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Diversity, disturbances and endemism of plants in Dens Natural Forest of *Ankober* District, Ethiopia

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Abstract

The population pressure on the vegetation of Ethiopia is not only declining the diversity, but also decreasing the endemism and forest resources by degrading land and causing the invasion of alien species. The current study was carried out to assess the diversity, endemism, and threats of Dens natural forest, which covers a total of 107 hectares. A total of 65 (20m x 20m) quadrats were laid in seven-line transects thrown from the edge of the forest using the systematic sampling method for trees and shrubs, and 325 sub-plots (1m x 1m) for herbaceous species were established at the four corners and at the center of the main quadrat. Among the five communities identified, community type 3 (*Croton macrostachyus* - *Maytenus arbutifolia*) had the highest species richness (89 species), diversity (H'=3.85) and species evenness (J=0.856). Community type 5 (*Bersama abyssinica* - *Allophylus abyssinicus*) had the least species richness (75 species), but its species diversity (H' = 3.58) was higher than community type 2 (*Podocarpus falcatus* - *Croton macrostachyus*) (H' = 3.54) because of higher equitability. Among the 129 plant species of Dens Forest, 10 plant species (7.8%) were identified as endemic to Ethiopia. Firewood collection (22.5%), collection of woods for house construction (21.8%) and farm instrument preparation (21.1%) were severe anthropogenic activities in the forest. Even though the endemism in Dens natural forest is lower, the diversity of Dens forest is the highest when compared with other forests.

Keywords: Dens Forest, Diversity, Endemism, Threats

Introduction

Vegetation is a collection of plants growing together in a particular area, which is comprised of many plants or plant communities with distinguishable characteristics that occupy an area (Jennings et al., 2003). It shows a definite association or affinity with each other (Werren and Arthington, 2002), has a high degree of spatial variability and a dynamic nature because of

changes in ecological processes, climatic change, human land use, and the interaction between them (Negusse, 2006), but it maintains itself with regularity over a given region (Christopher et al., 2004)

The vegetation of the mountainous landscapes of Ethiopia was characterized by the highest woody plant species diversity (Wondie and Temesgen, 2013). However, it is highly degraded and fragmented due to population pressure that increases agricultural investment, re-settlement schemes, charcoal production, livestock grazing, and the expansion of very aggressive invasive alien species (Wondie and Temesgen, 2013); and environmental problems such as: soil degradation and erosion (Kitessa and Tsegaye, 2008). These threats not only declined plant diversity, but also the potential natural resources of forests and indigenous knowledge on medicinal and other useful plants (Kitessa and Tsegaye, 2008).

The vegetation cover is used to maintain biodiversity and balance the ecosystem, which is the "lung" of the environment (Birhanu et al., 2014; Dereje, 2014; Mekbib, 2012), and provides information on the underlying environmental and anthropogenic drivers of species distribution (Christopher et al., 2004). The diversity of species in given vegetation is used to interpret the relative variation between and within the community and help explain the underlying threats for such a difference in vegetation (Gojjam, 2013).

Habitat loss and environmental pollution are currently the major causes of the worldwide decline of biodiversity. Particularly, habitat fragmentation, conversion, and overexploitation are the leading drivers of population decline and species extinctions in tropical hotspots (Esteban et al., 2019). Currently, human-induced impacts are severely threatening the country's diversity and also the consequences of those effects, which have not been completely studied in a specific area of vegetation. Besides, the country's vegetation still needs detailed scientific proof on the ecological processes of specific vegetation structures and its diversity for conservation and management. Our study creates an opportunity for ecologists and conservation biologists and also provides the complicated ecological process dynamics needed to take effective conservation actions. In the current study area, there is a knowledge gap about the structure, composition, and regeneration of Dens forest due to the absence of a previous study. Therefore, the objective of this study was to assess the diversity, endemism, and threats of Dens natural forest in order to come up with solutions for conservation and management actions in Dens natural forest.

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Materials and methods

Description of study area

The study was conducted in Dens Natural Forest, found in Ankober District, North Shewa Zone, Amhara National Regional State. Ankober District is found on the eastern highlands of Ethiopia, 172km from northern Addis Ababa and situated at 9° 22’ - 9°45’ N and 039° 40’ - 039° 53’ E. The district is bordered in the north by Tarmaber, in the south by Asagirt and in the west by Basonaworana District of the Amhara Region (Ermias et al., 2013 and 2014). Dens Natural Forest is located 11km from Gorebela town, which is the capital town, towards the northeast and is bordered by three kebeles namely: Eimemirete in the northeast, Mahale Wonze in the southwest, and Zego in the southeast direction of the forest (Figure 1).

