WOODY SPECIES COMPOSITION, VEGETATION STRUCTURE AND REGENERATION STATUS OF LEPHIS FOREST FIELD GENE BANK, SOUTHEASTERN ETHIOPIA

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ABSTRACT: This study was conducted in Lephis Forest field gene bank in West Arsi Zone, Southeastern Ethiopia. The study aimed to estimate stand structure, floristic composition and regeneration status. Systematic sampling method was used to collect vegetation data. Thirty plots of 20 m x 20 m (400 m^2) for trees, 120 subplots of 5 m x 5 m (25 m^2) for saplings and 30 subplots (2 m x2 m) for seedlings were laid. Specimens of all vascular plants were collected and brought to Ethiopian Biodiversity Institute for identification. A total of 63 woody species belonging 37 genera and 30 families were recorded. Rubiaceae was the most dominant family. The other dominant families were Asteraceae, Rutaceae, Mrysinaceae, Rosaceae and Oleaceae, each represented by two species (5.4%). Four plant communities were identified. The Shannon diversity and evenness indexes for the entire study area were 3.11 and 0.85 respectively. The total basal area of the forest was 174.58 m^2/ha. Density of mature trees, seedling and sapling were 1097, 2061 and 848 individuals per hectare respectively. The population structure and regeneration status of the forest indicated that there are anthropogenic disturbances in the forest. In the regeneration assessment, plants with few numbers of seedlings were found in the forest. Therefore, immediate conservation actions and implementation of forest management are required to facilitate healthy regeneration of the forest.

Key words: Basal area, Diversity, Important value index, Sapling, Seedling, Species richness

INTRODUCTION

The species composition and diversity in a forest can be affected by disturbances in forest which could be the result of both anthropogenic and natural drivers. Assessment of a forest serves as a base for sustainable utilization and conservation of the forest. Forest composition refers to all plant species found in a stand or landscape, including trees, shrubs, forbs, and grasses. It is also used to describe forest communities at the stand or landscape level whose canopies may be dominated by a single tree species or contain a mixture of species (Seidler, 2017). Each individual tree is a structural element of a forest ecosystem, with characteristics such as species, number, size, and spatial distribution (Hui et al., 2019).

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Tree regeneration is the process that allows a forest to sustain itself through the growth and survival of seedlings and saplings that replace large forest trees as they die. Natural regeneration in any plant community requires information on the presence and absence of persistent soil seed banks or seedling banks, quantity and quality of seed, durability of seeds in the soil, losses of seeds to predation and deterioration, triggers for germination of seeds in the soil and sources of re-growth after disturbances (Teketay, 2005).

The flora of Ethiopia reports about 6,027 vascular plant species of which 10% are endemic (Kelbessa and Demissew, 2014). This distribution makes Ethiopia the fifth largest floral composition in tropical Africa (Didita et al., 2010). However, the rich biodiversity of the country is under serious threat due to deforestation, overgrazing, shifting cultivation, forest fire and poaching of forest reserves. One of the forests facing such threat is Lephis forest field gene bank, which is one of the remnant dry Afromontane forests in the country. So far, the floristic composition, regeneration and structural analysis of Lephis forest field gene bank have not yet been investigated. Therefore, the objective of this study was to assess the floristic composition, structure and regeneration status of the species in the forest which could contribute for the effective conservation and management of the forest.

MATERIALS AND METHODS

Description of the study site

This study was conducted in Lephis forest field gene bank located in Gambo natural forest, one of the three forest districts in Arsi (*i.e.* Munessa, Gambo and Shashemene). It is a protected forest owned by Oromia Forest and Wildlife Enterprise (OFWE). It is located at 270 km south of Addis Ababa (Figure 1). Geographically, it is bounded between 7°80´86´´N and 38°49´68´´E. The altitude ranges from 2292 to 2465 m. a.s.l.

The total concession area of the Gambo natural forest is estimated to be 9023 ha, of which 1443 ha is plantation forest and 7580 ha is natural forest (OFWE). The area has a bimodal rainfall with a main

rainy season from the end of June to September, and a short rainy season from February to April (Duriax and Baudron, 2016).The mean annual rainfall of the area ranges from 500 mm to 1000 mm and the mean annual temperature is 15 ^{o}C (Duriaux and Baudron, 2016). The vegetation of the area is described as undifferentiated Afromontane forest (Friis and Lawesson, 1993; Muhammad and Elias, 2020).

