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ADDIS ABABA UNIVERSITY

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FLORISTIC COMPOSITION AND STRUCTURE OF THE VEGETATION OF MAGADA FOREST, BORANA ZONE, OROMIA NATIONAL REGIONAL STATE

BY

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A thesis submitted to the School of Graduate Studies of Addis Ababa University in partial fulfillment of the requirements for the Degree of Masters of Science in Biology (Botanical Science)

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The plant communities of the Magada Forest were described based onfloristic and structural analysis of the data collected between December 20004 and January 2005. Releves of 30 m x 3 m were taken for the woody species and 2 m x 2 m for field layers. A total of 66 releves were analysed at altitudes between 1750 and 2100 m a.s.l Data on the species list, cover-abundance, and diameter at breast height, density and height were collected.

A total of 197species of vascular plants belonging to 61 families were identified. Out of these 53.5 % are woody species and 46.5 % are field layers. 84.3 % of the families are dicots while 12.5 % are monocots, andgymnosperm andpteridophytes comprise 1.6 % each. Asieraceae is found to be the largest family with 18species followed by Acanthaceae with 16 species. The species and releves were classified using a FORTRAN computer program TWINSPAN and seven major plant communities were described.

The structural analysis of the forest showed that there was a high density of small sized trees. The forest was well represented by individuals in all height classes. There were high proportion individuals in low height class (i.e. 6 – 12 m) that is similar to the trend in DBH measurement.

Podocarpus falcatus is the main species and constituted 76 stemsha of trees ≥10 cm DBH. Other well-represented species were Celtis africana (103 stems/ha), Cassipourea malosana (67 stemsha) and Olea europaea (47stems /ha). Analysis of species population structure showed six patterns. Phytogeographically, the Magada Forest is more related to the dry, undifferentiated afromontaneforests than the moist afromontaneforests.
Most of the sampled plots revealed more evidence ofpast exploitation (stumps and pit sawing). The vegetation of the Magada Forest is disturbed through grazing and browsing by domestic livestock; cultivation and other human uses. This further retard regeneration processes of the trees and shrubs. Pressure on the resources from human populations could intensify and impose more rapid and more degenerative changes. Recognizing these issues as possible future scenario underlines the need for management intervention to increase quality of regeneration being recruited and to accelerate the growth of the young plants already present.

1. INTRODUCTION

The numerous isolated mature forest trees or patches of forest or woodland of approximately the same species composition as that of the remaining areas with closed forest indicates the extent to which Ethiopian highlands were once forested. This leads one to the belief that the large areas with evergreen bush land or farmland mixed with bushland represent formerly forested areas (Friss, 1992). Tamrat Bekele (1993) remarked on this point that the occurrence of isolated mature trees in farmlands and the patches of forests that are seen around church yard and religious burial grounds indicate the presence of vast expanse of forests earlier. There is no accurate or reliable information about the extent and location of the past and present natural forests and woody vegetation cover in Ethiopia.

However, historical sources indicate that, on the basis of potential climatic climax high forests might have once covered about 35-40% of the total land area of the country. If the savannah woodlands are included, 66% of the country has been believed to be covered with forests and woodlands (EFAP, 1994). However the country's forest and woodland resources have been declining both in size (deforestation) and quality (degradation). As a result, it has been estimated that high forests covered 16% of the land area in the early 1950's, 3.6% in the early 1980's and only 2.7% in 1989 (EFAP, 1994). Some 5 million ha. savannah woodlands were remaining at that time, giving a total forest and woody vegetation area of 7%. In 1994, it has been estimated that such forests cover less than 2.3% of the country (EFAP, 1994). With the current annual loss of high forests, estimated at 150,000 - 200,000 ha it has been projected that the area covered by high forests may be reduced to scattered minor stands of heavily disturbed forests in accessible areas of the country within a few decades.

The main reasons, of deforestation are clearing of forests and woodlands for expansion of permanently cultivated areas, uncontrolled exploitation for various purposes, notably for fuel wood, construction materials, etc, shifting cultivation and forest fire (Friis, 1992). The fact that plantation forestry has been very far from meeting the demand for wood for various purposes indicates inevitability of deforestation. The underlying causes of deforestation are however, closely linked with the vicious cycle of mutually reinforcing factors, i.e. poverty, population growth, poor economic growth and the state of the environment.

Ecological and environmental problems such as soil degradation erosion and decrease in biodiversity as well as the loss of potential natural resources are just some of the negative effects resulting from the destruction of forests. The depletion of the natural vegetation in many parts of the country has also led to the threat and decline in number and area of distribution of many plant species; and surprisingly, 120 threatened endemic plant species are known from Ethiopia (Ensermu *et al.*, 1992).

The other reason for such a high rate of forest destruction in Ethiopia is inadequate standard of forest management. At present there is insufficient knowledge of the forest resources and exploitation is not based on informed and adequate management plans. The State Forest Conservation and Development Department of the 1980's designated 58 important forest areas as National Forest Priority Areas (NFPAs) for their protection, production and biological conservation services (EFAP, 1994). These areas comprise natural forests, plantations, and non-forested land and cover a total of 4.8 million ha, of which 2.8 million ha have been estimated to be natural forests (Demel Teketay, 1999).

In the current situation with a population of 70 million, which is growing at a rate of 2.92 per annum in Ethiopia, this high population growth coupled with the present ambiguous land tenure system will lead to a strong demand for wood and subsequently to further depletion of the remaining forest (Eshetu Yirdaw, 2002).

Unless the present trend of exploiting the remaining spare forest resources and their conversion into agricultural land is changed, every piece of relict forest remaining will be gone in the very near future (Sebsebe Demissew, 1998). The trend can only be reversed if appropriate measures are taken to halt them.

In order to maintain the ecological equilibrium and to meet the forest resources requirement of the population, scientific information is the basis. 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. Therefore, ecological assessment of the existing forests is the basis for meaningful planning to rationally utilize the remaining forest resources.

The exercise in vegetation description and classification in Africa had mainly relied on physiognomic features (White, 1983). However the merits of having to ascribe floristic elements to the phytogeographical areas in which they occur have also been emphasized.

The purpose of vegetation description is to enable people build mental picture of an area and its vegetation and to allow the comparison and ultimate classification of different units of vegetation. Moreover, vegetation description is essential to know what species are present, what their distribution is and what the relative degree of abundance of each species is before any serious or detailed work can be commenced in an area (Kershaw, 1973). Therefore, the first objective in ecological work is to learn the composition and structure of the community under consideration. Then follows a research for causes, experimentation and interpretations based upon a firm foundation. Thus the floristic composition (simply expressed as a List of species) life form composition and structure of vegetation are the necessary basis of all ecological work.

This study was carried out in Magada Forest in Borana Zone of Oromia National Regional State, southern Ethiopia. The forest is one of the National Forest Priority Areas (NFPAs). The area covers about 25,012 ha of land from which 10,328 ha (41%) is natural forest, 11,964 ha (48%) woodland, 750 ha (3%) edaphic grass land and/or swamp vegetation and 2751 ha (11%) cultivation Magada Forest is distinctive in that *Podocarpm* is dominant and mapped by Chaffy (1980) as *Podocarpus* dominated coniferous forest (ORS, 2002). The main objectives of this study are:

> to provide a list of a plant species found in the forest;
> to classify the forest vegetation into community types;
> to compare the floristic composition and structure of the forest vegetation with other similar forests in Ethiopia;
> to recommend solutions for management and conservation problems.

2. LITERATURE REVIEW

2.1. The Forest Vegetation of Ethiopia

Ethiopia is a country of great geographical diversity with high and rugged mountains, flat-topped plateaus and deep gorges, incised river valleys and rolling plains. Altitude range from the highest peak of Ras Dejen, 4620 m a.s.l.down to the depression of the Kobat sink in the Afar Depression, about 110 m below sea level. The Great African Rift Valley runs from north to south bisecting the plateau, and in conjunction with the surrounding lowlands, this feature isolates and separates the plateau from other parts of the continent. The varied topography, the Rift valley and the surrounding lowlands have given the country a wide spectrum of habitats, and a large number of endemic plants and animals (Demel Teketay, 1999; Zerihun Woldu, 1999)

According to modified UNESCO Natural Terrestrial Cover classification, forests are areas dominated by trees with a total canopy cover of 61% or more, tree crowns usually interlocking. It is a continuous stand of trees, which may attain a height of 50 m or more, with crowns touching or intermingling and often interlaced with lianas. Its canopy may be of great thickness and usually consists of several distinct layers or storeys. Epiphytic plants, including orchids, ferns and mosses are characteristic, especially in the wetter type, and lichens are characteristic of the upland types. The trees have simple and buttressed boles and in mot types the majority are in leaf the year round, although semi deciduous types do also exist.

There has been a lack of unified approach to the description and identification of plant communities in the country so far. Vegetation types in Ethiopia have been described and classified based on physiognomic criteria by Pich Sermolli (1957), Breitenbach (1963), Mesfin Wolde Mariam (1972), Daniel Gamachu (1977), Wilson (1977), Friis *et al.*, (1982), Tewolde Berhan Gebre Egziabher (1986), Friis (1992), and Bonnefilleet al., (1993).

Few vegetation studies have also been based on floristic composition. These include: Vegetation of the Erer-Gota plain, Harar (Beals, 1969), Menagesha Suba State forest, Shewa (Sebsibe Demissew, 1980), Jemjem Forest, Sidamo (Hailu Sharew, 1982), grassland vegetation of Welmera (Zerihun Woldu, 1980), Harena forest, Bale (Lissanework Nigatu and Mesfin Tadesse, 1989), forest of the central plateau of Shewa (Tamrat Bekele, 1993), Afroalpine vegetation of Senatti plateau, Bale (Menassie Gashaw and Masresha fetene, 1996), Vegetation of Gambella region, Southwestern Ethiopia (Tesfaye Awas *et al.*, 2001), afromontane and transitional rainforest vegetation of southwestern Ethiopia (Kumlachew Yeshitla and Tamrat Bekele, 2001), vegetation of Denkoro Forest, South Wollo (Abate Ayalew, 2003) and vegetation of Dodolla Forest, Bale (Kitessa Hundera, 2003). Although most classifications are aimed at distinguishing ecological homogenous zones, they differ in one way or another according to the set objectives.

A previous study carried out in the area (Chaffey, 1980) focused on inventory for commercial value such as stem quality. Apart from this earlier work, there has been no thorough study yet that has attempted to describe the plant communities in Magada Forest.

Generally, the Ethiopian vegetation is classified into the following eight types: desert and semi desert scrub; dry evergreen montane forest; moist montane forest; lowland tropical forest; *Acacia - Commiphora* woodland; *Combretum- Terminalia* woodland; afroalpine and sub afroalpine vegetation; and wetland and riparian vegetation

The Magada Forest is part of the dry evergreen montane forest of Ethiopia, which is a very complex type occurring above 1500 m and below 3200(-3350) m and has annual temperature and rainfall of 14^0C to 25^0C and 500 to 1500 mm, respectively.

The characteristic plant species in this vegetation type include *Olea europaea ssp. cuspidata, Juniperus procera, Podocarpus falcatus, Nuxia congesta*, and *Ilex mitis*. The shrubs occurring in this vegetation type include *Carisa spinarum, Euclea shimperii*, and *Dodonaea angustifolia*.

Friis (1992) classified these forest types as follows:

a. Dry single dominant Afromontane forest which occurs in the NW and NE Ethiopian highlands at altitudes from (1600) /2200-c. 3200 (-3300) m, with annual temperatures from 12-18 °C and annual rainfall between 500 and 1500 mm.

b. Undifferentiated Afromontane forests, which are either *Juniperus - Podocarpus* forest, or predominantly *Podocarpus* forest, both with an element of broad-leaved species. They occur in both the NW and SE highlands, especially on the plateau of Shewa, Wollo, Sidamo, Bale and Harerge at altitudes from 1500-c. 2700 m, with average annual temperature between 14 and 20°C and annual rainfall between 700 and 1100 mm.

c. Dry single dominant Afromontane forest of the escarpments and transition between single dominant Afromontane forest and East African evergreen and semi-evergreen bushland occurring on the eastern escarpment of the NW highlands and on the eastern escarpment of the SE highlands on rocky ground with unimpeded drainage from an altitude of about 1500 m to 2400 m, annual rainfall between 400-700 mm' and average annual temperature between 15-20 ^{0}C.

2.2 Techniques of Vegetation Data Analysis

Quantitative community ecology is one of the most challenging branches of modern environmetrics. Community ecologists typically need to analyze the effect of multiple environmental factors on dozens of species simultaneously. Thus vegetation ecologists have employed a variety of multivariate approaches to study the complex nature of plant communities with the general objectives of summarizing large complex data sets obtained from community samples, aiding in the interpretation of the data and the generation of hypotheses about community structure and variation (Gauch and Whittaker, 1972; Gauch, 1982). The descriptive nature and functional characteristics of vegetation results from he interaction between the properties of the plant species it contains and the environment in which they occur.

Many studies have pointed out that among the multivariate approaches, ordination and classification are the two main methods. Both ordination and classification continue to contribute materially to the elucidating of the complexities within communities. Therefore, the choice of the method to be used depends on the ecological question to be answered (Gauch and Whittaker, 1972; Gauch, 1982).

2.2.1 Ordination

Ordination is the arrangement of 'ordering' of species and/or sample units along gradient. Although community ecology is a fairly young science, the application of quantitative methods began fairly early (McIntosh, 1985). Ramensky (1930) began to use informal ordination techniques for vegetation. Such informal and largely subjective methods became widespread in the early 1950's (Whittaker, 1967). In 1951 Curtis and

McIntosh (1951) developed the 'continuum index', which later lead to conceptual links between species responses to gradient and multivariate method. Shortly, there after; Goodall (1954) introduced the term 'ordination' in an ecological context for Principal Component Analysis. Bray and Curtis (1957) developed Polar Ordination, which became the fist widely used ordination technique in ecology. Austin (1968) used Canonical

Correlation to assess plant-environment relationships in what may have been the first example of multivariate direct gradient analysis in vegetation ecology. In 1973, Hill introduced Correspondence Analysis, a technique originating in the 1930's to ecologists. Correspondence Analysis gradually supplanted Polar Ordination.

Fasham (1977) and Prentice (1977) independently discovered and demonstrated the utility of Kruskal's (1964) nonmetric multidimensional scaling, originally intended as a psychometric technique, for community ecology. Hill (1979) corrected some of the flaws of Correspondence Analysis and thereby created Deterended Correspondence Analysis, which is the most widely used indirect gradient analyses technique today. Gaunch's (1982) described ordination in non-technical terms to the average practitioner, and allowed ordination techniques to enter the main stream. Fuzzy Set Theory introduced to ecologists by Roberts (1986), is a promising approach with ties to Polar Ordination. Ter Braak (1986) ushered in the biggest modern revolution in ordination methods with Canonical Correspondence Analysis. Ter-Braak and Prentice (1988) developed a theoretical unification of ordination techniques, hence placing gradient analysis on a firm theoretical foundation.

Ordination is a collective term for multivariate techniques that adapt a multi dimensional swarm of data points in such a way that when it is projected onto a two-dimensional space any intrinsic pattern the data may possess becomes apparent upon visual inspection (Pielou, 1984). Basically, ordination serves to summarize community data (such as species abundance data) by producing a low-dimensional ordination space in which similar species and samples are plotted close together and dissimilar species and samples are placed far apart. There are several different ordination techniques, all of which differ slightly, in the mathematical approach used to calculate species and sample similarity/dissimilarity.

The most commonly used methods are:

i. Principal Component Analysis (PCA),
ii. Reciprocal Averaging (RA)/ (Correspondence Analysis (CA)
iii. Deterended Correspondence Analysis (DCA)
iv. Nonmeteric Multidimensional Scaling (NMS), and
v. Canonical Correspondence Analysis (CCA)

Generally, ordination techniques are used to describe relationships between species composition, patterns and the underlying environmental gradient, which influenced these patterns.

2.2.2 Classification

Classification is the placement of species and/or sample units into groups. Classification aims at grouping individual stands into categories. The members of each category have in common a constellation of attributes, which serve to set them apart from members of another category (Anderson, 1965). The stands that are closely similar with one another form one class, which is separated from other classes that also consist of similar stands (Greig- Smith, 1979). Classification or putting samples into (perhaps hierarchical) classes is often useful when one wishes to assign names to, or to map, ecological communities.

