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Full Length Research Paper

Forest diversity and watercourse vegetation at Eastern base of Abaro Mountain, Wondo Genet, Southern Ethiopia

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Biodiversity covers the total range of variation in and variability among systems and organisms, at the regional, landscape, ecosystem and habitat levels, at the various organism levels, down to species, populations and individuals. Ethiopia is a country of diverse plant species forming the line share flora of 6200 species out of the total floral species of 7850 in East Africa. Of these diverse woody plants, about 12% of them are endemic. Irrespective of these truths, there is limited study on the fragmented forests and river courses in Ethiopia while vegetation resources in all areas of the country in general and in fragmented landscapes in particular , especially forests, are declining at alarming rate due to increased population followed by deforestation and land degradation. The main aim of this study was to compare the relative density, diversity and richness of woody plant species in disturbed secondary forest and river course at eastern base of Abaro Mountain at Wondo Genet. Twenty sample plots of size 10 x 10 m from each habitat type were used for vegetation inventory. It was found that the most densely populated species in the river course is *Discopodium peninervum* (1060 individuals/ha) and that in disturbed secondary forest is *Calpurnia urea* (780 individuals /ha). The Shannon Wiever Index is 2.7107 and 2.0378 for the disturbed secondary forest and river course vegetation, respectively. The Jacard's Similarity Index between the two habitat types is 0.491. The analysis showed that the disturbed secondary forest is more diverse than the river course vegetation at the study area.

Key words: Abundance, distribution, disturbance, woody plants, variability, vegetation resources.

INTRODUCTION

According to the definition of Convention on Biological Diversity (CBD) article two and other related studies "*Biological diversity*" means the variability among living organisms from all sources including, *inter alia*, terrestrial, marine and other aquatic habitats and the ecological complexes of which they are part; this includes diversity within species, between species and of habitats. And "*biological resources*" includes genetic resources, organisms or parts thereof, populations, or any other biotic component of habitats with actual or potential use or value for humanity (Giavelli et al., 1986; CBD 1992; Burley, 2002; Hamilton, 2005; Vivero et al., 2005; Elliott et al., 2011). As explained by (Heip and Engels, 1974; Roy and Behera, 2002; Hall et al., 2002; Khera et al., 2001; Sreenath et al., 2005; Ghazoul 2006; Jiang et al., 2007; Nautiyal, 2011; Lal and Singh, 2012) biodiversity covers the total range of variation in and variability among systems and organisms, at the regional, landscape, ecos-

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ystem and habitat levels, at the various organism levels, down to species, populations and individuals. Severe disturbance or even a prolonged absence of disturbance generally has depressing effect on biodiversity, but intermediate disturbance seems to enhance diversity in a system.

Ethiopia is a country of diverse plant species forming the line share flora of 6200 species out of the total floral species of 7850 in East Africa (Plant Talk, 2002; Teshome et al., 2004; IBC, 2009, 2010). Of these diverse woody plants, about 12% of them are endemic. Irrespective of these truths there is limited study on the fragmented forests and river courses in Ethiopia (Tewoldebirhan, 1991). Vegetation resources in all areas of the country in general and in fragmented landscapes in particular , especially forests, are declining at alarming rate due to increased population(with growth rate 3%) followed by deforestation and land degradation.

According to IUCN's Red List Categories, Ethipia possessed one endangered, 21 vulnerable, one lower risk/conservation dependent, 30 near threatened (includes lower risk/near threatened), one data deficit and three least concern (includes lower risk, least concern) plant species (Baillie et al., 2004; IUCN, 2006).

To document enough information on Ethiopia's vegetation resources a study of their floristic composition is an important issue of concern. The country has high compositions and levels of biodiversity including cultural diversity and human interactions at all levels (Heywood, 1995; Gole et al., 2008).

This study was conducted on the hypothesis that there might be difference in species composition in the two adjacent habitats of disturbed secondary forest and river course vegetation. And then to answer the research questions: what is the woody plant composition, density, diversity and richness in the disturbed secondary forest and river course vegetation at eastern base of Abaro Mountain at Wondo Genet? Objectives of the study were; i) to assess the relative density of species in disturbed secondary forest and river course vegetation; ii) to compare the diversity of species in disturbed secondary forest and river course vegetation; and iii) to compare the species richness in disturbed secondary forest and river course vegetation.

