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Population Structure and Regeneration Status of Woody Species in Dawsura Exclosure, Central Tigray, Ethiopia for Restoration and Biodiversity Conservation

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Author's contribution

The sole author designed, analysed, interpreted and prepared the manuscript.

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ABSTRACT

Research demonstrates that exclosures promote natural regeneration of of native species from soil seed banks, thus contributing to the rehabilitation of degraded lands. The present research was undertaken to examine the population structure and regeneration status of woody species to furnish insights into the sustainable management of the Dawsura exclosure. The methodology for data collection employed a transect line sampling approach as a design framework, with a total of 36 plots, each measuring 20 m × 20 m (400 m²), established along the transect line to assess the woody species. In every designated sample plot, all instances of woody species in the seedling, sapling, and mature tree/shrub categories were enumerated and recorded. Additionally, their diameter at breast height (DBH) was measured at a height of 1.3 meters above the ground,

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specifically for DBH values equal to or exceeding 2.5 cm. A cumulative total of 37 vascular plant species, classified into 33 genera and 19 families, were systematically recorded and identified across the 36 study plots. The overall density of woody plant species throughout all sampled plots within the study area was determined to be 1588 individuals per hectare. The respective total densities for seedlings, saplings, and trees/shrubs were quantified as 1082.11, 271.17, and 1588.19 individuals per hectare. Among the 37 species documented within the exclosure, only 10 species (27%) were represented at the sapling stage, whereas the remaining 27 species (72.97%) were not represented. In the seedling category, only 11 species (29.73%) out of the 37 were present, with the remaining 26 species (70.27%) lacking seedlings during the period of data collection. Only a single species demonstrated a healthy population structure among the 37 recorded woody species within the exclosure.

Keywords: Woody species; population structure; regeneration structure; exclosure, density; basal area.

1. INTRODUCTION

Land degradation represents a significant environmental challenge characterized by the reduction in the productive capacity of land due to a variety of physical, chemical, and biological processes [1]. This decline not only diminishes the utility of land but also threatens the diversity of ecosystems [1]. Manifestations of land degradation, such as soil erosion, desertification, and salinization, have profound implications for agricultural productivity and food security, particularly in vulnerable regions like sub-Saharan Africa [2]. Land degradation in Ethiopia is a critical problem caused mainly by water erosion of soils, deforestation, overgrazing and unsustainable agricultural practices, exacerbated by rapid population growth and climate shocks [3,2]. This degradation manifests itself in various forms, including loss of soil fertility, desertification and nutrient depletion, which significantly impacts agricultural productivity and food security, vital to the country's economy [2,4]. Its impacts extend beyond agriculture, affecting rural livelihoods and exacerbating poverty [3]. Mitigation strategies such as best management practices (BMPs), including agroforestry, soil bunds and fencing, have shown potential to restore degraded landscapes [2], although their effectiveness varies depending on local conditions [5]. Recent studies using remote sensing have revealed significant land use changes, indicating ongoing degradation and an urgent need for sustainable management practices to prevent further loss of vital ecosystems [6-9].

In Tigray region of Ethiopia is grappling with significant land degradation issues, characterized by deforestation, soil moisture stress, reduced biodiversity, and soil erosion. These environmental challenges are primarily attributed to population pressures and unsustainable agricultural practices, as noted by [10,11]. To combat these detrimental effects, the regional administration has been implementing a series of restoration programs since the 1991s. A key component of these initiatives were the establishment of exclosures, which are designated areas that are closed off from grazing to promote natural regeneration, as documented by [11,12]. These exclosures have demonstrated considerable success in increasing the density and diversity of woody species, improving soil properties, and supporting overall ecological restoration efforts [5,13,12]. Research indicates that exclosures facilitate the emergence of native vegetation from soil seed banks, thereby aiding in the recovery of degraded lands [11,12]. However, despite these positive outcomes, several challenges remain. Maine objective this study was to assess regeneration and population structure of woody species at the exclosure in order to further refine and enhance management practices. Addressing these challenges is crucial for ensuring the long-term sustainability and effectiveness of restoration efforts in the Tigray region.