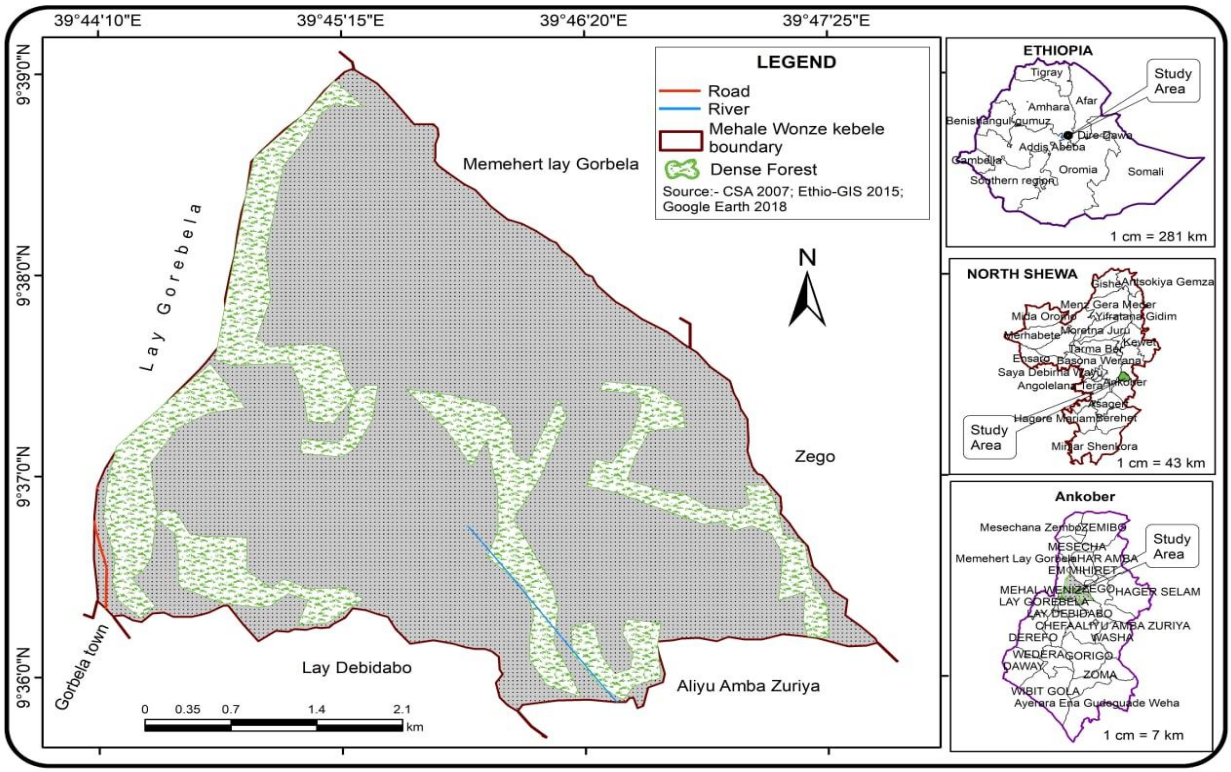

Figure 1. Map of study area

Sampling method

A preliminary survey was made in September 2020 in order to get an overview of the vegetation and topographic features of the study area. The current study was carried out from October 2020 to November 2021 in Dens natural forest, which has a total area of 107 hectares. A total of 65

main sampling plots were laid along the altitudinal gradient in seven-line transects thrown from the edge of the forest using the systematic sampling method. A total of 65 plots of size 20m x 20m for trees and shrubs and 325 subplots (1mx1m) for herbaceous species were established at the four corners and the center of the main quadrat. Quadrats were laid at every 100m horizontal distance along transect lines thrown using the systematic sampling method, which were 200m apart from each other.

Data collection

All trees, shrubs, and herbs were recorded in the established quadrats along each transect. Plant species occurring outside quadrats but inside the forest were also recorded to provide a complete list of species in the forest. The vernacular names of species were recorded during fieldwork; voucher specimens were coded, pressed, and dried for identification at the National Herbarium of Addis Ababa University (ETH) and the nomenclature of the species followed the published volumes of the Flora of Ethiopia and Eritrea (FEE).

