

# Indigenous Woody Species Regeneration under the Canopies of Exotic Tree Plantations at Tore Forest, Gelana District, Southern Oromia, Ethiopia

## Abstract

This study was conducted in Tore plantation forest in Gelana district, South Ethiopia. The major objectives of the study were to assess the diversity and density of the naturally regenerated tree species under the canopy of the plantation. Systematic sampling method was employed to collect vegetation data from 40 quadrants of size 20m x 20m at 100m intervals. Consequently, data on species abundance, height and Diameter at Breast Height (DBH) of woody plant species and altitude were recorded. A total of 69 naturally regenerated species of plants with different growth habits (trees, shrubs, woody climbers, herbs and ferns) were recorded. Plants belonging to 32 families were encountered in *Eucalyptus camaldulensis* plantation and whereas 36 families in *Cupressus lusitanica* plantation. Out of the total 69 plant species, 56 trees/shrubs were recorded in *Eucalyptus camaldulensis* and 48 in *Cupressus lusitanica* plantation. Species diversity index were used to determine the level of diversity of tree species under both plantations. Accordingly, species diversity ( $H'$ ) was found to be 3.74 for tree species in *Eucalyptus camaldulensis* and 3.51 for those in *Cupressus lusitanica* plantation. The understory tree species density in the *Eucalyptus camaldulensis* plantation was computed as 517.5 stems/ha, while it was 533.75 stems/ha in *Cupressus lusitanica* plantation forest. Comparison of the level of similarity in species composition between the two plantations was made using Jaccard's similarity coefficients and the level of similarity was found to be 0.743 (74.3%). This indicates that the two plantations harbor many species in common. The presence of recurrent drought and increasing population growth disturbances on indigenous woody species implies the need for its immediate conservation action in order to ensure the sustainable utilization of the forest.

**Keywords:** *Eucalyptus camaldulensis* plantation; *Cupressus lusitanica* plantation; Naturally regenerated species; Diversity and density

## Research Article

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**Abbreviation:** DBH: Diameter at Breast Height; FAO: Food Agriculture Organization of the United Nations; GPS: Global Positioning System; MASL: Meter Above Sea Level

## Introduction

Ethiopia has one of the longest forest plantation histories in Africa. Forest plantations in Ethiopia are mainly monocultures of exotic species, such as *Eucalyptus globulus*, *Eucalyptus camaldulensis*, *Cupressus lusitanica*, *Casuarina cunninghamiana*, *Pinus patula*, *Pinus radiata*, and the native species *Juniperus procera*. Accordingly, in the end of the 19<sup>th</sup> century *Eucalyptus* species were introduced to satisfy the high demand of firewood [1,2]. In addition to this, in the year 2005 it was estimated that Ethiopia had 509000 hectares of plantations, mainly monocultures, of *Eucalyptus*, *Cupressus* and *Pinus* species and 20000 hectares more were expected to be established by the year 2010 [3]. Forests provide a habitat for uncounted creatures and microorganisms, and over millions of people also depends on them for timber production, firewood, fruit, resins and other products. Appropriate monoculture plantation of fast-growing species like *Eucalyptus* species, *Acacia*, *Teak*, *Poplar*, etc., has

demonstrated to be one of relevant approach for afforestation programs, both in economic and ecological purposes, particularly, the only effective option to initially reforest the degraded areas, then to transform into permanent forest [4]. During recent years, the planting of large areas of fast growing trees species has set off much controversy, especially in the developing world. Critics of these "fast-wood" plantations include environmentalists, who argue that they are substituting natural forests and causing harm to wildlife, water bodies and the soil, and local communities, who complain that plantations are taking over land which previously provided them with the means to feed themselves and earn a living [5]. Whereas, plantations have been suggested to promote native plant species understory regeneration, and thus increase biodiversity [6-9]. The mechanisms that encourage the understory regeneration involves shading off grasses, enhancing soil nutrients (through uptake by deep roots and litter fall), bettering micro-climate, and in general increasing the chance for seed germination and establishment, which an area of highly degraded sites [8]. Furthermore, plantations can also protect sites from further degradation by preventing soil erosion and reducing fire hazard. For these reasons, trees of exotic or native origin are

