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Woody Species Composition and Natural Regeneration Status of *Ades* Forest, Oromia Regional State, West Hararghe Zone, Ethiopia

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Abstract

This study was conducted at *Ades* forest in West Hararghe Zone, Ethiopia, for determining the woody species composition and regeneration status of the forest. Systematic sampling method was used to collect vegetation data from 48 (20 m×20 m) main sample plots for woody species that was established along a transect line and spaced at 10 m altitudinal drop, from top to the bottom of the natural forest. Inside the main plot (400 m^2), subplots (5 m×5 m) were established to simplify the counting of seedlings and saplings. Species abundance and environmental variables were recorded in each sample plot. A total of 48 woody plant species belonging to 42 genera and 29 families were identified. Fabaceae family had the highest number of taxa followed by Rosaceae and Flacourtiaceae families. Woody plant species densities for mature individuals were 197.9 ha^{-1}, saplings 420 $ha^{-1}$and 849.5 $ha^{-1}$for seedlings. Although over all regeneration status of woody plants of the Forest revealed good regeneration status, the presence of anthropogenic disturbance in the area necessitates the need for conservation action in order to ensure sustainable utilisation and management of the Forest.

Key words: Regeneration, samplings, seedlings, woody species

1. Introduction

Quantitative information on composition, distribution, and abundance of woody species is significant to understand the form and structure of a forest community. It is also very important for planning and implementation of conservation strategy of the forest community. The species richness and diversity of trees are fundamental to total forest biodiversity because trees provide resources and habitat for almost all other forest species (Malik, 2014). In case of forest ecosystems, trees are responsible for the overall physical structure of habitats, and thus, they define fundamentally the templates for structural complexity and environmental heterogeneity (Malik et al., 2016). Forests are increasingly threatened as a result of deforestation, fragmentation, climate change and other stressors that can be linked to human activities such as agricultural expansion, forest clearance for fire wood, construction materials, timber and charcoal production (Yonas, 2001; Getachew and Demel, 2005; Liaison, 2013). These temporary benefit oriented deforestation is followed by land degradation and soil erosion which result in biodiversity loss (Tadesse and Demel, 2001; Feyera, 2006; Tadesse, 2008). In forest management, regeneration study is not only depicts the current status but also hints about the possible changes in forest composition in the future (Malik and Bhatt, 2016; Sharma et al., 2014). Survival and growth of seedlings and saplings determine the successful regeneration (Good and Good, 1972), which is perhaps the single most important step

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toward achieving long-term sustainability of forests (Saikia and Khan, 2013; Malik, 2014; Malik and Bhatt, 2016;).

The major problem in the mountain natural forest of Ethiopia is habitat degradation. It includes various forms of land degradation, adverse human impacts on plant resources, deforestation, and lowering of the productive capacity of rangelands. Other anthropogenic activities such as constructions of hill roads, forest fires, over grasing, lopping of trees for fodder and fuel wood, and removal of leaf and wood litter from the forest floor are also affecting plant diversity in the natural forest. Reliable data on regeneration trends are required for successful management and conservation of natural forests (Eilu and Obua, 2005).

Forests and forest products should be used in a way that could not compromise or harm the coming generation. Clearing of forest resources is accelerated as human needs became wider and wider. High level of dependency on agriculture, high rate of population growth and non-integrated investment activities are also factors that aggravated deforestation in Ethiopia (Ensermu and Teshome, 2008). Studies reported by (Demel, 2001; Yonas, 2001; FAO, 2007) indicated that there are continuous deforestation and land degradation in Ethiopia. Due to low level of peoples' awareness on the role that forests have in terms of ecosystem services, less attention has been given to their conservation. Adequate awareness regarding wise use of forest resources should be given to the whole society so that some multipurpose endogenous and medicinally important plant species can be saved from local extinction. Many studies have been conducted in different parts of the country to investigate the species composition, population structure and regeneration ecology of forests (Tesfaye et al., 2002; Simon and Girma, 2004; Ensermu and Teshome, 2008; Zegeye, et al., 2011). However, there is little scientific information available on woody species composition and regeneration status of natural forest at West Hararghe Zone, Ethiopia. This study wase therefore aimed at assessing woody plant species composition and regeneration status of the *Ades* natural forest.