Anthropogenic activities were recorded by observing the stumps, charcoal production sites, grazers, and breakout twigs to identify threats to the forest, and semi-structured interview questionnaires were developed to get the purposes of anthropogenic activities. A total of 10 key informants living around the forest who are not getting benefits from the forest were selected using purposive sampling methods. These key informants were individuals who had lived for more than 10 years in the area and were assumed to have adequate knowledge on threats to the forest. In the preferential ranking of the threats, the identified threats were ranked as follows: 4 for severe, 3 for slightly severe, 2 for intermediate, and 1 for rare.

Data analysis

Plant communities were identified by hierarchical cluster analysis (HCA) using R software based on the mean cover abundance of each species in a given quadrat, estimated, and finally converted to the Brown blanket scale (1–9). The naming of plant communities was carried out after the identification of two or three species with the highest mean cover abundance value in each cluster (Markos, 2016). The R software program, which determines the optimal number of clusters, was used to determine the number of plant community types. Ward's method and Euclidean distance were used to draw the dendrogram, showing dissimilarity among the communities at 0.5 intervals.

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Shannon diversity index (Kent and Coker, 1992) of the plant communities was computed using the number of individuals of each species by the following formula:

$H' = -\sum_{i=1}^{s} Pi \ln Pi$ Where: H' = = Shannon - Wiener diversity index, s = the number of species,Pi = the proportion of individuals abundance of the ith species, ln =log basee

The evenness index was calculated using the formula:

$J = \frac{H'}{H \max} = \frac{-\sum_{i=1}^{s} Pi \ln Pi}{\ln s}$ Where, J = evenness, H' = Shannon Wiener Diversity Index, S= total number of species in the sample, ln= natural logarithms.

The similarity of Dens forest with other forests having similar ecology is computed using the formula: Ss=2a/(2a+b+c); Where Ss is Sorensen's similarity coefficient, "a" is the number of species common to both samples, "b" is the number of species in sample 1 and "c" is the number of species in sample 2.

The data from the interview were analyzed using the preferential rank of the threats to identify the most sever factor that affects both the diversity and regeneration status of the forest.

Result and discussion

Floristic composition and growth forms

A total of 129 plant species belonging to 115 genera, representing 64 families, were described from Dens forest. Out of these, 17 species (13.18%) are trees, 14 species (10.85%) are trees or shrubs, 36 species (27.91%) are shrubs, 48 species (37.21%) are herbs, 9 species (6.98%) are climbers, and 5 species (3.88%) are grasses. The current finding indicated that herbs and shrubs were found to be more dominant than trees, climbers, and grasses (Figure 2).