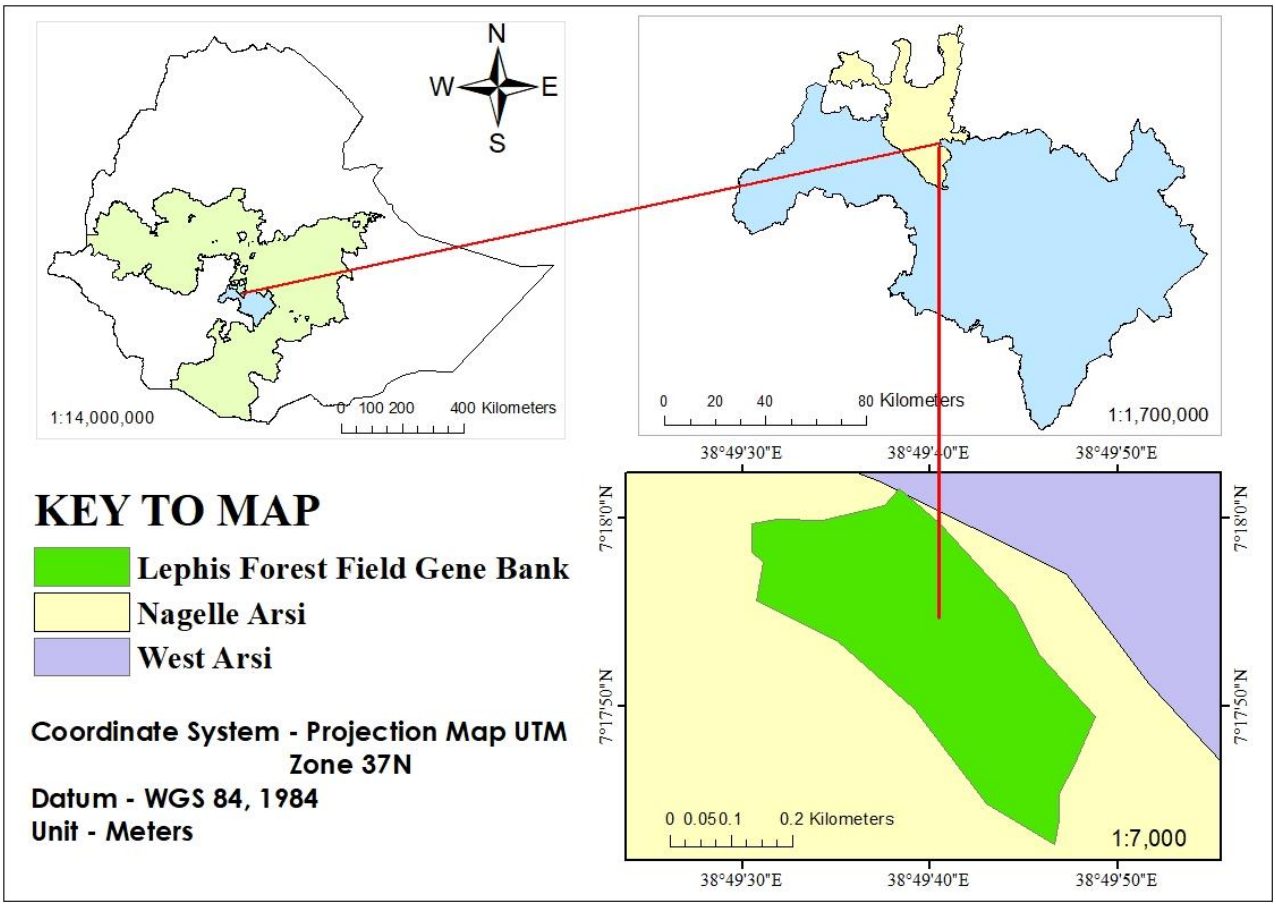

Figure 1. Location of the study area

Sampling procedure and data collection

A reconnaissance survey was carried out from April to June 2021 in order to obtain an impression of the site's conditions, collect information on accessibility and determine sampling sites. Systematic sampling design was used to collect vegetation data. Three transect lines and sampling plots were made based on the total area of the study site for vegetation data collection. The sampling plots were placed at every

100 m distance along the three transect lines laid across the forest. Thirty plots of 20 m x 20 m (400 m^2) were laid along three parallel transects to collect woody species parameters. Within these plots 120 subplots of 5 m x 5 m (25 m^2) for saplings and 30 subplots (2 m x 2 m) for seedlings were laid to count both saplings and seedlings (Owusu, 2019). A total of 30 sample plots (15 at transect number one, 13 at transect number two and 2 at transect number three) with an area of 0.6 ha, 0.52 ha and 0.08 ha respectively were surveyed.

Floristic data collection

All woody species in each plot were identified and scientific and vernacular names were recorded. Diameter at breast height (DBH) with DBH > 2.5 cm was measured using a tree caliper and diameter tape. Height of all individuals of woody species with a DBH > 2.5 cm were measured with a hypsometer. The heights of trees and shrubs 2 m and above were measured and recorded. For the purpose of this study, seedlings, saplings and "mature trees/shrubs" were defined as plants with heights < 1 m, 1–2 m and > 2 m, respectively. Representative plant specimens were collected and pressed to compile a complete list of species. The specimens were dried in deep freezer for 72 hours and identification was confirmed by referring to Flora of Ethiopia and Eritrea and comparing with authentically identified specimen at the Ethiopian Biodiversity Institute following Edwards et al. (1995; 1997), Tadesse (2002) and Hedberg et al. (2003; 2006; 2009). Physiographic variables like altitude, latitudes and longitudes were measured for each quadrant using GPS (Geographical Positioning System).

For vegetation structure data collection, the following activities were performed. Each individual of the woody species in the plots was counted. Basal area, relative dominance, relative density, relative frequency and important value index were determined to describe the vegetation structure of the study area by using Microsoft Excel following Mueller-Dombois and Ellenberg (1974) and Martin (1995). To

determine regeneration potential of the site, the total density of seedling, sapling and mature trees were determined.

Data analysis

To quantify biological diversity, species richness, Shannon–Wiener diversity index and evenness were computed following Maguran (1988) and Krebs (1999). To determine floristic similarity between the sample plots, Sorensen's similarity coefficient was computed.

Species richness is a biological appropriate measure of alpha diversity and the total number of species in an ecological community, landscape or region relative to total number of all individuals in that community. Species richness was calculated using Margalef's index of richness (Dmg) as follows:

$$\mathbf{Dmg = S\text{-}1/lnN}$$

where Dmg = Margalef's index of richness, S = total number of species, ln = natural logarithm, **N** = total number of individuals in a sample.

Evenness refers to the variability in the relative abundance of species. It describes the equality of species abundance in a community. Species evenness was calculated by dividing Shannon's diversity index H' by natural logarithm of species richness ln (S).

$$(\mathbf{H'}) = -\sum_{i=1}^{s} Pi \ln Pi$$

where H' = Shannon diversity index, S = the number of species, Pi = the proportion of individuals or the abundance of the i^{th} species expressed as a proportion of total cover and ln = log base n (Natural logarithm).

$$Evenness\ (J) = \frac{\mathrm{H'}}{\mathrm{H'}max}$$

Where, H' = Shannon-Wiener diversity index and H'max = lns where S is the number of species.

The higher the value of J, the more even the species are in their distribution within the community or the quadrants. Similarly, the higher the value of H', the more diverse the community or the quadrant are.

Sorensen's similarity coefficient was used to describe the similarity among community types. It is calculated as follows.

$$Sorensen's similarity\ coefficient\ (Ss) = \frac{2a}{2a+b+c}$$

Where, a = number of species in sample a and b, b = number of species in sample 'b' but not in 'a', and c = number of species in sample 'a' but not in 'b'.

