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FLORISTIC COMPOSITION, POPULATION STRUCTURE AND CONSERVATION STATUS OF WOODY SPECIES IN SHASHEMENNE-MUNESSA NATURAL FOREST, ETHIOPIA

Gemedo Dalle[1]

ABSTRACT: The study was conducted in Shashemenne-Munessa Natural Forest in West Arsi Zone, Oromia Regional National State. It was to determine floristic composition, population structure and regeneration status of indigenous woody species. Data was collected in 2003 from 33 sample plots of 500 m^2 established at every 50 m drop in altitude for sloppy or at 200 m interval for flat terrain. All woody species rooted within the sample plots were recorded and their Diameter at Breast Height (DBH) was measured for each. A total of 97 woody species belonging to 44 families and 76 genera were identified. Based on species richness, Fabaceae, Moraceae and Celastraceae were the most important families. The most diverse genera were Ficus, Maytenus, and Acacia. The total tree/shrub density was 446 per hectare with a total dominance of 57.3 m^2ha^{-1}. Species with lower Importance Value Index and therefore, that need high conservation attention included *Pittosporum viridiflorum, Pavetta sp, Discopodium penninervium, Rhus natalensis, Hypericum revolutum, Ehretia abyssinica, Rhus ruspolii, Apodytes dimidiata, Juniperus procera, Strychnos henningsii, Vepris dainellii* and *Phoenix reclinata.* Woody species with bad reproduction and recruitment were *Podocarpus falcatus, Mimusops kummel, Ficus sycomorus, Cordia africana, Prunus africana, Chionanthus mildbraedii* and *Ficus sur.* These species should be given priority both in planning and implementation of conservation activities. It was concluded that there is a high need to conserve those identified priority species using both *in situ* and *ex situ* conservation methods.

Key words/phrases: Density, Importance value index, Species diversity, Regeneration.

INTRODUCTION

Forests are extremely important ecosystems. According to the report by Secretariat of the Convention on Biological Diversity (SCBD) (2011), forests are more biologically diverse than any other land-based ecosystems and if these forests are conserved and sustainably used, more than two-thirds of all land-based animal and plant species can be protected. Forests have

[1] Ethiopian Biodiversity Institute, P.O.Box 30726, Addis Ababa, Ethiopia. E-mail: gemedod@yahoo.com

socio-cultural, economic and ecological importance. Shashemenne-Munessa Forest is one of such forests with diverse uses. The forest is home for many plants and animals, source of timber and firewood, trees and shrubs and also source of many rivers that flow into the central rift valley lakes. The forest serves to control the flow and quality of water and prevent erosion.

Studies have shown that tropical forests are being destroyed at an alarming rate (Hartshorn, 1989; Sabogal, 1992; Legesse Negash, 1995; Demel Teketay, 1996). Deforestation has been contributing to a decline in forest cover, loss of biodiversity both at global and national levels (Skole and Tucker, 1993; EPA, 1997; Kumar, 1997). Poverty and lack of alternative livelihoods have been driving forces of forest destruction. The Forest Genetic Resources Conservation Strategy of Ethiopia (2002) and Proclamation on Forest Development, Conservation and Utilization (2007) had identified deforestation as a major threat to Ethiopia's forest biodiversity. Deforestation of agricultural land as a result of ever-increasing population growth, increasing demand for fuel wood, and construction material, illegal settlements within forests, logging, and the expansion of illegal trade were considered major contributing factors to the loss of forest resources. The reduction in forest cover and loss of forest genetic resources pose a serious threat to conservation of forest biodiversity.

Dry Afromontane forests, including Shashemenne-Munessa (now under Arsi Forest and Wildlife Enterprise) Natural Forest, are among the most threatened natural forests in Ethiopia. SCBD (2011) reported that forests are disappearing partly due to their being undervalued, and failure of market economy to recognize ecosystem services provided by forests. It was also pointed out that more than 1.6 billion people depended on forests for their livelihoods.

Forests are home to an estimated 300 million people around the world; 80 per cent of people in developing countries rely on traditional medicines, of which up to 50% originate from plants found mainly in tropical forests. Forest biodiversity is the basis for more than 5,000 commercial products, ranging from aromatic oil (distilled from leaves) to herbal medicines, food and clothing. Besides, three quarters of the world's accessible fresh water comes from forested watersheds; forests purify drinking water for two-thirds of the major cities in developing countries.

Despite its socio-economic and environmental importance, Shashemenne-Munessa Forest has been under severe threat for years. The forest is easily accessible from the Addis Ababa–Shashemenne highway. Due to the easy

accessibility and lack of proper management, the forest has been under heavy exploitation for sawmills (which were established in 'Sole' and 'Jigessa') since the 1930's (Anonymous, 1990). According to Anonymous (1990), the forest has been exploited mainly for *Podocarpus falcatus* since the Italian invasion. Due to forest clearance for cultivation and, to a lesser extent, of logging, the natural forest is now confined largely to the main escarpment. There are smaller and more fragmented patches of forest and woodland on the plain and on the edge of the Hawassa basin to the south and southeast of the forest.

Therefore, the existing situation calls for an urgent mitigation action. Furthermore, studies of the woody plant diversity are essential so as to determine their current conservation status, and hence prioritize the threatened woody species. It is important to suggest and establish appropriate conservation methods for the prioritized species, and then develop and strengthen appropriate conservation strategies for the targeted species. The objective of the current study is, therefore, to determine the floristic composition and diversity of indigenous woody species and determine their conservation status in Shashemenne-Munessa Natural Forest.

MATERIALS AND METHODS

Study Area

Shashemenne-Munessa Forest is located about 200 km south of Addis Ababa at $7^0$13'N, $38^0$37'E along the escarpment east of the Addis Ababa-Hawassa high way in West Arsi Zone of Oromia National Regional State. Shashemenne-Munessa Forest area is divided into three districts; namely Munessa, Shashemenne, and Gambo. The forest area occupies the escarpment and associated highlands lying between the Rift Valley lakes (Abijata, Langano, and Shalla) and the eastern edge of the Rift Valley. The total area of Shashemenne-Munessa Forest was 21,380 ha, of which 15,280 was Natural High Forest. The forest is situated along the altitudinal gradient between 1450 m and 2600 m a.s.l.

