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Woody Species Diversity, Community Structure, and Regeneration Capacity in Central Ethiopian Urban Forest Patches

Arayaselassie Abebe Semu [1,2], Tamrat Bekele [2], Paloma Cariñanos [3,4], Tauseef Anwar [5] and Huma Qureshi [6,*]

1 Range Ecology and Biodiversity Program, College of Agriculture and Environmental Science, Haramaya University, Dire Dawa P.O. Box 138, Ethiopia; pbbmaraya@gmail.com or arayaselassie.abebe@haramaya.edu.et
2 Department of Plant Biology and Biodiversity Management, Addis Ababa University, Addis Ababa P.O. Box 3434, Ethiopia; tambek07@gmail.com
3 Andalusian Institute for Earth System Research (IISTA-CEAMA), 18006 Granada, Spain; palomacg@ugr.es
4 Department of Botany, University of Granada, 18071 Granada, Spain
5 Department of Botany, The Islamia University of Bahawalpur, Bahawalpur 63000, Pakistan; tauseef.anwar@iub.edu.pk
6 Institute of Biological Sciences, Gomal University, Dera Ismail Khan 29050, Pakistan
* Correspondence: humaqureshi8@gmail.com or drhuma@gu.edu.pk; Tel.: +92-315-8253252

Abstract: Land cover change in Addis Ababa, Ethiopia's capital, is driven by recurring drought and the economic problems of society-initiated afforestation. The goal of this study was to learn about the state of woody species regeneration in Yeka's urban forest patches. Thirty plots (20 m × 20 m in size) were sampled to identify plants for this purposE. All wooden trees with a height greater than 1.3 m in each plot were identified, enumerated, and their diameter were measured. *Acacia decurrens* was determined to be the predominant species, with an importance value index (IVI) of 161.09, followed by *Acacia melanoxlon* (IVI = 44.69). The bootstrapping PERMANOVA test was used to show how the species in the community overlapped. The result reveals that dissimilarity is low ($p > 0.05$), which is supported by the assumption of multivariate dispersion homogeneity. The area's generalized linear model (GLM) showed all species statistically significant for characteristics associated with closure year and presence of mature trees and the entire closure year. Two of the twenty tree species, i.e., *Acacia decurrens* and *Acacia melanoxylon* were found in nearly equal numbers in all three growth stages as well as having strong regenerating potential. The rapid expansion of exotic *Acacia* spp. necessitates careful attention to their regeneration. To reinforce and improve ecosystem services, conservation and restoration efforts should encourage the regeneration of native plant species.

Keywords: plantation; pre-urban; afforestation; native species; urban forests

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1. Introduction

Plantation forests are quickly expanding in degraded areas around the world to reduce deforestation and improve natural resource availability [1,2]. Monoculture plantations have been the most common type of reforestation plantation in practice, as well as thoroughly documented in several study areas [3]. In comparison to the exotic planted species, the native flora of the area receives very little attention. Tropical pines *Eucalyptus globules*, *E. camaldulensis*, exotic *Acacia* species (*Acacia decurrens*, *Acacia mearnsii*, *Acacia melanoxlon*, and *Acacia saligna*), *Grevilia robusta*, and *Cupressus lusitanica* are among the most commonly planted exotics [4,5]. Exotic plant species have been claimed to have wiped out a number of species in Queensland, Australia [6,7]. Plantations of native species are becoming more popular as part of restoration efforts. Despite the fact that native species have lower adaptability and are more prone to native pests, their use is promoted [8]. Some species, on the other hand, may be well suited to certain conditions, such as low soil nutrient and water content, which are common in degraded soils [7,9]. At 0–30 cm depth of soil, the amount of nitrogen (659–725 kg/ha), phosphorous (248–312 kg/ha), potassium (375–456 kg/ha), and soil organic carbon (4946–6780 kg/ha) was found to be higher in Sohagpur than in Bishrampur. [10]. Similarly, at different elevations of forests in the Garhwal Himalaya, the values of biomass, carbon, and density parameters were found to be significant ($p \leq 0.05$) [11].

Ethiopia is one of the world's top 25 biodiversity-rich countries, and it is home to two of the world's 34 biodiversity hotspots, the Eastern Afromontane and the Horn of Africa hotspots, respectively [12]. Since its beginnings, Addis Ababa, Ethiopia's capital city, has witnessed a constantly changing vegetation structurE. Hilltops surround the city, which are covered in native plant varieties. *Eucalyptus* species predominate in the city's forests, which may be found on the city's northern mountains. Anthropogenic activities, mostly tree cutting for fuel-wood and building, have had an impact on Addis Ababa's urban forests, which have resulted in a reduction in species composition and variety. Plantation programs on deteriorated sections of the city's hilltops were started by the government in partnership with NGOs [13]. Each year, through Ethiopia's winter time (June to mid-September), the plantation takes placE. These cultivated areas are not founded on methodical understanding, which has resulted in variations in the alignment of wooded types in peri-urban woods in Addis Ababa [14,15]. The seedlings distributed by government bodies are dependent on market and nursery availability, according to a report by the Foundation for Forestry [13]. Native tree species in plantation areas have limited development and they are on the verge of extinction [16].

