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FLORISTIC RICHNESS AND CONSERVATION STATUS OF BOGINDA FOREST, SOUTHWESTERN ETHIOPIA.

Getachew Berhan[1]

ABSTRACT: The main objective of this study was to assess the conservation status of Boginda forest and identify the endangered woody plant species for recommending appropriate genetic conservation approaches in the area. Systematic sampling was employed with a total of three parallel transects. A total of 29 sample quadrats were established and duly investigated. These sample quadrats were distributed within specified location fixed at regular intervals of 50m drop of altitude. The stand structure was enumerated in the 10x50m quadrats. All woody species were recorded and analysed. In setting the priority rank, the Important Value Index (IVI), population structure of species and regeneration status criteria were considered. Using these criteria, the woody species *Canthium oligocarpum, Cassipourea malosana, Ficus exasperate* and *Schefflera volkensi* were found to be the top priorities to be considered for conservation. Boginda forest was also found to be highly threatened by human pressure and needs attention for its conservation and sustainable utilization. From this research, an easy and manageable woody species prioritization and conservation approach is presented for threatened forests.

Key words/phrases: Boginda Forest; Density; Floristic; Frequency; Important Value Index.

INTRODUCTION

The conservation and sustainable utilization of endangered species has received the attention of scientists (Noss, 1983; Shackleton, 2000). This is due to the fact that in the geologic history of the earth, the present rate of species loss represented the sixth great extinction event (May *et al.*, 1995). The previous five extinctions were caused by natural processes, but the present fast rate of biological diversity loss is driven by anthropogenic activities (Chapin *et al.*, 2000). The increasing habitat change and degradation, mainly due to agricultural expansion and development, are the main causes of species diversity decline (Sala *et al.,* 2000). Dramatic increases in deforestation have produced numerous small and fragmented habitats especially in the tropics.

[1] School of Earth Science, Addis Ababa University, P.O.Box 1176, Addis Ababa, Ethiopia.
E-mail: getachewb2012@gmail.com /getachewb1@yahoo.com

Habitat fragmentation has a tremendous impact on the biodiversity of tropical forests with respect to species loss and, more recently, to a reduction of species diversity (Laurance and Bierregaard, 1997; White *et al.,* 2002). The impact of such habitat fragmentation on the genetic structure and gene flow within the fragmented landscapes is poorly understood. It is obvious that fragmentation decreases the size and increases the spatial isolation of populations, and its effect on the dynamics of gene flow can directly influence the genetic structure within a forest fragment (White *et al.*, 2002). Genetic isolation can cause a reduced gene flow among fragments and eventually has determinant consequences on the evolutionary variability of populations by way of increased levels of inbreeding and random genetic drifts (Young *et al.*, 1996; Wolf, 1999; White *et al.*, 2002). The montane forests in southwestern Ethiopia are facing such phenomena at present.

The Southwestern Montane Forests of Ethiopia are repositories and gene pools for several domesticated and/or wild plants and wild relatives of domesticated crops as well as wild animals and microbes. The few remaining high forests are, at present, threatened by pressure from investors who are converting these areas into other land use systems, such as coffee and tea plantations. A huge proportion of the Bonga and Masha-Anderacha forests have been cleared without any assessment of the economic and environmental contribution and significance to biodiversity in general and forestry in particular (Taye Bekele *et al.*, 2001). The role of investment in economic development is undeniable, but it should be done without harming the environment and should be accompanied by an appropriate environmental impact assessment before and after intervention.

Boginda Forest, one of the hotspots in southwestern part of Ethiopia, is penetrated by Diri-Masha road. The highest rate of deforestation of Boginda forest could lead to higher forest genetic erosion as in other parts of the country. The results obtained from the socio-economic survey of Consulting for Coffee Conservation (Anonymous, 1998) showed that the major causes of deforestation in Boginda forest are clearing/burning of the natural forest for cultivation of food crops, planting coffee, settlement, chasing of wild animals, pit-sowing, cutting of trees/shrubs for fuel wood, construction materials and cutting of big trees to harvest honey. The same report also confirmed that *Cordia africana* and *Pouteria adolfi-friederici* are in an endangered state as a result of heavy exploitation. This destructive exploitation of the forest has caused tremendous forest degradation leading to decrease and final extinction of the forest species. Taking these challenges into account, the main objective of the present study was to assess the conservation status of Boginda Forest and identify the endangered woody plant species for recommending appropriate genetic conservation approaches in the area.

MATERIALS AND METHODS

Study area

Boginda Forest covers some 7500 ha of natural high forest and is administratively located in Gimbo Woreda, Kafa-Shaka Zone in Southern Nations, Nationalities and Peoples Region. Medabo Kebele and Oromia Region border the area to the north while it is bordered by Gomma and Saja Kebeles to the south, respectively. Geographically, the forest is situated between 7^{0}29.000′ to 07^{0}33.400′N latitude and 36^{0}02.580′ to 36^{0}06.570′E Longitude.

Materials

The woody plant inventory of Boginda forest was carried out from December 26, 1999 – January 03, 2000. Geographic location of each quadrat was determined using Garmin GPS 48. The same instrument was also used to determine the position of the beginning of each quadrat. The altitude of each quadrat was recorded using an Alpin-El altimeter and the aspect (exposure) was measured by using a compass.

Methods

Systematic sampling was employed for this study. The optimum number of the transect lines, their spatial distribution and the total coverage was determined following a preliminary reconnaissance of the forest. A total of 3 parallel transects were selected. Each of these transect lines begin at the top of Saja escarpment that marks the highest altitude (2270m a.s.l.) as well as the southern boundary of the area and tend north to the bottom of Gojeb valley (1600m a.s.l.). The beginning and end points (the latitude and longitude) of the selected transects were marked using GPS as well as on the topomap of 1:50,000.

