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The species composition, diversity and regeneration status of Alamata woodlands, Tigray Regional State Northern Ethiopia–a descriptive analysis

Abstract

Woody species composition, diversity and regeneration of Alamata woodland forest were evaluated and sampled using systematic random sampling techniques. Fifteen temporary sample plots of 20m x 20m (400 m^2) each were established in the sampled woodland forest along altitudinal gradients 100m along plots. Three subplots, 5m x 5m were situated diagonally inside the 20m*20m one in the centre and edges for saplings, shrubs and seedlings data collection. Diameter at breast height (DBH) (cm) and height (m) were measured using a diameter tape and Haglöf Vertex IV Hypsometer. Woody species diversity, structure, important value index (IVI) and regeneration analyzed using appropriate formulas. Four tree species were found in the studied woodland forest. Most abundant tree species were *Acacia seyal, Acacia etabaica* and *Balanites aegyptica*, while the least abundant tree species was: - *Acacia tortilis*. The basal area (m^2 ha^{-1}) per plot basis (20m*20m) was ranged from 1.38 to 13.62, while the basal area for the sampled trees was ranged from 2.41 to 9.25. The volume for the sampled plots and trees were ranged from 5.91 to 46.11 and 10.58 to 41.25 m^3 ha^{-1}. The highest number of stems was recorded for *Acacia seyal* followed by *Acacia etbaica*. The lowest number of stems 43 N ha^{-1} were recorded for *Acacia tortilis* followed by *Balanites aegyptica*. The overall population distribution pattern of the targeted forest exhibited an inverted J - shaped distribution. Among the four sampled woody species in Alamata dry woodland forest regeneration was recorded for only two species *Acacia etbaica* and *Balanites aegyptiaca*, while others had no regeneration potential of seedlings and saplings. Better attention of development practitioners, policy makers and church communities may help to improve the woody species composition of this woodland forest and conservation role of Ethiopian dry woodland for carbon sequestration.

Keywords: Alamata, Northern Ethiopia, abundance, woody tree species, population structure, saplings, seedlings, shrubs

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Mehari A Tesfaye
Ethiopian Forest Development, Central Ethiopia Forest Research Centre, Ethiopia

Correspondence: Mehari A Tesfaye, Ethiopian Forest Development, Central Ethiopia Forest Research Centre, Box 30708, Addis Ababa, Ethiopia, Tel +251911356756, Email meharialebachew25@gmail.com

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Introduction

Ethiopian forest is divided into 12 different major vegetation types based on altitudinal gradient by Friis. Dry land forests of Ethiopia constitute about 76 - 81 % the country (CIFOR). Forest are sources of a wide variety of products which contributes domestic and national economy. However, these resources are declining at an alarming rate due to different anthropogenic factors like forest conversion into agricultural land and other commercial purposes (e.g. timber andcharcoal production) through slash – and burn forest clearing methods Therefore, the knowledge and awareness towards diversity, structure and regeneration potential is essential to manage the resource sustainably by Monjane.

Woodland vegetation can be described as the vegetation which comprises all the structural layers of trees, shrubs and grasses by Gardiner. Woodland vegetation can be hardly differentiated from forest vegetation by their height, but woodland vegetation do not have densely interlocking crowns at all by Kindt. Woodland vegetation broadly classified into broad - leaved deciduous woodland (*Combretum - Terminalia*) and the small - leaved deciduous woodland (*Acacia - Commiphora)* vegetation. The latter is dominated by either deciduous or small sized evergreen tree species by Motuma Didita. The vegetation is distributed along the Eastern and Southern lowlands, the Rift valley and Eastern slopes of the Northern plateau between 1000 and 1600 m above sea level. The plant genera that characterize the vegetation are mainly *Acacia*, *Commiphora*, *Balanites*, *Capparis*, *Combretum* and *Terminalia spp.* By Demel Teketay.

These woodlands are important sources of energy and building materials for the rural as well as for the urban community. Woodland vegetation is a good source of non - wood forest products such natural gums, myrrh, frankincense and honey. Furthermore, woodland vegetation creates habitat for a wide range of plant and animal species. However, land degradation and deforestation 92,000 $ha^{-1}yr^{-1}$ are the two most important causes of the decline of the vegetation size and quality in the woodland area (UNDP, 2012). The woodland vegetation in dry land areas of the country are changing into other forms of land use notably into agricultural land by Bekele. On the other hand, the reductions of emission from deforestation and degradation by managing the existing forests sustainably bring financial and technical incentives from industrialized nations to developing countries through REDD+. To tap this opportunity, accurate and consistent data that meet international standards while creating favorable policy environment are the most important requirements to derive benefits from climate change funds by Moges. Forest inventories and monitoring efforts are lacking in the country eventhough, they are most useful by Feyissa and Melese outlined that Ethiopia has limited information about the carbon stocks of its forests. Information on the environmental status of existing woodlands is mandatory to manage these natural resource sustainably. But resource based information about of the actual woodland area in the country are fragmented and not out –of date by Monjane.

