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SHORT COMMUNICATION

FLORISTIC COMPOSITION, STRUCTURE AND REGENERATION STATUS OF ACHERA NATURAL FOREST IN CHILGA DISTRICT, NORTHWEST ETHIOPIA

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ABSTRACT: This research focused on the floristic description and forest condition assessment comparisons of Achera Forest in Northwest Ethiopia. The floristic data were recorded from 20 x 20 m 30 sampling plots. Diameter at breast height, height and number of each species individuals were recorded from all plots. A total of 48 woody species, representing 41 genera and 25 families were recorded. The Fabaceae family was the richest (7 species) followed by Combretaceae (5 species) and Asclepiadaceae (4 species). Life-form composition was 60.87% trees, 9.57% shrubs, 17.37% tree/shrubs and 2.17% woody climbers. The overall Shannon diversity index H′ = 3.37 was high for the richness and evenness of the woody species. The low basal area (3.61 m^2/ha) and population structure revealed the need for conservation measures for species with poor regeneration status. The floristic diversity revealed that the forest was a *Combretum-Terminalia* woodland type. There was a density decline in the higher diameter class suggesting the existence of disturbance and unsustainable exploitation of the forest. Based on the results of the study, comprehensive studies and sound management system are recommended.

Key words/phrases: Achera, Ethiopia, Floristic description, Regeneration.

INTRODUCTION

Ethiopia has diverse physiogeographic features with high and rugged mountains, flat topped plateau, deep gorges, incised river valleys and rolling plains. Although Ethiopia is a tropical country with typically hot and dry lowland areas, it has varied macro and micro-climatic conditions. The influence of high altitudes modifies mean temperatures and leads to a more moderate Mediterranean type climate in the highlands. The highlands on each side of the rift valley give way to extensive semi-arid lowlands to the east, south and west of the country (Friis, 1992; Tamrat Bekele, 1994).

The varied climatic conditions have contributed to the formation of diverse ecosystems inhabited with a great diversity of life forms of both animals and plants (EWNHS, 1996; Tesfaye Awas *et al*., 2003; IBC, 2007). There are

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eight terrestrial ecosystems within Ethiopia. These range from afro-alpine and sub-afro-alpine grasslands to desert and semi-desert scrubland ecosystems. In addition, there are wetlands and aquatic ecosystems. Because of the diversity of ecosystems the country is endowed with a wide diversity of flora and fauna and considered as centre of diversity for a number of crop and animal genetic resources (Friis *et al*., 2001; Vivero *et al*., 2003; Thulin, 2004; IBC, 2005).

Together with Eritrea, Ethiopian flora has a wild flora of some 7000 taxa (Vivero *et al*., 2005). However, according to the most recent study, Ethiopian forest cover has declined to 3.56% and the annual loss of the highland montane forest of Ethiopia has been estimated at between 150,000 and 200,000 ha (IBC, 2005). According to IBC (2005), most of the remaining natural forests are found in the southern and southwestern parts of the country. This means that the national forests have virtually disappeared from the rest of the country except a few scattered and relatively small areas of forest cover that remained in the northern, central and eastern parts of the country. Natural vegetation, especially in the Amhara Region, is now almost exclusively limited to sacred places (churches, monasteries and mosques), remnants of hedges, very steep and less accessible areas (Alemayehu Wassie, 2002), the very highlands (above 3000 m), the lowland savannah woodlands of the Abay, Tekeze watersheds and the riparian vegetation of streams and small rivers (Jonathan, 2007).

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 Ethiopian natural vegetation (Ensermu Kelbessa *et al*., 1992). In general, because of a number of threats, the trend and the biodiversity status of Ethiopia's biodiversity is on decline. There are only a very few cases of improvement or stabilization of plant and animal populations.

Lemessa Kumssa (2010) and other authors (Tadesse Woldemariam, 2003; Simon Shibru and Girma Balcha, 2004) revealed that, in order to maintain the ecological equilibrium and to meet the forest resource requirements of the population and biodiversity conservation, scientific information on biodiversity and regeneration status are the basis. Some recent studies in the regional state that focused on floristic composition, structure and regeneration status of forests include Abate Ayalew *et al*. (2006); Aleminew Alelign *et al*. (2007); Sultan Mohammed (2011). However, as far as the researchers' knowledge there are very limited researches conducted in northwest Ethiopia in general, and Achera Forest in Chilga district is explored in this study. Thus, this study on the composition, structure and diversity of woody species of protected forests will undoubtedly enhance the rehabilitation and sustainable use efforts.