Vegetation Structure

Relative density, relative frequency, relative dominance and important value index (IVI) were calculated to determine the vegetation structure and the dominant species of the forest (Muller-Dombois and Ellenberg 1974).

Density is defined as the number of plants of certain species per unit area. Plant density helps to determine percentage germination in the field. It is calculated as:

$$Density = \frac{\text{Number of individuals of tree species per unit area of quadrant(hectare)} or\ total\ number\ of\ individuals}{\text{total area of quadrant (hectare)}}$$

Relative density is the study of the numerical strength of a species in relation to number of individuals of all the species and it is calculated as:

$$Relative\ density\ (RD) = \frac{\text{Number of individuals of a tree species}}{\text{Total number of individuals of all species}} x100$$

Frequency is defined as probability of finding plant species or vegetation in a given sample area. The higher the frequency, the more important the plant is in the community. Frequency is computed with the following formula.

$$Frequency = \frac{\text{Number of quadrants inwhich a species is recorded}}{\text{total number of sample quadrants}}$$

Relative Frequency is defined as the degree of dispersion of individual species in an area in relation to the number of all the species these occurred and it is computed as follow:

$$Relative\ frequency\ (RF) = \frac{\text{Frequency of a plant species}}{\text{Sum frequency of all species}} x100$$

Basal area (BA) is cross-sectional area of all of the stems in a stand at breast height (1.3 m above ground level). Basal area per unit area is used to explain the crowdies of the forest stand and expressed in square meter per hectare (m^2/ha). Area of forest stand is also used to calculate the dominance of species.

$$G = \frac{\pi \mathrm{d}2}{4}$$

Where G = basal area, π = 3.14; d = diameter at breast height or stump height.

$$Dominance = \frac{\text{Area covered by a species}}{\text{Sum of al area of quadrants in hectares}}$$

$$Relative\ Dominance = \frac{\text{Basal area of a single species}}{\text{Total basal area of all species}} x100$$

Important value Index (IVI) is the sum of three important parameters (Relative frequency, Relative density and Relative dominancy or abundance). Important value index is used to compare the ecological significance of species (Lamprecht, 1989) and it is calculated as follows:

$$Important\ Value\ Index\ (IVI) = \text{Relative density} + \text{Relative frequency} + \text{Relative dominance}$$

To determine the regeneration status of the site, the total density of seedling, sapling and mature trees were determined and the ratio of seedlings and saplings to adult individuals of woody species, as well as the ratio of seedling to saplings were also computed to make a comparison.

Plant community analysis

Plant communities were analyzed using Statistical Package for Social Science (SPSS Software version 20.0). A hierarchical cluster analysis was made to classify plant communities based on abundance data (McCune et al., 2002**).** A hierarchical agglomerative clustering technique was applied using Euclidean distance and Ward's method to classify plots that produced a dendrogram and cluster IDs. After

identification of the major clusters, characteristic species of plant communities were identified by considering abundance of tree species or indicator p-values. The plant communities were named after identifying plant species abundance and indicator p-values.

RESULTS

Floristic composition and species richness

A total of 63 plant species were identified and documented. Of the total plant species, 38 species (60.3%) were trees, 17 (27%) were shrubs, 8 (12.7%) species were liana (Appendix 1). The plant species belong to 37 genera and 30 families. Rubiaceae was the most dominant family in the forest represented by three species (8.1%), followed by Astraceae, Rutaceae, Myrsinaceae, Rocaceae and Olaceae each represented by two species (5.4%). The rest of the families were represented by only one species and each accounted for 2.7% (Figure 2).

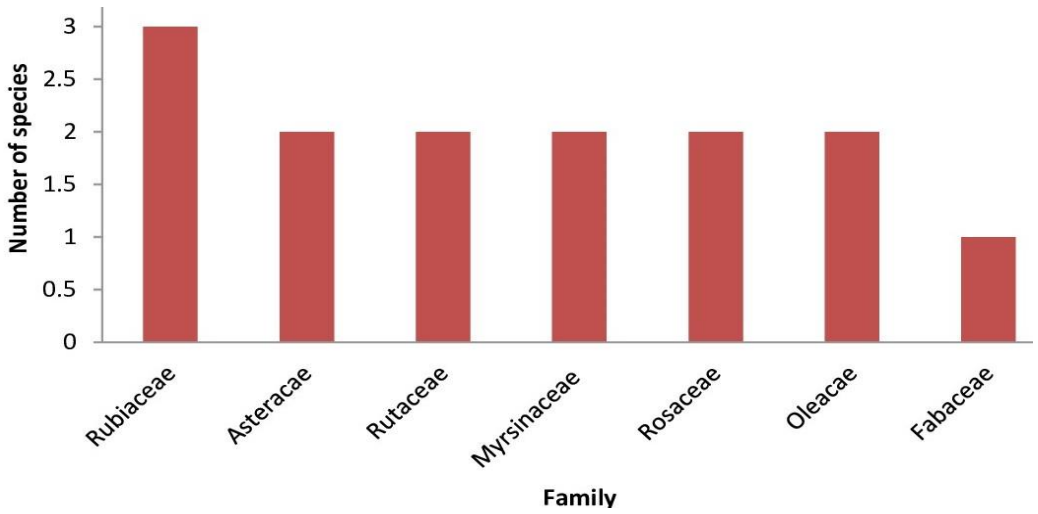

Figure 2. Dominant tree families in Lephis forest field gene bank

Eight (12.9%) endemic plants species namely *Pysnostachyus abyssinica, Solanecio gigus, Erythrina brucei, Lippia adoensis, Millettia ferruginea, Rhus glutinosa, Urtica simensis* and *Vepris dainellii* were identified in the study area.

Shannon diversity index and species evenness for Lephis forest field gene bank were 3.11 and 0.85 respectively.

Plant community classification

Plant community classification from hierarchical cluster analysis resulted in four plant communities (Figure 3).