MATERIALS AND METHODS

Study site

Wondo Genet is geographically located at 38° 37' 48" E and 7° 5' 37" N with an altitude of 1800 m a.s.l. According to Natural Resource Management and Regulatory Department of the Ministry of Agriculture and Rural Development (NRMRD-MOARD 2005), the agro-ecological region of the area is characterized by Tepid humid mid highland (H3). According to rainfall data from Wondo Genet Meteorological station of the year 1991 to 2004, the average annual rainfall was 1372 mm. It has bi-modal rainfall pattern with extended rainy season from March to October. The peak rain seasons of the area comes in April (210 mm) and August (185 mm). The mean annual temperature is 19°C. The mean maximum and minimum annual temperature is 29 and 10°C, respectively.

METHODOLOGY

The disturbed secondary forest (DSF) and river course vegetation (RCV) of eastern part of Abaro Mountain base at Wondo Genet was considered for the study. To study the species composition of these disturbed secondary forests and river course vegetation an inventory has been made by taking sample plots. The plots have been laid down by systematic sampling methods and then 40 sample plots of size 10 × 10 m were taken accordingly, twenty each for habitat types. The relative density, frequency, basal area and the important value index (IVI) of individual species is calculated by the following formulae. The first two letters from each of the genus and species name were used for species coding. Unknown species were collected by taking specimen in to plant press and sent to Addis Ababa University's Herbarium for identification.

Relative frequency (RF) = (n/N)*100

Relative density (RD) = (Di/DN)*100

Relative basal area (RB) = (Ai/AN)*100

IVI = RF + RD + RB

Where:

n = number of individuals of a particular species in the sampled plots

N = the total number of all species in the sampled plots Di = the density of individuals of a particular species in the sampled plots

DN = the density of all species in the sampled plots

Ai = basal area occupied by individuals of a particular species in the sampled plots

AN = basal area occupied by all species in the sampled plots

IVI = Important Value Index

Data collection

Every species with height less than or equals to 2 m for seedlings and saplings were measured with Vernier Caliper of calibration 150 mm and for bigger size diameter at breast height was taken with Vernier Caliper

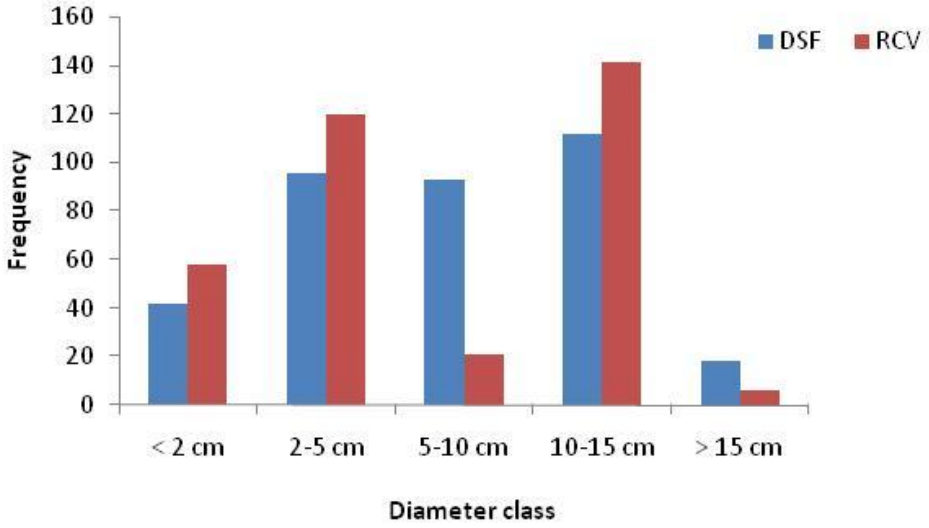

Figure 1. Distribution of species with diameter class.

50 cm calibration. The data was registered on data collection sheet for each individual stem with their corresponding height and diameter.