As described by Gardiner, (forest) vegetation can be described as community of plant species which comprises all the structural layers of trees, shrubs, lianas and herbs. Independent of whether it is a forest or a woodland, it is essential to examine these habitats in detail to get more insight into its floristic composition, structure and ecophisiological traits. Floristic study can provide brief and basic information about particular vegetation in relation to its ecological region. Diversity is measured using Shannon - Wiener Diversity and Sorenson's Similarity ratio.[2] The concept of density, frequency and dominance is very useful tool in the study of plant ecology by van der Maarel. Therefore, measuring the species importantance value (IVI) is important for management and conservation practices. Species with lower IVI need high conservation efforts whereas those with higher IVI require wise management. However, such studies have not yet done in the Alamata area. Therefore, our study aimed to conduct a basic research on the flora to evaluate compositional and structural diversity and regeneration success in Alamata woodlands.

Material and methods

Site description

Alamata district is found in Tigray Administrative region, Northern Ethiopia. A discussion forum was held with Tigray Agriculture and Natural Resources Management officials in Mekele to raise awareness and to get permission to conduct forest inventory. A reconnaissance survey was conducted for better understanding of the study site. A stratified systematic technique was applied for study site selection then a random sampling was used to establish observational sample plots 20mx20m. These plots were established along altitudinal gradients from top to bottom.

Scheme of sample plot

Fifteen squared sampled plots marked 100m apart from each other. They were laid out from the peak to the gentle slopes of the landscape using a measuring tape, GPS and compass. The boundaries of the main plots were pegged and marked, and then environmental datas were recorded. Four walking lines were used laid out from peak edge to bottom ridges. Moreover, the distance between two transect lines was 500m. Sampling and data collection were done in the aforementioned plots of the mixed natural forest and plantation. Data collection was conducted in October 2019.

Field data collection and sampling

Sampled tree species were classified into trees (height ≥ 5m, dbh ≥ 5 cm), shrubs (dbh 5 to 2.5 cm), saplings (height ≥ 1.3 m and dbh 2.5 to5.0 cm) and seedlings (height < = 30 cm DBH 10-30 cm). Bordering woody trees and shrubs were marked using red paints and numbered. Diameter was measured using tree caliper and diameter tape. Total height (in meters) was measured using Vertex III digital electronics tree height measurement instruments. In cases where trees branched at or below the breast height, the diameter was measured separately for each branch and $\sqrt{DBH12+(DBH_2)^2}$ was calculated. Diameter at each stem was measured separately for trees with multiple stems. In the case of tree individuals with buttresses, measurement was taken at the nearest lower point. Saplings and shrubs were sampled inside each main plot on 3 sub plots, 5m × 5m laid out diagonally. Height and diameter were a measurement for saplings done using marked wooden bars and metallic caliper. While seedlings were sampled in 3 subplots, 1m×1m, one at the center and 2 in the edge of the diagonal, measuring their average height using a wooden ruler.

Volume growth and yield data

Basal area (BA) ($m^2 ha^{-1}$) and volume (Vt) ($m^3 ha^{-1}$) was calculated using inventoried data. Total volume was calculated using the conventional volume equation because local volume equations were not available for these species. We used the form factor value of 0.42 for volume calculations:[3]

$$hV = \pi\left(\frac{DBH}{4}\right)2\times h\times f[24] \quad \text{eq 1}$$

Where V: tree volume, DBH: diameter at breast height, h: total height, f: form factor BA (Basal area) was calculated using the formula:

$$BA = \pi\frac{DBH2}{4} \quad \text{eq.}$$

Where BA: Basal area, DBH: Diameter at breast height, π:3.142

Data analysis

Aboveground biomass

Aboveground biomass was calculated using[4] (eq. 4). Because this equations is widely used in our case

$AGB_{est} = 0.0673(\rho HD^2)^{0.976}$…………………………………….... … eq.3

Where AGB_{est}; above ground biomass (kg), D; DBH (cm), H; height (m), and ρ ; basic wood density (g cm^{-3}). Accumulated above ground and below ground carbon density was calculated following eq.5 and eq.6.(IPCC 2006);[5–7]

$$ACD = AGB_{est} * 0.47 \text{ ------------------eq.3}$$

(IPCC 2006)------------eq.4

$$BCD = ACD * 0.24 \text{------------------eq.5}$$

Where ACD: Aboveground carbon density, BCD: below ground carbon density

The aboveground and below biomass for each tree was calculated separately in each plot, then the biomass of each tree was summed up to give plot biomass and converted into kb/ha^{-1}.

