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# Distribution, Abundance and Population Status of Four Indigenous Threatened Tree Species in the Arba Minch Natural Forest, Southern Ethiopia

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**Abstract:** The study on distribution, abundance and population structure of four indigenous threatened tree species in the Arba Minch natural forest, southern Ethiopia. The objective of this study was to assess the use of this species by local communities and its current population structure and status in its natural habitat in southern Ethiopia where it is poorly known. The study approach was categorized in to three; market survey, informant interview and species population inventory in the surrounding natural habitat. Market survey was mainly focused on market observation to estimate the amount of fruits, charcoal, timber, firewood and pole sold in the market. Informant interview was focused on the uses of the species and its availability in the surrounding forest fragments. The adult tree species abundance and regeneration status in the existing forest was estimated. The result indicates that the species are used source of food, charcoal production, timber production, house constriction, fuel- wood and farm implement. Local communities supplement their livelihood by selling wild collected ripe fruit, charcoal, timber, fuel-wood of these species for income. These species are locally very useful plant that needs attention for future research that benefits communities. Current over harvesting of mature tree influenced the regeneration of the species. If this unsustainable harvesting by local people continues, the capacity of the species to maintain its wild population is significantly reduced. Therefore, management and conservation strategies that incorporate this factor is required.

**Keywords:** Distribution, Abundance, Population Structure, Regeneration, Indigenous

## 1. Introduction

From the time immemorial people started exploiting the natural environment as the source of their livelihoods. About 8.7 million species are expected to exist on the planet, many of them with multiple values for human beings [27]. “People rely on biodiversity in their daily lives, often without realizing it. Biodiversity contributes to many aspects of people’s livelihoods and well−being, providing products, such as source of food, medicine, clothing, firewood, sources of different household utensils, whose values are widely recognized” [2, 11, 30]. On the other hand, intensified and unsustainable utilization of biodiversity promote negative effects such as land degradation and species extinction.

In the Ethiopia subcontinent, about 81.0 million rural people and 85% of the tribal population live in forested areas and have traditionally depended on forest resources for sustenance and cash income [48]. However, due to the increase in human density near and within the forested areas, the pressure on plant and animal populations has increased leading to forest degradation, loss of biodiversity and forest cover [7, 8]. The causes of forest loss and degradation need to be identified to formulate better management and policy decisions.

Nech Sar National Park is one of the important conservation sites in the country with diverse component of biological resources which are ecologically and economically important. However, the ongoing consequences of deforestation, cattle grazing, human settlement and overfishing in the park have brought severe stresses and degradation of park ecosystems, positioning the sustainability of the park in question [35].

The Arba Minch forest is the best component of Nech Sar National Park and is unique in its vegetation formation from which the miracle forty springs emanate. Currently, this forest is under great threats from the surrounding community particularly from Arba Minch Town. With increasing human population, demand for fuel and other forest products is also progressively increasing [1, 10, 24]. However, *Cordia africana, Trichilia dregeana* and *Teclea nobilis* are threatened tree species in Arba Minch natural forest [23] and in the IUCN threat category, *Vepris dainellii* is under species of least concern [46].

Based on the 2007 Census conducted by the CSA, the population size of Arba Minch town has greatly increased from 2,830 in 1966 to 74,879 in 2007. At present the rapid population growth of Arba Minch is related to immigration of people from Gamo highlands, Wolaita and Gofa. This dramatic increase of population coupled with the higher demand of fuel wood and construction materials create huge pressure on the Arba Minch ground water forests and Kulfo riverine forests [1].

Along with the fast population growth and the development of Arba Minch town there is a high demand for fuel wood and timber production by the urban dwellers and big institutions. For all these institutions the only source of heat and light energy for almost every household in Arba Minch town and for villagers who live near the forest is the Arba Minch forest. It is also used for construction of farm implements, fences, furniture and houses, serve as a source of food, feed and bee fodder, and provide other environmental and social services to the community [1,23]. The objective of this study was to assess the use of four indigenous threatened tree species by local communities and its current population structure and status in its natural habitat in southern Ethiopia where it is poorly known.

