

Floristic Composition, Structure, and Regeneration Status of Woody Plant Species in Hurubu Natural Forest, North Shewa, Oromia Region, Ethiopia

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Abstract

Ethiopia harbours the Eastern Afromontane and Horn of Africa hotspots of biodiversity. The general objective of this study was to investigate the floristic composition and diversity of species, the structure and the regeneration status of the Hurubu natural forest. Three parallel transects were systematically laid across the forest with an interval of 200m in north to south direction. Thirty sample quadrats of 20 m × 20 m were placed along transects at an interval of 100 m for mature trees and shrubs, while for the purpose of seedling and sapling inventory, four sub-quadrates of 1 m × 1 m were laid at each corner of the main quadrat. A total of 32 woody species representing 25 families was recorded consisting of trees and shrubs. The lower storey consisted of all woody plant species except *Ekebergia capensis* tree species. The middle storey consisted about 14.41% of the tree species while the upper storey involved only 2.35% of the total individual trees in the forest. The total basal area of woody plants in Hurubu forest was 90 m² per ha. The three most important woody species with the highest IVI were *Juniperus procera*, *Osyris quadripartita*, & *Myrsine africana* in decreasing order. The general regeneration status of the tree species of the study site was satisfactory at the community level showing a 'fair' regeneration status. Therefore, special conservation actions should be implemented for the poorly and not regenerating woody species of the forest.

Introduction

The geography of Ethiopia characterised by a great altitudinal variation from 116 metres below sea level to 4620 meters above sea level and diverse climatic conditions (IBC, 2012). The diverse altitude and climatic factors have driven the establishment of diverse vegetation, ranging from Afroalpine vegetation in the type of mountains to the arid and semi-arid vegetation in the lowlands (Asefa *et al.*, 2020). Ethiopia harbours the Eastern Afromontane and the Horn of Africa biodiversity hotspots and possesses an estimated 6000 species of which 10% are considered to be endemic. From these higher plants, woody plants constitute about 1000 species, out of which 300 are trees (IBC, 2012).

The forest ecosystem of Ethiopia covers about 17 069, 000 ha or 15.11 % of land area in 2020 (FAO, 2020). However, deforestation and forest degradation are ongoing processes in Ethiopia (Wassie, 2020). Currently, the remaining forests of the country found in South West and South East; Western lowlands; and in central and Northern highlands including around the churches respectively for Moist Afromontane forests, the Dry Forest (*Combretum-Terminalia* woodlands) and Dry Afromontane forests (Tigabu, 2016; MEFC, 2018). Currently, the establishment of protected and forest priority areas, as well as the sacred forest sites and large-scale intervention in forest rehabilitation in degraded highlands, is among the efforts that the government and local communities are employing to maintain and conserve existing natural forests (Tigabu, 2016; MEFC, 2018). Furthermore, the National REDD + Strategy (NRS) broadly targets intensifying efforts to protect existing natural forest resources while also increasing investments on forest restoration because forestry is among the four pillars of the Climate Resilient Green Economy Strategy which aims to reduce national emissions by 50% by 2030 (MEFC, 2018). It also highly emphasized the current need for large-scale restoration for the central and northern areas of Ethiopia,

which historically lost most of its forest cover due to various forces (MEFCC, 2018). Closing and rehabilitation of existing degraded native forests through natural regeneration (high forest zone) and assisted natural regeneration with enrichment planting (high forest zone and forests) are among the strategic options for the Oromia region (MEFCC, 2018).

Consequently, data on woody plant communities which are defined largely by species presence (or absence) is crucial to take conservation actions. Further formal description generally focuses on features such as complete floristic composition, floristic structure, species diversity, and information on regeneration status has important applications in sustainable use of natural forests, the preservation of biodiversity, and detecting changes in the plant cover of the area (Maarel, 2005).

From the Oromia regions of Ethiopia, the north Shewa zone (Salale) has the smallest area (11,290 km²). Consequently, north Shewa has the lowest forest cover share (0.06%) of the Oromia region (Bekele *et al.*, 2015), and deforestation is one of the main problems identified with respect to the management of natural resources in this zone (Agajie Tesfaye *et al.*, 2018). This zone is part of a highly emphasised area on the current need for large scale restoration. The Ellen forest is the largest forest cover found in this zone, having 728 ha and 1/3 (242 ha) of this forest is natural, which is called Hurubu forest. However, there is a lack of data on the floristic composition, species diversity, structure, and regeneration status of the Hurubu forest. Therefore, the purpose of this study was to give insight for policy makers and implementer on the conservation measures required for this forest. Furthermore, this reserch is the first paper published so far on this forest ecosystem. The general objective of this study was to investigate the floristic composition and species diversity, structure, and regeneration status of Hurbu forest. Specific objectives were i) to analyze the floristic composition and species diversity of Hurubu forest, (ii) to analyse the structure of the Hurubu forest, and (iii) to investigate the regeneration status of the Hurubu forest.

Materials And Methods

2.1 Description of the study area

The study was carried out in Ellen natural forest, specifically named Hurubu forest, Degem woreda, north Shewa Zone, Oromia Regional State. Degem Woreda, lies between 9° 47' 29" - 9° 47' 13" N latitude and 38° 31' 09" - 38° 32' 50" E longitudes. The forest area is geographically located at latitudes and longitudes of 09° 51' N and 38° 38' E respectively. Woreda was found 125 km north of Addis Ababa (Lemlem & Asfaw, 2018). The major soil types include verisols, nitosols, and cambisols. With regard to the soil color, 10% of the soil is black, 45% brown and 45% red (Lemma, 2011).

Climatic conditions in Degem woreda are divided into three agro-climatic zones: Dega (30%), woynadega (38%) and Kola (32%). Altitude ranges from 1500-3541m.a.s.l. The average annual rainfall is 1128.47mm with a bimodal distribution, small rains during the Belg season between February and April and big rain from the end of June to the beginning of October. Temperature varies between the mean annual

maximum of 20.3 ° C and the mean annual minimum of 8.17 ° C throughout the elevation gradient (Lemma, 2011) .

2.2 Sampling Design

A systematic sampling design was employed for woody plant data collection. Three parallel transects were systematically laid across the forest with an interval of 1000m in the south to north direction. Thirty sample quadrats of 20 m × 20 m were placed along transects at an interval of 200 m for mature trees and shrubs, while for the purpose of seedling and sapling inventory, four sub-quadraters of 1 m × 1 m were laid at each corner of the main quadrat. In each quadrant, all species of woody plants were identified by their local names, pressed, coded, and then grouped as trees and shrubs.

2.3 Data collection method

Floristic data collection: All woody plant species encountered in each sample quadrant were recorded and coded with local and vernacular names whenever possible. Plant species occurring outside sample quadrants but inside the forest was recorded only as present, but not used in subsequent vegetation data analyses (Shiferaw et al., 2018). These species and the rest plant specimens were collected, pressed, dried, and brought to the Ethiopia Biodiversity Institute, for taxonomic identification using flora of Ethiopia and Eritrea.