Data analysis

The data was analyzed by using Microsoft excel and SPSS-16 software package. Descriptive statistics was applied to determine the relative frequency and abundance of species. The species diversity, richness and evenness indices were calculated using Microsoft excel after properly encoding the parameters in to the proper indices formulae.

RESULTS

Density of species

Discopodium peninervum (1060 individuals/ha), *Maesa lanceolata* (510 individuals /ha) and *Maytenus arbutifolia* (480 individuals /ha) were found to be the most densely populated species in the RCV while *Calpurnia urea* (780 individuals /ha), *M. arbutifolia* (490 individuals /ha) and *D. peninervum* (350 individuals /ha) were the most densely populated.

Regeneration status

The cumulative regeneration status of species was found to be promising in that about 51% and 38% of the observed frequencies in RCV and DSF were seedlings and saplings (Figure 1). Whereas the frequency of species in the higher diameter class was very low indicating that higher diameter class trees were logged out by illegal logging that we have observed during field inventory.

Species diversity

The calculation of species diversity has showed that the DSF is more diverse (H = 2.7107) than the adjacent RCV (H = 2.0378).

About 12.2, 10, 8.3, 8.2 and 7.8% of the diversity index of DSF is explained by *C. urea*, *M. arbutifolia, D. peninervum*, *C. decaptala* and *M. lanceolata*, respectively. On the other hand, nearly 17.8, 13.8, 13.4, 11.7, 11.2 and 10.8% of the diversity index of RCV is explained by *D. peninervum, M. lanceolata, M. arbutifolia, C. didymobotrya, C. urea and C. decaptala,* respectively (Tables 1 and 2).

Species richness and evenness

Species richness is the number of different species present in an area. From the sampled population in the case of this study, 37 different species were recorded in DSF and 16 different species in the RCV and 13 species in common in both sites. The common species accounted about 77% of the species richness for the DSF and 98% of the RCV (Figure 2). Over and above, calculation of species richness by using Menhinick's index (D), has showed that DSF was more species rich (D = 1.9474) than the RCV which have species richness index of 0.8590. The species evenness indecie for DSF and RCV are 0.7507 and 0.7350 respectively and the Jacard's Similarity Index between the two habitat types is 0.491.

Table 1. Important value indices of woody plant species at eastern base of Abaro Mountain DSF.

Scientific name	Relative frequency (%)	Relative density (%)	Relative basal area (%)	IVI	IVI Rank
Acacia abyssinica	0.55	0.55	2.08	3.18	16
Albizia gumifera	1.94	1.94	1.58	5.46	10
Albizia lebbek	0.83	0.83	2.60	4.27	14
Aningeria altissima	0.28	0.28	0.53	1.08	31
Apodytes dimidiata	7.76	7.76	6.73	22.24	6
Barsama abyssinica	0.55	0.55	0.20	1.31	27
Buddleja polystachya	1.11	1.11	2.12	4.33	13
Caesalpinia decaptala	9.42	9.42	12.98	31.82	3
Calpurnia urea	21.61	21.61	19.01	62.22	1
Cassia didymobotrya	1.66	1.66	1.14	4.47	12
Celtis africana	5.54	5.54	2.97	14.05	7
Coffeea robusta	0.55	0.55	1.06	2.17	22
Combretum molle	1.94	1.94	3.43	7.31	9
Cordia africana	0.28	0.28	1.04	1.59	23
Croton macrostachyus	3.05	3.05	3.70	9.80	8
Diospyros abyssinica	0.28	0.28	0.53	1.08	31
Discopodium peninervum	9.70	9.70	3.24	22.63	5
Dombeya torrida	0.55	0.55	0.20	1.31	27
Duranta erecta	0.28	0.28	0.53	1.08	31
Ehretia cymosa	0.28	0.28	0.01	0.56	37
Fagaropsis angolensis	0.55	0.55	0.38	1.49	25
Ficus sur	0.55	0.55	2.08	3.18	16
Flacourtia indica	0.55	0.55	1.23	2.34	21
Galiniera saxifraga	0.28	0.28	0.19	0.74	34
Maesa lanceoata	8.59	8.59	12.51	29.68	4
Maytenus arbutifolia	13.57	13.57	8.83	35.98	2
Mellitia fruginia	0.28	0.28	1.04	1.59	23
Nuxia congesta	1.39	1.39	2.65	5.42	11
Ochna holstii	1.11	1.11	0.61	2.83	19
Oncoba spinosa	0.55	0.55	0.02	1.12	30
Pavetta oliveriana	0.55	0.55	0.08	1.19	29
Pittosporum viridiflorum	0.28	0.28	0.19	0.74	34
Podocarpus afrocarpus	0.83	0.83	1.09	2.75	20
Prunus africana	0.83	0.83	1.42	3.08	18
Rhus glutinosa	1.11	1.11	1.60	3.81	15
Schrebera alata	0.28	0.28	0.04	0.60	36
Teclea nobilis	0.55	0.55	0.38	1.49	25
	100.00	100.00	100.00	300.00	