The major objective of the study was to describe woody plant composition, structure and regeneration status of the Achera Forest. Thus, we documented woody plant composition, measured the diversity of woody plant species, described the structure of the forest, and assessed the regeneration status and disturbances of woody plant species.

MATERIALS AND METHODS

Description of the study area

The study site Achera Forest is situated (25°83′92″–26°18′51″ N and 38°97′60″–39°17′96″ E) in north Gondar Zone of the Amhara National Regional State. Aykel is the capital of Chilga district (Fig. 1). It is 820 km northwest from Addis Ababa, the capital of Ethiopia, and 82 km west of Gondar. The forest is situated in the intermediate altitudinal range between 975 and 1320 m a.s.l. (our GPS reading during fieldwork).

Data collection

To know the size of the vegetation, obtain a visual impression of the structure and physiognomy of the vegetation, a reconnaissance survey was made on December 1 to 3/2011. The field data were then collected from December 5 to 29/2011. Though the forest is protected, environmental disturbance indicators encountered during field work was recorded and photographed to show the existence of anthropogenic activities in the forest.

Transect lines were about 400 m apart from each other, based on physiognomic homogeneity following the Braun-Blanquet approach (Mueller-Dombois and Ellenberg, 1974) of phytosociology as modified by Van der Maarel (1979). A total of 30 sampling plots of 20 m x 20 m (400 m^2) were laid at about every 200 m along transect lines. Within the major quadrats, about three 25 m^2 (5 m x 5 m) sub-quadrats were laid to collect sapling and seedlings of all trees, shrubs and lianas. In each quadrat, all individual trees and shrubs with a DBH ≥2.5 cm and height ≥2 m were measured for DBH and height classes using a conventional tape-metre (converted by calculation) and Sunto-clinometer, respectively. Geographical coordinates were taken for each plot by using eTrex GPS receiver. Representative fertile samples of all plants encountered were collected in duplicate, numbered, dried and placed as a reference collection following standard methods of herbarium plant collection (Birdson and Forman, 1992) and stored in the teaching herbarium of Bahir Dar University (BDU). Identification and naming were done by district forestry and BDU experts determination and using keys of Flora of Ethiopia and Eritrea (Edwards *et al*., 1995; 1997; 2000; Hedberg and Edwards, 1989; Hedberg *et al*. 2003).