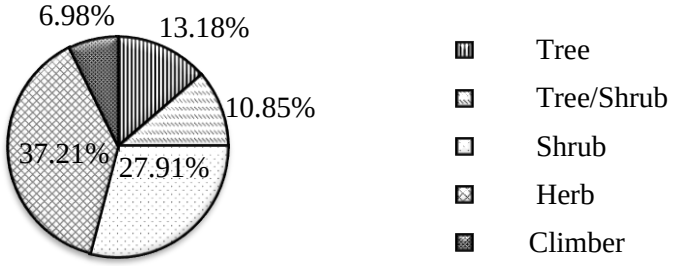

Figure 2. Growth form of plant species

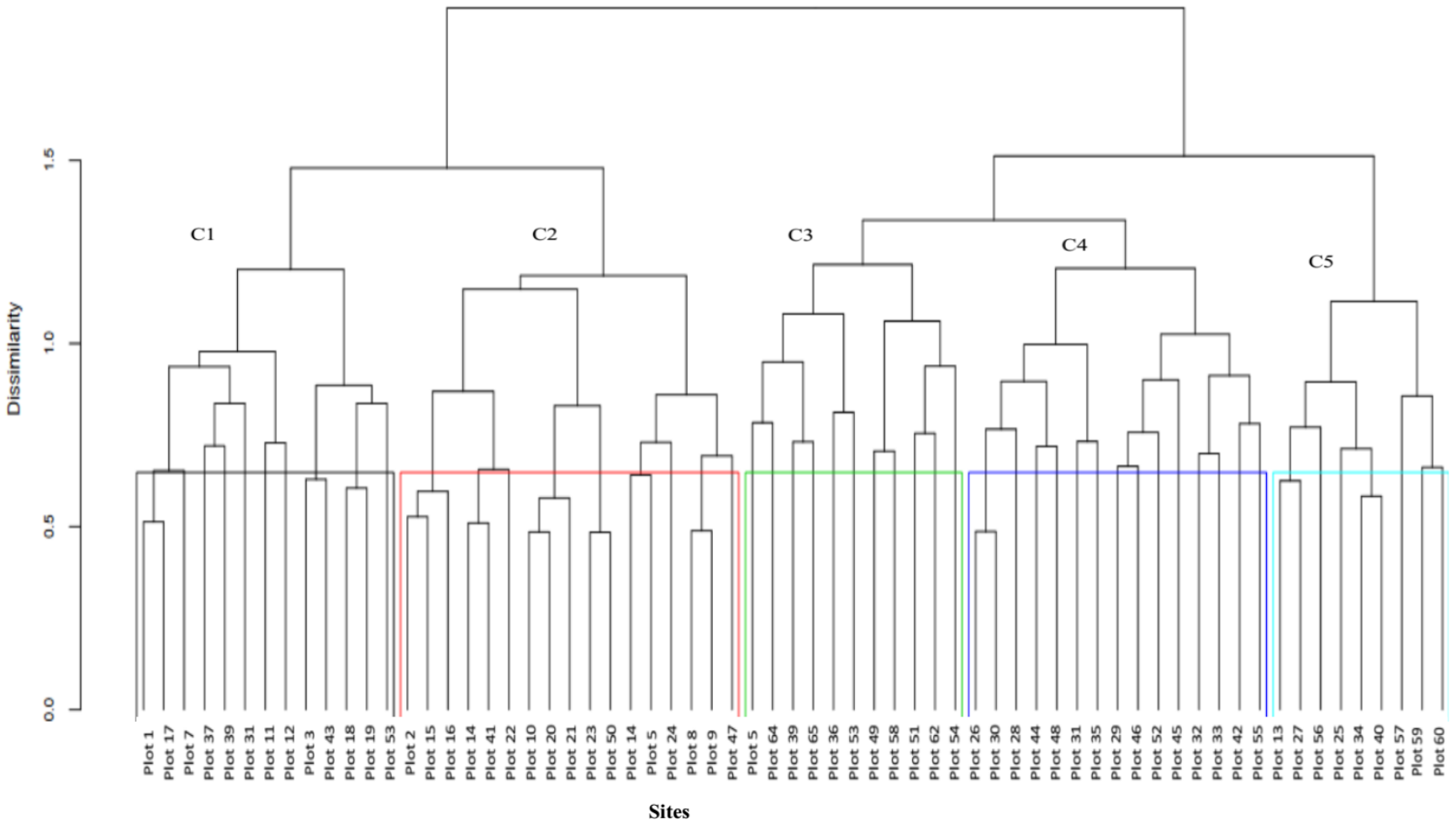

Figure 3: Dendrogram of community types of Dens Forest

Community types

Identification of the communities in the forest is not only crucial to compute their diversity, similarity, and even distribution of species, but also important for separate management and conservation by giving priority to those with lower species richness, lower evenness, and lower diversity. The hierarchical cluster analysis identified five plant communities C1=community one; C2= community two; C3= community three; C4= community four; and C5= community five) in the Dens forest (Figure 3).

***C1: Bersama abyssinica - Clutia abyssinica* community type**

This community includes 13(20%) quadrats and 87 species, which are distributed over an altitudinal range of 2192-2854 m asl. The tree species of this community were *Bersama abyssinica, Croton macrostachyus* and *Rhus glutinosa*. The shrub species in this community is *Clutia abyssinica* and the representative herb species include *Tapinanthus globiferus* and *Hypoestes forskaolii* (Table1).

***C2: Podocarpus falcatus - Croton macrostachyus* community type**

This community is distributed in altitudinal ranges between 2297 and 2505 m asl. It is represented by 17(26.2%) quadrats consisting of 77 species. *Podocarpus falcatus* and *Croton macrostachyus* were the most dominant tree species in this community. But *Ekebergia capensis*, *Maytenus arbutifolia*, *Vernonia auriculifera, Celtis africana, Ficus sur* and *Olea europaea* sub-spp. cuspidate from tree species, *Clutia abyssinica, Discopodium penninervum* from shrubs species and *Pteris pteridioides*, and *Hypoestes forskaolii* from herb species also contributed to the composition of this community type (Table 1).

