SINET: *Ethiop. J. Sci.*, 30(1):1–12, 2007

ISSN: 0379-2897

FLORISTICS AND PHYTOGEOGRAPHIC SYNOPSIS OF A DRY AFROMONTANE CONIFEROUS FOREST IN THE BALE MOUNTAINS (ETHIOPIA): IMPLICATIONS TO BIODIVERSITY CONSERVATION

Kitessa Hundera [1], Tamrat Bekele [2,*] and Ensermu Kelbessa [3]

[1] Jimma University, PO Box 378, Jimma, Ethiopia, E-mail: hkitessa@hotmail.com
[2] Department of Biology, Addis Ababa University, PO Box 3434, Addis Ababa, Ethiopia, E-mail: tambek@bio.aau.edu.et
[3] The National Herbarium, Addis Ababa University, PO Box 3434, Addis Ababa, Ethiopia, E-mail: nat.heb@ethionet.et

ABSTRACT: Only very few patches of scattered dry Afromontane coniferous forests remain in Ethiopia today. Most of these are secondary forests that have been severely exploited in the past for their timber. Dodola forest, one of the few forest patches that have survived extensive forest exploitation in the country, is considered to be unique in Ethiopia in that it is in an advanced stage of primary development. The prominence of *Juniperus procera*, once the dominant species of the dry Afromontane forests, makes this forest an interesting site for future conservation and management of Afromontane floristic elements in the country. Analyses of the floristic composition and structure, as well as floristic comparison with other Afromontane forests in the country, were made in the present study. Data on species composition, cover-abundance values, height and diameter at breast height (DBH) were collected from standard plots. A total of 113 species belonging to 95 genera and 55 families were identified. Six plant associations were recognized using the computer program TWINSPAN, and were recognized as community types. Phytogeographically, Dodola forest was found to be more related to the dry Afromontane forests of the Central Plateau of Ethiopia, which are geographically far apart, than to the nearby Afromontane forests of Harenna and those of SW Ethiopia. Considering the significance of Dodola forest, recommendation is made to the effect that a portion of Dodola forest be blocked as a nature reserve for its biodiversity value.

Key words/phrases: Dodola, nature reserve, phytogeography, plant community

INTRODUCTION

The extent of past forest cover on the Ethiopian highlands is evident from the numerous isolated mature forest trees or small patches of forests or woodlands that make conspicuous landmarks on the plateau. Large areas with evergreen bush land, or farmland mixed with bush land represent formerly forested areas (Friis, 1992). The original forest cover of Ethiopia is not well documented, and estimates are not consistent. Decline in forest cover from the original 35% to 16% in 1952, 3.6% by 1980, 2.6% by 1987, and an estimated 2.4% in 1992 has been made by Sayer *et al.* (1992).

The Ethiopian plateau has been long settled with human population, representing an area with a very long history of agriculture. Clearance of natural vegetation to meet the demands of an ever-increasing human population has been an ongoing process for as long as permanent settlements existed, and is still going on today.

Ecological and environmental problems such as soil degradation, soil erosion and alteration of natural ecosystems, as well as the loss of potential natural resources are just some of the negative effects resulting from the destruction of these habitats. Indigenous knowledge on medicinal and other useful plants is eroded with the destruction of these forests too (Fichtmuller, 1997).

In order to maintain the ecological equilibrium, and meet the demand for forest resources, there is a need for informed decisions to be made at all levels. Without a full assessment of the properties of the various sites in a forest and their relation to vegetation growth, the management of the forest will be severely handicapped.

The forest of Dodola has been identified as a National Forest Priority Area (NFPA) (EFAP, 1994), and represents one of the rare surviving examples

*Author to whom correspondence should be addressed.

of dry Afromontane coniferous forests (Fichtmuller, 1997) in the country. Its current management system, however, deserves a close scrutiny.

The present study was carried out with the main objective of providing baseline information on the forest, and the following specific objectives in mind:

a) To study the floristic composition of the forest,
b) To identify plant associations in the forest vegetation,
c) To make a structural analysis of the major woody species in the forest, and
d) To compare the floristic composition of the forest with that of other forests in the country.

MATERIALS AND METHODS

Description of the study area

The Dodola forest is situated on the northern slope of the Bale Mountains at altitudes between 2500–3500 m above sea level. The study area lies between latitudes 6°50′ N and 7°10′ N, and longitudes 39°05′ E and 39°16′ E, in the Dodola district, Bale Zone, Oromia Regional State, Ethiopia.

The study area is characterized by two topographic landscape units or physiographic features. The northern half is a plain, with an average elevation of about 2400 m above sea level, which has been converted to agricultural land. The southern half is mountainous, with a maximum elevation of ca. 4300 m above sea level. Forest vegetation covers the mountains up to altitudes of 3300 m above sea level. Several perennial watercourses originate from the mountains and flow northwards, into the Wabe-Shebele River, and to the south, into the Genale River basin.

The Bale Mountains appear to be of volcanic origin resulting from the Oligocene eruptions of the trappean lava, which cover the Mesozoic strata (Mohr, 1963). The volcanic succession in Bale has been sub-divided into four major groups, and the Dodola area belongs to the Dodola ignimbrites and Aroresa trachytes. These groups of rocks consist of rhyolitic ignimbrites, trachytes and ash flow tuffs, with fluvio-lacustrine intercalations within the ignimbrites (Asfawossen Asrat *et al.*, 1997).

The soil of the Dodola area is of volcanic origin, mainly from alkali basalt and tuffs, and generally well structured silt or clay of more than one meter deep on gentle slopes, in valleys and depressions, but shallow on steep slopes and top ridges where rock out-crops are observed (Asfawossen Asrat *et al.*, 1997).

According to Hillman (1986), the climate of the Bale Mountains has a four-month dry season, (November-February) with low rainfall, low temperature, and low humidity, and an eight-month wet season (March-October) with high rainfall, high humidity, and higher night and lower day temperatures during the wet season than the dry season. Local variations in climate could, however, exist over the area largely as a result of topographic variability.