Makin *et al*. (1975) and King and Birchall (1975) described the geology and landform of Shashemene-Munessa area. Rocks are volcanic, principally ignimbrite but with basalt in the north and tuff near the southern extremity of the forest, that is, near Wondo Genet. The Duro Mountain at the southeastern tip of the main compact block of the forest, north of Kofele, is a dissected volcano composed of tephra and trachyte (Chaffey, 1978).

Lundgren (1971) investigated in some detail the soils of the Shashemenne-Munessa Forest. The reddish soils are derived from weathered parent rock, freely draining and of medium to heavy texture. Lundgren (1971) described them as ferrisols and his analyses showed that the soils contain high levels of all the available chemical nutrients, except phosphorous, which these soils are deficient. According to the Lundgren (1971), the pH of the soil varies between 5.8 and 6.7, and high level of humus was recorded under Podocarpus forest.

The forest area drains mainly into Lake Langano and Lake Shalla through surface streams and rivers, many of which contain water of good quality throughout the year. The main escarpment contributes to the Langano catchments while drainage from the plain above drains largely into Lake Shalla. The Hawassa basin receives water from the southernmost remnants of the forest, near Wondo Genet.

Some of the major rivers that drain from the Shashemene-Munessa Forest area are Lephis, Gedemso, Huluka, Awade, Shoba, Dalele, Metena, Teji, and Mokonisa (all of which drain into Lake Langano); and Dhadhaaba Guddaa, Dhadhaaba diqqaa, Agemsa, Meti, (all drain to Lake Shalla), and Wosha to Lake Hawassa (Anonymous, 1990).

Vegetation

The principal categories of the forest vegetations are: high forest from approximately 2100 m to 2450 m, Bamboo thicket from 2450 to 2650 m, and low forest and woodland at the edge of and on the plain above the steep slopes occupied by bamboo. On the most gently sloping terrain to south of the main escarpment and / or where the bamboo stratum is absent, there is a less distinct transition in the forest types, and blocks of closed forest extends exceptionally to 3000 m.

Podocarpus falcatus is the dominant tree in both size and frequency in the forest occupying the lower elevations and below the bamboo. Other large trees include *Celtis africana, Olea capensis* and *Prunus africana*. In places where the canopy is low and in former gaps and clearings, *Croton macrostachyus* is a frequent component species (Chaffey, 1978; Gemedo Dalle, 1999). Less common canopy species are *Pouteria adolfi-friederici, Apodytes dimidiata, Ficus sur, Schefflera abyssinica*, and *Syzygium guineense*. Frequent smaller trees are *Allophylus abyssinicus* and *Bersama abyssinica*. Some of the understorey species include *Brucea antidysenterica, Cassipourea malosana, Lepidotrichilia volkensii*, Maytenus spp., and *Vepris*

dainellii. At or near the forest edge, *Albizia schimperiana*, *Calpurnia aurea*, *Cordia africana*, *Maytenus* species and *Olea europaea* subsp. *cuspidata* are frequent at the forest edge.

Methods

A systematic random sampling design was used to collect the data from sampling plots established at regular intervals along predetermined transects. Six transects were laid systematically and made to cover the major aspects (Southeast, West and North). Vegetation data was collected in 2003 from 33 sample plots of 50m x 10m (500 m^2) that were established at every altitudinal drop of 50m, where there is altitudinal gradient, and at a horizontal distance of 200 m interval for the flat terrains.

Indigenous woody species rooted within each sampling plot were identified and listed. All woody species with DBH > 2.5 cm were measured for their DBH and height. Lianas spp. and other species occurring outside the sampling quadrates were registered as 'present'. Species occurring outside the plot were also recorded to study their floristic composition. The growth habit of each woody species and the physiognomy of the vegetation within each quadrate were described. Regeneration status was also assessed within each quadrate, which involved counting seedlings and saplings on 2 X 2m by 10m sub-quadrates (40m^2) laid at the two endings of the quadrate. Plant specimens were collected, pressed, dried and identified and checked at the National Herbarium of the Addis Ababa University. Nomenclature of plant species followed the published volumes of the Flora of Ethiopia and Eritrea (Hedberg and Edwards, 1989, 1995; Edwards *et al*. 1995, 1997).Voucher specimens were kept in the Ethiopian Biodiversity Institute and National Herbarium of Addis Ababa University.

Data Analysis

Descriptive statistics were used in organizing, summarizing and describing sample data. Access and excel software programs were used for the data analysis.

1. Density was calculated using the equation

$$d = \frac{\sum t}{s_{ha}}$$

where d is density of all tree/shrub species, t total number of stems of all tree/shrub species, s_{ha} = sample size in hectare.

2. Relative density was calculated using the equation

$$rd = \frac{\sum t}{ts}$$

where rd is relative density of each individual tree/shrub, t is total number of stems of all tree/shrub species, ts is total number of stems of all tree/shrub.

3. Frequency = $$f = \frac{nQ}{tQ} \times 100$$

where f is frequency, nQ is number of quadrates in which a species recorded and tQ is total number of quadrates.

4. Relative frequency = $$rf = \frac{f}{\sum tf}$$

where rf is relative frequency, f is frequency of a species and $\sum tf$ is sum frequency of all tree/shrub species.

5. Basal area $$Ba = 22 \times \frac{d^2}{28}$$

where Ba is = basal area and d is diameter at breast height or stump height.

6. Dominance $$Do = mBa \times d$$

where Do is dominance, mBa is mean Ba per tree/shrub species and d is density of a tree/shrub species.

7. Relative Dominance $$rDo = \frac{mBa}{\sum mBat} \times 100$$

where rDo is relative dominance, mBa is mean Ba per tree/shrub species and $mBat$ is mean BA of all tree/shrub species.

8. Importance Value Index $IVI = rd + rf + rDo$

where IVI is importance value index, rd is relative density, rf is relative frequency and rDo is relative dominance.