Table 2. Important value indices of woody plant species at eastern base of Abaro Mountain RCV.

Scientific name	Relative frequency (%)	Relative density (%)	Relative basal area (%)	IVI	IVI Rank
Acacia abyssinica	2.02	2.02	4.15	8.18	8
Albizia gumifera	0.29	0.29	1.14	1.72	11
Barsama abyssinica	0.86	0.86	0.14	1.87	10
Caesalpinia decaptala	9.22	9.22	13.82	32.26	3
Calpurnia urea	9.80	9.80	12.30	31.89	4

Table 2 Contd.

Cassia didymobotrya	10.66	10.66	7.04	28.37	6
Celtis africana	0.29	0.29	0.05	0.62	15
Cordia africana	0.29	0.29	1.14	1.72	11
Croton macrostachyus	5.48	5.48	2.64	13.59	7
Discopodium peninervum	30.55	30.55	30.23	91.32	1
Ehretia cymosa	0.29	0.29	0.05	0.62	15
Ficus vasta	0.29	0.29	1.14	1.72	11
Maesa lanceolata	14.70	14.70	23.13	52.53	2
Maytenus arbutifolia	13.83	13.83	2.39	30.06	5
Toddalia asiatica	0.58	0.58	0.02	1.17	14
Vernonia amalgdalina	0.86	0.86	0.63	2.36	9
	100.00	100.00	100.00	300.00	

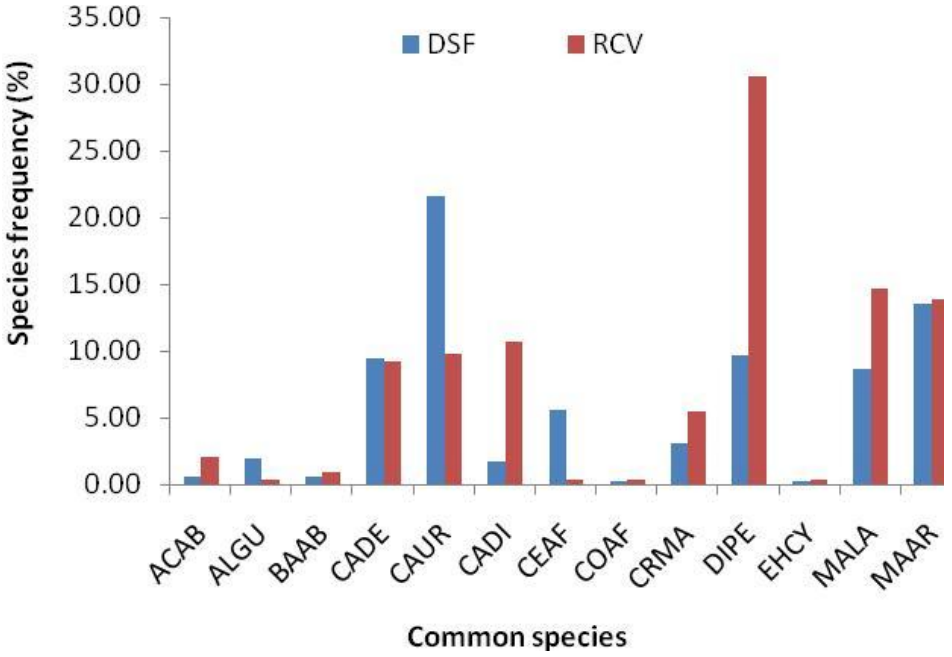

Figure 2. Distribution of the common species in DSF & RCV at eastern base of Abaro Mountain.

