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Research article

Woody species diversity and regeneration status of Sub-Alpine forest of Mount Adama exclosure site, Northwestern highlands of Ethiopia

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A R T I C L E I N F O

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A B S T R A C T

Forests provide a wide range of ecosystem services. Despite these facts, the expansion of agriculture and settlement at the expense of forest resources has threatened the forest resources and results in biodiversity loss. To halt this problem, various conservation practices that believed to restore the degraded lands and biodiversity of the country have been implemented. Area exclosure is among the conservation strategies that have been used to restore the degraded lands in Mount Adama forest. However, its role in woody species regeneration in Mount Adama was not investigated. Thus, the objective of the study was to evaluate the impact of area exclosure on woody plant species composition, regeneration status, structure and diversity in Mount Adama. A systematic transect sampling method was used to collect vegetation data. Hence, 53 plots with 400 m^2 area were laid along 11 transects. Then, within the main plots, five subplots with 1 m^2 were laid to determine the abundance and frequency of seedlings. The results showed that about 31 woody species that belong to 30 genera and 19 families including four endemic species were identified. The majority (67.74%) of the species were categorized under shrub habitat, while the remaining 19.35% and 12.90% were trees and lianas or climbers, respectively. Asteraceae family was dominant by contributing 4 species followed by Rosaceae and Solanaceae each contributed 3 species. Hypericum revolutum was the dominant species with 53.38 important value index followed by Erica arborea and Hagenia abyssinica with 49.12 and 40.05, respectively. The overall Shannon- Wiener diversity index and Shannon evenness in the exclosure site were 2.6 and 0.73, respectively. Furthermore, the number of seedlings and saplings were higher in the exclosure than the untreated site. The results of the study evidently showed that area exclosure that implemented in Mount Adam successfully contributed to the biodiversity restoration. Therefore, further conservation efforts targeting species with low IVI values are needed for sustainable management and ecological recovery of the area.

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1. Introduction

Forests haven most of the Earth's terrestrial biodiversity [1] which covers nearly one third of the world's total land area and are vital in regulating climate and, conserving soil and water, besides maintaining biodiversity [2]. Africa is the richest continent in biodiversity [3] and constitutes nearly one fifth of the world's forest including a majority of the global biodiversity hotspots [4]. Comparably, Ethiopia is the home of biodiversity ranking of the world's top 25 biodiversity-rich countries, and hosts the Eastern Afromontane and the Horn of African biodiversity hotspots of Africa [5]. It also consists of the fifth largest flora in tropical Africa [6].

In forest biodiversity, woody species diversity is central which provides resources and habitats for almost all other species found and the basis for territorial ecosystem [7]. Ecosystem services provided by forests through water and microclimate regulation, soil protection and nutrient cycling support the productivity of agriculture, livestock, and ensures food security [8]. Thus, most of the communities both in low- and high-income countries and in all climatic zones, rely on forest biodiversity for their lives and livelihoods [1].

However, with rapidly increasing population pressure, climate change, and deforestation, forests are under serious threats and, subject to fragmentation and degradation with subsequent loss of forest diversity [2]. Globally, between 1990 and 2020, forest area declined by 4.4%, representing a net loss of 178 million ha [1]. This problem is more pronounced in developing countries like Ethiopia [9]. More importantly, the problem is serious in the northern highlands of Ethiopia which are attributed to agricultural expansion, settlement, and concomitant deforestation, and biodiversity loss [10,11]. Consequently, important mountain ecosystems of the country have been severely degraded, deforested, or converted to cultivated land [12]. Therefore, more than half of the rural highland areas are severely degraded [13]. In this regard, recent reports show that nationally, over the last two decades, about 3.6% forest cover (in reference to 2001 forest covers) was lost. Among the regions, the Amhara National Regional State, where this study was conducted, lost about 2.0% (2,449ha) of its forest cover [14]. Nevertheless, forest degradation and the consequent biodiversity loss have continued as one of the major ecological and environmental problems in the Ethiopian highlands [15].

Hence, forest degradation and biodiversity loss potentially disrupt important ecological services provided by forests and lead to overall impoverishment of the environment and livelihoods [16]. Thus, managing forests sustainably and restoring them is essential to circumvent environmental problems [7] though, forest conservation and biodiversity are utterly dependent on the significance of the problem and the availability of technologies. Designing economically feasible, socially acceptable and ecologically viable management and conservation strategies for forest resources is an important step [17]. In this regard, in response to the ever increasing land degradation, the government of Ethiopia has designed and implemented several conservation strategies including soil and water conservation, sustainable land management, green legacy, integrated watershed management, forest restoration, and rehabilitation programs. Those conservation practices are pertinent to restore the vegetation cover and biodiversity, and improve the livelihoods of the local community [18]. They are also instrumental to realize Sustainable Development Goals (like goal 15 and 13) [19], and conventions on biodiversity [20].

Selecting an appropriate conservation strategy for restoring degraded forest, necessitates site-specific information associated with the biophysical characteristics of the fragmented forest ecosystem and the human interaction with it [21]. In Ethiopia, area exclosure becomes one of the popular land management practices and showed promising results in rehabilitating degraded lands through natural regeneration [22]. Exclosures are land areas that have lost a significant level of their productive capacity and are set aside for natural regeneration by permanently removing human and livestock interference during the course of rehabilitation [23]. It is advantageous over other methods because it is inexpensive, relatively easy, and requires less inputs and investment [24]. Furthermore, several studies confirmed that, exclosure ensures the rehabilitation of degraded lands, and vegetation regeneration [17,22] and reduces soil loss and, improve soil conditions and microclimate [25], in turn enhance woody species diversity [15]. Eventually, it improves the income and food security of the local community [26–28]. As a result, in the highlands of Ethiopia, there has been a growing trend of degraded areas being placed under exclosures.

The mount Adama forest is one of the highly degraded forests in the northwest highlands of Ethiopia. The forest has experienced significant expansion of cultivated land and settlement which resulted in deforestation and biodiversity loss. The forest degradation in the study forest is both in terms of quality (species reduction) and quantity (decline in area). Coupled with its rugged topography, poor land management worsened problem. A recent survey conducted by Geospatial Data and Technology Center (GDTC[1]) of Bahir Dar University showed that more than 65% of Mount Adama has been used for cultivation. Besides, nearly 50% of the area has experienced high to very high soil loss with an average rate of more than 60 t ha^{-1} yr^{-1} [29].

Thus, as part of the national forest conservation strategy, Bahir Dar University in collaboration with the local government and communities took the initiative to rehabilitate the degraded Mount Adama forest for more than a decade. Bahir Dar University has initiated a considerable number of rehabilitation programs such as area exclosure, planting native trees and other management practices. However, the effectiveness of the approach on woody species regeneration and composition of Mount Adama forest was not studied. Assessing the floristic composition, vegetation structure, and regeneration of the given forest patch and evaluating changes is imperative to evaluate the role of exclosure on the status of forests. Therefore, this study was intended to evaluate the impact of exclosure that has been implemented over the last fourteen years on woody plant species composition, regeneration status, structure and diversity of Mount Adama forest, Northwest Ethiopia.