# 2. Methodology

### *2.1. Description of the Study Area*

Nech Sar National Park is located in the eastern edge of Arba Minch town, at about 500kms south of Addis Ababa. The Park lies within the floor of the Ethiopian Great Rift Valley and extends from 5°51'N to 6°50'N and from 37°32'E to 37°48'E with an elevation varying between 1,108-1,650 meters above sea level. It covers an area of 514km$^2$ of which 85% is land and 15% is water [20]. The study area comprised the western part of Nech Sar National Park, Arba Minch forest and the northern parts of Arba Minch forest (Figure 1). It has an area of 60km$^2$. The temperature of the area ranges between (17-30°C). Rainfall distribution is bimodal mostly occurring in March, April and May and between September and November. Annual rainfall averages around 900mm. The wet season includes March, April, May, September, October and November and the dry season includes December, January and February. The vegetation type of the study area had five habitats. These included riverine forest, underground water forest and savannah bush land in Nech Sar National Park.

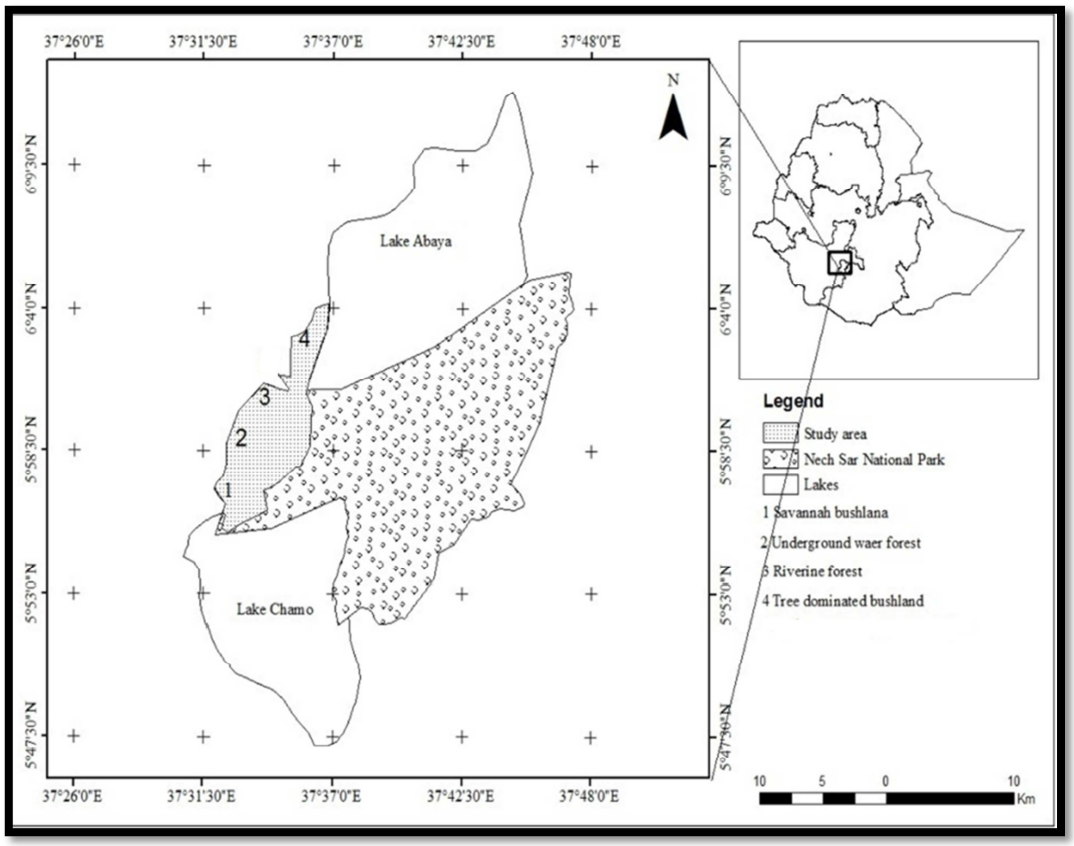



***Figure 1.*** *Map of the study area.*

### *2.2. Rational for Selecting Species*

The rationale behind the selection of the four tree species are: (1) *Vepris dainellii* is an Ethiopian endemic plant and basis of their IUCN Red list status [46] (2) *Cordia africana*, *Teclea nobilis* and *Trichilia dregeana* are the threatened tree species in Arba Minch natural forest [23] and (3) basis of their commercial and economical importance [23, 31, 46].