A total of 29 sample quadrats were established and duly investigated. These sample quadrats were distributed within specified location fixed at regular intervals of 50 m drop of altitude. The stand structure was enumerated in the 10x50 m quadrats along the direction of the transect.

Each woody plant within the quadrats was measured and plant specimens were collected for every woody species. Most woody species encountered in the quadrats were recorded using both scientific and local names, and whenever scientific names were not identified, the woody species were recorded using their local names.

The diameter and height of all tree and shrub species > 2.5cm in diameter were measured for the 10 x 50m quadrats. The type of ligneous plant was also defined using the following codes: S = Shrub, T = Tree and L = Liana. The DSH (diameter at stump height) (at a height of 0.3 m from the ground) and DBH (Diameter at breast height) (1.3 m from the ground) was measured over bark using a caliper. The DSH measurement was taken for shrub species and DBH measurement was done for tree species. The heights of all tree/shrub species were measured by Suunto clinometer and were estimated when it was difficult to measure. For Liana species, only their scientific and/or local names were recorded.

All seedlings and saplings were also enumerated by species from two (2 x 10m) sub-quadrats inside each quadrat. The sub-quadrats (2 x10m) were laid at the beginning and endpoints of the quadrats (i.e., 1m on each side of the base line of the 50 m) and for each quadrat $40m^2$ of sub quadrats were laid and the number of seedlings and saplings encountered were counted in these sub-quadrats.

Data analysis

The vegetation, physiographic and anthropogenic data analysis were performed by Access and Excel software. The structural analysis of the woody plants, basal area and dominance calculations were also performed by using this software. Accordingly, the density was calculated using equation 1 and the relative density using equation 2.

$$d = \frac{\sum t}{s_{ha}}$$ Equation 1

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

$$rd = \frac{\sum t}{ts}$$ Equation 2

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.

The frequency (equation 3), relative frequency (equation 4), basal area (Ba) (equation 5), dominance (equation 6) and relative dominance (equation 7) and importance value index (equation 8) were also calculated for each tree/shrub species with DBH/DSH >2.5cm.

$$f = \frac{nQ}{tQ} \times 100$$

Equation 3

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

$$rf = \frac{f}{\sum tf}$$

Equation 4

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

$$Ba = 22 \times \frac{d^2}{28}$$

Equation 5

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

$$Do = mBa \times d$$

Equation 6

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

$$rDo = \frac{mBa}{\sum mBat} \times 100$$

Equation 7

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

$$IVI = rd + rf + rDo$$

Equation 8

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 73 woody plant specimens were identified from Boginda Forest, of which 70 were within the sample plots and three were outside the sample plots. Out of 73 specimens encountered in this forest, 66 have been identified to the species level, four to the genus level and three have been left unidentified. The specimen identified belongs to 60 genera and 36 families.

The most diverse family of this forest was Rubiaceae followed by Euphorbiceae, Celasteraceae and Fabaceae (represented by six, five, four and four species respectively). About 47% of the families were represented by one species. The three species recorded using local names were "Chamo", "Dio" and "Tio". These three species were also found to be liana in their growth habit.

The Humid Montane Jibat Forest, which has close floristic similarity with the Moist Evergreen Montane forests of southwestern Ethiopia, has 53 tree and shrub species (Tamrat Bekele, 1994), and when these two forests were compared, Boginda Forest is said to be much richer than Jibat Forest.

The growth habit distribution of all the woody species recorded in Boginda Forest showed that 48% were trees, 23% were trees/shrubs, 12% were shrub, 14% were lianas and two species were encountered as regeneration. The species that were found as regeneration only were *Vangueria sp* and *Vernonia amygdalina.*

The upper canopy of this forest was dominated by *Pouteria adolfi-friedericii*, *Polyscias fulva*, *Prunus africana* and *Macaranga capensis*. The middle canopy is also dominated by *Croton macrostachyus*, *Ficus sur*, *Elaeodendron buchananii*, *Syzygium guineense*, *Trema orientalis*, *Apodytes dimidiata*, *Bersama abyssinica*, *Trilepsium madacascariense*, *Allophylus abyssinicus*, *Millettia ferruginea*, *Maesa lanceolata*, *Olea capensis*, *Pittosporum virdiflorum*, *Ilex mitis*, *Canthium oligocarpum*, *Albizia gummifera* and *Ehretia abyssinica*.

Some species such as *Albizia schimperiana, Blighia unijugata* and *Ocotea kenyensis* were reported to be dominating the upper canopy in the southwestern forests as a whole, and species such as *Erythrina brucei*, *Drcaena fragrans, Oxyanthus speciosus, Rithiea albersii, Phyllanthus limuensis,* and *Whitfieldia elongata* were found to be dominating in the middle, lower canopy and shrub stratum (Fris, 1992) were not encountered at all during this woody plant inventory survey. On the other hand four species namely, *Dalbergia lactea, Elaeodendron buchanani, Phyllanthus reticulates* and *Trilepsium madagascariensis* have never been reported to exist in southwestern forests as a whole. Therefore, Boginda forest may be the place where the marginal populations of these species exist and special attention should be given concerning these species.

The woody species recorded in this forest had also unequal abundance (here defined as the number of individuals of each tree/shrub species in 1.45 ha) and the forest area is dominated by few species (Fig. 1). *Millettia ferruginea*, which alone accounted for 301 (13%) of the total 2275 individuals), was 2.4 times more abundant than the fourth abundant species, *Vepris dainellii*. At the other extreme, there were 15 species with less than five individuals. The reasons for the unequal distribution of these species could be the exploitation of some species, which have potential for commercial or local use of the woody products. Moreover, some species may require special habitat for their regeneration and this may contribute to the different number of individuals of each species as well as the rare species, which are rare, which could be recent immigrants from population centers outside the forests (Tadesse Woldemariam, 1998).