Woody species diversity and structure analysis

The Species diversity was analyzed using the Shannon diversity index (H')[8] (eq.5): Shannon - Wiener diversity index was calculated as

$$H' = -\sum_{i=1}^{s} p_i \ln p_i \quad \text{eq 6}$$

Where; H'; Shannon-Wiener index of species diversity, pi: relative proportion of individual found from the "*i*"th species.

Evenness were calculated using the following formula

$$\text{Equitability}(\text{evenness})\ J = \frac{H'}{H'_{max}} \quad \text{Eq 7}$$

Where H'max is ln (natural logarithm) of S (number of species).

Simpson's index of diversity was calculated as follows:

$$D = 1-\sum_{i=1}^{s}(pi)^2 \quad \text{eq 8}$$

Where, D; Simpson's diversity index; pi; as described in equation 1Simpson diversity index gives relatively little weight to the rare species and more weight to the most abundant species.[9] The value ranges from 0 (low diversity) to a maximum of (1-1/s), where S is the number of species. It is predominantly affected by sample size:[9]

$$\textit{Simpson or dominance index } (D) = \sum_{i=1}^{S} \frac{[(\mathrm{ni}(\mathrm{ni}-1)]}{\mathrm{N}(\mathrm{N}-1)} \quad \text{eq } 9$$

Where, n_i is the number of individuals of the "*i*"th species; N is the total number of individuals of all species. As index values increase, diversity decreases.

Importance value index (IVI)

The importance value index (IVI) was calculated to rank species contribution to the forest community composition:[8]

IVI = RD + RF + RDO ------eq.10

Where, RDO) is relative dominance, RF s relative frequency, and RA is relative abundance.

$$RD = \frac{\text{Number of individual of a Spp}}{\text{Total number of individual of Spp}} \times 100 \quad \text{eq } 11$$

$$RF = \frac{\text{Frequency of a Spp}}{\text{Frequency of all Spp}} \times 100 \quad \text{eq } 12$$

$$RDO = \frac{\text{Dominance of a Spp}}{\text{Dominance of all Spp}} \times 100 \quad \text{eq } 13$$

Regeneration

Regeneration was analyzed based on the sampled seedlings, saplings, and stems (matured individuals) ha^{-1} and categorized as (a), Good regeneration (GR) if the ratio of:- " seedlings: (b), Fair regeneration (FR): (c), Poor regeneration (PR) (d), No regeneration (NR) and (e) New (N).[10]

Results

Characterization of the studied forest patches

Diversity of trees and shrubs: Four woody species found in the sample plots (Table 1). Tree data measurements were made in total, 242 individuals were measured. The species abundance was ranged from 162 stem ha^{-1} for *Acacia seyal to* 43 stem ha^{-1} for *Acacia tortilis.* The most abundant tree species were *Acacia seyal, Acacia etabaica* and *Balanites aegyptica*, respectively. The least abundant tree species *Acacia tortilis* (Table 2). The DBH of the sampled woody species were ranged from 4.5 to 101 for *Acacia etbaica*. Total heights of the sampled trees were also ranged from 3.1 m for *Acacia tortilis* to 16.9 *Acacia etbaica* species. The diameter distribution was a slight inverted J - shaped distribution (Figure 1). Richness was ranged from one to three, while, the maximum Shannon Weiner diversity index was 1.08 and the minimum was 0.25 (Table 2). The evenness was ranged from 0.35 to 0.98 (Table 2).

Table 1 Total abundance of each Alamata Woodland forest

S. N	Species name		Abundance (N ha^{-1})
	Local name	Scientific name	
1	Bedano	*Balanites aegyptica*	112
2	Carwara	*Acacia tortilis*	43
3	Tsaeda chea	*Acacia seyal*	162
4	Siraw	*Acacia etbaica*	152

Table 2 Shannon Wiener and richness index of the sampled plots of Alamata Wood Land Forest

Plot No	Shannon-Weiner Diversity (H)	Richness	Evenness
01	0.67	2	0.97
02	0.47	2	0.68
03	0.93	3	0.85
04	1.013	3	0.92
05	0.89	3	0.81
06	0.88	3	0.80
07	0.25	2	0.35
08	0.96	3	0.87
09	0.45	2	0.65
10	0.68	2	0.98
11	0.62	2	0.89
12	0.62	2	0.89
13	0.94	3	0.85
14	1.08	3	0.98
15	0.43	3	0.39