Structural and regeneration data collection: In each quadrant, for all woody plants having diameter at breast height (DBH) ≥ 2.5 cm, the circumference measurements were made at breast height (around 1.34 m) by using diameter tape and calliper following the methods described by (Martin, 1995). According to (Ayanaw Abunie & Dalle, 2018), stems born from the same root were considered a single plant during measurement for the woody plants. The diameter of stems branching below or at the breast height was measured separately for each branch and summed.

For regeneration survey, seedlings (height less than 1.0 m) their numbers only were recorded. Individual woody categorization performed at a height of less than 1.0 m and DBH less than 2.5 cm for the seedlings. Height 1.0 to 3.0 m and DBH 2.5–10 cm for saplings and height greater than 3.0 m and DBH greater than or equal to 10 cm for tree species were measured (Ostrom, 2007). Height was measured using the clinometer. Where slope, topography, and/or crown structure made it difficult to use clinometer, height was estimated visually.

2.4 Data Analysis Method

Species diversity in the forest was calculated using the Shannon Wiener Diversity Index and species richness (Magurran, 2004) :

$$H' = -\sum P_i \ln P_i$$

Where, H' = Shannon diversity index, P_i = proportion of individual found in the i -th species. The Ratio of observed Shannon index to maximum diversity ($H_{\max} = \ln S$) was used to measure evenness (J') (Magurran, 2004). Equitability (evenness) $J = H'/H_{\max}$ or $J = -\sum P_i \ln P_i / \ln S$, where S is the number of species.

Structural Data Analysis

Basal area was calculated as follows (Mueller-Dombois & Ellenberg, 1974):

$$\text{Basal area (BA)} = \frac{\pi DBH^2}{4}, \text{ Where, BA: basal area, DBH: depth at breast height, } \pi = 3.14$$

The Importance Value Index (IVI) indicates the importance of species in the system and was calculated with three components as follows (Nguyen et al., 2014).

$$\text{Relative density (RD)} = \frac{\text{Number of individual species}}{(\text{Total number individual})} \times 100$$

$$\text{Relative dominance (RDo)} = \frac{\text{Dominance of species}}{\text{Total dominance of all species}} \times 100, \text{ where dominance is the basal area of species times number of species}$$

$$\text{Relative frequency (RF)} = \frac{\text{Frequency of species}}{\text{frequency of all species}} \times 100, \text{ where frequency is number of plots in which species found divided by the total number of plot times one hundred}$$

$$\text{Importance value index (IVI)} = \text{RD} + \text{RDo} + \text{RF}$$

Vertical structure

The vertical structure of trees in the Hurubu Forest was described based on the International Union for Forestry Research Organisation (IUFRO) classification scheme (Lamprecht, 1989). According to the scheme, three vertical structures were distinguished in tropical forests. These are: upper floor (tree height >2/3 of top height), middle storey (tree height between 1/3 and 2/3 of top height) and lower storey (<1/3 of the top height).

Height and DBH class distribution: was analysed using height and DBH class categorization.

Regeneration status: was analyzed by comparing saplings and seedlings with the matured trees as given below (Dhaukhandi *et al.*, 2008):

1. Good regeneration, if seedling is greater than sapling and mature tree/adult (seedling density > sapling density > mature tree/adults);
2. Fair regeneration, if seedling > or $\leq$ sapling $\leq$ mature tree;
3. Poor regeneration, if a species survives only in the sapling stage, but has no seedlings (even though saplings may be <, >, or = mature);
4. Not regenerating, if a species is present only in an adult form; and
5. New, if a species has no matured, but only sapling and/ or seedling stages.

Results And Discussion

3.1. Floral composition and the species diversity of Hurubu forest

A total of 32 woody species representing 25 families were recorded consisting of trees (46.88%), shrubs (40.63%), creeping shrubs (6.25%), climbing shrub, and tree/shrub (3.13% each). This forest had 2 endemic, 29 indigenous and 1 exotic woody species. The families with the highest number of species were Fabaceae (15.63 %) followed by Apocynaceae (6.25%), Loganiaceae (6.25%), and Myrsinaceae (6.25%). The remaining 21 families contained one species (3.13%) (Table 1 and Fig. 2). This study showed that the Hurubu forest's Shanon diversity index was 2.76 with 0.83 evenness index.

4.2 The Structure of Hurubu Forest

Vertical structure

The vertical structure of woody species of the Hurubu forest was analyzed into three vertical layers based on the maximum 50m tree height of this forest. These were upper storey (top height > 33.33 m), middle storey (height between 16.67-33.33 m) and lower storey (height <16.67 m).

The lower storey consisted of all woody plant species except *Ekebergia capensis* tree species. The most dominant woody plant in the lower story were, *Juniperus procera* (15.95%), *Myrsine africana* (12.56 %), *Dodonaea angustifolia* (9.16 %), *Erica arborea* (8.82 %) and *Osyris quadripartita* (7.58 %), the remaining accounts less than 6% each.

The middle storey of the forest (16.67-33.33 m) contributed by eleven tree species about 14.41% of the total tree species. This layer was dominated by *Juniperus procera* (69.9%), *Brucea antidysenterica* (13.7%) and *Olea europaea* (4.6 %) and the remaining contributed less than 3% each.

The upper storey involved only 2.35 % of the total of individual trees in the forest with five tree species. The dominant emergent tree species in this layer were *Juniperus procera* (48%) and *Podocarpus falcatus* (20)%. The rest of the emergent tree species were *Olea europaea* (16%), *Brucea antidysenterica* (8%) and *Ficus sur* (8%). *Juniperus procera*, *Podocarpus falcatus*, and *Olea europaea* tree species were common to all storeys (Figure 3).

Height and DBH Class Distribution

The tallest tree was 50 m and the largest DBH was 450 cm. Height and DBH classes of woody species of the forest were categorized in to ten and eleven classes respectively (figure 4 and 5). The height classes of this forest indicated that decrease in number of individuals with increase in class sizes. Woody plant species of the forest that belongs to 1-5m (class 1) account 62.8% while, 40-50m contributed 0.3% (see figure 4).

In the same way, the DBH classes of the forest belonging to DBH classes 1(2.5- 10 cm) contributed 50.09 % of the number of individuals. This indicate that half of the individuals of the forest are small sized(see figure 5).

DBH class

The *Basal Area (BA)* and importance value index (IVI) of a forest

The total basal area of the woody plants in the Hurubu forest was 90.00 m² per ha. *Juniperus procera* was the most important tree species of the forest with BA of 48.4m² per ha which is about 53.8%. The second most important tree species was *Podocarpus falcatus* with BA of 12.2m² per ha which is 13.6%. Others plant species were *Brucea antidysenterica* with 8.1 and *Olea europaea* with 8.0 BA in m² per ha (see Table 2). *Pittosporum viridiflorum* contributed the least amount of BA, approximately 0.01 m² per ha, to the Hurubu forest.