In classification similar samples are combined in the same category, but in ordination the objective is to consider sample differences rather than similarities, so as to dispose the samples in a linear or multi dimensional network that reveals the relationships between the samples and their environment (Kumar, 1981). It is now, generally accepted that the choice between classification and ordination depends on the objective of data analysis and the structure of the data set being examined, rather than on preconception about the nature of the vegetation (Greig Smith, 1979) and there is no prior reason to accept either classification or ordination is inherently correct techniques (Anderson, 1965). Both ordination and classification will contribute materially to the elucidation of complexities of vegetation and their value lies in their use as tools in helping to provide useful information from a particular situation; they are tools of convenience and both approaches can be appropriate in certain circumstances (Anderson, 1965). The difference in approach is artificial and classification of ecological communities will often provide summary for large data matrices, particularly when complemented by ordination (Digby and Kempton, 1987). Therefore, in the controversy over the relative merits of classification and ordination in vegetation study, the choice rests more on the convenience of the user than the preconceptions as to continuity or discontinuity of vegetation. If the prime requirement is to produce vegetation units, which can be used for mapping or description, then classification is more applicable (Kershaw, 1973). Bearing this in mind classification technique is employed for this study.

Vegetation classification attempts to identify discrete, repeatable classes of relatively homogenous vegetation communities or associations about which reliable statements can be made. Classification assumes either that natural vegetation grouping (communities) do occur, or that it is reasonable to separate a continuum of vegetation in vegetation composition and/or structure into a series of arbitrary classes.

There are a large number of contrasting algorithms available for the classification of samples. Clustering strategies may be classified according to whether they are hierarchical or non-hierarchical, divisive or agglomerative and polythetic or monothetic (Lambert and William 1966; Orloci, 1967; Gauch and Whittaker, 1981). Non-hierarchical techniques partition samples into a number of clusters but specify no structure interrelating the clusters. Hierarchical clustering techniques define relationships among the clusters too. A single hierarchical analysis allows one to choose the final number of groups by selecting an appropriate level in the hierarchy, and this choice can be made after seeing what kind of structure the data set has. If the only requirement in a clustering application is that a given number of clusters be formed (but not related to one another), non-hierarchical may be best (Gauch and Whittaker, 1981).

Divisive hierarchical clustering strategies begin with all samples in a single cluster and divide them usually into two clusters; these clusters are further subdivided until each cluster contains no more than a specified number of samples. Agglomerative clustering strategies begin with the individual samples, and fuse these into successively larger cluster until finally a single cluster contains all samples. Divisive methods have an advantage over agglomerative ones in that they use all available information at the initial stage and are less likely to be irrevocably led astray by chance; the computations are much quicker, since they do not usually continue to the point at which individual classes are recognized as classes (Pielou, 1984).

Monthetic techniques partition on the basis of presence or absence of a single character usually species in the case of community samples. Association analysis was an important early monothetic technique but had an undesirable high rate of misclassification (William and Lambert, 1959; Orloci, 1967). Polythetic techniques partition on the basis of more than one (usually all) species, such techniques use the data as fully as possible. It has the obvious advantage over monothetic techniques in that it can be made to take account of as many properties of the vegetation as we wish to measure or record (Noy Meir, 1973; Pielou, 1984). On theoretical grounds, divisive polythetic procedures are superior to both divisive montothetic and agglomerative procedures because a maximum amount of information is used at the major (first) division of hierarchy (Pielou, 1984; Goldsmith *et al.*, 1986).

TWo-way INdicator SPecies ANalysis (TWINSPAN) is a polythetic divisive technique (Hill, 1979). The data are first ordinated by reciprocal averaging (RA). Then those species, which characterize the RA axis extremes, are emphasized in order to polarize the samples, and the samples are divided into two clusters by breaking in the RA axis near its middle. The sample division is refined by reclassifications using species with maximum indicator value. The process is repeated on the two subsets to give four clusters, and so on, until each cluster has no more than a chosen minimum number of members. A corresponding species classification is produced, and the sample and species clusters are used together to produce re ordered data matrix. In its emphasis on indicator species (and their fidelity to noda) the technique has similarities to the approach of Braun-Blanquet

(Gauch and Whittaker, 1981). The program TWINSPAN produces a hierarchy with integer levels to express relative cluster similarity, but the levels at which clusters are united can be calculated as the average distance between all pairs of samples (within a cluster using all pairs of members, and between clusters using all pairs with one member from each cluster).

The TWINSPAN method differs fundamentally from the agglomerative techniques in its divisive strategy, it uses ordination for an overall view of the data, then imposes divisions. TWINSPAN is usually more informative. Generally, advantages of polythetic-divisive (TWINSPAN) method are:

i. it uses the original vegetation data, rather than secondary matrix;
ii. it orders the sample sequence in a dendrogram;
iii. it clusters species also;
iv. it produces an ordered data matrix; and
v. it is economical in the use of computer time and store.

These advantages make TWINSPAN the best general method, and is employed in the present study.

3. MATERIALS AND METHODS

3.1 Description of the Study Area

3.1.1 Location and general feature of the study area

The Magada Forest is one of the National Forest Priority Areas (NFPAs), which is located in the southern part of the country in the Borana Zone of Oromia National Regional state. It lies approximately between longitudes of 38^0 15' E and 38^0 20' E and latitudes of 5^0 27' N and 5^0 32' N (EMA, 1987) in the Hagere Mariam (Bulle-Hora) District (Fig. 1). The area comprises essentially a single compact block of forest, roughly four sided and divided into two unequal sized area by the main road running north-south from Addis Ababa to Nairobi and it is about 485 km away from Addis Ababa.

The forest lies on an undulating plain dissected by numerous valleys. The central and eastern part of the forest is fairly flat but elsewhere, especially towards the forest edge, the topography is moderately to strongly undulating. The altitude of the forest ranges between 1750-2100 m a.s.l.

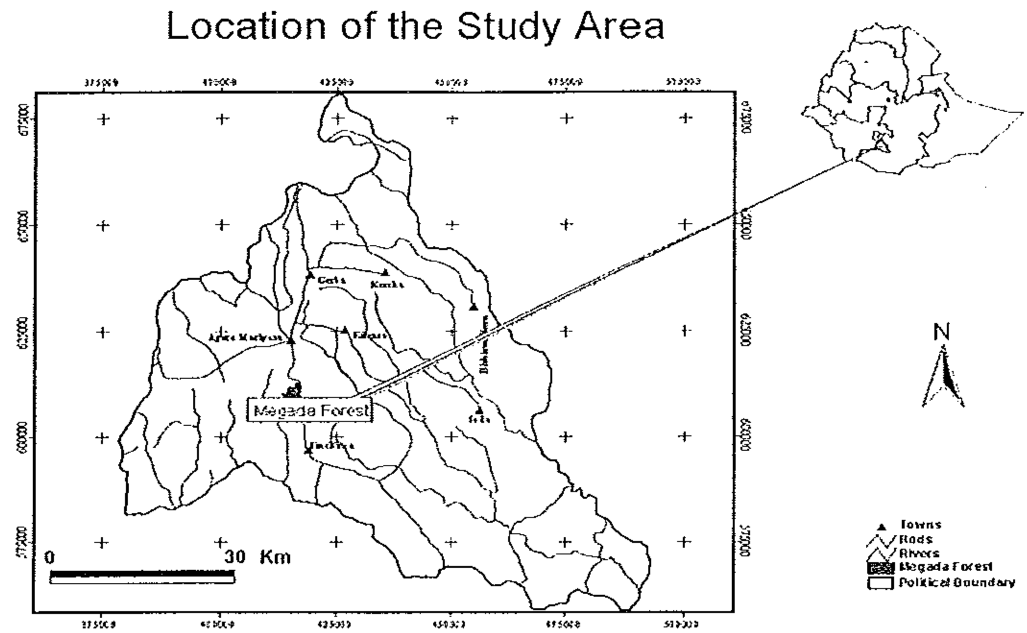

Figure 1: Location Map of the Study Area

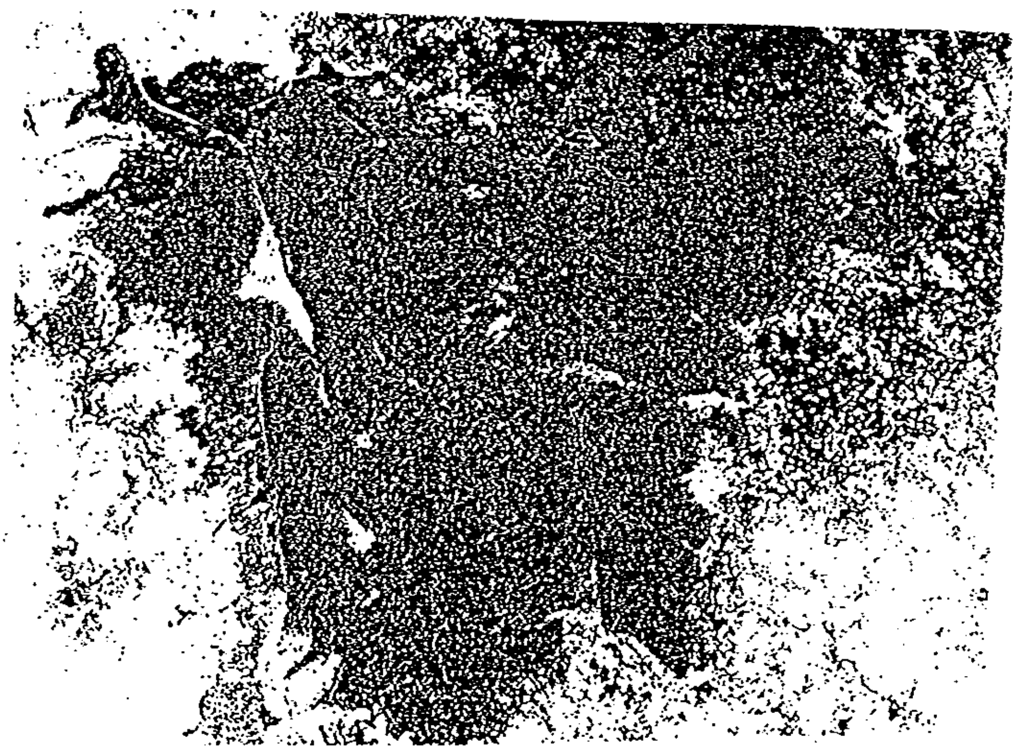

Figure 2. Satellite image of Magada Forest (2000)

(Adopted from Yoshikura Toshihide, 2004)

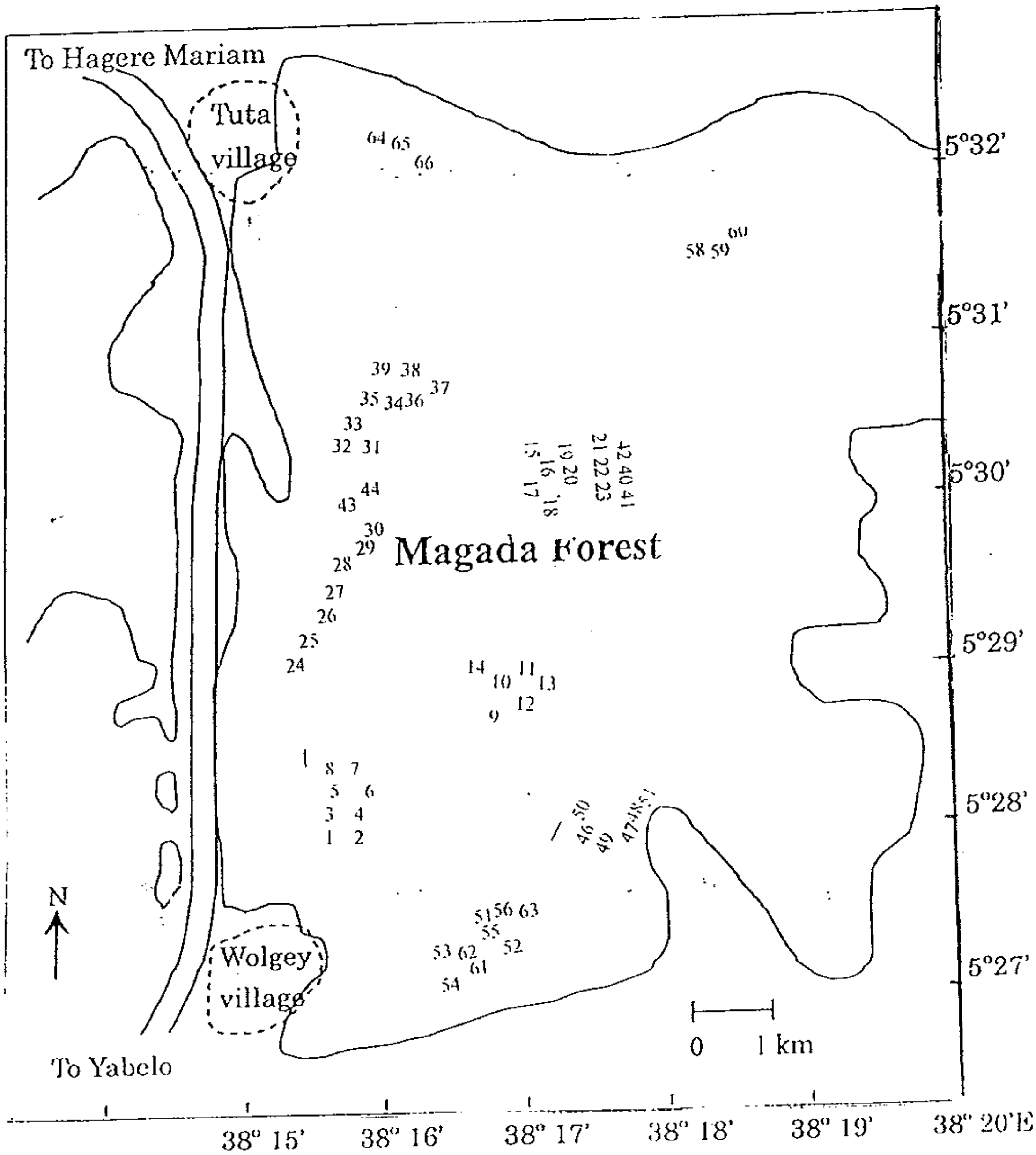

Figure 1c. Location of Magada Forest and Sampled area (Adopted from Yoshikura Toshihide, 2004)

3.1.2. Geology

Magada forest is located towards the southern edge of the Ethiopian plateau. The rocks of the area are metamorphosed Precambrian. They are partly volcanic origin and partly intrusive. It is in Borana that areanceouns metamorphic rocks are most extensively developed, especially in the Magada Forest area. The Basement complex of the Magada Forest area is composed of paraschists and paragneisses. In addition, psammitic schists and hardened sandstones are predominant in the Basement compiled (Mohr, 1971).

3.1.3. Climate

The southern and southeastern part of the country including the Magada Forest area experience a bimodal rainfall pattern brought about by the wind system coming from the Indian Ocean from September to November and from March to May. The most reliable rainy months are April and May.

The nearest weather station to Magada Forest is Hagere Mariam (Bule-Hora) located at about 10 km north of the forest edge. From meteorological data for 1995 – 2004 the climatic diagram was prepared (Fig. 4). Mean annual rainfall in Hagere Mariam was 809 mm, and there are two rainfall peaks (April and October). The mean annual maximum and the mean annual minimum temperatures were 24.5° C and 11.56° C respectively. The mean maximum temperature for the hottest month was 28.3° C in February and mean minimum temperature for coldest month was 8.8° C in December. The mean annual temperature was 18.03° C. According to FAO (1984); cited in Yoshikura (2004) mean annual rainfall and mean temperature were 18.6° C and 973 mm respectively. The recent data indicated a decrease in precipitation.