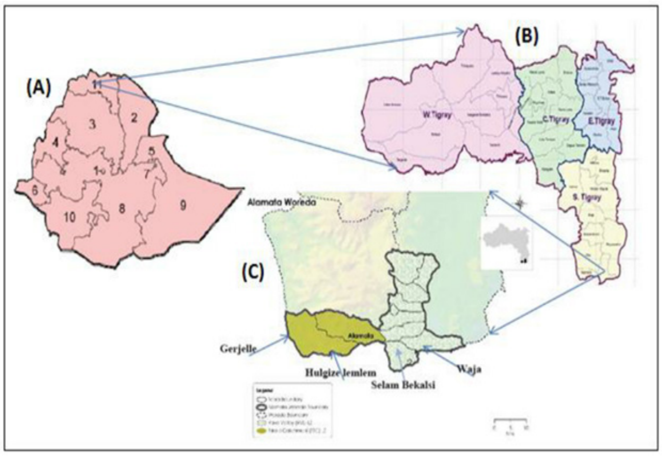

Figure 1 Location map of the study site.

Woody species structure

Growth parameters

The growth parameters and carbon pools of Alamata church forest are presented in Table 3&4. The basal area was ranged from 1.38 to 13.62 m^2 ha^{-1} per plot, while in total the sampled trees basal area was also ranged from 2.41 to 9.25 m^2 ha^{-1}. The volume was ranged from 5.91 to 46.11 m^3 ha^{-1} per plot and 10.58 to 41.25 m^3 ha^{-1} in total (Table 3&4). The number of stems for sampled plots and woody plant species were ranged from 150 to 725 and stems ha^{-1} per plot and 43 to 162 stems ha^{-1} in total. The highest number of stems was found for *Acacia seyal (*162±5.3.23) followed by *Acacia etbaica (*125±5.3.23*)*. While, the minimum number of stems were recorded for *Acacia tortilis* (43 stems ha^{-1} +5.3) followed by *Balanites aegyptica* 72±5.3.23*Acacia etbaica* produced the highest growth and biomass followed by *Balanites aegyptica*, while *Acacia seyal* followed by *Acacia tortilis* had the lowest volume and biomass respectively (Table 4).

Table 3 Stem density, Basal area, Volume growth and biomass values of the studied plots in Alamata church forest (mean)

Plot #	N (Nha^{-1})	BA	V	AGB	BGB	ACD	BCD (t C ha^{-1})
01	450±166.7	6.65±3.47	28.84±14.63	92.98±48.86	22.32±11.73	43.70±24.2	4.20±5.6
02	275±166.7	4.48±3.47	20.00±14,63	64.71±48.86	15.53±11.73	30.41±24.2	7.30±5.6
03	450±166.7	7.26±3.47	35.00±14,63	107.07±48.86	25.70±11.73	50.32±24.2	12.08±5.6
04	475±166.7	8.08±3.47	38.93±14,63	115.34±48.86	27.68±11.73	54.21±24.2	13.01±5.6
05	500±166.7	2.64±3.47	11.46±14,63	34.65±48.86	8.32±11.73	16.29±24.2	3.91±5.6
06	475±166.7	3.81±3.47	14.54±14,63	45.55±48.86	10.93±11.73	21.41±24.2	5.14±5.6
07	375±166.7	2.50±3.47	9.75±14,63	27.93±48.86	6.70±11.73	13.13±24.2	3.15±5.6
08	300±166.7	5.01±3.47	27.71±14,63	89.75±48.86	21.54±11.73	42.18±24.2	10.12±5.6
09	150±166.7	1.36±3.47	6.39±14,63	18.97±48.86	4.55±11.73	8.91±24.2	2.14±5.6
10	725±166.7	13.62±3.47	46.11±14,63	148.57±48.86	35.66±11.73	69.83±24.2	16.76±5.6
11	325±166.7	2.00±3.47	7.03±14,63	23.09±48.86	5.54±11.73	10.85±24.2	2.60±5.6
12	325±166.7	5.05±3.47	18.53±14,63	60.45±48.86	14.51±11.73	28.41±24.2	6.82±5.6
13	450±166.7	9.29±3.47	4.83±14,63	151.06±48.86	36.25±11.73	81.00±24.2	17.04±5.6
14	300±166.7	1.38±3.47	5.91±14,63	18.18±48.86	4.36±11.73	8.54±24.2	2.05±5.6
15	450±166.7	8.56±3.47	45.05±14,63	145.38±48.86	34.89±11.73	68.33±24.2	16.40±5.6

Table 4 Stem density, basal area, volume growth and biomass values of the available tree species in Alamata church forest