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2. Methodology

2.1. Description of the study area

The study was conducted on the area exclosure of Mount Adama which is part of the Birr Adama integrated watershed development site of Bahir Dar University in the west Gojjam zone of Amhara National Regional State. The study area is located 62 and 20 km away from Bahir Dar City and Adet town, respectively. It is bordered by four *woredas* (districts) of West Gojjam Administrative Zone, namely: Quarit, Sekela, Mecha and Yilmana Densa. Mt Adama area is one of the peaks of central Gojjam highlands, and a continuum of Choke Mountain ranges. It is geographically located between 11^0 03′ 00″ to 11° 11′ 10″ N and 37° 15′ 00″ to 37° 31′ 00″ East (Fig. 1). Its elevation ranges from 2160 to 3538 m a.s.l. and the slope ranges from flat to very steep. It is a source of many rivers and streams such as Jemma, Birr, Shina, Shigez, Kotet, Gerima, etc. It could be the main attractions of tourists because of the existence of an impressive landscape, unique and source of biological diversity and the cool agro-ecological zone.

2.2. Sampling and data collection techniques

A reconnaissance survey was conducted across five different forest patches which are under area exclosure and adjacent degraded lands to have an overview of the study area ahead of the actual field survey. A systematic sampling design was implemented to frame the sampling and data collections following Mueller-Dombois and Ellenberg [30] methods. 11 transects were constructed systematically that lie parallel to the slope of the stand and considering the aspects of the area [31] using a compass. The number of transect lines depends on the vegetation density, spatial heterogeneity of vegetation and the size of the area following [32]. Alongside every transects a 20 × 20 m (400 m^2) size quadrants were laid down with a one hundred m distance within and between transects and 50 m from the forest edge in the exclosure and open site. Shrubs and sapling data collection had been carried out on five sub-quadrats of 1 m × 1 m (1 m^2) size located at the four corners and center of the main quadrats following [30]. These subplots were used to determine the abundance and frequency of seedlings. The inventory data were collected from 53 plots in 11 transects. In each major plot, altitude and geographical positions in degrees were taken using Global Positioning System.

2.2.1. Floristic data collection

All plant species consisting of trees, shrubs, and lianas in every plot have been documented. Plant species found outside the plots

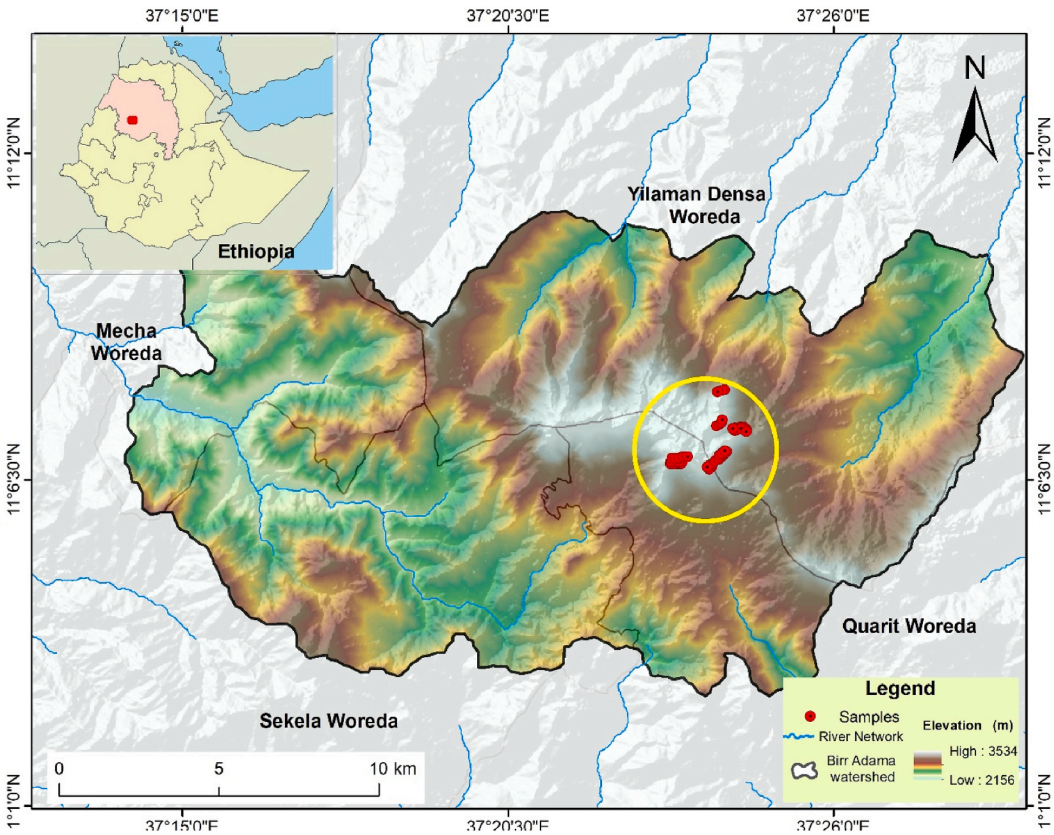

Fig. 1. Map of Birr Adama integrated watershed community service site and sample sites.

but in the study site were also recognized as "present". The common names of each species were recorded and included within the list of taxa. Plants with a height of ≥3 m have been considered as shrubs or trees; between 1.5 m and <3 m long was recorded as a sapling, and those below 1.5 m long were considered as seedlings. Similar approaches were applied by Ref. [33].

In each sample plot and sub-plots, all woody species were identified, counted, and height and diameter at breast height (DBH) was measured and recorded. For tree/shrubs that branched at breast height or below, the diameter of each branch were measured separately and the average was taken. The height of each woody plant in the plot was measured using Sunto Hypsometer and calibrated bamboo stick, where topography and crown structure made it difficult to measure the aforementioned variables using Clinometer. Diameter tape was used to measure the diameter of woody plants at breast height (about 1.3 m). Cover or abundance values for all woody species were visually estimated in each sample plot and converted to Braun-Blanquet scale as modified by Ref. [34].

The growth forms of all plants were listed, and voucher specimens were collected. Then the collected specimens were tagged, dried, pressed, identified and deposited at the National Herbarium of Ethiopia in Addis Ababa University. The identification of specimens had been performed both using recognition methods in the field and later at ETH by comparison with authenticated herbarium specimens. The nomenclature of plant specimens was based on Flora of Ethiopia and Eritrea [35].

2.2.2. Diameter at breast height (DBH) measurement

In the present study DBH was measured at about 1.3 m average height from the ground by using a diameter tape. TRUBs (Trees and shrubs) with a DBH above 2.5 cm were only considered for DBH measurement. TRUBs having multiple stems below 1.3 m average height were treated as a single tree and measured separately according to Kent and Coker [36]. For TRUBs that are branched around the breast height, the diameter was measured separately for the branches and averaged. Woody plant species in the study area were classified into ten DBH classes: (**A**) 2.5–5 cm, (**B**) 5.1–10 cm, (**C**) 10.1–15 cm, (**D**) 15.1–20 cm, (**E**) 20.1–25 cm, (**F**) 25.1–30 cm, (**G**) 30.1–35 cm, (**H**) 35.1–40 cm, (**I**) 40.1–45 cm, (**J**) > 45 cm.

2.2.3. Height measurement

The tree height was measured using Sunto Hypsometer. The values were classified into different height classes. The height class frequency distribution of woody plants in the study forest was classified into five different height classes: (**A**) <5 m, (**B**) 5.1–10 m, (**C**) 10.1–15 m, (**E**) 15.1–20 m, (**F**) > 20 m.

2.3. Data analysis

2.3.1. Vegetation data analysis

Hierarchical cluster analysis is one of the most commonly used techniques to analyze community ecological data, and it helps to group a set of observations (vegetation samples) together, based on their attributes or floristic similarities [36]. In this study, agglomerative hierarchical classification using similarity ratio cluster analysis was performed using R software.