often planted on degraded areas for rehabilitation, in order to preventing further site degradation and catalyzing native plant colonization. Particularly mixed tree plantations are believed to promote the regeneration of a great diversity of species in their understory than pure species of plantation. They could also create a greater variability of habitat conditions that may favor seed dispersal, germination and growth of tree species [10]. On the other hand, some believe that the regeneration of indigenous woody species under the canopy of exotic tree plantation could be hampered. This is mainly associated with idea that plants can compete with each other for natural resources and this could in turn pose nutrient and water stress in surrounding community particularly on the native species [11]. Sustainable use of natural resources at present is one of main agenda for a number of global conservation organizations, national authorities and non-government organizations. Various studies indicate that conservation of natural vegetation is under threat mainly due to anthropogenic activities [12]. The study site was highly degraded and often affected by recurrent drought. This is mainly associated with the clearing of native woody species by the local community for various purposes for a very long period. Thus, before 1981 only few patches of the native vegetation were observed in the study area. Taking into account, this problem in 1981 GC the government took the initiative to establish protected tree plantations in area that could in the end sustainably harvested for commercial purpose. For this purpose mainly the exotic species *Eucalyptus camaldulensis*, *Eucalyptus globules* and *Cupressus lusitanica* were planted in the area. Therefore, this study was initiated to generate basic data on the regeneration status of indigenous tree species from under the canopy of plantation forest and determine the diversity of these native tree species under these plantations. Understanding the regeneration status of these tree species undoubtedly provides valuable information for researches and policy makers to devise sound conservation and management strategies that could contribute towards sustainable utilization of vegetation resources and the associated biodiversity.

## Materials and Methods

### Description of the study site

Gelana Wreda is one of the woredas in the Oromia Region of Ethiopia. It is part of the Borena Zone. The administrative center of Gelana is Tore. Gelana is located at 5°54'65"N and 5°55'80"N latitude and between 38°10'05"E and 38°10'59"E longitude with an altitudinal range between 1700 and 1900 ma.s.l. It is bordered on the south by Bule Hora, and on the west, north and east by the Southern Nations, Nationalities, and Peoples Region (SNNPR). Lake Abaya, on the western border, is divided between this woreda and the SNNPR. Tore located at distance of 425 km from Addis Ababa. The Woreda is situated at the northern tip of Borena Zone ca 155 Km from the zonal capital Yabello. Regarding the study forest, Tore forest plantation was established on 62 ha of land for production of wood for commercial purposes. During its establishment, the forest was dominated by exotic species such as *Eucalyptus camaldulensis*, *Eucalyptus globules* and *Cupressus lusitanica*. However, currently about five ha is covered by *Juniperus procera* plantation which were planted in 2008 with

the aim of promoting the conservation of indigenous trees of Ethiopia.

### Sampling design

Following a reconnaissance survey, actual sampling of vegetation was done focusing on appropriate sampling methods. Hence, Systematic sampling design was employed for data collection by laying a total of 40 quadrants, each with 20 m x 20 m area. A total of 40 quadrats, 20 plots were laid in *Cupressus lusitanica* forest plantation and the remaining 20 in *Eucalyptus camaldulensis* plantation. These quadrat were laid out along line transects with 100 m distance from adjacent quadrat. Data regarding seedling, sapling and herbaceous species under the canopy were collected by systematically laying five 2m x 2m subplots within each main quadrant (four at the four corner of the main plot and one at the center). Accordingly, Tore forest plantation, two areas located with each of three exotic species such as *Eucalyptus camaldulensis*, *Cupressus lusitanica*, *Eucalyptus globules* and one indigenous, *Juniperus procera*. For this study, *Eucalyptus camaldulensis* and *Cupressus lusitanica* plantation forests were selected. The plantations were 0.2km apart from each other.

### Methods of data collection and analysis

**Floristic data collection and plant identification:** Specimens of all woody plant species encountered at the sampling sites were collected, pressed, dried and then taken to the National Herbarium (ETH), Addis Ababa University for identification. The specimens were identified by comparing with already identified (authentic) specimens, consulting experts and referring the Flora of Ethiopia and Eritrea books [13-15] and Useful Trees and Shrubs for Ethiopia [16].