Hagere Mariam (2000) 18.03 809.82

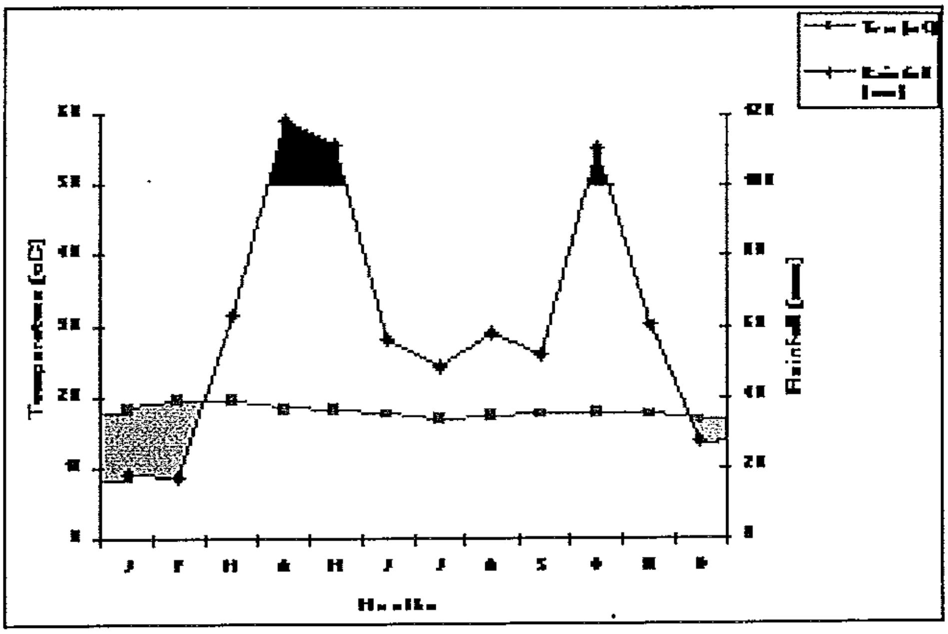

Figure 4: Climate diagram for the town of Hagere Mariam, 2000 m a.s.l. (after Walter 1985).

3.1.4. Water

Magada Forest lies in the Ganale Dawa catchment. A few surface watercourses drain the southern side of the forest, some or all of which probably dry up for part of the year. Elsewhere the valleys are dry for most of the year or contain only water holes providing water of poor quality (Chaffey, 1980).

3.1.5. Soil

Soils in the forest are reddish brown, freely draining and with depth in excess of one meter. According to FAO Unesco World Soil Map (FAO, 1990), the soil type is categorized as eutric nitisols (Ne) or ferric acrisols (Af), which are good agricultural soils. They are subject to severe erosion on slopes from which the forest cover has been removed and gully formation is widespread on the agricultural land surrounding the forest. Soils associated with glades (edaphic grass lands) on flat terrain and in valley bottoms are black and generally have impeded drainage, which is likely to be a constraint upon their use for forestry (Chaffy, 1980).

3.1.6. Natural vegetation

The principal vegetation type is high forest composed of over mature *Podocarpus falcatus* above associated broad-leaved species. The *Podocarpus* forms an irregular upper storey and the canopy at lower levels is completed by broad-leaved species, of which the more frequent are *Celtis africana, Ekebergia capensis, Syzygium guineense, Croton macrostachyus, Olea europaea* sub sp. *cuspidata, Olea capensis* sub sp. *macrocarpa* and *Trichilia drageana*. Of the less frequent trees are *Millettia ferruginea, Nuxia congesta, Prunus africana, Schrebera alata, Mimusops kummel, Polyscias fulva, Bersama abyssinica,* etc. and the understorey tree species include *Acokanthera schimperii, Cassipourea malosana, Teclea nobilis, Teclea simplicfolia, Psydrax schimperiana,* etc. Shrubs include *Calpurnea aurea, Carissa spinarum, Grewia ferruginea, Maytenus gracilipes, Rytigynia neglecta*, etc.

Acanthaceous species such as *Thunbergia* alata, *Acanthus pubescens, Hypoestes aristata, H. forskaolii, Justicia bizuneshiae, J. ladanoides,* etc. predominate in the herb layer within the forest and some of the herbs occurring in the edaphic grasslands are

Commelina diffusa, *C. benghalensis*, *Cyperus nigricans*, *Cynoglossum coeruleum*, *Guizotia scabra leucas argentea*, *Bidens biternata*, *and Drimia altissima*.

3.1.7 Human population

The total population of the Borana zone for the year 2000 estimated by the CSA is indicated in Table 1. The estimated size and density of the population of the District where the study area is located were about 425,042 and 68.3 person per km² respectively. Also indicated are the rural population density for the total land area and the rural population density by arable land area (land suitable for rain fed crop cultivation). The low densities in the Borana zone reflect the extensive and low intensity land use of this zone (mainly pastoralism).

Table 1. Rural and urban population estimate of Borana Zone for the year 2000

Locality	*Population size*
Urban	175,927
Rural	1,527,450
Total	1,703,378
Density: total area (p.p.km²)	16
Density: arable area (p.p.km²)	34

Source: ORS (2002)

3.1.8. Land cover

The natural vegetation patterns are closely related to patterns of rainfall and temperature, with local variations due to soil and drainage factors. In the highlands of Borana zone

Podocarpus-Juniperus forests and/or *Podocarpus* dominated forests occur on the higher and wetter slops, with *Juniperus* alone on the lower and drier slops.

The area of land cover types of Borana Zone mapped by Woody Biomass Inventory and Strategic Planning Project (WBISPP) are indicated in Table 2.

Table 2: Area (ha) and % of land cover type of the Borana Zone

Land cover	Area (ha)	%
Cultivation	419,434	4.3
Forest	296,725	3.0
Plantation	10,354	0.1
Woodland	5,631,271	57.3
Shrub land	2,707,716	27.6
Grassland	466,161	4.7
Afro alpine	0	0
Swamp	292147	3.0
Total	9,823,808	100

Source: ORS (2002)

Although there is no exact estimate of the extent of the Magada Forest, previous studies (Chaffey, 1980; Yoshikura, 2004) tell that the forest has been shrinking. According to Chaffey (1980) high forest part of the Magada Forest occupied around 10,328 ha. However, 20 years later the area was estimated to be reduced to 8460 ha (Satellite image data (Fig. 2) cited in Yoshikura (2004)).

3.1.9. Current management and use

Tree cutting in Magada Forest was banned after the forest was designated a Natural Forest Priority Area (NFPA), before which a sawmill operated for many years. In 1994 a ban on exploiting *Podocarpus falcatus* and other forest vegetations came into operation. It is not clear if this is still in force. However, local people and pastoralist continued to use Magada Forest as their source of poles and firewood, for hunting animals such as wild pig, and for livestock feed (cows and goats). During the dry season (December – February), large numbers of pastoralists move to Magada Forest with their large numbers of livestock every year. Cattle and goats graze in the forest especially during the dry season when the forest vegetation provides fodder not available outside. Cattle pens were built in the forest by the local people and as a result of livestock grazing and browsing there are numerous trails.

Tree planting has been practiced since the 1980's mostly in the southwest part of the forest. The planted species is mainly *Juniperus procera.* A nursery is located near the forest, producing seedlingsof indigenous trees such as *Juniperus procera, Cordia africana* and *Teclea nobilis.*

Around the forest area, indigenous Guji Oromo farmers carry out maize cultivation, as the staple cropping. Other crops grown are wheat, enset, sugarcane, bean and cabbage. As commercial crops, some farmers grow coffee (*Coffea arabica*) and chat (*Catha edulis*) on their farms.

3.2 Data Collection

A reconnaissance survey was made across the Magada Forest on 10-12 December 2004 in order to obtain an impression of the site conditions and variation in physiognomy of the vegetation, and to identify sampling sites. Field data were collected between December 13/2004 and January 27/2005. During sampling visually checked homogenous representative stands were subjectively selected (preferential sampling) in such a way that the various conditions encountered were represented by at least one sample.

3.2.1. Vegetation data collection

Sixty-six sampling (Fig. 3) sites 900 m^2 (30 m x30 m) in size were considered to sample trees (Westhoff and van der Maarel, 1978; Tamrat Bekele, 1993) and shrubs. Floristic analysis of shrubs and herbaceous species was made on a 5 m x 5 m and 2 m x 2 m sub plots respectively laid within the larger plot where the vegetation was assumed to be representative. At each sampling site altitude was measured using Pretzel digital altimeter and aspect and/or position using Magellan GPS.

From each plot a complete List of trees, shrubs and herbs was made. The height and diameter at breast height (DBH), i.e. 1.3 m, of all trees and shrubs were measured. Individuals with a DBH $\geq$ 2 cm and height $\geq$ 2 m were measured. Height measurements were estimated visually. DBH values were calculated from circumference measurements, using the formula **C= πd** where C= circumference, π= 3.14, and d= diameter.

Estimation of cover/abundance was performed using a 1-9 modified Braun Blanquet scale (van der Maarel, 1979) as follows:

Scale 1: rare, generally one individual
2: occasional, with less than 5% cover of the total area
3: abundant, with less than 5% cover of the total area
4: very abundant, with less than 5% cover of the total area

5: 5-12% cover of the total area

6: 12-25% cover of the total area

7: 25-50% cover of the total area

8: 50-75% cover of the total area

9: 75-100% cover of the total area

Additional plant species out of the plots but in the forest including the edaphic grasslands were recorded. In addition to the floristic analysis, dead standing trees, stumps and logs in the plots were noted to assess the cause of disturbance in the forest.

Identification of plant specimens was conducted in the National Herbarium (ETH), Addis Ababa University, using published volumes of Flora of Ethiopia and Eritrea and by comparing with authenticated plant specimens. Written descriptions of the flora of Ethiopia and Eritrea and those of the Flora of Tropical East Africa were used to verify the identification that has been made. Nomenclature follows that of the published volumes of the Flora of Ethiopia and Eritrea.

3.3 Methods of Data Analysis

3.3.1 Floristic data analysis

The vegetation data were analyzed and classified using a FORTRAN computer program TWINSPAN, TWo- way INdicator SPecies ANalysis, Version 1.0 (Hill, 1994). TWINSPAN is a divisive polythetic method of vegetation classification. It classifies both samples and species.

The following options were chosen:

Number of cut levels: 0
Minimum group size for division: 5
Maximum number of indicators per division: 7
Maximum division level: 6
Different weights at different cut levels: All values set to 1 and
Indicators at different cut levels: All values set to 1.

The resulting groups are recognized as community types. The community types distinguished were further refined in a synoptic table where each column represents a community type and species occurrences are summarized as synoptic cover-abundance values (van der Maarel *et al.*, 1987). The synoptic values were given as the product of average cover abundance value and frequency in the community. The types were named after two of the characteristic and/or dominant species.

3.3.2 Structural data analysis

From the woody species (trees and shrubs) identified all tree species recorded in the sample plots were used in the analysis of structural features (density, height, diameter and basal area).

Density: the number of individuals of a size class in the stand is important to characterize vegetation. Density is determined by counting the number of individuals of each size class of each sample plot. Tree density was computed by converting the count from the total quadrats into a hectare basis.

DBH (Diameter at Breast Height): DBH is the most frequent measured variable in vegetation surveys and has multiple uses. Over bark diameter measurements at breast height (1.3 m from the ground) are quick, easy, inexpensive, relatively accurate, and usually correlated with other variables such as basal area. DBH was classified in to ten classes and the percentage distribution of each tree was computed for each species.

Tree height is a straightforward parameter used for direct measurement purposes. Height reveals some thing about the age of a plant. It can also tell something about disturbance and recolonization (for example, a stand comprised of a single species of tree all of the same height could indicate vegetation removal and subsequent invasion). Tree height was classified into nine classes and the percentage distribution of trees in each class was computed for each species.

Basal area: Basal area is the horizontal (cross-sectional) area occupied by the trunk of a species or size class. Basal area calculations were made on the diameter measurements of the stem with DBH 's of two centimeter and above. It is expressed in square meter per hectare (m^2/ha) and computed by using the formula:

$$\text{Basal area} = (\text{DBH} / 2)^2 * 3.14$$

Frequency: frequency is the number of times a particular species is recorded in the sample area. The frequency distribution of tree species was calculated as:

$$\%\ \text{Frequency of species A} = \frac{(\text{Number of quadrats in which species A occurs})}{\text{Total number of quadrates examined}} * 100$$

Important Value Indices (IVI) were calculated for twenty-eight tree species to determine their dominance as follows:

$$IVI = \text{Relative basal area} + \text{Relative abundance} + \text{Relative frequency}$$

Where,

$$\text{Relative basal area} = \left(\frac{\text{Basal area of the species}}{\text{Total basal area}}\right) * 100$$

$$\text{Relative abundance} = \left(\frac{\text{Number of all individuals of a species}}{\text{Total number of tree species}}\right) * 100$$

$$\text{Relative Frequency} = \left(\frac{\text{Number of plots where a species occurs}}{\text{Total occurrences of the species in all the plots}}\right) * 100$$

Population structure of all tree species in the sample plots were analyzed using the data of stems having DBH $\geq$ 2 cm. The frequency diagrams were constructed for each species taking the population size and maximum DBH obtained into consideration. The population structure diagrams used to discuss the different patterns of population structure.

Phytogeographic comparison was carried out to evaluate the relationship between Magada Forest and other eight Afromontane forests in Ethiopia. The similarity index used is Sorensen's similarity coefficient (S) 2c/a + b (Sorensen (1948); cited in Muller and Dombois (1974).

4. RESULTS AND DISCUSSION

4.1 Floristic Composition

A total of 197 species of vascular plants representing 64 families were recorded from the tree, shrubs, and field layers (Appendix 1). Of these 39 species (19.8%)were trees, 13 species (6.6%) were trees/shrubs, 39 species (19.8%) shrubs 14 species (7.1%)climbers, 91 species (46.2%) herbs, and 2 species (0.5%) epiphytes and semi-parasitic plants. 84.3 per cent of the families were dicots, while 12.5 % monocots, 1.6 % pteridophytes and 1.6 % gymnosperms. The families with the highest number of species were Asteraceae (18 species), Acanthaceae (16 species), Rubiaceae (14 species), Fabaceae (13 species) and Lamiaceae (13 species). Fourteen species of climbers belonging to 11 families were recorded from the plots. Three species belonged to Asclepiadaceae, two species to Fabaceae and two Vitaceae, where as the rest belonged to Acanthaceae, Apocynaceae, Asparagaceae, Celastraceae, Cucurbitaceae and Rubiaceae. Vernacular names in "Afaan oromoo", authorities for scientific names, family and habit of the species are provided in appendix 1.

A total of 14 endemic species (Ensermu Kelbessa, unpublished database) and 12 indicator species (Mathooko and Kariuki, 2000) for forest disturbance were identified from the area.