Ethiopia has woods that have naturally regenerated in numerous areas. Indeed, managed forests have been produced in Ethiopia as afforestation or reforestation on a variety of scales, from individually held woodlots to large-scale plantation attitudes accomplished by forestry firms for wood production or participative community managed forests for diverse reasons [17]. On previously unforested or deforested land, forests based on afforestation and reforestation are established as even-aged stands [18]. On the other hand, several methods of usual reestablishment of public woodlands such as enclosure are suitable, more popular and cost-effective in the country today. Despite the fact that anthropogenic activities have diminished the overall vegetation cover of Ethiopian woodlands [19], the country continues to be a major source of woody species variety. Woody species diversity is highly connected with forests, with notable exceptions such as agroforestry systems [20–22] and small-scale portions of plantation stands. Ethiopia has worked for the past 30 years to repair degraded lands for long-term use, employing diverse strategies such as Sustainable Land Management (SLM). Replanting, enclosure, and threatened expanse administration have all aided in the renovation of wooded classes in specific [23,24]. The most commonly used species in central Ethiopia during the plantation season are *Acacia decurrens*, *Acacia mearnsii*, *Acacia melanoxylon*, and *Acacia saligna* [5].

The process by which plants replenish themselves is known as natural regeneration. Trees are essential for natural regeneration. Forest regeneration is essential for forest growth. It ensures the survival of tree species in managed forests after the overstory layer has been harvested. It is critical to an ecosystem's resilience following natural disturbances in natural forests [25]. As a result, a forest's eco-destiny system is determined by its forest regeneration state [26]. The regeneration layer, on the other hand, is directly dependent on the structure of the standing tree layer and shows the resilience and health of the forest [27,28]. Tree species variety is lost when a forest ecosystem lacks sufficient natural regeneration of particular tree species, which might influence related ecosystem functions and services in the long run [29,30]. As a result, studies into natural forest regeneration dynamics and potential factors influencing effective regeneration will contribute to a better understanding of forest ecosystems' long-term functioning and stability.

Using exotic plant species in degraded land is not in and of itself a problem, but it must be carried out with caution and responsibility because the species have a tendency to take over the area in a short period of time [31,32]. The central Ethiopian highlands are one of the locations where native species are being lost as a result of unchecked exotic plant plantation. Natural regeneration is reliant on alien species plantations and site conditions. The exotic plant influences the amount and quality of light, as well as allelopathy, that can occur under its canopy [33]. According to a previous study, the number of exotic plantation sites, particularly *Eucalyptus* stands, which regenerate woody plants, is decreasing [34]. Ground cover varies greatly in natural forests and exotic plantation sites, suppressing the establishment of native species from soil seed banks.

The composition and density of the community are influenced by regenerating tree species. By focusing on the floristic composition and regeneration state of woody species, we explored natural forest restoration in archeologically significant zones of Yeka Hilltops and Millennium Parks in Addis Ababa, Ethiopia.

2. Materials and Methods

2.1. Study Area

The research was carried out at Addis Ababa, Ethiopia's capital city (9°1′48′′ N, 38°44′24′′ E). The city is located in the country's heartland, at an elevation of 2,200 m above sea level (7200 feet), and has an area of 540 square kilometers. The city is divided into ten administrative sub-cities, each having its own set of 100 districts (Figure 1).

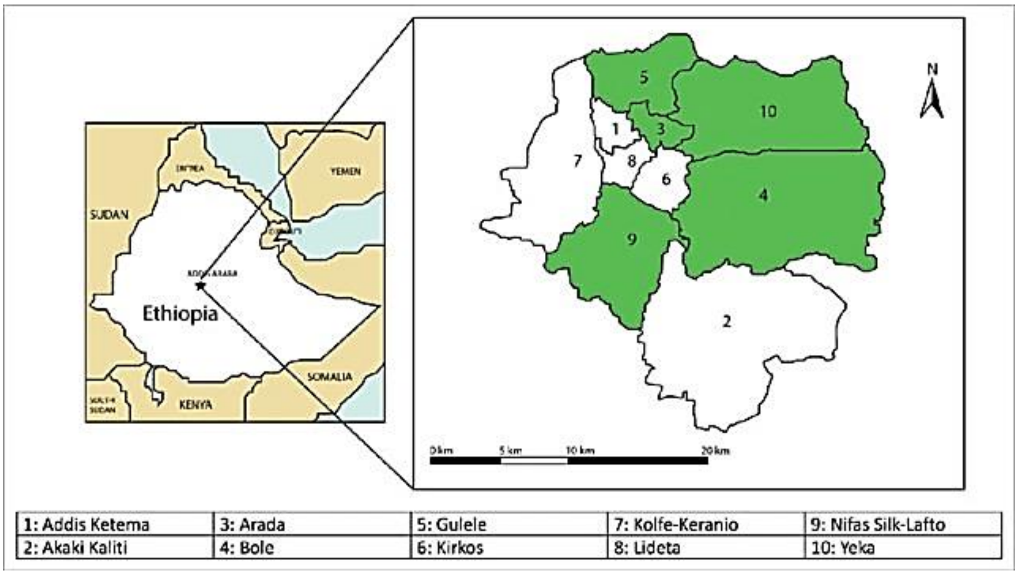
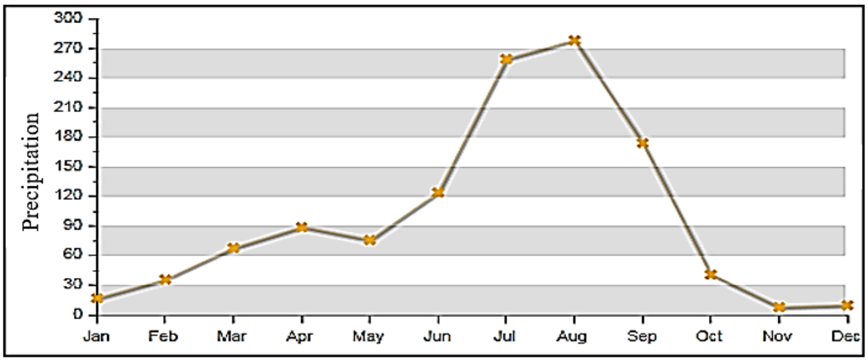