**Plant diversity and evenness:** Shannon-Wiener index was computed to determine species richness and evenness for woody plant species regenerated under the canopy of both *Eucalyptus camaldulensis* and *Cupressus lusitanica* plantation stands. Shannon-Wiener diversity index was calculated using the formula:

$$H' = -\sum_{i=1}^s p_i \ln p_i$$

$$\text{Equitability } J = \frac{H'}{H'_{\max}} \text{ or } J = \frac{H'}{\ln(S)}$$

Jaccards similarity index was used to determine the degree of similarity in species composition between the two stands using the following formula:

$$J = a/(a+b+c),$$

**Vegetation structure:** In the field within each plot DBH of all trees and shrubs, species (at 1.3m above ground level) were measured using a measuring diameter tape. Information on location (latitude and longitude) and elevation (altitude) were obtained by using GPS (Garmin model 60). The vegetation structure of tree/shrub species was analyzed using data from DBH, height, density, frequency, basal area and importance value index. Every individual tree and shrub with DBH greater than 2.5cm, height

measurements were taken using a Sunto-Clinometer. Analysis of vegetation structure based on height data was carried out by categorizing height measurements into eight classes (I. 1 -5m, II. 5.01 - 10 m, III. 10.01 - 15 m, IV. 15.01 - 20 m, V. 20.01 - 25 m, VI. 25.01 - 30 m, VII. 30.01 - 35 m and VIII. > 35 m).

Stand density were computed on hectare basis using the following formula

$$D = \frac{\text{Number of above ground stems of a species counted}}{\text{sample area in hectare (ha)}}$$

Frequency, (F) was calculated by using the following formula [17].

$$F = \frac{\text{Number of plots in which a species occur}}{\text{total number of plots sampled}} \times 100$$

Basal Area (BA): is often calculated to measure stand density and to provide a basis for calculation stand volume. The area outline of a plant near ground surface for trees is measured through diameter, usually at breast height (DBH). Generally used for trees, BA measurements are calculated based on measurement of tree diameters at breast height.

$BA = \pi d^2 / 4 = (DBH/2)^2 \times 3.14$ , where d is diameter at breast height.

Importance Value Index (IVI): It is combines data for three parameters (Relative density, Relative frequency and Relative dominance).

Thus,  $IVI = RD + RF + RDO$

Where, Relative density (RD): the number of all individuals of a species per the total number of all individuals.

$$RD = \frac{\text{Number of above ground stems of a species counted}}{\text{total number of above ground stems in the sample area}} \times 100$$

Relative frequency (RF): frequency of a species per total frequency of all species x 100

$$RF = \frac{\text{frequency of a species}}{\text{total frequency of all species}} \times 100$$

Relative dominance: basal area of a species per basal area of all the species x 100

The basal area was calculated for all species from diameter at breast height,

$$RDO = \frac{\text{dominance of tree species}}{\text{sum of dominance of all tree species}} \times 100$$

**Regeneration status:** Individuals with DBH less than 2.5cm and height less than 1.5m were counted and recorded as seedling and where as individuals with height between 1.5m and 2m and DBH less than 2.5cm were recorded as saplings. Regeneration status of the plantation forest was studied by comparing the frequency of sapling and seedling with matured trees according to [18] i.e., good regeneration if seedling > sapling > matured tree, fair regeneration if seedling > or = saplings ≤ adult trees; poor regeneration, if the species survives only in sapling, but no seedling (saplings may be ≤ adults): and if a species is only in mature form it is considered as not regenerating. Comparative regeneration status of the two forest stands was also assessed by computing density ratios

between seedlings and mature individuals, seedlings and saplings, and sapling and mature individuals as [19] used formula.

$$\text{Seedling to tree ratio} = \frac{\text{Estimated number of seedlings}}{\text{Number of trees}}$$

$$\text{Sapling to tree ratio} = \frac{\text{Estimated number of saplings}}{\text{Number of trees}}$$

## Results and Discussion

### Floristic composition

A total of 69, species of (trees, shrubs, herbs, climbers and grasses) belonging to 39 families were identified in the study area. Out of these 39 families, 28 families were found to be common to both plantations. Thirteen species were found to be associated with only *Eucalyptus camaldulensis* plantation whereas six species were found to be associated with only *Cupressus lustanica* plantation (Table 1). Among the families, fabaceae was found to be represented by the highest number of species (with seven species in *Cupressus lustanica* plantation and nine in *Eucalyptus camaldulensis*). Among the 69 plant species identified in the study area trees constitute the largest proportion (> 60%,) followed by shrubs (above 14%), grasses (5.6%), ferns (above 4%) and lianas (2.85%) (Figure 1).