The importance value index (IVI) of the most common and frequent trees of Hurubu Forest was calculated and *Juniperu sprocera* (19) was found to have the highest IVI (Table 2). The ten most important woody species with the highest IVI were *Juniperus procera*, *Osyris quadripartite*, *Myrsine Africana*, *Erica arborea*, *Podocarpus falcatus*, *Olea europaea*, *Dodonaea angustifolia*, *Maytenus obscura*, *Calpurnia aurea* and *Brucea antidysenterica* in their descending order of IVI. These woody plant species contributed over 67.7% of the total IVI (Table 2) and implies that these ten species are the most ecologically important woody species at Hurubu Forest.

3.3. The Regeneration Status of Hurubu Forest

In this study, 14.29 %, 46.43%, 7. 14% of woody plant species were found to have good, fair and poor regeneration status, respectively. A total of 28.57% of the woody plant species did not re-generate at all. Woody plant species which were available only in a sapling or seedling stage were considered as new

and Hurbu forest constituted 3.57 % woody species (Appendix 1). The good regenerating woody species were *Calpurnia aurea* and *Myrsine Africana*, while *Dodonaea angustifolia*, *Juniperus procera*, *Maytenus obscura*, *Olea europaea*, *Osyris quadripartite* and *Podocarpus falcatus* woody species had fair regeneration status from the top ten ecologically important woody species.

Species which were found in not regenerating category from the top ten ecologically important woody species were *Erica arborea* and *Myrica salicifolia*. Of all woody species of the study area, *Rytigynia neglect* and *Maesa lanceolata* had poor regeneration, while *Pterolobium stellatum* had a new regeneration status. The newly regenerated species may have reached or colonized the study site by different mechanisms like the dispersal of seeds through drooping of birds, mammals, and wind.

The poor and non-regenerating categories that comprise around 35.7 % of the woody plants in the study area have many important and useful tree species which have certain economic, medical, and ecological values. The general regeneration status of the tree species of the study site was satisfactory at the community level showing a fair regeneration status (Figure 6), but as stated above, 35.7% of the woody species fall into a poor and not regenerate state.

Discussion

Woody Species Composition

The study demonstrated the presence of significant diversity of woody plant species in terms of composition. The total woody plant species and the represented number of families were nearly similar to the findings of (Yineger *et al.*, 2011) in the Dry Afromontane forest at Bale Mountains National Park with 32 woody plant species; (Tesfaye, Gardi and Blaser, 2019) in the case of Chilimo dry Afromontane forest (31 woody plant species belonging to 25 families); and (Yahya *et al.*, 2019) in the case of Yerer dry-evergreen montane forest (31 woody plant species belonging to 23 families). Similarly to this study, (Mesfin, Zerihun, and Lulekal, 2018) found that Fabaceae were the dominant family in the Yegof Dry Afromontane Forest. Endemic tree species of *Acacia negrii* were also found in the dry evergreen Afromontane Forest of Kumuli (Woldemariam, Demissew, and Asfaw, 2016). The Shannon-Wiener index of Hurubu forest diversity showed 2.76 with 0.83 evenness index, which is nearly similar with the dry Afromontane forest (2.82) (Reshad, 2019).

However, Hurubu forest had less woody species composition and represented by less families than Kumuli Dry Evergreen Afromontane forest (133 woody plant species belonging to 53 families) (Woldemariam, Demissew and Asfaw, 2016); Yegof Dry Afromontane forest (64 woody plant species belonging to 43 families) (Mesfin, Zerihun and Lulekal, 2018); Amoro Dry evergreen Afromontane forest (57 woody plant species belonging to 38 families) (Liyew, Tamrat and Sebsebe, 2018); Wanzaye Dry Afromontane natural forest (49 woody plant species belonging to 29 families) (Asfaw, 2018); Ades Dry Afromontane forest (65 woody plant species belonging to 38 families) (Reshad, 2019); Debre Libanos church forests (70 woody plant species) (Koricho *et al.*, 2020); Gelawoldie community dry Afromontane forest (59 woody plant species belonging to 38 families) (Muchege and Yemata, 2020); and Gennemar

Dry Afromontane forest (55 woody plant species belonging to 34 families) (Ahmed, Lemessa and Seyum, 2022).

Basal Area

The basal area of woody species of the forest was 90.00 m² per ha. This finding was comparable to the study reported by (Tilahun, 2015) for the Menagesha Amba Mariam forest with a BA of 84.17m² /ha; (Mucheye and Yemata, 2020) for the dryAfromontane forest of the Gelawoldie community with BA of 93.8m²/ha. However, it was higher than dry Afromontane forest at Bale Mountains National Park (in Adelle and Boditi forests 26 m² ha-1 and 23 m² ha-1respectively)(Yineger *et al.*, 2011); wanzaye natural forest (23.3m² ha-1.)(Asfaw, 2018); Yegof forest (15.85 m² ha-1)(Mesfin, Zerihun and Lulekal, 2018); Kumuli Dry Evergreen Afromontane forest (30.16 m² ha-1) (Woldemariam, Demissew and Asfaw, 2016) while less than from Boda forest (114.64 m² ha-1) (Fikadu, Melesse and Wendawek, 2014).

Juniperus procera, *Podocarpus falcatus*, *Brucea antidysenterica* and *Olea europaea* were the top four largest woody species of the study site in terms of BA in decreasing order. This was similar with Adelle forest (*Juniperus procera*)(Yineger *et al.*, 2011); Boda forest (*Juniperus procera* and *Podocarpus falcatus*) (Fikadu, Melesse and Wendawek, 2014); Menagesha Amba Mariam Forest (*Juniperus procera*)(Tilahun, 2015);Chilimo-Gaji forest dry Afromontane Forest and (*Juniperus procera*, *Podocarpus falcatus*, and *Olea europaea*)(Mammo and Kebin, 2018). In contrast to this findings, the largest trees of this forest based on BA were different from Boditi forest (*Hagenia abyssinica*) (Yineger *et al.*, 2011); Gelawoldie community forest (*A. abyssinica*)(Mucheye and Yemata, 2020); and wanzaye natural forest (*Ficus sycomorus*) (Asfaw, 2018).

Importance Value Index

Species importance value index is a measure of how dominant a species is in a given ecosystem, and conservation status (Cottam and Curtis, 1956). Higher IVIs were recorded for *Juniperus procera*, *Osyris quadripartita*, and *Myrsine Africana* in this study. They are considered the most ecologically important woody species due to their relatively higher frequency, density, and dominance in the forest. This finding was in agreement with the study reported by (Fikadu, Melesse and Wendawek, 2014) for Boda dry evergreen Montane Forest; (Mammo and Kebin, 2018) for Chilimo-Gaji dry Afromontane forest; (Tesfaye, Gardi, and Blaser, 2019) for Chilimo dry Afromontane forest; (Yahya, Gebre, and Tesfaye, 2019) for Yerer dry evergreen montane forest; (Koricho *et al.*, 2020) for Debre Libanos church forests; (Ahmed, Lemessa and Seyum, 2022) for Gennemar dry Afromontane forest in which *Juniperus procera* tree was the most important by having highest IVI. Whereas it was not inline with the study reported by (Woldemariam, Demissew and Asfaw, 2016) in Kumuli dry Evergreen Afromontane forest (*Carisa spinarum* exhibited the highest IVI); (Asfaw, 2018) in Wanzaye dry Afromontane natural forest (*Ficus sycomorus* exhibited the highest IVI); (Mesfin, Zerihun and Lulekal, 2018) inYegof dry Afromontane forest (*Albizia gummifera* exhibited the highest IVI); (Reshad, 2019) in Ades dry Afromontane forest (*Podocarpus falcatus* exhibited

the highest IVI); and (Muchege and Yemata, 2020) in Gelawoldie community dry Afromontane forest (*B. abyssinica* exhibited the highest IVI).