### *2.3. Data Collection*

#### *2.3.1. Structural Data Collection*

The study was carried out during 2014-2015 in Arba Minch Natural Forest. A total of 76 quadrats (20m×20m) lying far apart at 100m was used for plant data based on aspect of the vegetation. Systematic sampling technique and transect walks was used to collect vegetation data [14, 28]. The plant species encountered in each quadrate was recorded. In each major plot, subplots ($1m^2$) were established at the center and corner for seedlings and saplings data. The plant with DBH ≥ 2.5cm was recorded as mature plant. In each of these quadrats, the numbers of all seedlings that are less than 1m in height were recorded. Individuals attaining 1m and above with DBH less than 2.5cm were considered as sapling and counted [16].

#### *2.3.2. Interview*

Four elders were selected from the community based on purposive sampling technique [5]. These key informants were selected for interview based on the assumption that they are members of the community most knowledgeable about the species. Group as well as individual interview was conducted with them. The interview was semi-structured and based around a predetermined set of questions that were designed as together information about the use of species, how it is collected from the wild and which community member uses or depends on it.

### *2.4. Data Analysis*

Density, Diameter at Breast Height (DBH) and frequency were used for description of vegetation structure. Bar graphs were developed using the DBH versus density of individuals for six arbitrary diameter classes (< 20cm, 20.1 - 40cm, 40.1 - 60cm, 60.1 - 80cm, 80.1 - 100cm and 100.1 -120cm) of the selected tree species. The structural parameters were analyzed using the following formula:

1. Diameter at Breast Height (DBH) = $(C/\pi)$.
2. Density = (number of individuals of species A / area sampled).
3. Frequency = (number of plots in which species A occurs / total number of plots sampled).

Regeneration status of the forest was analyzed by comparing saplings and seedlings with the matured trees. According to [13] and [44]; that is, the status was good regeneration, if seedlings > saplings > adults; the status was fair regeneration, if seedlings > or ≤ saplings ≤ adults; the status was poor regeneration, if the species survives only in sapling stage (saplings may be ≤ or ≥ adults); and if a species is present only in an adult form it is considered as not regenerating.

## 3. Results and Discussion

### *3.1. The Forest and Its Resources*

The PRA survey conducted in the Nech Sar National Park and the woody plant inventory of Arba Minch natural forest study revealed that there are about 32 tree and 23 shrub species were identified from Arba Minch natural forest [23, 24]. The forest comprised the western part of Nech Sar National Park, Arba Minch forest and the northern parts of Arba Minch forest, and the adjacent areas. It covers an area of 600ha. Arba Minch town dwellers as well as people whose livelihood depends on the Arba Minch natural forest are proud to have such natural resource in their vicinity and to be the user of the forest resources. Particularly timber extract or sand fuel wood collectors strongly depend on the forest to cover their daily expenses and accomplish their daily life activities. The finding agrees with the findings of [1, 23, 33]. This further could be explained since the study is focused on distribution, abundance and population structure of four indigenous threatened tree species than the forest and its resources. People use these tree species for several purposes, both for market and household consumption.

Recent studies showed that the population size of Arba Minch town has greatly increased. The rapid population growth, the physical expansion of the town and the development of various institutions tend to increase lead to a high demand of fuel wood and timber. The result from the group discussion showed that the Arba Minch forest that serves as the main source of heat and light energy for almost every household in Arba Minch town and for villagers who live near the forest. The forest and its resources are also used for construction of farm implements, fences, furniture and houses, serve as a source of food, feed and bee fodder, and provide other environmental and social services to the community. Correspondingly the participants have identified tree species found in the Arba Minch forest, and parts of trees used for various purposes. This used of tree plants have been observed in early study and other different area of Ethiopia [1, 23]. The study show that their knowledge of the forest is limited as compared to farmers interviewed in other forests, where the same woody species inventory and socioeconomic survey took place in 34 priority forest area of the country since 1999 [32]. It is also observed that people who already lived with in or near to the forest for a long time have a deeper knowledge of the forest than migrants.