Figure 1. A map of the research area.

The city has a total population of 2,112,737 people, with 1,023,452 men and 1,089,285 women. The city features mixed highlands and a warm and temperate climatE. The temperature fluctuates from 7.9 degrees Celsius in January to 25 degrees Celsius in May, with an annual average of 16.6 degrees Celsius. Figure 2 shows annual rainfall (mm) and temperature (°C) data for the study area.



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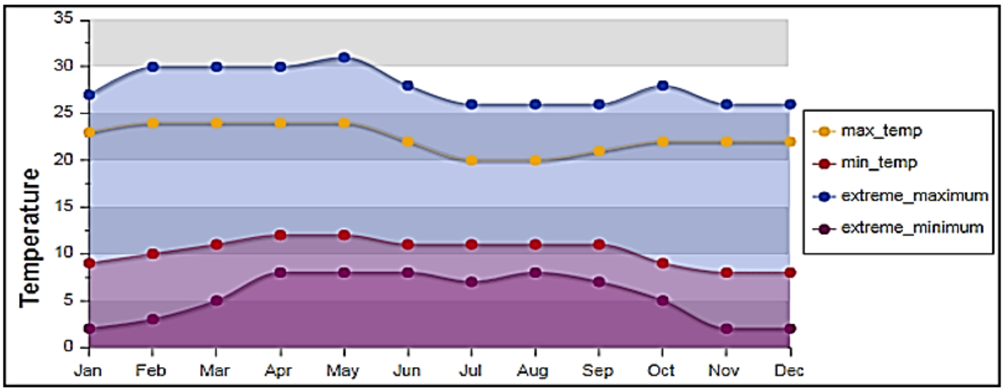

(**b**)

Figure 2. (**a**) Annual precipitation and (**b**) annual temperature for the research area (Source: National meteorology of agency Ethiopia database).

2.2. Vegetation Sampling

Before the actual data collection, a reconnaissance survey was organized. To acquire an overview of the performance of foreign and native plant species, data was collected from 10 February to 18 February 2019. Each stand was analyzed using 400 m^2 (20 m × 20 m) sampling plots. The quadrats were spread out according to the structure and topography of the stands. All trees with a height greater than 1.3 m in each plot were recognized, counted, and their diameter at breast height measured. All woody species with a height of 0.3–1.3 m was counted inside a 9 m^2 (3 m × 3 m) sampling frame set-up in the middle of each plot. Seedlings were defined as plants with a height of less than 1.5 m, while saplings were defined as plants with a height of 1.5 m to 2 m. Seedlings with a height of less than 0.3 m were excluded from the study because they were difficult to identify and have a high mortality rate [35].

Seedlings had their diameter measured at 5 mm above ground, whereas woody trees had their diameter measured at 1.3 m above ground. A visual estimate was used to determine the percent cover of each species in each plot. It was carried out at the same time as the enumeration and recording of species in each plot. Finally, the collected species were identified at the Addis Ababa University (AAU) national herbarium using the Flora of Ethiopia and Eritrea (ETH).

2.3. Regeneration Status

The data was collected for both saplings and mature forms of woody plants. By comparing the frequency of saplings and seedlings with adult trees, the regeneration state of the plantation forest was investigated [36–39].

i. Plantlet > sprout > developed tree → Worthy redevelopment

ii. Plantlet > or ≤ sprouts ≤ developed trees → Fair restoration
iii. Classes continues only in seedling, but no sprout (saplings may be ≤ adults) → Poor redevelopment
iv. Classes establish only in matured form → No restoration.