2. Materials and Methods

2.1 The study area

The study was conducted on *Ades* natural forest, located in Western Hararghe Zone, Oromia Regional State, Ethiopia. The zone is 371 Km from Addis Ababa, has an average altitude of 1,600-3,100 meters above sea level and average annual rain fall of 250-900 ml and average annual temperature of 16-18^o C. The area is mainly covered by an irregular topography with depressions, numerous Chain Mountains, flat lands, gorges, scattered trees and dense shrubs of patch natural vegetation.

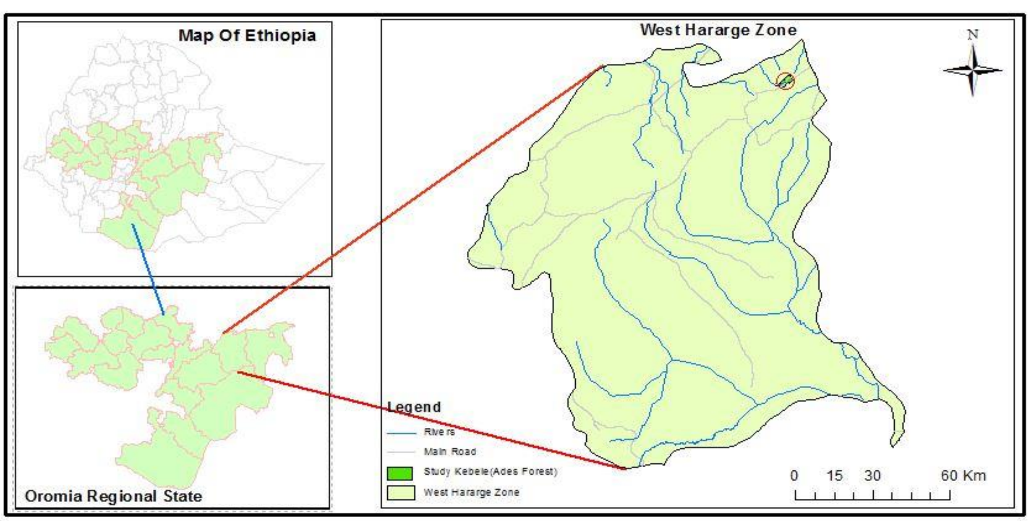

Figure 1: Map of the study area.

2.2 Floristic and structural data collection

Reconnaissance survey was made across the *Ades* natural forest in order to obtain vegetation patterns and determine representative sampling sites. Vegetation data were collected using a systematic sampling method as described by (Kent and Coker, 1992). Sampling was done along an altitudinal gradient between 3100 m and 1600 m above sea level. The data of vegetation attributes were measured for trees and shrubs, and recorded using twenty by twenty meter size plots which were established along a transect line, starting from top to the bottom of the natural forest. All the woody plant species encountered in each sample plot were recorded using vernacular or local names and code was given for unknown specimen. Sampling plotess were arranged along transects line, which were spaced at 10 m altitudinal drop, along the elevation gradient of the Forest. Inside the major plot (20 m×20 m), sixteen subplots were established.

We partitioned the major quadrats (400 m^2) into sixteen, each 25 m^2 (5 m×5 m), to ease the counting of seedlings and saplings. The undergrowths of woody species with height less than 1 m were considered as seedlings, height greater than 2 m are considered as matures trees/shrubs and those in between 1-2 m and dbh<2 cm are considered as sapling (Singhal, 1996). The height of seedlings and saplings were measured using a meter tape and for trees visual estimation was made. Environmental variables such as altitude and geographical coordinates were also measured for each plot using Geographical Position System (GPS) (Kent and Coker, 1992).Specimens were collected, pressed, dried and brought to the Haramaya University Herbarium for identification and to National Herbarium (ETH), Addis Ababa University for further authentication. The specimens were dried in the dryer, kept in a deep freezer for 72 hours and identified referring to the volumes of Flora of Ethiopia and Eritrea and finally documented.