The endemic species include the following

Maytenus addat	*Cynoglossum coeruleum*	*Maytenus gracilipes* ssp *arguta*
Lippia adoensis	*Justicia bizuneshiae*	*Kalanchoe petitiana*
Senecio ochrocarpu	*Thunbergia ruspolii*	*Milletia ferruginea*
Echinops longisetus	*Plectocephalus varians*	*Satureja paradoxa*
Solanecio gigas	*Otostegia tomentosa*	

The indicator species for disturbances of the forest (Mathooko and Kariuki. 2000) include:

Achyranthes aspera	*Triumfetta tomentosa*	*Cyathula uncinulata*
Solanum incanum	*Tagetes minuta*	*Dodonaea angustifolia*
Galinsoga parviflora	*Asparagus africanus*	*Bidens biternata*
Pterolobium stellatum	*Croton macrostachyus*	*Girardinia diversifolia*

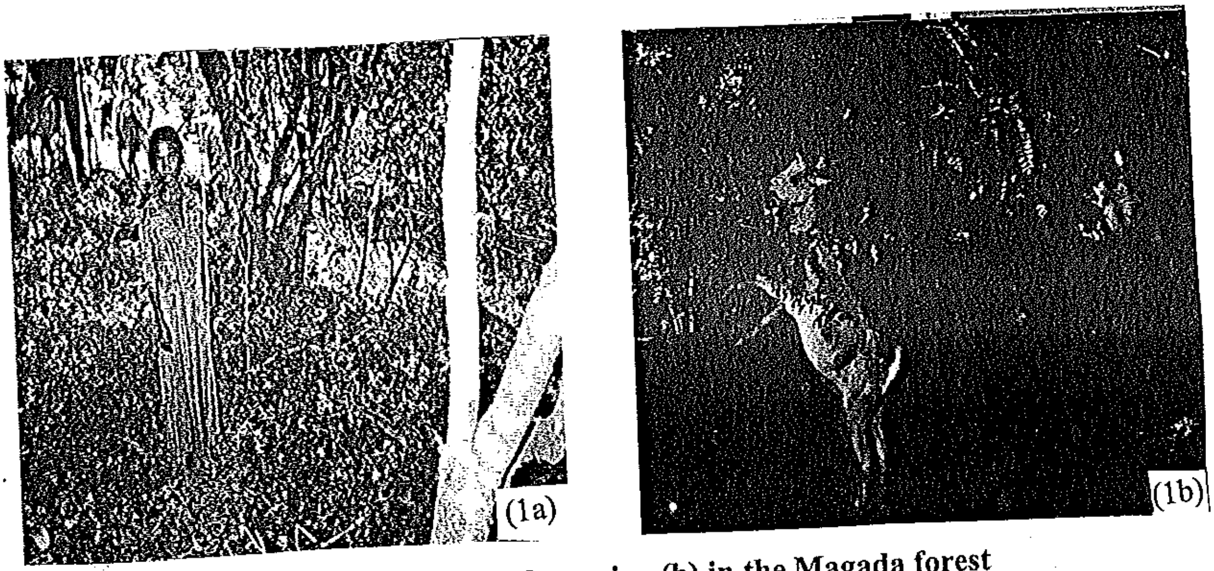

Plate 1: Cattle grazing (a) ; Goat browsing (b) in the Magada forest

Plate 2.
Cattle grazing in the edaphic grassland located in the centre of the forest

4.2 Vegetation Community Classification

The releves were classified using TWINSPAN (Hill, 1979), a standard computer programme for classification of releves on the basis of species composition similarity. Accordingly, seven clusters could be recognized from the TWINSPAN output. The community types distinguished were further refined in a synoptic table where each column represents a community type and species occurrences are summarized as synoptic cover/abundance values. These synoptic values are the product of the species' frequency and average cover/abundance values. The types were named after two of the characteristic and/or dominant species. Synoptic cover/abundance values for the most important species are shown in Table 3. Cluster numbers in the table correspond to numbers of the community types described below.

A description of the seven community type is given as follows:

1. *Pittosporum viridiflorum – Flacourtia indica* type

This community is distributed between altitudes of 1860 – 1915 m. a.s.l. *Pittosporum viridiflorun* and *Apodytes dimidiate* in the tree layer and *Flacourtia indica* and *Lepidotrichilia volkensii* in the shrub layer characterize this community type. *Podocarpus falcatus* and *Ekebergia capensis* are the most dominant tree species in the community. *Rytigynia neglecta, Maytenus arbutifolia, M. grassilipus and Calpurnea aurea are common shrub species. Justicia bizuneshiae* and *Phaulopsis imbricata* are the dominant species in the herb layer.

2. *Grewia ferruginea– Brucea antidysentrica* type

This community is situated between altitudes of 1900 – 1975 m a.s.l. *Podocarpus falcatus* and *Celtis africana* are dominant canopy tree species. *Grewia ferruginea and Brucea antidysentrica are characteristic species.* Associated with this species *Trichilia dregeana, Teclea nobilis, Clutia abyssinica and Rytigynia neglecta* are common tree and shrub species in this community. *Justicia bizuneshiae* and *Phaulopsis imbricata* are the dominant herbs. Whenever shrub is present *Calpurnea aurea* is dominant. Many weeds such as *Bidens biternata*, *Galinsoga parviflora*, *Tagetes minuta*, *Achyranthes aspera* and *Solanum incanum*, which originate from the surrounding farmland, form the field layer.

3. *Millettia ferruginea* – *Cyathula uncinulata* type

This community is situated between altitudes of 1950 and 2050 m a.s.l. In this community *Podocarpus falcatus*, *Celtis africana* and *Cassipourea malosana* are dominant tree species. *Milletia ferruginea* and *Cyathula uncinulata* are the characteristic tree and herb species respectively.

4. *Ekebergia capensis* – *Trichilia dregeana* type

This community is distributed at altitude between 1950 – 2100 m a.s.l. In this community *Ekebergia capensis* is characteristic species. Associated dominant tree species are *Podocarpus falcatus* and *Celtis africana*. Other tree species include *Olea europaea ssp cuspidata*, *Margaritaria discoidea*, *Teclea simplicifolia*, *Psydrax schimperiana* and *Acokanthera schimperi*. The characteristic species in the field layer is *Cyperus fischerianus*. *Justicia bizuneshiae* and *Phaulopsis imbricata* are the dominant species in herb layer.

5. *Olea capensis* – *Olinia rochetiana* type

This community is found distributed between altitudes of 1900 and 1980 m a.s.l. The characteristic tree species of this community is *Olinia rochetiana*. The dominant tree species are *Podocarpus falcatus and Celtis africana*. The dominant shrub species is *Calpurnea aurea*. Other tree and shrub species of this community include *Olea europaea ssp cuspidata*, *Maytenus addat*, *Euclea divinorum*, *Margaritaria discoidea*, *Nuxia congesta*, *Teclea simplicifolia*, *Maytenus undata* and *Acokanthera schimperi*. The characteristic field layer of this community is *Tragia mixta*. Associated herbs include *Plectranthus punctatus and Justicia bizuneshiae* and *Phaulopsis imbricata*.

6. *Olea europaea – Teclea simplicifolia* type

This community is located at the southern side of the forest between 1830 and 1880 m a.s.l. This community is significantly different from the above communities in that, although *Podocarpus falcatus and Celtis africana* are present, the dominant tree species is *Olea europaea ssp cuspidata*. The characteristic tree species of the community is *Schrebera alata*. Other tree species include *Maytenus undata, Psydrax schimperiana, Margaritaria discoidea, Nuxia congesta*, and *Acokanthera schimperi*. *Cyperus nigricans* is the characteristic field layer species. The dominant field layer species are *Justicia bizuneshiae* and *Phaulopsis imbricata*.

7. *Syzygium guineense ssp macrocarpum – Rhus vulgaris* type

This community is found along the southwestern edge of the forest on highly degraded and eroded soil at altitude between 1904 and 1922. The characteristic tree species in this community is *Syzygium guineense ssp macrocarpum* and the characteristic shrub species is *Dodonea angustifolia*. Associated woody species of this community are *Clutia abyssinica, Carisa spinarum* and *Premna schimperi*. The characteristic species in the field layer are *Setaria verticillata* and *Panicum hochstetteri*. *Justicia bizuneshiae* and *Phaulopsis imbricate are* also common in this community.

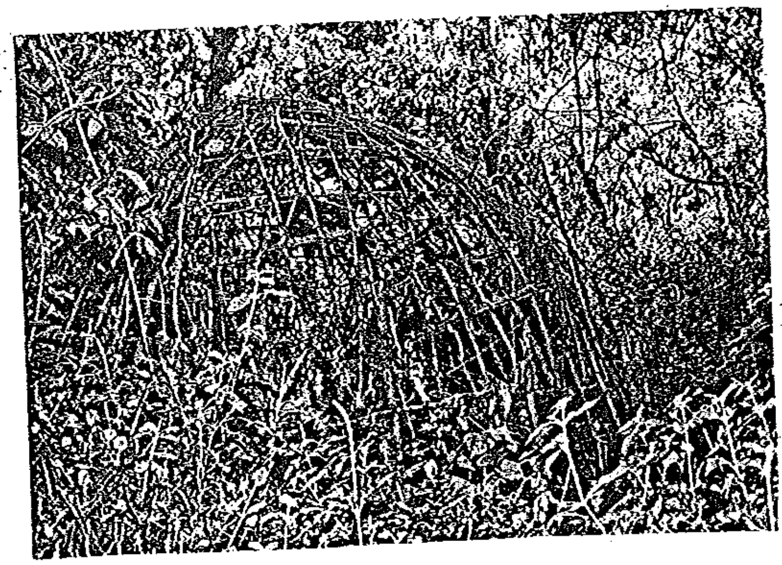

Plate 3
Pastoralist's dry season house in the centre of the Magada forest

Table 3. Synoptic cover/abundance value for species reaching a value of >1.0 in at least one community type. Values in bold refer to occurrences as characteristic and/or dominant species.

Community	**I**	**II**	**III**	**IV**	**V**	**VI**	**VII**
Cluster size	**6**	**11**	**9**	**17**	**10**	**6**	**7**
Flacortia indica	**1.9**	0.0	0.4	0.0	0.0	0.0	0.0
Syzygium guineense	1.6	0.0	0.0	0.4	1.0	0.0	1.7
Pittosporum viridiflorum	**4.7**	0.0	0.0	0.0	0.0	0.0	0.0
Apodytes dimidiata	4.2	0.0	0.0	0.5	0.0	0.0	1.7
Lepidotrichilia volkensii	3.4	0.7	0.0	0.0	1.0	0.0	0.3
Rytigynia neglecta	5.3	2.1	0.4	0.0	0.0	0.0	0.0
Teclea nobilis	3.3	2.6	0.4	1.4	0.4	0.0	0.0
Clutia abyssinica	2.8	1.4	0.0	0.0	0.0	1.7	0.5
Abutilon longicuspe	0.3	3.8	1.8	0.5	0.0	0.0	0.1
Achyranthes aspera	0.0	2.2	4.2	0.3	0.0	0.0	0.0
Grewia ferruginea	0.0	**2.9**	0.0	0.0	0.0	0.0	0.1
Brucea antidysentrica	0.4	**2.1**	0.0	0.0	0.0	0.0	0.0
Clausena anisata	0.3	1.3	0.2	0.0	0.0	0.0	0.0
Cyathula uncinulata	0.5	1.1	**5.5**	0.3	0.3	0.0	0.0
Millettia ferruginea	0.0	0.0	**1.4**	0.0	0.0	0.0	0.0
Cassipourea malosana	5.7	3.8	5.5	3.9	0.9	0.0	0.0
Trichilia dregeana	3.7	2.6	4.2	**3.0**	1.1	0.2	0.0
Croton macrostachyus	5.7	6.0	4.8	5.8	2.8	1.1	2.5
Celtis africana	5.8	6.1	6.8	7.0	6.2	6.3	0.8
Podocarpus falcatus	7.2	7.7	3.9	7.9	7.6	1.5	1.6
Ekebergia capensis	7.0	0.0	0.0	**6.2**	0.5	0.0	0.0
Cyperus fischerianus	0.0	2.3	0.3	3.9	1.2	0.3	0.0
Olea capensis ssp *macrocarpa*	0.5	0.0	0.0	0.8	**4.3**	0.0	0.0
Olinia rochetiana	0.0	0.0	0.0	0.0	**5.1**	0.0	0.0
Maytenus addat	0.1	0.0	0.0	0.1	2.3	0.0	0.7
Euclea divinorum	0.5	0.0	0.0	0.5	3.2	0.1	0.7
Nuxia congesta	0.0	0.0	0.0	0.0	4.7	5.1	2.8
Maytenus undata	0.1	0.0	0.0	0.6	4.1	6.3	0.0
Olea europaea ssp *cuspidata*	0.1	0.0	0.0	2.3	3.9	**7.7**	2.1
Psydrax schimperiana	0.0	0.0	0.0	1.2	4.9	6.5	0.0
Acokathera schimperi	0.1	0.0	0.0	1.8	5.4	6.3	1.7
Teclea simplicifolia	0.0	0.0	0.0	3.6	5.5	**7.0**	0.5
Schrebera alata	0.0	0.0	0.0	0.0	0.0	3.3	0.0
Premna schimperi	0.0	0.0	0.0	0.0	0.7	1.9	3.8
Rhus vulgaris	0.0	0.0	0.0	0.0	0.2	0.0	**4.4**
Syzigium guineense ssp *macrocarpum*	0.0	0.0	0.0	0.0	0.0	0.0	**7.7**
Panicum hochstetteri	0.0	0.0	0.0	0.0	0.0	0.0	7.3
Setaria verticillata	0.0	0.0	0.0	0.0	0.0	0.0	6.7
Dodonaea angustifolia	0.0	0.0	0.0	0.0	0.0	0.0	2.6

Pittosporum viridiflorum – Flacourtia indica type community is located adjacent to livestock watering site. Along the steep slopes of the *Psychotria orophila* is found abundantly (releve 9). *Mimusops kummel*, culturally which is one of the most important tree species is found in this type community. It is used to make stick of 'Abbaa Gadaa' and it is culturally banned to use this tree species for other purposes. However, this tree species has clumped distribution in only one releve (releve 13). This may initiate further study on ecology and reproductive biology of this tree species. In this community particularly along the valley bottoms. disturbance might lead to the establishment of large herbs such as *Girardinia diversifolia, Triumfetta tomentosa, and Rumex nepalensis, and Persicaria setosula.* Large numbers of *Cassipourea malosana* were found topped by humans as for using it as fodder for livestock.

Grewia ferruginea– Brucea antidysentrica type is located relatively nearer to the human settlement areas at the southern edge of the forest. It is subjected to high human interference. People from the surrounding village took their livestock to the forest every day for grazing and returned holding bunches of firewood for their daily use as energy source and finance (income) sources. The local informant told that people in coffee cultivating 'kebeles' (for example 'Fincaa' and 'Qilenso') were supplied firewood in large scale from this forest. Large bunches of firewood for selling is common along the main asphalt road near the village that confirmed the information. As a result of such frequent disturbance by man and his livestock the community has an open canopy. and the trees are scarce and short. Moreover human interference led to the establishment of different climbers. such as *Pterolobium stellatum.* In this type community, although many of them were resprouting. stumps of *Trichilia dregeana. Rytigynia neglecta. Celtis africana* and *Cassipourea malosana* were noted.

Millettia ferruginea - Cyathula uncinulata type is located nearly in the centre of the forest. The peak of this area is situated at an altitude of 2050 m a.s.l. and it is severely disturbed by human interference. To the northern and southern faces of the peak the altitude drops sharply leading to the valley bottoms while the eastern and western faces are flat to gentle slopes. There were cattle pens and pastoralists' dry season houses and around one hectare of the land of this area was devoid of trees, which are indications of pastoralists' settlement during the dry season finding fodder for their cattle (Plate 3). On the steeper slopes, down to the valley bottoms of the southern face *Millettia ferruginea* is found clumped in four releves (releves 16,17,18,and 19). Field layer species grow to their maximum height than any of other communities. These releves showed less human interference. This is because the releves were found on steep slopes where it is difficult for people and their livestock to use the forest product.

According to the local people the other reason for the less human interference was fear from toxic and dangerous animals such as python and snakes. It was in this community where large wild animals are found running here and there which confirmed less human interference. As a result of less human disturbance the logs together with the large pile of litter had been decayed which made the forest floor spongy and fertile. This in turn created a suitable condition for fast circulation of nutrients between the soil and the vegetation.

Type 4 and 5 communities are found in the flat terrain and valley bottoms. They occupied larger area of the forest. The communities have large number of vegetation species in common. Most rare tree species such as *Polyscias fulva, Olea welwitschii, Ficus vasta* and *Albizia schimperiana* are part of these communities. The communities are highly disturbed by human interference with their cattle since they are found in the flat terrain and valley bottoms. Most matured and overmatured canopy tree species are found in these communities.

Community type 6 is found at the lower end of hill slopes. The community is significantly different from the above communities in that the canopy is formed of *Olea europaea* ssp *cuspidata* tree species. Regenerating *Podocarpus falcatus* trees are abundant and form a conspicuous sub canopy. On the other hand *Olea europaea* ssp *cuspidate, Schrebera alata, Nuxia congesta* and *Maytenus undata* showed no sign of regeneration.

Syzygium guineense ssp *macrocarpum* – *Rhus vulgaris* type is found at the lower end of hill slopes and valley bottoms at the southern edge of the forest. At the hill slopes, under the shade of small trees and shrubs large number of seedlings (height of > 1 m and DBH < 2 cm) and sapling (height of < 1 m) of *Olea europaea* ssp *cuspidate and Podocarpus falcatus* were noted. At the valley bottoms large trees of *Syzygium guineense* ssp *guineense* are common and significant numbers of resprouting stumps of this tree species were noted.