Species found in the communities with their corresponding *P* values are given in Table 1. The four communities were *Croton macrostachyus–Maytenus gracilipes, Juniperus procera–Measa lanceolata, Croton macrostachyus–Measa lanceolata,* and *Podocarpus falcatus–Croton macrostachyus*.

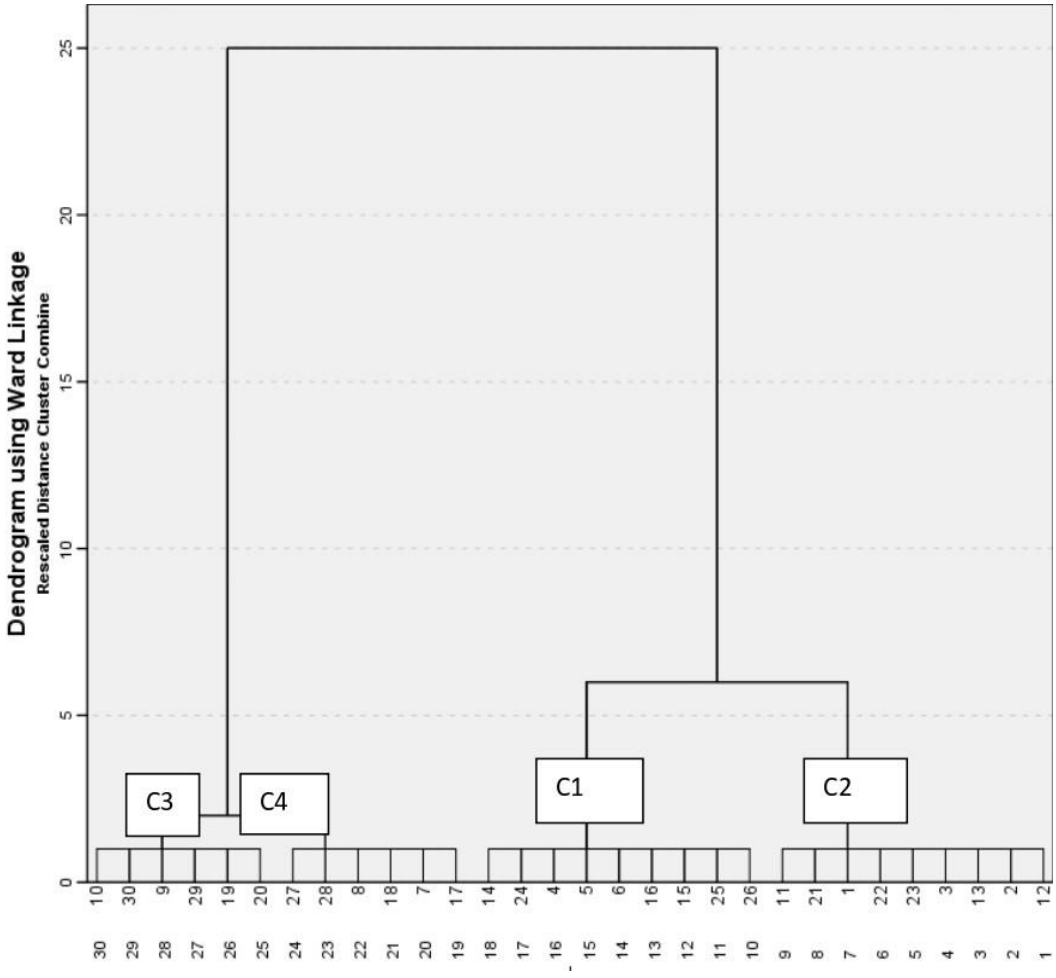

Figure 3. Dendrogram of the vegetation data obtained from hierarchical cluster analysis of Lephis forest field gene bank using Ward's method and Euclidean distance.

Community 1: *Croton macrosthacyus –Mytenus gracilipes* Community type

This community constitutes nine plots (4, 5, 6, 14, 15, 16, 24, 25 and 26). The community occurred in the altitudes between 2292 and 2465 m a.s.l. Tree species found in the community included *Hagenia abyssinica, Measa lanceolata, Podocarpus falcatus, Bersama abyssinica, Teclea nobilis* and *Vepris dainellii.*

Community 2: *Juniperus procera–Measa lanceolata* community type

This community constitutes nine plots (1, 2, 3, 11, 12, 13, 21, 22 and 23). It occurs in the altitudes between 2302 and 2442 m a.s.l. Tree species found in the community included *P. falcatus, Olea europaea, C. macrostachyus, M. gracilipes, T. nobilis, B. abyssinica, Nuxia congesta* and *Pittosporum viridiflorum.*

Community 3: *Croton macrosthacyus– Measa lanceolata* community type

This community comprises six plots (9, 10, 19, 20, 29 and 30). It occurs between altitudes 2326 and 2445 m a.s.l. Tree species found in this community included *M. gracilipes, Juniperus procera, O. europea* and *Myrsine africana.*

Community 4: *Podocarpus falcatus –Croton macrosthacyus* community type

This community comprises 6 plots (7, 8, 17, 18, 27 and 28). It occurs between altitudes 2330 and 2431 m a.s.l. *B. abyssinica, M. lanceolata, M. grascilipes, Canthium oligocarpum, Rhus vulgaris* and *J. procera* were the tree species found in this community type.

Table 1. Species found in the four communities with their corresponding P-values.