Height and Diameter at breast height distribution

The height classes of the study forest indicated that there was a decrease in the number of individuals with an increase in class sizes. These findings were similar to the findings of Menagesha Amba Mariam Forest (Tilahun, 2015); Kumuli Dry Evergreen Afromontane Forest (Woldemariam, Demissew, and Asfaw, 2016); wanzaye natural forest (Asfaw, 2018); Gelawoldie dry Afromontane community forest (Muchege and Yemata, 2020); and Bradi dry evergreen Afromontane forest (Yemata and Haregewoien, 2022).

The DBH class distribution of woody species of the study forest showed gradual decrease in number of individual woody plant species from lower to higher DBH classes having a reverse “J” distribution. This was in line with (Yineger *et al.*, 2011) in the case of dry Afromontane forest at Bale Mountains National Park; (Tilahun, 2015) in the case of Menagesha Amba Mariam forest; (Woldemariam, Demissew and Asfaw, 2016) in the case of Kumuli dry Evergreen Afromontane forest ; (Liyew, Tamrat and Sebsebe, 2018) in the cases of Amoro Forest; (Asfaw, 2018) in the case of wanzaye natural forest; (Mammo and Kebin, 2018) in the case of Chilimo-Gaji forest; (Muchege and Yemata, 2020) in the case of Gelawoldie dry Afromontane community forest; (Yemata and Haregewoien, 2022) for Bradi dry evergreen Afromontane forest; and (Ahmed, Lemessa and Seyum, 2022) for Gennemar dry Afromontane forest.

Woody Species Regeneration Status

The overall regeneration status of the woody species of the study site was satisfactory at community level showing fair regeneration status. The good regenerating woody species were *Calpurnia aurea* and *Myrsine Africana*, while *Dodonaea angustifolia*, *Juniperus procera*, *Maytenus obscura*, *Olea europaea*, *Osyris quadripartite* and *Podocarpus falcatus* woody species had fair regeneration status from the top ten ecologically important woody species. This result was similar to the study conducted by (Muchege and Yemata, 2020) that indicated *Calpurnia aurea* was found to have good regeneration in the Gelawoldie community forest.

Species which were found in not regenerating category from the top ten ecologically important woody species were *Erica arborea* and *Myrica salicifolia*. Similarly, (Tesfaye, Gardi and Blaser, 2019) reported that *Erica arborea* was not regenerating in Chilimo dry Afromontane. Regarding to *Myrica salicifolia* species, poor regeneration status was documented in Susgen-Bosena Forest (Awoke, 2018). Of all woody species of the study area, *Rytigynia neglect* and *Maesa lanceolata* had poor regeneration. For *Maesa lanceolata* woody species, (Hailemariam and Temam, 2018) reported that no saplings in Gole natural forest. The reason for not-regenerating and poorly regenerating species could be the intensive trampling by livestock while browsing and grazing in the forest that compacts the soil and thereby reduces the germination of the seeds from the soil seed bank.

Conclusions And Recommendations

This study revealed that the Hurbu natural forest has various species of woody plants. The characteristic tree species of dry Afromontane tree species such as *Juniperus procera*, *Podocarpus falcatus* and *Olea europaea* were found to be dominant in this forest. About one-third of woody species, including the dominant tree species were either not regenerating or fail to regenerate due to frequent movement of livestock and humanbeing in the forest.

Thus, we recommend conservation and management actions are mandatory for the entire forest. We suggest that free grazing within the forest and trampling of seedlings should be abandoned. Additionally, for the species *Erica arborea* and *Myrica salicifolia*, special consideration should be given to ensure the presence of their seedlings and saplings. Furthermore, enrichment planting should be undertaken for the species that has fewer seedlings than their saplings and mature trees.

Declarations

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Conflict of interest

The authors declare that there are no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Tables

Table 1. Woody Floristic Composition of the Hurubu Forest

No	Scientific name	Local name (Afaan Oromoo)	Family	Habit	To Ethiopia
1	<i>Acacia decarance</i>	-	Fabaceae	Tree	Exotic
2	<i>Acacia negrii</i>	Laaftoo	Fabaceae	Tree	Endemic
3	<i>Acokanthera schimperi</i>	Qaraaruu	Apocynaceae	Tree	Indigenous
4	<i>Albizia schimperiana</i>	Mukaa Arbaa	Fabaceae	Tree	Indigenous
5	<i>Apodytes dimidiata</i>	Calalaqaa	Icacinaceae	Tree	Indigenous
6	<i>Bersama abyssinica</i>	Lolchiisaa	Melanthaceae	Tree	Indigenous
7	<i>Brucea antidysenterica</i>	Liqimmee	Simaroubaceae	Shrub	Indigenous
8	<i>Buddleja polystachya</i>	Adaadii	Loganiaceae	Shrub	Indigenous
9	<i>Calpurnia aurea</i>	Ceekaa	Fabaceae	Shrub	Indigenous
10	<i>Carissa spinarum</i>	Agamsa	Apocynaceae	Creeping shrub	Indigenous
11	<i>Croton macrostachyus</i>	Baakkanniisaa	Euphorbiaceae	Tree	Indigenous
12	<i>Dodonaea angustifolia</i>	Itacha	Sapindaceae	Shrub	Indigenous
13	<i>Dombeya torrida</i>	Daanniisaa	Sterculiaceae	Tree	Indigenous
14	<i>Dovyalis abyssinica</i>	Koshammii	Flacourtiaceae	Shrub	Indigenous
15	<i>Ekebergia capensis</i>	Somboo	Meliaceae	Tree	Indigenous
16	<i>Erica arborea</i>	Astii	Ericaceae	Shrub	Indigenous
17	<i>Ficus sur</i>	Harbuu	Moraceae	Tree	Indigenous
18	<i>Juniperus procera</i>	Gaattiraa haabasha	Cupressaceae	Tree	Indigenous
19	<i>Maesa lanceolata</i>	Abbayyii	Myrsinaceae	Shrub	Indigenous
20	<i>Maytenus obscura</i>	Qarxammee	Celastraceae	Shrub	Indigenous
21	<i>Myrica salicifolia</i>	Kataba	Myrtaceae	Tree	Indigenous
22	<i>Myrsine africana</i>	Qacama	Myrsinaceae	Shrub	Indigenous
23	<i>Nuxia congeta</i>	Adaadii garraami	Loganiaceae	Tree/Shrub	Indigenous
24	<i>Olea europaea</i>	Ejarsa	Oleaceae	Tree	Indigenous
25	<i>Osyris quadripartita</i>	Waattoo	Santalaceae	Shrub	Indigenous