### *3.2. Multi-purpose Values of Selected Trees*

Some of the surveyed wild tree plants in the study area were found to have multi-purpose values in various ways such as forage / fodder, medicine, fuel wood (charcoal and fire wood), material culture and miscellaneous uses. *Cordia*

*africana, Trichilia dregeana, Teclea nobilis* and *Vepris dainellii* was the most commonly used wild tree species. They are among the gift of nature for the indigenous people in Arba Minch town and for villagers who live near the forest. It is used as fuel wood, local construction, timber, bee fodder, making of bee hives, source of food, feed for wild life, farm implement, wood carving, feed for livestock, shading, soil fertility restoration and house construction (Table 1). This and field observation during data collection clearly confirmed the occurrence of high disturbance in matured tree of the forest by cutting of trees for charcoal production, fire wood, house construction and timber production.

During market survey we also observed that the product of the tree (construction material, farm material, charcoal, fuel wood and timber) was widely sold in the local market and serve as a means of income generation to support the livelihood of the local people. These indicating that the tree species is highly demanded. This use of wild plants has been observed in different regional state of Ethiopia [9, 19, 23, 26].

The collection of the fruit from the natural forest is usually undertaken when it is fully matured and ripened. For example, the fruit of *Cordia africana* and *Vepris dainellii* are used more during season of food shortage since eating fruit do not take much time to prepare. Those who feel hungry harvest from the natural growing environment and eat without waiting for cooking or preparation. Similar trend has been reported in Konso, Chilga [36], Chelia District of Ethiopia [29]. However, the nutritional value and mineral content of the fruit / seed of this species was not included under this study and entails future investigation with consent of local users.

The use of *Cordia africana, Teclea nobilis* and *Vepris dainellii* as traditional medicine was reported by [4, 39, 40, 43]. The indigenous people in Arba Minch town and around the forest use the fruit of *Cordia africana, Teclea nobilis* and *Vepris dainellii* as a source of food. The seed of *Vepris dainellii* and *Teclea nobilis* used in treatment of abdominal cramp was reported by [43] and the use of bark and fruit was reported by [40]. The fresh stem bark of *Cordia africana* chewed to treat teeth problem and sudden sickness. Its leaf is burned and the remaining as his mixed with butter and creamed on affected part through dermal was reported by [4].

Due to high demand and value by the community people started keeping *Cordia africana, Trichilia dregeana, Teclea nobilis* and *Vepris dainellii* as semi-domesticated species around their home-garden witnessing that there is still a process of domestication of wild plants in south Ethiopia. The species is widely used in the local market as a means of income earning by men and women.

***Table 1.*** *The targeted plants species and their parts used.*

| Name of the plants | | Uses of the plants | Parts of the plants used |
|---|---|---|---|
| Local name | Scientific name | | |
| Wanza | *Cordia africana* | Fuel wood | Stem and branch |
| | | Local construction | Stem |
| | | Timber | Stem |
| | | Bee fodder | Flower |
| | | Making of bee hives | Stem |
| | | Source of Food | Fruit |
| | | Feed for wildlife | Fruit |
| | | Farm implement | Stem |
| | | Wood carving | Stem |
| | | Feed for livestock | Leaves |
| Dimo | *Trichilia dregeana* | Fuel wood | Stem and branch |
| | | Timber | Stem |
| | | Wood carving | Stem |
| | | Feed for wildlife | Fruit |
| | | Shading | Stem and branch |
| Gobogolta | *Teclea nobilis* | Local construction | Stem |
| | | Farm implements | Stem |
| | | Handle for implements | Stem and branch |
| | | Soil fertility restoration | Leaves |
| Gobogolta | *Vepris dainellii* | Local construction | Stem |
| | | Farm implements | Stem |
| | | Handle for implements | Stem and branch |
| | | Soil fertility restoration | Leaves |
| | | Feed for wildlife | Fruit |

### *3.3. Distribution and Abundance of Selected Trees in Its Natural Habitats*

In this study *Trichilia dregeana* and *Teclea nobilis* were recorded in 96.05% and 60.53% of the plots showing that the species are widely distributed and abundant in the study area. *Vepris dainellii* and *Cordia africana* also recorded in 51.32% and 21.05% of the plots respectively (Table 2). The explanation behind is the low density of *Cordia africana* is an indication of high disturbance in matured tree of the species by cutting of species for charcoal production, fire wood, house construction, and timber production. The density of matured four selected threatened indigenous plant species whose DBH $\geq$ 2.5cm was 489.8ha$^{-1}$. *Trichilia dregeana;* 96.05ha$^{-1}$, *Vepris dainellii;* 60.53ha$^{-1}$, *Teclea nobilis;* 51.32ha$^{-1}$ and *Cordia africana;* 21.05ha$^{-1}$ were

density of selected four indigenous tree species in the study area (Table 2). The explanation behind is the high density of the above two species is an indication of well adaptation to the ecological condition in study area.