Frequency

All the woody species encountered in Boginda forest were grouped into five frequency classes. These frequency classes are: woody species with frequency value of 81 – 100 = A, 61 – 80 = B, 41 – 60 = C, 21 – 40 = D and 0 – 20 = E (Fig. 2).

The frequency gives an approximate indication of the homogeneity or heterogeneity of a stand. Lamprecht (1989) pointed out that high values in frequency class A/B and low values in D/E indicated constant or similar species composition. On the other hand, higher values in lower frequency classes and lower values in higher frequency classes indicated a higher degree of floristic heterogeneity. In this regard, only 10% of the species recorded in Boginda forest were found in frequency class A/B and 79% of the species were found in frequency class D/E. Therefore, it is possible to say that Boginda forest has heterogeneous species composition.

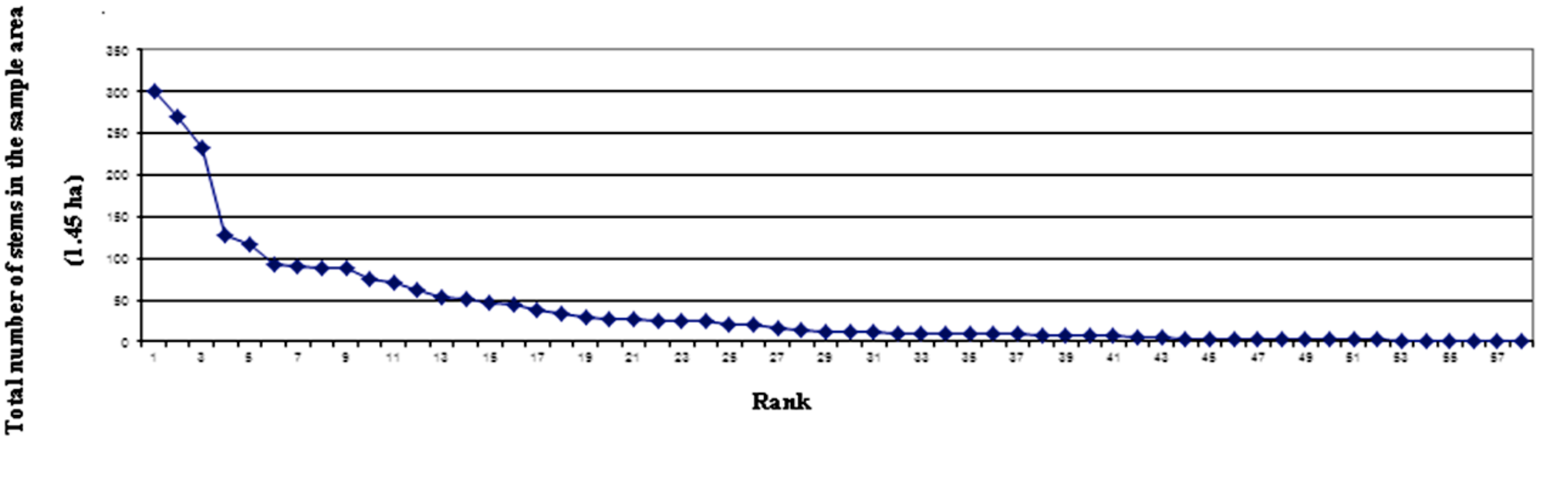

Fig. 1. Number of individuals against their rank (abundance curve) of the woody species recorded in all quadrats.

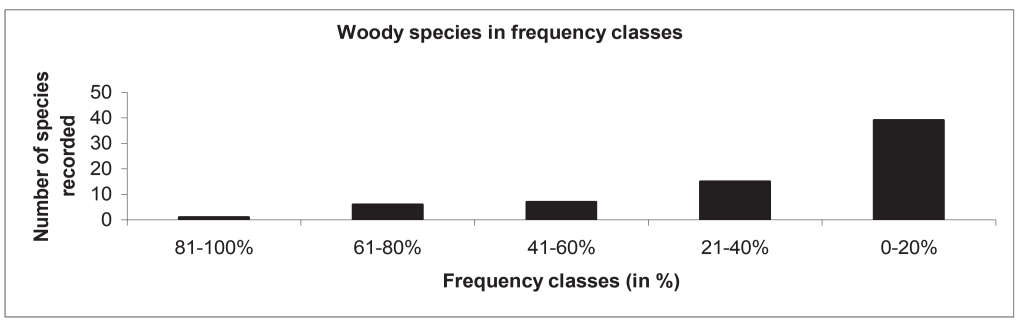

Fig. 2. Frequency class distribution of all species recorded in Boginda Forest.

The most frequent species in this forest were: *Millettia ferruginea, Chionanthus mildbraedii, Vepris dainellii, Bersama abyssinica* and *Galinera saxifraga* (with a frequency of 86.2, 79.3, 75.9, 75.9 and 72.4%, respectively). Apart from these, the following woody species were recorded in more than 50% of the assessed quadrats: *Dracaena afromontana, Dracaena steudneri, Croton macrostchyus, Psychotria orophila and Pouteria adolpfi-friedericii.* Interestingly, the most frequent tree species in this forest, *Millettia ferruginea*, was the least frequent and rarest species in Chaffey's (1982) reconnaissance survey of the southwestern forest as a whole. This indicates that Boginda Forest and its surroundings might be the natural territory of *Millettia ferruginea*.