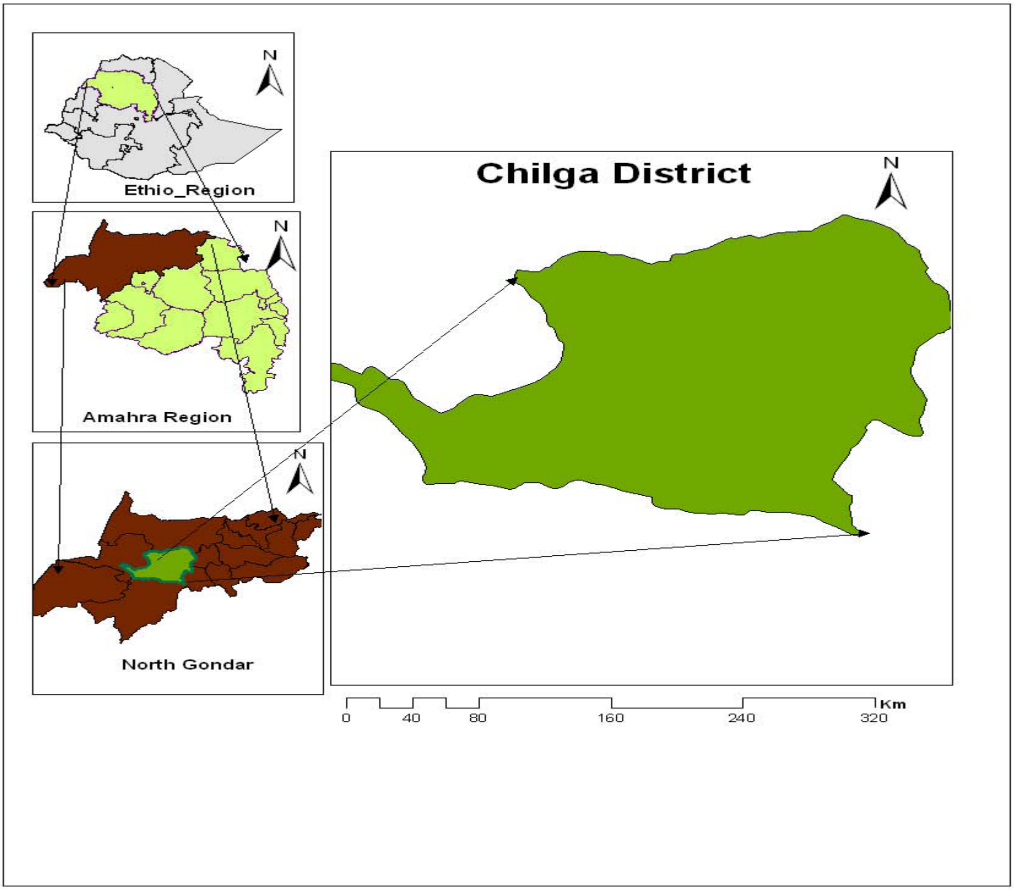


Fig. 1. Location of the study area in Chilga District.

Data analysis

Data were computed and summarized using Microsoft office Excel (2007). The description was based on the analysis of species density, diameter at breast height (DBH), height, basal area, frequency and important value index following Simon Shibru and Girma Balcha (2004). The DBH and tree height were classified into DBH classes and height classes. The tree or shrub basal area and density were computed on hectare basis according to Mueller-Dombois and Ellenberg (1974) and Kent and Coker (1992). Density and height were classified following Lamprecht (1989). The basal area was calculated as $BA = \frac{\pi d^2}{4}$ (Elledge and Barlow, 2010). Diversity and similarity indices such as species richness, evenness and diversity were measured (Shannon and Weiner, 1949).

RESULTS AND DISCUSSION

Floristic composition of Achera Forest

A total of 48 woody plant species belonging to 39 genera and 24 families were recorded and identified from Achera Forest. Among these two species were identified outside the sample quadrats. Of all the families, Fabaceae was the most dominant contributing seven species (15.22%) to the total followed by Combretaceae, Anacardiaceae and Asclepiadaceae with five species (10.87%), three species (6.52%), and three (6.25%), respectively. The remaining (60.87%) families were represented by two or one species each, i.e., eight families with two species each and twelve families with one species each. Of the total species recorded, 28 species (60.87%) were trees, nine species (19.57%) were shrubs, eight species (17.39%) were tree/shrubs and one species (2.17%) was a climber (Fig. 2).