***C3: Croton macrostachyus - Maytenus arbutifolia* community type**

This community type consists of 11(16.9%) quadrats and 89 species, with *Croton macrostachyus* and *Maytenus arbutifolia* as the most dominant tree species. This community type is distributed in plots with altitudinal ranges between 2198 and 2954 m asl. Besides, *Podocarpus falcatus*, *Maesa lanceolata,* and *Rhus glutinosa* from tree species; *Myrsine africana, Calpurnia aurea, Lippia adoensis,* and *Debregeasia saeneb* from herbs; and *Pteris pteridioides* and *Hypoestes forskaolii* from herbs also contributed to the composition of this community type (Table 1).

***C4: Podocarpus falcatus - Allophylus abyssinicus* community type**

There are 15(23.1%) quadrats consisting of 87 species in this community type, which is distributed over an altitudinal range of 2297-2566 m asl. *Podocarpus falcatus* and *Allophylus*

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abyssinicus were the most dominant tree species in the community. Besides, this community was also composed of *Maytenus arbutifolia, Olinia rochetiana* and *Croton macrostachyus* from tree species, and *Pteris pteridioides* and *Hypoestes forskaolii* from herbs, following the dominant species (Table 1).

***C5: Bersama abyssinica - Allophylus abyssinicus* community type**

There were 9(13.9%) quadrats and 75 species composed by this community type an altitudinal range of 2217-2630 m asl. The most dominant species of this community were *Bersama abyssinica* and *Allophylus abyssinicus.* Following the most dominant species, *Halleria lucida, Ekebergia capensis, and Croton macrostachyus* from trees; *Carissa spinarum, Clutia abyssinica, Urera hypselodendron, Dovyalis abyssinica,* and *Rosa abyssinia* from shrubs, and *Pteris pteridioides* and *Hypoestes forskaolii* from herbs contributed a lot to the composition of this community (Table1).

Table 1. Distribution of quadrats in five plant communities with their altitudinal ranges

Community	Altitude (masl)	Number of plots	Lists of plots	No. of species	Percent
I	2192-2854	13	1,17,7,37,38,61,11,12,3,43,18,19,63	87	20.96
II	2297-2505	17	2,15,16,14,41,22,10,20,21,23,50,4,6,24,8,9,47	77	18.55
III	2198-2954	11	5,64,39,65,36,53,49,58,51,62,54	89	21.45
IV	2297-2566	15	26,30,28,44,48,31,35,29,46,52,45,32,33,42,55	87	20.96
V	2217-2630	9	13,27, 56,25,34,40,57,59,60	75	18.07

Species richness and diversity in communities

Community type 3 has the highest species richness (89 species), diversity (H'=3.85) and species evenness (J=0.856). Community types 1 and 4 were the second and equally rich in communities (87 species), but the diversity of species was better in community 1(H' = 3.63) than community type 4 (H' = 0.767) due to the higher equitability of species. Community type 5 has the least species richness (75 species), but it is second in species equitability (J = 0.828) and third in species diversity (H' = 3.58). The species richness in community 5 was found to be small (75 species), even compared with community 2 (77 species), but its species diversity (H' = 3.58) is higher than community 2 (H' = 3.54) because of higher equity (0.828 > 0.814) (Table 2).

Table 2. Species richness and diversity comparison among communities

Community Type	Richness	Simpson's Index	Shannon's Diversity(H')	Evenness(J)
1	87	0.047	3.63	0.812
2	77	0.057	3.54	0.814
3	89	0.031	3.85	0.856
4	87	0.055	3.43	0.767
5	75	0.042	3.58	0.828
Dens Forest	129	0.036	3.96	0.815

Comparison of diversity

Dens Natural Forest was the most species-rich forest (129 species), and it was followed by Yegof (123 species), Menagesha Suba (112 species), Munessa (61 species), and Weiramba (32 species). Even though the equitability of Dens forest (J=0.82) is less than Menagesha's Suba forest (J=0.92), Shannon's diversity is higher in Dens natural forest (H'=3.96) than Menagesha's Suba forest (H'=2.57). In this case, the diversity in both forests is based on the richness of the species, but in forests like Munessa and Weiramba the diversity is based on the even distribution of species (Table3). This confirms that the diversity in the forest depends not only on the even distribution, but also on the richness of the species.