The relative redevelopment position of the two forestry attitudes was also analyzed using the following formulae to compute solidity percentages among sprouts and developed individuals, sprouts and plantlets, and saplings and matured entities [16,40,41].

$$\text{Plantlet to tree ratio} = (\text{Estimated number of seedlings})/(\text{Number of trees}) \quad (1)$$

$$\text{Sapling to tree ratio} = (\text{estimated number of saplings})/(\text{number of trees}) \quad (2)$$

2.4. Data Analysis

The species significance value was utilized to estimate the domination of types in the research zonE. It was calculated by adding the relative density and relative frequency.

$$\text{Relative density} = (\text{density of species})/(\text{density of all species}) \times 100 \quad (3)$$

Density of a species was calculated as the number of individuals of that species per hectare.

$$\text{Relative frequency} = (\text{frequency of spp.})/(\text{total frequency of spp.}) \times 100 \quad (4)$$

Generalized linear model (GLM) with a logistic function was employed for modeling the presence or absence of seedlings and GLM with a negative binomial distribution (logitlink) for predicting seedling counts. Permutation-based multivariate analysis of variance (PERMENOVA) is a highly flexible "semi-parametric" MANOVA design which uses a distribution-free permutation technique and chosen dissimilarity measure for detecting cumulative differences amongst groups. The multivariate PERMANOVA analysis found cumulative forest structure on R package.

3. Results and Discussion

3.1. Vegetation Sampling and Regeneration Status

Nine woody species, including *Acacia abyssinica*, *Allophylus abyssinicus*, *Bersama abyssinica*, *Croton macrostachyus*, *Ekebergia capensis*, *Juniperus procera*, were found in the sampled plots. *Maesa lanceolata*, *Erythrina brucei*, and *Olea ferruginea* were native species, while the other were exotic species that had recently been brought to the area. *Becium grandiflorum*, *Clutia lanceolata*, *Maytenus arbutifolia*, *Olea europaea*, and *Juniperus procera* were found to have good recruitment status compared to other species in a previous study of seedling and sapling assessment in Yemrehane Kirstos Church Forest of Lasta Woreda, North Wollo Zone, Amhara Region, Ethiopia [42]. *Pouteria adolfi-friedericii*, *Podocarpus falcatus*, *Celtis africana*, *Mimusops kummel*, *Pyschotria orophila*, and *Olea capensis* subsp. *Macrocarpa* were the most dominant tree species with the greatest significance values reported in the Kenech Forest, Southwest Ethiopia. [43]. *Acacia decurrens* and *Acacia melanoxylon*, two of the twenty tree species identified in the area, were found in nearly equal numbers in all three growth stages. Only adult individuals of *Acacia mearnsii*, *Eucalyptus camaldulensis*, and *Cupressus lusitanica* were observed. *Millettia ferruginea* was only observed as a seedling, whilst *Casuarina equisetifolia* and *Afrocarpus falcatus* were only found as seedlings and saplings, with no mature species in the vicinity (Figure 3). According to conservationists all across the world, invasive alien species are the second most serious threat to fragile plant species after habitat degradation. It is the other major threat that has a considerable influence on plant species diversity in many places of the world. They are a serious impediment to the conservation and sustainable use of plant species diversity on a global, regional, and local scale, as well as having a significant detrimental influence on ecosystem goods and services [44].