The least frequent woody species of this forest were: *Cassipourea malosana*, *Acanthus sennii*, *Deinbolia kilimandscharica*, 'Tio', *Tiliacora funifera*, *Schefflera volkensii*, *Rubus apetalus*, *Rhamnus prinoides*, *Dalbergia lactea*, 'Dio', *Ficus exasperata*, *Euphorbia candelabrum* and *Euphorbia abyssinica* (with frequency value of 3.45%) and *Tiliacora troupinni*, *Phyllanthus reticulates*, *Phoenix reclinata*, *Jasmiium abyssinicum*, *Embelia schimperi*, *Dmbeya torrida*, 'Chamo', *Canthium oligocarpum* and *Albizia grandibracteata* (with frequency value of 6.9%). It is shown that 15% of the woody species had a relative frequency of 3 – 6%, 36% of them had 1 –3%, and 49% of them had a relative frequency of <1%.

Density

The total density of the woody species (with DBH/DSH >2.5cm) in Boginda forest was 1569 individuals (stems) per ha. Density of tree/shrub species over 10cm DBH >600 is normal for virgin rain forest in Africa (Richard, 1966, cited in Lamprecht, 1989). The density of all species with DBH/DSH over 10cm in Boginda forest was found to be 478.6. Therefore, the stems per ha coverage of Boginda Forest is below normal coverage and this may be due to serious exploitation in the past.

The density of all the species recorded were assessed and grouped into five density classes. These density classes are: woody species with stem numbers per ha of >100 = A, 50.1 – 100 = B, 10.1 – 50 = C, 1.1 – 10 = D and <1 = E. Only 5% of the species were represented with >100 stems per ha, while 54% had an average density of less than 10 stems per ha (Fig. 3).

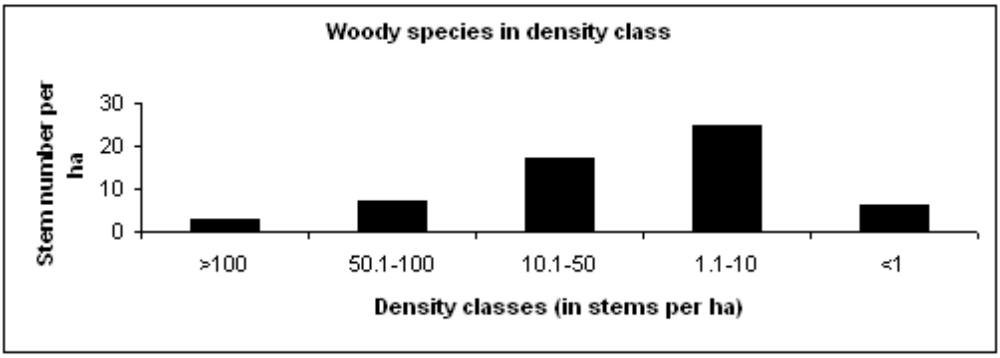

Fig. 3. All woody species in different density classes.

The woody species with <1 stem per ha were: *Cassipourea malosana, Dalbergia lactea, Euphorbia abyssinica, Euphorbia candelabrum, Hypericum sp.* and *Schefflera volkensii.* About 19% of the woody species in this forest had also a relative density of 3 –13%. These include *Millettia ferruginea, Dracaena afromontana, Chionanthus mildbraedii, Vepris dainellii, Bersama abyssinica, Galinera saxifraga, Macaranga capensis, Coffea arabica, Psychotria orophila, Dracaena steudneri* and *Clausena anisata.* About 59% of the woody species had a relative density of less than one. Some of the woody species with least relative density were: *Dalbergia lactea, Cassipourea malosana, Schefflera volkensii, Ficus exasperata, Albizia grandibracteata, Canthium oligocarpum, Dombeya torrida, Deinbolia kilimandscharica, Maytenus gracilipus, Appodytes dimidiata, Olea capensis* and *Cordia africana.*

Basal area and Dominance

The total basal area (m^2/ha) of all species with DBH/DSH >2.5cm of Boginda forest was 63.5. The normal value of basal area for virgin tropical rain forest in Africa is 23 – 37m^2 ha^{-1} (Dawkins, 1959, cited in Lamprecht, 1989). Therefore, it could be said that the basal area per ha coverage of Boginda Forest is very high.

Schefflera abyssinica accounted for the highest proportion of mean basal area in this forest, followed by *Pouteria adolfi-freidrcii, Prunus africana, Olea capensis, Polyscias fulva and Schefflera volkensii* (with mean basal area values of 0.94, 0.86, 0.50, 0.31, 0.27, and 0.11 m^2, respectively). The following woody species were found to be with smaller mean basal area: *Phyllanthus reticulates, Acanthus eminens, Justicia schimperiana, Maytenus gracilipes, Acanthus sennii, Rhamnus prinoides* and *Solanecio gigas* (with mean basal area value of <0.0016 m^2).

About 73% of the total basal area of Boginda Forest was contributed by the highest diameter class (>42.5 cm) and the remaining diameter classes have roughly a uniform distribution of basal areas (Fig. 4).