**Table 1:** List of plant species associated with only one of the two plantations in the study area.

Eucalyptus Plantation	Cupresses Plantation
<i>Acacia bussei</i>	<i>Dracaena steudneri</i>
<i>Acacia nilotica</i>	<i>Ficus sur</i>
<i>Apodytes dimidiata</i>	<i>Hagenia abyssinica</i>
<i>Celtis toka</i>	<i>Phoenix reclinata</i>
<i>Fagaropsis angolensis</i>	<i>Teclea nobilis</i>
<i>Grewia ferruginea</i>	<i>Vepris dainellii</i>
<i>Juniperus procera</i>	
<i>Maesa lanceolata</i>	
<i>Millettia ferruginea</i>	
<i>Rhamnus staddo</i>	
<i>Salix mucronata</i>	
<i>Syzygium guineense</i> spp. <i>afromontanum</i>	
<i>Terminalia schimperiana</i>	

### Species diversity and species composition

Species diversity is generally assessed by using diversity index, which incorporates information on species richness and evenness. Accordingly analysis of species diversity of woody species under the canopy of *Eucalyptus camaldulensis* and *Cupressus camaldulensis* plantations using Shannon - Wiener diversity index indicated that the species diversity for woody species for the former ( $H' = 3.74$ ) was found to be slightly greater than the later ( $H' = 3.51$ ). This indicates slightly higher species diversity for woody plant species growing under the canopy of *Eucalyptus*

*camaldulensis* plantation. This has been also demonstrated by both species richness and evenness indices computed for both plantations (Table 2).

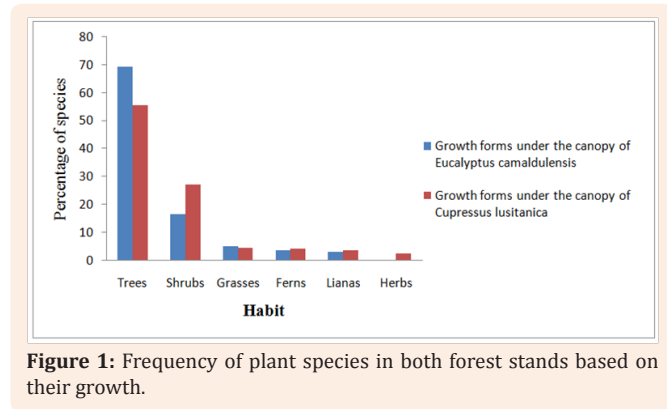


Figure 1: Frequency of plant species in both forest stands based on their growth.

Table 2: Shannon-Wiener diversity index (H'), species richness and evenness, woody species regenerated under *Eucalyptus* and *Cupressus* plantation forests.

Forest Plantation	Shannon - Wiener Diversity Index (H')	Species Richness (S)	Evenness (E)
<i>Eucalyptus camaldulensis</i>	3.74	56	0.93
<i>Cupressus lusitanica</i>	3.51	48	0.9

Species similarity index is generally used to characterize the degree of spatial heterogeneity in diversity at the landscape scale, or to measure the change in diversity along transects or environmental gradients. Jaccard's similarity index was used to determine the pattern of species turnover between two plantations. Its coefficient value ranges from zero (complete dissimilarity) to 1 (total similarity). Accordingly the level of overlap in species composition between *Eucalyptus camaldulensis* and *Cupressus lusitanica* plantations was found to be 74.3 % (J= 0.743).

### Vegetation structure

**Stand density:** Density was expressed as the number of individuals per hectare. Depending on this, the total density of all woody species identified from the 40 sample plots (1.6ha) that regenerated under the canopy of both plantation was 1101.5individuals/ha. Out of this total stand density of regenerated woody species under *Eucalyptus camaldulensis* and *Cupressus lusitanica* plantation was found to be 583.75 and 517.75 individuals/ha respectively.

**Diameter at breast-height (DBH):** In both plantation forests, the first two lower diameter classes (DBH = 1-10cm and 10-20cm) were found to be relatively dominant (Figure 2). Furthermore, in both plantations out of the 56 species encountered the majority of species fall under the lowest DBH class (29 species for *Eucalyptus* and 27 for *Cupressus*). The number of species that fall under each of the succeeding higher DBH classes decreases considerably. For example, the tree species under the two successive higher

DBH classes were only seven, namely: *Ficus glumosa*, *Ficus sycomorus*, *Terminalia laxiflora*, *Combretum collinum*, *Cordia africana*, *Dombeya torrida* and *Combretum molle*. These trees probably represent the first batch of trees regenerated or planted during the establishment of the plantation. Few very large sized trees could even be remnants from the previous natural forest vegetation before the area was declared as protected.