Community type	Plant species	Abundance	P-value (P<0.005)
Community 1	*Croton macrostachyus*	347	0.0045*****
	Mytenus gracilipes	295	0.0035*****
	Hagenia abyssinica	69	0.067
	Measa lanceolata	61	0.150
	Podocarpus falcatus	39	0.275
	Bersama abyssinica	35	0.345
Community 2	*Juniperus procera*	92	0.0023*****
	Measa lanceolata	72	0.0032*****
	Podocarpus falcatus	60	0.174
	Olea europea	46	0.0034
	Croton macrostachyus	27	0.340
	Mytenus graspalis	19	0.165
Community 3	*Croton macrosthacyus*	97	0.0042*****
	Measa lanceolata	75	0.0038*****
	Mytenus graspalis	33	0.154
	Juniperus procera	33	0.152
	Olea europea	32	0.126
	Myrsine africana	31	0.137
Community 4	*Podocarpus falcatus*	40	0.0024*****
	Croton macrosthacyus	39	0.0022*****
	Bersama abyssinica	28	0.134
	Measa lanceolata	26	0.428
	Mytenus graspalis	24	0.362
	Canthium oligocarpum	15	0.257
	Juniperus procera	13	0.482
	Rhus vulgaris	12	0.325

Similarity between plant communities

Sorenson's similarity coefficient revealed that Community type 1 and 3 had the highest similarity ratio. The least similarity was observed between communities 1 and 4

Vegetation structure

Tree density

The density of individual trees species in the field gene bank was 1097 individuals per ha. *Croton macrostachyus* had the highest density with 159 trees/ha (Table 2). *Measa lanceolata* and *Podocarpus falcatus* had the second and third density with 127 and 120 trees/ha respectively. The least density value

was recorded for *Calpurnia aurea* with only one individual per ha (0.09%). The second least densely populated tree species was *Flacourtia indica* with two trees/ha (0.18%).

Table 2. Density of plant species in Lephis forest field gene bank

Plants name	Density of plants
Croton macrostachyus	159
Measa lanceolata	127
Podocarpus falcatus	120
Maytenus gracilipes	87
Hagenia abyssinica	83
Berasama abyssinica	69
Teclea nobilis	64
Vepris dainellii	26

Frequency

The frequency of species with DBH > 2.5 cm ranged from 3.3% to 96.67%. There were five frequency classes which constituted number of plants found in each class (Figure 4). The relative frequency of the species ranged from 2.93 for *Ekebergia capensis* to 8.53% for *Croton macrostachys.*

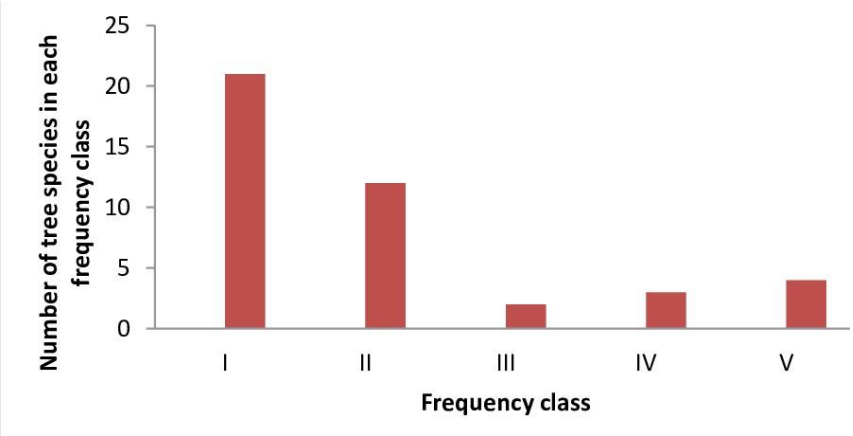

Figure 4. Number of tree species in each frequency classes (I: 1-20%, II: 21-40%, III: 41-60%, IV: 61-80%, V: 81-100%).

Height class distribution

About 1964 tree species attained height > 2 m in Lephis forest field gene bank. Height was classified in to seven classes (Figure 5). Only 2.03% of the plants attained height > 30 m. The general pattern of height class distribution of the forest is reversed J-shaped.

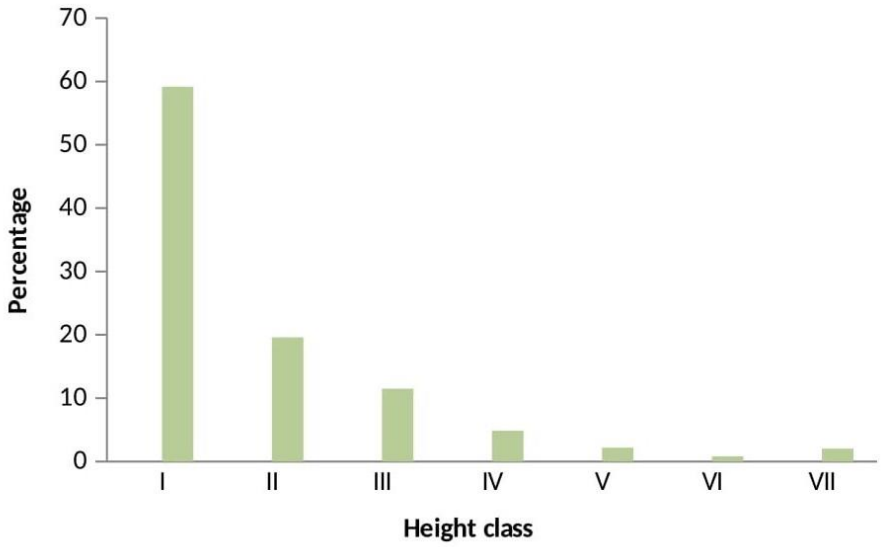

Figure 5. Height class distribution in Lephis forest field gene bank. I: 2.1-6 m; II: 6.1-10 m; III: 10.1-15 m; IV: 15.1-20 m; V: 20.1-25 m; VI: 25.1-30 m and VII: > 30 m.

DBH Class distribution

DBH was classified in to seven classes (Figure 6). Based on the DBH class distribution 79.45% of the individuals were found in the first size class (*i.e.* 2.5 -10 cm). When viewed from the whole set of population structure, the distribution of all individual tree and shrub across size classes showed an inverted “J” shape.