A reconnaissance survey and data collection trip was made to the study area between December 6, 2002 and January 20, 2003. Three sampling sites were selected at altitudinal ranges between 2650 and 3250 m above sea level. At each site, two transects, 500 m apart, were laid. At every 50 m altitudinal gradient along these transects, a total of 62 sampling plots (10 m x 50 m) were established for the description of trees and shrubs. For the herbaceous layer a 2 m x 2 m subplot was established within the main sampling plot.

Vegetation data collection and plant identification

All plant species in each quadrat were recorded, and voucher specimens taken to the National Herbarium (ETH), Addis Ababa University, for identification. Nomenclature followed Edwards *et al.* (1995; 1997; 2000) and Hedberg and Edwards (1995).

Trees and shrubs with DBH>2 cm were measured for height and diameter at breast height (DBH). Percentage cover was estimated for each species within the sample plot. These were later used for the estimations of cover/abundance values following the 1-9 Braun-Blanquet scale as modified by van der Maarel (1979).

Data analysis

The vegetation data was analyzed by using the TWINSPAN program (Hill, 1994). Synoptic values, calculated as the product of average cover/abundance value and frequency in the community, were employed in constructing a summary table for the detection of community types in the natural forest vegetation.

Floristic similarity between forests was computed with the use of Sorensen's similarity coefficient as follows: 2C/(A+B), where 'C' is number of species shared by the two forests; 'A' is number of species in one of the forests; and 'B' is number of species in the other forest.

Density of a species was estimated by converting total counts of individuals in all quadrats into number per hectare. DBH measurements were divided into 10 classes, and the percentage distribution of individuals in these classes was computed for each species. Tree heights were grouped into 6 classes, and the percentage distribution of individuals in each class was computed for each species.

Estimations of basal area, relative density, relative frequency, relative dominance and importance value index were calculated following Mueller-Dombois and Ellenberg (1974).

The pattern of woody species richness along altitudinal gradient was analyzed by using the regression equation:

$$\text{Number of species} = 74.18 + (-0.02)^{*} \text{ altitude}$$

RESULTS AND DISCUSSION

Floristic composition

A total of 113 species belonging to 95 genera and 55 families were identified. Out of these, 60 species (48%) are trees and shrubs, and 64 species (52%) are herbs and grasses. Forty-nine families (89.1 %) are dicots, while 4 families (7.3%) are monocots and 2 families (3.6%) are gymnosperms. One hundred and one species (88.6%) are dicots, while 11 species (9.6%) are monocots, and 2 species (1.75%) are gymnosperms. Asteraceae is the largest family, represented with 16 species, followed by Rosaceae with 8 species. A complete list of scientific names, family and habit of the species are provided in Appendix 1. Vernacular names in Oromiffa are included for those having one.

Plant community analysis

Six clusters of plant associations could be recognized from the TWINSPAN output, and these were identified as plant community types and given names after one or two dominant and/or characteristic species (Table 1). The descriptions of these community types are given as follows:

I) Olinia rochetiana-Olea europaea community type

The altitudinal range of this community type is between 2750 and 2850 m, and the upper canopy is dominated by *Juniperus procera* and *Podocarpus falcatus*. The broad-leaved species *Nuxia congesta, Olea europaea, Ekebergia capensis, Olinia rochetiana,* and shrubs such as *Myrsine africana* and *Conyza spinosa* are very common in this community type. The herbaceous layer consists of species of *Kalanchoe petitiana, Stachys alpina, Haplocarpha ruepellii, Crepis ruepellii* and *Plecranthus punctatus.*

Table 1. Synoptic phytosociological table of species reaching a value of > 0.8 in at least one community type.

Type	I	II	III	IV	V	VI
Cluster size	11	11	9	11	17	2
Olinia rochetiana	**2.0**	0	0	0	0	0
Olea europaea subsp. cuspid.	**1.2**	0	0	0	0	0
Osyris quadripartita	1.4	0	0	0	0	0
Ekebergia capensis	1.0	0	0	0	0	0
Maytenus addat	3.5	**5.3**	0	0	0	0
Podocarpus falcatus	5.9	**4.5**	0	0	0	0
Dovyalis abyssinica	1.5	2.0	0	0	0	0
Plectranthus punctatus	1.4	0.6	0	0	0	0
Swertia kilimandschari	0.2	2.8	0.3	0	0	0
Isoglosa somalensis	0.8	0.2	0.8	0	0	0
Myrsine africana	**3.4**	0	**3.3**	0.9	0	0
Rosa abyssinica	1.0	1.9	**2.9**	0	0	0
Nuxia congesta	2.0	0.5	0.9	0	0	0
Kalanchoe petitiana	1.6	2.0	1.1	1.3	0	0
Galiniera saxifraga	0.6	1.9	0.8	1.3	0	0
Jasminium abyssinicum	0.7	0.5	0.2	2.0	0	0
Conyza hypoleuca	2.4	0	0.5	1.0	0	0
Thymus schimperii	0	0	2.4	1.0	0	0
Hypoestes triflora	0	0	0.6	0.8	0.4	0
Mikaniopsis clematoides	1.6	2.2	1.2	1.4	0.4	0
Salvia nilotica	0.8	1.9	1.0	1.5	1.3	0
Crepis ruepellii	1.0	0	1.2	2.9	2.1	0
Juniperus procera	8	8	8	7.7	7.0	0
Myrsine melanophloeos	3.0	4.8	4.0	5.0	5.0	3.5
Rubus steudneri	2.5	2.6	4.0	3.8	3.7	2.0
Haplocarpha ruepellii	1.0	0	2.1	3.9	3.5	3.0
Trifolium simense	0	0	1.3	0.4	2.0	3.0
Kniphofia foliosa	0	0	0	1.1	2.0	2.0
Hagenia abyssinica	0	0	0	**4.5**	**4.2**	0
Hypericum revolutum	0	0	0	2.0	**3.8**	5.0
Erica arborea	0	0	0	0	**2.7**	**9.0**
Schefflera volkensii	0	0	0	0	0.1	**3.5**
Pittosporum viridiflorum	0	0	0	0	0.3	**4.5**

Note: The values of the species used in the naming of community types are indicated in bold.