26	<i>Phytolacca dodecandra L'Herit.</i>	Andoodee	Phytolaccaceae	Shrub	Indigenous
27	<i>Pittosporum viridiflorum</i>	Shoolee	Pittosporaceae	Tree	Indigenous
28	<i>Podocarpus falcatus</i>	Birbirsaa	Podocarpaceae	Tree	Indigenous
29	<i>Pterolobium stellatum</i>	Qanxaaffaa	Fabaceae	climbing shrub	Indigenous
30	<i>Rhus glutinosa</i>	Xaaxeessaa	Anacardiaceae	Shrub	Endemic
31	<i>Rosa abyssinica</i>	Goraa	Rosaceae	Creeping shrub	Indigenous
32	<i>Rytigynia neglecta</i>	Gagaafataa	Rubiaceae	Shrub	Indigenous

Table 2. The Basala Area and Importance Value Index (IVI) of woody plant species in the Hurubu Forest.

No	Local name of Species (Afaan oromoo)	Scientific name of the species	RBA (m ² ha ⁻¹)	RDO (%)	RD(%)	RF(%)	IVI	IVI (%)
1	Gaatiraa Haabashaa	<i>Juniperus procera</i>	48.4	53.8	24.5	76.7	154.9	19.0
2	Waattoo	<i>Osyris quadripartita</i>	0.4	0.4	6.3	60.0	66.7	8.2
3	Qacamme	<i>Myrsine africana</i>	0.2	0.3	10.5	46.7	57.4	7.0
4	Astii	<i>Erica arborea</i>	2.1	2.4	7.6	40.0	50.0	6.1
5	Birbirsa	<i>Podocarpus falcatus</i>	12.2	13.6	5.3	30.0	48.9	6.0
6	Ejarsa	<i>Olea europaea</i>	8.0	8.9	2.8	33.3	45.1	5.5
7	Ittacha	<i>Dodonaea angustifolia</i>	0.1	0.2	7.6	26.7	34.5	4.2
8	Qarxammee	<i>Maytenus obscura</i>	0.6	0.6	2.5	30.0	33.2	4.1
9	Ceekaa	<i>Calpurnia aurea</i>	0.1	0.1	4.6	26.7	31.3	3.8
10	Liqimnee	<i>Brucea antidysenterica</i>	8.1	9.0	2.3	20.0	31.3	3.8
11	Goraa	<i>Rosa abyssinica</i>	0.0	0.0	2.0	23.3	25.4	3.1
12	Koshammii	<i>Dovyalis abyssinica</i>	0.0	0.0	4.0	20.0	24.1	2.9
13	Mukarba	<i>Albizia schimperiana</i>	1.9	2.1	2.0	20.0	24.1	2.9
14	Gagaafataa	<i>Rytigynia neglecta</i>	0.3	0.4	3.3	20.0	23.7	2.9
15	Agamsa	<i>Carissa spinarum</i>	0.0	0.0	1.8	20.0	21.8	2.7
16	Adaadii	<i>Buddleja polystachya</i>	0.1	0.1	1.2	16.7	17.9	2.2
17	Xaaxeessaa	<i>Rhus glutinosa</i>	0.1	0.1	2.3	13.3	15.7	1.9
18	Lolchiisaa	<i>Bersama abyssinica</i>	0.3	0.3	1.9	13.3	15.5	1.9
19	Bakanniisaa	<i>Croton macrostachyus</i>	1.3	1.5	2.2	10.0	13.7	1.7

20	Kataba	<i>Myrica salicifolia</i>	1.4	1.6	0.4	10.0	12.0	1.5
21	Harbuu	<i>Ficus sur</i>	3.0	3.3	1.6	6.7	11.5	1.4
22	Qanxaffaa	<i>Pterolobium stellatum</i>	0.0	0.0	0.9	10.0	10.9	1.3
23	Daannisaa	<i>Dombeya torrida</i>	0.0	0.0	0.6	10.0	10.6	1.3
24	Qaraaruu	<i>Acokanthera schimperi</i>	0.0	0.0	0.5	10.0	10.5	1.3
25	Somboo	<i>Ekebergia capensis</i>	0.8	0.9	0.4	6.7	7.9	1.0
26	Abayyii	<i>Maesa lanceolata</i>	0.0	0.0	0.5	6.7	7.1	0.9
27	Shoolee	<i>Pittosporum viridiflorum</i>	0.0	0.0	0.3	6.7	7.0	0.9
28	Calalaqaa	<i>Apodytes dimidiata</i>	0.4	0.4	0.3	3.3	4.0	0.5
			90.00	100.00	100.00	616.67	816.67	100.00