RESULTS AND DISCUSSION

Floristic composition

A total of 97 woody species representing 76 genera and 44 families were recorded from Shashemenne-Munessa Natural Forest (Annex 1). Of these, 65 species were recorded within the sample plots and 32 outside the sample plots. The most diverse genera, Ficus, were represented by (six species), Maytenus (four species) and Acacia (three species). Diverse families such as Fabaceae, which was represented by (7 species, belonging to 5 genera), Moraceae (6 species all belonging to a single genus), Celastraceae (5 species belonging to two genera), Oleaceae, Rosaceae, Euphorbiaceae, Loganiaceae and Rubiaceae (four species each), Asteraceae, Boraginaceae, Myrsinaceae, Rutaceae and Apocynaceae (three species each), Meliaceae, Anacardiaceae, Araliaceae, Flacourtiaceae, Sapotaceae and Solanaceae (two species each) were also included.

The predominant species in the forest was *P. falcatus*, which occupied the lower elevations and below the bamboo. This species was dominant both in size and frequency. This is in agreement with Chaffey (1978). Other large broad-leaved species were: *Ficus sycomorus*, *Cordia africana*, *C. macrostachyus*, *Myrsine melanophloëos, Celtis africana*, and other *Ficus spp.* Smaller trees included: *Apodytes dimidiata, Bersama abyssinica*, *Brucea antidysenterica*, *Teclea simplicifolia*, *Vepris dainellii*, *Hypericum revolutum*, *Nuxia congesta*, and *Polyscias fulva.* The common shrubs of the area include: *Carissa spinarum*, *Vernonia auriculifera*, *Euclea racemosa*, *Pavetta abyssinica* and *Rhus natalensis*. The common lianas were *Embelia schimperi*, *Jasminum abyssinicum*, and *Landolphia buchananii*.

Structure

Frequency

There was no species that belonged to the frequency class A. Only *P. falcatus,* which is the most frequent tree species in Shashemenne-Munessa Natural Forest, belonged to the frequency class B, and *Bersama abyssinica* belonged to the frequency class C. Eleven species belonged to the frequency class D while the remaining species belonged to the last frequency class

(Fig. 1). Some of the tree species that were not frequent included *Cordia africana, Ekebergia capensis, Polyscias fulva, Prunus africana, Celtis africana, Juniperus procera, Apodytes dimidiata, Hagenia abyssinica, Mimusops kummel, Croton macrostachyus, Albizia gummifera, Teclea simplicifolia, Cassipourea malosana* and *Schefflera volkensii*.

Fig. 1. Species distribution by frequency classes.

Frequency gives an approximate indication of the homogeneity of a stand. Studies pointed out that high values in the higher frequency classes (Frequency classes A and B in this case) and low values in the lower frequency classes (Frequency classes D and E) indicated constant or similar species composition in the area. High values in the lower frequency classes and low values in the higher frequency classes, on the other hand, indicated a high degree of floristic heterogeneity. In the present study, high values were obtained in the lower frequency classes whereas low values were obtained in the higher frequency classes (Fig. 1). Therefore, according to the above interpretation it is possible to conclude that there exists a high degree of floristic heterogeneity in Shashemenne-Munessa Natural Forest Priority Area. The species that appear in the lower frequency classes have irregular occurrence while those appearing in the higher classes such as *P. falcatus* have regular horizontal distribution.

Density

The total tree/shrub density of Shashemenne-Munessa forest was 446 per ha. Species were classified into 5 density classes, from E to A; where species that belonged to class E have lower density while those in class A have higher density and the intermediates were also assigned accordingly.

Species that belonged to density class E were *Polyscias fulva, Apodytes dimidiata, Juniperus procera, Phoenix reclinata, Pittosporum viridiflorum, Pouteria adolfi-friederici, Rhus ruspollii, Strychnos henningsii* and *Vepris dainellii*. Some of the tree species that belonged to density class D were *Hagenia abyssinica, Prunus africana, Chionanthus mildbraedii, Teclea simplicifolia, Ilex mitis, Cassipourea malosana* and *Ekebergia capensis*. On the other hand, abundant species in the forest were *Maytenus senegalensis, Myrsine melanophloëos, Arundinaria alpina, Acokanthera schimperi,* and *Podocarpus falcatus*.

The density of tree/shrub species over 10 cm DBH and over 20 cm DBH was 230.9 and 144.6, respectively and their ratio was about 1.6. Density of tree/shrub species over 10cm DBH greater than 600 is normal for Virgin Rainforest in Africa (Richard, 1966, cited in Lamprecht, 1989). Density ratio of individuals >10 cm DBH to that of individuals > 20 cm DBH showed prevalence of small-sized individuals for some species but comparable distribution for few and even fewer for others.

Basal area and dominance

Total dominance of Shashemenne-Munessa forest is 57.3 m^2ha^{-1}. The total basal area/dominance of Shashemenne-Munessa forest were greater than that of Jibat, Menagesha and Chilimo forests, which were 49.8, 36.1 and 30.1 m^2ha^{-1}, respectively (Tamrat Bekele, 1994). The highest basal area was recorded for fewer large-sized individuals, especially DBH greater than 42.6 cm. *Podocarpus falcatus* was the most dominant species, followed by *Ficus sycomorus, Maytenus senegalensis, Celtis africana, Maytenus addat, Cordia africana, Schefflera volkensii, Maesa lanceolata* and *Mimusops kummel.* On the other hand, some species such as *Juniperus procera, Apodytes dimidiata, Pouteria adolfi-friederici, Vepris dainellii* and *Cassipourea malosana* have insignificant or no contribution to the total basal area of the forest.

High density and high frequency, coupled with high dominance, indicate the overall dominant species of the forest (Lamprecht, 1989). Accordingly, *Podocarpus falcatus* and *Maytenus senegalensis* were the most dominant species. On the other hand, high density and high frequency indicates regular horizontal distribution in the forest, which was shown by *Podocarpus falcatus*, *Maytenus senegalensis* and *Maesa lanceolata.* High density, low frequency and low dominance are typical for understorey species that occur in clusters. These species included: *Myrsine melanophloëos, Arundinaria alpina, Erythrococca trichogyne* and

Acokanthera schimperi. *Prunus africana, Hagenia abyssinica, Pouteria adolfi-friederici, Juniperus procera, Polyscias fulva, Ekebergia capensis* and *Cassipourea malosana* were some of the tree species with low density, low frequency and low dominance.