II) Podocarpus falcatus-Maytenus addat community type

This community type occurs at altitudes between 2650 and 2750 m, and the upper canopy is dominated by *Juniperus procera* and *Podocarpus falcatus* with *Maytenus addat* as a frequent admixture tree species in the type. The under storey consists of *Galiniera saxifraga, Myrsine melanophloeos, Dovyalis abyssinica* and *Nuxia congesta.* Stranglers like *Rubus steudneri, Mikaniopsis clematoides* and *Rosa abyssinica* are common. The herbaceous layer consists of *Salvia nilotica, Swertia* *kilimandischarii, Carduus chamaecephalus* and *Plecranthus punctatus.*

III) Myrsine africana–Rosa abyssinica community type

This community type lies in altitudinal range between 2700 and 2950 m and the canopy is dominated by *Juniperus procera. Myrsine africana* and *Rosa abyssinica* are very frequent in the under storey. *Mikaniopsis clematoides, Galiniera saxifraga, Nuxia congesta* are the other common species in this community type. The herbaceous layer includes *Swertia kilimandischarii, Thymus schimperii, Carduus chamaecephalus, C. nyassanus Stachys alpina, Trifolium burcheliana, T. simense* and *Cynoglossum coeruleum.*

IV) Hagenia abyssinica-Hypericum revolutum community type

This community type occurs between altitudes of 2850 m. and 3100 m. The canopy is dominated by *Juniperus procera. Hagenia abyssinica* and *Hypericum revolutum* are conspicuous species in this community type. *Myrsine melanophleos* is very frequent but *Erica arborea* is sporadic. Next in the canopy are *Galiniera saxifraga, Dombeya torrida, Ilex mitis* and *Schefflera volkensii.* The under storey shrubs include *Myrsine africana, Rosa abyssinica* and *Rubus steudnerii.* The herbaceous layer consists of *Alchemilla abyssinica, Asparagus africanus, Cynoglosum coeruleum, Euphorbia schimperii, Satureja paradoxa, Hydrocotyle mannii, Kalanchoe petitiana, Haplocarpha ruepellii, Crepis ruepellii* and *Alchemilla fischerii.*

V) Erica arborea-Hagenia abyssinica-Hypericum revolutum community type

This community lies in altitudes between 2950 to 3200 m and is dominated by *Juniperus procera* and *Erica arborea,* with *Hagenia abyssinica and Hypericum revolutum* as admixture in the canopy. *Myrsine melanophloeos, Pittosporum viridiflorum* and Schefflera *volkensii* are also the common tree species in the community. The herbaceous layer consists of *Trifolium simense, T. burchelianum, Sebea brachyphyla, Crepis ruepellii, Haplocarpha ruepellii, Hydrocotyle mannii, Kalanchoe petitiana* and *Kniphofia foliosa.*

VI) Erica arborea-Pittosporum viridiflorum-Schefflera volkensii community type

This community type is found at altitudes above 3250 m and is dominated by *Erica arborea.* Other tree species such as *Hypericum revolutum, Myrsine melanophloeos, Pittosporum viridiflorum,* and *Schefflera volkensiii* occur as admixture species towards the lower limits of the distribution of the community. The herb layer consists of *Alchemilla fischerii, Clematis simensis, Haplocarpha ruepellii, Satureja punctata, S. paradoxa, Kniphofia foliosa* and *Trifolium simense.*

Analysis of vegetation structure

Density

The total density for trees and shrubs is 761 /ha and 532/ha for individuals with DBH greater than 2 cm and greater than 10 cm respectively. A considerable proportion of the density is attributed to the species *Juniperus procera,* which contributed 34.4% for individuals > 2 cm and 39% for individuals > 10 cm. The following seven tree species contributed, in total, to about 82.6% and 85.3% to the density of the respective groups: *Juniperus procera, Podocarpus falcatus, Hagenia abyssinica, Maytenus addat, Hypericum revolutum, Erica arborea,* and *Myrsine melanophloeos.*

Compared with other dry Afromontane forests in Ethiopia, Dodola forest has a lower density than Chilimo and Hugumburda-Gratkassu forests, but a higher density than that of Menagesha and Wof-Washa forests for individuals with DBH > 10 cm. However, for individuals in the diameter class >20 cm, the density of Dodola forest is greater than all the other forests.

The ratio of the density of individuals greater than 10 cm to those greater than 20 cm is taken as a measure of the distribution of the size classes (Grub *et al.*, 1963). This ratio is 1.5 for the Dodola forest, indicating only slight variability between the proportion of small-sized and large-sized individuals.

Comparison of this ratio with that of other Afromontane forests reveals a similar trend between Dodola forest and Wof-Washa forest, but a strong variability with those of Menagesha, Hugumburda-Gratkassu, Denkoro and Chilimo forests, which have large number of small-sized individuals (Table 2).

The forests of Chilimo, Hugumburda-Gratkassu, Denkoro and Menagesha have been severely exploited for their timber, and at present, represent forests in secondary state of development. The forests of Dodola and Wof-Washa have a different land use history compared to the rest. The kind of large-scale timber exploitation, which was historically the case in the others, did not take place in the forests of Dodola and Wof-Washa. The predominance of very large sized individuals over smaller ones, and the absence of large-scale human exploitation suggest that the forests are in an advanced state of primary forest development.

Table 2. Comparison of tree density ratio of Dodola forest with other Afromontane forests in Ethiopia.

Forests	A	B	C
Dodola	521	351	1.5
Chilimo[a]	638	250	2.6
Menagesha[a]	484	208	2.3
Wof-washa[a]	329	215	1.5
Hugumburda-Gratkassu[b]	938	286	3.28
Denkoro[c]	526	285	1.84

Note: A=individuals with DBH > 10 cm, and B = individuals with DBH > 20 cm, and C = A:B.
Source: [a] Tamrat Bekele (1993), [b] Leul Kidane (2003), [c] Abate Ayalew (2003)

Diameter at breast height

The DBH class distribution of all woody species is given in Fig. 1. The general pattern that emerges is an inverted 'J' shape with a slight depression in the 11-30 cm class, indicating selective harvesting of individuals in that particular size class.