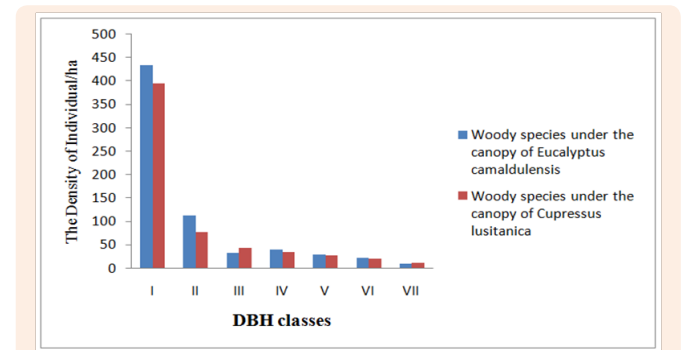


Figure 2: Diameter at breast height class distribution in *Eucalyptus* and *Cupressus* plantation.

I: 1-10cm, II: 10.01-20cm, III: 20.01-30cm, IV: 30.01-40cm, V: 40.01-50cm, VI: 50.01-60cm, VII: 60.01-70cm and VIII: > 70cm.

**Basal area (BA) and height distribution of trees:** The total basal area of naturally regenerated tree species in *Eucalyptus camaldulensis* and *Cupressus lusitanica* plantations of Tore forest was found to be low (7.267m<sup>2</sup> /ha and 5.671 m<sup>2</sup>/ha for *Eucalyptus camaldulensis* and *Cupressus lusitanica* plantations respectively). This result indicates that Tore forest is composed of mainly small sized naturally regenerated woody species. Some of the species that contributed most to the total BA includes: *Ficus glumosa* (28.4%), *Ficus sycomorus* (12.22%), *Terminalia laxiflora* (10.32%), *Cordia Africana* (7.91%) for *Eucalyptus* plantation forest and *Cordia Africana* (19.98%), *Terminalia laxiflora* (15.9%), and *Combretum molle* (13.05%) for *Cupressus lusitanica* plantation forest.

The dominance of small sized trees in both forests was also assessed by comparison the frequency of individual trees categorized under the eight height distribution classes. The result indicated that in both plantations higher frequencies were recorded for the first three succeeding lowest height classes (Figure 3). Thus, their contribution is more than 95% for the total density of the forest (500 individual/ha for *Eucalyptus* plantation and 518.75 individuals/ha for *Cupressus* plantation). And trees in height class IV, V, VI, VII, and VIII contributed less than 3.5% of the total density of forest (17.5 individual/ha for *Eucalyptus* plantation and 15 individuals/ha for *Cupressus* plantation). In general, from both DBH and height distribution measurements analyses, both plantation forests are dominated by small sized trees.

### Important value index

Important value index (IVI) is a measure of the relative importance of a species and it is the sum of the relative density, relative dominance, and relative frequency. IVI expression reflects the relative ecological importance of a species much

better than the single absolute measures like frequency, density and basal cover. Four species (*Terminalia laxiflora*, *Schrebera alata*, *Celtis africana* and *Cordia africana*) were found to display higher IVI values for both *Eucalyptus camaldulensis* and *Cupressus lusitanica* plantations (with IVI value 9.22-26.64). In addition four species (IVI, 9.99-31.04) in *Eucalyptus camaldulensis* 7 species (*Ficus glumosa*, *Terminalia laxiflora*, *Ficus sycamoros*, *Schrebera alata*, *Celtis africana*, *Calpounia aurea* and *Acokanthera schimperi*), 7 species (IVI= 9.02-15.87) in *Cupressus lusitanica* plantations (*Combretum molle*, *Schrebera alata*, *Celtis africana*, *Combretum collinum*, *Ekebergia capensis*, *Maytenus arbutifolia* and *Lanearivae*) were found to display high IVI (IVI class two). On the other hand, in both plantations, low IVI was recorded for two species (*Podocarpus falcatus* (0.83%) and *Steganotaenia araliaeae* (0.83%)) in *Eucalypt camaldulensis* and *Hagenia abyssinica* (0.63%), and *Vepris dainellii* (0.67%) in *Cupressus lusitanica* plantation.