Basal area provides a better measure of the relative importance of the species than simple stem count (Cain and Castro, 1959, cited in Tamrat Bekele, 1994). Therefore, species with the largest contribution in basal area can be considered as the most important woody species in the forest. Accordingly, the most important species of Shashemenne-Munessa Forest were *Podocarpus falcatus, Ficus sycomorus, Maytenus senegalensis, Celtis africana, Ficus sur, Maytenus addat, Cordia africana, Schefflera volkensii, Mimusops kummel* and *Maesa lanceolata.*

Importance Value Index (IVI)

For the sake of setting priority using importance value index (IVI) analysis all woody species encountered in the forest were grouped into five classes based on their total IVI values. Those species with lower IVI were grouped into the fifth IVI class while those species with higher IVI value were put under the first IVI class. Those species, which were grouped in the fifth IVI class, need high conservation effort while those grouped in the first IVI class, need monitoring management (Table 1). About 40% of the importance value was constituted by *Podocarpus falcatus, Maytenus senegalensis, Myrsine melanophloëos, Ficus sycomorus*, and *Arundinaria alpina*. The remaining percentage was shared among 44 species (Annex 2).

The importance value index is useful to compare the ecological significance of species (Lamprecht, 1989). It indicates the extent of dominance of a species in the structure of a forest stand (Curtis and McIntosh, 1951). Species with the greatest importance value are the most dominant in the forest (Curtis, 1952 cited in Greig-Smith, 1983). Accordingly, *Podocarpus falcatus, Maytenus senegalensis, Myrsine melanophloëos, Ficus sur, Arundinaria alpina, Celtis africana, Acokanthera schimperi, Maesa lanceolata, Erythrococca trichogyne* and *Calpurnia aurea* were the 10 most dominant species in the forest.

Table 1. List of species under each priority class.

Priority class				
5	**4**	**3**	**2**	**1**
P. viridiflorum	*E. trichogyne*	*M. melanophloëos*	*M. senegalensis*	*Podocarpus*
Pavetta sp	*C. aurea*	*F. sycomorus*		
Discopodium	*B. abyssinica*	*A. alpina*		
Rhus natalensis	*M.obscura*	*Celtis africana*		
Hypericum	*C. macrostachyus*	*A. schimperi*		
Acacia sp.	*Cordia africana*			
Ehretia abyssinica	*Ficus sur*			
Rhus ruspolii	*M. kummel*			
Apodytes dimidiata	*M. addat*			
J. procera	*F. sur*			
Strychnos	*G. saxifraga*			
Vepris dainellii	*P. africana*			
Phoenix reclinata	*S. volkensii*			
	F. vallis-choudae			
	H. abyssinica			
	N. congesta			
	B.antidysentrica			
	I. mitis			
	C. spinarum			
	Vernonia			
	F. ovata			
	D. verrucosa			
	E. capensis			
	A. gummifera			
	L. gebbroa			
	C. mildbraedii			
	Teclea simplicifolia			
	Croton dichogamus			
	Euclea racemosa			

Population structure of species

The population structure of a species can show whether the population has a stable distribution that allows continuous regeneration and recruitment to higher diameter classes. The analysis of density distribution of species by diameter classes has resulted in different patterns (Fig. 2a-h). High densities

in small diameter classes indicate a good regeneration capacity, while under representation of these classes indicates little regeneration capacity. The implication is that the potential to replace such species will be very low once the matured individuals have disappeared due to some reasons. That is, the species is endangered and needs conservation action. Population patterns indicating selective removal of individuals (Fig. 2d and 2h) were detected for *P. falcatus* and *P. africana,* respectively. *Podocarpus falcatus* showed peaks at lower size classes, an abrupt decline in the middle and then a rise at larger size class, i.e. a U-shaped population pattern. The decline and/or missing in the population of middle and/or upper height classes clearly showed that there is a selective removal of individual tree species of preferred size.

The local people as well as the saw-millers usually carry out selective removal of these individuals for the purpose of construction, fuelwood, agricultural encroachment and above all for logging (PRA report of the project). The other recognizable pattern indicated a good reproduction but discontinuous recruitment (Fig. 2c). Species with this pattern are *M. melanophloëos*, *Acokanthera schimperi*, *Bersama abyssinica*, *Brucea antidysenterica*, *Nuxia congesta*, *Teclea simplicifolia* and *Cassipourea malosana*. Some species show a gauss type pattern (Fig. 2e). A good example showing this pattern was *Croton macrostachyus*. This species showed good representation in the middle classes but not well-represented in lower and upper diameter classes. The other recognized pattern was an inverted J-shape (Fig. 2b). Species exhibiting this normal diameter class distribution were *Celtis africana*, *Maesa lanceolata*, *Maytenus senegalensis* and *Maytenus obscura*. Some other economically and ecologically important species were represented by abnormal density distribution pattern. Species under this pattern were missing in many of the diameter classes (Fig. 2h). For example, *Prunus africana*, *Cordia africana*, *Ficus* spp., *Chionanthus mildbraedii*, *Schefflera volkensii*, *Hagenia abyssinica*, *Albizia gummifera*, *Apodytes dimidiata*, *Juniperus procera*, *Polyscias fulva*, and *Pouteria adolfi-friederici*, which are economically important for log production, were missing in the DBH classes. Other species in the forest were represented by J-shaped pattern i.e. small representation in lower DBH classes but well-represented by old-aged individuals (Fig. 2f). *Mimusops kummel* was good example of this type that showed poor regeneration and over-representation of large-sized trees, incapable of regeneration. Therefore, there is an urgent need to regenerate these species before their regeneration capabilities are lost.