Local name	Scientific name	N	BA	V	AGB	BGB (t ha^{-1})	ACD (t C ha-1)	BCD (t C ha^{-1})
Bedano	*Balanites aegyptica*	72±5.3.23	4.06±3.05	18.75±14.29	16.67±13.94	4.00±3.35	7.84±6.55	1.88±1,57
Carwara	*Acacia tortilis*	43±5.3.23	2.41±3.05	11.53±14.29	11.23±13.94	2.69±3.35	5.28±6.55	1.27±1.57
Tsaeda chea	*Acacia seyal*	162±5.3.23	3.47±3.05	10.58±14.29	8.95±13.94	2.15±3.35	4.21±6.55	1.01±1.57
Siraw	*Acacia etbaica*	125±5.3.23	9.25±3.05	41.25±14.29	39.40±13.94	9.46±3.35	18.52±6.55	4.44±1.57

Species structure of Alamata woodland forest

The full range of relative frequency was between 10.53 to 34.21 % in Alamata Woodlands. *Balanites aegyptica* and *Acacia seyal* had the highest total relative frequency which accounted about 65.79 % of the overall frequency (Table 5). The relative density was ranged from 10.83 % (*Acacia tortilis)* to 40 % (*Acacia seyal*). The relative dominance was ranged from 13.08 % (*Acacia tortilis*) to 50.04 % (*Acacia etbaica)*. The IVI was ranged from 34.44 (*Acacia tortilis*) to 104.97 (*Acacia etbaica)*. *Acacia etbaica, Acacia seyal* and *Balanites aegyptica* were most important tree. *Acacia tortilis* had the lowest IVI species. The most dominant tree in the Alamata wood were *Acacia etbaica, Acacia seyal* (Table 5).

Table 5 RF, RD, RDO and IVI for Alamata woodland forest

S.N	Local name	Scientific name	RF (%)	RD (%)	RD (%)	IVI
1	Bedano	*Balanites aegyptica*	31.58±10.64	17.92±13.10	22.00±17.13	71.50±30.30
2	Carwara	*Acacia tortilis*	10.53±10.64	10.83±13.10	13.08±17.13	34.44±30.30
3	Tsaeda chea	*Acacia seyal*	34.21±10.64	40±13.10	14.88±17.13	89.09±30.30
4	Siraw	*Acacia etbaica*	23.68±10.64	31.25±13.10	50.04±17.13	104.97±30.30
	Overall total		100	100	100	300

Diameter distribution of most common tree species

The majority of the stems were belonged in the lower diameter class in the Alamata woodland forest. As a result, the overall diameter distribution followed an inverted J - shaped pattern (Figure 1). The diameter distribution of the tree species are presented in Figures 2–7.

Regeneration status

Based on the results the regeneration of Alamata woodland forest was poor and most of the species did not have young individuals which could have ensured a successful regeneration. Among the four so that means they were more tree species but field samplings did not find them due to wrong study design available woody species in Alamata dry woodland forest regeneration was recorded for only two species *Acacia etbaica* and *Balanites aegyptiaca*. Even the regeneration status of these two species was poor and other species can out compete them *Acacia seyal* and *Acacia tortilis* had no recorded seedlings and saplings, therefore their regeneration cannot be ensured.

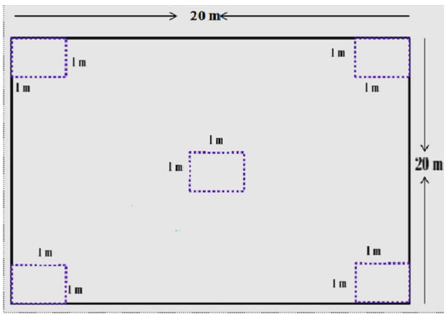

Figure 2 Design of main plot and sub-plots for sampling of carbon pool.

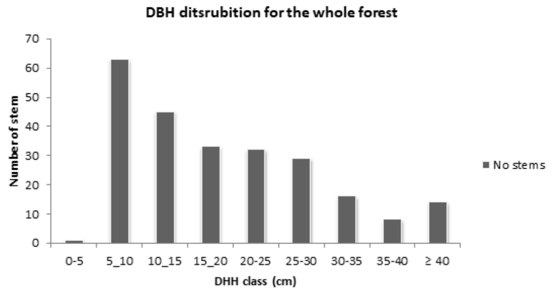

Figure 3 DBH distribution of the whole forest.

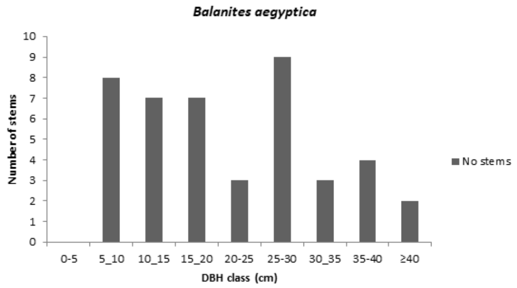

Figure 4 DBH distribution for *Balanites aegyptica*.