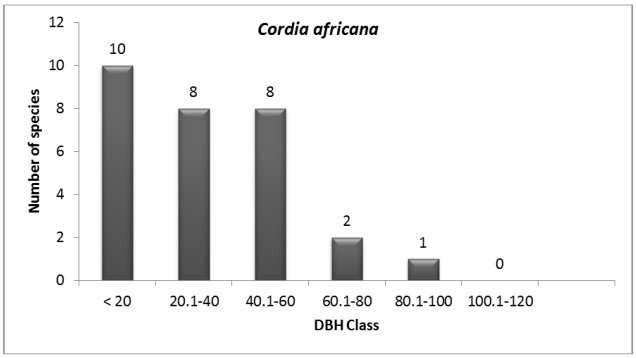
***Table 2.*** *Scientific name, Number of plot in which species recorded and Number of tree species.*

| Scientific Name | No of plot in which species recorded out off 76 | % | No Mature | Density/ha |
|---|---|---|---|---|
| *Cordia africana* | 16 | 21.05 | 29 | 9.54 |
| *Teclea nobilis* | 46 | 60.53 | 175 | 57.57 |
| *Trichilia dregeana* | 73 | 96.05 | 1138 | 374.34 |
| *Vepris dainellii* | 39 | 51.32 | 147 | 48.36 |
| | | | 1489 | 489.80 |

### *3.4. Population Structure of Selected Trees*

In the absence of long-term demographic data on population trends, the use of diameter class distributions of woody species from a single survey has been shown to be a potential and reliable tool to reveal status of population structures and regeneration of woody species as well as predict responses of the species to disturbance and resultant changes in population structure [15, 18, 34, 42, 45]. A population size structure is simultaneously the outcome of past demographic events and an indicator of its demographic future [21, 47].

Based on the assessment of diameter class distributions, the population structure patterns of the selected tree species recorded from Arba Minch Natural forest was categorized in to two groups from four species selected (Figure 2). The species in the first group exhibited reverse J shaped distribution. Inverted J shaped pattern shows high distribution of individuals of a species in the lower diameter classes and a gradual decrease towards the higher classes. In other words, it shows good reproduction and recruitment potential of the species. Population structure of the selected tree species indicated the absence of individuals in almost all species of the selected tree species in DBH class 100.1 - 120. This and field observation during data collection clearly confirmed the occurrence of high disturbance in matured tree by cutting of trees for charcoal production, fire wood, house construction, and fencing. Typical examples are *Cordia africana* and *Trichilia dregeana.* The second group pattern consists those species that occur only in the first and second DBH classes, but absent in the rest DBH classes. This pattern was represented by *Teclea nobilis* and *Vepris dainellii*. This and field observation during data collection clearly confirmed the occurrence of high disturbance in matured tree in the middle and higher DBH classes by the local people for charcoal production, fire wood, house construction, and fencing (Figure 2).