2.3 Data analysis method

All individuals of plant species recorded in all quadrants were used in the analysis of woody species composition and regeneration status of the forest. After all the seedlings, saplings and mature plants found in each established quadrant were counted, identified and recorded, their density and ratio of seedlings to adult individuals seedlings to saplings and saplings to mature individuals were calculated. In order to use the regeneration analysis outcomes for priority setting, woody plant species in the study area were grouped into three regeneration status classes (priority classes for conservation) based on the method reported by (Simon and Girma, 2004). Based on the result, regeneration status of the forest was determined and appropriate conservation and management methods were suggested.

3. Results and discussions

The result of vegetation composition study showed that *Ades* natural forest has different woody plant species. Some of the dominant species in this natural forest were found to be J*uniperus procera*, *Podocarpus falcatus, Croton macrstachyus, and Maytenus* sp. The vegetation composition varied with altitude changes. High and dense forest with dominant secondary generation of *Podocarpus falcatus* at lower and middle altitudes to J*uniperus procera and Croton macrstachyus* with intermingled of other species at higher altitudes.

3.1 Woody plant species composition

A total of 48 woody plant species were recorded from *Ades* natural forest in current study. Out of these, 15 (52.08%) species were trees while 23 (47.92%) species were shrubs. The list of all species is given in Appendix 1. The identified species were belonging to 42 genera and 29 families. Fabaceae was the most dominant family, contributed 5 (16.7%), followed by Rosaceae and Flacourtiaceae both represented by 4 (13.7%) families.

3.2 Regeneration status of woody species in Ades forest

The status of tree population and the persistence of existing species in future forest composition are dependent on sufficient amount of age categories of plant species. The total density of seedlings (849.5 individuals ha^{-1}) was found to be higher than the saplings (420 individuals ha^{-1}) and adults (197.9 individuals ha^{-1}) in *Ades* natural forest, thus exhibiting overall 'good' regeneration condition of woody plant species at the community level (Figure 2). As far as the regeneration status of each species is concerned and based on the categories used by Dhaulkhadi et al. (2008) and Chauhan et al. (2008), out of the 48 wood species, twenty four (50%) woody species achieved good regeneration, three (6.3%) species had fair regeneration, four (8.5%) had poor regeneration, seven (14.6%) no regeneration, and ten (20.8%) were considered as 'new' species in *Ades* forest.

In the current study, seedling density ha^{-1} is greater than both sapling and mature density and sapling density is greater than mature tree (i.e. density of seedling>sapling>mature trees/shrubs) within the study area, which indicate a successful regeneration potential of the forest. According to Dhaulkhadi et al. (2008), a given forest had good regeneration if seedling is greater than sapling and mature tree/shrubs (seedling density>sapling density>mature; fair regeneration if seedling>or≤sapling≤mature tree; poor regeneration if seedling<sapling≥or ≤mature tree; and no regeneration if species are represented only by adult/mature trees. In line with this evidence, *Ades* forest has good regeneration status since seedling density ha^{-1} is greater than sapling and mature tree/shrubs for a general count. However, during data collection, some evidence of biotic disturbance like selective cutting of some woody species by local communities, open grassing area, many paths in the forest that can damage the seedling development in to adult individuals in the forest were observed. Mature density might have decreased in near future as a result of selective cutting of trees by local people for different purposes like construction, charcoal production, farming materials, medicinal use and others. Even if most of the species showed good regeneration status, however, some species like *Prunus africana, and Olea europaea* subsp. *cuspidata* were represented only by seedling and sapling stage which indicates selective using of this species at mature stage by local peoples. There is also encroachment of forested area as a result of farming activities. Unless appropriate management activities are undertaken, the regeneration status of this forest will be threatened in the future.