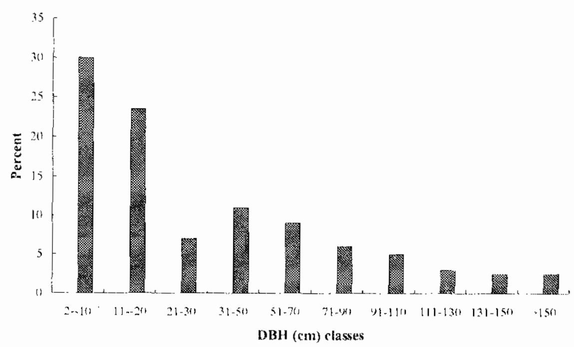

Fig. 1. Percentage DBH class distribution of trees and shrubs in the Dodola forest.

Of all the individuals sampled in Dodola forest, 4% that attained DBH's greater than 130 cm belonged to the species of *Juniperus procera, Podocarpus falcatus,* and *Hagenia abyssinica.* Individuals of *Juniperus procera* and *Podocarpus falcatus* that attained a DBH of 229 cm and 210 cm respectively had been encountered in this forest.

Height

The height class distribution of trees and shrubs (Figure 2) indicates that more than 42% of the individuals fall in the height class between 2-5 m. Only a small proportion, i.e. about 26 %, reached heights up to and greater than 15 m. In fact, *Juniperus procera, Podocarpus falcatus* and *Hagenia abyssinica* are the only species that were represented by individuals exceeding heights of 20 m and forming the upper canopy of the forest. The species *Maytenus addat, Olea europaea* subsp. *cuspidata,* and *Myrsine melanophloeos* have been represented with individuals that reached heights of 20 m.

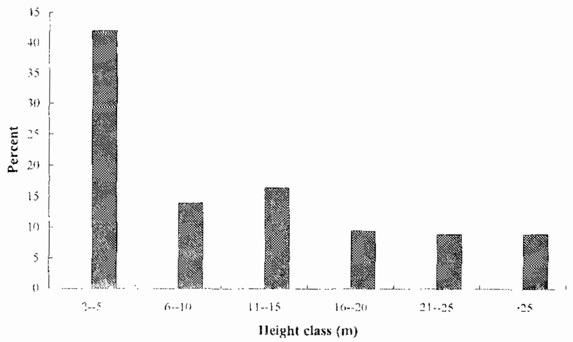

Fig. 2. Percentage height class distribution of trees in the Dodola forest.

Total basal area for the forest is 129 m^2/ ha, and this constitutes only 1.29% of the total ground area. A comparative contribution of the different DBH classes to the total basal area is presented in Table 3. It is evident from the Table that, even though more than 50% of all individuals have DBH less than 20 cm, the percentage contribution of this class to the total basal area is only 2.2%. Conversely, individuals in the DBH classes greater than 90 cm have a density of about 12% of the total, but they contribute to about 59.7% of the total basal area computed for the forest. Thus, the ecological significance of large sized individuals in this forest cannot be undermined.

Table 3. Comparison of the contribution of DBH classes to the density and total basal area of the forest.

DBH class (cm)	Density (No./ha)	%	Basal area (m^2/ha)	%
2-10	229	30	0.48	0.4
11-20	181	24	2.38	1.8
21-30	57	7.5	2.87	2.2
31-50	88	11.5	11.03	8.5
51-70	67	8.8	15.8	12.2
71-90	47	6.2	19.33	15
90-110	43	5.6	28.5	22
>110	49	6.4	48.6	37.7

A significant share of the total basal area in the Dodola forest (*i.e.*, about 97%) is accounted for by six tree species: *Juniperus procera, Podocarpus falcatus, Hagenis abyssinica, Maytenus addat, Erica arborea,* and *Hypericum revolutum*. Out of these, *Juniperus procera* and *Podocarpus falcatus* contribute 68% (88 m^2/ha), and 13.7% (17.7 m^2/ha), respectively.

The basal area of this forest (*i.e.*, 129 m^2/ ha) is in sharp contrast with that of the forests of Chilimo (30.1 m^2/ha) and Menagesha (36.1 m^2/ha). However, the basal area of Wof-Washa forest (101.8 m^2/ha) resembles that of the Dodola forest. These differences, as pointed out earlier, are due to the fact that the former two forests have been under heavy exploitation for their timber. On the other hand, Wof-Washa forest, just like Dodola forest, had been free from such abuse, and therefore, still contains very old and large individuals.

Frequency and importance value index

Results of frequency computations and estimations of importance value indices reveal *Juniperus procera* to be the most frequent (95%) and most dominant species, followed by *Myrsine melanophloeos, Podocarpus falcatus,* and *Hagenia abyssinica*.

Population structure

The population structure of individual species in the forest falls into one of four general patterns. These patterns are illustrated by that of the four dominant species that have been selected in terms of their importance value indices (Fig. 3a-d).

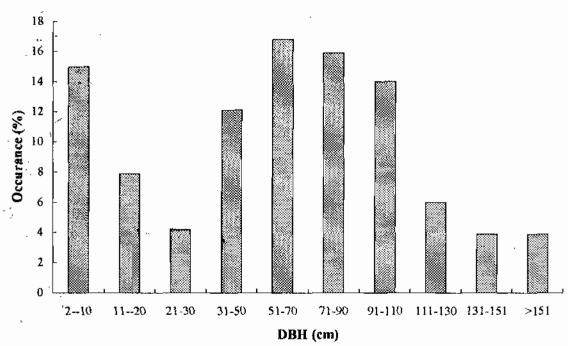

Fig. 3a. Population structure of *Juniperus procera* in Dodola forest.