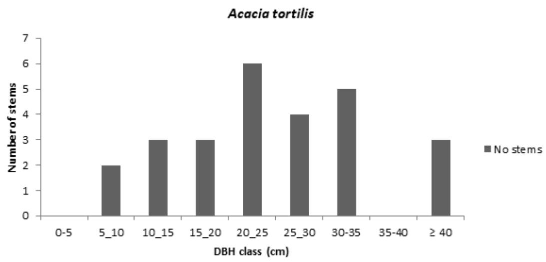

Figure 5 DBH distribution for *Acacia tortilis*.

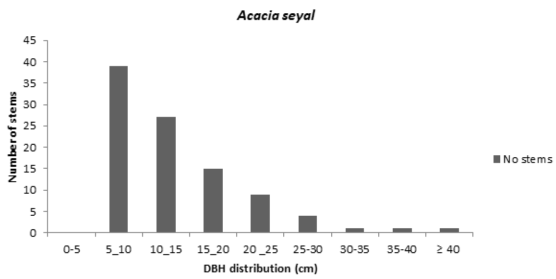

Figure 6 DBH distribution for *Acacia seyal*.

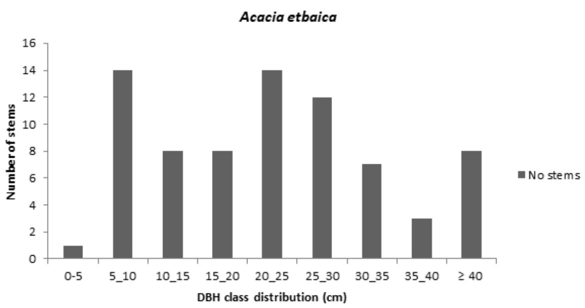

Figure 7 DBH distribution for *Acacia etbaica*.

Discussion

Four tree species was less than Humera woodland forest reported by Adamu et al. (2012) (87 vascular plants spp), Sire Beggo woodland forest, reported by Abyot Dibaba et al.,[11] (185 plant species), Ilu Geland District of woodland vegetation reported by Zerihun Tadesse[12] (213 species) and Nechisar national park forest (208 plant Spp).[13]

Acacia etbaica, Acacia seyal and *Balanites aegyptica* are the most dominant tree species. In contrast, *Acacia tortilis* was rare Spp.. The Spp dominance and abundance were also varied among plots and species. This might be due to variation in altitudinal gradient and aspect, which affects rainfall condition and disturbance. Density and thickess of Alamata woodland less than Humera woodlandt reported by Haile Adamu et al.,[14] Sire Beggo woodland forest, reported by Abyot Dibaba et al.,[11] Ilu Geland District of woodland vegetation reported by Zerihun Tadesse[12] and Nechisar national park forest (208 plant Spp, Shimelse et al. 2010). The Shannon diversity index of this study is 0.5 to 1.97 in line with 1.5 to 3.5 recommended by[2] but lower than other evergreen forest.[15] Achera forest (H' was 3.37).[16]

The diameter distribution of Alamata woodland forest was inverted J shaped distribution. This is might be due to more stems. The contribution of each tree and or shrub species is also varied among the size of the trees. The DBH distribution of Alamata woodland forest is J shaped which is in line with Tara Gedam dry afromontane forest,[17] Kumli forest,[18] forest of North East India.[19,20]

The regeneration potential of the Alamata woodland forest was very poor and for only for two species regeneration was recorded. This is might be due to differences in species adaptability and disturbance level. For others no regeneration was recorded, so these Spp either they produce non - viable seeds or there might be some problems of regeneration. Thus further investigation should be made in these regards. This implies the need for practicability of forest management regimes in the area in order to promote healthy regeneration. The lack of sapling individuals as compared to seedlings implying the death of most of seedlings before reaching sapling stage due to human intervention, browsers, grazers and nature of the seeds. Uriarte et al.,[21] reported seedling recruitment of many Spp of trees. It is one of the most important factor in determine the local abundance of adult trees and this calls for urgent conservation strategy.[22–44]

Conclusion and recommendations

Alemata woodland forest is located Tigary Region. The most dominant tree were: - *Acacia etbaica, Acacia seyal* and *Balanites aegyptica*. The diversity, structure and regeneration were significantly varied among. This has an inverted-J-shape diamater distribution, irregular shaped and bell shaped distribution. Volume and number of stems Alamata woodland forest was also lower than other woodland forest. Among the studied woody plant species 2 species had regeneration and 2 had no regeneration and 1 species had new regeneration. Sustainable forest management practices should be applied to increase productivity and yield of the targeted species. Efforts should be made to enhance regeneration status. Moreover research should be made on seedling establishment, soil seed bank and regeneration status should be enhanced.

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None.

Conflicts of interest

Authors declare that there is no conflict of interest.