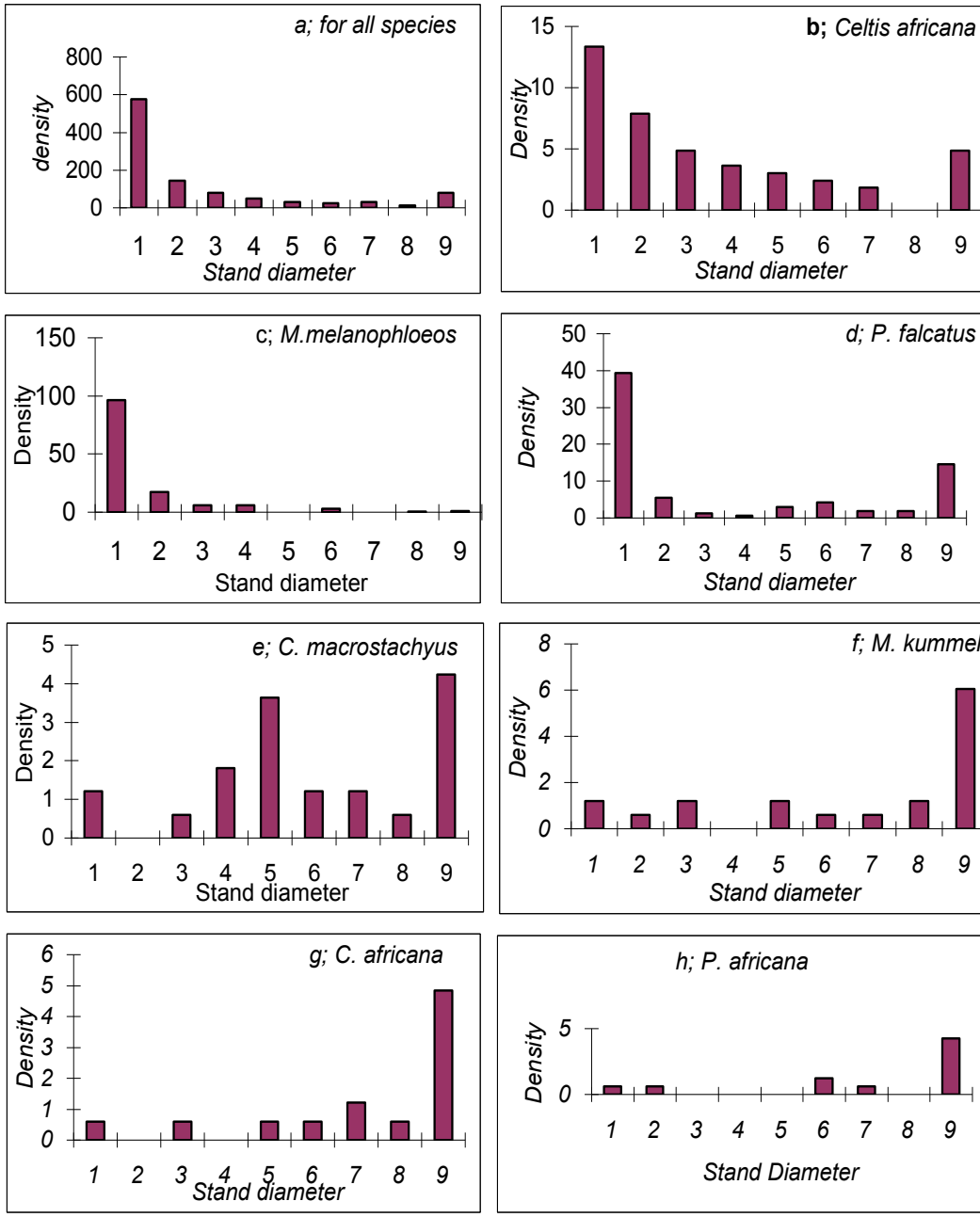

Fig. 2. Population structure of Shashemenne-Munessa Forest and some representative species; wherein stand diameter: 1=2.6-7.5, 2=7.6-12.5, 3=12.6-17.5, 4=17.6-22.5, 5=22.6-27.5, 6=27.6-32.5, 7=32.6-37.5, 8=37.5-42.5, 9=>42.6

In general, the analysis of the population structure of the species in the forest can be summarized into three groups:

1. The first group includes those tree/shrub species with bad reproduction and recruitment (Group I).
2. The second group includes those tree/shrub species with reproduction but bad recruitment (Group II).
3. The third group includes those tree species with good reproduction and recruitment (Group III).

To analyze the conservation status of the species in the forest, the structural distribution pattern was also used and the species were grouped for such purpose. Accordingly, all the species under Group I should be considered the top priority for the genetic conservation measures; and those under Group II are prioritized secondly. The list of species under the three groups is presented in Table 2.

Table 2. List of species according to population structure grouping.

Group I	**Group II**	**Group III**
P. falcatus	*M. melanophloëos*	*M. senegalensis*
M. kummel	*Acokanthera schimperi*	*Celtis africana*
Ficus sycomorus	*Bersama abyssinica*	*Maesa lanceolata*
Cordia africana	*Brucea antidysenterica*	*Galiniera saxifraga*
Prunus africana	*Nuxia congesta*	*Maytenus obscura*
Chionanthus mildbraedii	*Vepris dainellii*	
Ficus sur	*Teclea simplicifolia*	
Ekebergia capensis	*Croton macrostachyus*	
Schefflera volkensii		
Ficus vallis-choudae		
Hagenia abyssinica		
Albizia gummifera		
Cassipourea malosana		
Ficus ovata		
Apodytes dimidiata		
Juniperus procera		
Polyscias fulva		
Pouteria adolfi-friederici		

Regeneration status: Species composition and density

A total of 35 species were represented in the seedlings class, representing 30 genera belonging to 23 families. This accounted for about 53.8% of the floristic composition of the matured forest species. The total seedling density was 3537.9 per ha. However, the mean density was 101.1 per ha.

The sapling class was composed of more than 30 species representing 26 genera which belonged to 19 families. This equaled to 46.2% of the floristic composition of the matured forest species. The total sapling density was 2606.1 per ha and mean density was 86.8 per ha.

Myrsine melanophloëos, Calpurnia aurea, Acokanthera schimperi, Podocarpus falcatus and Celtis africana were the five abundant species in the natural regeneration. Although Demel Teketay (1996) suggested the seedling bank as the major regeneration route of most woody plants in dry Afromontane forests of Ethiopia, some species of economic and ecological importance were absent in the regeneration strata (seedling and sapling). These species included *Hagenia abyssinica, Prunus africana, Croton macrostachyus, Ficus sur, Schefflera volkensii, Polyscias fulva, Apodytes dimidiata, Ilex mitis, Juniperus procera, Pouteria adolfi-friederici, Nuxia congesta, Phoenix reclinata, Maytenus addat, Cordia africana, Chionanthus mildbraedii, Ficus sycomorus, Ficus vallis-choudae, Ficus ovata,* and *Albizia gummifera*. This may suggest that these species were either under threat of local extinction or may prefer coppices or sprouts as the strategy of survival. For instance, *Hagenia abyssinica* and *Prunus africana* regenerate mainly through vegetative sprouts (Getachew Tesfaye, 2001). Some species such as *Syzygium guineense*, *Olea europaea* subsp. *cuspidata* and *Dovyalis abyssinica* appeared only in the regeneration phase.