Juniperus procera (Fig. 3a) shows good reproduction and recruitment. Individuals within DBH classes between 11 and 50 cm, especially 21–30, are poorly represented. This is due to the selective cutting of individuals in these size classes for different construction purposes. The density of this species in the intermediate classes is high, and then declines at the upper limit of the DBH range.

A typical inverted 'J' shape curve is shown by *Myrsine melanophloeos,* indicating a good reproduction (Fig. 3b). *Myrsine melanophloeos* is a gap colonizer, becoming more common in areas where gaps are created by the fall of big trees.

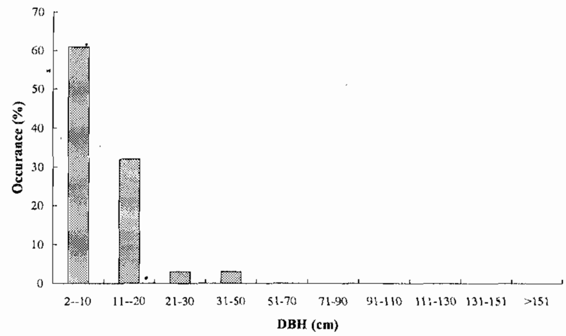

Fig. 3b. Population structure of *Myrsine melanophloeos* in Dodola forest.

Podocarpus falcatus shows good regeneration (Fig. 3c). The distribution of individuals in the remaining classes is poorly represented. This indicates that there is an indiscriminate exploitation of large individuals of this species. Species with such a pattern could become endangered in the future, because individuals are being harvested before reaching reproductive ages, and this could result in the future decline of the species population.

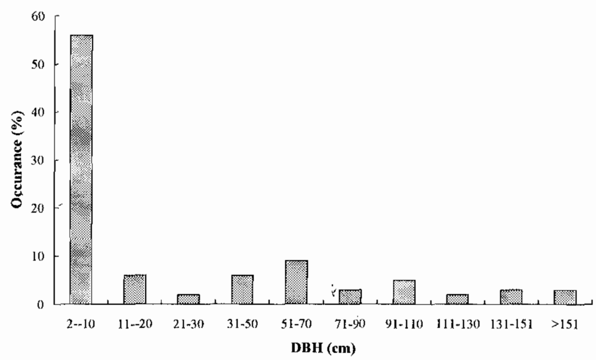

Fig. 3c. Population structure of *Podocarpus falcatus* in Dodola forest.

The fourth type of population pattern is represented by the population structure of *Hagenia abyssinica* (Fig. 3d). A major proportion of the population of *Hagenia abyssinica* is found in the very large size classes. Such a pattern represents poor regeneration and thus a declining population. The flower of the female tree of this species is widely used traditionally in the treatment of tapeworm infection, thus contributing to the decline in the reproductive capability of the species.

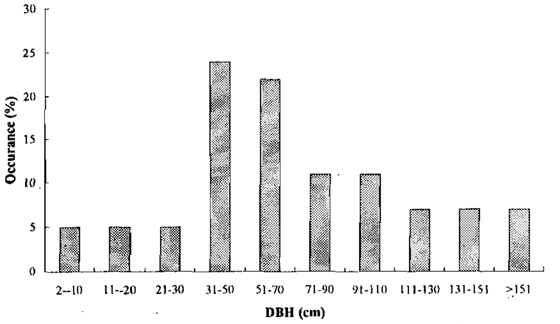

Fig. 3d. Population structure of *Hagenia abyssinica* in Dodola forest.

Similar observations on *Hagenia abyssinica* have been noted by Tamrat Bekele (1993) and Abate Ayalew (2003) in other forests. Unless some strict conservation plan is put in place, *Hagenia abyssinica* will become critically endangered, and may even face possible extinction in the near future.

Woody species richness along altitudinal gradients

The composition of woody species richness along the altitudinal gradient indicates a decrease in woody species composition with increasing altitude. The R-square value shows that 89% of the variation in composition is due to altitudinal variation (Fig. 4). This is because altitude is an important environmental factor, which, by affecting temperature, radiation, moisture and atmospheric pressure, influences the growth and development of plants and the distribution of vegetation (Hedberg, 1964).

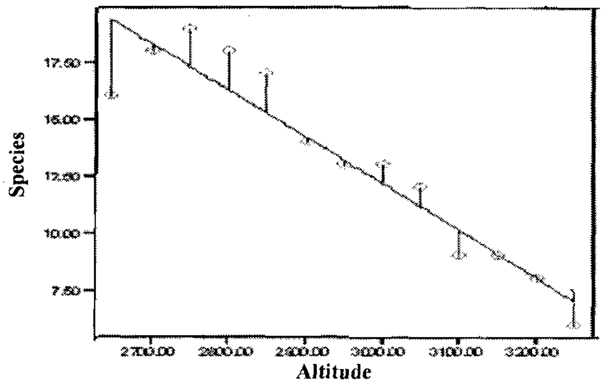

Fig. 4. Comparison of altitude and species richness in the Dodola forest by regression analysis.
Regression equation: Species=74.18-0.02*Altitude. R^2=0.89

Phytogeographic comparison

The tree species *Juniperus procera, Hagenia abyssinica, Podocarpus falcatus, Ilex mitis, Nuxia congesta, Myrsine melanophloeos* and *Halleria lucida,* which characterize the undifferentiated Afromontane forest (White, 1983), and which could thus be used to define the Afromontane region as a whole, are the major tree species in the Dodola forest. In addition to these Afromontane endemics, *Ekebergia capensis,* belonging to the linking elements, and considered as one of the ecological and chorological transgressors (White, 1983) is present in this forest. Dowsett-Lamaire (1988) considered *Ekebergia capensis* as a wide spread species in Africa.