2.3.2. Similarity and dissimilarity among community types

Inter and intra cluster distance is used to measure the distance between communities and the distance of the quadrats within a single community, respectively. For this, the Euclidean distance measurement method is an appropriate method to measure such distances in vegetation ecology [37]. Generally, its matrices help to provide information on the ecological distance between all pairs of sites within the data [37].

The generalized formula for Euclidean distance is (Equation (1)):

$$EDij = \sqrt{\sum (yki - ykj)2} \tag{1}$$

where, *EDij* = Euclidean distance between quadrats *i* and j, and *yki* = abundance of kth species in quadrat **I,** ykj = abundance of k^{th} species in quadrat ***j***:

IV. Jaccard similarity index (*Cj*) between the transects and the two sites was calculated following Magurran equation (Equation (2)):

$$Cj = \frac{a}{(a + b + c)}, \tag{2}$$

where, a is the number of species common to both sites, b is the number of species in site A not in site B (species in transect A not in transect B), and c is the number of species in site B not in site A (species in transect B not in transect A).

2.3.3. Species richness, diversity and evenness of plant communities

The species richness is the number of species within the community and species equitability is how even the numbers of individual species within the community are. The index of species richness has a great importance in assessing taxonomic, structure and ecological value of a given habitat, and evenness is used to measure the abundance of different species in the area and that makes the richness of the area.

Shannon-Wiener diversity index (H') is the most popular measure of species diversity, because it accounts both for species richness and evenness, and this index is not affected by sample size [36]. Therefore, Shannon-Wiener diversity index, species richness and

Shannon's evenness were computed to describe the diversity of the community types which is explained by the following formulas.

(i) Simpson's diversity index (D) was calculated using a formula stated in Equation (3):

$$D = \frac{\sum ni(ni-1)}{N(N-1)} \tag{3}$$

where *ni* the total number of each species and N is the total number of all the species

(ii) The Shannon and Weiner index (H') can be computed using the formula as modified by Shannon and Weiner (Equation (4)):

$$H' = \frac{-3.3219\sum ni}{NLog\left(\frac{ni}{N}\right)} \tag{4}$$

where, ni shows the total number of each species and *N* is the total number of all the species.

(iii) The evenness (*E*) was computed from Pielou's index (Equation (5)):

where, H' = Shannon and Weiner diversity and ln S′ is the natural log of the total number of species recorded

$$E = \frac{H'}{Ln\ S'} \tag{5}$$

The higher the value of the *E*, the more even the species is in their distribution within the community. Equitability assumes a value between 0 and 1 where the value 1 implying complete evenness. Similarly, the higher the value of *H*', the more diverse is the community or the quadrant.

2.3.4. Structural data analysis

2.3.4.1. Density (D). Density is a measure of the spatial distribution and ranges of species over time. It considers the sum of individuals per species in all quadrats is calculated in terms of species density per convenient area unit such as a hectare [30]. It was computed using Equations (6) and (7):

$$D(density) = \frac{Number\ of\ above\ ground\ stems\ of\ species\ counted}{Sample\ area\ by\ ha} \tag{6}$$

$$RD(relative\ density) = \frac{Density\ of\ species\ A}{Total\ Density\ of\ all\ species} * 100 \tag{7}$$

2.3.4.2. Frequency (F). Frequency was obtained by using quadrats and expressed as the number of quadrats in which a species was recorded per total number of quadrats as a percentage. It is dependent on quadrat size, plant size and patterning in the vegetation [36]. It was computed using Equations (8) and (9).

$$f(frequency) = \frac{the\ number\ of\ plots\ where\ which\ that\ species\ occurs}{Total\ number\ of\ plots} \tag{8}$$

$$RF(relative\ frequency) = \frac{frequency\ of\ species\ A}{Total\ frequency\ of\ all\ species} * 100 \tag{9}$$

Basal area (BA): Basal area is also used to calculate the dominance of species which was computed using Equation (10).

$$BA = \pi\ (D/2)^2 = (DBH/2)^2 * 3.14 \tag{10}$$

where, D or DBH is diameter at breast height.

2.3.4.3. Importance value index (IVI). IVI is a useful index to compare the ecological significance of species in a particular ecosystem. It is used to express the relative dominance of the species in the community [36]. The IVI for each woody species was calculated using the formula (Equation (11)).

$$IVI = RD + RF + RDO \tag{11}$$

Importance Value = Relative density + Relative frequency + Relative dominance.

2.4. Regeneration data analysis

The regeneration status of woody species in the Mt Adama forest was analyzed by comparing seedling with sapling and sapling with matured trees data [38] in the following categories: 1) "good" regeneration, if present in seedling > sapling > mature tree; 2) "fair" regeneration, if present in seedling > sapling < mature tree; 3) "poor" regeneration, if a species survives only in the sapling stage, but not as seedlings (even though saplings may be less than, more than, or equal to mature); 4) "none", if a species is absent both in sapling and seedling stages, but present as mature; and 5) "new", if a species has no maturity, but only sapling and/or seedling stages.

3. Results and discussion

3.1. Species accumulation curve

In ecological communities, the number of species increases with the increase in the area sampled. However, the rate of newly added species decreases with increasing sampling effort. This trend of species accumulation in the sampling effort could be represented graphically using species accumulation curve [39]. The curve was plotted for the cumulative number of species recorded as a function of sampling effort which illustrate the rate at which new species are included as the sampling effort proceeds [40]. One of its applications is to assess whether a study area has been sufficiently sampled or not. A curve labeled off (or approximately reaching an asymptote) indicating that no or few species would be collected if the sampling effort was further continued. Accordingly, in this study the curve (Fig. 2), almost leveled off showing that a few species would be collected if the sampling effort was further continued which proves the representativeness of the samples collected in the study area.

3.2. Woody species composition and plant communities

The result of species composition analysis revealed that 31 woody plant species in 30 genera and 19 families were identified in the exclosure and adjacent degraded sites of Mt. Adama forest (Appendix 1), of which 30 species were identified to species level and only one was unknown species. Thus, a total of 1825 individual plants were recorded. Major identified families were *Asteraceae* contributed 4 (12.90%) species; *Rosaceae* and *Solanaceae* each contributed 3 (9.68%) species, *Cupressaceae*, *Fabaceae*, *Loganiaceae, Ranunculaceae* and *Malvaceae* each contributed 2 (6.45%) species, while the remaining 11 families were represented by one species each (Table 1). *Asteraceae* was the dominant family group in this study with four species. It is one of the largest families of vascular plants and the most species-rich families comprising 133 genera and 472 species [6]. Similarly, studies in Arsi Mountains National Park [41], Gesha and Sayilem Forest [42], Dodola dry evergreen Afromontane forest [43] were reported the dominancy of the *Asteraceae* family in the Subalpine vegetation stands. The parachute-like structures in their seeds of the *Asteraceae* family improve air flotation and contribute to their widespread dispersal, especially when strong winds are prevalent in the Afro-alpine zone [44] and adapt to different ecological niche are the possible reason for the success of *Asteraceae* in the Afro-alpine zone.

Besides, in the study forest, four species (13.3%) of the total species were endemic to Ethiopia where three (75%) of them belong to the family *Asteraceae*; and all of these species were shrubs. The proportion of endemic plant species in the study forest is higher than the endemic plant species found in the other afromontane forests of Ethiopia such as Borena Saint National Park 8.7% [45], Yayu forest (1.36%) [46], Wurg forest 5.2% [47] and Gesha and Sayilem Forest 4.5% [42]. As per IUCN [48], three of the identified endemic species (*Inula confertiflora*, *Laggera tomentosa, Maytenus addat*) are grouped as near threatened and one (*Echinops longisetus*) under least concern.