Relative abundance

Out of the thirty-seven species recorded in the DSF, *C. urea* accounted 21.61% of the relative abundance followed by *M. arbutifolia, D. peninervum, C. decaptala, M. lanceolata* and *A. dimidiata* accounting 13.6, 9.7,9.42, 8.59 and 7.76% of the relative abundance respectively. In the case of RCV, it is found that *D. peninervum* accounted for about 31% of the relative abundance in the sampled population. In this same habitat type *M. lanceolata, M. arbutifolia, C. didymobotrya, C. aurea* and *C. decaptala* accounted 14.7, 13.83, 10.66, 9.8 and 9.22% of the relative abundance respectively (Figures 3 and 4).

DISCUSSION

As described by (IBC, 2005), the forest resources of Ethiopia are seriously threatened by deforestation, habitat destruction and subsequent decline in regeneration, forest fire and vegetation clearance for farm/settlement establishment and this has caused loss of biodiversity. In this study, we found that in both

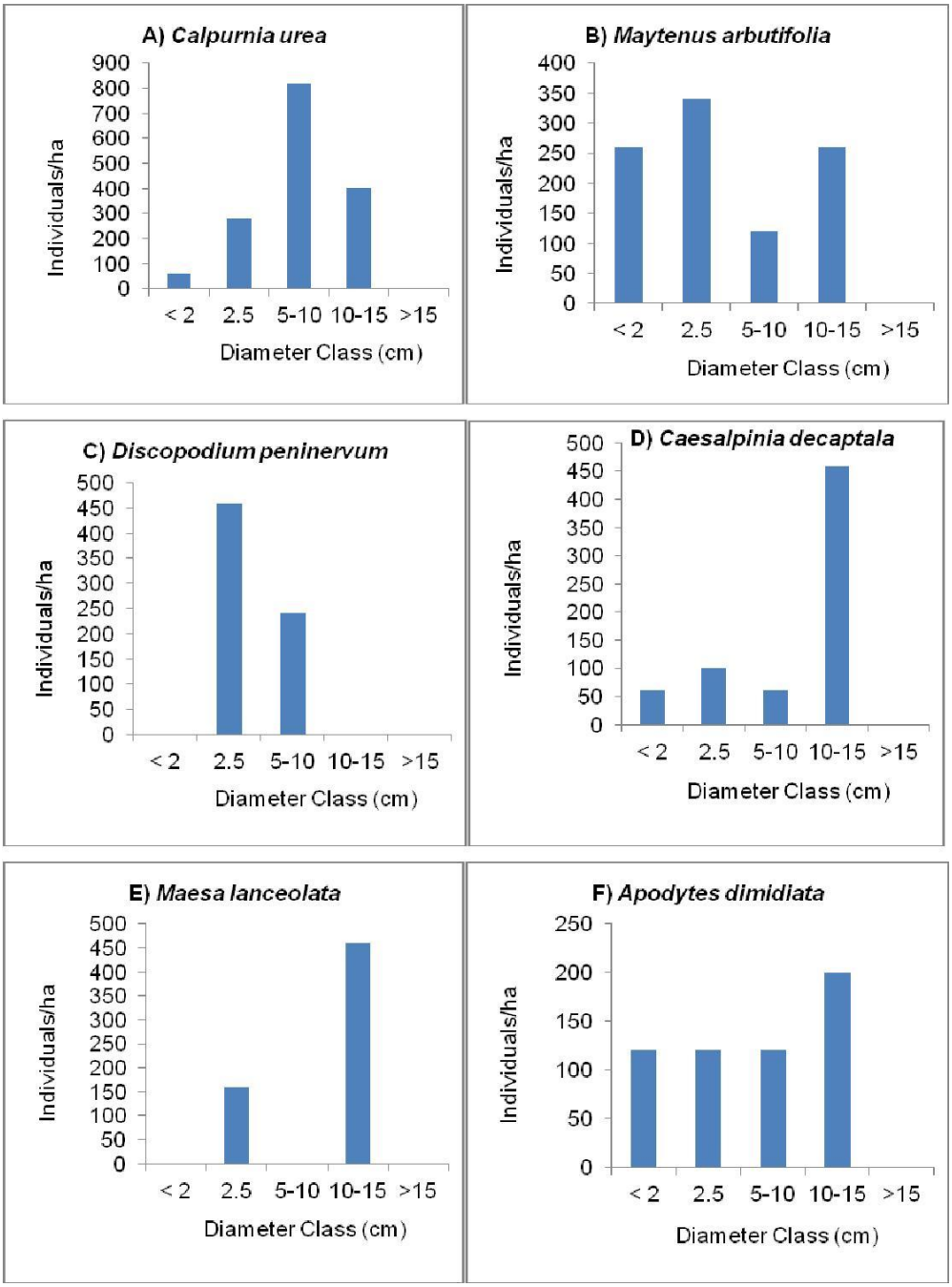

Figure 3. The six top IVI ranked species in the DSF at eastern base of Abaro Mountain.

habitats the species diversity and richness at eastern base of Abaro Mountain is low. Rodgers (1995) stated that deforestation and forest degradation in developing countries like Ethiopia, are influenced by underlying socio-economic features, which includes: i) ultimate factors (encompasses population growth and resource demand; economic dependence on natural resources; general widespread poverty) and ii) proximate factors (including inadequate policy regimes; lack of stakeholder participation; lack of adequate tenure and access rights; inadequate investment in the forest sector; inappropriate valuation systems and inadequate land-use planning capacity and systems). Similar to these, the biodiversity threats at Wondo Genet watershed are associated with subsistence cultivation to the hills tops as well as settlement expansion. The watershed is source of two rivers which supports a lion share of livelihood support of the communities for irrigation of sugarcane, *chata edulis*,