Gemedo Dalle (1999) reported that the regeneration of *Podocarpus falcatus* in the forest appeared to be from the suppressed seedlings and saplings under shade while that of *Croton macrostachyus* was from seed bank in the treefall gaps. Besides, *Myrsine melanophloëos, Maytenus addat, Bersama abyssinica, Dovyalis abyssinica*, and *Teclea nobilis* might have regenerated from seed bank.

CONCLUSION AND RECOMMENDATIONS

Shashemenne-Munessa is a diversified forest with more than 90 woody species. The total density (446 per ha) of tree and shrub species is low as compared to normal density of 600 per ha, which probably implied external pressure. *Podocarpus falcatus* is the principal commercially and

ecologically important species in the forest. *Podocarpus falcatus* was the most preferred species for logging as it is the most commonly used timber tree. In connection with timber production, local farmers and daily laborers of sawmill exploit valuable trees, primarily *Podocarpus falcatus.* Therefore, this unwise exploitation should be monitored before these species run out of our eyes. In addition to unwise utilization of valuable timber resources, an on-going agricultural encroachment is also taking place in the forest. Each year some areas of forestlands have been converted into cultivation land. The on-going destruction consequently leads to loss of indigenous species and associated biodiversity. It has also negative effects on soil fertility and water cycle.

Some important species had bad population structures that showed abnormal patterns with no or few individuals at lower size or middle classes, or well-represented at larger size classes, which meant old-aged population. There is, therefore, a need to develop and implement effective forest management activities in the area to facilitate healthy regeneration and eventually ensured the sustainable use of these species.

Podocarpus falcatus, Ficus sycomorus, Maytenus senegalensis, Celtis africana, Ficus sur, Maytenus addat, Cordia africana, Schefflera volkensii, Mimusops kummel, Maesa lanceolata, Myrsine melanophloëos, Arundinaria alpina, Acokanthera schimperi, Erythrococca trichogyne and Calpurnia aurea were important species that need conservation measures.

Economically as well as ecologically important species such as Hagenia abyssinica, Prunus africana, Croton macrostachyus, Pouteria adolfi-friederici, Albizia gummifera, Apodytes dimidiata, Polyscias fulva, Ficus sur, Schefflera volkensii, Juniperus procera, Cordia africana and Ilex mitis were absent in the regeneration assessment. This may suggest that these species are either under threat of local extinction or may prefer coppices or sprouts as the strategy of survival. Therefore, further investigation is strongly recommended to find out the actual causes for such species loss.

Finally, it was concluded that there is need to use multiple criteria in identifying threatened species and/or species that need conservation priority.

The recommendations are:-

- Carry out further investigation on the patterns of ecosystem functioning, the soil seed banks, germination characteristics and establishment of seedlings.

- Conduct studies on the role of gap dynamics since tree fall gaps are necessary for the establishment of seedlings and saplings of forest tree species. The knowledge of natural gap dynamics is also important where forest management objectives include maintaining biological diversity.
- Raise public awareness on the value of forest genetic resources and the problems related to loss of genetic information and devise a mechanism by which human impacts can be minimized through discussion and consultation with the local people.
- Establish *in situ* and *ex situ* conservation sites to conserve priority species.
- Conduct research on storage behavior (seed physiology) and reproduction biology of woody species that focus on threatened and economically important species.

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Annex 1. Floristic composition of Shashemenne-Munessa Natural Forest.

No	Species			Family	Hab.	Vern. Name (Oromo)
1	*Acacia*	*sp*		Fabaceae	T	Ajo
2	*Acacia*	*abyssinica**	*Hochst. Ex Benth.*	Fabaceae	T	Lafto
3	*Acacia*	*sp**		Fabaceae	T	Gerbi
4	*Acokanthera*	*schimperi*	*(A. DC.) Schwein*	Apocynaceae	T/S	Qararu
5	*Albizia*	*gummifera*	*(Gmel.) C. A. Sm.*	Fabaceae	T	Qerch'eche
6	*Aleyo*					*Aleyo*
7	*Allophylus*	*abyssinicus**	*(Hochst.) Radlkofer*	Sapindaceae	T	Hirqemo
8	*Apodytes*	*dimidiata*	*E. Mey. ex Arn.*	Icacinaceae	T	Arebdotessa
9	*Arundinaria*	*alpina*	*K. Schum.*	Poaceae	T/S	Lemen
10	*Bersama*	*abyssinica*	*Fresen.*	Melianthaceae	T	Foreqa
11	*Brucea*	*antidysenterica*	*J. F. Mill.*	Simarubaceae	T/S	Ch'ironta
12	*Buddleja*	*polystachya**	*Fresen.*	Loganiaceae	S	Bulchara
13	*Calpurnia*	*aurea*	*(Ait.) Benth.*	Fabaceae	T/S	Chekata
14	*Canthium*	*oligocarpum**	*Hiern*	Rubiaceae	S	Wontefulasa
15	*Capparis*	*tomentosa**	*Lam.*	Capparidaceae	S	Obo meda
16	*Carissa*	*edulis*	*Vahl*	Apocynaceae	S	Agamssa
17	Cassipourea	malosana	*(Baker)Alston*	Rhizophoraceae	T	Tilo
18	*Celtis*	*africana*	*Burm f.*	Ulmaceae	T	Amalaqa
19	*Chionanthus*	*mildbraedii*	*(Gilg & Schellenb.) Stearn*	Oleaceae	T	Sigeda
20	*Combretum*	*collinum**	*Fresen.*	Combretaceae	T	Rukessa
21	*Cordia*	*sp*		Boraginaceae	T	Mandhera
22	*Cordia*	*africana*	*Lam.*	Boraginaceae	T	Wedesa
23	*Crotalaria*	*sp**		Fabaceae	S	
24	*Croton*	*dichogamus*	*Pax*	Euphorbiaceae	T	Uleefooni
25	*Croton*	*macrostachyus*	*Del.*	Euphorbiaceae	T	Mekanisa
26	*Diospyros*	*abyssinica**	*(Hiern.)F. White*	Ebenaceae	T	Tilo-dima
27	*Discopodium*	*penninervium*	*Hochst.*	Solanaceae	S	Meraru
28	*Dombeya*	*torrida**	*(J.F. Gmel.) Bamps*	Sterculiaceae	T	Danisa
29	*Dovyalis*	*verrucosa*	*(A. Rich.)*	Flacuortiaceae	T/S	Dengogo

