Introduction

Worldwide estimate of tropical deforestation range from 69 million ha in early1980 to 165 million ha $year^{-1}$ in the late 1980s (Skole and Tucker, 1993). In Africa this accounts for 2 million ha $year^{-1}$ (Kumar, 1997) while in Ethiopia it is estimated at the rate of 80,000-200,000 ha $year^{-1}$ (EPA, 1997). According to the latest data, the forest cover of Ethiopia is 3.6% (Woody Biomass Inventory Data, Unpublished). If the current destruction of forests continues at this rate, the remaining patches of natural forests may be reduced to scattered minor stands of heavily disturbed forests in inaccessible areas in near future

Deforestation poses a serious threat to the conservation of biodiversity in general and Forest genetic resources in particular. In Ethiopia, rural people look for land to grow crops and graze animals, use wood as a source of household energy, for construction and farm implements as a means of survival. In addition to the above reasons, fire, road construction and the investment activities are also the major reasons for the reduction of forests in Ethiopia. Poor people in poor country willingly or unwillingly damage the forests. The ultimate cause that has to be addressed for the forest destruction in Ethiopia is poverty. The rapidly growing population aggravates the cause, which by itself is triggered by poverty.

Sheko forest was selected for this study because of the following unique features (Anonymous 1986): (1) It forms part of the watershed between Baro and Abay catchments and their tributaries, (2) It plays a decisive role in arresting the expansion of desertification from southeast Sudan and northern Kenya through Maji valley to the central highlands of Ethiopia and (3) Being humid, Sheko forest inhabits species from Lowland semi deciduous forest and afromontane forests.

The objectives of this study were to:

1. Determine the floristic composition of indigenous woody species.
2. Study the structure of the forest.
3. Assess the regeneration status.

Study Area Description

Sheko Natural Forest is one of the southwest forests of Ethiopia located in South Nations, Nationalities and Peoples Region, Bench-Maji Zone, Sheko Woreda. It lies within 07^0 00'-07^0 30'N and $035^0$15' - $035^0$45'E, 705 km southwest of Addis Ababa.

According to the meteorological data from the National Meteorological Service Agency of Ethiopia, total annual rainfall ranges from 594.1 mm in January to 5988.4 mm in July, the average being 2300 mm. The annual temperature of this region was reported to range from 20-25 ^{0}C (Demel *et al*., 1998 unpublished data). Sheko Woreda is known to be humid and receives rainfall in all months of the year except between October and February (Demel *et al.,* 1998 unpublished data).

Sheko forest is said to be a transitional forest with respect to the lowland forest of Gambella and the highland forest of Kefa and Ilubbabor. It is similar in physiognomy and composition to the humid broad-leaved moist montane forests of southwest Ethiopia in general with the addition of some species from the low land semi-deciduous forests in Gambela region.

3. METHODOLOGY

3.1 Sampling Design

First hand information on the forest vegetation composition and possible variations in relation to different environmental parameters was gathered during a field survey, which was carried out in February 2000. Three transects were laid systematically and the distribution of transects were made in such a way that aspects of the forest area could be covered. Accordingly, one transect was laid to the east direction, the second transect to the northwest and the third one to the north direction. Forty-six 50m by 10m sampling plots were established at every 50m-altitudinal drop for established species. The same number but 2m by 10m sub- quadrates were established within the main quadrate for regeneration assessment.

3.2 Data Collection

3.2.1 Vegetation Data

In each sampling plot indigenous woody species were listed. Diameter and height for tree/shrub species with DBH > 2.5cm was measured. Lianas were registered as present. The growth habit of each woody species and their physiognomy was described. Within each quadrate the regeneration status was assessed by counting seedlings and saplings in

two 2m by 10m sub - quadrates ($40m^2$) laid on 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 the species follows Edwards *et al*. (1995) and Hedberg *et al.* (1989).

3.2.2. Socio-economic Data

Data on useful species was collected through pair-wise ranking. The major land use types and major disturbance types were also recorded.

4. RESULTS AND DISCUSSIONS

4.1 Land Use/Land Cover

The major land cover types in Sheko forest area were forest (natural and plantation), agriculture, pasture and settlement whereas the main land use types were logging (traditional), grazing of livestock, and clearance for agriculture and honey production. Logging was the major destructive force in the forest. *Cordia africana, Pouteria adolfi-friederici, Trichilia dregeana* and *Ficus vasta* were the preferred species. Agricultural encroachment was the second destructive force. There is clear cutting for cultivation of *coffea arabica* and other perennial and annual crops. In this way, each year certain areas of forests were converted into farmland. In connection to this peasant farmers frequently cut some tree/shrub species for purpose of farm implements. The preferred species were *Cordia africana*, *Olea capensis*, *Ehretia abyssinica*, *Celtis philippensis* and *Millettia ferruginea*. The ongoing destruction had a serious consequence due to irreversible loss of indigenous species and associated biodiversity.