In addition to the type communities, the forest of Magada includes large area of edaphic grassland (Plate 2). The vegetation of this area includes *Leucas martinicensis, L. argentea, Thunbergia ruspolli, T. alata, Lantana viburnoides, L. trifolia, Bidens biternata, Cycnium tubulosum, Cycniopsis humifusa, Cynoglossum coeruleum, Plectocephalus varians, Guizotia scabra, Commelina africana, C. benghalensis, C. diffusa, Cyperus nigricans, C. fischerianus,* and *Panicum hochstetteri.* Although this area has natural beauty, its presence inside the forest exerts high pressure on the forest vegetation. It invites human interference. The local communities use this area as communal grazing field so that large numbers of livestock move long distance crossing the forest in all directions to arrive the field. The trampling effect not only damages the standing vegetation but also severely affects the regeneration capacity of the forest vegetation.

To the northern part of the forest, hundreds of hectares of forested land were heavily deforested and replaced by annual and perennial food and cash crops including maize, enset, coffee and chat. Expansion of coffee and chat cultivation in the area, which is driven by economic need of the local people, has brought a new dimension of forest destruction.

Over the years, large tracts of the vegetation of Magada Forest have been subjected to forest grazing (Plate 1), illegal logging (Plate 4), permanent and temporary expansion of human settlement and plantation agriculture. Selective logging in this forest involves the removal of best individuals from the forest with out regard for replacement or regeneration of the exploited stand. This may lead to a shift in species composition increasing the proportion of more light demanding and fast growing trees.

In general, the vegetation of Magada Forest is disturbed through grazing and browsing by domestic livestock, cultivation and other human uses. Trampling, which is one of the main source of disturbances in the forest is not uncommon. Timber harvest, spread of human settlement and the intensification of agriculture are some principal forces behind changes in land use. All disturbed forests are considered as secondary forests, irrespective of the intensity of disturbance (Chokkalingam and de Jong, 2001; UNESCO, 1978).

Regular and frequent disturbance by goats and cattle may lead to abnormally small tree sizes. This further retards regeneration of the trees and shrubs. Human disturbances in the forest are manifested by the presence of abundant *Achyranthes aspera* population in the herb layer. This species is known to be indicator of previous human disturbance (Mathooko and Kariuki, 2000). Most of the community types revealed more evidence of past exploitation (stumps and pit sawing). Pressure on the resources from human population could intensify and impose more rapid and more degenerative changes. Recognizing these issues as a possible future scenario underlines the need for management interventions to increase the quality of regeneration being recruited and to accelerate the growth of the young plants already present.

Plate 4: Evidence of logging in the Magada Forest

4.3 Vegetation Structure

4.3.1 Tree density

The density of tree species of the Magada Forest is shown in Table 4. The number of individuals with DBH greater than 2 cm is 959 per hectare (959/ha). Out of these those with DBH greater than 10 cm are 608 per hectare (608/ha) and the remaining 351/ha were undergrowth and juveniles (2 cm < DBH < 10 cm). *Podocarpus falcatus* (10.41 %), *Celtis africana* (20.05 %), *Olea europaea* ssp. *cuspidata* (4.97 %) and *Cassipourea malosana* (6.88%) are the four most abundant tree species of the forest, which comprise 42.31 % of the density of trees of DBH greater than 10 cm.

Comparison of the density of trees in the Magada Forest with other Afromontane forests in Ethiopia is shown in Table 5. The Magada Forest is less dense in trees over 10 cm DBH than Chilimo Forest and is less dense in trees over 20 cm DBH than Dodolla Forest while it is denser with trees over 2 cm DBH than Dodolla Forest and with trees over 10 cm DBH than Menagesha, Wof-Washa and Denkoro Forests. The ratio of density of one DBH class to the other DBH class gives a measure of the distribution of the size class (Grubb *et al.*, 1963). The ratio of density greater 10 cm (DBH > 10 cm) to the density greater than 20 cm (DBH >20 cm) for the Magada Forest is 1.8. Therefore, the $^{a}/_{b}$ ratio in the Magada Forest indicates the predominance of small sized individuals. This is a result of excessive cutting, which took place here a long time ago.

Table 4. Density of trees with DBH greater than 2 cm and 10 cm per hectare

Tree Species	Density of individuals per hectare	
	DBH ≥ 2	DBH≥10
Acokanthera schimperi	26.09	13.64
Allophylus abyssinicus	4.04	2.36
Apodytes dimidiata	9.26	7.58
Cassipourea malosana	121.04	66.50
Celtis africana	192.26	103.54
Cordia africana	1.18	1.18
Croton macrostachyus	50.17	33.84
Ekebergia capensis	35.86	34.51
Euclea divinorum	20.37	11.45
Ficus thonningi	4.88	2.19
Margaritaria discoidea	21.89	9.09
Maytenus undata	51.68	42.09
Milletia ferruginea	27.27	15.15
Mimusops kummel	6.57	5.39
Nuxia congesta	18.35	12.79
Olea capensis ssp. *macrocarpa*	16.50	14.65
Olea europaea ssp. *cuspidata*	51.85	47.64
Olea welwitschii	2.36	2.36
Olinia rochetiana	15.66	6.73
Pittosporum viridiflorum	5.05	1.52
Podocarpus falcatus	99.83	78.11
Prunus africana	1.85	1.85
Psychotria orophila	8.42	2.69
Psydrax schimperiana	30.47	22.56
Schrebera alata	19.53	17.00
Syzygium guineense ssp *guineense*	8.75	8.08
S. guineense ssp. *macrocarpum*	86.87	45.62
Trichilia drageana	20.71	14.48
Total density/ hectare	**958.75**	**608**

Table 5. Comparison of tree density (no/ha) of the Magada Forest and other five afromontane Forests in Ethiopia; A=for trees > 10 cm DBH; B = for trees > 20 cm DBH; $^{A}/_{B}$ = ratio between A and B

Forest	A	B	$^{A}/_{B}$
Magada	608	332	1.8
Chilimo[1]	638	250	2.6
Menagesha[1]	484	208	2.3
Wof-Washa[1]	329	215	1.5
Dodolla[2]	521	351	1.5
Denkoro[3]	526	285	1.8

Sources: [1] =Tamrat Bekele (1993); [2] = Kitessa Hundera (2003); [3] = Ayalew Abate (2003)

4.3.2 DBH (Diameter at breast height)

The distribution of trees in different DBH class is shown in Table 6. It is shown that 45.4 % of the individuals have DBH between 10 and 20 cm, 44.1 % have DBH between 20 and 50 and 10.5 % of the individuals have DBH greater than 50 cm.The Magada Forest is composed of large proportion of small sized trees. Trees with DBH between 2 and 20 cm attain 65.4 %. The Magada Forest has higher proportion (41.1 %) of trees with DBH between 20 and 50 cm when compared to forests of Jibat (39.5 %), Chilmo (36.8 %), Menagesha (32.8 %), and Wof-Washa (31.7 %) (Tamrat Bekele, 1993), and Dodolla (20.3 %) (Kitessa Hudera, 2003).

Percentage distribution of trees in DBH classes shows nearly the same rank for the Magada and Denkoro Forests (Abate Ayalew, 2003).

A very small proportion (i.e. < 1 %) of individuals attains DBHs of > 140 cm. The same has also been observed in Jibat Forest (Tamrat Bekele, 1993). This indicates that there are more individuals with lower DBH class in Magada Forest than in Dodolla and Wof-Washa Forests. High total density but low density of trees greater than 20 cm diameter at breast height (DBH), low basal area and short trees with small diameters are the main structural characteristics typifying secondary forest (Brown and Lugo, 1990). Therefore, the very large proportion of small sized individuals and small number of big trees indicates that the Magada forest is in the stage of secondary development.

Table 6. Percentage distribution of trees in DBH class (cm) in the Magada Forest

DBH (cm)	Dens/ha	%
10 - 20	276	45.39
20 - 50	268	44.08
50 – 80	38	6.25
80 – 110	16	2.63
110 – 140	6	0.99
> 140	4	0.66
Total	**608**	**100.00**

4.3.3 Height

The height class distribution of trees is shown in Figure 5. Although there is selective cutting of tree species at certain height (15-18 m and 21-24 m) the Magada Forest is well represented by individuals distributed in all height classes, including trees having a height greater than 30 m. The forest has high proportion of (> 40 %)of individuals in the lower height classes (6 – 12 m). Young trees (12 – 21 m classes) are represented by 36.10 %. Height reveals something about the age of a plant. Old and big individuals (> 27 m) are represented by about 9 %. Part of the upper canopy is largely formed of *Podocarpus falcatus* (41.7 %), *Celtis africana* (10.8 %), *and Ekebergia capensis* (8.9 %). The height shows similar trend as that of DBH class distribution. This indicates that the forest contains large proportion of small to medium sized individuals, which in turn indicating that the forest is in secondary stage of development.

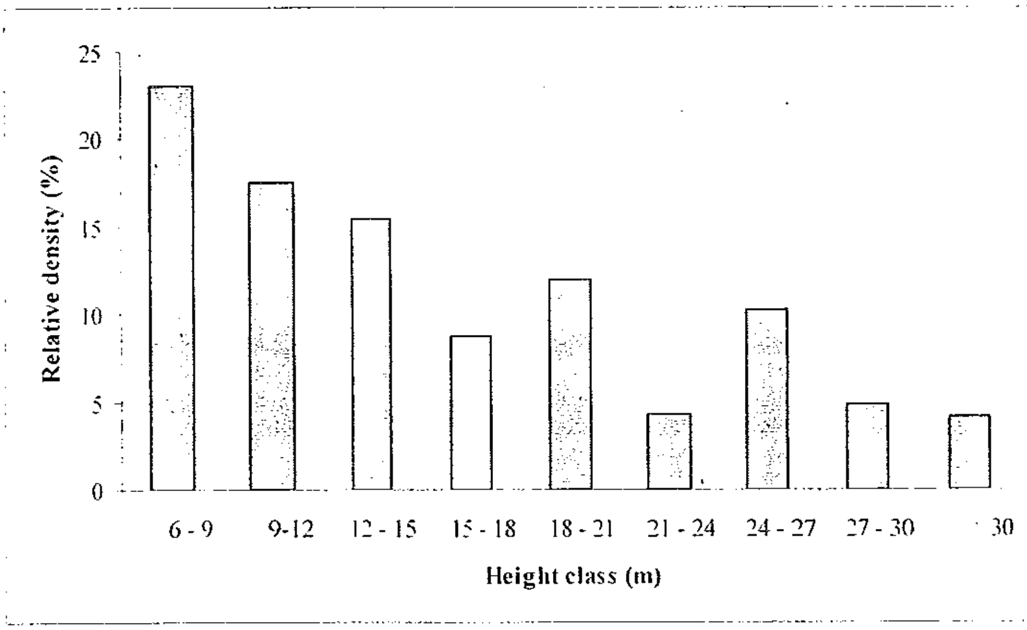

Figure 5. Height-class (m) distribution of trees in the Magada Forest.

4.3.3 Basal area

The basal area of the Magada Forest is shown in Table 7. The total basal area of the forest was about 68.5 m^2/ ha. The basal area for individuals greater than 10 cm DBH was 67.27 m^2/ ha (or 98.2% of the total basal area). Comparison of the contribution of the different DBH classes is shown in Figure 6. There is a considerable decrease in the number of individuals with increasing DBH. Most of the trees with DBH less than 50 cm attain 89.5 % of the total density while those that are relatively bigger (larger) trees are only 9.5 %. Although the trees belonging to higher DBH classes (> 50 cm) are fewer, they contribute higher (57.4 %) to the total basal area. Many individuals in the lowest DBH classes are of small stature; hence the basal area contributed by these classes is small. The basal area contribution by the lowest and the highest DBH classes in any one forest is very low as compared to the contributioin of the intermediate classes. irrespective of the state of successional stage of the forest.

Table 7. Basal area (m²/ha) of trees in the Magada Forest

Species	Ba/ha	%
Acokanthera schimperiana	0.7	1.02
Allophylus abyssinicus	0.13	0.19
Apodytes dimidiata	0.67	0.98
Cassipourea malosana	1.53	2.23
Celtis africana	8.44	12.32
Cordia africana	0.01	0.01
Croton macrostachyus	1.83	2.67
Ekebergia capensis	5.88	8.58
Euclea divinorum	0.37	0.54
Ficus thonningi	0.24	0.34
Margaritaria discoidea	0.37	0.54
Maytenus undata	1.32	1.93
Millettia ferruginea	1.14	1.66
Mimusops kummel	0.28	0.41
Nuxia congesta	0.65	0.95
Olea capensis ssp. *macrocarpa*	1.62	2.36
Olea europaea ssp. *cuspidata*	6.49	9.47
Olea welwitschii	0.32	0.47
Olinia rochetiana	0.19	0.28
Pittosporum viridiflorum	0.04	0.06
Podocarpus falcatus	29.05	42.40
Prunus africana	0.08	0.12
Psychotria orophila	0.06	0.09
Psydrax schimperiana	1.42	2.07
Syzygium guineense	1.50	2.18
Syzigium guineense ssp. *macrocarpum*	0.89	1.30
Schrebera alata	1.54	2.25
Trichilia drageana	1.77	2.58
Total	**68.52**	**100.00**

The density distribution of the five tree species (Table 8) does not follow the same trend as that of the basal area. Species with the highest basal area/ha donot always have the highest density, indicating size differences between the species (e.g. *Ekebergia capensis and cassipourea malosana*).

Table 8. Basal area and density distribution of five tree species in Magada Forest

Species	Basal area		Density	
	m²/ha	%	Stem/ha	%
Podocarpus falcatus	29.05	42.40	99.83	10.41
Celtis Africana	8.44	12.32	192.26	20.05
Olea europaea ssp. *Cuspidate*	6.49	9.47	51.85	5.40
Ekebergia capensis	5.88	8.58	35.86	3.74
Cassipourea malosana	1.53	2.23	121.04	12.6

4.3.5 Frequency

The frequency of 28 tree species is shown in Table 10. Frequency indicates how the species are dispersed and is an ecological meaningful parameter for species represented by several individuals in a plot. Small frequency suggests a clumped distribution of a species while larger frequency indicates wide distribution of a species. The three most frequently occurring tree species in Magada Forest are *Celtis africana* (93.9 %). *Podocarpus falcatus* (92.4 %) and *Croton macrostachyus* (87.9 %). *Mimusops kummel* (1.5 %) is the least frequent tree of the forest. *Cordia africana* and *Prunus africana* are very rare and less frequent tree species with relative frequency 4.5 % and 7.6 % respectively. This indicates that *Celtis africana* (93.9 %), *Podocarpus falcatus* (92.4 %) and *Croton macrostachyus* (87.9%) are widely distributed through out the forest while *Mimusops kummel* (1.5 %) has clumped distribution.

Table 9. Frequency of tree species in the Magada Forest

SPECIES	Frequency (FR)	%FR	Relative FR
Acokanthera schimperi	29	43.9	4.5
Allophylus abyssinicus	11	16.7	1.7
Apodytes dimidiata	17	25.8	2.6
Cassipourea malosana	47	71.2	7.2
Celtis africana	62	93.9	9.5
Cordia africana	3	4.5	0.5
Croton macrostachyus	58	87.9	8.9
Ekebergia capensis	28	42.4	4.3
Euclea divinorum	20	30.3	3.1
Ficus thonningi	17	25.8	2.6
Margaritaria discoidea	41	62.1	6.3
Maytenus undata	21	31.8	3.2
Millettia ferruginea	5	7.6	0.8
Mimusops kummel	1	1.5	0.2
Nuxia congesta	27	40.9	4.1
Olea capensis ssp. *macrocarpa*	20	30.3	3.1
Olea europaea ssp. *cuspidata*	36	54.5	5.5
Olea welwitschii	8	12.1	1.2
Olinia rochetiana	14	21.2	2.2
Pittosporum viridiflorum	11	16.7	1.7
Podocarpus falcatus	61	92.4	9.4
Prunus africana	5	7.6	0.8
Psychotria orophila	4	6.1	0.6
Psydrax schimperiana	22	33.3	3.4
Schrebera alata	20	30.3	3.1
Syzygium guineense ssp *guineense*	13	19.7	2.0
Syzygium guineense ssp. *macrocarpum*	8	12.1	1.2
Trichilia drageana	42	63.6	6.5
Total	651	986.4	100.0

4.3.6 Importance value index (IVI)

Importance value index gives a more realistic figure of dominance from the structural standpoint (Curtis and McIntosh. 1951). The importance value index for the tree species of Magada Forest is given in Table 11. The six dominant tree species. *Podocarpus falcatus, Celtis africana, Cassipourea malosana, Olea europaea* ssp *cuspidata, Croton macrostachyus* and *Ekebergia capensis* comprised 60.06 % of the IVI in the forest. The fact that much of the IVI values were attributed to a few tree species alone had been observed in Tiera Firme Forest. Venezuela. by Uhl and Murphy (1981), Southwest Forest. Ethiopia. by Abayneh Derero *et al*., (2003) and Dodolla Forest. Ethiopia. by Kitessa Hundera (2003).