Based on the abundance of species within a plot vegetation cluster analysis was conducted and four species (*Echinops longisetus, Maytenusaddat*, *Sida schimperiana*) were observed outside the plots in the study area within the range of 10-m distance. Among the total of 31 species identified in the study forest area, majority (21 or 67.74%) of them were categorized under shrub habitat, (6 or19.35%) were trees and the remaining (4 or 12.90%) were lianas or climbers (Table 2).

Based on a hierarchical cluster analysis using Ward's method and Euclidean distance, four different communities (clusters) were identified for Mt. Adama Forest (Fig. 3). The communities were described based on their synoptic cover values (Appendix 2). The plant communities were named based on the two dominant woody species which have the highest mean cover or abundance that appears within the cluster**.**

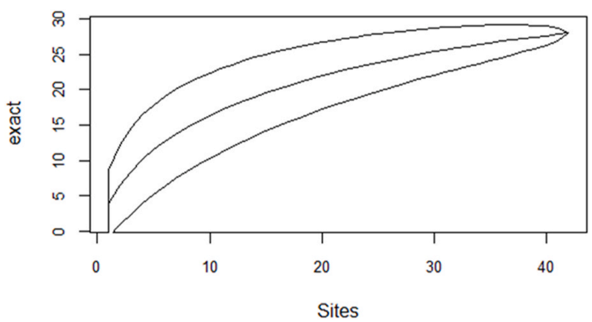

Fig. 2. Species accumulation curve for Adama forest.

Table 1
Family names of woody plant species of Mt. Adama forest with their number of genera and species.

No.	Family	No. of genus/genera	No. of species	Percent
1	*Asteraceae*	4	4	12.90
2	*Rosaceae*	3	3	9.68
3	*Solanaceae*	2	3	9.68
4	*Cupressaceae*	2	2	6.45
5	*Fabaceae*	2	2	6.45
6	*Loganiaceae*	2	2	6.45
7	*Ranunculaceae*	2	2	6.45
8	*Malvaceae*	2	2	6.45
9	*Celastraceae*	1	1	3.23
10	*Asparagaceae*	1	1	3.23
11	*Ericaceae*	1	1	3.23
12	*Guttiferae*	1	1	3.23
13	*Myrtaceae*	1	1	3.23
14	*Phytolaccaceae*	1	1	3.23
15	*Poaceae*	1	1	3.23
16	*Polygonaceae*	1	1	3.23
17	*Rhamnaceae*	1	1	3.23
18	*Sterculiaceae*	1	1	3.23
19	*Urticaceae*	1	1	3.23
	Total	**30**	**31**	**100.00**

Table 2
Growth form based categories of plant species identified in Mount Adama forest.

S N	Habit	No	Percentage %
1	Tree	6	19.35
2	Shrub	21	67.74
3	Liana/Climber	4	12.9

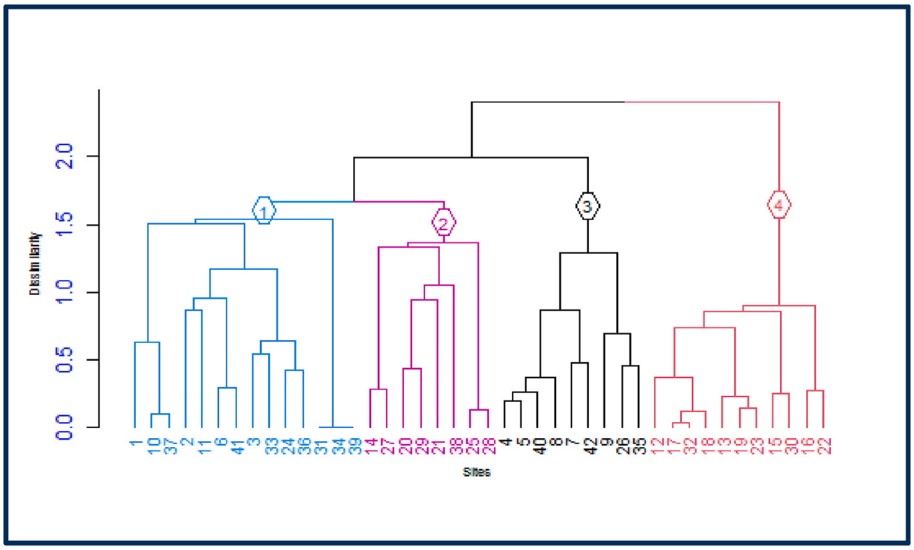

Fig. 3. Dendrogram of the vegetation data obtained from hierarchical cluster analysis of vegetation of Mt. Adama forest.

Table 3
Jaccard's similarity coefficient among the 4 communities of Mt. Adama forest.

Community	1	2	3	4
1	1.00			
2	**0.73**	1.00		
3	0.64	0.61	1.00	
4	0.63	0.55	0.52	1.00

3.2.1. *Hagenia abyssinica - Rosa abyssinica*

This community contained 14 plots and 11 species between the altitudinal range of 3158 and 3454 m.a.s.l (Table 3). The most dominant plant species in this community type were *Hagenia abyssinica,* and *Rosa abyssinica* (Appendix 2). The tree layer was represented by *Hagenia abyssinica*, *Acacia decurrens, Dombeya torrida, Cupressus lusitanica* and *Erythrina abyssinica*. The shrubs layer was represented by *Rosa abyssinica*, *Hypericum revolutum*, *Erica arborea*, *Nuxia congeta, Buddleja polystachya Discopodium penninervium* and Vernonia hymenolepis. The common climber/liana in this community was *Phytolacca dodecandra*.

3.2.2. *Hypericum revolutum- Dombeya torrida*

This community is formed by 8 plots and 17 species and lie in the altitudinal ranges of 3341 and 3448 m.a.s.l. (Table 3). *Hypericum revolutum* and *Dombeya torrida* are the dominant plant species in this community type (Appendix 2). The tree layer was represented by *Dombeya torrida*, *Hagenia abyssinica*. The shrubs layer was represented by *Hypericum revolutum*, *Vernonia hymenolepis*, *Erica arborea*, *Rosa abyssinica*, *Discopodium penninervium*, *Arundinaria alpine*, *Indigofera hirsute*, *Rumex nervosus*, and *Rhamnus prinoides*. The common climbers/liana were Phytolacca dodecandra and *Clematis simensis*.

3.2.3. *Hagenia abyssinica - Cupressus lusitanica*

This community contained 9 plots and 10 species between the altitudinal range of 3186 and 3442 m.a.s.l. (Table 3). The most dominant plant species in this community type were *Hagenia abyssinica* and *Cupressus lusitanica* (Appendix 2). The tree layer was represented by *Hagenia abyssinica*, *Cupressus lusitanica*, *Eucalyptus globulus*, *Dombeya torrida* and *Juniperus procera*. The shrubs layer was represented by *Discopodium penninervium*, *Inula confertiflora*, *Hypericum revolutum*, *Erica arborea*, *Rumex nervosus*, *Rosa abyssinica*, *Vernonia hymenolepis*, *Rubus steudneri*, *Erica arborea*, *Rumex nervosus*, *Rosa abyssinica*, *Vernonia hymenolepis*, *Rubus steudneri, Solanum incanum, Arundinaria alpina, Nuxia congeta, Buddleja polystachya, Lobelia giberroa*, *Solanum adoenese* and *Laggera tomentosa*. The common climbers/liana were *Phytolacca dodecandra, Urera hypselodendron* and *Clematis simensis*.