2. MATERIALS AND METHODS

2.1 Study Area

Dawsura Exclosure is located in the Tigray region's central zone in northern Ethiopia. It spans around 336.17 hectares and is located geographically between 13.568º and 13.59o N and 39.00º and 39.023º E. It was founded in the 1980s and is located in the Tanqua-Milash district. Based on Ethiopia's agroecological zones, the exclosure has a dry semi-arid climate. There is only one rainy season in the study area, and it peaks between June and September. Rainfall in the area ranges from 400 to 900 mm annually. In low-lying places, the temperature ranges from 21 to 41 degrees Celsius, while in high-lying parts, it varies from 14 to 21 degrees Celsius [14].

2.2 Data Collection

2.2.1 Sampling design

After conducting a reconnaissance survey, the sampling of woody species was carried out from September to November 2018. Transect line sampling technique was used to sample the woody species [15]. To determine the population structure, the diameter of trees/shrubs with a diameter at breast height (DBH) ≥ 2.5 cm was measured utilizing a diameter tape. All woody species found in the exclosure were recorded to assess the regeneration status. A total of 36 samples measuring 20 m × 20 m (400 m^2) for trees or shrubs, 10 m x 10 m (100 m^2) for saplings and 5 m × 5 m (25 m^2) for seedlings were designated for this study [16]. The trees and shrubs present were meticulously documented and identified by referencing the volumes of the Flora of Ethiopia and Eritrea and Use Full Tree and Shrubs in Ethiopia and Eritrea [15].

2.3 Data Analysis

2.3.1 Population structure

Using Microsoft Excel, the vegetation data entry form was created, and the same program was used for the data analysis that followed. Spreadsheets for Excel were used to create the graphs. The analysis of vegetation structure employed all of the individual species that were recorded in each of the 36 plots. Analysis was done on the species structure of the forest's tree species, including their frequency, density, abundance, basal area, and significance value index (IVI). By adding together relative frequency (RF), relative density (RD), and relative dominance (RD), the importance value index (IVI) was determined. The vegetation structure was described using the DBH, basal area, frequency, tree density, and important value index. The density of each woody species per hectare was calculated by dividing all collected numbers of individuals by the area sample [17,18].

2.3.2 Basal area

By assuming that a tree stem is completely spherical and that the base of the tree has the same diameter as the stem at 1.3 meters