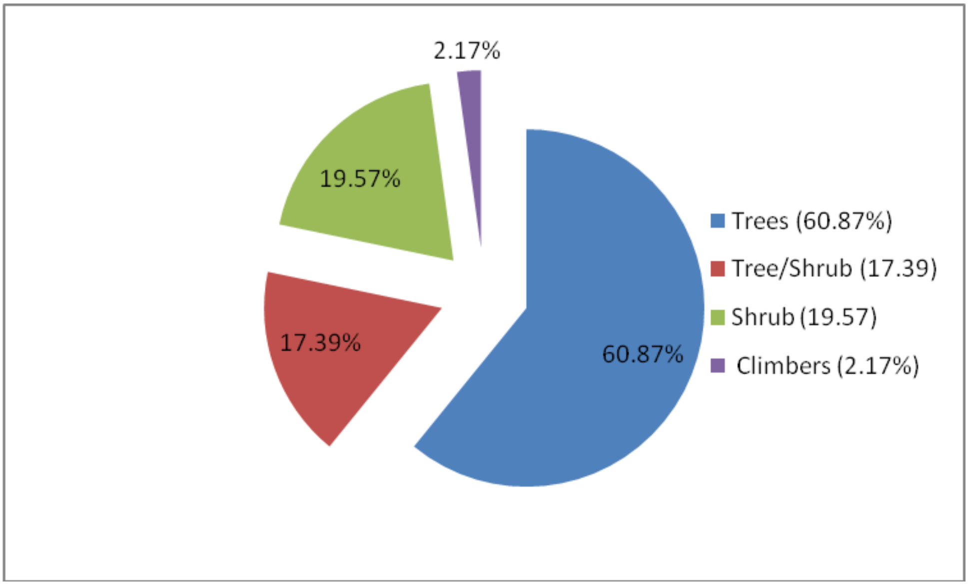


Fig. 2. Growth habit of woody plants in Achera Forest.

Even though Achera Forest is protected with armed guards, clearing for agricultural expansion, charcoal production and firewood cutting was observed in the area.

Species diversity

The diversity and evenness of woody species in Achera Forest was 3.37 and 0.87, respectively indicating that the diversity and evenness of woody species in the forest is relatively high. According to Kent and Coker (1992), Shannon-Weiner index is in the very good range (between 3.0 and 3.5). Thus, the result of the present study showed that Achera Forest has high evenness. Given the small richness, it is evident that the relatively high diversity index (H′ = 3.37) of the forest could be the due to the high evenness, comparable with the 5 year area closure (3.42) of north Wollo (Wendwessen Girmay, 2009).

Vegetation structure

Density

The total density of all woody species in Achera Forest was 2632 stems ha^{-1}. Out of these *Anogeissus leiocarpa* has the highest species density with a value of 242 individuals per hectare, followed by *Myrsine africana* (240 individuals), *Ziziphus mauritiana* (222 individuals), *Gardenia* sp. (201 individuals), *Acacia albida* (192 individuals), *Sarcostemma viminale* (143 individuals) and *Acacia polycantha* (103 individuals) ha^{-1}. In contrast to these, the least abundant species recorded were *Solanum indicum*, *Euphorbia tirucalli*, *Ficus thonningii*, *Prunus africana*, and *Acanthus pubescens*. Such a result reflects variability in abundance among the plant species that could arise from differences in altitude, aspect and anthropogenic activities.

In the forest the most frequently distributed woody species in the sample quadrats were *Myrsine africana*, *Stereospermum kunthianum* and *Ziziphus mauritiana* each with a percentage frequency of 93.33% followed by *Anogeissus leiocarpa* (90%), *Gardenia* sp. (86.67%), *Terminalia brownii* (80.00%), *Ximenia americana* (76.67%), *Acacia albida* and *Ziziphus abyssinica* (73.33% each). This indicates that the forest was *Combretum-Terminalia* type ecosystem that provides many services to the inhabitants (Tesfaye Awas *et al*., 2003).

The density of mature woody species was 762 stems ha^{-1}, that is, within the density class 5 and 7. The only mature woody species in class 6 was *Myrsine africana*, which contributed 2.08%. The 4^{th} and 3^{rd} classes comprised 8.33% and 14.58% of the woody species, respectively. Density class 1 and 2 together comprised 75% of the total mature density class. In the forest, the most abundant woody plant species were represented in density class 6, and those in the lower density classes were represented with less abundant species. This indicates more abundant individual species were very small which may be due to human interventions. Therefore, species in the lower density classes require conservation attention in order to obtain species that are more abundant in the higher density classes.

The total density of sapling was 836 stems ha^{-1}. The highest number of sapling density per unit area were placed in class 6 (4.17%) and in the remaining classes, species distribution increased respectively except class four. However, there was no species encountered in density class 7 and less number of species prevailed in class 4 and 6 compared to the rest classes. Even though the majority of the woody species sapling prevailed in class 1 and 2 (35.42% each), special attention should be given to species with absence or represented by very small number of saplings since these are at risk.