3.2.4. *Erica arborea - Rosa abyssinica*

This community contained 11 plots and 20 species between the altitudinal ranges of 3344 and 3452 m.a.s.l. (Table 3). The most dominant plant species in this community type were *Erica arborea* and *Rosa abyssinica* (Appendix 2. There was no tree layer in this community. The shrub was represented by *Discopodium penninervium*, *Hypericum revolutum*, *Nuxia congeta*, *Vernonia hymenolepis*, *Solanum adoenese* and *Inula confertiflora*. The common climbers/liana were *Clematis simensis* and *Asparagus africanus*.

3.2.5. *Similarity and dissimilarity among community types*

Jaccard's similarity coefficient of four communities was computed to compare the similarity among communities. The result revealed that community 1(*Hagenia abyssinica - Rosa abyssinica)* and 2 (*Hypericum revolutum- Dombeya torrida)* had the highest similarity (73%), followed by community 1 (*Hagenia abyssinica - Rosa abyssinica community type)* and 3 (*Hagenia abyssinica - Cupressus lusitanica)* (64%) (Table 5). On the other hand, community 3 ((*Hagenia abyssinica - Cupressus lusitanica)* and 4 (*Erica arborea - Rosa abyssinica*) showed lowest similarity (0.56%) this could be explained by variation in conservation efforts and extent of human disturbance [31].

3.3. *Species richness, diversity and evenness of the plant communities*

Species diversity is a useful parameter to compare communities under the influence of biotic disturbances or to identify the state of succession and stability in the community which imply the well-functioning of the ecosystem. The results of Shannon- Wiener diversity index showed that, Community 4 had the highest species richness (20 species), evenness (0.84) and diversity (2.52) followed by community 1 with 1.93 diversity index and 0.81 evenness index. Community 3 showed the lowest species richness (10 species), evenness (0.63) and diversity index (1.45) (Table 4). Alemayehu [49] on his study of church forests has found different value of *H'* and *E* for the different communities, and he attributed low species diversity and evenness in a community to selective utilization of some species, high disturbance and variable conditions for regenerations. Wakjira [50] also discussed that the variation in species richness and diversity of the plant communities could be attributed to variation in elevation, level of forest disturbance, and other factors, however the variation in the environmental factors of the study area seems to be insignificant. Furthermore, study by Ref. [51] mentioned climate and topographic factors have broad effects on diversity across the landscape, while biological factors and availability of suitable environmental gradients seem to influence diversity more at the site level.

The overall Shannon- Wiener diversity index (H') and Shannon evenness (E) of the study forest area was 2.6 and 0.73, respectively.

Table 4
Species richness, diversity and evenness index of the Mt. Adama plant communities.

Community	Species richness (S)	Diversity index (H')	Shannon Evenness(E)
1	11	1.93	0.81
2	17	1.77	0.63
3	10	1.45	0.63
4	20	2.52	0.84
Overall diversity		**2.6**	**0.79**

Table 5
Basal area of the top 5 common woody plant species in Mt. Adama Forest.

Species	Basal area/m^2	Basal area/ha	Percent %
Hagenia abyssinica	0.27	0.13	24.56
Erica arborea	0.23	0.11	20.91
Eucalyptus globulus	0.18	0.09	16.65
Rosa abyssinica	0.09	0.04	8.19
Discopodium penninervium	0.07	0.03	6.26
Five species total	0.83	0.40	76
Twenty two species total	0.26	0.13	24
Over all total	1.09	0.52	100

According to Wakjira [50] the value of *H*′ usually lies in between 1.5 and 3.5, and its value is high when the relative abundance of the different species in the sample is even. The *H*' value in the present study falls below this range and is consistent with studies conducted in Mt. Damota exclosure site 2.54 [52], Yemrehane Kirstos Church Forest 2.88 [53], and Gra-Kahsu natural forest 2.29 [26]. However, it contradicts with species diversity analysis results of Alemayehu [49] who conducted a research on church forests in fragmented Ethiopian Highland. Thus, Mt. Adama exclosure forest site is diverse in species which implies good interaction among the species and the higher value of *E* also show the equivalent proportion of individual species in their allocation in the exclosure area.

3.4. Structural analysis

3.4.1. Density

The density of a given species is expressed as a number of stems per hectare. Thus, the overall density of mature woody species with DBH >2.5 cm in the Mt. Adama forest was 1604.40 stems per ha. Previous studies by Boz and Maryo [47] have reported a density of 1745.27 ha−1, Mammo and Kebin [54] 3328.47 individuals ha−1 and Tegene, Gamo [31] 1288 individuals ha−1 which are higher than the present study. The intensity of disturbance could be attributed to the variations. The density was classified into seven density classes (Fig. 4) with the highest density in 1st class (<5 DBH) which contributed about 52.27% (954 individual steam per ha) of the overall density followed by the 2nd class (5.01–20.3 DBH) with about 554 species per ha steams. At species level, *Hypericum revolutum* was the densest species (37.36%) followed by *Erica arborea* (14.8%), *Rosa abyssinica (11.67%), Hagenia abyssinica (7.5%)* and *Rumex nervosus (4.7%)*. This density variation between species might be due to habitat preferences among the species, species characteristics for adaptation, degree of exploitation and conditions for regeneration [55].

3.4.2. Frequency

Frequency is the probability of a species occurrence in a given quadrant [36] which indicates the homogeneity or heterogeneity of species [56]. Conversely, As Shibru and Balcha [57] described, the higher the percentage of the number of species in the lower frequency classes and low percentage of the number of species in the higher frequency classes point out a high degree of floristic heterogeneity. In the present study, the value of frequency was classified into five frequency classes: A = 0–20, B = 20.1–40, C = 40.1–60, D = 60.1–80 and E = 80.1–100. The result showed that about 22 of the total woody species were distributed in the lower frequency class (Fig. 5). Thus, Mt. Adama exclosure area has high degree of floristic heterogeneity with clumped distribution of species. The most frequently occurred species in the study area was *Rosa abyssinica* which occurred in 30 plots out of 52 plots under study.

3.4.3. DBH distribution

In the present study woody plants were classified into seven diameter classes (Fig. 6). The first DBH class (<2.5–5 cm) had the highest distribution of species density per hectare (709.62), followed by the second (5.1–10 cm) with 139.42 species density per hectare. As the DBH classes size increases, the species density per hectare decreases gradually from 709.62 in the first class down to

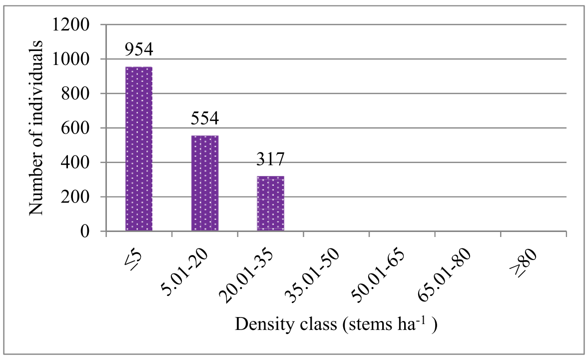

Fig. 4. Distribution of individuals in different density classes.