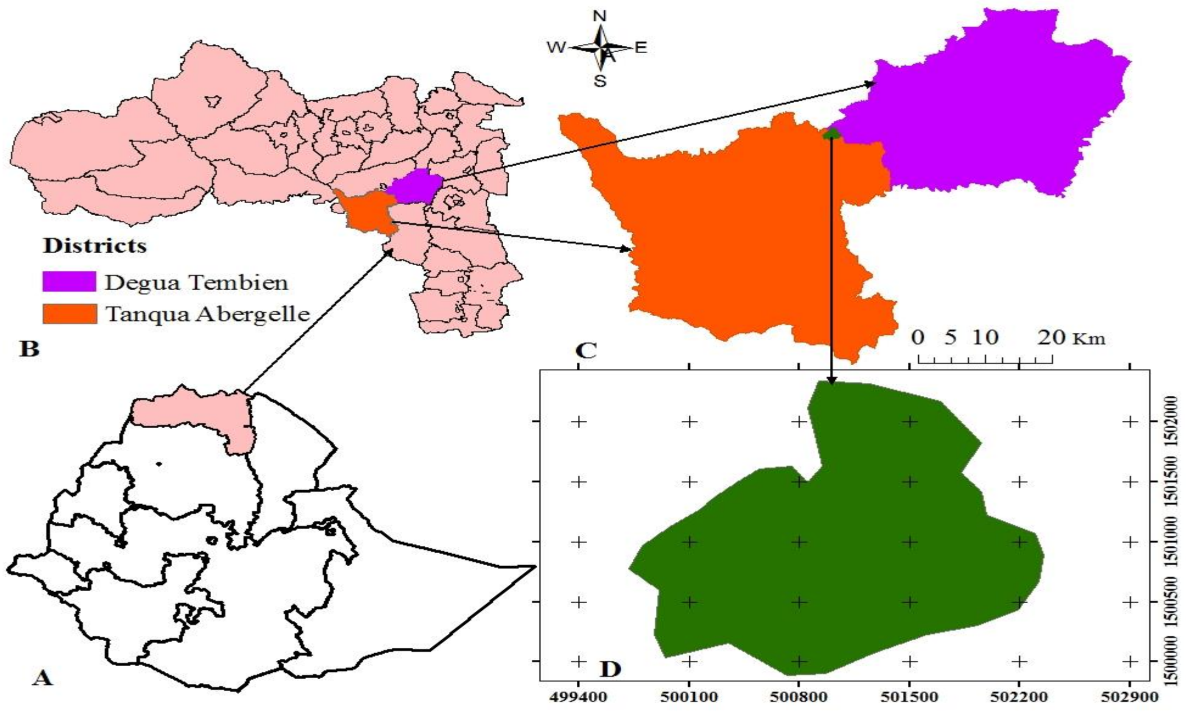


Fig. 1. Map of the study site Ethiopia (A), Tigrai (B) Degua-Tembien and Tanqua-Abergelle (C) and Dawsura exclosure (D)

above ground—the height for DBH measurement—the basal area of a tree stem can be computed from a tree's diameter measurement (DBH). Its basal area was computed as one of the primary features to ascertain dominance, and it is measured from DBH. As a result, for all woody species, the relative value of basal area (BA) was computed to determine relative dominance [19].

$$BA = \frac{\pi(DBH)^2}{4} \quad \text{Equation 1}$$

Where, BA= Basal area in m^2, π= 3.14, DBH=Diameter at breast height.

2.3.3 Dominance

Dominance (DO) was calculated by the sum of the basal area (BA) of individual woody species per ha^{-1}.

2.3.4 Relative dominance (RD)

It is calculated by dividing the basal area of individual woody species by the total basal area of all woody species multiplied by 100 and it is expressed in%.

$$RD = \frac{Basal\ area\ of\ individual\ specie}{Basal\ area\ of\ all\ species} * 100 \quad \text{Equation 2}$$

The important value index (IVI) indicates the relative ecological importance of the woody species in the study area. It is determined from the summation of the relative values of density, frequency, and dominance of each woody species [19].

$$IVI = RD + RDE + RF \quad \text{Equation 3}$$

Where, IVI= Importance value index, RDE= Relative density, RF= Relative frequency

2.3.5 Relative density (RDE)

It is calculated by dividing density of individual woody species to total density of all woody species and multiplied by 100.

$$RDE = \frac{Density\ of\ individual\ specie}{total\ density\ of\ all\ woody\ species} * 100 \quad \text{Equation 4}$$

2.3.6 Regeneration status

The regeneration status of woody species was summarized based on the total count of seedlings and saplings of each species across all plots. The regeneration status of the forest was assessed using the following categories used by [17,20].

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 ≤ sapling ≤ 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. 'If a species is present only in an adult form, it is considered as not regenerating'.
5. 'New', if a species has no mature, but only sapling and/ or seedling stages.

3. RESULTS

3.1 Floristic Composition of Woody Species

At the exclosure a total of 2287 individual woody tree species, with a density of 1588 trees/shrubs ha^{-1} was recorded. These individual woody species belongs to 37 species, 33 genera, and 19 family. The dominant family Fabaceae is represented by ten species and ten genera, two families (Anacardiaceae and Malvaceae) each represented by three species and three genera, six families (Capparaceae, Celastraceae, Combretaceae, Ehretiaceae, Moraceae, Rhamnaceae) each represented by two species two genera, nine families (Apocynaceae, Burseraceae, Cannabaceae, Capparidaceae, Ebenaceae, Phyllanthaceae, Pittosporaceae, Sapindaceae, Ximeniaceae) each represented by one species and one genus.