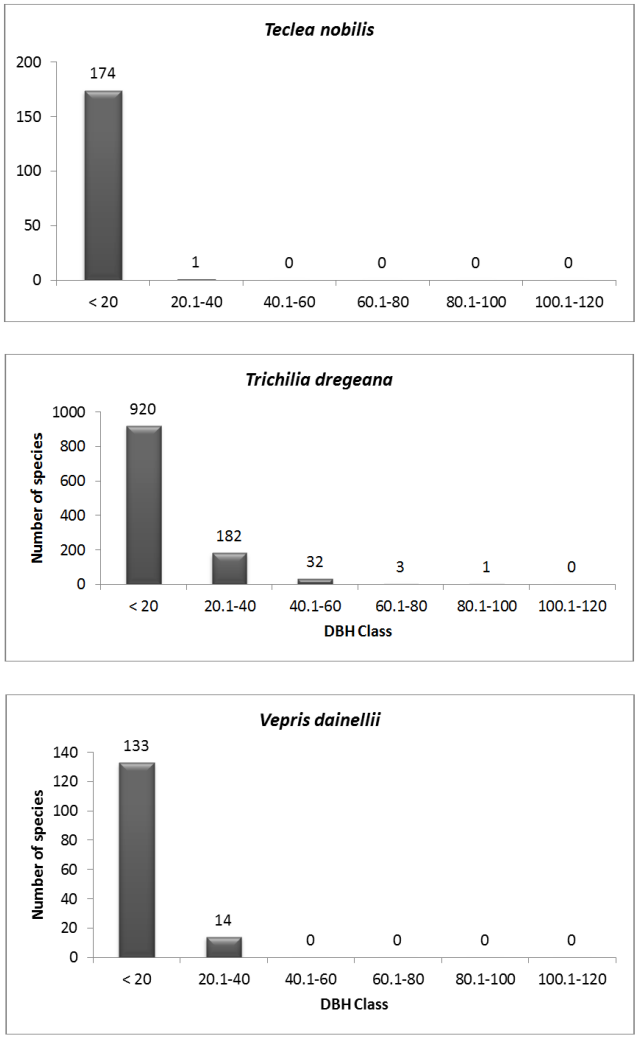




***Figure 2.*** *Population Structure of the four selected tree Species.*

### *3.5. Regeneration Status of Selected Trees*

One of the effective criteria for successful conservation and management of the forest resources are determining the regeneration status of the forest on the basis of the composition, distribution and density of seedling and sapling [17, 37]. In the forest the total density of seedling, sapling, and matured tree of selected tree species were 2283.55, 549.01, and 489.80ha$^{-1}$ respectively (Table 3). Density ha$^{-1}$ of individuals of species showed the seedling > sapling > matured tree in Arba Minch natural forest. According to [13], the density values of seedling and saplings are considered as regeneration potential of the species. Based on the criteria of

[13] and [44] the selected tree of Arba Minch natural forest was categorized under the tree with good regeneration. *Trichilia dregeana* was the most abundant species in seedling (2174.34) and sapling (460.86) and *Cordia africana* was the least abundant species in seedling (2.30) and sapling (1.64). In the present study area, some physiographic conditions, worse habitats, lack of awareness of villagers for conservation of tree, series previous disturbance occurring in the area, and immaturity of old trees to produce seed were considered as the causes of less regeneration of the tree.

According to [6] the calculation of the ratio among the mature tree, sapling and seedling can provide information regarding the distribution of mature tree, sapling and seedling and the regeneration status of the forest. In line with [6] the ration of seedling to sapling, seedling to mature tree and sapling to mature tree of Arba Minch natural forest was conducted and the result was 287:69, 345:74 and 102:91 respectively. These reveal that the distribution of seedling density is greater than both sapling and mature tree (i.e. density of seedling > density of sapling > density of mature tree) within study area. According to [13], a given forest had good regeneration if seedling is greater than sapling and mature tree /adult (seedling density > sapling density > mature tree / adults); fair regeneration if seedling > or ≤ sapling ≤ mature tree; poor regeneration if seedling < sapling ≥ or ≤ mature tree; and no regeneration if species are represented only by adult / mature trees. From the three conditions, the four threatened tree with in study area fulfills the first condition and in general, it had good regeneration status.

Depending up on the general pattern of frequency distribution, the regeneration of all tree species within the study area were divided in to two distinct regeneration patterns. The first distribution pattern shows the presence of small density of trees and gradually increases towards the highest density value of seedling and they formed inverted J - shaped distribution pattern (Figure 3). According to the study of [41] and [3], plant species with such distribution pattern had good regeneration and recruitment potential. This pattern was exhibited by *Trichilia dregeana* and *Vepris dainellii.*

The second distribution pattern shows highest density value of tree species, smaller value of sapling followed by highest value of seedling density (Figure 3). *Cordia africana* and *Teclea nobilis* are tree species that are categorized under this distribution pattern. These plant species exhibited poor regeneration pattern due to poor stocking, adverse conditions in the forest [38]. These species have smaller value of sapling and this might be due to perishing of seedling before reaching sapling stage [12, 17, 23]. According to [25], the regeneration of the forest is affected not only by environmental factors but also by anthropogenic activities. Some of the anthropogenic activities seriously observed during data collection were cutting of trees for charcoal production, constructing wood, fence, farm material, fuel wood and timber.