Table 3. Comparison of diversity of Dens Forest with other forests having relatively similar altitude in Ethiopia

Forest	Richness	Diversity(H')	Evenness(J)	Source
Menagesha Suba	112	2.57	0.92	Dinkissa (2011)
Yegof	123	3.73	0.79	Sultan and Berhanu (2013)
Weiramba	32	2.3	0.66	Zelalem *et al*. (2018)
Munessa	61	2.6	0.39	Annissa and Eyasu (2020)
Dens	129	3.96	0.82	The current study

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Comparison of similarity

Sorenson's similarity of species of Dens Forest was 44% with Zerat Forest, 40% with Yegof Forest, 37% with Chilimo Forest, and 12% with Bale Mountain Forest. The similarity of the Dens forest with the Zerat, Chilimo and Yegof forests was due to the relative similarity of the Dens forest altitude (2192- 2954 m asl) and may also be due to the similarity of their conservation status and ecology (Table 4). Because of the variation in altitude, Bale Mountain forest species' similarity with Dens forest species was very small (12%). This indicated that the species growing in the lowlands of Dens Forest could not grow in the highlands of Bale Mountain due to variations in altitude.

Table 4. Similarity comparison of Dens Forest with other forests in Ethiopia

Forest	Altitude	a	b	c	Sc%	Source
Chilimo	2170-3054	64	65	149	37	Teshome and Ensermu (2014)
Zerat	2350-2620	63	66	93	44	Dagne and Tamru (2016)
Bale	3010-3410	22	107	208	12	Haile (2008)
Yegof	2000-3014	50	79	73	40	Sultan and Berhanu (2013)

Where; a = Species common to Dens Forest and the forest in comparison, b = Species unique to Dens Forest, c = Species found only in the Forest in comparison with Dens Forest, and Sc = Similarity coefficient.

Endemism in Dens Forest

Among 129 plant species from the Dens forest, 10 plant species (7.8%) were identified as endemic to Ethiopia. Among the endemic species in Dens Forest, the most dominant endemic species was *Laggera tomentosa* (34.05%), followed by Festuca macrophylla (27.8%). The remaining eight (*Urtica simensis*, *Mikaniopsis clematoides*, *Kniphofia foliosa*, *Inula confertiflora*, *Kalanchoe petitiana*, *Solanum marginatum*, *Vernonia leopoldi*, and *Lobelia rhynchopetalum*) species contributed 38.15% of the endemism of the forest. Studies confirmed that Masha Forest contributes 7 endemic species (Abreham, 2009), Chato Forest 12 endemic species (Feyera, 2010), Menagesha Amba Mariam Forest 16 endemic species (Abiyou et al., 2011), Chilimo Forest 17 endemic species (Teshome and Ensermu, 2014), Komto Forest 18 endemic species (Fikadu et al., 2013) and Dens Forest contributed 10 endemic plant species

(Table 5). Therefore, the endemism of plant species in Dens forest is better than that in Masha forest but less than that of the others. This could be due to the conservation, management, and ecological differences between the areas.

Table 5. Endemic plant species of Dens forest

Scientific Name	Family	Number of individuals	Percent
Laggera tomentosa	Asteraceae	207	34.05
Festuca macrophylla	Poaceae	169	27.80
Urtica simensis	Urticaceae	60	9.87
Mikaniopsis clematoides	Asteraceae	44	7.24
Kniphofia foliosa	Asphodelaceae	42	6.91
Inula confertiflora	Asteraceae	34	5.59
Kalanchoe petitiana	Crassulaceae	34	5.59
Solanum marginatum	Solanaceae	11	1.81
Vernonia leopoldi	Asteraceae	5	0.82
Lobelia rhynchopetalum	Lobeliaceae	2	0.33