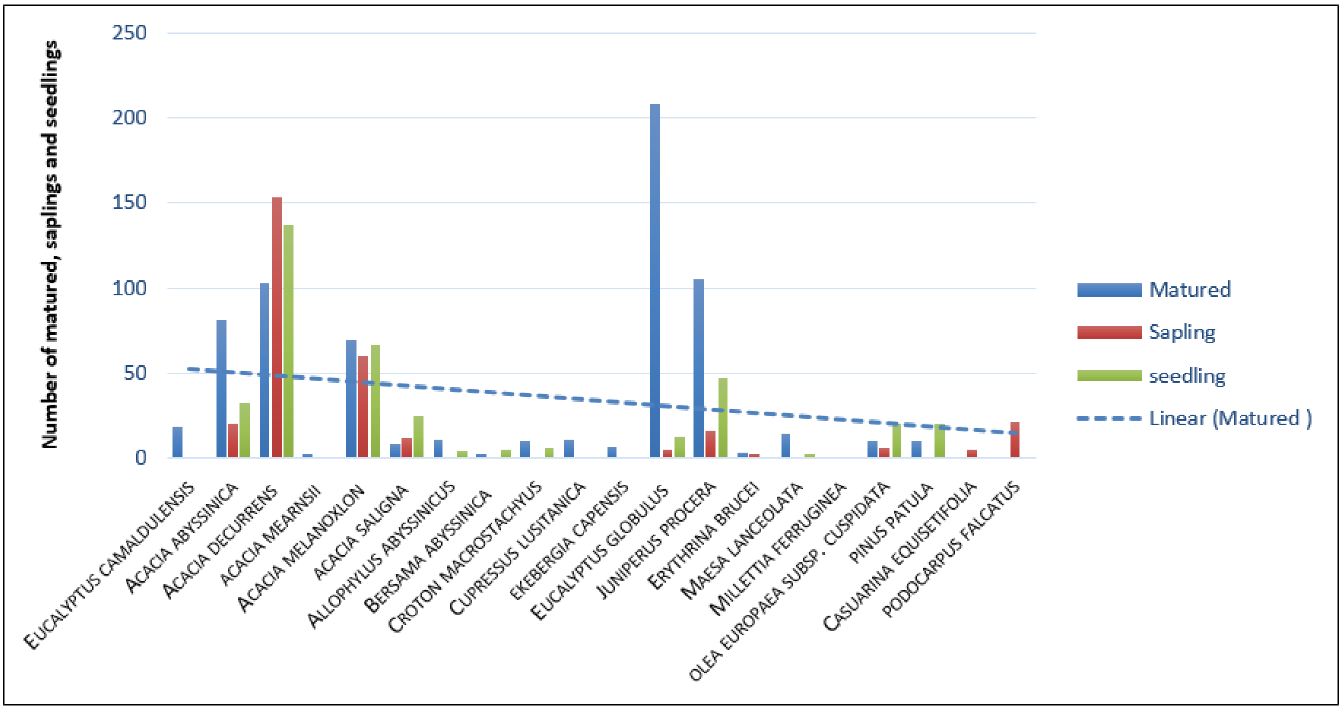

Figure 3. Forest areas in various stages of regeneration.

The top three dominant species in the dualistic forestry spots are *Eucalyptus globulus*, *Juniperus procera*, and *Acacia decurrens*, according to the developed tree variety of the two forestry spots. *Eucalyptus globulus*, *Juniperus procera*, and *Acacia abyssinica* are the top three types with advanced comparative incidences in the studied region. The species' IVI value also implies similar outcomes (Table 1). Small IVI values were found for *Acacia mearnsii*, *Bersama abyssinica*, and *Erythrina brucei*. The smaller IVI value is also used as a species indicator for conservation purposes. Amongst the intrinsic types in the zone that require protection are *Bersama abyssinica* (IVI = 1.23) and *Erythrina brucei* (IVI = 1.41).

Table 1. Phytosociological attributes of adult individuals recorded in Urban forest patches.

Species	Frequency	Relative Frequency	Density	Relative Density	Abundance	Relative Dominance	IVI
Acacia abyssinica Benth.	53.33	14.95	2.7	12.03	5.06	2.39	29.38
Acacia decurrens Willd.	43.33	12.15	3.43	15.30	7.92	7.18	34.64
Acacia mearnsii De Wild.	6.66	1.86	0.06	0.29	1	0.01	2.17
Acacia melanoxylon R.Br.	6.66	1.86	2.3	10.25	34.5	4.82	16.94
Acacia saligna (Labill.) Wendl.	43.33	12.15	0.26	1.18	0.61	0.12	13.46
Allophylus abyssinicus (Hochst.) Radlk.	10	2.80	0.36	1.63	3.66	1.08	5.52
Bersama abyssinica Fresen.	3.33	0.93	0.067	0.29	2	0.0006	1.23
Croton macrostachyus Hochst. ex Delile	6.66	1.86	0.333	1.48	5	0.034	3.38
Cupressus lusitanica Mill.	10	2.80	0.36	1.63	3.66	0.32	4.76
Eucalyptus camaldulensis Dehnh.	10	2.80	0.63	2.82	2.33	0.03	3.88
Ekebergia capensis Sparrm.	10	2.80	0.23	1.04	5.06	2.39	29.38
Eucalyptus globulus Labill.	70	19.62	6.93	30.91	9.90	75.10	125.63
Juniperus procera Hochst. ex Endl.	56.66	15.88	3.5	15.60	6.17	8.75	40.24
Erythrina brucei Schweinf.	3.33	0.93	0.1	0.44	3	0.035	1.41
Maesa lanceolata Forssk.	6.66	1.86	0.46	2.08	7	0.002	3.95
Olea ferruginea Wall. ex Aitch.	10	2.80	0.33	1.48	3.33	0.04	4.33
Pinus patula Schiede ex Schltdl. & Cham.	6.66	1.86	0.33	1.48	5	0.01	3.36

Acacia decurrens, *Acacia melanoxylon*, and *Juniperus procera* had the highest sapling density among the woody species, surveyed by *Acacia melanoxylon* and *Juniperus procera*. *Acacia saligna*, *Acacia mearnsii*, *Cupressus lusitanica*, and *Millettia ferruginea* do not have a plantlet or sprout stage representative; only *Millettia ferruginea* has a plantlet stage representative Table 2.

Table 2. Phytosociological characteristics of the saplings growing in the urban forest patches.