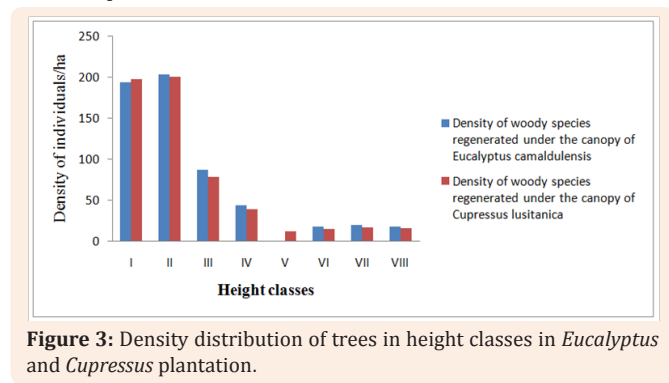


Figure 3: Density distribution of trees in height classes in *Eucalyptus* and *Cupressus* plantation.

The IVI could also be used to identify species under threat and set up conservation priority plans. Accordingly, for *Eucalyptus camaldulensis* species under IVI class 5, (*Podocarpus falcatus*, *Steganotaenia araliaeae*) and for *Cupressus lusitanica* plantations species (*Hagenia abyssinica* and *Vepris dainellii*) are represented by small number of species and also their contribution to the total IVI is small and hence conservation priority plans should first focus on these species (*Podocarpus falcatus*, *Steganotaenia araliaeae* and *Millettia ferruginea* in *Eucalypt* plantation and *Hagenia abyssinica*, *Veprisdainellii* in *Cupressus* plantation). Quite a large number of species from both plantations (34 from *Eucalyptus camaldulensis* and 24 from *Cupressus lusitanica* plantation) fall under priority class number 2 indicating that conservation strategy needs to be in place.

### Regeneration status of woody species under plantation forests

Composition and density of seedlings and saplings would indicate the status of regeneration in the study area. The total seedling, sapling and mature tree/shrub species densities in both plantation were found to be 310 (193.75 ha<sup>-1</sup>), 304.5 (190.31 ha<sup>-1</sup>) and 487 (304.38 ha<sup>-1</sup>) individuals per hectare respectively (Table 3 & Table 4). These are indicators of the future regeneration status of any forest.

Accordingly, from both plantations a total of 14 species were found to be represented only by mature tree/shrub. Thus, no

single individual was recorded either at seedling or sapling stages. Saplings and mature (no seedling) trees were encountered for *Hagenia abyssinica*, *Juniperus procera* and *Millettia ferruginea*. These species could generally be considered as not regenerating. This showed us these species might be abundant before the establishment of plantation here and gradually triggered by human for different purposes or affected by the canopy of plantation forest.

Table 3: Composition and density of woody species under the canopy of *Eucalyptus camaldulensis*.

<i>Eucalypt Camaldulensis</i>	Individual Species	Percent
Trees	254	42.12
Sapling	165	27.36
Seedling	184	30.51

Table 4: Composition and density of woody species under the canopy of *Cupressus lusitanica*.

<i>Cupressus lusitanica</i>	Individual Species	Percent
Trees	233	46.74
Sapling	139.5	27.98
Seedling	126	25.28

Comparative regeneration status of the two forest stands was made by comparing the ratio of trees to both saplings and seedlings were computed. Accordingly, the ratio of seedlings to trees and saplings to trees were found to be 1 to 1.38 and 1 to 1.5 respectively in *Eucalyptus camaldulensis* plantation. On the other hand, 1 to 1.85 (seedling to tree) and 1 to 1.67 (saplings to trees) ratios were observed in *Cupressus lusitanica* plantation. This showed the density values of seedling and saplings are considered as regeneration potential of the species. Based on the criteria woody species regeneration under Tore Forest Plantation was categorized under fair regeneration. Lack of awareness for conservation of forest and drought of the area leads 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 forest. Regeneration of a particular species is poor if seedlings and saplings are much less than the mature trees. However, when we compare the two stands better regeneration was observed under *Eucalyptus camaldulensis* plantation stand compared to *Cupressus lusitanica*.