The seedling density of the forest was 1034.17 stems ha^{-1}. The highest seedling density ha^{-1} was observed for five species in the density class 7 (10.42%), namely: *Myrsine africana* (95 ha^{-1}), *Gardenia volkensii* (100 ha^{-1}), *Acacia albida* (102 ha^{-1}), *Ziziphus mauritiana* (110 ha^{-1}) and *Anogeissus leiocarpa* (139 ha^{-1}). Woody plant species included in density class 5 and 4 each were represented by two species (4.17% each). Plant species that did not have seedling at all (22.92%) include *Ficus thonningii*, *Prunus africana*, *Ficus sycomorus*, *Acacia seyal*, *Mimusops kummel*, *Euphorbia tirucalli*, *Acacia abyssinica*, *Diospyros mespiliformis*, *Apodytes dimidiata* and *Dalbergia melanoxylon*. This may be due to excessive browsing of the areas by domestic animals in the rainy season and/or uncontrolled fire in the dry seasons when the grasses are not browsed.

The ratio of the density of individuals with DBH >10 cm to those with DBH >20 cm is taken as a measure of the size class distribution (Grubb *et al*., 1963). The density of tree species with DBH <10 cm, DBH >10 cm, and DBH >20 cm in Achera Forest were 377 (49.49%), 182 (23.94%) and 202 (26.56%) stems ha^{-1}, respectively. From the analysis of trees with DBH >20 cm, *Acacia albida* (14.59%), *Stereospermum kunthianum* (8.97%), *Anogeissus leiocarpa* (6.86%), *Chionanthus mildbraedii* (6.26%), *Dalbergia melanoxylon* (6.18%) and *Ficus sycomorus* (6.18%) contributed 49.01% of the total density. *Combretum adenogonium*, *Boswellia papyrifera*, *Acacia* *seyal*, *Combretum collinum* and *Acacia polycantha* each contributed less than 2% of the total density. The small contribution of these tree species may be due to over exploitation of selective cutting for charcoal production and for farm implements.

Concerning tree density with DBH <10 cm, the highest contributors were *Myrsine africana* (18.57%) and *Ziziphus mauritiana* (10.09%) which may be due to the selection of the trees for fire wood, fencing and cattle feed. *Gardenia* sp. (7.16%) was also more browsed by the domestic animals. The three species mentioned above contributed 35.82% of the total density.

The proportion of DBH >10cm (a) to DBH >20cm (b) of Achera Forest is smallest (0.9) comparable to Sanka Meda Forest. This indicates that the proportion of small-sized and large-sized individuals do not differ much in the forest. Four forest types in the comparison have more a/b ratio than Achera Forest indicating that they have more predominance of the lower DBH class than Achera. The predominance of small-sized woody species (DBH <10 cm) in Achera Forest might be the result of excessive cutting for firewood and charcoal, which took place in the forest a long time ago. This was witnessed by the subsequent structural analysis based on tree height and DBH class distribution result which showed high proportion of individuals in the lower DBH and the least in the higher classes.

Tree height classes

Tree individuals obtained in the study were classified into eight height classes. There was higher number of tree individuals in the height class I (221 ha^{-1}), which accounted for 29.02% of the total height classes. Trees in height class III, IV, V and VI together made up 44.07% (336 ha^{-1}) of the total height classes in the forest.

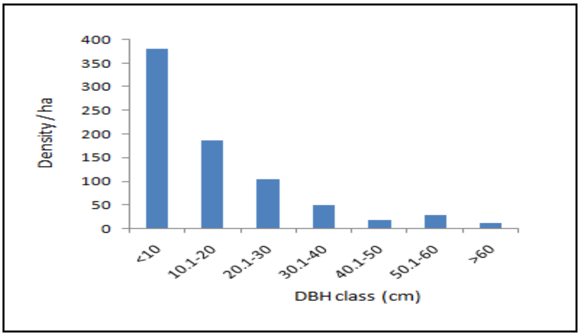
Tree height class values were higher in the lower class and decreased in the higher classes showing an inverted J-shape. This revealed that the forest has been heavily influenced by anthropogenic activities through selective cutting of trees for charcoal production, construction, timber production and farm implements. Thus, the forest was dominated by small to medium-sized individuals, which is attributed to high rate of regeneration but low recruitment potentials. Similar results were reported in Komto Forest (Fekadu Gurmessa, 2010).

The vertical structure of the woody species occurring in the Achera Forest was analyzed following the International Union for Forestry Research Organization (IUFRO) classification scheme (Lamprecht, 1989). According to this scheme, the top height is used to determine the vertical structure. The scheme classifies the storey into upper storey (tree height >2/3 of top height), middle storey (tree height between 1/3 and 2/3 of the top height) and the lower storey (tree height <1/3 of the top height).