The high importance value indices of the two species, *Podocarpus falcatus* and *Celtis africana* are highly attributed to their abundance, distribution and basal area in the forest. In total these two species contributed 30 % of the total number of stems in the forest. They are the most frequent (found over 92 % of the sampled area in the forest) and they have the highest basal areas, 29.05 m^2/ha and 8.44 m^2/ha. respectively. These two tree species contributed 54.7 % of the total basal area in the forest. The high IVI value of *Cassipourea malosana and Croton macrostachyus* is highly attributed to the fact that they have high density and high relative frequency. These two tree species have the lowest basal area compared to the other four most dominant tree species. *Podocarpus falcatus. Celtis africana. Olea europaea* ssp *cuspidata*, and *Ekebergia capensis*. The high IVI values of the other two tree species. *Olea europaea ssp cuspidata*, and *Ekebergia capensis* are highly attributed to the fact that they have high basal areas. 6.49 m^2/ha and 5.88 m^2/ha respectively that contributed 18.05 % of the total basal area in the forest.

Table 10. Importance value index of tree species in the Magada Forest

Species	IVI
Acokanthera schimperii	8.19
Allophylus abyssinicus	2.30
Apodytes dimidiata	4.56
Cassipourea malosana	22.08
Celtis africana	42.36
Cordia africana	0.59
Croton macrostachyus	16.81
Ekebergia capensis	16.33
Euclea divinorum	5.73
Ficus thonningi	3.46
Margaritaria discoidea	9.12
Maytenus undata	10.54
Millettia ferruginea	5.27
Mimusops kummel	1.24
Nuxia congesta	7.01
Olea capensis ssp.*macrocarpa*	7.15
Olea europaea ssp. *cuspidata*	20.40
Olea welwitschii	1.94
Olinia rochetiana	4.06
Pittosporum viridiflorum	2.27
Podocarpus falcatus	62.17
Prunus africana	1.07
Psychotria orophila	1.580
Psydrax schimperiana	8.630
Schrebera alata	7.350
Syzgium guineense ssp *guineense*	5.093
Syzgium guineense ssp. *macrocarpum*	11.580
Trichilia drageana	11.194
Total	300.000

4.3.7 Species population structure

The population structures of all tree species found in the sample plots were analysed. For the description of the size structure of populations of different species it is not very accurate to use uniform diameter classes for the construction of frequency diagrams. In most studies the same size- class limits are used for small sized species as for large sized ones. This results in a differentiation between species with a different population structure. According to Bongers *et al.* (1988) it is better to construct a separate diagram for each species, taking into account the population size and the maximum DBH obtained.

Five general patterns, suggesting different population dynamics in the forest were distinguished. These patterns are: (1) inverted 'J' shaped curve: (2) a broken up inverted 'J' shaped curve: (3) a Gauss type curve; (4) 'J' shaped curve and (5) U-shaped curve.

Representative patterns depicting different population structure are shown in Fig. 7. Species fitting to the inverted 'J' shaped curve included *Podocarpus falcatus, Celtis africana, Croton macrostachyus, Cassiporea malosana, Psydrax schimperi, Margaritaria discoidea, Olinia rochetiana, Psychotria orophila, Euclea divinorum,* and *Syzygium guineense* ssp *macrocarpum. Trichilia dregeana, Pittosporum viridiflorum, Millettia ferruginea* and *Allophylus abyssinicus* revealed a broken up inverted 'J' curve type. *Ekebergia capensis, Syzygium guineense* ssp *guineense. Olea europaea* ssp *cuspidata, Olea capensis* ssp *macrocarpa, Schrebera alata* and *Apodytes dimidiata* showed Gauss type curve. *Acokanthera schimperi and Ficus thonningi* followed U-shaped curve while *Maytenus undata, Nuxia congesta, Mimusops kummel, Cordia africana, Prunus africana and Olea welwitschii* revealed 'J' curve type pattern.

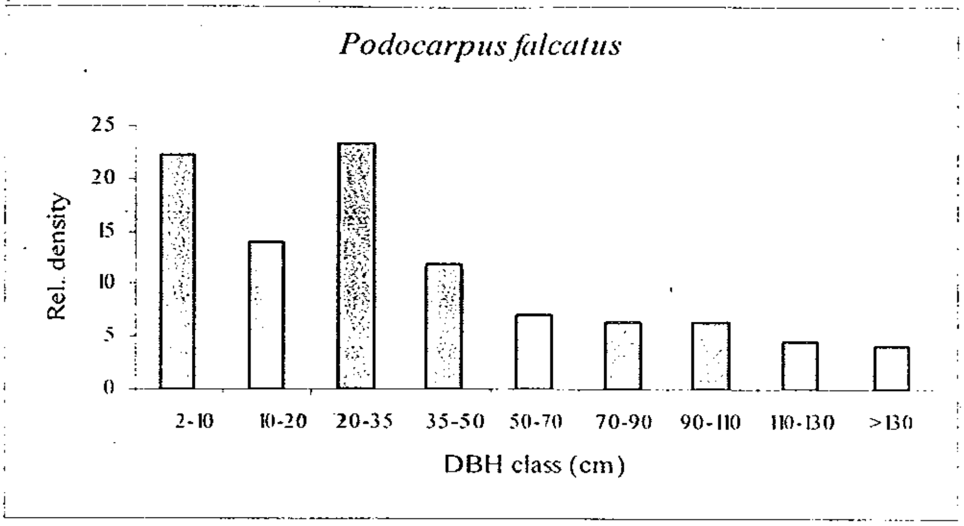

Fig. 7a. Population structure of *Podocarpus falcatus*

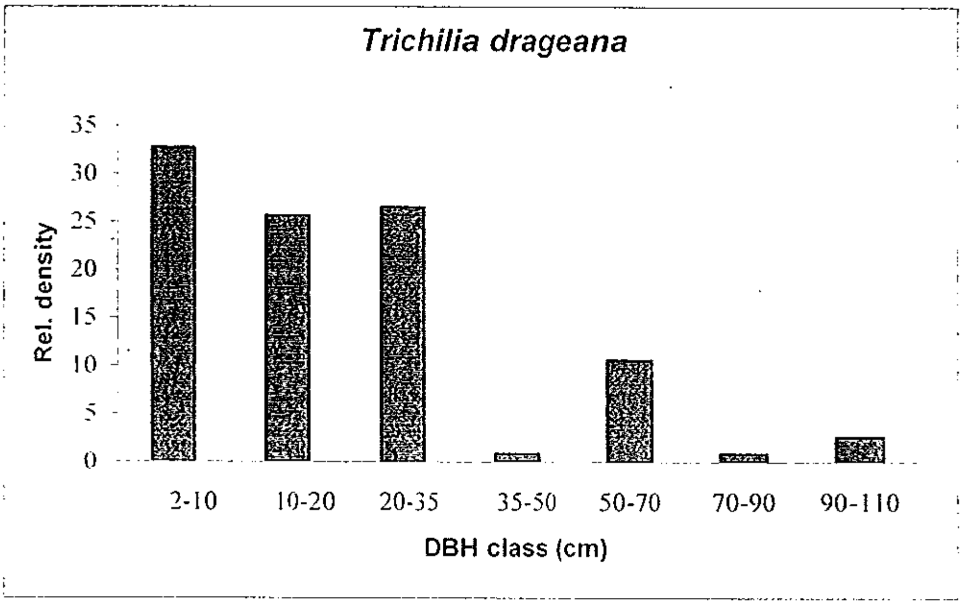

Fig.7b. Population structure of *Trichilia drageana*

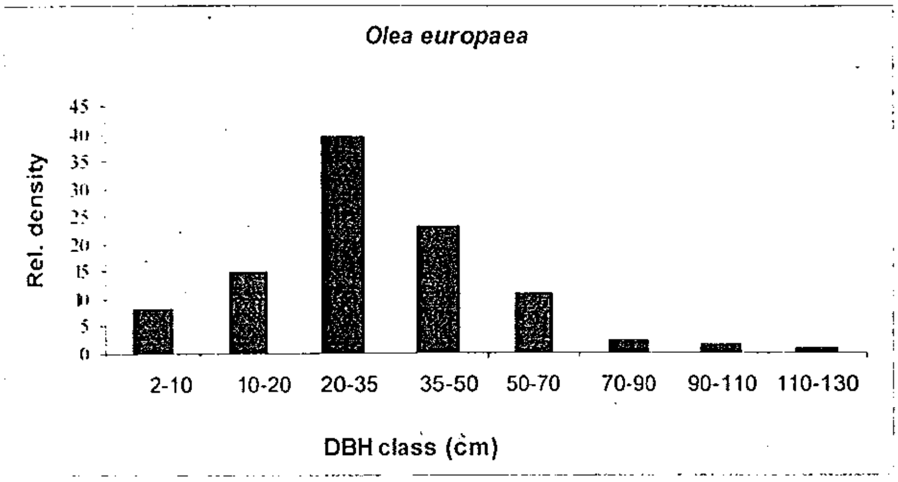

Fig. 7c. Population structure of *Olea europaea*

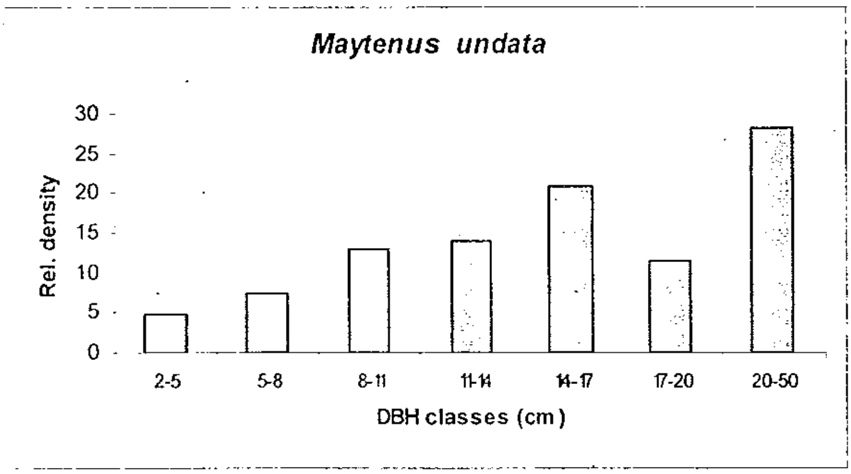

Fig. 7d. Population structure of *Maytenus undata*

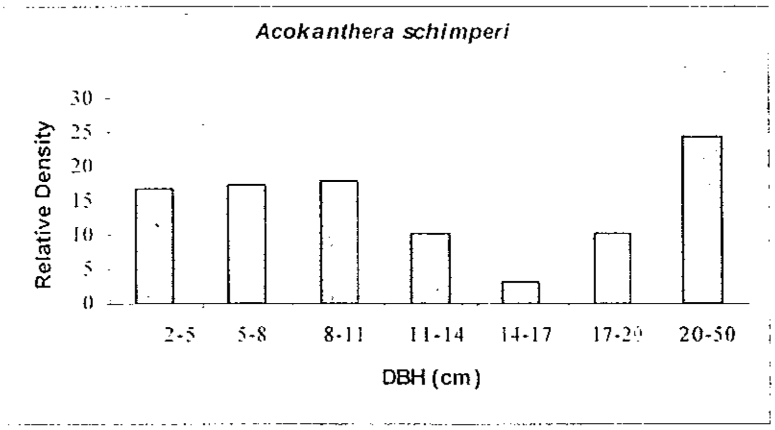

Fig. 7e. Population structure of *Ackocanthera schimperi*

Figure 7. Five representative patterns of frequency distribution of tree density value over DBH classes in the Magada Forest

The tree species examined for their population structures showed different patterns because of environmental and inherent factors as well as human intervention. Species represented by the first type structure (inverted 'J' curve) indicates good regeneration and continuous recruitment status, and their density decreases rather regularly with increasing size (Fig. 7a). However there is selective logging of *Podocarpus falcatus* at the second and forth DBH classes. Hall and Swain (1976) explained that canopy species typically fail to regenerate in the same area of forests as the adult trees, and that in consequence the canopy in any given stand would change from generation to generation. Similarly it was observed that most of the regeneration of canopy trees in Magada Forest, *Podocarpus falcatus* in particular, was restricted to areas of heavy shrub cover.

Species represented by the broken up inverted 'J' curve structure also show good regeneration but discontinuous recruitment into larger size classes (Fig. 7b). One of the possible reasons for the discontinuity in this type of structure could be the local disturbance (natural as well as human). This is particularly true for *Trichilia dregeana* as it is among the species that were highly affected by the disturbance in the forest. The same could be true for the breaks in the structure of *Allophylus abyssinicus, Pittosporum viridiflorum* and *Millettia ferruginea.*

A Gauss type distribution, that included *Ekebergia capensis, Olea europaea* ssp *cuspidata, Olea capensis* ssp *macrocarpa* and *Syzygium guineense* ssp *guineese*, indicates poor regeneration and recruitment (Fig. 7c). These species are among the highly affected species by the local disturbance. Particularly *Syzygium guineense* and *Ekebergia capensis* are the most highly exploited tree species for construction purposes. They are on the verge of disappear once from the forest if the present trend continues.

The fourth structure (Fig. 7d) included *Maytenus undata, Mimusops kummel, Cordia africana, Prunus africana, Nuxia congesta* and *Olea welwitschii*. This pattern shows J-shaped structure where frequency is very low in the lowest DBH classes and gradually increases towards the higher DBH classes and it also includes very big and old individuals that are no longer reproducing or regenerating. This pattern indicates poor regeneration.

Acokanthera schimperi and *Ficus thonningi* (Fig. 7e) showed U-shaped pattern. The pattern tells that the frequency is high in the first three DBH classes, a gradual decrease in the number of individuals towards the medium classes, and then a subsequent increase in frequency towards the high DBH classes. Such structure does not actually occur in nature; it is somewhat artificial. It probably indicates selective cutting and removal of medium sized individuals of these species.

Studies on forest dynamics, particularly patterns of population structure of the species in the forest enrich our knowledge that can help to understand the status of species, and thereof, natural regeneration (Harper, 1977). Population structure of species can show whether the population has a stable distribution that allows continuous regeneration to take place or not. If regeneration were taking place then the species would have a stable population distribution with reverse J in shape, which is an indicator of healthy regeneration. Such population structure (reverse"J" shape) is common in natural forests where external disturbance is limited. However, several forests and forest tree species of Ethiopia had shown variation in their population structure, for example, some with little or no recruitment at the middle or upper size classes implying hampered regeneration as a result of previous disturbance (Tamrat Bekele, 1993). Human caused disturbance such as intensive removal of trees for timber, construction and fuel can place significant pressure on regeneration status of the selectively removed species. Population structures of trees in the forest and factors affecting their potential regeneration have significant implications to the management, sustainable utilization and conservation of the forest.

4.4 Phytogeographic Comparison

The total species that were recorded from the Magada Forest is not assumed to be complete since it was a single season collection. More species will probably be added as the taxonomic work on the flora proceeds. This would particularly be more important for herbaceous species, which need repeated collection to produce a more complete list.

Among the seven community types described by Friis (1992), Magada Forest represents the undifferentiated Afromontane ones. This forest represents both transitional rain forest and undifferentiated Afromontane forest consisting of dominant tree species like *Olea europaea ssp. cuspidata* and *Croton macrostachyus* (Friis, 1992). From the present analysis however, it was understood that the forest has some elements of Afromontane rain forest and some species of undifferentiated ones. Only one of the species, *Ehretia cymosa* is Guineo- Congolian floral element is found in the Magada Forest. The presence of this species has to do with the close proximity of the forest to the lowland floral region, and the presence of suitable habitats at lower altitudes in the forest.