References

1. MELCA Mahiber. Rapid Assessment of Biofuels Development Status in Ethiopia and Proceedings of the National Workshop on Environmental Impact Assessment and Biofuels. 2008.
2. Kent M, Coker P. *Vegetation description and analysis. A practical approach*, John Wiley and Sons, New York; 1992. 363 p.
3. Atta–Boateng J, Moser JR. A method for classifying commercial tree species of an un–even–aged mixed species tropical forest growth and yield model construction. *Forest Ecology and Manage*. 1998;104:89-99.
4. Chave J, Réjou–Méchain M, Búrquez A, et al. Improved allometric models to estimate the above–ground biomass of tropical trees. *Global Change Biology.* 2014;3177–3190.
5. IPCC. Guidelines for national green gas inventories, Chapter 4, forest land. 2006.
6. Gibbs HK, Brown S, Niles JO, et al. Monitoring and estimating tropical forest carbon stocks: Making REDD$^+$ a reality. *Environmental Research Letters.* 2007;2:045023.
7. Ponce–Hernandez R. Assessing carbon stocks and modeling win–win scenarios of arbon sequestration through land–use changes. FAO, UN, Rome; 2004.
8. Magurran AE. Ecological diversity and its measurement. Chapman and Hall, London; 1988.
9. Tolera M. Woody Species Diversity of Agricultural Landscapes in Arsi Negele District. MSc Thesis. Hawassa University, WGCF and NR, Ethiopia; 2006. 82 p.
10. Mwavu EN, Witkowski TF. Population structure and regeneration of multiple–use tree species in a semi–deciduous African tropical rainforest: 71 implications for primate conservation. *Forest Ecology and Management*. 2009;258:840–849.
11. Abyot Dibaba, Teshome Soromess, Ensermu Kelbess, et al. Diversity, structure and regeneration status of the woodland/reverine vegetation of Sire Beggo in Gololcha district, Eastern Ethiopia; 2014.
12. Zerihun Tadesse Gemeda. Floristic composition and structural analysis of woodland vegetation in Ilu Gelan District, West Shewa Zone of Oromiya Region, Central Ethiopia. MSc Thesis, AAU, Ethiopia; 2015.
13. Shimelse S, Bekele T, Mengistu A. Floristic Diversity and Structure of Nechisar National Park, Ethiopia. *Journal of the Drylands*. 2010;3(1):165–180.
14. Haile Adamu Wale, Tamirat Bekele, Gemedo Dalle. Floristic composition, regeneration status and vegetation structure of woodlands in Metema Area, Amhara regional state, North Western Ethiopia. *Journal of Forestry Research*. 2012.
15. Lalfakawma Sahoo UK, Roy S, Vanlalhriatpuia K, et al. Community composition and tree population structure in undisturbed and disturbed tropical semi–evergreen forest stands of North– East India. *Applied Ecology and Environmental Research*. 2009;7:303–318.
16. Getaneh H, Seid A. Floristic composition, structure and regeneration status of Achera Natural forest in Chilega district, Northwest Ethiopia, Ethiopian. *J Biol Sci.* 2015;14(2):217–231.
17. Haileab Z, Demel T, Ensermu K. Diversity and regeneration status of woody species in Tara Gedam and Abebaye forests, North–western Ethiopia. *Journal of Forestry*. 2011.
18. Woldemariam G, Demissew S, Asfaw Z. Woody species composition, diversity and structure of Komuli dry afromontane forest in Yem district, Southern Ethiopia. *Journal of Environment and Earth Sciences*. 2016;6(3):2224–3216.
19. Mishra BP, Tripathi OP, Laloo RC. Community characteristics of a climax subtropical humid forest of Meghalaya and population structure of ten important tree species. *Tropical Ecology*. 2005;46:241–251.
20. Tynsong H, Tiwari BK. Diversity and population characteristics of woody species in natural forests and arecanut agroforests of south Meghalaya, Northeast India. *Tropical Ecology.* 2011;52:243–252.
21. Uriarte M, Canham CD, Thompson J, et al. Seedling recruitment in a hurricane–driven tropical forest: Light limitation, density dependence and the spatial distribution of parent trees. *J Ecol.* 2005;93:291–304.
22. Aliyi K, Hundera K, Dalle G. Floristic Composition, Vegetation Structure and Regeneration Status of Kimphe Lafa Natural Forest, Oromia Regional State, West Arsi, Ethiopia. *Research and Reviews: Journal of Life Sciences*. 2015;5(1):19–32.
23. Ayalew A, Bekele T, Demissew S. The undifferentiated afromontane forest of Denkoro Forest in the Central Highland of Ethiopia: A floristic and Structural Analysis. *Ethiopian Journal of Science*. 2006;29(1):45–56.
24. Bogale T, Datiko D, Belachew S. Floristic composition and community analysis of Berbera Forest, Bale zone, South East Ethiopia. *J Agriculture, Forestry and Fisheries*. 2017;6(6);206–213.
25. Bongers F, Tenngkeit T. Degraded Forests in Eastern Africa: Introduction. In: Bongers F, Tenningkeit T, editors. Degraded forests in Eastern Africa: Management and Restoration. Earths can Ltd., London, UK; 2010. p. 1–18.
26. Devi LS, Yadava PS. Floristic diversity assessment and vegetation analysis of tropical semi evergreen forest of Manipur, North East India. Tropical Ecology. 2006;47:89–98.
27. Erenso F, Mary M, Abebe W. Floristic composition, diversity and vegetation structure of woody plant communities in Boda dry evergreen montane forest, West Showa, Ethiopia. *International Journal of Biodiversity and Conserve*. 2014;6(5):382–391.
28. Hassen N. Carbon stock along altitudinal gradient in Gera Moist Evergreen Afromontane forest, South Western Ethiopia, MSc Thesis, AAU, Addis Ababa, Ethiopia; 2015.
29. Hundera K, Bekele T, Kelbessa E. Floristic and phytogeographic synopsis of a dry afromontane coniferous forest in Bale Mountains, Ethiopia: Implication to Biodiversity Conservation. *SINET: Ethiopian Journal of Science.* 2007;30:1–12.
30. Kelbessa E, Soromessa T. Interfaces of regeneration, structure, diversity and uses of some plant species in Bonga Forest: A reservoir for wild coffee gene pool. *SINET: Ethiopian Journal of Science.* 2008;31(2):121–134.
31. Khan ML, Rai JPN, Tripathi RS. Population structure of some tree species in disturbed and protected sub–tropical forests of North–East India. *Acta Oecologica–OecologiaApplicata*. 1987;8:247–255.
32. Köhl M, Magnussen SS, Marchetti M. Sampling methods, Remote sensing and GIS multi resource forest inventory. Springer–Verlag, Berlin Heidelberg, Germany; 2006.
33. Lamprecht H. Silviculture in the tropics. Tropical forest ecosystems and their tree species–possibilities and methods for their long term utilization. Technical Cooperation–Federal Republic of Germany. Eschborn; 1989.
34. Moges Y, Eshetu Z, Nune S. Ethiopian forest resources: Current status and future management options in view of access to carbon finances. Ethiopian Climate Research and Networking Report, UNDP, Addis Ababa, Ethiopia; 2010.
35. Parthasarathy N, Karthikeyan R. Plant biodiversity inventory and conservation of two tropical dry evergreen forests on the Coromandel Coast, south India. *Biodiversity and Conservation*. 1997;6:1063–1083.
36. Rasingam L, Parathasarathy N. Tree species diversity and population structure across major forest formations and disturbance categories in Little Andaman Island, India. *Tropical Ecology*. 2009;50:89–102.
37. Sahu SC, Dhal NK, Mohanty RC. Tree species diversity, distribution and population structure tropical dry deciduous forest of Malyagiri Hill Ranges, Eastern Ghats, India. *Tropical Ecology*. 2012;52:163–168.