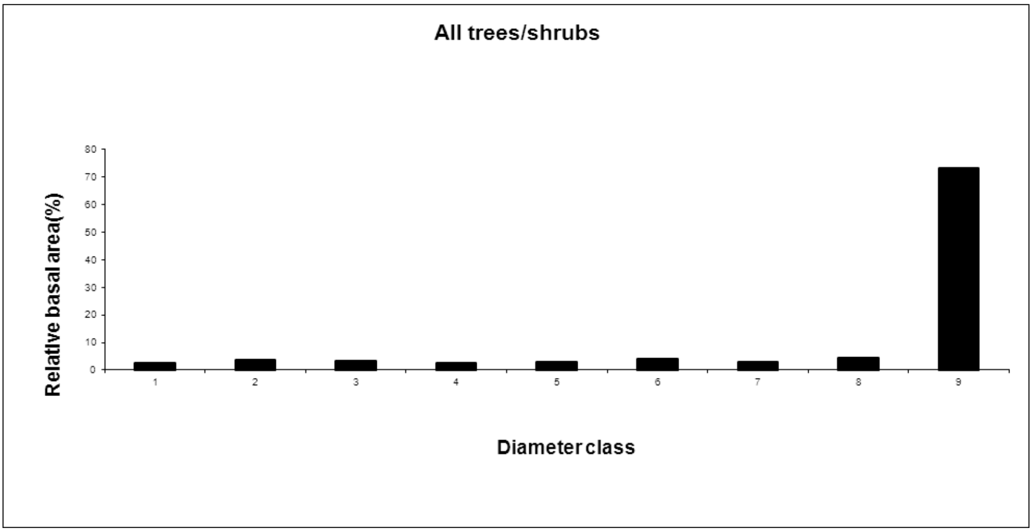

Fig. 4. Basal area distribution in diameter class of Boginda forest 1= 2.6 - 7.5; 2= 7.6 - 12.5; 3= 12.6 - 17.5; 4= 17.6 - 22.5; 5= 22.6 - 27.5; 6= 27.6 - 32.5; 7= 32.6 - 37.5; 8=37.6 - 42.5; 9= >42.5

Species dominance is the mean basal area per ha coverage of each individual woody species in the forest. About 89% of the dominance was accounted by 12 woody species of the forest. These include: *Pouteria adolfi-friedericii, Schefflera abyssinica, Millettia ferruginea, Prunus africana, Macaranga capensis, Syzygium guineense, Dracaena afromontana, Dracaena steudneri, Polyscias fulva*, *Croton macrostachyus, Olea capensis* and *Trilepsium madagascariense*.

The woody species with least dominance value in this forest were *Hypericum* sp., *Euphorbia abyssinica*, *Dalbergia lactea*, *Acanthus eminens*, *Acanthus sennii*, *Rhamnus prinoides*, *Maytenus gracilipes*, *Cassipourea malosana*, *Phyllanthus reticulates*, *Albizia grandibracteata*, *Justicia schimperiana* and *Dombeya torrida*.

Importance Value Index (IVI)

Importance Value Index (IVI) is useful to compare the ecological significance of species (Lamprecht, 1989). The Importance Value Index of all species with DBH/DSH >2.5 cm was calculated for all tree/shrub species. The most important tree/shrub species in Boginda forest were: *Pouteria adolfi-friederici, Millettia ferruginea, Dracaena afromontana, Chionathus mildbraedii, Schefflera abyssinica, Vepris dainellii, Macaranga capensis, Dracaena steudneri* and *Bersama abyssinica* (with IVI values of >10).

The most important woody species, *Pouteria adolfi-friedericii*, was 2 times more important than the second ranked species, *Millettia ferruginea*, and 2.5 times more important than the third important woody species *Dracaena afromontana.* It can be observed from Fig. 5 that *Pouteria adolfi-friederici* got the highest value of IVI due to its high relative dominance. Though the diameter distribution of this species was not normal, there were extremely huge trees in inaccessible areas of the forest.

In the prioritization of the species for genetic conservation, the woody species with higher IVI value will probably get less priority for conservation. In Boginda Forest, *Pouteria adolfi-friederici* is with the highest value of IVI, therefore, it gets less priority. In reality, it is one of the woody species that was poorly represented in diameter class distribution and it was also not totally encountered in sapling assessment. Therefore, the scoring matrix developed for the prioritization of the woody species should consider diameter class distribution and regeneration status of the species in question for genetic conservation.

Woody species with low IVI values in this forest included: *Euphorbia abyssinica*, *Hypericum* sp., *Dalbergia lactea*, *Cassipourea malosana*, *Euphorbia candelabrum*, *Acanthus sennii*, *Rhamnus prinoides*, *Schefflera volkensii*, *Deinbolia kilimandscharica*, *Ficus exasperata*, *Albizia gradibracteata*, *Phoenix reclinata*, *Dombeya torrida*, *Canthium oligocarpum*, *Phyllanthus reticulates*, and *Trema orientalis* (with priority rank of 1 – 16).

Boginda Forest is selected for coffee conservation in the country and highly known for its mother forest coffee spots. But this commercially known woody species got a priority rank of 45. Other woody species, which are highly known for their timber and log value such as *Pouteria adolfi-friedercii, Millettia ferruginea, Macarnga capensis, Syzygium guineense, Prunus africana, Olea capensis* and *Cordia africana* got a priority rank of 58, 57, 52, 48, 44, 39 and 24, respectively. The IVI class distribution showed that 58% of the woody species have an IVI value of 1.1 – 10, 28% between 0 – 1 and only 14% had an IVI value of >10 (Fig. 5).