Four woody species (*Albizia amara*; *Dodonaea angustifolia*, *Terminalia brownii* and *Dichrostachys cinerea*) contributes 93% of the basal area of the exclosure and the rest 7% of the basal area also contributed by the rest 33 woody species (*Senna singueana*, *Ozoroa insignis*, *Ficus thonningii Blume*, *Acacia etbaica, Combretum molle*, *Ficus vasta*, *Cordia monoica*, *Erythrina abyssinica*, *Acacia tortilis*, *Ziziphus spina-christi*, *Grewia mollis*, *Commiphora habessinica*, *Acokanthera schimperi*, *Euclea schimperi*, *Pittosporum viridiflorum*, *Combretum molle*, *Grewia villosa*, *Boscia angustifolia*, *Ximenia americana*, *Ziziphus abyssinica*, *Acacia seyal Delile*, *Lannea fructicosa*, *Erythrina brucei*, *Maytenus undata*, *Grewia kakothamnos K.Schum*, *Flueggea virosa* (Willd). *Royle*, *Capparis tomentosa Lam*., *Maytenus senegelensis*, *Ehretia cymosa*, *Celtis africana*, *Calpurnai aurea (Lam.) Benth*., *Maerua* *angolensis* and *Rhus natalensis*). The five dominant and thus ecologically most important woody species (IVI) were *A. amara* (142.98%), *D. angustifolia* (69.06%), *T. brownii* (22.13%), *D. cinerea* (17.88%), *S. singueana* (16.02%).

3.1.1 Frequency (F)

This is the number of plots in which a species recorded divided by the total number of plots it gives an approximate indication of the homogeneity and heterogeneity of a forest area and relative frequency (RF) was computed as the ratio of the number in which a species occurred and the total occurrences of all species in all. *A. amara* (97%) is the most frequent species followed by *Dodonaea angustifolia (*69%*)*, *Terminalia brownii* (61%) *S. singueana* (44%), and *D. cinerea* (36%).

Table 1. Importance value index of woody species of Dawsura exclosure

Botanical Name	Relative density	Relative frequency	Relative dominance	IVI	Rank
Albizia amara	44.59	18.91	55.91	119.41	1
Dodonaea angustifolia	37.86	13.45	18.91	70.22	2
Terminalia brownii	4.28	11.89	11.71	27.88	3
Dichrostachys cinerea	4.15	7.02	6.53	17.70	4
Senna singueana	3.08	8.58	0.67	12.33	5
Ozoroa insignis	0.13	0.19	0.60	0.93	24
Ficus thonningii Blume	0.06	0.58	0.57	1.22	21
Acacia etbaica	0.69	2.14	0.53	3.36	10
Combretum molle	0.13	1.56	0.49	2.17	12
Ficus vasta	0.06	0.58	0.49	1.14	22
Cordia monoica	0.25	2.73	0.38	3.36	9
Erythrina abyssinica	0.13	1.56	0.36	2.05	13
Acacia tortilis	0.13	1.56	0.34	2.02	14
Ziziphus spina-christi	0.19	2.53	0.32	3.04	11
Grewia mollis	0.44	3.31	0.31	4.06	8
Commiphora habessinica	0.06	0.58	0.30	0.95	23
Acokanthera schimperi	0.06	0.58	0.25	0.90	25
Euclea schimperi	1.51	2.73	0.24	4.48	7
Pittosporum viridiflorum	0.06	0.58	0.20	0.85	26
Ormocarpum pubescens	0.13	1.17	0.19	1.49	18
Grewia villosa	0.19	1.56	0.10	1.84	15
Boscia angustifolia	0.57	4.29	0.10	4.95	6
Ximenia americana	0.19	1.56	0.10	1.84	15
Ziziphus abyssinica	0.06	0.58	0.09	0.73	27
Acacia seyal Delile	0.06	0.58	0.09	0.73	27
Lannea fructicosa	0.06	0.58	0.09	0.73	27
Erythrina brucei	0.06	0.58	0.06	0.71	30
Maytenus undata	0.06	0.58	0.06	0.71	30
Grewia kakothamnos	0.06	0.58	0.02	0.67	32
Flueggea virosa (Willd)	0.06	1.17	0.00	1.23	19
Capparis tomentosa Lam.	0.06	0.58	0.00	0.65	33
Maytenus senegelensis	0.25	1.56	0.00	1.81	17
Ehretia cymosa	0.06	1.17	0.00	1.23	19
Celtis africana	0.06	0.58	0.00	0.65	33
Calpurnai aurea (Lam.)	0.06	0.58	0.00	0.65	33
Maerua angolensis	0.06	0.58	0.00	0.65	33
Rhus natalensis	0.06	0.58	0.00	0.65	33
Total	100.00	100.00	100.00	300.00	