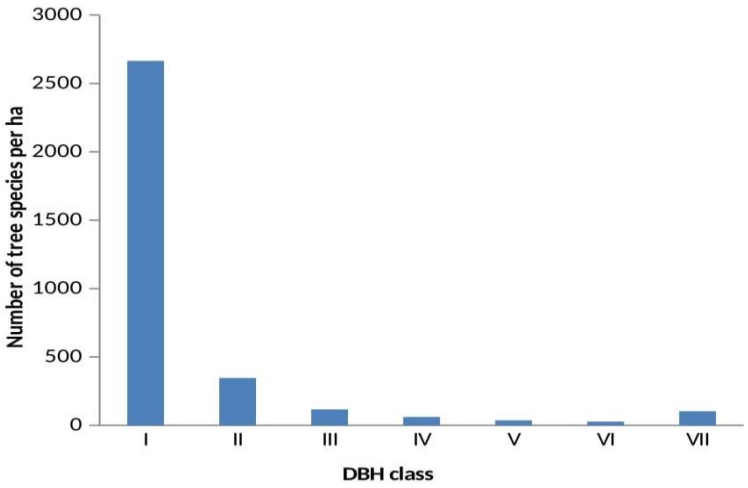

Figure 6. DBH class distribution in Lephis forest field gene bank. Class I: 2.5-10 cm; class II: 10.1-20 cm; class III: 20.1-30 cm; class IV: 30.1-40 cm; class V: 40.1-50 cm; class VI: 50.1-60 cm and class VII: >60.1 cm.

Basal area (BA)

Total BA for Lephis forest field gene bank was 174.58 m^2/ha. From the total basal area 75.13% was contributed by six tree species only (Table 3). *Croton macrostachyus* was the most important tree species because it had the biggest contribution to total basal area. *Pavetta abyssinica* and *Dovyalis abyssinica* exhibited the least BA in the field gene bank with BA values 0.01 m^2 /ha and 0.05 m^2/ha, respectively.

Table 3. Basal area of selected woody species in the study area

Plants name	BA (m^2/ha)
Croton macrosthacyus	62.44
Podocarpus falcatus	26.67
Schefflera abyssinica	20.09
Juniperus procera	19.7
Measa lanceolata	17.9
Prunus africana	10.65
Berasama abyssinica	9.71
Vernonia amygdalina	7.91
Dovyalis abyssinica	0.05
Pavetta abyssinica	0.01

Important Value Index (IVI)

The IVI of the forest ranged from 10.77 to 50.44 (Table 4). The first four tree species (*Croton macrostachyus, Podocarpus falcatus, Mytenus gracilipes* and *Measa lanceolata*) contributed 45.86% of the IVI and the rest of the species together contributed 54.14% of the IVI. Two species: *Calpurnia aurea* and *Acokanthera schimperi* contributed the least IVI value of 0.39 and 0.40, respectively.

Table 4. IVI of the top 8 tree species with their corresponding Relative Dominance (RDo), Relative Frequency (RF) and Relative Density (RD) in Lephis forest field gene bank

Scientific name of trees	Relative frequency (RF)	Relative dominance (RDO)	Relative density (RD)	IVI
Croton	8.53	27.04	14.87	50.44
Podocarpus falcatus	7.94	11.55	11.23	30.72
Mytenus graspalis	7.65	11.80	8.13	27.58
Maesa lanceolata	7.65	7.75	11.88	27.28
Berasama	7.06	4.20	6.45	17.72
Juniperus Procera	3.53	8.53	3.26	15.33
Haigenia abyssinica	2.64	0.94	7.76	11.35
Teclea nobilis	4.12	0.67	5.98	10.77

Regeneration status of Lephis forest field genebank

Analysis of seedlings and sapling of Lephis forest field gene bank revealed that the total density of mature individuals, seedling and sapling were 1097, 2061 and 848 individuals per hectares respectively (Figure 7). The ratio of seedling to sapling was 2.4, seedling to mature tree was 1.87, and sapling to mature trees was 0.77. Seedling density varied among species that ranges from one individual per hectares for *Dombeya torrida*, *Drasena studeneri*, *Erythrina brucei*, *Flacourtia indica*, *Milletia ferruginia* to 274 for *vernonia auriculifera*.

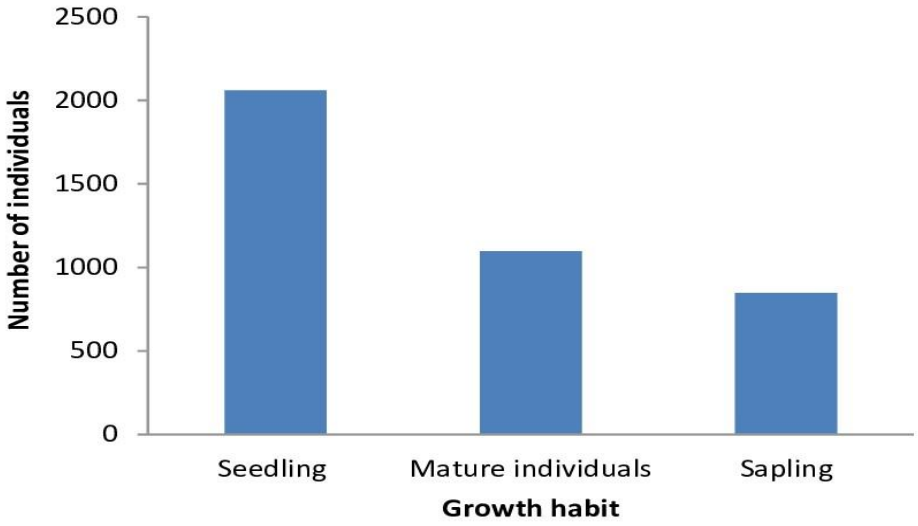

Figure 7. Density of mature trees, sapling and seedling in Lephis forest field gene banks

DISCUSSION

A total of 63 plant species belonging to 37 genera and 30 families were identified and documented. Woody species dominated the forest while Lianas have the least density compared to trees and shrubs. Shannon diversity index and species evenness for Lephis forest field gene bank were 3.11 and 0.85 respectively. Comparison of the Shannon diversity index with similar Afromontane forests in Ethiopia showed that Lephis forest field gene bank is only less than Zege forest which has Shannon diversity index of 3.72 (Alelign et al., 2007). But it is higher than other Afromontane forests such as Kuandisha forest with Shannon diversity index of 2.5 (Birhanu et al., 2016), Menagasha suba forest with Shannon diversity of 2.57 (Beche, 2011), Munesa forest which has Shannon diversity index of 2.6 (Muhammad and Elias, 2020) and Tara Gedam and Abebaye which have Shannon diversity index of 2.88 (Zegeye et al., 2011). The value of Shannon diversity index and evenness of species are affected by both the number of species and the number of stands in the community. The higher the Shannon diversity index the more plant species are in the study area and the lower the diversity index indicates the more disturbance of the forest. The Shannon diversity index obtained in this study (3.11) indicated that Lephis

forest field gene bank had diversified plant species. The species evenness value (0.85) indicated that the plant species in the forest were equally distributed.