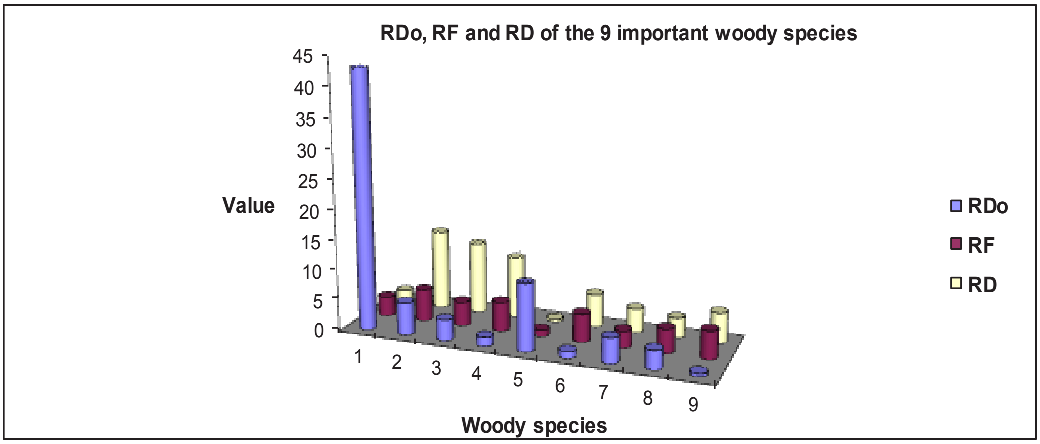

Fig. 5. Relative density (RD), Relative frequency (RF) and Relative dominance (Rdo) of the woody species with IVI value>10; 1: *Pouteria adolfi-friedrci,* 2: *Millettia ferruginea,* 3: *Dracaena afromontana,* 4: *Chionanthus mildbraedii,* 5: *Schefflera abyssinica,* 6: *Vepris dainellii,* 7: *Macaranga capensis,* 8: *Dracaena steudneri,* 9: *Bersama abyssinica.*

Population structures

The population structures of some selected woody species were analyzed. The first six are those with an IVI value of >11 and the rest are valuable timber species. The patterns of population structure of species that emerge can be interpreted as an indication of variation in population dynamics in the forest (Popma *et al.,* 1988 cited in Tamrat Bekele, 1994).

The analysis of population structures of the above 12 woody species resulted in the following three distinct types of structural patterns:

1. Woody species which had bad reproduction and bad recruitment;
2. Woody species which had good reproduction but bad recruitment;
3. Woody species which had good reproduction and good recruitment.

To analyze the conservation status of all woody species of this forest, the types of structural distribution patterns were used and all the woody species encountered were grouped as: Group 1 = Woody species which had bad reproduction and bad recruitment; Group 2 = Woody species which had good reproduction but bad recruitment; and Group 3 = Woody species which had good reproduction and good recruitment.

Accordingly, the following results were obtained from the analysis: about 24% of woody species of Boginda Forest in Group 1, 43% in Group 2 and 33% in Group 3. Based on the analysis of population structure of species, all species in Group 1 were with first priority; species in Group 2 were with second priority and those in Group 3 were with third priority for genetic conservation measures. The list of species under the three groups is given in Table 1.

Table 1. List of species under population structures.

No.	Group 1		No.	Group 2		No.	Group 3	
1	*Albizia*	*grandibracteata*	1	*Acanthus*	*eminens*	1	*Allophylus*	*abyssinicus*
2	*Albizia*	*gummifera*	2	*Acanthus*	*sennii*	2	*Clausena*	*anisata*
3	*Canthium*	*oligocarpum*	3	*Apodytes*	*dimidiata*	3	*Coffea*	*arabica*
4	*Cassipourea*	*malosana*	4	*Bersama*	*abyssinica*	4	*Croton*	*macrostachyus*
5	*Cordia*	*africana*	5	*Brucea*	*antidysenterica*	5	*Cyathea*	*manniana*
6	*Euphorbia*	*candelabrum*	6	*Chionanthus*	*mildbraedii*	6	*Deinbollia*	*kilimandscharica*
7	*Ficus*	*exasperata*	7	*Dalbergia*	*lactea*	7	*Dracaena*	*steudneri*
8	*Ficus*	*sur*	8	*Dombeya*	*torrida*	8	*Ehretia*	*abyssinica*
9	*Phoenix*	*reclinata*	9	*Dracaena*	*afromontana*	9	*Lepidotrichilia*	*volkensii*
10	*Polyscias*	*fulva*	10	*Euphorbia*	*abyssinica*	10	*Macaranga*	*capensis*
11	*Pouteria*	*adolfi-friederici*	11	*Galinera*	*saxifraga*	11	*Maytenus*	*sp*
12	*Prunus*	*africana*	12	*Hypericum*	*sp*	12	*Pittosporum*	*viridiflorum*
13	*Schefflera*	*abyssinica*	13	*Ilex*	*mitis*	13	*Psychotria*	*orophila*
14	*Schefflera*	*volkensii*	14	*Justicia*	*schimperiana*	14	*Rothmannia*	*urcelliformis*
			15	*Maesa*	*lanceolata*	15	*Rytigynia*	*neglecta*
			16	*Maytenus*	*gracilipes*	16	*Solanecio*	*gigas*
			17	*Millettia*	*ferruginea*	17	*Turraea*	*holstii*
			18	*Olea*	*capensis*	18	*Vepris*	*dainellii*
			19	*Phyllanthus*	*reticulatus*	19	*Vernonia*	*auriculifera*
			20	*Rhamnus*	*prinoides*			
			21	*Syzygium*	*guineense*			
			22	*Teclea*	*nobilis*			
			23	*Trema*	*orientalis*			
			24	*Trilepisium*	*madagascariense*			
			25	*Vernonia*	*amygdalina*			

Regeneration status of Bongida Forest

For the regeneration status, seedling (all species with height <=30cm and DBH <=2.5 cm) and saplings (all species with height >30 cm and <2 m and DBH <=2.5 cm) were assessed. A total of 27 woody species were recorded as seedlings in Boginda Forest, which belonged to 25 genera and 18 families. Only 40% of the woody species recorded as matured species were represented in the seedling count in the forest. A total of 45 species were recorded as saplings in this forest, which belonged to 41 genera and more than 23 families. Only 66% of the woody species recorded as matured species were represented in the sapling count in the forest.

To analyze the conservation status and for the sake of priority setting of all the species encountered in this forest, the species were classified into three groups based on total regeneration density. Those species, which were totally absent in the regeneration, were categorized under Group 1; others whose density was greater than zero but less than 50 were categorized under Group 2; and those with density greater than or equal to 50 were categorized under Group 3. Accordingly, those species in Group 1 are with first priority; those in Group 2 are with second priority; and those in Group 3 are with third priority for conservation. Table 2 presents the list of species under these three groups. From all tree/shrub species encountered in this forest, about 29% were found in Group 1, 29% in Group 2 and 42% in Group 3.