Regeneration of woody plants refers to the recruitment, survival and growth of seedlings and/or sprouts of these plants in a given area (Lalfakawma, 2010). When the source of this process is occurring in nature from seeds or other vegetative propagules, the regeneration is known as natural regeneration. Harmer (2001) defined natural regeneration as ''the establishment of trees from seeds that fall and germinate in situ''. Seedlings represent the final stage in the process of regeneration from seed (Kitajima and Fenner, 2000). The density values of seedling and saplings are considered as regeneration potential of the species (Robi, 2016). The successful regeneration of a given forest requires the occurrence of a sufficient number of young trees, saplings and seedlings in population (Hanief et al., 2016). Germination, growth and survival of any species is confined to a particular range of habitat conditions and the extent of those conditions is a major determinant of its geographic distribution. Both climatic and biotic factors interference influences the regeneration of different species in the forest. Higher seedling density values get reduced to sapling due to biotic disturbances and competition for space and nutrients. The regeneration status of a forest was summarised based on the total count of seedlings, saplings and adult individuals of each species across all plots. This finding supported the research by Habtam and Ali (2015), which stated as, compared to seedling individuals there were less sapling individuals implying the death of most seedlings before reaching sapling stage due to factors such as human interventions, browsers, grazers, fire and nature of the seeds.

Calculation of the ratio among the seedling, sapling and mature tree can provide information about the distribution of age categories and the regeneration status of the species (Chauhan et al., 2008; Robi, 2016). In line with this, the ration of seedling to sapling, seedling to mature tree and sapling to mature tree of the species was calculated and the result was 2.02:0.49, 4.29:0.23 and 2.12:0.47, respectively. These revealed that the distribution of seedling individuals is greater than both sapling and mature tree or shrub individuals. This showed that there was sufficient number of seedling and sapling available as a potential for regeneration and recruitment (Figure 2). Hanief et al. (2016) stated that the successful regeneration of a given forest requires the occurrence of a sufficient number of young trees, saplings and seedlings in population. Hence, in this study there is sufficient amount of seedling and sapling is available as a potential for successful regeneration this forest (Figure 2).

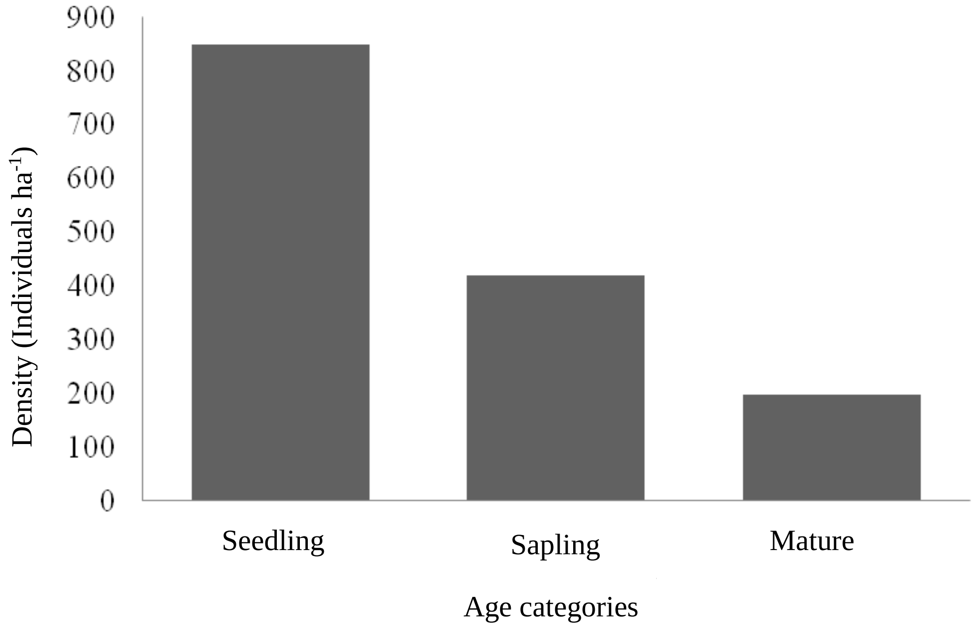

Figure 2: Over all regeneration status of *Ades* forest.

The regeneration status of plant species in a community can be accessed from the total population dynamics of seedlings and saplings in the forest community (Tesfaye et al., 2002; Duchok et al., 2005). The overall pattern of population dynamics of seedlings, saplings and adults of a plants species can exhibit the regeneration profile, which is used to determine their regeneration status (Khan et al., 1987; Tamirat, 1994). A population with sufficient number of seedlings and saplings depicts satisfactory regeneration behavior, while inadequate number of seedlings and saplings of the species in a forest indicates poor regeneration (Khan et al., 1987; Tripathi and Khan, 2007). Pokhriyal et al. (2010), mentioned that research in this field contributes to planning conservation and decision making in forest resource management programs. The presence of good regeneration potential shows stability of the species in the environment. Climatic factors and biotic interferences influence the regeneration potential of different species in the forest. Such study should be supported since it has important implications for the management of natural forests.