The following 15 endemic species have been recorded from the forest:

Acanthus senni	*Conyza spinosa*
Kalanchoe petitiana	*Kniphofia foliosa*
Lobelia rhynchopetalum	*Maytenus addat*
Mikaniopsis clematoides	*Phragmanthera macrosolen*
Rhus glutinosa	*Satureja paradoxa*
Senecio myriocephalus	*Solanum marginatum*
Thymus schimperi	*Urtica simensis*
Vernonia rueppellii	

A similarity analysis between Dodola forest, and three dry and two moist montane forests in Ethiopia shows it to be more related to the dry forests than the moist forests. The Dodola forest shows high similarity with the Chilimo, Menagesha and Wof-Washa forests than to the Harenna forest. The former are located in the central plateau of Ethiopia, and are geographically situated in the north and farther away from Dodola than the latter. Although Harenna and Dodola forests situated on different aspects of the Bale Mountains and are geographically the closest to each other, interestingly enough, they reveal the least resemblance.

The reason for this low similarity can be attributed to the position (*i.e.,* aspect) the forests occupy on the Bale Mountains, and the consequence of it on the amount of precipitation received. Harenna forest, being on the southern and windward side of the Bale Mountains receives more rainfall, while Dodola is located on the northern and leeward side, and as a result gets less rainfall. The Harenna escarpment appears to intercept the flow of moist air currents from the south, thus increasing the precipitation in the area (Hillman, 1986).

There is no meteorological data from within the area covered by the Harenna forest (1500-3200 m a. s. l.) to compare with that of Dodola forest. The mean annual rainfall for Dinsho (3170 m a. s. l.), headquarter for Bale Mountains National Park, where the Harenna forest is situated, is 1150 mm (Lisanework Nigatu, 1987). Compared to it, the rainfall of Dodola forest (i.e., 823.5 mm) is much less.

As Bussman (1997) noted, the Harenna forest, phytogeographically, shows very distinct links especially to the more southern Afromontane forests, and particularly no relations to the dry Ethiopian forests north of the Bale Mountains. Friis (1992) also noted the floristic similarity of the Harenna forest to be more towards the southwestern Ethiopian Afromontane rainforests than to the dry plateau forests.

The absence of species such as *Aningeria adolfi-friederici* (Sapotaceae) and *Olea welwitschii* (Oleaceae) from Dodola forest differentiate it from Harenna forest, where these species are characteristic. However, towards their upper limits, both forests harbour a typical *Hagenia-Hypericum* forest complex.

RECOMMENDATIONS

The undifferentiated dry Afromontane forest of Dodola, situated on the northern face of the second highest mountain in the country, i.e. the Bale Mountains, is one of the three distinct ecosystems present on the mountain along with the Alpine (and sub-Afro-alpine) ecosystem prevalent on the top of the mountain, and a humid Afromontane forest ecosystem on the southern face of the Bale Mountains, thus forming a unique environmental mosaic in the region.

It has been shown that in this forest resides an important coniferous species, *Juniperus procera*, with a very good population structure, but which at present is very poorly represented in almost all other similar forests in the country.

The increased demand for agricultural land, emanating from the very high human population growth, is posing a threat to the Dodola forest. To overcome the likely impoverishment of the forest in the future, participatory forest management approach is being tested in a portion of the forest at present.

Considering the uniqueness of this environment in terms of its current floristic status and forest structure, there is a felt need for urgency in the design of a more sound development plan for the conservation and management of this ecosystem.

The following recommendations follow from this felt need;

1. Some block of the forest be delimited as a nature reserve and protected from human interference, except for scientific work.
2. The ongoing participatory forest management approach be strengthened with tangible outcomes that will ensure the well being of the forest and local communities. Eco-tourism, currently started, should further develop, with the local community as the prime beneficiary. This needs to be accomplished with the view to develop a sense of ownership, and the subsequent assumption of communal responsibility towards the management and conservation of the forest.
3. Tree planting by the local community has to be encouraged to reduce the pressure on the natural forests and to create buffer zones.

REFERENCES

1. Abate Ayalew (2003). The undifferentiated Afro-montane forest of Denkoro in the Central Highlands of Ethiopia: a floristic and structural analysis. M.Sc. Thesis, Addis Abeba University, Addis Ababa, Ethiopia.
2. Asfawossen Asrat, Seifu Kebede, Zemedu Geremew, and Fisseha Itanna (1997). Study report on the geology and pedology of Dodola area, Bale zone, Oromiya region, Addis Ababa, Ethiopia (unpublished report).
3. Bussman, R. (1997). The forest vegetation of the Harenna escarpment (Bale province, Ethiopia) -Syntaxonomy and phytogeographical affinities. *Phytocoenologia* 27:1–27.
4. Dowsett-Lamaire, F. (1988). The forest vegetation of Mt. Mulanje (Malawi): a floristic and chorological study along an altitudinal gradient. *Bull. Jard. Bot. Nat. Belg.* 58:77–107.
5. Edwards, S., Mesfin Tadesse and Hedberg, I. (eds) (1995). *Flora of Ethiopia and Eritrea.* Vol. 2 part 2. Addis Ababa University, Addis Abeba, 456 pp.
6. Edwards, S., Mesfin Tadesse and Hedberg, I. (eds) (1997). *Flora of Ethiopia and Eritrea.* Vol. 6. Addis Abeba University, Addis Abeba, 586 pp.
7. Edwards, S., Mesfin Tadesse and Hedberg, I. (eds) (2000). *Flora of Ethiopia and Eritrea.* Vol. 2 part 1. Addis Ababa University, Addis Ababa, 532 pp.

8. EFAP (1994). Ethiopian Forestry Action Program. EFAP, Addis Ababa, Ethiopia.

9. Fichtmuller, S. (1997). Useful plants of the Adaba-Dodola mountains, IFMP, Dodola (unpublished report).

10. Friis, I. (1992). Forests and forest trees of northeast tropical Africa: Their natural habitats and distribution pattern in Ethiopia, Djibouti and Somalia. *Kew Bull. Add. Ser.* **15**:1–396.

11. Grub, P.J., Lloyd, J.R., Pennington, J.D. and Whitmore, J.C. (1963). A comparison of montane and lowland rain forest in Ecuador. I. The forest structure, physiognomy, and floristics. *J. Ecol.* **51**:567–601.