38. Saxena AK, Singh JS. Tree population structure of certain Himalayan forest associations and implications concerning their future composition. *Vegetatio*. 1984;58:61–69.

39. Shumi G. The structure and regeneration status of tree and shrub species of Chilimo forest–Ecological sustainability indicators for participatory forest management (PFM) in Oromiya, Ethiopia. MSc Thesis, University of Dresden, Germany; 2009.

40. Tesfaye AM. Forest management options for carbon stock and soil rehabilitation in Chilimo dry afro–montane forest, Ethiopia. PhD Thesis, INIA–Palencia, University of Valladolid, Palencia, Spain; 2015.

41. Tesfaye MA, Bravo F, Ruiz Peinado R, et al. Impact of changes in land use, species and elevation on soil organic carbon and total nitrogen in Ethiopia Central Highlands. 2016.

42. Tesfaye MA, Oliver Gardi, Tesfaye Bekele, et al. Temporal variation of ecosystem carbon pools along altitudinal gradient and slope: The case of Chilimo dry afromontane natural forest, Central Highlands of Ethiopia. *International Journal of Ecology and Environment.* 2019.

43. Woldemariam TG. Diversity of woody plants and avifauna in a dry Afromontane forest: On the Central plateau of Ethiopia. MSc Thesis, Swedish University of Agricultural Sciences, Skinnskatteberg, Sweden; 1998.

44. Yineger H, Kelbessa E, Bekele T, et al. Floristic Composition and Structure of the Dry Afromontane Forest at Bale Mountains National Park, Ethiopia. *Ethiopian Journal of Science*. 2008;31(2):103–120.

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