species richness appears as the most intuitive and basic parameter to measure biodiversity and provides an extremely useful and comprehensible expression of diversity (Magurran, 1988; McCune and Grace, 2002 and Kent, 2012). Among the communities, Community VI (H=4.48, S=138) is in middle altitudes, which shares species with the higher altitude and lower altitudes communities; the environmental conditions mean of the lower and higher agro-ecologies. Community II is at a higher altitude and the second in richness and diversity (H=4.2, S=113), followed by Community I (H=4.20, S=96) Community II is an intermediate forest patch between community I and community III along age gradients. It consists, species of both communities. The comparative richness of Community V (H=3.95, S=103) than Community IV (H=3.88, S=89) was the relative location of community V at mountain foot of middle altitudes even, they found in the lower altitudes. Relatively communities V are in moist environment than community IV. Most species are moving along altitudinal gradients following the climate change. The higher evenness community II (0.95) followed by Community VI (0.93), community V and I each with 0.92, community IV (0.91) and the least community III (0.89) is the relative number of each species. As community II is a descendant of community I, the soil is richer and can support any species that has migrated out from other forest patches. Climax forests, which cover the growth of lower and middle layer canopy trees, predominate in Community III. Communities V and IV are located at lower elevations where fire can alter the distribution of vegetation equally. In community III, unequal distribution results from the overexploitation of some economically valuable species. These are similar to the finding of different authors (Pielou, 1966; Spellerberg, 1991) who stated Evenness as an indicator of equitable distributions among these species.

CONCLUSION

A total of 375 species representing 90 families and 70 genera were identified in six forest patches of Wombera district. Among the families Fabaceae were the richest, followed by Asteraceae and Poaceae.The Six plant community types showed variation in their species richness, diversity, and evenness. The assemblage difference among Community I, II and II community is due to disturbance and age gradients. Community I is the earlier successor and Community III is the oldest community or the final climax of the community. Community I is dominated by Lower canopy tree: *Acacia abyssinica*, *Nuxia congeta*, *Maytenus arbutifola* and *Maesa lanceolata*,which were able to invade non forest areas and form pioneer forests. Community III are dominated by upper canopy such as: *Syzygium guineense*, *Ficus sur*, *Olea europaea*, *Prunus africana*, *Apodytes dimidiata* and *Ekebergia capensis*.Communities VI are located at a middle altitude and share species with communities at higher and lower altitudes; their environmental conditions range somewhere between lower and higher agroecologies. Communities IV and V are located at lower elevations. They are mostly adapted to conditions with high fire intensity and frequency, high temperatures, little rain, and shallow soil layers.

RECOMMENDATIONS

These study attempts to assess floristic structural composition, diversity and richness of in six forest patches of wombera district, however there were some forest patches that are inaccessible to study.Thus further study should cover the gap. The soil composition on vegetation distribution has not yet studied. Therefore further study of the vegetation should include soil composition carbon stock and soil seed bank.

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