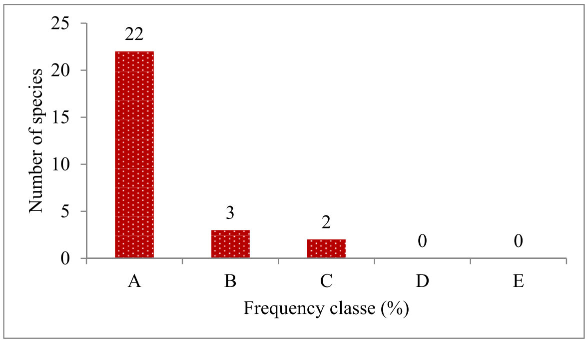

Fig. 5. Frequency distribution class. (A = 0–20, B = 20.1–40, C = 40.1–60, D = 60.1–80).

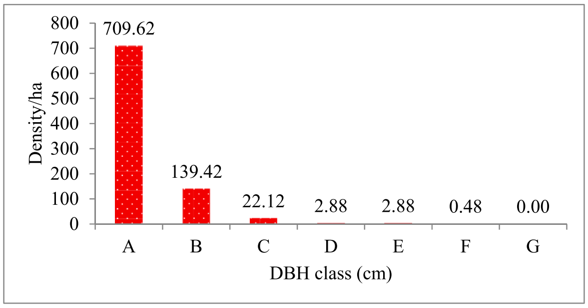

Fig. 6. DBH class distribution of woody plants in Mt. Adama forest.

0.48 in the sixth DBH class. The shape of population distribution of the study forest was inverted 'J' curve (Fig. 6). This implies selective removal of middle and high diameter class trees Silvertown and Doust [58] and overall healthy regeneration status or stable population structure of the forest [59]. Previous studies [43,55,60–62] in different afromontane forests of Ethiopia reported similar pattern of population structure.

3.4.4. Height

In the present study individual woody species were classified into seven classes (Fig. 7) and density ha^{-1} was computed. The result of height class distribution of trees and shrubs showed that, high individuals had the lowest height class (78.02%) in class "A" which was an inverted "J" distribution pattern (Fig. 7). As height increases from one class to the other, the density of individuals falls dramatically this reveals the dominance of lower stature individuals in forest. The percent distribution of trees and shrubs decreased with increasing height classes showing an inverted J-shape pattern of distribution is a characteristic of the high rate of regeneration and selective cutting or exploitation of bigger trees. The dominance of shrubs and smaller trees in the lower height class implies the absence of enough number of adult tree species indicating selective cutting of individuals in that particular height class [31].

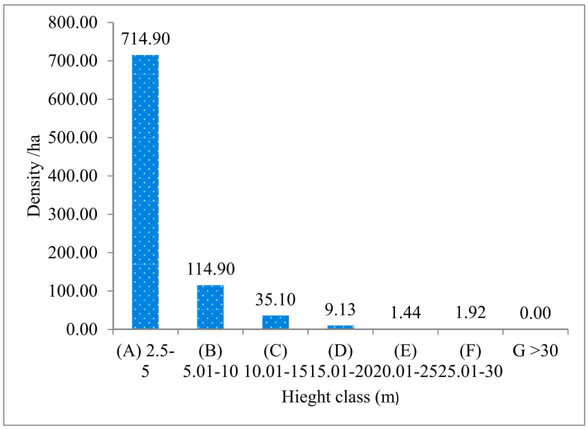

Fig. 7. Height class distributions of woody plant species in Mt Adama forest.

According to Lenhard, Sandelin [63] shrubs and small trees were dominant in the floristic composition of Kimphe forest and they suggested this is a consequence of selectively removal exploitation of bigger tree species.

3.5. Basal area (BA)

Basal area is the cross-sectional area of all of the stems in a stand at breast height which measures of the relative importance of a species rather than simple stem count [56]. The total basal area of the Mt. Adama exclosure forest was 1.09/m^2 or 0.52/ha for woody species >2.5 cm in DBH and >1.3 m in height. About 76% of the total basal area of the vegetation was covered by five species (*Hagenia abyssinica*, *Erica arborea*, *Eucalyptus globulus*, *Rosa abyssinica and Discopodium penninervium)* while the other 22 species contributed only 24% of the total basal area (Table 5). Species with the higher basal area could be considered as the most important species in the study vegetation. In comparison to previous studies, the basal area values of Mt. Adama exclosure forest was lower than other studies conducted in other forest area of Ethiopia [26,53] and nearly the similar with the value reported by Solomon, Derero [52]. This suggests that the study forests have relatively unfavorable growing conditions and unable to retain higher biomass (Table 5).

3.6. Importance value index (IVI)

The ecological significance of a given species in a particular ecosystem is analyzed using importance value index (IVI) [56]. The analysis result of IVI revealed that Mt. Adama forest was highly dominated by six (*Hypericum revolutum*, *Erica arborea*, *Hagenia abyssinica*, *Rosa abyssinica*, *Eucalyptus globulus* and *Discopodium penninervium)* woody plant species (Table 6). Among these species *Hypericum revolutum* was the most dominant species (53.38) followed by *Erica arborea* (49.12) and *Hagenia abyssinica* (40.05) IVI values. This high IVI value attributed to the high values of relative frequency, relative dominance and relative density of these species. The woody species with high IVI value are considered as ecologically very important in Mt. Adama. Conversely, *Juniperus procera* (0.85), *Indigofera hirsute (0.84), Laggera tomentosa* (0.82) and *Rhamnus prinoides* (0.72) were found with lower IVI values. The higher IVI value indicates the magnitude of dominancy of a given species in relation to the other species in the forest structure and ecological status of the species which help to prioritize species management and conservation practices [36]. Thus, the aforementioned species with high value of IVI of Mt. Adama were in a good ecological status and those with lower IVI value (*Juniperus procera,Indigofera hirsute, Laggera tomentosa* and *Rhamnus prinoides*) were threatened and need high conservation efforts [64,65], while those with higher IVI values need monitoring management.

3.7. Regeneration status and progress of Mt. Adama forest

So as to determine the regeneration status of the study forest, the density and composition of seedlings and saplings were analyzed in both exclosure and unprotected sites. In Mt. Adama forest a total of 1812 individuals; 1127 seedlings and 685 saplings had been counted from the exclosure site, while only 211 seedlings and 97 saplings were counted in the unprotected site. This shows that the number of seedlings were greater than the number of saplings in both enclosed and unprotected sites although, it was less than the number of matured trees and shrubs. *Hypericum revolutum* followed by*, Erica arborea and Maytenus arbutifolia* were contributed the largest seedling counts with 528, 239 and 141seedlings, respectively (Appendix 5). Conversely*, Nuxia congeta, Clematis simensis, Maytenus addat* and *Buddleja polystachya* were among the woody species which were not represented by seedlings. Species such as *Rhamnus prinoides Dombeya torrida, and Lobelia giberroa* were represented by only one seedling.

According to Tesfaye, Gardi [66] the regeneration status of a given natural vegetation is considered as good if sapling is greater than seedling and seedling is greater than matures. In the present study the ratio of seedlings and saplings were lower than matured trees (Table 8). The enrichment planting done by the university in each year contributes to the high number of matured trees on the area. Besides, the existence of strong competition for resources among emerging seedlings from the already established matured Solomon, Derero [52] and the poor germination and biotic potential of the selective woody species [26], and poorly developed soil could be the

Table 6
The list of ten most dominant woody plant species with their corresponding relative frequency, relative density, relative dominance and Importance Value Index in Mt. Adama Forest.