Based on the presence or absence of seedling, sapling or both, woody species recorded in *Ades* forest were grouped into three priority classes for conservation. These are priority class 1: those species with no seedling and sapling, priority class 2: those with seedlings but no sapling, and priority class 3: those with both seedlings and saplings≥1 individual ha^{-1} (Table 1). The first and second priority classes, therefore, need due attention in order to save them from local extinction. According to Harmer (2001), analyses of vegetation structure using growth stages of trees as seedlings, saplings and mature trees within a population can be one of the elements of diversity that allows or denies the chance of rapid recovery after disturbances.

Table 1: Species conservation priority classes.

Priority Class 1	Priority Class 2	Priority Class 3
Allophylus abyssinicus	*Asparagus africanus*	*Apodytes dimidiate*
Bersama abyssinica	*Maesa lanceolata*	*Brucea antidysenterica*
Dovyalis verrucosa	*Millettia ferruginea*	*Calpurnea aurea*
Ficus sur	*Oncoba spinosa*	*Carissa spinarum*
Halleria lucida	*Psydrax schimperiana*	*Croton macrostachyus*
Rhus natelensis	*Rhus glutinosa*	*Dombeya torrid*
Schefflera abyssinica	*Teclea nobilis*	*Dovyalis abyssinica*
	Vernonia amygdalina	*Ekebergia capensis*
		Euphorbia ampliphylla
		Euphorbia tirucalli
		Juniperus procera
		Lepidotruchilia volkensii
		Maytenus sp.
		Myrica salicifolia
		Nuxia congesta
		Olea europaea L. subsp. *Cuspidate*
		Osyris quadripartite
		Pittosporum viridiflorum
		Podocarpus falcatus
		Prunus Africana
		Pterolobium stellatum
		Rhamnus staddo
		Rubus steudneri
		Scolopia theifolia
		Vangueria madagascariensis
		Vernonia urticifolia

Those species listed under the first priority class (*Allophylus abyssinicus, Bersama abyssinica, Dovyalis verrucosa, Ficus sur, Halleria lucida, Rhus natelensis* and *Schefflera abyssinica),* need urgent conservation and management activities while plants listed under priority classes 2 and 3 need follow up management. According to Grau (2000), there are different factors which cause threats to the regeneration of some woody species. Among these, endogenous factors like vegetation structure and species interaction between adults and at lower age are the major threats. Although the relative abundance, growth and distribution of seedlings and/or saplings are important in determining species that replace the canopy, abundance of seedlings and/or saplings should not at all considered as an indicator of the ultimate establishment of young individuals. The reason for this is that, the establishment of many indigenous woody plants seedlings and/or saplings is not easy to regenerate because of unfavorable microhabitat.

Saxena and Singh (1984) stated that population structures, characterised by the presence of a sufficient population of seedlings, saplings and young trees, indicate a successful regeneration of forest species. The current study result confirmed this idea, since seedlings represented by the highest proportion followed by saplings and matured individuals respectively. The distribution of seedlings is greater than that of sapling and mature individuals whereas that of matured individuals are the least one. Sapling density might decrease as a result of biotic or abiotic factors that prevent the development of seedlings to saplings in the area. For example, no saplings were recoreded for *Maesa lanceolata, Millettia ferruginea, Oncoba spinosa, Rhus glutinosa, Psydrax schimperiana, Schefflera abyssinica, Teclea nobilis* and *Vernonia amygdalina* in the forest. This might be because of biotic disturbance or environmental factors. Studying the regeneration status of forest has important implications for the management of natural forests. Pokhriyal et al. (2010), mentioned that research in this field contributes to planning conservation and decision making in forest resource management programs. The presence of good regeneration potential shows stability of the species in the environment. According to Dhaulkhandi et al. (2008), the density values of seedlings and saplings are considered as regeneration potential of the species. Climatic factors and biotic interferences influence the regeneration of different species in the vegetation.