Threats to the forest

In Dens Forest, seven anthropogenic activities were observed as threats based on the observations carried out during data collection. The preferential ranking indicated that firewood collection (22.5%) was the most severe activity that disturbs the forest and was followed by collection of wood for house construction (21.8%) and farm instrument preparation (21.1%). The remaining disturbances (charcoal preparation, furniture work, and medicinal plant collection) contributed 34.6% of the disturbance for the forest of Dens (Table 6). The informants and observers identified the most important plant species that were under threat due to anthropogenic activities, including *Juniperus procera*, *Teclea nobilis* and *Hagenia abyssinica* in Dens Forest. The finding confirmed that anthropogenic activities (cattle grazing, collection of fuelwoods, and building materials) are not only leading to deforestation but also degradation of land and invasion by invasive species. Similarly, a study on the threats of woody plant species in Ethiopia by Wondie and Temesgen (2012), confirmed that land degradation, deforestation, and invasive species were the main threats to the forest in Ethiopia. The current study confirmed that firewood collection was found to be the most severe activity that results in loss of biodiversity. A similar

study has confirmed that the exploitation of firewood has harmful consequences for the environment and biodiversity, especially on climate change, reduction of soil fertility, disappearance of fauna and flora, soil degradation, and desertification (Tchobsala et al., 2022).

Table 6. Preferential rank of anthropogenic activities of Dens Forest

Anthropogenic activities	Informants' response											
	I1	I2	I3	I4	I5	I6	I7	I8	I9	I10	Total	%
Firewood	4	2	3	3	4	1	4	4	4	3	32	22.5
House construction	3	3	4	4	4	4	3	3	1	2	31	21.8
Farm instruments	3	4	4	1	4	3	3	3	1	4	30	21.1
Charcoal	2	1	3	1	1	1	2	2	2	3	18	12.7
Furniture	2	1	1	1	1	2	3	2	2	1	16	11.3
Medicinal value	1	2	3	1	2	2	1	1	1	1	15	10.6

Key**:** 4 = Severe, 3 = slightly severe, 2 = Intermediate, 1 = Rare (nil) and I= Informants

Conclusion and recommendation

The population pressure on the vegetation of Ethiopia is not only declining the biodiversity, but also decreasing the endemism and declining forest resources, degrading lands, and causing invasions of alien species. Finally, anthropogenic activities lead to the instability of the ecosystem. Dens Forest is facing challenges of less diversity and a lower number of endemic plant species due to severe anthropogenic activities. Severe anthropogenic activities are not only leading to deforestation, but also to the degradation of land and the invasion of alien species. Therefore, the concerned bodies should take immediate measures to conserve and manage communities of plants with less diversity and less equitable distribution. Besides, in order to minimize anthropogenic activities, alternative income generation methods must be incorporated into their day-to-day activities.

Conflict of Interest

We, authors, affirm that there is no conflict of interests regarding the publication of this paper.

Data Availability

Data could be obtained upon request from the corresponding author.

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References

Abiyou Tilahun, Teshome Soromessa, Ensermu Kelbessa, Abyot Dibaba. 2011. Floristic composition and community analysis of Menagesha Amba Mariam Forest (EGDU Forest) in Central Shewa, Ethiopia. Ethiop. J. Biol. Sci. 10 (2): 111- 136.

Abreham Assefa. 2009. Floristic composition, structure and regeneration status of Masha Forest southwest Ethiopia, MSc Thesis. Addis Ababa University, Ethiopia.

Annissa Muhammed, Eyasu Elias.2020. Tree species composition, structure regeneration status in Munessa Natural Forest, Southeastern Ethiopia. Eurasian J. For. Sci, 8(1): 35-53.

Birhanu Kebede, Teshome Soromessa, Ensermu Kelbessa. 2014. Floristic composition and community type of Gedo Dry Evergreen Montane Forest, West Shewa, and Ethiopia. Acta Ecol. Sin. 36: 392-400.

Christopher J. Lortie, Rob W. Brooker, Philippe Choler, Zaal Kikvidze, Richard Michalet, Francisco I. Pugnaire, Ragan M. Callaway.2004. Rethinking plant community theory. Division of Biological Sciences, University of Montana, Missoula, MT, 59812, USA.

Dagne Abebe, Tamru Demsis. 2016. Floristic composition and structure of Zerat forest, Central Ethiopia. American Scientific research Journal for engineering technology and Sciences (ASRJETS). 18 (1): 326-342.

Dereje Atomsa Oncho. 2014. Natural regeneration status and population structure of Suba Sebeta Forest, Central Ethiopia: a comparative assessment over a period of 20 years. Addis Ababa, Ethiopia.

Dinkissa Beche. 2011. Floristic composition, diversity and structure of woody plant species in Menagesha suba state forest, Addis Ababa University, Ethiopia.