3.2 Regeneration Status of Woody Species Dawsura exclosure

3.2.1 Density of trees/shrubs, saplings, and seedlings

An analysis was conducted on the regeneration status of the 37 woody species present in the study plots of the exclosure, with calculations and implementation of the findings. The collective density of trees/shrubs, saplings, and seedlings across all 36 sample plots within the Exclosure were 1588.19, 270.17, and 1083.11 per hectare respectively.

In the mature trees/shrubs stage the top four densest (ha^{-1}) were listed in descending order *A. amara* (709), *D.angustifolia* (602), *T. brownie* (68), and *D. cinerea* (66), and these species comprises (90.88%) of all mature woody species densities of stems in the exclosure. The other 33 mature trees/shrubs (*S. singueana*, *O. insignis*, *F. thonningii Blume*, *A. etbaica*, *C. molle*, *F. vasta*, *C. monoica*, *E. abyssinica*, *A. tortilis*, *Z. spina christi*, *G. mollis*, *C. habessinica*, *A. schimperi*, *E. schimperi*, *P. viridiflorum*, *O. pubescens*, *G. villosa*, *B. angustifolia*, *X. americana*, *Z. abyssinica*, *A. seyal Delile*, *L. fructicosa*, *E. brucei*, *M. undata*, *G. kakothamnos*, *F. virosa* (Willd), *C. tomentosa Lam*, *M. senegelensis*, *E. cymosa*) comprises (9.12%) of all mature woody species densities of stems in the exclosure.

Table 2. Table Density of trees/shrubs, saplings and seedlings of Dawsura exclosure

Scientific Name	Family	Seedling	Sapling	Tree/Shrub
Albizia amara	Fabaceae	345.83	86.81	709.03
Dodonaea angustifolia	Sapindaceae	932.29	209.02	602.08
Terminalia brownii	Combretaceae	19.53	-	68.06
Dichrostachys cinerea	Fabaceae	153.35	25.69	66.67
Senna singueana	Fabaceae	90.65	25.69	49.31
Ozoroa insignis	Anacardiaceae	0.69	-	2.78
Ficus thonningii Blume	Moraceae	-	-	0.69
Acacia etbaica	Fabaceae	10.41	16.87	11.11
Combretum molle	Combretaceae	-	-	2.08
Ficus vasta	Moraceae	-	-	0.69
Cordia monoica	Ehretiaceae	-	-	4.17
Erythrina abyssinica	Fabaceae	-	-	2.08
Acacia tortilis	Fabaceae	-	2.08	2.08
Ziziphus spina-christi	Rhamnaceae	3.47	10.41	3.47
Grewia mollis	Malvaceae	-	-	6.94
Commiphora habessinica	Burseraceae	-	-	0.69
Acokanthera schimperi	Apocynaceae	-	-	0.69
Euclea schimperi	Ebenaceae	2.08	10.41	24.31
Pittosporum viridiflorum	Pittosporaceae	-	-	0.69
Ormocarpum pubescens	Fabaceae	-	-	2.08
Grewia villosa	Malvaceae	-	-	2.78
Boscia angustifolia	Capparaceae	0.69	-	9.03
Ximenia americana	Ximeniaceae	-	-	2.78
Ziziphus abyssinica	Rhamnaceae	-	-	0.69
Acacia seyal Delile	Fabaceae	-	-	0.69
Lannea fruticose	Anacardiaceae	-	-	0.69
Erythrina brucei	Fabaceae	-	-	0.69
Maytenus undata	Celastraceae	-	-	0.69
Grewia kakothamnos	Malvaceae	-	-	0.69
Flueggea virosa (Willd)	Phyllanthaceae	-	-	1.39
Capparis tomentosa Lam.	Capparaceae	-	-	0.69
Maytenus senegelensis	Celastraceae	-	1.38	4.17
Ehretia cymosa	Ehretiaceae	-	0.69	0.69
Celtis africana	Cannabaceae	-	-	0.69
Calpurnai aurea (Lam.)	Fabaceae	-	-	0.69
Maerua angolensis	Capparidaceae	0.69	-	0.69
Rhus natalensis	Anacardiaceae	-	-	0.69

In the sapling stage the four woody species were listed in descending order of density ha^{-1} *D. angustifolia* (209.02), *A. amara* (86.81), *D. cinerea* (25.69), and *S. singueana* (25.65) which comprises (89.24%) of all saplings of the exclosure.