No	Species			Family	Hab.	Vern. Name (Oromo)
			Warburg			
30	*Ehretia*	*abyssinica*	*R. Br. ex Fresen.*	Boraginaceae	S	
31	*Ekebergia*	*capensis*	*Sparrm.*	Meliaceae	T	Ononu
32	*Embelia*	*schimperi**	*Vatk.*	Loganiaceae	L	Qanqu
33	*Erythrococca*	*trichogyne*	*(Muell.Arg) Prain*	Euphorbiaceae	S	Orjefuga
34	*Euclea*	*racemosa*		Ebenaceae	S	Measa
35	*Euphorbia*	*sp*		Euphorbiaceae	T	
36	*Ficus*	*ovata*	*Vahl*	Moraceae	T	Qilit'u
37	*Ficus*	*sur*	*Forsssk.*	Moraceae	T	
38	*Ficus*	*sycomorus*	*L.*	Moraceae	T	
39	*Ficus*	*thoninngi**	*Blume*	Moraceae	T	Dembi
40	*Ficus*	*vallis-choudae*	*Del.*	Moraceae	T	
41	*Ficus*	*vasta**	*Vahl.*	Moraceae	T	Qilt'u
42	*Flacourtia*	*indica**	*(Burm.f.)Merrill*	Flacourtiaceae	S	Hudha
43	*Galiniera*	*saxifraga*	*(Hochst.) Bridson*	Rubiaceae	T	Korala
44	*Galmiyo**					
45	Geto				T	
46	Grewia	bicolor*	*Juss.*	Tiliaceae	S	Haroressa dima
47	*Hagenia*	*abyssinica*	*(Bruce) G.F. Gmel.*	Rosaceae	T	Heet'o
48	*Hypericum*	*revolutum*	*Vahl*	Hypericaceae	T	Geramba
49	*Ilex*	*mitis*	*(L.) Radlk.*	Aquifoliaceae	T	Amshiqa
50	*Jasminum*	*abyssinicum**	*Hochst. ex DC.*	Oleaceae	L	Diki
51	*Juniperus*	*procera*	*Endl.*	Cupressaceae	T	Hindhesa
52	*Justecia*	*schimperiana**	*T. Anders*	Acanthaceae	S	T'umuga
53	Kembecha				T	
54	*Landolphia*	*buchananii*	*(Hall. f.) Stapf*	Apocynaceae	L	T'it'it'a
55	*Lobelia*	*giberroa*	*Hemsl.*	Lobeliaceae/Campanulaceae	T/S	Terura
56	*Maesa*	*lanceolata*	*Forssk.*	Myrsinaceae	T/S	Abeyi
57	*Maytenus*	*gracilipes**	*(Welw. Ex Oliv.) Exell*	Celastraceae	S	Kombolcha
58	*Maytenus*	*senegalensis*	*(Lam.) Exell*	Celastraceae	T/S	Kombolcha

No	Species			Family	Hab.	Vern. Name (Oromo)
59	*Maytenus*	*addat*	*(Loes.) Sebsebe*	Celastraceae	T	
60	*Maytenus*	*obscura*	*(A. Rich.) Cuf.*	Celastraceae	T/S	Wantafulasa
61	*Mimusops*	*kummel*	*A. DC.*	Sapotaceae	T	Olati
62	*Myrsine*	*africana**	*L.*	Myrsinaceae	S	Qech'amo
63	*Myrsine*	*melanophloeos*	*(L) R.Br.*	Myrsinaceae	T/S	Tula
64	*Nuxia*	*congesta*	*Fresen.*	Loganiaceae	T	Bitena
65	*Olea*	*capensis sp. macrocarpa**		Oleaceae	T	Sigeda
66	*Olea*	*europaea ssp. cuspidata**		Oleaceae	T	Ejersa
67	*Olinia*	*rochetiana**		Oliniaceae	T	Guna
68	*Oncinotis*	*tenuiloba**		Asclepediaceae	L	Hadhemene
69	*Pavetta*	*abyssinica*	*Fresen.*	Rubiaceae	S	Galo
70	*Phoenix*	*reclinata*	*Jacq.*	Palmae	T	Mit'I
71	*Phytolacca*	*dodecandera**	*L'Herit*	Phytolaccaceae	L/S	Handode
72	*Pittosporum*	*viridiflorum*	*Sims*	Pittosporaceae	T	Ara
73	*Podocarpus*	*falcatus*	*(Thunb.) Mirb*	Podocarpaceae	T	Birbirsa
74	Polyscias	fulva	*(Hiern)Harms*	Araliaceae	T	Harfatu
75	Pouteria	adolfi-friederici	*(Engl.)Baehni*	Sapotaceae	T	Suduba
76	*Prunus*	*africana*	*(Hook. f.) Kalkm*	Rosaceae	T	Suke
77	*Psydrax*	*schimperiana**	*(A.Rich.)Bridson*	Rubiaceae	S	Galo buno
78	*Pterolobium*	*stellatum*	*(Forssk.) Brenan*	Fabaceae	L	Gort'a
79	Qechachilo				T	Qechachilo
80	*Rhus*	*natalensis*	*Krauss*	Anacardiaceae	S	T'at'essa
81	*Rhus*	*ruspolii*	*Engl.*	Anacardiaceae	T	Qamo
82	Rosa	abyssinica*		Rosaceae	S/L	Harengama
83	*Rubus*	*apetalus*	*Poir.*	Rosaceae	L	Gora
84	*Schefflera*	*volkensii*	*(Engl.) Harms*	Araliaceae	T	Ansha
85	*Solanecio*	*mannii**	*(Hook.f.)C. Jeffrey*	Asteraceae	S	Worqiye
86	*Solanum*	*gurae**	*Friis*	Solanaceae	S	Oromo Halala
87	*Strychnos*	*henningsii*	*Gilg*	Loganiaceae	T	Galo
88	*Syzygium*	*gueneense**	*(Willd.) DC*	Myrtaceae	T	Bedesa
89	*Teclea*	*simplicifolia*	*(Engl.) Verdoorn*	Rutaceae	T	Hadhessa
90	*Toddalia*	*asiatica*	*(L.) Lam*	Rutaceae	L	Go'o