No.	Species	RD	RF	RDO	IVI	Priority class
1	*Hypericum revolutum*	37.37	10.30	5.71	53.38	1
2	*Erica arborea*	14.79	13.33	20.99	49.12	1
3	*Hagenia abyssinica*	7.51	7.88	24.66	40.05	1
4	*Rosa abyssinica*	11.67	18.18	8.22	38.07	1
5	*Eucalyptus globulus*	1.10	1.21	16.72	19.03	1
6	*Discopodium penninervium*	3.73	8.48	6.28	18.49	1
7	*Dombeya torrida*	2.30	4.85	3.75	10.90	2
8	*Inula confertiflora*	3.89	3.64	0.70	8.23	3
9	*Vernonia hymenolepis*	1.92	4.24	1.79	7.95	3
10	*Phytolacca dodecandra*	2.79	3.64	1.04	7.47	3

Based on the value of IVI, Mt. Adama's plant species were grouped into five conservation priority classes (Appendices 4). Majority of the species were found in the 3rd and 4th IVI classes (Table 7).

Table 7
The IVI classes with the number of woody plant species in each class and total IVI.

IVI classes and values	Number of species	IVI total	Percentage
5 (<1)	4	3.22	1.07
4 (1.01–5)	9	20.18	6.73
3 (5.01–10)	7	47.54	15.85
2 (10.1–15)	1	10.90	3.63
1 (>15)	6	218.14	72.72
Total	**27**	**300**	**100.00**

Table 8
Regeneration status of the study forest in the exclosure site and open lands.

Stage of regeneration	Enclosed with intervention	Open lands
Seedlings	1127	211
Saplings	685	97
Matured trees or shrubs	1547	278

other reason for a smaller number of seedlings.

Comparatively, both the number of seedlings and saplings were greater in the exclosure site than in the unprotected site (Table 8) which was attributed to the establishment of area exclosure in Mt. Adama. Study by Solomon, Derero [52] confirmed that establishment of area exclosure improves regeneration and vegetation cover, provide better products and services for the people [67], and better carbon sequestration [27,68].

4. Conclusion & recommendation

Plant species are the potential stock for future genetic resources, and would have great implications for the ecosystem, biodiversity and socio-economic importance. A comprehensive floristic analysis is vital to evaluate the impact of conservation practices on degraded landscapes. Thus, the objective of the study was to evaluate the impact of area exclosure on woody plant species composition, structure, diversity and regeneration status. The results of the study revealed that following an area exclosure, significant improvements on the floristic composition, richness, diversity, structure and regeneration status of woody species were observed. In the area under area exclosure, about 31 woody plant species which belong to the 30 genera and 20 families were identified of which four species are endemic to the Flora of Ethiopia. Asteraceae and Rosaceae were the dominant families. High species richness (20), diversity (2.52) and evenness (0.84) were observed in *Erica arborea - Rosa abyssinica* community. The overall Shannon- Wiener diversity index (H') and Shannon evenness (E) of the study forest was 2.6 and 0.73, respectively. In conclusion, area exclosure has significant contribution on woody species diversity, composition and regeneration status of the intervention site i.e. Mount Adama forest. Therefore, the findings of this study would provide relevant empirical evidences for decision makers about the viability of exclosure to restore the composition, diversity, richness and density of woody species in degraded lands. Finally, further studies on the patterns of ecosystem functioning, the soil seed banks, seed physiology, and on the role of gap dynamics and population distribution for selected species are recommended.

Author contribution statement

Daniel Ayalew Megistu - conceived and designed the experiments and wrote the paper.

Daiel Asfaw Bekele-conceived and designed the experiments and performed the experiments and wrote the paper.

Agumassie Genet - conceived and designed the experiments, performed the experiments and analyzed and interpreted the data, wrote the paper.

Derege Tsegaye Meshesha-conceived and designed the experiments and contributed reagents, materials, analysis tools or data.

Mulatie Mekonnen - conceived and designed the experiments and contributed reagents, materials, analysis tools or data.

Data availability statement

Data will be made available on request.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

APPENDICES.

Appendix 1. List of plant species collected from Mt. Adama Forest

Key: T = Tree; SH = Shrub; L/Cl= Liana/Climber, * = Found outside the plot as matured plant.

No.	Scientific name	Family	Local name	Habit	To Ethiopia
1	*Acacia decurrens*	Fabaceae	Diccurens	T	Introduced
2	*Arundinaria alpina*	Poaceae	Kerkeha	SH	Indigenous
3	*Asparagus africanus*	Asparagaceae	Yeset kest	L/Cl	Indigenous
4	*Buddleja polystachya*	Loganiaceae	Nech Anfar	SH	Indigenous
5	*Clematis simensis*	Ranunculaceae	Azo Areg	L/Cl	Indigenous
6	*Clutia abyssinica*	Euphorbiaceae	Fiyelfegi	SH	Indigenous
7	*Cupressus lusitanica*	Cupressaceae	Yeferenji tid	T	Indigenous
8	*Discopodium penninervium*	Solanaceae	Aluma/Almiti	SH	Indigenous
9	*Dombeya torrida*	Sterculiaceae	Wulkifa	T	Indigenous
10	*Echinops longisetus*	Asteraceae	Yeahya shohe	SH	Endemic
11	*Erica arborea*	Ericaceae	Erica arborea	SH	Indigenous
12	*Eucalyptus globulus*	Myrtaceae	Nech bahirzaf	T	Introduced
13	*Hagenia abyssinica*	Rosaceae	Kosso	T	Indigenous
14	*Hypericum revolutum*	Guttiferae	Amija	SH	Indigenous
15	*Indigofera hirsuta*	Fabaceae	Dima	SH	Indigenous
16	*Inula confertiflora*	Asteraceae	Weynagift	SH	Endemic
17	*Juniperus procera*	Cupressaceae	Yehabesha tid	T	Indigenous
18	*Laggera tomentosa*	Asteraceae	Shetie	SH	Endemic
19	*Lobelia giberroa*	Lobeliaceae	gemero	SH	Indigenous
20	*Maytenus addat* *	Celastraceae	Atat	SH	Endemic
21	*Nuxia congeta*	Loganiaceae	Wondi Anfar/Atikuar	SH	Not Applicable
22	*Phytolacca dodecandra*	Phytolaccaceae	Endod	L/Cl	Indigenous
23	*Rhamnus prinoides*	Rhamnaceae	Gesho	SH	Indigenous
24	*Rosa abyssinica*	Rosaceae	Kega	SH	Not Applicable
25	*Rubus steudneri*	Rosaceae	enjori	SH	Indigenous
26	*Rumex nervosus*	Polygonaceae	Embacho	SH	Indigenous
27	*Sida schimperiana**	Malvaceae	Chifrig	SH	Indigenous
28	*Solanum adoenese*	Solanaceae	Zirch Embuay	SH	Indigenous
29	*Solanum incanum*	Solanaceae	Embuay	SH	Indigenous
30	Unkown*	Malvaceae	Abonkie	SH	Indigenous
31	*Urera hypselodendron*	Urticaceae	Lankisho	L/Cl	Indigenous
32	*Vernonia hymenolepis*	Asteraceae	Dengerita	SH	Indigenous

Appendix 2

Synoptic cover-abundance values for species having a value of >0.5 at least in one community type, highlighted values shows species having high abundance in each clusters.