In the seedling stage, the four species were arranged in descending order in terms of their densities ha^{-1} were *D. angustifolia* (932.29 ha^{-1}), *A. amara* (345.83 ha^{-1}), *D. cinerea* (153.35 ha^{-1}) and *S. singueana* (90.65 ha^{-1}) and these consist (97.57%) of the Exclosure total seedlings density.

3.3 Population Structure

DBH class distribution of all woody species shows an inverted J-shape (Fig. 2). This pattern indicates that normal population structure could be considered as stable or good regeneration status where most species had the highest number of individuals at the lower DBH classes. This may be because the exclosure is dominated by shrubs (*D. angustifolia*, *A. amara*, *D. cinerea,* and *S. singueana*). The DBH class distribution of the four selected species demonstrated a different pattern of distribution from the all-species diameter class distribution (Fig. 3).

A. amara shows almost a bell-shaped population structure it has few individuals at the lower and higher DBH classes but a high number of individuals in the middle and this indicates the species has an unstable population structure. *D. angustifolia* has a stable population structure, exhibiting an inverted J-pattern shape. *T. brownii* DBH class shows an unstable population

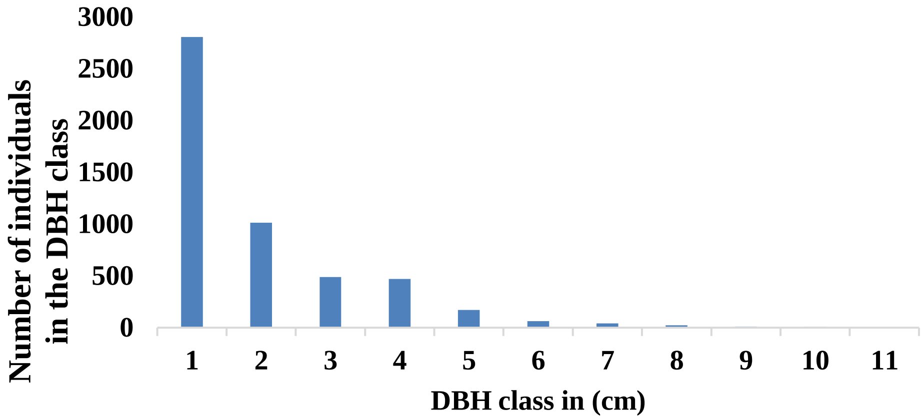
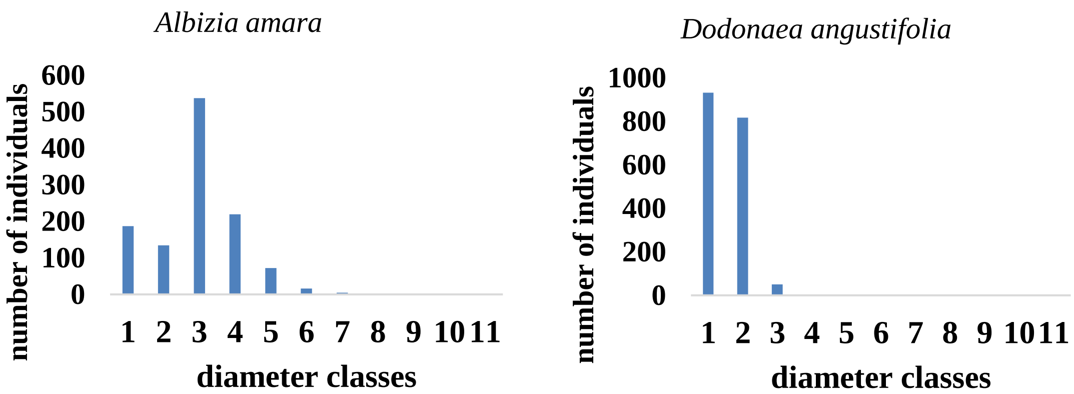
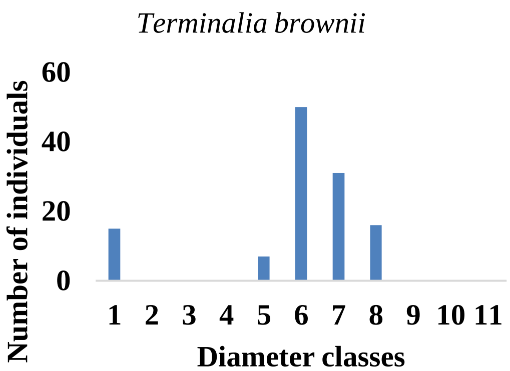