The current result showed that six species, *Crotalaria laburnifolia*, *Combretum molle*, *Hagenia abyssinica*, *Maytenus undata*, *Rosa abyssinica*, *and Indigofera rothii* (12.5%) of the total 48 woody species were not represented by seedling stages, while seven individual species in the forest (14.6%) were not represented by both seedlings and saplings. These species include: *Allophylus abyssinicus*, *Bersama abyssinica*, *Ficus sur*, *Dovyalis verrucosa*, *Halleria lucida*, *Rhus natelensis,* and *Schefflera abyssinica.* On the other hand eight species (16.7%) of the total were not represented by sapling stage in *Ades* forest. These species include: *Asparagus africanus, Maesa lanceolata, Millettia ferruginea, Oncoba spinosa, Psydrax schimperiana, Rhus glutinosa, Teclea nobilis, Vernonia amygdalina*. Individual species with such type of population pattern are poor in their regeneration and recruitment potential since there are no juveniles which tend to become a mature individuals in the future unless appropriate conservation and management actions undertaken. This might be due to over grazing by both wild and domestic animals or other factors such as lack of safe site for seed recruitment. In the contrast, most species 26 (54.2%), were represented by at least one or greater than one of both seedling and sapling stages. As a result, these were species with good regeneration status than those without seedling or/and sapling stages (Table 1). Species that lack seedling, sapling or both have poor/no regeneration status so that they are either under threat of local extinction or may prefer coppices or sprouts as the strategy of survival. For exaple, *Prunus africana, Rhus glutinous, Teclea nobilis, and Scolopia theifolia* were species that can reproduce by coppices or sprouts (recorded from observation during data collection on the field). Similar findings were also reported by (Simon and Girma, 2004; Dereje, 2007; Teshome, 2009).

4. Conclusion

Assessment of natural regeneration status of woody species in the forest is important for their management, conservation, and sustainable utilisation of forest and forest products. In this study, the overall regeneration potential of trees/shrubs plant species revealed that contribution of seedlings to the total population was highest followed by saplings and adult trees. In general, it shows that, regeneration status of woody species in the study area is “good” and the future communities may be sustained unless there is any challenging environmental stress or anthropogenic activities. However, the growth, survival, and reproduction potential of the tree species showing “poor” or “no” regeneration may be at risk in the near future. Therefore, appropriate management plan is required for their conservation and sustainable utilisation.

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Appendix

Appendix 1: List of woody species collected from ades forest with their age categories.

Scientific name	Family	Local name	H	Sdl	Sap	Mat
Allophylus abyssinicus (Hochst.) Radlk.	Sapindaceae	Embis (Amh.)	T	0	0	2
Apodytes dimidiate E. Mey. ex. Am	Icacinaceae	Ararsaa (Or)	S	22	21	0
Asparagus africanus Lam.	Asparagaceae	Sariiti (Or.)	S	2	0	0
Bersama abyssinica Fresen.	Melianthaceae	Waakkaa (Or)	T	0	0	9
Brucea antidysenterica J.F. Mill.	Simaroubaceae	Qommongo (Or)	T	2	1	0
Calpurnea aurea (Ait.) Benth.	Fabaceae	Ceekaa (Or.)	S	74	71	0
Carissa spinarum L.	Apocynaceae	Agemssa (Or.)	S	44	31	1
Combretum molle G.Don	Combretaceae	Maldhisaa (Or.)	S	0	1	0
Crotalaria laburnifolia L.	Fabaceae	-	S	0	1	0
Croton macrostachyus Del.	Euphorbiaceae	Bekenissa (Or.)	T	17	3	8
Dombeya torrida (J.F.Gmel.) P.Bamps	Sterculiaceae	Daanisa(Or.)	T	6	3	3