Accordingly, the emergent tree in the forest was *C. mildbraedii* with 36 m height. Trees in the lower, middle and upper storey were those in the height array of <12 m, 12–24 m and >24 m, respectively. Tree species that occupied the upper storey in Achera Forest include *Chionanthus mildbraedii*, *A. leiocarpa*, *D. mespiliformis*, *C. collinum* and *P. thonningii*. The most dominant trees in the lower story (<12 m) of the forest were *Gardenia* sp., *A. albida*, *B. papyrifera*, *C. spinarum* and *A. abyssinica*. Trees in the middle storey of the forest were *Q. glutinosa*, *A. polycantha*, *P. africana*, *A. dimidiata*, *C. adenogonium* and *S. kunthianum*.

Diameter at breast height (DBH) and basal area classes

The distribution of trees in different DBH classes was analyzed after classifying into seven classes (Fig. 3). About 58.9% of the individuals were found in the first two classes (2.5 cm–10 cm and 10.01 cm–20 cm) with 376.96 stems/ha^{-1} and 182.37 stems/ha^{-1}, respectively.



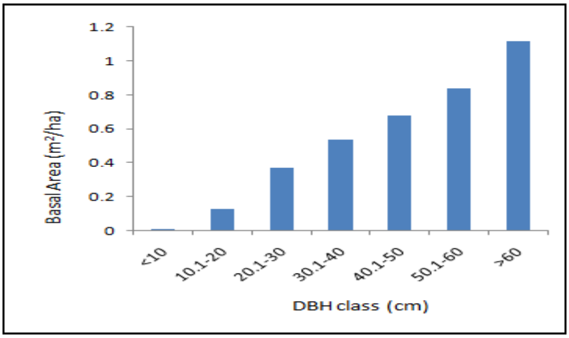


Fig. 3. DBH class verses Density (Left) and Basal Area of woody species ha^{-1}(Right).

DBH measurement in the forest revealed the same trend as that of the height distribution (Fig. 3). As the DBH class size increased, the number of individuals gradually decreased which fosters a regular inverted J-shaped distribution. Shiferaw Belachew (2010) and Shambel Bantiwalu (2010) reported similar results. This indicates the dominance of small-sized individuals in the forest and the forest is in the status of good regeneration but low recruitment potential, which might have been due to history of selective cutting of large tree individuals.

The basal area is used to explain the crowdedness of a stand of forests. The total basal area of all tree species in Achera Forest was calculated from DBH data. A stand of large trees has more stocks than that of the same number of trees of smaller diameter (Martin, 1989). It was found to be 3.61 m^2 ha^{-1}. About 30.35% of the total area was distributed in the highest diameter class which was due to the presence of large-sized individuals such as *F. sycomorus*, *F. thonningii*, *S. kunthianum* and *P. africana*. The contribution of these species to the total basal area was 13.82%, 10.61%, 10.03% and 7.73%, respectively. According to Dawins (1959; cited in Lamprecht, 1989), the normal basal area of virgin tropical forest in Africa is 23–37 m^2 ha^{-1}. Based on this report, the basal area for Achera Forest was very low indicating that the tree species were thin and very scattered.

The comparison of the basal area and densities in the diameter classes in Achera Forest revealed the occurrence of more number of individuals in the first two DBH classes (Fig. 3 right). However, the contribution of these individuals to basal area was low. This indicates that species with the highest basal area do not necessarily have the highest density but indicative of size differences between species (Tamrat Bekele, 1994). Basal area provides a better measure of the relative importance of the species than simple stem count (Cain and Castro 1959; cited in Tamrat Bekele, 1994). Therefore, species with the largest contribution in basal area can be considered as the most important woody species in the forest. Otherwise, in most cases shrubs could be the dominant species irrespective of density.

As reported by Lamprecht (1989), high density and high frequency coupled with high basal area indicate the overall dominant species of the forest. The result further showed that even though some of the associated species were less abundant in terms of individual count, they were found to be among the top ten dominant species in the area. *F. sycomorus* and *F. thonningii* were some of the species scarcely located per hectare, yet with relatively average dominance and this was because of the big diameter size they had. The basal area increment response of trees is correlated with climatic and topographic factors (Spiecker *et al*., 1996).