### Discussion

#### Floristic composition and diversity

The results of the study identified 69 species of plants belonging to 39 different families. Among the 39 families, fabaceae was represented higher number of species in both forests plantation stands. This study also identified 48 woody species in *Cupressus lusitanica* plantation and 56 in *Eucalyptus camaldulensis*. However, the result of the woody species diversity index indicated that the *Eucalyptus camaldulensis* plantation was slightly greater than in diversity that of the *Cupressus lusitanica* plantation, and the species distribution in the *Eucalyptus camaldulensis* plantation (0.93) was almost similar to that of the *Cupressus lusitanica*

plantation (0.90). However, as compared to similar studies done before in Ethiopia, in this study, more number of native woody species were recorded. For instance, a total of 18 and 11 naturally regenerated woody species under the canopy of 14 years and 24 years *Cupressus lusitanica* plantation within the area of the central Ethiopian highlands were recorded [20]. In addition to this, 27, 26, 17 and 15 native woody species recorded under 17 years *Eucalyptus globules*, 26 years *Juniperus procera*, 24 year *Pinus patula* and 15 years *Pinus radiate* plantations [21]. Similarly, [22] recorded a total of 36 woody plant species in Munessa Shashemene forest. The differences might be associated with the abiotic and biotic factors such as temperature, precipitation, floristic history, disturbances, grazing, human interferences, ecological variation and forest logging (legal and illegal) topography and soil character.

### Vegetation structure

For the analysis of tree species diversity, the tree DBH, height and frequency class distribution in both plantation forest have been described. As DBH and height of tree species increases population density of forest was decrease. The description of frequency class showed that higher percentage at lower class. This indicates that the plantation forests are heterogeneous. The height, DBH and frequency classes shows an inverted J-shape. This indicates the normal regeneration of forest plantation. This finding similar with other study that reported by [23], who reported species had the highest number of individual at low DBH and Height classes with gradual decreases towards the high for both classes. However, the dominance of small sized naturally regenerating native woody species also implies that the colonization is at an early stage of development in both plantation stands and poor recruitment in the forest, which might have been caused by selective cutting of large sized individuals.

### Regeneration status of woody species

Composition and density of seedlings and saplings would indicate the status of regeneration in the study area. The total seedling, sapling and mature tree/shrub species densities in *Eucalyptus camaldulensis* were found to be 230 ha<sup>-1</sup>, 206.25ha<sup>-1</sup> and 317.5ha<sup>-1</sup> respectively. While, in *Cupressus lusitanica* were found to be 157.5 ha<sup>-1</sup>, 174.38 ha<sup>-1</sup> and 291.25 ha<sup>-1</sup> individuals per hectare respectively. This study dissimilar with the researchers, [24] who reported woody plants 5790 ha<sup>-1</sup> were recorded under *Cupressus lusitanica* and 1090 ha<sup>-1</sup> *Eucalyptus globules*. The variation might be due to soil chemical attributes, the canopy of plantation, ecological character, human interference and abiotic and biotic conditions.

### Conclusion and Recommendations

The results of this study indicated that tree plantations foster native woody species and useful in an area of natural forest edge in order to minimize natural forest disturbance and also useful for degraded land due to erosion. However, the woody plant species observed in this study was greater in *Eucalyptus* plantation than in *Cupressus* plantation. This result implies *Eucalyptus camaldulensis* play a significant role in fostering for the regeneration of indigenous woody species diversity. Beside this, this plantation could be attributed to facilitate microclimate to soil seed and seed rain. Results from this study revealed that most indigenous

plant species regeneration in the plantation forest could be comes from forests accumulate small quantities of viable seeds in the soil. While, the *Cupressus lusitanica* plantation suggested that relatively less indigenous woody species diversity could be due to high shading conditions and less litter decomposition. As a result, seed germination and establishment may be disability of unfavorable soil conditions. Such conditions might include no suitable site for germination as a result of soil compaction, close canopy of plantation (that protect sun light), loss of topsoil, lack of mycorrhizal fungi (fungi which associate with plant roots and assist with nutrient uptake). This diminishes the air spaces in the soil and reduces its capacity to absorb and retain water. We recommend that further study should be carried out on soil seed bank, seed physiology, the mechanism of seed dispersal and land use management system in the area.

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### Conflict of Interest

I confirm you there is no any conflict of interest about this manuscript.

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