No.	Species	Cluster 1	Cluster 2	Cluster 3	Cluster 4
1	*Acacia decurrens*	0.39	0	0	0
2	*Arundinaria alpina*	0	0.25	0.09	0
3	*Asparagus africanus*	0	0	0	0.14
4	*Buddleja polystachya*	0.09	0	0.09	0
5	*Clematis simensis*	0	0.03	0.09	0.25
6	*Cupressus lusitanica*	0.06	0	1.73	0
7	*Discopodium penninervium*	0.03	0.3	1.36	0.91
8	*Dombeya torrida*	0.14	1.75	0.55	0
9	*Erica arborea*	0.19	0.6	1	5.45
10	*Eucalyptus globulus*	0	0	1.45	0
11	*Lobelia giberroa*	0	0	0.09	0
12	*Hagenia abyssinica*	0.56	1.7	1.73	0
13	*Hypericum revolutum*	0.45	12.5	1.32	0.45
14	*Indigofera hirsuta*	0	0.25	0	0
15	*Inula confertiflora*	0	0	1.36	0.09
16	*Juniperus procera*	0	0	0.09	0

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(*continued*)

No.	Species	Cluster 1	Cluster 2	Cluster 3	Cluster 4
17	*Laggera tomentosa*	0	0	0.05	0
18	*Nuxia congeta*	0.19	0	0.09	0.27
19	*Phytolacca dodecandra*	0.06	0.75	1.45	0
20	*Rhamnus prinoides*	0	0.22	0	0
21	*Rosa abyssinica*	0.56	0.4	0.51	2.82
22	*Rubus steudneri*	0	0	0.27	0
23	*Rumex nervosus*	0	0.25	1	0
24	*Solanum adoenese*	0	0	0.09	0.18
25	*Solanum incanum*	0	0	0.18	0
26	*Urera hypselodendron*	0	0	0.45	0
27	*Vernonia hymenolepis*	0.03	1.12	0.35	0.18

Appendix 3. Density of matured trees and shrubs

No.	Species	Density/m^2	Density/ha
1	*Acacia decurrens*	12	5.77
2	*Arundinaria alpina*	49	23.56
3	*Asparagus africanus*	10	4.81
4	*Buddleja polystachya*	2	0.96
5	*Clematis simensis*	13	6.25
6	*Cupressus lusitanica*	8	3.85
7	*Discopodium penninervium*	68	32.69
8	*Dombeya torrida*	42	20.19
9	*Erica arborea*	270	129.81
10	*Eucalyptus globulus*	20	9.62
11	*Lobelia giberroa*	7	3.37
12	*Hagenia abyssinica*	137	65.87
13	*Hypericum revolutum*	682	327.88
14	*Indigofera hirsuta*	3	1.44
15	*Inula confertiflora*	71	34.13
16	*Juniperus procera*	1	0.48
17	*Laggera tomentosa*	3	1.44
18	*Nuxia congeta*	3	1.44
19	*Phytolacca dodecandra*	51	24.52
20	*Rhamnus prinoides*	1	0.48
21	*Rosa abyssinica*	213	102.40
22	*Rubus steudneri*	11	5.29
23	*Rumex nervosus*	87	41.83
24	*Solanum adoenese*	13	6.25
25	*Solanum incanum*	7	3.37
26	*Urera hypselodendron*	6	2.88
27	*Vernonia hymenolepis*	35	16.83
Total density		1825	877.40

Appendix 4. Important value index

No.	Species	RD	RF	RDO	IVI	Priority class
1	Hypericum revolutum	37.37	10.30	5.71	53.38	1
2	Erica arborea	14.79	13.33	20.99	49.12	1
3	Hagenia abyssinica	7.51	7.88	24.66	40.05	1
4	Rosa abyssinica	11.67	18.18	8.22	38.07	1
5	Eucalyptus globulus	1.10	1.21	16.72	19.03	1
6	Discopodium penninervium	3.73	8.48	6.28	18.49	1
7	Dombeya torrida	2.30	4.85	3.75	10.90	2
8	Inula confertiflora	3.89	3.64	0.70	8.23	3
9	Vernonia hymenolepis	1.92	4.24	1.79	7.95	3
10	Phytolacca dodecandra	2.79	3.64	1.04	7.47	3
11	Rumex nervosus	4.77	1.82	0.23	6.81	3
12	Cupressus lusitanica	0.44	1.82	4.45	6.70	3
13	Acacia decurrens	0.66	3.64	1.01	5.30	3
14	Clematis simensis	0.71	3.64	0.74	5.08	3
15	Arundinaria alpina	2.68	1.21	0.73	4.63	4

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(*continued*)

16	Nuxia congeta	0.16	1.82	1.03	3.02	4
17	Urera hypselodendron	0.33	1.21	0.58	2.12	4
18	Solanum adoenese	0.71	1.21	0.14	2.06	4
19	Rubus steudneri	0.60	1.21	0.16	1.98	4
20	Solanum incanum	0.38	1.21	0.26	1.86	2
21	Asparagus africanus	0.55	1.21	0.09	1.85	4
22	Buddleja polystachya	0.11	1.21	0.25	1.57	4
23	Lobelia giberroa	0.38	0.61	0.11	1.10	4
24	Juniperus procera	0.05	0.61	0.19	0.85	5
25	Indigofera hirsuta	0.16	0.61	0.07	0.84	5
26	Laggera tomentosa	0.16	0.61	0.05	0.82	5
27	Rhamnus prinoides	0.05	0.61	0.06	0.72	5
Total		**100.00**	**100.00**	**100.00**	**300.00**	

Appendix 5. Total number of seedlings and sapling recorded in Mt Adama Forest

No.	Scientific name	Local name	No seedling	No sapling
1	*Hypericum revolutum*	Amija	528	289
2	*Erica arborea*	Erica arborea	239	171
3	Unkown*	Abonkie	124	60
4	*Maytenus addat*	Atat	141	28
5	*Rosa abyssinica*	Kega	38	34
6	*Sida schimperiana*	Chifrig	31	38
7	*Inula confertiflora*	Weynagift	40	25
8	*Phytolacca dodecandra*	Endod	33	27
9	*Rumex nervosus*	Embacho	25	25
10	*Vernonia hymenolepis*	Dengerita	30	12
11	*Discopodium penninervium*	Aluma/Almiti	19	22
12	*Hagenia abyssinica*	Kosso	14	13
13	*Asparagus africanus*	Yeset kest	13	10
14	*Clutia abyssinica*	Fiyelfegi	18	2
15	*Acacia decurrens*	Diccurens	14	5
16	*Dombeya torrida*	Wulkifa	1	9
17	*Rubus steudneri*	enjori	5	5
18	*Indigofera hirsuta*	Dima	8	0
19	*Solanum incanum*	Embuay	3	2
20	*Cupressus lusitanica*	Yeferenji tid	3	1
21	*Urera hypselodendron*	Lankisho	3	0
22	*Arundinaria alpina*	Kerkeha	2	0
23	*Nuxia congeta*	Wondi Anfar/Atikuar	0	1
24	*Rhamnus prinoides*	Gesho	1	0
25	*Lobelia giberroa*	gemero	1	0
26	*Eucalyptus globulus*	Nech bahirzaf	0	0
27	*Juniperus procera*	Yehabesha tid	0	0
28	*Solanum adoenese*	Zirch Embuay	0	0
29	*Laggera tomentosa*	Shetie	0	0
30	*Echinops longisetus*	Yeahya shohe	0	0
31	*Buddleja polystachya*	Nech Anfar	0	0
32	*Clematis simensis*	Azo Areg	0	0

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