Olea welwitschii and *Prunus africana* that were considered typical species of moist montane forest (Linda and Morrison, 1974) were found very rarely in the forest. On the other hand, Afromontane endemics such as *Olea europaea ssp. cuspidata, Podocarpus falcatus, Apodytes dimidiata, Olinia rochetiana* and *Maytenus undata* are present in the forest. According to Coetzee (1978), cited in Tamrat Bekele (1993), *Olea europaea* ssp. *cuspidata* and *Maytenus undata* are known to possess strong xeromorphic features that enable them to survive during severe dry conditions.

In addition to the Afromontane endemics, other species belonging to connecting elements have also been identified in the Magada Forest. These include the 'ecological transgressors', such as *Cassipourea malosana* and *Ekebergia capensis*, and forest pioneer connecting species, e.g. *Clausena anisata* and *Bersama abyssinica.* These species can be found abundantly over the wider geographical areas of the forest. Some of the montane forest species listed from Magada Forest have also been recorded from shrub land vegetation of the central plateau of Ethiopia (Zerihun Woldu and Backeus, 1991). These species include *Olea europaea ssp. cuspidata, Pittosporum viridiflorum, Prunus africana,* and *Maytenus arbutifolia.* These species must have a high tolerance of variations in temperature, humidity and moisture availability to be able to survive in different vegetation types such as forest shrub lands (Tamrat Bekele, 1993). This shrub land type has been described as secondary community that has expanded from lower altitude and drier sites as the forest gradually disappeared (Zerihun Woldu and Backeus, 1991).

The forest of Magada is compared with other eight Afromontane forests in Ethiopia. The forests included in the comparison are Bonga, Jemjem, Jibat, Chilimo, Menagesha, Wof-Washa, Denkoro and Dodolla Forests.

Bonga Forest is found in southwestern Ethiopia within the geographical location of 07° 18'- 07° 26'N and 35° 53'- 36° 36'E. The forest lies at an altitude between 1500 to 3000 m a.s.l. (Abayneh Derero *et al.*, 2003). Jemjem Forest is located in Borana (Guji) Zone, southern Ethiopia within the geographical location of 38° 5' and 39° 29'E – 5° 32' and 5° 53'N and lies at an altitude between 1570 and 1940 m a.s.l. (Hailu Sharew, 1982). Jibat Forest is located in western Shewa about 200 km west of Addis Ababa. The forest extends between ca 2000 and 2950 m a.s.l. Chilimo Forest is situated 90 km west of Addis Ababa, very near to the small town Ghinchi and lies at an altitude between ca. 2400 and 2900 m a.s.l. Its geographical location is 38° 35'E, and 9° 00'N. It is situated at an altitude between ca. 2300 and 3000 m a.s.l. The Wof-Washa Forest is situated on the slopes of the eastern escarpment of NW Highlands. The forest is located 39° 45'E 9° 35'N. It lies at an altitude between 2100 and 3600 m a.s.l. (Tamrat Bekele, 1993). Denkoro Forest is located in south Wollo and lies at altitudes between 1500 to 3500 m a.s.l. (Abate Ayalew, 2003). The Dodolla Forest is located at the northern part of Bale Mountains and situated at an altitude between 2400 and 3600 m a.s.l. (Kitessa Hundera, 2003).

The comparison is based on the similarities in species distribution. A similarity analysis was carried out based on the presence of tree and shrub species in order to evaluate the relationship between Magada and other forests. The similarity index used is Sorensen's Similarity Coefficient (S) 2c/(a + b), where 'c' is the number of species shared by the forest compared, 'a' is the number of species in one forest, 'b' is the number of species in the other forest. The results of the analysis are presented in Table 12.

Table 11: Floristic similarity between the Magada Forest (with 91 tree and shrub species) and eight other forests in Ethiopia. N= number of species included in the comparison. C= number of species in common. S= Sørensen's Coefficient of Similarity.

Forest	N	C	S
Bonga	51	29	0.42
Chilimo	30	19	0.31
Denkoro	51	23	0.30
Dodolla	36	14	0.22
Jemjem	54	38	0.80
Jibat	52	30	0.40
Menagesha	30	16	0.26
Wof-Washa	27	15	0.25

The forest of Magada shows a higher similarity to Jemjem than to any other forest. Considering the geographical proximity of these forests to each other and the similar human influence they have been exposed to, it is expected that they will not show much variation. Magada Forest has also close similarities with Chilimo Forest, Denkoro Forest, Jibat Forest and Bonga Forest. Its similarity with Bonga and Jibat Forests could be because Magada Forest has moist forest characteristics and high species diversity. The Magada Forest is situated close to Dodolla forest. However it shows the least similarity in species composition. This is probably for three reasons. The first reason is the difference in altitudinal range at which Magada forest is located (1750 – 2100 m a.s.l.) and Dodolla forest is situated (2400 – 3600 m a.s.l.). This in turn affects vegetation distribution. The second reason may be the difference in success ional stage of development. The Dodolla Forest is in late secondary stage of development where as Magada Forest is in early stage of secondary development. The third reason is that the

Magada Forest is in early stage of secondary development. The third reason is that the Dodolla Forest is poor in species composition (Kitessa Hundera, 2003) compared to the Magada Forest.

Although the Magada Forest is located far away from the Denkoro Forest the reason for the similarity may be because the Magada Forest is located with in the altitudinal range of the Denkoro Forest (1500 – 3500 m a.s.l.). The other reason may be, both Magada and Denkoro Forests are under similar secondary stage of development and both are rich in their floristic composition. Finally from the floristic comparison between Magada Forest and the forest types of Friis (1992), Magada Forest represents undifferentiated Afromontane forest.

5. CONCLUSION

The floristic description indicated the presence of high species diversity (64 families represented by 197 species) in the forest. Out of this 14 endemic species, which are already in the red List of IUCN, and indicator species for forest disturbances have been recorded. The indicator species showed that the forest was under degradation and had not got emphasis by the scientific community and concerned department that should manage the forest.

Structural description on Magada Forest based on tree density implied the predominance of small sized to medium sized individuals and the limited occurrence of large woody species. The height and diameter structures support the notions of stratification of species per unit area. The very high abundance of small trees, young trees and shrubs can indicate that the forest is highly disturbed or is a secondary forest.

Podocarpus falcatus is the most dominant canopy tree species in the forest area. Other well-represented species were *Celtis africana*, *Cassipourea malosana*, *Olea europaea* ssp *cuspidate* and *Croton macrostachyus*.

Analysis of species population structure pointed out the variability of population dynamics in the forest. It confirmed at least the existence of two major types of woody species: species able to regenerate in the forest understory and large and old trees with difficulties to reproduce in the understory environments.

In most parts of the forest evidence of past exploitation (e .g. stumps and pit sawing) have been observed. The vegetation of the Magada Forest is disturbed through grazing and browsing by domestic livestock, cultivation and other human uses. This further retard regeneration processes of the trees and shrubs. Pressure on the resources from human populations could intensify and impose more rapid and more degenerative changes. Recognizing these issues as possible future scenario underlines the need for management intervention to increase quality of regeneration being recruited and to accelerate the growth of the young plants already present.

The phytogeographic description indicated that the floristic composition of Magada Forest compared with the eight forests of Ethiopia revealed that the forest is very close to the floristic composition of Jemjem Forest. This was because the forests are found in similar geographic location and climatic conditions as well as similar human influences they have been exposed to. Magada Forest has also better similarities with Chilimo and Denkoro Forests. The similarity of the Magada Forest with Bonga Forest and Jibat Forest could be accounted for the fact that the Magada Forest has some moist forest characteristics and high species diversity.

6. RECOMMENDATION

Effective utilization of the forests on sustainable basis requires effective management. Since the Magada Forest is one of the National Forest Priority Areas (NFPAs) and is distinctive in that it is *Podocarpus* dominated coniferous forest, due attention has to be given to its conservation and management. Therefore the following recommendations are made to meet these objectives.

- Permanent boundary demarcation should be carried out to serve as a basis for protection. The forest boundary should be aliened to take account of existing land use.

- For improving regeneration status, protection from livestock might be needed. At the same time of applying management practices for the forest, the activities of pastoralists, such as rotation of browsing and grazing zones or planting fodder trees among woodlands, should be considered and the stakeholders should be involved in planning appropriate action.

- Forest areas, which are eventually young forest, should be protected from excessive and damaging disturbance, particularly logging and livestock browsing until fully-stocked.

- Excessively exploited areas of the forest, especially areas with no *Podocarpus falcatus* trees (with in 20 m), should be rehabilitated through protection and possibly enrichment planting of indigenous trees and effort to be made to prevent further widening of the gaps.

- In an area of the forest, which constitutes very old forest (many >120 DBH trees), selective cutting of old trees may be effective to promote growth of regeneration and juvenile trees (although cutting of *Podocarpus falcatus* tree is currently suspended). However, it should be done with careful regard to keeping a satisfactory size class distribution and assuring no damage to regeneration or juvenile trees.

- There should be full use of local peoples' knowledge for exploring appropriate management option and fostering peopples' interest and motivated engagement in forest conservation and progress towards long-term resource security

- Involving of local people would be effective in management of the forest for being sensitive to changes in the forest and applying appropriate practices in right time.

- Investigation and monitoring should be continued to understand the changes in population structures in broad areas of Magada Forest.

- For further management work, studies on alternative propagation methods such as nursery practices and coppice system are needed. Association of plants should be investigated to increase the production and enable interplantation work.

- To extend silviculture knowledge and experiences there should be permanent research plot established and maintained by forestry research center in Ethiopia.

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APPENDICES

Appendix 1. List of species in Magada Forest. T= Tree; T/S= Tree/Shrub; S=Shrub; H=Herb; C=Climbers; G=Graminoid; F=Fern; E= Epiphyte; SP= Semi-parasit

Scientific Name	Local Name	Family	LF
Abutilon longicuspe Hochst. ex A. Rich.	Arxumme keraabaa	Malvaceae	H
Acacia abyssinica Hochst.ex Benth.	Xadacha	Fabaceae	T
Acacia albida Del.	Xadacha	Fabaceae	T
Acanthus eminens C.B.Clarke	Koriisa	Acanthaceae	S
Achyranthes aspera L.	Anqabatto	Amaranthaceae	H
Achyrocline glumacea (DC.) Oliv. & Hiern	Tombo-loonii	Asteraceae	H
Acmella caulirhiza Del.	Jilo-qalaa	Asteraceae	H
Acokanthera schimperi (A. DC.) Schweinf	Qaraaru	Apocynaceae	T
Aerva lanata (L.) Juss.ex Schutes	Ruffo-qaalu	Amaranthaceae	H
Ageratum conyzoides L.		Asteraceae	H
Albizia schimperiana Oliv.	Garbii	Fabaceae	T
Allophylus abyssinicus (Hochst.) Radelk	Saarajji	Sapindaceae	T
Allphylus macrobotryus Gilg.	Hiqa-qamu	Sapindaceae	S
Apodytes dimidiata E.Mey.ex. Benth	Me'ee	Icacinaceae	T
Asparagus africanus Lam.	Sarittii	Asparagaceae	C
Asparagus racemosus Willd.	Hiddo	Asparagaceae	S
Aspilia mossambicensis (Oliv.) Wild.	Hirbo	Asteraceae	H
Dalbergia lacteal Vatke	Jibaata	Fabaceae	S
Barleria ventricosa Hochst. ex Nees	Uddoottu	Acanthaceae	H
Bersama abyssinica Fresen.	Xibirro	Meliantaceae	T/S
Bidens biternata (Lour)	Hadaa	Asteraceae	H
Brucea antidysenterica J.F. Mill.	Lalaatto	Simaroubaceae	S
Calpurnia aurea (Ait.) Benth.	Ceekataa	Fabaceae	S
Canthium lactescens Hiern.	Korbo	Rubiaceae	S
Carissa spinarum L.	Agamsa	Apocynaceae	S
Cassipourea malosana (Baker) Alston	Xillo	Rhizophoraceae	T
Celtis africana Brum.f.	Mataqomaa	Ulmaceae	T
Ceropegia microgaster M.G.Gilbert	Dhamsa-wacco	Asclepiadaceae	C
Chenopodium murale L.		Chenopodiaceae	H
Chionanthus mildbraedii (Gilg & Schellenb.) Stearn	Walicho	Oleaceae	T/S
Cissus petiolata Hook.f.	Arraye	Vitaceae	C
Clausena anisata (Willd.) Benth	Xir'dhoo	Rutaceae	S
Clematis longicauda Steud. Ex A. Rich.	Fittii	Ranunculaceae	C
Clerodendrum myricoides L.		Lamiaceae	S
Clutia abyssinica Jaub. & Spach.	Muka-dhigaa	Euphorbiaceae	S
Combretum collinum Fresen.	Haallo	Combretaceae	T

Combretum molle R.Br. ex G.Don	Rukeensa	Combretaceae	T
Commelina africana L.		Commelinaceae	H
Commelina benghalensis L.	Liittu	Commelinaceae	H
Commelina diffusa Burm.f.	Qaayyo	Commelinaceae	H
Cordia africana Lam	Waddessa	Boraginaceae	T
Crinum abyssinicum Hochst. Ex A.Rich	Bute-waraabesaa	Amarylidaceae	H
Crotolaria cylindrica A.Rich.	Saayisaa	Fabaceae	H
Croton macrostachyus Hochst.ex.A.Rich.	Makonisa	Euphorbiaceae	T
Cucumis aculeatus Cogn.		Cucurbitaceae	C
Cynoglossum coeruleum Steud. ex DC	Maxxanii	Boraginaceae	H
Cyathula uncinulata (Schrad.) Schinz	Nenqo	Amaranthaceae	H
Cycniopsis humifusa (Forssk) Engl.		Scrophulariaceae	H
Cycnium tubulosum (L.f.) Engl.	Maa'saltu	Scrophulariaceae	H
Cyperus fischerianus A. Rich	Shakkotaa	Cyperaceae	H
Cyperus nigricans Steud.	Qundhii	Cyperaceae	H
Desmodium repandum (Vahl) DC.	Qoffe-baddaa	Fabaceae	H
Dicliptera maculata Nees.	Dergu	Acanthaceae	H
Dicrocephala integrifolia (L.f.) O.Kuntze		Asteraceae	H
Dodonea angustifolia L.	Dhitacha	Sapindaceae	S
Dombeya torrida (J.F.Gmel.) P.Bamps	Daaniisa	Sterculiaceae	T
Dovyalis abyssinica (A. Rich.) Warb.		Flacourtiaceae	S
Dregea schimperii (Dec.) Bull.	Yabaluu	Asclepiadaceae	C
Drimia altissima (L.f.) Ker-Gwal	Miirtu	Hyacintaceae	H
Dyschoriste multicaulis (A. Rich.) O. Ktze	Xuyyale	Acanthaceae	H
Dyschoriste radicans Nees		Acanthaceae	H
Echinops longisetus A.Rich	Gogoodhu	Asteraceae	S
Ehretia cymosa Thonn.var.Silvatica (Guerke) Brenen	Uraagaa	Boraginaceae	T/S
Ekebergia capensis Sparm.	Annonu	Meliaceae	T
Erianthemum dregei (Eckl. & Zeyh.) Tiegh	Baaldo	Loranthaceae	SP
Euclea divinorum Hiern.	Mi'eessaa	Ebenaceae	T
Euphorbia adjurana Bally & Carter	Adaammaa	Euphorbiaceae	T
Faurea speciosa Welw.	Daanse	Proteaceae	T/S
Ficus thonningii Blume	Dembii	Moraceae	T
Ficus vasta Forssk.	Qilxaa	Moraceae	T
Flacourtia indica (Burm.f.) Merrill	Akkoku	Flacourtiaceae	S
Galinsoga parviflora Cav.	Ruffo-kadhe	Asteraceae	H
Galium spurium L.	Qaqabatto	Rubiaceae	H
Gardenia ternifolia Schumach. & Thonn.	Gambello	Rubiaceae	T
Girardinia diversifolia (Link) Friis	Dobbii	Urticaceae	H
Gnidia stenophylla Gilg.		Thymelaeceae	H