Plant community classification from hierarchical cluster analysis resulted in four plant communities. Communities 3 and 4 had low plant density. This could be due to susceptibility to human encroachment and free grazing in these communities. Plant community distribution is the manifestation of physical gradients (elevation, soil heterogeneity and microclimate), biotic response to these gradients and historical disturbances (Urban et al., 2000). *Maytenus gracilipes* and *Measa lanceolata* were found to be distributed in all communities while *Hagenia abyssinica, Canthium oligocarpum, Myrsine africana* and *Pittosporum viridiflorum* were found in only one of the four communities. Except *H. abyssinica* all species were found naturally in the communities while *H. abyssinica* was planted by Ethiopian Biodiversity Institute.

Sorenson's similarity coefficient revealed that Community type 1 and 3 had the highest similarity ratio compared to other communities indicating that these communities had more species in common. This might be associated to slope, altitude, anthropogenic and other environmental factors such as soil type. The least similarity was observed between communities 1 and 4 implying that these communities share less species.

The density of individual trees species in the field gene bank was 1097 individuals per ha. These density is lower compared to some other Afromontane forests in Ethiopia such as Kimphee forest (3059 stems/ha) (Senbeta and Teketay, 2003), Masha Anderacha forest (1709 stems/ha) (Yeshitela and Bekele, 2003), and Dindin forest (1750 stems/ha) (Shibru and Balcha, 2004) but greater than Munesa Natural Forest which is 481 stem/ha (Muhammad and Elias, 2020). This could be due to differences in topographic variations, temperature, rainfall and other climatic factors as well as habitat qualities linked to ecological requirements of component tree species in the respective forests. *Croton macrostachyus* had the highest density with 159 trees/ha. *M. lanceolata* and *Podocarpus falcatus* had the second and

third density with 127 and 120 trees/ha respectively. These species together covered 73.25% of the stand density and the rest of the plant species covered only 26.75%.

The frequency of species with DBH > 2.5 cm ranged from 3.3% to 96.67%. There were five frequency classes which constituted number of plants found in each class. *Croton macrostachyus* was the most frequent species with frequency of 96.67%. *P. falcatus* and *M. lanseolata* were the second and third most frequent species with frequency of 90% and 86.67% respectively. A high number of species were found in lower frequency classes and low numbers of species were found in higher frequency classes. This pattern showed the heterogeneity of tree species in the study area.

Based on the DBH class distribution 79.45% of the individuals were found in the first size class (*i.e*. 2.5-10cm). Sum of all classes (class II-class VII) accounted only 20.52% which is much less than half of the first class (Figure 6). As the DBH size increased, the number of individual tree continuously decreased in the size class II up to size class VI but in size class VII a slight increment (3.07%). was observed When viewed from the whole set of population structure, the distribution of all individual tree and shrubs across size classes showed an inverted “J” shape. This indicates a healthy population structure with high densities of seedling (Boz and Maryo, 2020).

The height of woody plant species in the forest has normal distribution pattern except class VII which is slightly exceeding their predecessor. Only 2.03% plants attained height >30 m. This indicated that the small sized individuals dominated the forest, which implies healthy regeneration. In contrast the density of tree species increased a little in class VII. Presence of high number of plant species in the higher height classes in a natural forest indicates presence of adult plant species for reproduction potential of a forest. The general pattern of height class distribution of the forest is reversed J-shaped. Theoretically, such trend depicts healthy population that are naturally replacing themselves through good recruitment (Boz and Maryo, 2020)

Dominance is the measure of tree density (Bettinger et al., 2017). Total BA for Lephis forest field gene bank was 174.58 m^2/ha. Although density of trees of Lephis forest field gene bank is the lowest compared to other Afromontane forest it had high basal area. This may be due to the availability of plant density in height class VII which had large diameter.

Analysis of seedlings and sapling of Lephis forest field gene bank revealed that the density of seedlings was greater than density of mature trees and saplings. The ratio of seedling to sapling (2.4), seedling to mature tree (1.87) and sapling to mature trees (0.77) showed that the density of seedlings was greater than that of saplings. On the other hand, density of mature trees was greater than density of saplings. Density of seedlings indicated normal regeneration in the study area. However, at sapling stage, there is disturbance resulting in decrease in sapling density.

CONCLUSION

A total of 63 plant species were identified and documented in Lephis forest field gene bank which indicated that it is a diversified forest. The variation in species composition and diversity among communities identified in the forest could be associated to different factors, such as altitude, anthropogenic impacts, soil properties, and slope. The density of individual trees species is lower compared to some other Afromontane forests in Ethiopia. Based on the DBH class distribution, small sized plant species dominated the forest. Density of seedling is greater than density of mature individuals which indicated normal regeneration. However, density of sapling has decreased due to disturbance.

RECOMMENDATIONS

Lephis forest field gene bank provides a great economic, ecological and social value for the rural communities living around the forest as a source of cultural medicinal plants and honey bee production. Additionally it is serving as a tourist attraction area since it has other biological resources and a water

fall. To continue these services there is a need to enhance conservation efforts. Utilization of the forest genetic resources has to be monitored regularly and forest management plans are required to facilitate healthy regeneration of the forest. Further investigation which can reduce overexploitation of the forest resources in general and remnant tree species particularly species like *J. procera* and *H. abyssinica* is recommended. Species with low Important Value Index and threatened plant species found in the study area need to be prioritized for conservation.

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Appendix 1. List of woody species identified from Lephis forest field gene bank.