Species	Frequency	Relative Frequency	Density	Relative Density	Abundance	Relative Dominance	IVI
Acacia abyssinica Benth.	30	15.78	0.66	6.53	2.22	0.91	23.24
Acacia decurrens Willd.	40	21.05	5.1	50	12.75	90.04	161.09
Acacia melanoxylon R.Br.	36.66	19.29	2	19.60	5.45	5.79	44.69
Acacia saligna (Labill.) Wendl.	10	5.263	0.4	3.92	4	0.30	9.49
Allophylus abyssinicus (Hochst.) Radlk.	3.33	1.75	0.03	0.32	1	0.02	2.10
Bersama abyssinica Fresen.	3.33	1.75	0.03	0.32	1	0.03	2.11
Croton macrostachyus Hochst. ex Delile	3.33	1.75	0.03	0.32	1	0.08	2.16
Ekebergia capensis Sparrm.	3.33	1.75	0.03	0.32	1	0.06	2.14
Eucalyptus globulus Labill.	3.33	1.75	0.16	1.63	5	0.31	3.70
Juniperus procera Hochst. ex Endl.	26.66	14.03	0.53	5.22	2	0.98	20.24
Erythrina brucei Schweinf.	3.33	1.75	0.06	0.65	2	0.06	2.46
Maesa lanceolata Forssk.	3.33	1.75	0.03	0.32	1	0.03	2.11
Olea ferruginea Wall. ex Aitch.	6.66	3.50	0.2	1.96	3	0.36	5.83
Pinus patula Schiede ex Schltdl. & Cham.	3.33	1.75	0.03	0.32	1	0.03	2.11
Casuarina equisetifolia L.	3.33	1.75	0.16	1.63	5	0.12	3.51
Afrocarpus falcatus (Thunb.) C.N.Page	10	5.26	0.7	6.86	7	0.81	12.94

The number of seedlings and saplings in each of the twenty species was compared to the adult and vice versa to determine the degree of regeneration. According to the numeral of sprouts, plantlet to matured vegetal percentage, *Acacia decurrens* and *Acacia saligna* were determined to have strong redeveloping latent between the entire of twenty forested tree types in the learning region. Nine species were discovered to be relatively regenerativE. *Ekebergia capensis*, *Maesa lanceolata*, *Millettia ferruginea*, *Casuarina equisetifolia*, and *Afrocarpus falcatus*, as shown in Table 3, are significantly regenerating in the area. The repose of the types are not regenerating, implying that only adult types are established. *Acacia saligna*, *Acacia mearnsii*, *Cupressus lusitanica*, and *Erythrina brucei* tree species were only shown as adult trees, implying that they are not regenerating.

Table 3. The extent to which tree types in the learning zone are regenerating.

Species	Matured	Sapling	Seedling	Regeneration States
Acacia abyssinica Benth.	81	20	32	FR
Acacia decurrens Willd.	103	153	137	GR
Acacia mearnsii De Wild.	2	0	0	NR
Acacia melanoxylon R.Br.	69	60	67	FR
Acacia saligna (Labill.) Wendl.	8	12	25	GR
Allophylus abyssinicus (Hochst.) Radlk.	11	1	4	FR
Bersama abyssinica Fresen.	2	1	5	FR
Croton macrostachyus Hochst. ex Delile	10	1	6	FR
Cupressus lusitanica Mill.	11	0	0	NR
Eucalyptus camaldulensis Dehnh.	19	0	0	NR
Ekebergia capensis Sparrm.	7	1	1	PR
Eucalyptus globulus Labill.	208	5	13	FR
Juniperus procera Hochst. ex Endl.	105	16	47	FR
Erythrina brucei Schweinf.	3	2	0	NR
Maesa lanceolata Forssk.	14	1	2	PR
Millettia ferruginea (Hochst.) Baker	0	0	1	PR
Olea ferruginea Wall. ex Aitch.	10	6	20	FR
Pinus patula Schiede ex Schltdl. & Cham.	10	1	20	FR
Casuarina equisetifolia L.	0	5	0	PR
Afrocarpus falcatus (Thunb.) C.N.Page	0	21	0	PR

FR = Fair regenerating; GR = Good regenerating; NR = Not regenerating; PR = poor regenerating.

3.2. Communal Configuration of the Two Spots

The seedling populations of large trees (wooded vegetal types) remained studied by non-metric multidimensional scaling (NMDS) to segregate them along two consequent axes (Figure 4). The forest community structure shows less variancE. There are a few areas where the different communal kinds intersect. The bootstrapping PERMANOVA test was used to check for similarities. The result reveals that dissimilarity is low ($p > 0.05$), which is supported by the assumption of multivariate dispersion homogeneity. The number $p > 0.3455$ denotes a satisfactory degree of similarity.