Figures

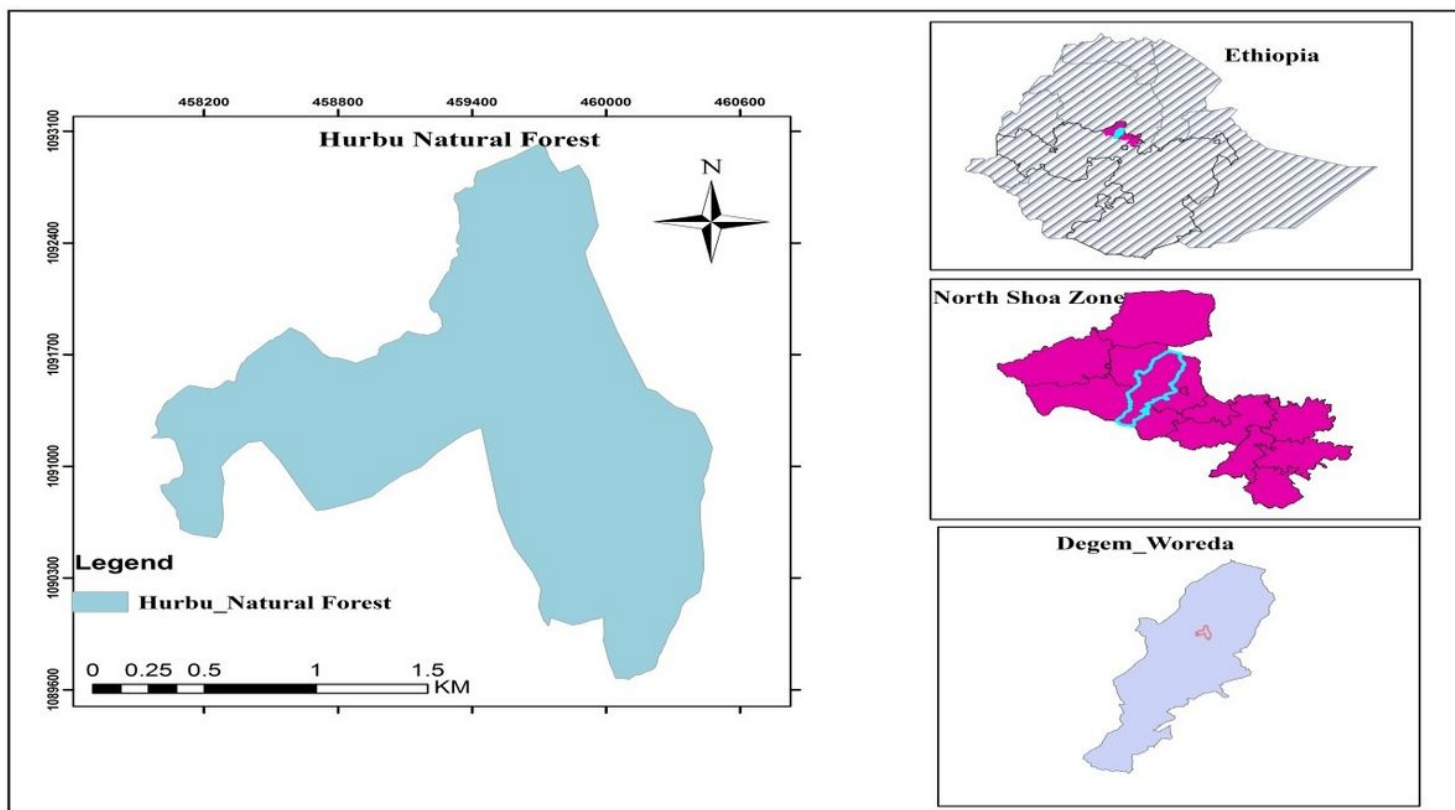


Figure 1

Map of study area

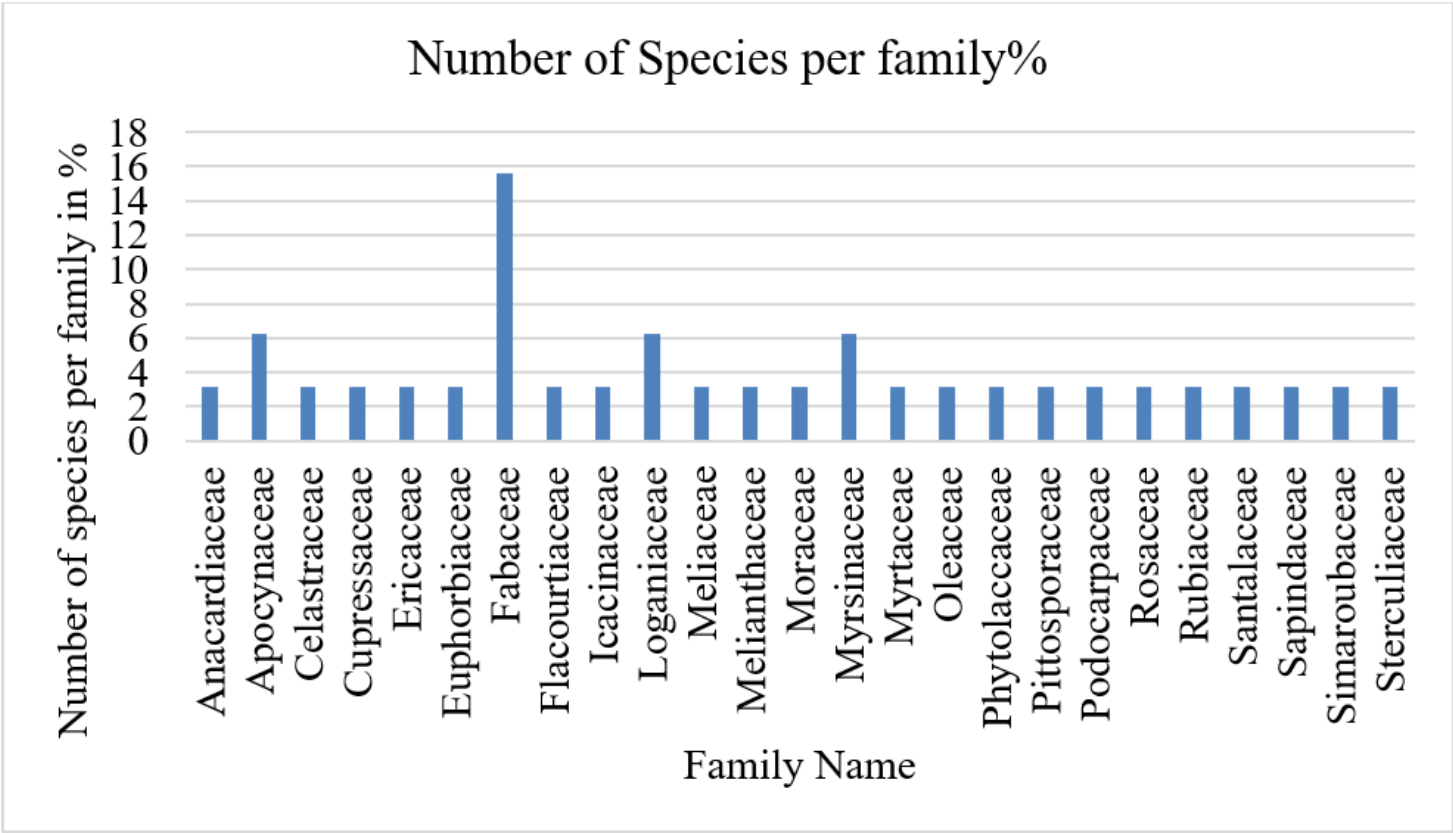


Figure 2

Number of species per family

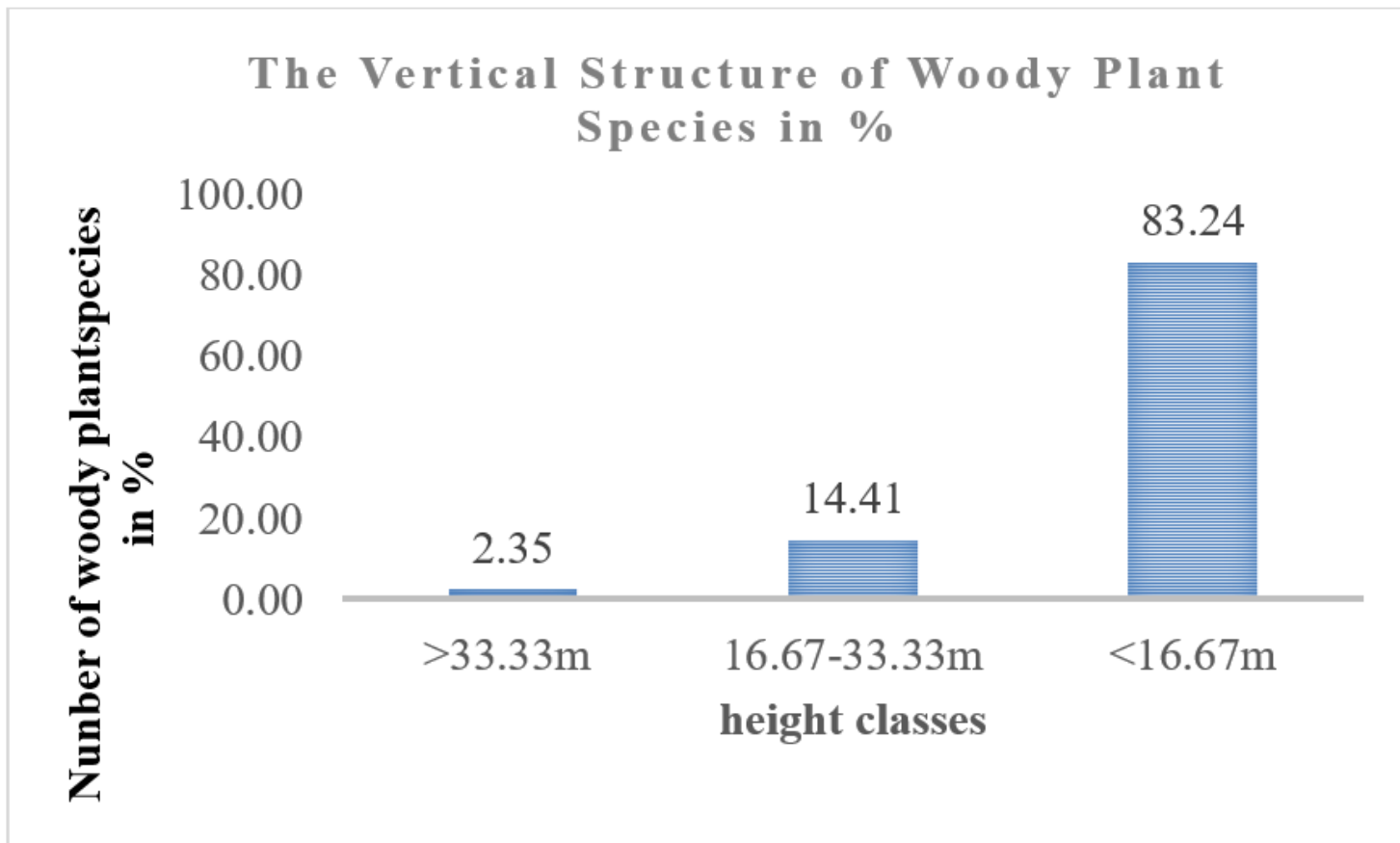


Figure 3

Vertical structure of woody plant species in Hurubu forest