Scientific name	Family	Local name	H	Sdl	Sap	Mat
Dovyalis abyssinica (A. Rich.) Warb.	Flacourtiaceae	Shimbirqoli (Or.)	S	77	35	0
Dovyalis verrucosa (Hochst.) Warb.	Flacourtiaceae	Liqqimme (Or)	T	0	0	1
Ekebergia capensis Sparrm.	Meliaceae	Sombo (Or.)	T	21	19	2
Euphorbia ampliphylla Pax.	Euphorbiaceae	Adaamii (Or.)	T	2	1	0
Euphorbia tirucalli L.	Euphorbiaceae	Caadaa (Or.)	T	21	19	2
Ficus sur Forssk.	Moraceae	Harbuu (Or.)	T	0	0	2
Hagenia abyssinica (Bruce) J.F.Gmel.	Rosaceae	Hexoo (Or.)	T	0	1	4
Halleria lucida L.	Scrophularaceae	-	S	0	0	24
Indigofera rothii Baker	Fabaceae	Ooshee (Or.)	S	0	2	0
Juniperus procera Hochst. ex. A. Rich.	Cuppressaceae	Getera (Or.)	T	36	7	112
Lepidotruchilia volkensii (Gurke) Ler'y	Meliaceae	Miixoo (Or.)	S	19	16	3
Maesa lanceolata Forssk	Myrsinaceae	Abbayyi (Or.)	T	5	0	5
Maytenus sp.	Celasteraceae	Qaxamme (Or.)	S	105	80	13
Maytenus undata (Thunb.) Blackelock	Celasteraceae	Wontofulasa (Or.)	T	0	1	0
Millettia ferruginea (Hochst.) Bak.	Fabaceae	Birbirraa (Or.)	T	2	0	
Myrica salicifolia Hochst ex. A. Rich.	Myricaceae	Macheensoo (Or.)	S	33	24	0
Myrsine africana L.	Myrsinaceae	Kechemo (Amh.)	S	77	9	0
Nuxia congesta R. Br. ex Fresen.	Loganiaceae	Machalo(Or.)	T	1	1	0
Olea europaea L. subsp. *cuspidata* (Wall. ex. G. Don.) Cif.	Oleaceae	Ejerssa (Or.)	T	77	4	8
Oncoba spinosa Forssk	Flacouriaceae	Garabagush (Or.)	T	3	0	13
Osyris quadripartita Decn.	Santalaceae	Watto (Or.)	S	7	5	0
Pittosporum viridiflorum Sims	Pittosporaceae	dhamaye (Or.)	T	6	1	1
Podocarpus falcatus (Thunb) R.B. ex. Mirb.	Podocarpaceae	Birbirssa (Or.)	T	257	141	106
Prunus africana (Hook. f.) Kalkm.	Rosaceae	Muka gurach(Or.)	T	123	13	2
Psydrax schimperiana (A.Rich) Bridson	Rubiaceae	Gallee (Or.)	S	1	0	
Pterolobium stellatum (Forssk.) Brenan	Fabaceae	Kuntir (Amh.)	S	1	2	0
Rhamnus staddo A. Rich	Rhamnaceae	Sibiillo (Or.)	T	2	1	0
Rhus glutinosa A. Rich.	Anacardiaceae	Tatessa (Or.)	T	2	0	4
Rhus natelensis Meikle	Anacardiaceae	Nanfaree (Or.)	S	0	0	1
Rosa abyssinica Lindley	Rosaceae	Qajima (Or.)	S	0	1	0
Rubus steudneri Schweinf.	Rosaceae		S	7	6	0
Schefflera abyssinica (A.Rich.) Harms	Araliaceae	Habaratuu (Or.)	T	0	0	1
Scolopia theifolia Gilg.	Flacourtiaceae	Qillisaa (Or.)	T	193	110	44
Teclea nobilis Del.	Rutaceae	Hadheessa (Or.)	S	1	0	2
Vangueria madagascariensis Gmel.	Rubiaceae	Ababunee (Or.)	S	360	164	0
Vernonia amygdalina	Asteraceae	-	S	5	0	3
Vernonia urticifolia A. Rich.	Asteraceae	Reji Or.)	S	3	3	0
Total	**29 family**	**48 spps**		**1614**	**798**	**376**

H=habit, T=Tree, S=Shrub, Sdl=Seedlings, Sap=Saplings, Mat=Matured.