Fig. 2. Diameter class distribution (cm) of all woody species (1 = <2.5 cm, 2 = 2.5 – 5.5 cm, 3 = 5.6- 8.6 cm 4 = 8.7.1-11.7 cm, 5 = 11.8-14.8 cm, 6 = 14.9-17.9 cm, 7 = 18.0-21.0 cm, 8 = 21.1-23.1 cm, 9 = 23.2 - 25.2 cm, 10 =25.3-28.3 cm, 11 >28.3)





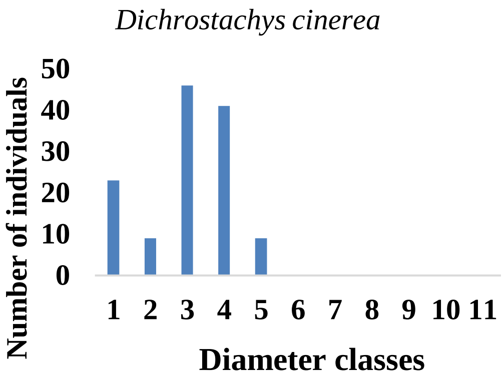


Fig. 3. Diameter class (cm) distribution of *A. amara*, *D. angustifolia* and *T. brownii* recorded at the exclosure (1 = <2.5 cm, 2 = 2.5 – 5.5 cm, 3 = 5.6- 8.6 cm 4 = 8.7.1-11.7 cm, 5 = 11.8-14.8 cm, 6 = 14.9-17.9 cm, 7 = 18.0-21.0 cm, 4.8 = 21.1-23.1 cm, 9 = 23.2 - 25.2 cm, 10 =25.3-28.3 cm, 11 >28.3)

structure as almost there was no recorded number of individuals in the lower diameter class. *D. cinerea* this species also exhibits an unstable population structure as the number of individuals in the lower DBH class was less than the number of individuals in the upper DBH class.

4. DISCUSSION

4.1 Floristic Composition of Woody Species

Within this exclosure, a total of 37 woody species have been recorded, a figure that aligns closely with other regional exclosures. For instance, Tselemti hosts 41 species [21], Hirmi supports 71 species [22], and Kafta Sheraro National Park is home to 70 species [23]. The variation in species composition across these sites can be attributed to differing agroecological conditions, site quality, and the extent of human influence. Factors such as soil type, climate, elevation, and land use practices significantly impact the specific floristic composition of species in each location. Despite these differences, exclosures play a crucial role in enhancing the diversity of woody species. It provides a protected environment that facilitates the natural regeneration of vegetation, thereby promoting increased biodiversity.