Regeneration status of the woody plant species

Regeneration of any species is confined to a particular range of habitat conditions and the extent of those conditions is a major determinant of its geographic distribution. Regeneration status of trees can be predicted by the age structure of their populations. From the analysis of seedlings and saplings data, the densities of tree, tree/shrub and shrub species seedlings were 392.5 ha^{-1}, 286.67 ha^{-1} and 303.17 ha^{-1}, respectively. Similarly, the densities of trees, tree/ shrub and shrub species saplings were 376.67 ha^{-1}, 227.5 ha^{-1} and 197.33 ha^{-1}, respectively. Regeneration is the process of silvigenesis by which trees and forests survive over time. Research in this field contributes to planning, conservation and decision-making in forest resource management programs (Pokhriyal *et al*., 2010).

Regeneration of a particular species is poor if seedlings and saplings are much less than the mature trees. The ratio of seedling to mature individuals of woody species in the forest was 1.34:1; the ratio of seedling to saplings was 1.23:1 and sapling to mature individuals was 1.09:1. According to Dhaulkhandi *et al*. (2008), the density values of seedling and saplings are considered as regeneration potential of the species. The presence of good regeneration potential shows stability of the species to thrive in the environment.

Both climatic and biotic factors interference influences the regeneration of different species in the forest. Higher seedling density values get reduced to sapling due to biotic disturbances and competition for space and nutrients. The data analysis revealed that the density values for seedling and sapling of the population structure of the forest are high compared to the mature individuals and agrees with the normal patterns of the population. This implies the need to develop and implement forest management regimes in the area in order to promote healthy regeneration of the species.

Compared to seedling individuals, there were less sapling individuals implying the death of most seedlings before reaching sapling stage due to factors such as human interventions, browsers, grazers, fire and nature of the seeds. From the total density of tree species seedlings, 64.5% of the total density was contributed by *Terminalia brownii*, *Chionanthus mildbraedii* and *Acacia seyal*. About 58.04% of the total density of tree species sapling was contributed by *Brucea antidysenterica*, *Acacia polycantha*, *Chionanthus mildbraedii*, *Euclea divinorum*, *Chioanthus retusus* and *Acacia seyal*. About 67.7% of the total density of shrub species seedlings was covered by *Qmmorhus glutinosa*, *Opuntia ficus-indica* and *Premna schimperi*. About 79.08% of the total density of shrub saplings was contributed by *Qmmorhus glutinosa*, *Opuntia ficus-indica* and *Balanites aegyptica*.

As reported by Uriarte *et al*. (2005), seedling recruitment is a block in the population dynamics of many species of trees. It is one of the important factors in determining the local abundance of adult trees and this calls for urgent conservation measures through prioritization. Hence, those species that do not have seedling and sapling at all, and species represented by one seedling individual were grouped under priority class I; others whose seedling density was between one and ten were categorized under class II and the remaining species came under class III. The species under priority class I should get the first priority as they are found without seedlings and then followed by class II that are represented by few seedling individuals. Subsequently for the sake of conservation endeavours, the third group is also recommended to be given the appropriate conservation priority.

CONCLUSION

Achera Forest is one of the few numbers of natural forests in north Gondar with relatively high species diversity comprising 48 woody species belonging to 25 families and 41 genera. The overall distribution of diameter classes of the species recorded indicates a relatively high proportion of individuals from the lowest DBH classes that ensures sustained regeneration of the forest if properly managed. The fact that very few mature trees are left in the forest might also suggest reduced seed production that could jeopardize future regeneration of trees and, therefore, the welfare and even existence of the forest as a whole.

The floristic diversity of the forest revealed that Achera Forest is a *Combretum-Terminalia* type of ecosystem. It has somewhat indicated that the local people are critically affecting the woody plants diversity and population structure of the forest. Because of the escalating exploitation of the forest, richness of woody plants in the forest was relatively low and the presence of a large number of seedlings in the forest indicates the great potential for sustainable future recruitment (regeneration) of the forest, provided that appropriate management is to be employed.

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