No	Species	Family	Local name in Afaan Oromoo	Habit
1	*Acokanthera schimperi* (A.DC) Schweinf.	Apocynaceae	Qararu	Sh
2	*Allophylus abyssinicus* (Hochst.) Radlkofer	Sapindaceae	Hirqamu	T
3	*Apodytes dimidiata* Mey. ex Arn.	Icacinaceae	Oda baddaa	T
4	*Bersama abyssinica* Fresen	Melianthaceae	Koraqqaa	T
5	*Brucea antidysenterica* J. F. Mill.	Simaroubaceae	Cironta	T
6	*Buddleja polystachya* Fresen	Loganiaceae	Bulchana	T
7	*Calpurnia aurea* (Ait.) Benth	Fabaceae	Ceekataa	Sh
8	*Canthium oligocarpum* Hiern	Rubiaceae	Wantefulasa	T
9	*Celtis africana* Burm.f	Cannabaceae	Amallaqqa	T
10	*Clematis hirsuta* Perr. & Guill	Ranunculaceae	Fiitii	L
11	*Cordia africana* Lam	Boraginaceae	Wadessa	T
12	*Croton macrostachyus* Del	Euphorbiaceae	Makkaniisa	T
13	*Discopodium penninervium* Hochst	Solanaceae	Maraaroo	Sh
14	*Dombeya torrida* (J. F. Gmel.) P. Bamps.	Sterculiaceae	Dannisa	T
15	*Dovyalis abyssinica* (A. Rich.) Warb	Flacourtiaceae	Dhangago	T
16	*Dracaena steudneri* Engl.	Dracaenaceae	Worqicha	Sh
17	*Ekebergia capensis* Sparrm	Meliaceae	Ononuu	T
18	*Embelia schimperi* Vatke	Myrsinaceae	Qaanquu	L
19	*Erythrina brucei* Schweinf	Fabaceae	Waleensuu	T
20	*Ficus thonningii* Blume	Moraceae	Danbii	T
21	*Ficus vasta* Forssk.	Moraceae	Odaa	T
22	*Flacourtia indica* (Burm.f.) Merr.	Flacourtiaceae	Hudha	T
23	*Galiniera saxifraga* (Hochst.) Bridson	Rubiaceae	Korolla	T
24	*Hagenia abyssinica* (Bruce) J.F.Gmel	Rosaceae	Heexoo	T
25	*Halleria lucida* L	Scrophulariacea	Minkero	T
26	*Hippocratea africana* (Willd.) Loes.	Celasteraceae	Hombaa	L
27	*Hypericum revolutum* Vahl	Hypericaceae	Garamba	Sh
28	*Ilex mitis* (*L.*) Radlk.	Aquifoliaceae	Xillo	T
29	*Jusminum abyssinicum* Hochst.ex DC.	Oleaceae	Dikii	L
30	*Juniperus procera* Hochst. ex Endl.	Cupressaceae	Hindhessa	T
31	*Justicia schimperiana* (Hochst.ex Nees) T.	Acanthaceae	Dhumuga	T
32	*Lippia adoensis* Hochst. ex Walp	Verbenaceae	Sukayi	Sh
33	*Maesa lanceolata* Forssk	Myrsinaceae	Abbayyii	T
34	*Maytenus arbutifolia* (A. Rich.) Wilczek	*Celastraceae*	*Kombolcha adi*	*Sh*
35	M*yrsine melanophloeos* (L.) R. Br.	Myrsinaceae	Tulla	T

No	Species	Family	Local name in Afaan Oromoo	Habit
36	*Myrsine africana* L	Myrsinaceae	Qacamaa	Sh
37	*Maytenus gracilipes* (Welw. ex Oliv.) Exell	Celastraceae	Kombolcha	T
38	*Nuxia congeta* R.Br. ex Fresen.	Loganiaceae	Bixanna	T
49	*Ocimum urticifolium* Roth.	Lamiaceae	Minantofa	Sh
40	*Olea europaea* L.	Oleaceae	Ejersa	T
41	*Olea capensis*	Oleaceae	Siigida	T
42	*Olinia rochetiana* A. Juss.	Oliniaceae	Gunaa	T
43	*Oncinotis tenuiloba* Stapf	Apocynaceae	Hadha mane	L
44	*Pavetta oliveriana* Hiern	Rubiaceae	Ara	Sh
45	*Pavetta abyssinica* Fresen	Rubiaceae	Gallo dhalaa	Sh
46	*Periploca linearifolia* Quart.-Dill. & A. Rich.	Asclepiadaceae	Aannanno	Sh
47	*Phytolacca dodecandra* L'Her.	Phytolaccacea	Andode	Sh
48	*Pittosporum viridiflorum* Sims.	Pittosporaceae	Amshiqa	T
49	*Podocarpus falcatus* (Thunb.) Mirb.	Podocarpaceae	Birbirsa	T
50	*Polyscias fulva* (*Hiern*) Harms	Araliaceae	Sudubaa	T
51	*Prunus africana* Lam	Rocaceae	Sukkee	T
52	*Psydrax schimperiana* (A. Rich.) Bridson	Rubiaceae	Gallo korma	Sh
53	*Rhus tenuinervis* Engl	Anacardiaceae	Dabobessaa	T
54	*Rhus vulgaris* Meikle	Anacardiaceae	Qamo	Sh
55	*Rubus apetalus* Poir.	Rosaceae	Goraa	Sh
56	*Schefflera abyssinica* (Hochst. ex A. Rich.)	Araliaceae	Gatamee	T
57	*Solanecio gigas* (Vatke) C. Jeffrey	Asteraceae	Workicho	Sh
58	*Stephania abyssinica* (Dillon & A. Rich.)	Menispermacea	Kalaalaa	L
59	*Teclea nobilis* Del.	Rutaceae	Hadhessa	T
60	*Urera hypselodendron* A. Rich.	Urticaceae	Halila	T
61	*Vepris dainellii* (Pichi-Serm)	Rutaceae	Kolaasaa	T
62	*Vernonia amygdalina* Del.	Asteraceae	Ebicha	T
63	*Vernonia urticifolia* A. Rich	Asteraceae	Reejjii	Sh

T = Tree, Sh = Shrub, L = Liana