4.2 Population Structure

The population structures of various species offer insightful patterns that reflect their stability and growth potential [24]. For instance, *A. amara* exhibits a near bell-shaped distribution in its diameter at breast height (DBH) classes. This distribution is marked by a scarcity of individuals in both the lower and higher DBH classes, while there is a significant number of individuals in the middle classes. Such a pattern suggests an unstable population structure, which may indicate challenges in recruitment or survival at the extremes of its growth spectrum and selective cutting at the upper diameter class [25]. This instability could be due anthropogenic influence, environmental factors or the species' ability to thrive at different life stages [26]. In contrast, *D. angustifolia* displays a stable population structure characterized by an inverted J-pattern. This pattern is indicative of a healthy recruitment of younger individuals, ensuring a sustainable population over time [25]. The presence of numerous younger individuals suggests robust regeneration processes and adaptability to environmental conditions that favor long-term population maintenance [27]. On the other hand, *T. brownii* demonstrates an unstable population structure, as evidenced by an almost complete absence of individuals in the lower-diameter classes [25]. This lack of younger individuals could signal potential long-term sustainability issues for the species, possibly due to inadequate seedling establishment or high mortality rates among juveniles [28]. Similarly, *D. cinerea* also presents an unstable population structure, with fewer individuals in the lower DBH classes compared to the upper ones. This imbalance suggests difficulties in the regeneration process, potentially impacting the species' future viability and resilience. Such a pattern could be attributed to ecological pressures or anthropogenic influences that hinder the natural regeneration cycle [25]. The four dominant species population structure indicates that only *D. angustifolia* has a stable population structure which highlighting potential conservation needs and strategies to enhance their survival prospects. Understanding these structures is essential for developing targeted conservation efforts that address specific challenges faced by each species, ensuring their continued existence and ecological contributions [28].

4.3 Regeneration Status

The overall densities of mature trees/shrubs, saplings, and seedlings were 1588.19, 270.17, and 1083.11, ha^{-1} respectively. Successful forest regeneration characterized by density of seedlings> saplings> mature trees/shrubs [25]. From this point the regeneration status of the exclosure was not successful this may be the seedling recruitment is may be affected by stand climate variability, soil disturbance and human interference [29].

For mature trees/shrubs, the most densely populated species were *A. amara* with a density of (709) individuals ha^{-1}, followed by *D. angustifolia* (602) individuals ha^{-1}, *T. brownii* (68) individuals ha^{-1}, and *D. cinerea* (66) individuals ha^{-1}. These four species collectively accounted for a significant (90.88%) of the total mature woody species density, highlighting their dominance in the exclosure. In the sapling stage, *D. angustifolia* was the most prevalent, with a density of (209.02) individuals ha^{-1}, followed by *A. amara* (86.81) individuals ha^{-1}, *D. cinerea* (25.69) individuals ha^{-1} and *S. singueana* (25.65) individuals ha^{-1} and totally constituting (89.24%) of all saplings at the exclosure. Out of the 37 species recorded at the exclosure only 10 species (27%) represented at this sapling stage but the rest 27 species (72.97%) not represented. This suggests a strong threat for these species to mature and maintain their presence in the ecosystem [30].

Regarding seedlings, *D. angustifolia* dominated with a remarkable density of (932.29), *A. amara* (345.83) *D. cinerea* (153.35) and *S. singueana* (90.65. These four species made up an overwhelming (97.57%) of the total seedling density. In this stage only 11 (29.73%) species out of the 37 represented but the rest 26 (70.27%) not hade seedlings during the data collection time. Form this study we found that majority of the woody species found at this exclosure not represented at the seedling and sapling stage and this indicates that the exclosure is not successful in regeneration status [25]. This unsuccessful regeneration status may be due to influence of human intervention, environmental condition and climate change on the exclosure [29].

5. CONCLUSION AND RECOMMENDATION

In this study, floristic composition population structure and regeneration status were determined for the Dawsura exclosure. *A. amara*; *D. angustifolia*, *T. brownii* and *D. cinereal* the dominant species which contributes (93%) of the basal area of the exclosure. The results of this study is important in understanding the patterns of the population structure and regeneration status of wood species at the Dawsura exclosure, which is important for the sustainable utilization, management and decision making for the future conservation of the excosure. Abundance of seedlings and saplings are indicators of the establishment of young individuals. In this study, generally, the regeneration of wood species has shown that contribution of seedlings density was lowest than mature trees but higher than density of saplings, indicating a poor regeneration status of the species. This implies that the overall regeneration status of wood species in the study area has poor regeneration and recruitment potential and dominated by few species. This poor regeneration and recruitment of species is an important input to take effective management action to improve and sustain regeneration of the woody species of the exclosure. Therefore, the exclosure needs systematic management plan for conservation and sustainable utilization and priority should be given.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

COMPETING INTERESTS

Author has declared that no competing interests exist.

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