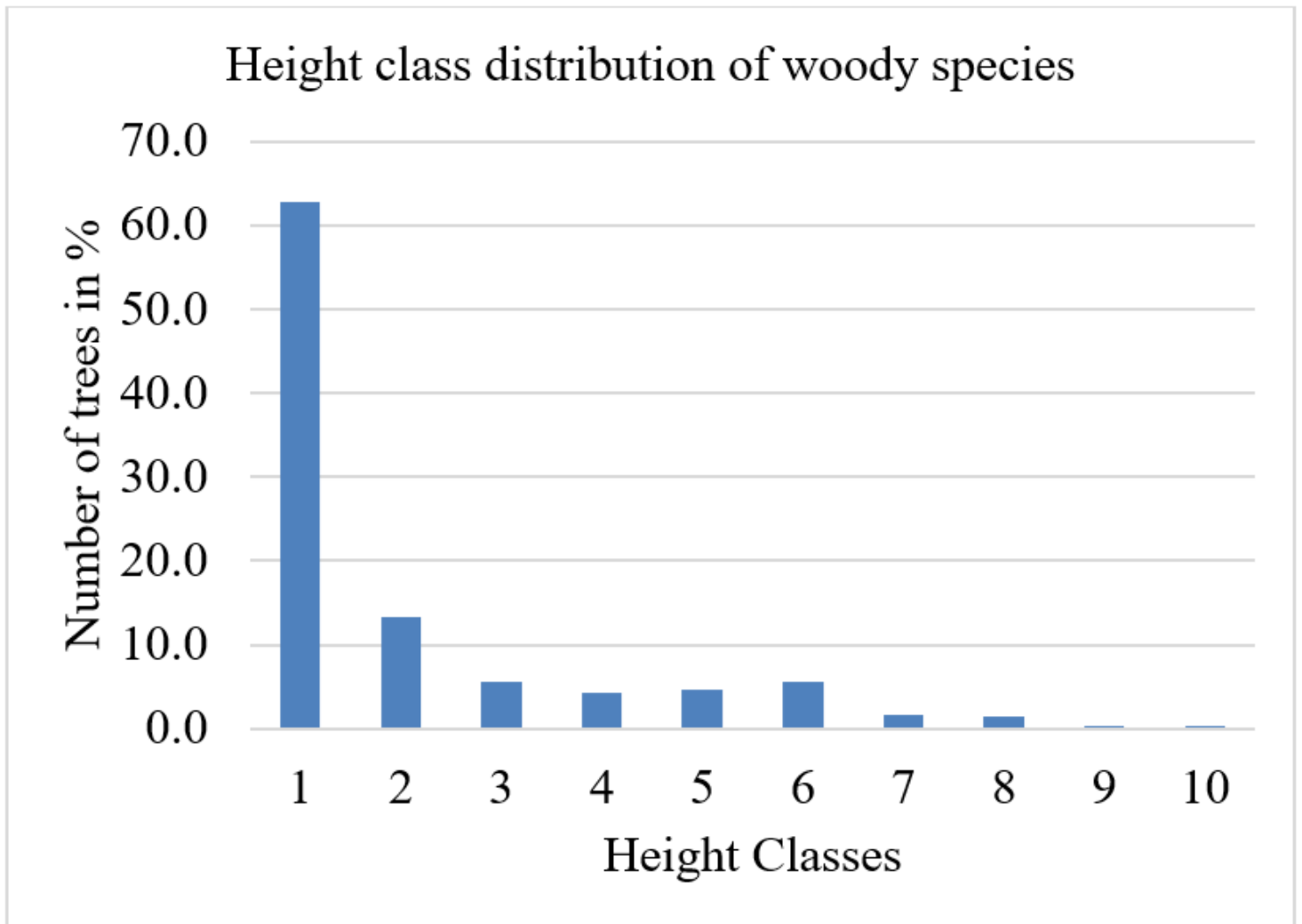


Figure 4

Distribution of the height class in Hurubu forest (m) 1=1-5, 2=5.1-10, 3=10.1-15, 4=15.1-20, 5=20.1-25, 6=25.1-30, 7=30.1-35, 8=35.1-40, 9=40.1-45. and 10= 45.1-50