Grewia bicolor Juss.	Dhaqqonu	Tiliaceae	S
Grewia ferruginea Hochst. Ex A. Rich.	Dhaqqonu	Tiliaceae	S
Guizotia scabra (Vis.) Chiov	Hirbbo	Asteraceae	H
Helinus mystacinus (Ait.) E.Mey.ex Steud	Homachisaa	Rhamnaceae	C
Hippocratea goetzei Loes.	Xixiixaa	Celastraceae	C
Hypoestes aristata (Vahl) Roem. & Schult	Dergu	Acanthaceae	H
Hypoestes forsskaolii (Vahl) R.Br	Dergu	Acanthaceae	H
Hypoestes triflora (Forssk) Roem. & Schult.	Dergu	Acanthaceae	H
Indigofera atriceps Hook. F.	Siliinqaa	Fabaceae	H
Isoglossa somalensis Lind		Lamiaceae	H
Jasminum abyssinicum Hochst. Ex DC	Dikkii	Oleaceae	C
Justicia bizuneshiae Ensermu	Dergu	Acanthaceae	H
Justicia exigua S. Moore	Dergu	Acanthaceae	H
Justicia ladanoides Lam.	Dergu	Acanthaceae	H
Kalanchoe schimperiana A. Rich	Bosoqqe	Crassulaceae	H
Kleinia grantii (Oliv. & Hiern) Hook.f.	Tombo-loonii	Asteraceae	H
Kohautia platyphylla (K.Schum.) Bremek.	Danse-diqqo	Rubiaceae	H
Landolphia buchananii (Hall.f.) Stapf	Hophii	Apocynaceae	C
Lantana trifolia L.	Uddo	Verbanaceae	H
Lantana viburnoides (Forssk.) Vahl	Dubaro	Verbanaceae	S
Leonotis ocymifolia (Burm.f.) Iwarson	Qimamii-gaalaa	Lamiaceae	H
Lepidotrichilia volkensii (Gurke) Leroy	Saakaro	Meliaceae	T S
Leucas argentea Gurke var. argentea		Lamiaceae	H
Leucas martinicensis (Jacq.) R. Br.		Lamiaceae	H
Lippia adoensis Hochst. ex Walp	Damaa-kasse	Lamiaceae	H
Lippia viburnoides (Forssk.) Vahl.	Qaya-dubra	Lamiaceae	H
Margaritaria discoidea (Baill.) Webster	Bobi`aa	Euphorbiaceae	T
Maytenus addat (Loes.) Sebsebe	Haagalaa	Celastraceae	T S
Maytenus arbutifolia (A.Rich.) Wilczek	Kombolcha	Celastraceae	S
Maytenus grasilipes (Welw. Ex Oliv.) Exell	Kombolch-hiddo	Celastraceae	S
Maytenus senegalensis (Lam.) Exell	Kombolch- boffe	Celastraceae	S
Maytenus undata (Thunb.) Blacklock	Okoluu	Celastraceae	T
Millettia ferruginea (Hochst.) Bak.	Dhaadhattu	Fabaceae	T
Mimusops kummel A. DC	Olaatii	Sapotaceae	T
Monothecium glandulosum Hochst.	Qaxine	Acanthaceae	H
Mussaenda arcuata Poir.	Idime	Rubiaceae	C
Nuxia congesta R.Br.ex Fresen.	Udeessaa	Loganiaceae	T
Ochna holstii Engl.	Koraayyu	Ochnaceae	T.S
Ocimum gratissimum L.	Hanceebii	Lamiaceae	H
Oldenlandia corymbosa L.		Rubiaceae	H
Olea capensis ssp. *macrocarpa* (C.H. Wright) Verdc.	Gagamaa	Oleaceae	T

Olea europaea ssp. *cuspidata* (Wall. ex. G. Don.) Cif.	Ejarsa	Oleaceae	T
Olea welwitschii (Knobl.) Gilg & Schellenb	Sawwaa	Oleaceae	T
Olinia rochetiana A.Juss.	Qadiida-daalachaa	Oliniaceae	T
Oplismenus hirtellus (L.) P.Beauv.	Bushee	Poaceae	G
Otostegia tomentosa A. Rich		Lamiaceae	H
Oxalis corniculata L.	Butiyye	Oxalidaceae	H
Oxalis radicosa A. Rich	Sodaro'oo	Oxalidaceae	H
Oxyanthus speciosus DC.		Rubiaceae	S
Panicum hochstetteri Steud.	Mara	Poaceae	G
Pavetta abyssinica Fresen.	Dhoggo	Rubiaceae	S
Pavonia glechomifolia (A.Rich.) Garcke	Icinnii	Malvaceae	H
Pentanisia ouranogyne S. Moore		Rubiaceae	H
Pentas lanceolata (Forssk.) Deflers	Cunfaa	Rubiaceae	H
Periploca linearifolia Quart. -Dill & A.Rich.	Gaalee	Asclepiadaceae	C
Persicaria setosula (A.Rich.) K.L.Wilson		Polygonaceae	H
Phaulopsis imbricata (Forssk.) Sweet	Qaxine	Acanthaceae	H
Phoenix reclinata Jacq.	Meexxii	Arecaceae	S
Phyllanthus boehmii Pax.	Guurii	Euphorbiaceae	H
Phyllanthus mooneyi M.Gilbert	Haadha -waayyu	Euphorbiaceae	H
Phyllanthus sepialis Muell Arg.	Dhirii-baddaa	Euphorbiaceae	H
Physalis peruviana L.		Solanaceae	H
Pittosporum viridiflorum Sims.	Hirbaa	Pittosporaceae	T
Plantago lanceolata (Tourn.) L.	Qunnii	Plantaginaceae	H
Plantago palmate Hook.F.		Plantaginaceae	H
Plectocephalus varians (A.Rich) C.Jeffery ex. Cuf		Asteraceae	H
Plectranthus punctatus (L.) L' Herit	Obbaa	Lamiaceae	H
Plectranthus sylvestris Gurkee	Bulle	Lamiaceae	H
Podocarpus falcatus (Thurn) Mirb	Birbirsa	Podocarpaceae	T
Polyscias fulva (Hiern) Harms	Talaa	Araliaceae	T
Polystachya rivae Schweinf.	Liiqaaqaa	Orchidaceae	E
Premina schimperi Engl.	Xulangee	Verbanaceae	S
Prunus africana (Hook.f.) Kalkm	Sukke	Rosaceae	T
Psychotria orophila Petit.	Buna-durii	Rubiaceae	T
Psydrax schimperiana (A.Rich.) Bridson	Gaalloo	Rubiaceae	T
Pteridium aquilinum (L.) Kuhn	Tarcaa	Dennstaedtiaceae	F
Pterolobium stellatum (Forssk.) Brenan	Qajimaa	Fabaceae	C
Ranunculus multifidus Forssk.		Ranunculaceae	H
Rhamnus prinoides L'Herit	Gesho	Rhamnaceae	S
Rhoicissus tridentata (L.f.) Wild & Drummond	Laaloo	Vitaceae	C
Rhus natalensis Krauss	Daboobeesa	Anacardiacea	T/S

Rhus vulgaris Meikle	Xaaxesaa	Anacardiacea	S
Ritchiea albersii Gilg.	Qalqalcha	Capparidaceae	T/S
Rubus steudnerii Schweinf.	Gooraa	Rosaceae	S
Ruellia prostrata Poir.		Acanthaceae	H
Rumex nepalensis Spreng.	Dhangaggo	Polygonaceae	H
Rytigynia neglecta (Hiern) Robyns	Miqqe	Rubiaceae	S
Salvia nilotica Juss. Ex Jacq.		Lamiaceae	H
Satureja paradoxa (Vatke) Engl		Lamiaceae	H
Schrebera alata (Hochst.) Welw.	Dhamee	Oleaceae	T
Senecio ochrocarpus Oliv. & Hiern		Asteraceae	H
Setaria verticillata (L.) Beauv	Suutaa	Poaceae	G
Sida ovata Forssk.	Arxume-karabaa	Malvaceae	S
Sida ternate L.f.	Dekela	Malvaceae	H
Solanecio gigas (Vatke) C. Jeffery	Giinbodhaa	Asteraceae	S
Solanum anguivi Lam	Hiddii- warabeesaa	Solanaceae	S
Solanum capsicoides Guatteri	Hiddii	Solanaceae	S
Solanum incanum L.	Hiddii-gaamojji	Solanaceae	S
Steganotaenia araliaceae Hochst. ex A.Rich.	Luqaan-luqqe	Apiaceae	T
Stephania abyssinica (Dill. & A. Rich.) Walp	Kalaaltu	Menispermaceae	H
Syzygium guineense ssp. *guineense* (Willd.) Dc.	Badeessaa	Myrtaceae	T
Syzygium guineense ssp. *macrocarpum* (Engl.) F. White	Awaajjo	Myrtaceae	T/S
Tagetes minuta L.	Sunkii	Asteraceae	H
Teclea nobilis Del	Hadheea arabe	Rutaceae	T/S
Teclea simplicifolia (Engl) Verdoorn	Hadheesa	Rutaceae	T/S
Terminalia schimperiana Hochst.	Dabaqqaa	Combretaceae	T
Thalictrum rhynchocarpum Dillon and A. Rich.	Ali-hanqaa	Ranunculaceae	H
Thunbergia alata Boj.ex Sims.	Surupha-waraabeesaa	Acanthaceae	H
Thunbergia ruspolii Lindau	Nitii-buqataa	Acanthaceae	H
Tragia cinerea (Pax) Gilbert & Radcl.-Smith	Laalessaa	Euphorbiaceae	H
Trichilia dregeana Sond	Siisaa	Meliaceae	T
Trifolium multinerve A. Rich.	Saayisa	Fabaceae	H
Triumfetta tomentosa Boj.	Daanigoolaa	Tiliaceae	H
Vangueria apiculata K.Schum.	Naa'dhala	Rubiaceae	T/S
Vernonia amygdalina Del.	Ebicha	Asteraceae	S
Vernonia auriculifera Hiern.	Reejjii	Asteraceae	S
Vernonia bipontinii Vatke	Soyyame	Asteraceae	S
Vernonia leopoldi (Sch.Bip. Ex Walp) Vatke	Soyyamme	Asteraceae	S
Vigna membranacea A. Rich	Dirro	Fabaceae	H
Zornia pratensis Milne-Redh.		Fabaceae	H

Appendix 2. Releve Characteristics of Magada Forest

Releve	Geographical location	Altitude	Number of species
1	05°28' 60N and 38 ° 16' 46 E	1920	48
2	05 ° 28' 55N and 38 ° 16' 58 E	1885	25
3	05 ° 28' 65N and 38 ° 16' 49 E	1913	38
4	05 ° 28' 73N and 38 ° 16' 52 E	1939	26
5	05 ° 28' 81N and 38 ° 16' 56 E	1908	30
6	05 ° 28' 86N and 38 ° 16' 43 E	1925	24
7	05 ° 28' 87N and 38 ° 16' 32 E	1959	30
8	05 ° 28' 80N and 38 ° 16' 29 E	1975	37
9	05 ° 28' 55N and 38 ° 17'08 E	1878	36
10	05 ° 28' 11N and 38 ° 17' 11 E	1906	35
11	05 ° 28' 43N and 38 ° 17' 17E	1916	31
12	05 ° 28' 44N and 38 ° 17' 21 E	1861	36
13	05 ° 28' 31N and 38 ° 17' 24 E	1889	31
14	05 ° 28'56N and 38 ° 17' 02 E	1914	34
15	05 ° 29' 29N and 38 ° 16' 94 E	1977	19
16	05 ° 29' 39N and 38 ° 17' 16 E	1972	22
17	05 ° 29' 36N and 38 ° 17'20 E	1981	15
18	05 ° 29'38 N and 38 ° 17'21 E	1964	22
19	05 ° 29' 43 N and 38 ° 17'29 E	1947	21
20	05 ° 29' 46 N and 38 ° 17' 26E	1932	24
21	05 ° 29' 60 N and 38 ° 17' 27 E	1908	22
22	05 ° 29' 62 N and 38 ° 17' 29 E	1921	27
23	05 ° 29' 64 N and 38 ° 17' 04 E	1937	28
24	05o ° 29' 61 N and 38 ° 15' 80E	1933	36
25	05 ° 29' 70 N and 38 ° 15' 78E	1957	29
26	05 ° 29' 87N and 38 ° 15' 70E	1970	42

27	05 ° 30' 21 N and 38 ° 15'53 E	1968	40
28	05 ° 30'45 N and 38 ° 15' 52E	1958	35
29	05 ° 30'47 N and 38 ° 15'55 E	1970	37
30	05 ° 30' 49 N and 38 ° 15' 56 E	1977	36
31	05 ° 30' 51 N and 38 ° 15' 53 E	1990	29
32	05 ° 30' 56N and 38 ° 15' 50 E	1952	29
33	05 ° 30' 85N and 38 ° 15' 73 E	1872	33
34	05 ° 30' 81N and 38 °.15'.62 E	1910	32
35	05 ° 30' 61N and 38 ° 15' 71 E	1920	34
36	05 ° 30' 70N and 38 ° 15' 57 E	1942	42
37	05 ° 30' 99N and 38 ° 16' 14 E	1858	34
38	05 ° 30' 97N and 38 ° 16' 27E	1847	32
39	05 ° 30' 94N and 38 ° 16' 45E	1828	35
40	05 ° 29' 55N and 38 ° 16' 94 E	1905	32
41	05 ° 29' 69N and 38 ° 17' 11 E	1897	29
42	05 ° 29' 77Nand 38 ° 17' 17 E	1886	27
43	05 ° 30' 59N and 38 ° 16' 48E	1841	30
44	05 ° 30' 70N and 38 ° 16' 49E	1837	30
45	05 ° 30' 70N and 38 ° 16' 12 E	1892	32
46	05 ° 27' 38N and 38 ° 17' 13 E	1883	28
47	05 ° 27' 37N and 38 ° 17' 17E	1864	23
48	05 ° 27' 34N and 38 ° 17' 30 E	1851	26
49	05 27' 24N and 38 ° 17' 33 E	1833	24
50	05 ° 27' 33N and 38 ° 17' 15 E	1871	28
51	05 ° 27' 32N and 38 ° 17' 12 E	1880	23
52	05 ° 27' 82N and 38 ° 16' 21 E	1910	33
53	05 ° 27' 96N and 38 ° 16' 24 E	1904	26
54	05 ° 27' 96N and 38 ° 16' 20 E	1898	38
55	05 ° 27' 94N and 38 ° 16' 23 E	1912	28

56	05 ° 27' 90N and 38 ° 16' 15 E	1880	35
57	05 ° 28' 83N and 38 ° 16' 07 E	1887	39
58	05 ° 32' 06N and 38 ° 18' 74 E	1974	29
59	05 ° 32' 18N and 38 ° 18' 71 E	1982	31
60	05 ° 32' 25N and 38 ° 18' 77 E	1945	31
61	05 ° 27' 86N and 38 ° 16' 19 E	1910	22
62	05 ° 27' 88N and 38 ° 16' 25 E	1912	23
63	05 ° 27' 90N and 38 ° 16' 15 E	1880	28
64	05 ° 32' 38N and 38 ° 16' 06 E	2064	27
65	05 ° 32' 15N and 38 ° 16' 44 E	2053	28
66	05 ° 32' 17N and 38 ° 16' 32 E	2056	30

Appendix 3. Clusters with their respective releves

Clusters	Releves
I	9, 12, 14, 10, 11, 13
II	8, 41, 42, 1, 5, 3, 6, 7, 2, 4, 40
III	16, 17, 18, 19, 20, 15, 21, 22, 23
IV	33, 34, 37, 39, 45, 25, 26, 35, 43, 44, 58, 59, 60, 24, 64, 65, 66
V	36, 38, 27, 28, 29, 30, 31, 32, 56, 57
VI	47, 48, 49, 50, 51, 46
VII	54, 63, 52, 53, 61, 62, 55

DECLARATION

I, the undersigned, declare that this thesis is my work and that all sources of materials used for the thesis have been dully acknowledged.