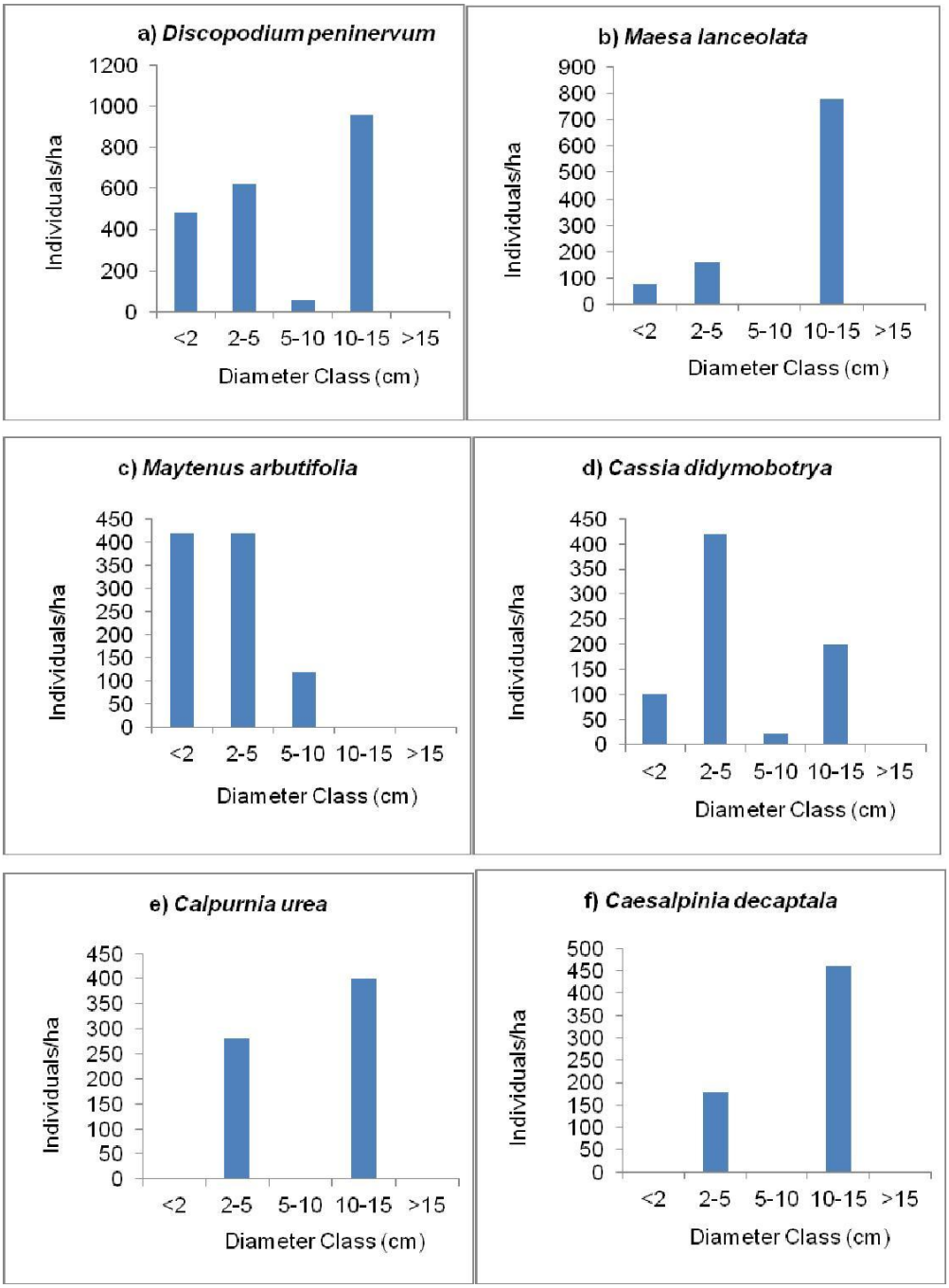

Figure 4. The six top IVI ranked species in the RCV at eastern base of Abaro Mountain.

Ensete ventricosum and other agricultural crops and dirking for humans as well as livestock. However, the forest cover in the hills both in the disturbed secondary forest and river course vegetation is facing threat from deforestation and land degradation. River systems in Ethiopia in general have no legal protection despite their importance (Nune, 2008). In Ethiopia, policies and strategies are in place among which Environmental Policy of Ethiopia, National Policy on Biodiversity Conservation and Research, Forest Policy and Forest Proclamation No.542/2007. Despite good policies on paper, deforestation and forest degradation in the country in general and the site in focus of this study in particular are running faster and faster and the potential of those polices to stop this acceleration is less.

This study showed that forest fragmentation has lowered the species diversity in both DSF and RCV in this particular study area. In the same way, Opdam and

Wascher (2004) indicated that habitat fragmentation lowers the density of species per plot of land and the percentage of space occupancy through less effective distribution of species over the habitat net work. Habitat loss leading to decreased species richness is the most common land use change and biodiversity relationship considered with less attention being given to other land use changes and biodiversity characterizations and responses (de Chazal et al., 2009).

CONCLUSION

The result of this study from Shannon diversity index has showed that the disturbed secondary forest at eastern base of Abaro Mountain is more diverse than the river course vegetation. In regard of seedling and sapling density however, the river course vegetation has more, which may be due to the available light coming to the ground and moisture drift from the river that facilitated the germination of seeds in the soil seed bank. In order to have successful rehabilitation of both the disturbed secondary forests and river course vegetation this study also showed the need for conservation to keep the promising upcoming of seedlings and saplings for better succession and further studies will be required in broader scale in the larger landscape.

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Abbreviation: CBD; convention on biological diversity, **DSF;** disturbed secondary forest, **IBC;** institute of biodiversity conservation, **IVI;** important value index, **NRMRD-MOARD;** Natural Resource Management and Regulatory Department of the Ministry of Agriculture and Rural Development, **RB;** relative basal area, **RCV;** river course vegetation, **RD;** relative density, **RF;** relative frequency.

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