No	Species			Family	Hab.	Vern. Name (Oromo)
91	*Trichilia*	*emetica**	*Vahl.*	Meliaceae	T	Kokolfa
92	*Urera*	*hypselodendron*	*(A.Rich.) Wedd.*	Urticaceae	L	Halilu
93	*Vepris*	*dainellii*	*(Pich.-Serm.) Kokwaro*	Rutaceae	T	Hadhessa
94	*Vernonia*	*amygdalina**	*Del.*	Asteraceae	T/S	Ebicha
95	*Vernonia*	*auriculifera*	*Hiern*	Asteraceae	S	Reji
96	*Wontafulesa-Dima**			Celastraceae		*Wontafulesa-Dima**
97	Worqicha				T/S	Worqicha

Annex 2. Important Value Index (IVI) of species in Munessa-Shashemene Natural Forest (in descending order).

No.	Species		RD	RelDom	RF	IVI	%age	Rank
1	*Podocarpus*	*falcatus*	7.0	19.5	9.4	35.9	12.7	1
2	*Maytenus*	*senegalensis*	15.4	8.1	4.1	27.6	9.7	2
3	*Myrsine*	*melanophloeos*	12.8	2.1	4.5	19.4	6.8	3
4	*Ficus*	*sycomorus*	0.8	14.4	1.1	16.3	5.8	4
5	*Arundinaria*	*alpina*	12.3	0.3	2.3	14.9	5.2	5
6	*Celtis*	*africana*	4.1	5.7	4.1	14.0	4.9	6
7	*Acokanthera*	*schimperi*	7.1	1.5	2.6	11.3	4.0	7
8	*Maesa*	*lanceolata*	3.8	3.0	3.4	10.2	3.6	8
9	*Erythrococca*	*trichogyne*	5.9	0.4	3.4	9.6	3.4	9
10	*Calpurnia*	*aurea*	4.3	2.3	3.0	9.6	3.4	9
11	*Bersama*	*abyssinica*	2.1	0.1	6.4	8.7	3.1	11
12	*Maytenus*	*obscura*	1.8	3.4	3.4	8.6	3.0	12
13	*Croton*	*macrostachyus*	1.4	2.9	3.8	8.1	2.8	13
14	*Cordia*	*africana*	0.9	3.5	3.4	7.8	3.0	14
15	*Ficus*	*sur*	0.4	5.7	0.8	6.9	2.4	15
16	*Mimusops*	*kummel*	0.9	2.7	2.6	6.3	2.2	16
17	*Maytenus*	*addat*	0.3	4.8	0.8	5.8	2.0	17
18	*Galiniera*	*saxifraga*	2.5	1.1	1.9	5.6	2.0	17
19	*Prunus*	*africana*	0.7	2.7	1.9	5.3	1.9	19
20	*Schefflera*	*volkensii*	0.3	3.5	0.8	4.6	1.6	20
21	*Ficus*	*vallis-choudae*	0.2	2.9	1.1	4.3	1.5	21
22	*Hagenia*	*abyssinica*	0.2	2.8	1.1	4.2	1.5	21
23	*Nuxia*	*congesta*	1.1	0.3	2.3	3.7	1.3	23
24	*Brucea*	*antidysenterica*	1.7	0.1	1.9	3.6	1.3	23
25	*Ilex*	*mitis*	0.6	1.8	1.1	3.5	1.2	25
26	*Carissa*	*spinarum*	1.0	0.0	1.9	2.9	1.0	26
27	*Vernonia*	*auriculifera*	0.9	0.0	1.9	2.8	1.0	26
28	*Ficus*	*ovata*	0.1	1.7	0.8	2.6	0.9	28
29	*Dovyalis*	*verrucosa*	0.5	0.0	1.9	2.4	0.8	29
30	*Ekebergia*	*capensis*	0.4	0.3	1.5	2.2	0.8	29
31	*Albizia*	*gummifera*	0.2	0.7	0.8	1.7	0.6	31
32	*Lobelia*	*giberroa*	0.7	0.1	0.8	1.5	0.5	32

No.	Species		RD	RelDom	RF	IVI	%age	Rank
33	*Chionanthus*	*mildbraedii*	0.4	0.6	0.4	1.4	0.5	32
34	*Teclea*	*simplicifolia*	0.6	0.0	0.8	1.4	0.5	32
35	*Croton*	*dichogamus*	0.5	0.0	0.8	1.2	0.4	35
36	*Euclea*	*racemosa*	0.2	0.1	0.8	1.0	0.4	35
37	*Pittosporum*	*viridiflorum*	0.1	0.4	0.4	0.8	0.3	37
38	*Pavetta*	*abyssinica*	0.3	0.0	0.4	0.7	0.3	37
39	*Discopodium*	*penninervium*	0.3	0.0	0.4	0.7	0.2	39
40	*Rhus*	*natalensis*	0.2	0.0	0.4	0.6	0.2	39
41	*Hypericum*	*revolutum*	0.1	0.0	0.4	0.5	0.2	39
42	*Acacia*	*sp*	0.1	0.1	0.4	0.5	0.2	39
43	*Ehretia*	*abyssinica*	0.1	0.0	0.4	0.5	0.2	39
44	*Rhus*	*ruspolii*	0.1	0.0	0.4	0.5	0.2	39
45	*Apodytes*	*dimidiata*	0.1	0.0	0.4	0.5	0.2	39
46	*Juniperus*	*procera*	0.1	0.0	0.4	0.4	0.2	39
47	*Strychnos*	*henningsii*	0.1	0.0	0.4	0.4	0.2	39
48	*Vepris*	*dainellii*	0.1	0.0	0.4	0.4	0.2	39
49	*Phoenix*	*reclinata*	0.1	0.0	0.4	0.4	0.2	39
	Total					283.7	100.0	