Table 2. List of species under regeneration status*.

No	Group 1	No	Group 2	No	Group 3
1	*Acanthus sennii*	1	*Ilex mitis*	1	*Croton macrostachyus*
2	*Canthium oligocarpum*	2	*Macaranga capensis*	2	*Maytenus addat*
3	*Cassipourea malosana*	3	*Solanecio gigas*	3	*Phoenix reclinata*
4	*Cordia africana*	4	*Trilepisium madagascariense*	4	*Apodytes dimidiata*
5	*Dalbergia lactea*	5	*Turraea holstii*	5	*Lepidotrichilia volkensi*
6	*Deinbolia kilimandscharica*	6	*Vangueria sp*	6	*Brucea antidysenterica*
7	*Dombeya torrida*	7	*Vernonia amygdalina*	7	*Phyllanthus reticulatus*
8	*Ehretiaa abyssinica*	8	*Olea capensis*	8	*Millettia ferruginea*
9	*Euphorbia abyssinica*	9	*Rytigynia neglecta*	9	*Allophylus abyssinicus*
10	*Ficus exasperata*	10	*Elaeodendron buchananii*	10	*Bersama abyssinica*
11	*Ficus sur*	11	*Albizia gummifera*	11	*Teclea nobilis*
12	*Hypericum sp*	12	*Maesa lanceolata*	12	*Pittosporum viridiflorum*
13	*Polyscias fulva*	13	*Syzygium guineense*	13	*Cyathea manniana*
14	*Prunus africana*	14	*Trema orientalis*	14	*Galinera saxifraga*
15	*Rhaminus prinoides*	15	*Vernonia auriculifera*	15	*Maytenus gracilipes*
16	*Schefflera abyssinica*	16	*Albizia grandibracteata*	16	*Vepris dainellii*
17	*Schefflera volkensii*	17	*Rothmannia urcelliformis*	17	*Pouteria adolfi-friederici*
				18	*Clausena anisata*
				19	*Acanthus eminens*
				20	*Justicia schimperiana*
				21	*Dracaena steudneri*
				22	Coffea arabica
				23	Chionanthus mildbraedii
				24	Psychotria orophila
				25	Dracaena afromontana

*NB: Liana species are not included in this list.

Species prioritization for conservation

In this study, woody species with lower IVI values were taken as threatened or rare species that needed conservation measures. Even though some species had higher IVI values, their population structure showed that these species had bad reproduction and bad recruitment. The population structures of all woody species were analyzed and classified into 3 groups (Table 1). The grouping was based on their reproduction and recruitment patterns. The woody species, which were found under Group 1 (the species which have bad reproduction and bad recruitment), are the first priority species to be considered for conservation. To analyze conservation status by regeneration status, all of the species were again classified into three groups based on total regeneration density (Table 2). Those species under Group 1 (the species which were absent in the regeneration assessment) were the first priority species to be considered for conservation.

Accordingly, the woody species in IVI Class C (i.e., those species which had IVI value of <1) were the priority species by IVI selection criteria. The woody species with IVI value <1 in the present forest were: *Euphorbia abyssinica, Hypericum sp., Dalbergia lactea, Cassipourea malosana, Euphorbia candelabrum, Acanthus sennii, Rhamnus prinoides, Schefflera volkensii, Deinbolia kilimandscharica, Ficus exasperata, Albizia gradibracteata, Phoenix reclinata, Dombeya torrida, Canthium oligocarpum, Phyllanthus reticulates* and *Trema orientalis* (with priority rank of 1 – 16).

The woody species which had bad reproduction and bad recruitment were: *Albizia grandibracteata, Albizia gummifera, Canthium oligocarpum, Cassipourea malosana, Cordia africana, Euphorbia candelabrum, Ficus exasperata, Ficus sur, Phoenix reclinata, Polyscias fulva, Pouteria adolfi-friederici, Prunus africana, Schefflera abyssinica* and *Schefflera volkensii.*

The species selected by regeneration status criteria were: *Acanthus sennii, Canthium oligocarpum, Cassipourea malosana, Cordia africana, Dalbergia lactea, Deinbolia kilimandscharica, Dombeya torrida, Ehretia abyssinica, Euphorbia abyssinica, Ficus exasperata, Ficus sur, Hypericum sp, Polyscias fulva, Prunus africana, Rhamnus prinoides, Schefflera abyssinica* and *Schefflera volkensi.*

In setting the priority rank, the IVI selection criteria, population structure criteria of species and regeneration status criteria were considered to have equal values. As observed from the list, the priority species selected by these analyses overlapped in that four species were found in all the three cases.

For further prioritization of these species, the three criteria for threat category selection were given equal weights, and all the species selected by the three criteria were again assessed for these criteria. Therefore, if a species was found in the specified criteria, the species got 1; if not, it got 0.

Then these values were added and the species were prioritized by the total values of the three scores that the species got. The priority species selected by the 3 criteria are presented in Table 3. Out of the 24 priority species selected, 17% were selected by three criteria, 63% by two of the criteria, and 20% were selected by one of the three criteria (Table 3).

Table 3. List of all the species selected by IVI, population structure and regeneration status criteria.