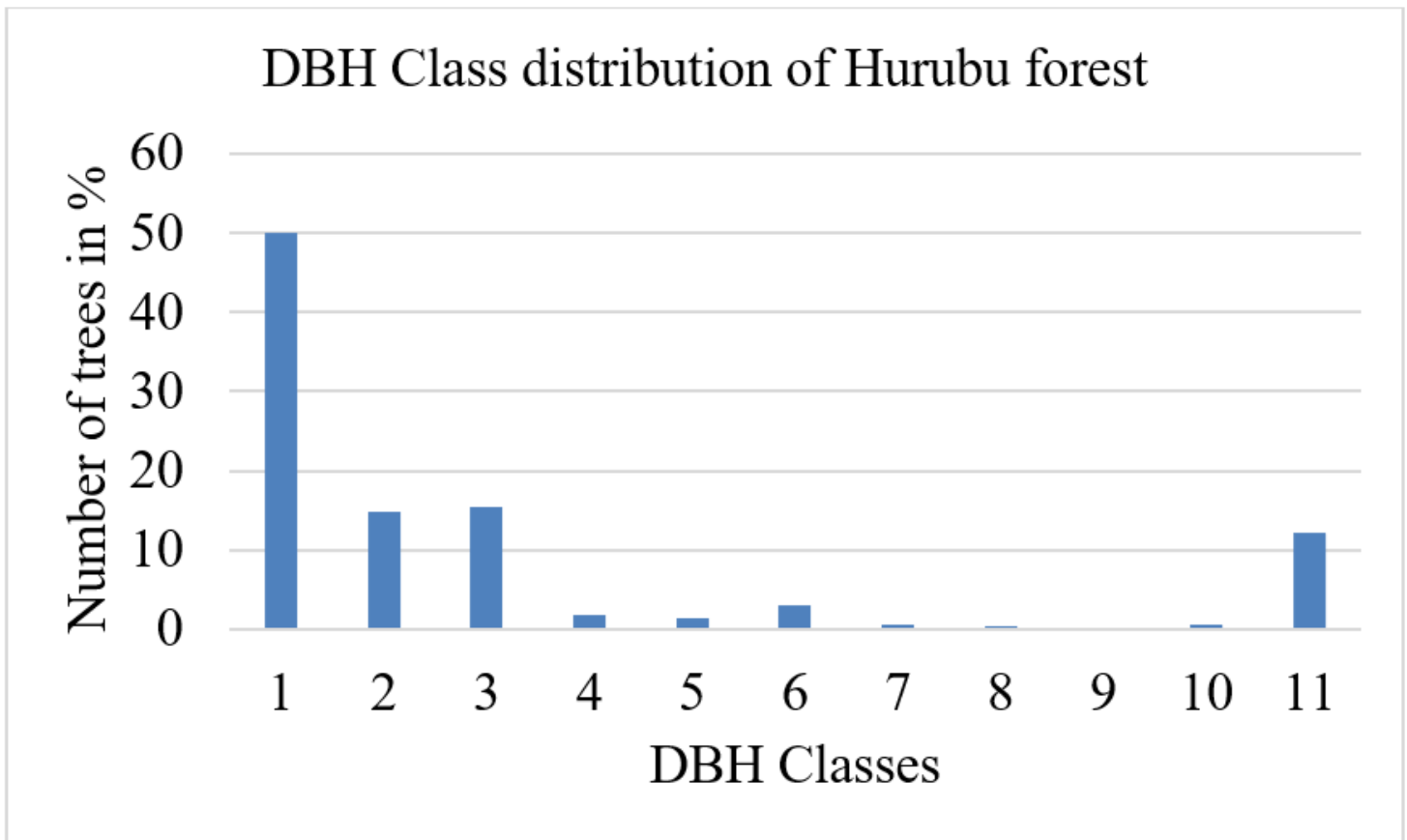


Figure 5

Distribution of the DBH class in Hurubun forest (cm) 1=2.5-10, 2=101-20, 3=20.1-30, 4=30.1-40, 5=40.1-50, 6=50.1-60, 7=60.1-70, 8=70.1-80, 9=80.1-90., 10= 90.1-100, and 11=>100.

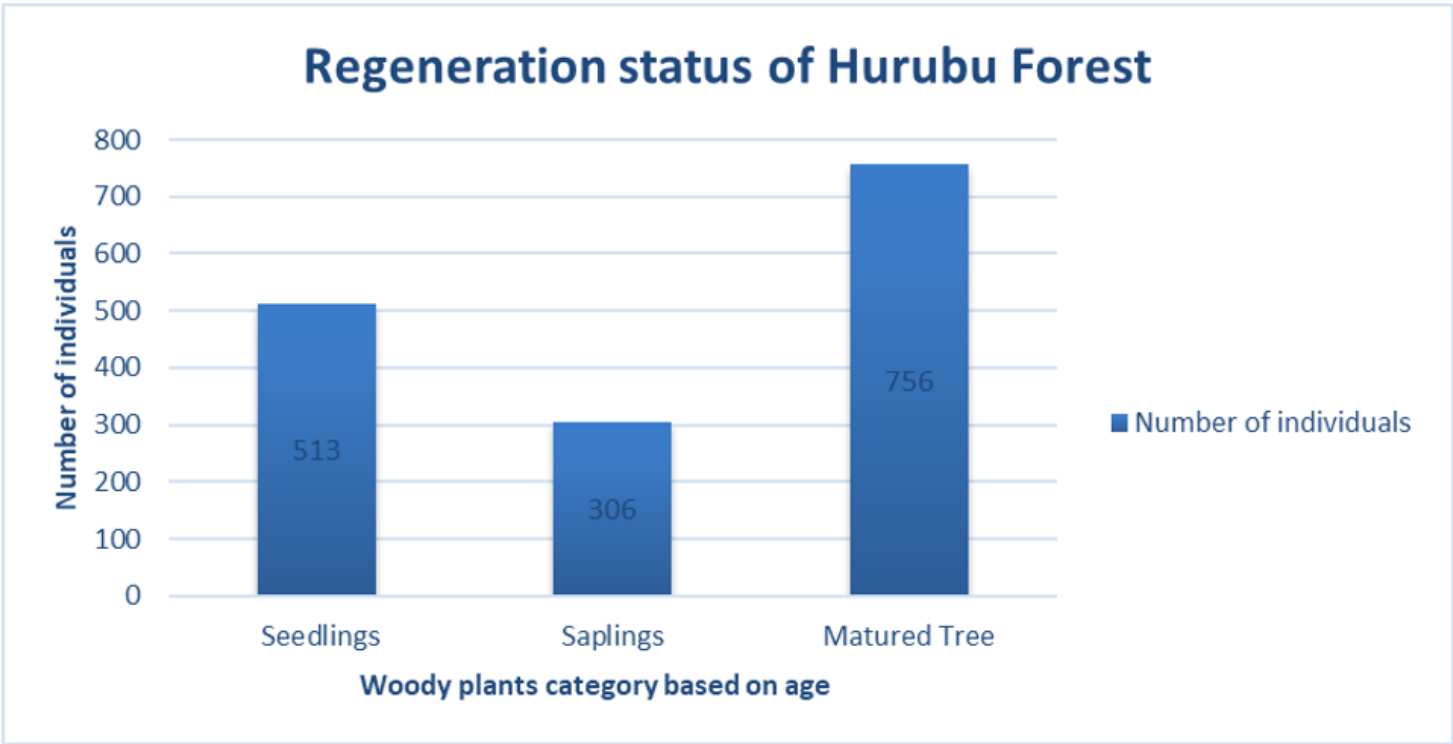


Figure 6

The Status of woody plantspecies in the Hurbu Forest

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