12. Hedberg, O. (1964). Features of Afroalpine plant ecology. *Acta Phytogeogr. Suec.* **49**:1–144.

13. Hedberg, I. and Edwards, S. (eds.) (1995). *Flora of Ethiopia and Eritrea.* Vol. 7. Addis Abeba University, Addis Abeba, 420 pp.

14. Hill, M.O. (1994). DECORANA and TWISPAN for ordination and classification of multivariate species data: a new edition, together with supporting programs, in FORTRAN 77. Huntington, UK.

15. Hillman, J.C. (1986). Harenna forest expedition: preliminary report. Addis Ababa (unpublished report), Ethiopia.

16. Lisanework Nigatu (1987). An ecological study of the vegetation of the Harenna forest. M.Sc. thesis, School of Graduate Studies, Addis Ababa University, Addis Ababa, Ethiopia.

17. Leul Kidane (2003). Vegetation composition and human-forest interaction in Hugumburda-Gratkahassu national forest priority area (South Tigray) N. Ethiopia. M. Sc. Thesis, Addis Abeba University, Addis Ababa, Ethiopia.

18. Maarel, E. van der (1979). Transformation of cover/abundance values in phytosociology and its effect on community. *Vegetatio.* **39**:47–114.

19. Mohr, P.A. (1971). *The Geology of Ethiopia.* Haile Selassie University Press, Addis Ababa, Ethiopia.

20. Mueller-Dombois, D. and Ellenberg, H. (1974). *Aims and Methods of Vegetation Ecology.* John Wiley and Sos, Inc., 347 pp.

21. Sayer, J. A., Harcourt, C.S., Caroline, S. and Collins, N. Mark (eds) (1992). *The conservation Atlas of Tropical Forests, Africa.* Macmillan Publishers Ltd., 288 pp.

22. Tamrat Bekele (1993). Vegetation Ecology of Remnant Afromontane Forests on the Central Plateau of Shewa, Ethiopia. *Acta phytogeogr. Seuc.* **79**:1–58.

23. White, F. (1983). The vegetation of Africa. A descriptive memoir to accompany the UNESCO/AETFAT/UNIDO vegetation map of Africa. *Nat. Resources Res.* (Paris) , Vol. **20**, 356pp.

Appendix 1. List of Species present in Dodola forest.

Species	Family	Vernacular name	Habit
Acanthus sennii Chiov.	Acanthaceae	Kosoru	shrub
Acacia abyssinica Hochst. ex Benth.	Fabaceae	Lafto	Tree
Achyranthes aspera L.	Amaranthaceae		Herb
Acritochate volkensiii Pilg.	Poaceae		Grass
Agrocharis melanata Hochst.	Apiaceae		Herb
Alchemillai abyssinica Fres.	Rosaceae		Herb
A. cryptantha Steud. ex A. Rich.	Rosaceae		Herb
A. fischerii Engl.	Rosaceae		Herb
A. kuwiensis Engl.	Rosaceae		Herb
Allophylus abyssinicus (Hochst.) Radlk.	Sapindaceae		Tree
Ammocharis tinneana (Kotsch & Peyr) Milne-Redh. & Schweick.	Amryllidaceae		Herb
Arundinaria alpigna K. Schum.	Poaceae	Lemana	Shrub
Asparagus africanus Lam.	Aspargaceae	Sariti	Shrub
Bersama abyssinica Fressen.	Melianthaceae		Shrub
Bidens prestinaria (Sch.- Bip) Cuf.	Asteraceae		Herb
Buddelja polystachya Fresen.	Loganiaceae	Bulchana	Shrub
Bulbostylis hispidula (Vahl) R. Haines.	Cyperaceae		Grass
Carduus chamaecephalus (Vatke) Oliv. And Hiern.	Asteraceae	Qoree Harree	Herb
C. nyassanus (Engl.) Fries	Asteraceae	Qoree Harree	Herb
Chrysopogon plumulosa Hochst..	Poaceae		Grass
Clematis simensis Fressen.	Ranunculaceae	Fiitii	Climber
Convolvulus kilimandischari Engl.	Convolvulaceae		Climber
Conyza hypoleuca A. Rich.	Asteraceae		Shrub
Conyza spinosa Sch.-Bip. ex Oliv & Hiern.	Asteraceae	Hamaressa	shrub
Crassula alsinoides (Hook. F.) Engl.	Crassulaceae		Herb
Crepis rueppelii Sch. Bip.	Asteraceae	Canaa	herb
Cynoglossum coeruleum Steud. ex DC.	Boraginaceae	Qaccabbaa	Herb
Cyperus pauper Hochst. ex A.Rich.	Cyperaceae		Herb
C. nigricans Steud.	Cyperaceae	Qunnii	Herb
Dierama pendulum (L.) Bak.	Iridaceae		Herb
Discopodium penninervum Hochst.	Solanaceae	Maraaroo	Shrub
Dombeya torrida (J. F. Gmel.) P. Bamps	Sterculiaceae	Dannisa	Tree
Dovyalis abyssinica (A. Rich.) Warb.	Flacourtiaceae	Dhangagoo	Shrub
Dregea schimperii (Decne) Bullock	Ascelpidaceae	Hadh Namee	Climber
Echinops angustilobus S. Moore	Asteraceae	Qoree Harree	herb
Ekebergia capensis Sparm.	Meliaceae	Annoonnuu	Tree
Erica arborea L.	Ericaceae	Saattoo	Tree
Euphorbia schimperiiana Scheele	Euphorbiaceae		Herb
Galiniera saxifraga (Hochst. ex A. Rich.) Bridson	Rubiaceae	Koralla	Tree
Galium simense Fresen.	Rubiaceace	Maxxannee	Herb
Geranium arabicum Forssk.	Geraniaceae		Herb
Gnidia glauca (Fressen.) Gilg.	Thymelaceae	Diddigsaa	Shrub
Girardinia bullosa (Steud.) Weddel.	Urticaceae	Doobbii-arbo	Herb
Hagenia abyssinica (Bruce) J. Gmel.	Rosaceae	Heexoo	Tree
Halleria lucida L.	Scrophulariaceae	Daadhii	Shrub
Haplocarpha reuppelii (Sch.-Bip.) Beauv.	Asteraceae	Canaa	Herb
Helichryssum odoratissimum (L.) Less	Asteraceae		Shrub
H. cymosum (L.) Less	Asteraceae		Shrub