***Table 3.*** *Density (number of individual) per ha of seedling, sapling and mature tree species.*

| Scientific Name | No Seedling | Density/ha | No Sapling | Density/ha | No Mature | Density/ha |
|---|---|---|---|---|---|---|
| *Cordia africana* | 7 | 2.30 | 5 | 1.64 | 29 | 9.54 |
| *Teclea nobilis* | 161 | 52.96 | 100 | 32.89 | 175 | 57.57 |
| *Trichilia dregeana* | 6610 | 2174.34 | 1401 | 460.86 | 1138 | 374.34 |
| *Vepris dainellii* | 164 | 53.95 | 163 | 53.62 | 147 | 48.36 |
| Total | 6942 | 2283.55 | 1669 | 549.01 | 1489 | 489.80 |

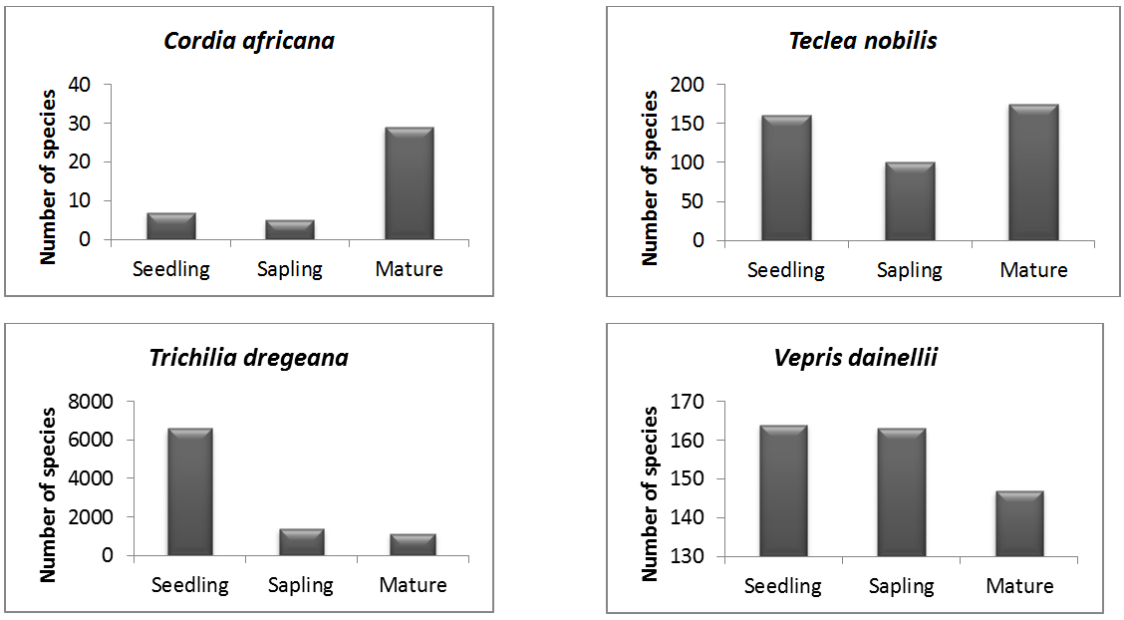



***Figure 3.*** *Selected tree species with their seedling, sapling and mature tree density/ha.*

## 4. Conclusion and Recommendation

*Cordia africana, Trichilia dregeana, Teclea nobilis* and *Vepris dainellii* are the most locally useful indigenous plant species that needs attention for future research. Current over harvesting of mature tree influenced the regeneration of these species. The inability of adult to establish large number of population due to early harvest by local people will be conservation concern that needs attention for future management. If the unsustainable harvesting by local people continues, the capacity of the species to maintain its wild population will be significantly reduced. Therefore, management and conservation strategies are essential to be put in place to save the species.

## Conflict of Interests

Mulugeta Kebebew Robi and Erchafo Mohamed Edris, the authors of the paper, declare that there is no conflict of interests regarding its publication.

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