Ermias Lulekal, Zemede Asfaw, Ensermu Kelbessa, Patrick Van Damme. 2014. Ethnoveterinary plants of Ankober District, North Shewa Zone, and Amhara Region, Ethi opia. J. Ethnobiol. Ethnomed. 10:21.

Esteban Avigliano, Juan JoseRosso, Dario Lijtmaer, Paola Ondarza, Luis Piacentini, Matías Izquierdo, Adriana Cirigliano, Gonzalo Romano, Ezequiel Nuñez Bustos, Andres Porta, Ezequiel Mabragaña, Emanuel Grassi, Jorge Palermo, Belen Bukowski, Pablo Tubaro,

NahuelSchenone.2019. Biodiversity and threats in non-protected areas: A multidisciplinary and multi-taxa approach focused on the Atlantic Forest. Heliyon, 5(8).

Feyera Abdena. 2010. Floristic composition and structure of vegetation of Chato Natural Forest in Horo Guduru Wollega Zone, Oromiya National Regional State, west Ethiopia Unpublished MSc. Thesis, Addis Ababa.

Gojjam Bayeh. 2013. Floristic composition and diversity analysis of vegetation at Amba Asrat Monastery forest, East Gojjam. Addis Ababa University, Ethiopia.

Haile Yineger, Ensermu Kelbessa, Tamrat Bekele, Ermias Lulekal. 2008. Floristic composition and structure of the dry afromontane forest at Bale mountains National Park, Ethiopia. SINET: Ethiop. J. Biol. Sci. 31(2):103–120.

Jennings M, Jennings O, Barbour M, Walker M, Talbot S, Walker J, Waggoner G, Abrams M, Hill A, Roberts D, Tart D. 2003. Guidelines for describing Associations and Alliances of the U.S. National vegetation Classification Panel.

Kent M, Coker P. 1992. Vegetation description and analysis. Ambo Practical approach. Bent Haven Press, New York.

Kitessa Hundera, Tsegaye Gadissa. 2008.Vegetation composition and structure of Belete Forest, Jimma zone, Southwestern Ethiopia. Ethiop. J. Biol. Sci. 7:1-15.

Markos Kuma. 2016. Diversity of woody plant species of Gamuawa and Oda Forest of Humbo Carbon Project Wolaita, Ethiopia: Conservation and Management of Forests. Int. J. Biodivers.1-8.

Mekbib Fekadu. 2012. Floristic composition and diversity analysis of vegetation of Awash Melka Kunture Prehistoric Archaeological Site, plant Biodiversity and Management, Addis Ababa University, Ethiopia.

Negusse Tadesse. 2006. Ecology and plant use diversity in Sof Umer Area of Bale southeastern Ethiopia. A Thesis Submitted to the School of Graduate Studies. Addis Ababa University.

Sultan Mohammed, Berhanu Abraha. 2013. Floristic Composition and Structure of Mountain Forest, South Wollo, Bahir Dar University, Ethiopia. Ethio J SciTechno 1: 33-45.

Tchobsala, BelloHaman, HaiwaGilbert, KodjiPaul, Dieudonné DjakbaDanra, KairaDenis. 2022. Socio-economic and environmental influences of firewood exploitation in Bongor and its surroundings (Chad). Environmental Challenges *6.*

Teshome Soromessa, Ensermu Kelbessa. 2014. Interplay of regeneration, structure and uses of some woody species in Chilimo Forest, Central Ethiopia: Arts Res J Sci Techno. 3(1): 90-100.

Werren G, Arthington AH. 2002. The assessment of riparian vegetation as an indicator of stream condition, with particular emphasis on the rapid assessment of flow-related impacts. In: Landscape Health of Queensland (Eds J.Playford, A. Franks), Royal Society of Queensland, Brisbane, 194-222.

Wondie Mebrat, Temesgen Gashaw. 2013. Threats of Woody plant species diversity and their conservation techniques in Ethiopia. European Journal of Botany, Plant Science and phytology 3: 10-17.

Zelalem Teshager, Mekuria Argaw, Abeje Eshetie. 2018. Woody species diversity, structure and regeneration status in Weiramba Forest of Amhara Region, Ethiopia: Implication Management Forest, for Biodiversity in Conservation. J. Nat. Sci. Res 8(5): 2224-3186.