No	Species name	Selection criteria for threat status			Total score	Priority rank
		IVI	Population structure	Regeneration status		
1	*Canthium oligocarpum*	1	1	1	3	1
2	*Cassipourea malosana*	1	1	1	3	1
3	*Ficus exasperata*	1	1	1	3	1
4	*Schefflera volkensi*	1	1	1	3	1
5	*Acanthus sennii*	1	0	1	2	2
6	*Albizia gradibracteata*	1	1	0	2	2
7	*Cordia africana*	0	1	1	2	2
8	*Dalbergia lactea*	1	0	1	2	2
9	*Deinbolia kilimandscharica*	1	0	1	2	2
10	*Dombeya torrida*	1	0	1	2	2
11	*Euphorbia abyssinica*	1	0	1	2	2
12	*Euphorbia candelabrum*	1	1	0	2	2
13	*Ficus sur*	0	1	1	2	2
14	*Hypericum sp.*	1	0	1	2	2
15	*Phoenix reclinata*	1	1	0	2	2
16	*Polyscias fulva*	0	1	1	2	2
17	*Prunus africana*	0	1	1	2	2
18	*Rhamnus prinoides*	1	0	1	2	2
19	*Schefflera abyssinica*	0	1	1	2	2
20	*Albizia gummifera*	0	1	0	1	3
21	*Ehretia abyssinica*	0	0	1	1	3
22	*Phyllanthus reticulates*	1	0	0	1	3
23	*Pouteria adolfi-friederici*	0	1	0	1	3
24	*Trema orientalis*	1	0	0	1	3

CONCLUSION AND RECOMMENDATIONS

The objective of this study was to assess the conservation status of Boginda Forest and identify the endangered woody plant species for recommending appropriate genetic conservation approaches in the area. Accordingly, this forest was found to be threatened. About 73 woody species, which belonged to 60 genera and 36 families, were recorded. The stems per ha coverage of this forest was found to be below normal coverage of virgin rain forest in Africa.

Even though there is limited information on the ecological requirements and mating systems of the species, selection of conservation measures could be done on available knowledge and on an informed guess (Erikson, 1998 cited in Wolf, 1999). Therefore, for the conservation of these woody species in Boginda Forest, the following recommendations were made.

1. Carry out further study on the population and population distribution of the priority species selected for genetic conservation in the area;
2. Establish legal basis for the *in situ* and *ex situ* conservation sites for the conservation of the priority species.
3. Carry out further studies on the patterns of ecosystem functioning, biology and ecology of the key stone species to be able to restore the composition and structure of the forest.

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REFERENCES

Anonymous (1998). Study on status of forest coffee Resources, Coffee Improvement Program II, Addis Ababa, Ethiopia.

Chaffey, D.R. (1982). **A reconnaissance inventory of forest in Southwest Ethiopia**. Project Report 31, Land Resources Development Center, UK.

Chapin, F.S., Zavaleta, E.S., Eviner, V.T., Naylor, R.L., Vitousek, P.M., Reynolds, H.L., Hooper, D.U., Lavorel, S., Sala, O.E., Hobbie, S.E., Mack, M.C. and Diaz, S. (2000). Consequences of changing biodiversity. *Nature* **405**: 234–242.

Fris, I. (1992). Forests and forest trees of Northeast Tropical Africa. *Kew Bull. Add.* Ser.**15**:1-396.

Lamprecht, H. (1989). **Silviculture in the tropics - Tropical forest ecosystems and their tree species: Possibilities and methods for their long-term utilization.** T2-Verlagsgesells chaft mbH, postach 1164, D6101 RoBdort, Federal Republic of Germany.

Laurance, W.F. and Bierregaard, R.O. (1997). **Tropical forest remnants, ecology, management and conservation of fragmented communities.** Chicago, University of Chicago Press.

May, R.M., Lawton, J.H. and Stork, N.E. (1995). Assessing extinction rates. In: **Extinction rates**, pp. 1–24 (Lawton, J.H. and May, R.M, eds.). New York, Oxford University Press.

Noss, R.F. (1983). A regional landscape approach to maintain diversity. *BioScience* **33**: 700-706.

Sala, O.E., Chapin, F.S., Armesto, J.J., Berlow, R., Bloomfield, J., Dirzo, R., Huber-Sanwald, E., Huenneke, L.F., Jackson, R.B. Kinzig, A., Leemans, R., Lodge, D., Mooney, H.A. Oesterheld, M., Poff, N.L. Sykes, M.T. Walker, B.H., Walker, M. and Wall, D.H. (2000). Global biodiversity scenarios for the year 2100. *Science* **287**: 1770–1774.

Shackleton, C.M. (2000). Comparison of plant diversity in protected and communal lands in the Bushbuckridge lowveld savanna, South Africa. *Biol. Conserv.* **94**: 273-285.

Tadesse Woldemariam (1998). **Diversity of woody plants and Avifauna in a dry Afromontane Forest on the Central Plateau of Ethiopia**. Ethiopian MSc in Forestry Programme thesis work, Report No. 1998:37. Skinnskatteberg.

Tamrat Bekele (1994). **Studies on remnant Afromontane Forest on the Central Plateau of Shewa, Ethiopia.** Comprehensive summary of Upsala Dissertations from the Faculty of Sciences and Technology.

Taye Bekele, Getachew Berhan, Elias Taye, Matheos Ersado and Kumilachew Yeshitila (2001). Regeneration status of moist Montane forests. *Walia* **22**: 45-62.

White, G.M., Boshier, D.H. and Powell, W. (2002). Increased pollen flow counteracts fragmentation in a tropical dry forest: An example from Swietenia humilis Zucc. *Proc. Natl. Acad. Sci.* (USA) **99**: 2038-2042.

Wolf, H. (1999). Methods and strategies for the conservation of forest genetic resources. In: **Proceedings of Forest Genetic Resources Conservation: Principles, Strategies and Actions** (Sue Edwards, Abebe Demissie, Taye Bekele and Gunther Haas, eds.). Addis Ababa.

Young, A., Boyle, T. and Brown, A.H.D. (1996). The population genetic consequences of habitat fragmentation for plants. *Trends Ecol. Evol.* **11**: 413-418.