4.2 Species richness

A total of 66 woody specimens were collected from Sheko Forest belonging to 50 genera and 25 families. The diverse genera were Ficus and Celtis, which were represented by four species each, Dracaena and Vernonia, (three species each.), Hippocratea, Albizia and Pouteria (two species each.). The remaining genera were represented by a single species. Diverse families include Moraceae, which is represented by 7 species of 4 genera and Euphorbiaceae represented by 5 species that belonged to 5 genera. This indicates high genetic diversity of the family in the locality. On the other hand, Ulmaceae is represented by 5 species but in this case all the species belonged to one genus implying less genetic diversity as compared to the former one. Celastraceae, Fabaceae, Rubiaceae and

Sapotaceae were represented by 4 species each. All the 4 species of Rubiaceae belonged to 4 genera; those of Fabaceae and Sapotaceae belonged to 3 genera. Dracaenaceae and Rutaceae were represented by 3 species each. Oleaceae, Sapindaceae, Meliaceae, Boraginaceae and Asteraceae were represented by 2 species. The remaining families were represented by a single species and a single genus. Since the floristic list included in the present study was only woody plants, conclusion regarding floristic composition was by no means definitive. Table 1 summarizes growth habit distribution of the encountered species.

Table 1. Habit distribution of woody species in the study area

S/No.	Growth Habit	Number of species	Percentage
1.	Tree	31	47.0
2.	Tree/Shrub	24	36.4
3.	Shrub	4	6.1
4	Lianas	7	10.6
	Sum	66	100

4.3 Structure

4.3.1 Species Dimensions

The maximum height attained in Sheko forest was 46m whereas the maximum DBH was 250cm. The species, which attained the maximum height, was *Olea capensis* whereas it was *Pouteria altissima,* which attained the maximum DBH. The mean height and the mean DBH of the former species were 16.86m and 44.7cm, respectively. Similarly the mean height and the mean DBH of the latter species were 19.73m and 31.72cm, respectively. Some species that attained maximum DBH and maximum height following *Pouteria altissima* and *Olea capensis* were *Ficus vasta, Ficus ovata, Manilkara butugi, Cordia africana, Millettia ferruginea, Celtis zenkeri, Blighia unijugata* and *Ficus vallis-choudae.*

4.3.2 Vertical Structure

According to Leibungut (1958) cited in Lamprecht (1989), three simplified vertical structures are distinguished in tropical montane forests: upper, middle and lower storey.

Accordingly, the forest vegetation of Sheko forest was classified into three strata. The upper layer includes those individual tree species whose height exceeds 30.6m while the middle stratum includes those in between 15.3 and 30.6m. The lower stratum comprises those below 15.3m. The result of the inventory indicated that the highest species density (87.4%) was found in the lower storey. There are many species, which couldn't attain the upper storey and the middle storey by their nature. Though most of the species under this category were shrubs, there are also tree species such as *Antiaris toxicaria* and *Chionanthus mildbraedii*. It is only 5.6% of the individuals, which were found in upper layer. All the species that have representatives in upper layer also appeared in the middle and lower strata. Species of this kind are termed "species with regular vertical distribution" (Lamprecht, 1989). A number of economically and ecologically important species such as *Cordia africana, Blighia unijugata, Cassipourea malosana, Celtis zenkeri, Celtis philippensis, Croton macrostachyus, Diospyros abyssinica, Ficus ovata, Ficus sur, Ficus vallis-choudae, Ficus vasta, Lecaniodiscus fraxinifolius, Manilkara butugi, Millettia ferruginea, Mimusops kummel, Olea capensis, Polyscias fulva, Pouteria adolfi-friederici, pouteria altissima and Trichilia dregeana* belongs to this group.

4.3.3 Frequency

No species belonged to frequency class A (81-100%). Three species, namely*: Cordia africana, Coffea arabica* and *Diospyros abyssinica* belonged to frequency class B (61-80%). Five species*, Manilkara butugi, Celtis zenkeri, Pouteria altissima, Alchornea laxiflora* and *Argomuellera macrophylla* belonged to frequency class C (41-60%). Some infrequent tree species were *Antiaris toxicaria, Celtis gomphophylla, Deinbollia kilimandscharica, Dombeya torrida* and *Lepidotrichilia volkensii.*

The frequency gives an approximate indication of the homogeneity of a stand. Studies pointed out that high values in higher frequency classes (Frequency classes A and B in this case) and low values in lower frequency classes indicate constant or similar species composition. High values in lower frequency classes and low values in higher frequency classes on the other hand indicate a high degree of floristic heterogeneity. In the present study high values were obtained in lower frequency classes whereas low values were obtained in higher frequency classes. Therefore, according to the above interpretation it is possible to conclude that there exists a high degree of floristic heterogeneity in Sheko Forest Area. The species that appear in the lower frequency classes have irregular occurrence whereas those appearing in higher classes have regular horizontal distribution.