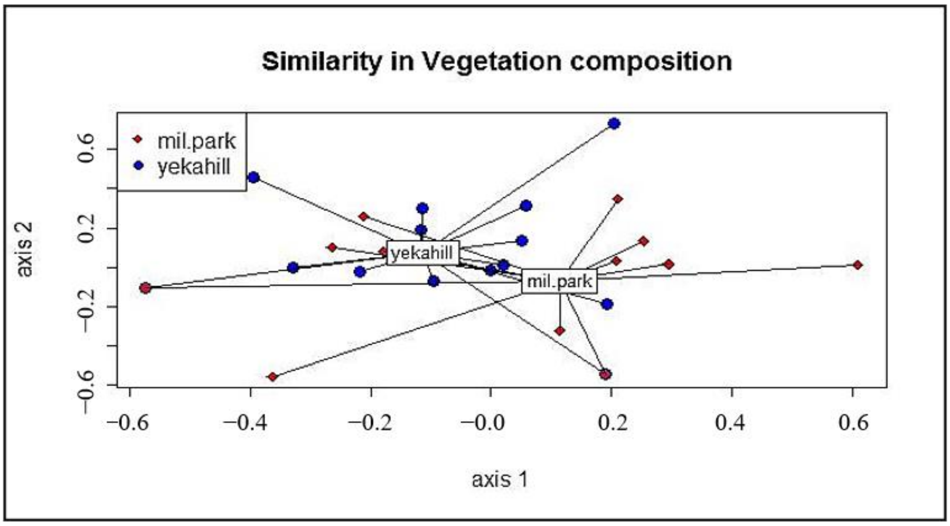

Figure 4. PERMANOVA test with bootstrapping reveals similarities in species composition.

Species including *Acacia abyssinica*, *Acacia melanoxylon*, and *Acacia decurrens* show survivorship at varying diameters at breast height (DBH) and class sizes, according to the research area's survivorship graph. According to the data, *Acacia decurrens* can be found in a variety of DBH classes, as shown in Figure 5. The remaining species were restricted to a DBH class range of less than 10 and an occurrence quantity of fewer than 20. The research area's two most likely surviving woody plant species are in the DBH class range of 10 to 20.

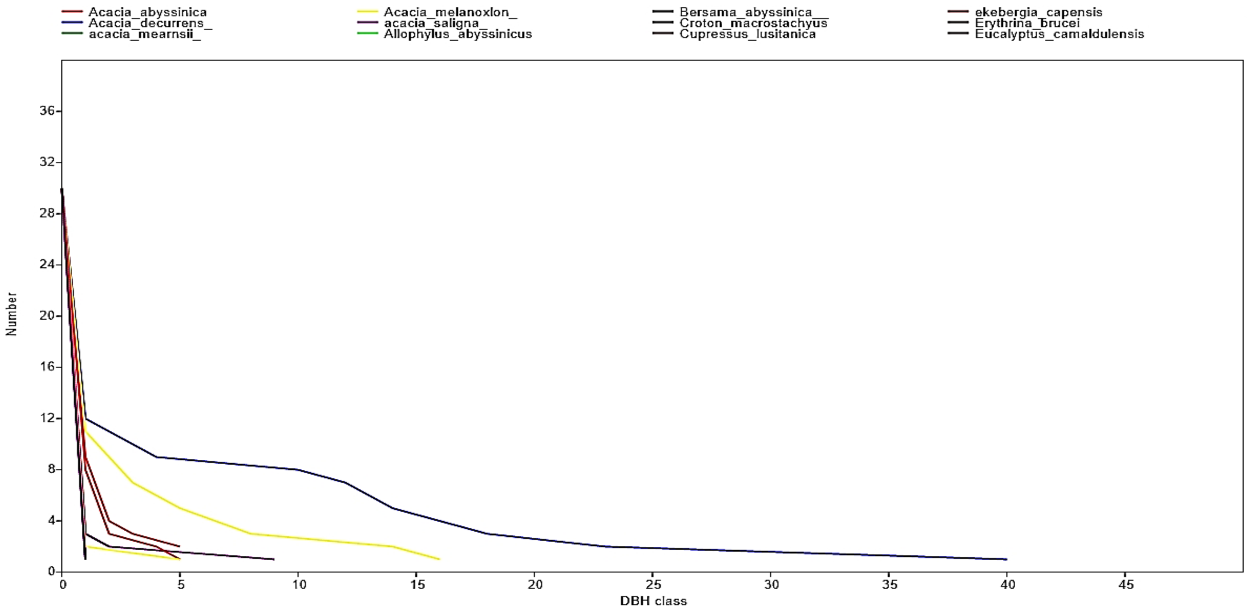

Figure 5. Species with varying DBH classes.

3.3. Comparison of Seedling to Tree Ratio

The density ratios between seedlings and mature individuals, seedlings and saplings, and sapling and mature individuals, as well as the regeneration condition of the two-forest patch stands, were computed using the formula [40,41]. According to the findings, the dominant trees in the region have a ratio of less than one (Table 4). In both sites, the seedling and sapling ratios show that *Acacia decurrens* and *Acacia saligna* have good regeneration capability when compared to their sapling and seedling to tree ratios. In comparison to the others, species such as *Olea ferruginea* have a better ratio.

Table 4. The ratio of seedlings to trees is compared.