Species	Family	Vernacular name	Habit
Hypericum revolutum Vahl	Hypericaceae	Garambaa	Tree
Hypoestes triflora (Forssk.) Roem. & Schult.	Acanthaceae		Herb
Ilex mitis (L.) Radlk.	Aquifoliaceae	Amshiqa	Tree
Isoglossa somalensis Lind.	Acanthaceae	Heeraayyee	Herb
Jasminum abyssinicum Hochst. ex DC.	Oleaceae	Diki	Liana
Juniperus procera L.	Cupressaceae	Hindheesa	Tree
Kalanchoe petitiana A. Rich.	Crassulaceae	Hancuuraa	Herb
Kniphofia foliosa Hochst..	Asphodelaceae	Ledhaa	Herb
Laggeria pterodonta (D C.) Sch.ulz.- Bip. ex A .Rich	Asteraceae		Heb
Lobelia rhynichopetalum (Hochst.) Hem.	Campanulaceae	Taruuraa	Shrub
Maesa lanceolata Forssk.	Myrsinaceae	Abbayyii	Tree
Maytenus addat (Loes) Sebsebe	Celastraceae	Kombolsha	Tree
M. arbutifolia (Hochst. ex A.Rich.) Wilczt.	Celastraceae	Kombolsha	Shrub
M. heterophylla (Eckl. & Zeyh.) Robson	Celastraceae	Kombolsha	Shrub
Mikaniopsis clematoides (A. Rich.) Milne- Redh.	Asteraceae		Climber
Mimulopsis solmsii Schweinf.	Acanthaceae		Herb
Myrica salicifolia A. Rich.	Myricaceae	Xoonaa	tree
Myrsine africana L.	Myrsinaceae	Qacamsa	Shrub
M. melanophloeos (L.)R Br.	Myrsinaceae	Tuullaa	Tree
Nuxia congesta R. Br. ex Fresen.	Loganiaceae	Bixxanaa	Tree
Olea europaea subsp. cuspidata (Wall. ex DC.) Cifferi	Oleaceae	Ejersa	Tree
Olinia rochetiana A.Juss.	Oliniaceae	Gunaa	Tree
Osyris quadripartita Decn.	Santalaceae	Karoo	Shrub
Oxalis radicosa A. Rich	Oxalidaceae		Herb
Panicum hochstetterii Steud.	Poaceae		Grass
Phragmanthera mucrosolon (Steud. ex A. Rich.) Balle	Loranthaceae		Parasite
Phytolacca dodecandra L.	Phytolacaceae	Andoodee	Shrub
Peperomia abyssinica Miq.	Piperaceae		Epiphyte
Pittosporum viridiflorum Sims.	Pittosporaceae	Aaraa	Tree
Plectranthus assurgens (Baker) Morton	Lamiaceae		Herb
P. punctata L' Herit	Lamiaceae		Herb
Podocarpus falcatus (Thunb.) Mirb	Podocarpaceae		Tree
Pterocephalus frutescens Hochst. ex A. Rich.	Dispacaceae		Herb
Rhamnus prinoides L' Herit	Rhamnaceae		Shrub
R. staddo R.Rich.	Rhamnaceae	Qadiidaa	Shrub
Rhus glotinosa A. Rich.	Anacardiaceae	Xaaxessaa	Shrub
Rosa abyssinica Lindley	Rosaceae	Goraa	Shrub
Rubus steudnerii Schweinf.	Rosaceae		Shrub
Rumex nepalensis Spreng.	Polygonaceae		Herb
Salvia nilotica Juss. ex Jacq.	Lamiaceae		Herb
Satureja paradoxa (Vatke) Engl.	Lamiaceae		Herb
Satureja punctata (Benth.)Birq.	Lamiaceae		Herb
Scabiosa columbaria L.	Dispacaceae		Herb
Schefflera volkensii (Harms. ex Engl.) Harms.	Araliaceae	Ansha	Tree
Sebaea brachyphylla Girseb.	Gentinaceae		Herb
Senecio myriocephalus Sch.- Bip. ex A. Rich	Asteraceae		Shrub
Sida schimperiiana Hochst. ex A. Rich.	Malvaceae		Shrub
S. ternata Linn.f	Malvaceae		Shrub
Smilax aspera L.	Smilacaceae	Riga ilkaanii	Shrub
Solanum benderianum Dammer.	Solanaceae	Galmayyoo	Shrub
S. incanum L.	Solanaceae	Hiddii oromo	Shrub
S. marginatum L. f.	Solanceae	Hiddii	Shrub

Species	Family	Vernacular name	Habit
Sporobolus africanus Robyn & Tour.	Poaceae		Grass
Stachys alpigna T. C. E. Fries	Lamiaceae		Herb
Stephania abyssinica (Dill. Rich.) Walp.	Menispermaceae	Kalaala	herb
Swertia kilimandischari Engl.	Gentinaceae		Herb
Thymus schimperiii Ronniger	Lamiaceae	Xooshinee	Herb
Trifolium burchellianum Ser.	Fabaceae	Siddisa	Herb
T. simense Fresen	Fabaceae	Sidisa	Herb
Urtica simensis Hochst. ex steud.	Urticaceae	Doobbii	Herb
Vernonia amygdalina Del.	Asteraceae	Eebicha	Shrub
V. rueppelii Sch.- Bip.	Asteraceae	Kokkolfaa	Shrub
V. wollastoni S. Moore	Asteraceae		Shrub
Zehneria scabra (Linn.f.) Sond.	Cucurbitaceae		climber