4.3.4 Density

The total tree/shrub density of Sheko forest is 1304 per ha. Species were classified into 5 density classes, E to A; where species that belonged to class E have lower density while those in A have higher density and the intermediates were also assigned accordingly. Species that belonged to density class E were *Albizia gummifera*, *Antiaris toxicaria*, *Celtis gomphophylla*, *Dracaena steudneri*, *Lepidotrichilia volkensii*, *Margaritia discoidea*, *Vernonia amygdalina*, *Canthium oligocarpum*, *Deinbollia kilimandscharica*, *Dombeya torrida, Dracaena fragrans* and *Psychotria orophila.*

On the other hand abundant species in the forest are *Coffea arabica*, *Argomuellera macrophylla*, *Alchornea laxiflora*, *Manilkara butugi*, *Diospyros abyssinica*, *Rothmannia urcelliformis*, *Ehretia abyssinica*, *Lecaniodiscus fraxinifolius* and *Cordia africana.*

The density of tree/shrub species over 10cm DBH and over 20 cm DBH is 373 and 183, respectively and their ratio is about 2. Density of tree/shrub species over 10cm DBH greater than 600 is normal for virgin rain forest in Africa (Richard 1966, cited in Lamprecht, 1989). Density ratio of individuals >10cm DBH to that of individuals > 20cm DBH showed preponderance of small-sized individuals for some species whereas comparable distribution for others.

4.3.5 Diameter and Height Class Distribution

More than 60% of the individual tree/shrub species have fallen under DBH class 1 (2.6-7.5cm). By the same token about 75% of the individual tree/shrub species have height $\leq$ 10m. This might indicate that the rate of recruitment is high in the forest.

4.3.6 Basal Area and Dominance

Total basal area in Sheko forest is about $43m^2ha^{-1}$. The highest basal area was recorded for fewer large size individuals, especially DBH greater than 32.6cm. *Cordia africana* was the dominant species followed by *Manilkara butugi*, *Pouteria altissima*, *Ficus vasta*, *Olea capensis*, *Celtis zenkeri*, *Ficus vallis-choudae, Lecaniodiscus fraxinifolius*, *Mimusops kummel*, *Millettia ferruginea* and *Morus mesozygia*.

The highest contribution to their total basal area was by those individual trees that attain greater than 42.6cm DBH for many species. Some of the examples under this category were *Cordia africana*, *Manilkara butugi*, *Pouteria altissima*, *Ficus vasta*, *Olea capensis* and *Celtis zenkeri*.

The total basal area of Sheko forest was less than that of Jibat forest, which is $50m^2$/ha (Tamirat Bekele, 1994). It is high as compared to Menagesha and Chilimo forests, whose basal areas are $36m^2$/ha and $30m^2$/ha respectively (Tamirat Bekele, 1994). The normal value of basal area for virgin tropical rain forests in Africa is 23 to $37m^2\ ha^{-1}$ (Dawkins 1959, cited in Lamprecht, 1989).

Basal area provides a better measure of the relative importance of the species than simple stem count (Cain and Castro 1959, cited in Tamirat 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 Sheko forest were *Cordia africana, Manilkara butugi, Pouteria altissima, Ficus vasta, Olea capensis, Celtis zenkeri, Ficus vallis-choudae, Lecaniodiscus fraxinifolius, Mimusops kummel* and *Millettia ferruginea*.

High density and high frequency indicates regular horizontal distribution in the forest. *Cordia africana, Manilkara butugi, Pouteria altissima, Mimusops kummel, Lecaniodiscus fraxinifolius* and *Celtis zenkeri* were some of the species with such type of distribution. High density, low frequency and low dominance are typical for understorey species that occur in clusters. These species include *Coffea arabica*, *Argomuellera macrophylla* and *Alchornea laxiflora*. Some tree species with low density, low frequency and low dominance were *Deinbollia kilimandscharica*, *Dombeya torrida*, *Antiaris toxicaria*, *Lepidotrichilia volkensii*, *Margaritaria discoidea*, *Ficus sur*, *Albizia gummifera*, *Celtis gomphophylla* and *Trichilia dregeana.*

4.3.7 Importance Value Index

For the sake of setting priority using IVI analysis all woody species encountered in the forest were grouped into five IVI classes based on their total IVI values. Those species, which receive lower IVI value, were grouped into the fifth IVI class whereas those species with higher IVI value were put under the first IVI class. Those species, which were grouped in the fifth IVI class needs high conservation effort while those grouped in the first IVI class, need-monitoring management.