Species	Plantlet to Tree Ratio		Plantlet to Tree Ratio	
	Yeka Hill	Mil Park	Yeka Hill	Mil Park
Acacia abyssinica Benth.	0.15	0.26	0.53	0.36
Acacia decurrens Willd.	1.53	1.30	1.42	1
Acacia melanoxylon R.Br.	0.64	2.2	0.79	2
Acacia saligna (Labill.) Wendl.	1	1.57	4	3
Allophylus abyssinicus (Hochst.) Radlk.	0	0.09	0	0.36
Bersama abyssinica Fresen.	0	0.5	0	2.5
Croton macrostachyus Hochst. ex Delile	0.1	0	0.6	0
Ekebergia capensis Sparrm.	0.14	0	0.14	0
Eucalyptus globulus Labill.	0.04	0	0.09	0.02
Juniperus procera Hochst. ex Endl.	0.17	0.13	0.47	0.43
Maesa lanceolata Forssk.	0.07	0	0.14	0
Olea ferruginea Wall. ex Aitch.	0.2	1	1.8	2.2
Pinus patula Schiede ex Schltdl. & Cham.	0	0.1	0	1

3.4. Generalized Linear Growth Model (GLM) of the Sapling

The GLM results for the four most common tree types in the area show that the factors utilized are not statistically important for all of the types in the region. A termination age developed tree types in the quadrat, and entire figure of types in the quadrat were all considered in the GLM. All types are statistically momentous aimed at characteristics associated with termination time, according to the results (Table 5). It was also disovered that the existence of adult species in the quadrant has no effect on the rest of the species. Furthermore, the model shows that the number of species observed in each quadrant has little statistical significance for plantlet presentation. The R^2 score indicates that the classical elucidates 89.73 percent of the modification in seedling thickness, indicating that the classical is thriving-fitting to the data.

Table 5. Summary table of seedling variation by year and the presence of grown trees.

	A. decurence	*A. melanoxylon*	*J. procera*	*A. abyssicica*
Closure year	0.00	0.00	0.00	0.00
Mature trees in the quadrat	0.02	0.00	0.321	0.02
Total species	0.12	0.85	0.63	0.98

$p < 0.05$ = Significant.

The data on a forest's species composition is crucial for developing management tools and making plans. Tulod et al. [36] and Bekele [16] assessed species richness and composition using information acquired from the area. Natural regeneration potential is an important indicator of a forest ecosystem's health. Three of the twenty woody species studied in this study failed to recruit seedlings or saplings. Conservationists in several areas have made similar observations [45–47]. As a result, several species in the forest lack representation in their saplings or seedlings. The length of a forest's closure year affects its degree of regeneration. As a result, the research data shows that regeneration is facilitated as the area of closure time increases and the contact with the human reduces. Shankar [37] and Shono et al. [48] both recorded the same data. In their discussions, they discussed the impact of humans on natural forest regeneration.

Any species' importance value index (IVI) is a measure of its dominance in a mixed population. *Acacia decurrens*, *Acacia melanoxlon*, *Eucalyptus globulus*, and *Juniperus procera* are the major tree species in the current study. *Eucalyptus globulus* and *Juniperus procera* are prominent, according to studies from the similar altitude range in Ethiopia [49,50]. The regeneration of woody species is linked to the ecosystem service they provide to the local community and biological processes, according to Rahman et al. [51]. The degree of dissemination by the plants and their ability to overcome the effects of growth stressors were also factors in regeneration.

The survival of species in a particular community was studied using hazard regression and survival tree approaches. In the current study, species such as *Acacia saligna*, *Acacia abyssinica*, *Acacia decurrens*, and *Acacia melanoxlon* outperform the others in terms of survivorship. Similar findings were found in a related study, suggesting any species' survival is linked to its genetic and environmental adaptation. Woody species' regeneration and survival are strongly dependent on the species that came before them and the environmental conditions in which they grew [16,48,52].

The density of seedlings and saplings in forest areas varies [46,53,54]. The degree of anthropogenic activity, the years of closure, and community awareness of the closed ecosystem all influence the population of forest patches. When Rahman et al. analyzed the two forest patches' regeneration capacity, they came to the same conclusion. In terms of foreign and native plant regeneration, exotic species are the most common [51]. Hailu et al. described the biomass increase in the area in their study for above ground biomass determination [55] In the Nech Sar National Park (NSNP), Ethiopia, Utaile et al. discovered a positive correlation between the Human Disturbance Index (HDI) and community composition, species richness, and diversity, revealing three distinct woody vegetation types (*Acacia mellifera-Combretum aculeatum*; *Lecaniodiscus fraxinifolius-Deinbollia kilimandscharica* and *Acacia polyacantha-Ficus* sycomorus) [56].

4. Conclusions

Understanding the structural pattern and regeneration status of tree species is a critical step in assessing the forest's vegetation dynamics and destruction factors, as well as the forest's management history and ecology. Introduced species regrew at a far faster rate than native species, according to our findings. The presence of "disturbed" habitats is likely to provide possibilities for nonnative species to locate niches and compete with native species, potentially resulting in the emergence of invading species. We propose effective human intervention protection and scientific natural regeneration management. Quarantine action to minimize the entrance of exotic and invasive species from other countries is also recommended, as some exotic species harm and compete with native species.

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