Based on the IVI output, the following species accorded the highest priority for conservation efforts: *Deinbollia kilimandscharica*, *Dracaena fragrans*, *Canthium oligocarpum*, *Psychotria orophila*, *Dombeya torrida*, *Antiaris toxicaria*, *Lepidotrichilia volkensii*, *Vernonia amygdalina*, *Dracaena steudneri*, *Margaritaria discoidea*, *Albizia gummifera*, *Celtis gomphophylla* and *Trichilia dregeana*

About 40.3% of the importance value is contributed by *Coffea arabica, Cordia africana, Manilkara butugi, Pouteria altissima* and *Argomuellera macrophylla*. These species were abundant, frequent and dominant in the forest. So they must accord less priority for conservation effort according to this criterion.

The importance value index is imperative 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). It is stated that species with the greatest importance value are the leading dominants of the forest. Accordingly, the ten leading dominants in Sheko forest were *Coffea arabica, Cordia africana, Manilkara butugi, Pouteria altissima, Argomuellera macrophylla, Alchornea laxiflora, Celtis zenkeri, Diospyros abyssinica, Lecaniodiscus fraxinifolius and Rothmannia urcelliformis*.

4.3.8 Species population Structure

A reversed J- shape population structure represented Sheko forest in general. Tamirat Bekele (1994) showed that the population structure of some dry montane forests of Ethiopia such as Chilimo, Menagesha, Wof-washa and humid forest (Jibat) also follows the same pattern. The analysis of density distribution among diameter classes of woody species in the forest resulted in different patterns. High densities in small diameter classes indicate a good regeneration capacity, while under representation of these classes indicates little regeneration capacity. An implication here is that the potential to replace such species will be very low once the matured individuals have disappeared. This means that the species is endangered and needs conservation. Population patterns indicating selective removal of individuals were detected for *Olea capensis*, *Blighia unijugata*, *Pouteria adolfi-friedrici*, *Croton macrostachyus*, *Albizia grandibracteata*, *Polyscias fulva*, *Morus mesozygia*, *Trilepisium madacascariense*, *Celtis zenkere* and *Manilkara butugi*. Some of these species show peaks at lower size classes followed by decline in the middle and then arise again 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 show that there is a selective removal of individuals of preferred size of these species. The local people carry out selective removal of these individuals for the purpose of construction, fuelwood, agricultural encroachment and logging. The other recognizable pattern indicates a good reproduction but discontinuous recruitment. Species with this pattern are *Celtis philippensis*, *Millettia ferruginea*, *Celtis africana*, *Ficus sur*, *Lepidotrichilia volkensii* and *Antiaris toxicaria*. The other recognized pattern was an inverted J shape. Species

exhibiting this normal diameter class distribution were *Diospyros abyssinica Lecaniodiscus fraxinifolius*, *Bersama abyssinica*, *Maesa lanceolata*, *Strychnos mitis*, *Ehretia abyssinica*, *Rothmannia urcelliformis* and *Coffea arabica*. Other groups of species were represented by abnormal patterns, e.g., *Sapium ellipticum* and *Albizia gummifera* were missing from the economically important classes. Some species showed under-representation of smaller size classes and overrepresentation of larger size classes. Examples include: *Cordia africana*, *Ficus vallis-choudae*, *Morus mesozygia*, *Malacantha alnifolia*, *Ficus ovata* and *Ficus vasta*

4.4 Regeneration Status: - **Species composition and density of seedlings & saplings**

A total of 33 species that belonged to 27 genera and 22 families, were represented in the seedling class. The total seedling density was 3962 per ha. The sapling class was composed of 36 species representing 33 genera and 27 families. The total sapling density was 3315 per ha.

Economically as well as ecologically important species such as *Antiaris toxicaria, Celtis gomphophylla, Celtis zenkeri, Dombeya torrida, Ficus ovata, Ficus vallis-choudae, Ficus vasta, Lepidotrichilia volkensii, Malacantha alnifolia, Margaritaria discoidea, Mimusops kummel, Morus mesozygia, Olea capensis and Sapium ellipticum* 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, this work strongly recommends further investigation to find out the actual reasons for the absence of regeneration.

5. CONCLUSIONS

Sheko forest area was diversified natural forest, which should be considered as one of the biodiversity conservation center in general and the forest genetic resources conservation in particular. The forest has floristic richness of about 66 woody species all belonging to 50 genera and 25 families. Furthermore, the forest is an important area as water catchments for the lower areas and the tributaries of Abay and Baro Rivers. Due to these facts the main strategy should consider the conservation of the existing woody vegetation. This helps to conserve the gene pool of the species under threat and maintain original plant community with large species diversity.

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